Printed Text = 42 pages

Household Pests

The following information is from the Certification Training Manual (pages 19-53) for the Structural Pesticide Applicator published around 1975.

Most of the information about pest information, habits, and damage control has not changed. But control practices, especially those involving pesticides may have. So always follow the instructions printed on the label of **your** pesticide container.

You should also study another leaflet, "Equipment and Techniques of Application".

Prepared for Pesticide Applicator Training courses; 1/92; Department of Environmental Biochemistry; 1800 East-West Road, #329; Honolulu, Hawaii 96822; C. Nagamine.

HOUSEHOLD PESTS

ANTS

Ants are one of the most common insects. They belong to the order Hymenoptera (bees and wasps) and can be readily distinguished from other hymenopterous pests by the presence of 1 or 2 nodes or bumps on the narrow waist (petiole) joining the thorax to the abdomen and by their characteristic elbowed antennae (Figure 1-3). At first glance, ants superfically resemble termites; however, in termites the petiole is lacking and the thorax is broadly joined to the abdomen. Also, termite antennae are straight and bead-like, and there are distinct differences in the wing structure of winged termites and ants (Figure 1-3). The front and hind wings of termites are almost equal in size and shape, with the tip of the wings extending well beyond the tip of the abdomen. In ants, the hind wings are smaller and of different form than the forewing and neither extend beyond the tip of the abdomen.

As with bees, wasps, and termites, ants are social in habit. They live within colonies, tend their young and have a distinct division of labor. The size of a mature ant colony may vary from less than 50 to over several hundred thousand individuals depending on species. Smaller colonies are usually situated under stones, in stumps and logs, or in galleries in the soil. Many of the large colonies build large mounds of earth, sticks and debris and are interspersed with a complex system of galleries and chambers.

There are usually 3 forms or castes of ants found within a colony. These castes are the workers, queens, and

males. The worker is a female whose reproductive organs have not developed. This class usually lacks wings and amd is smaller than both the males and queens. In some species there are different size workers in the colony; in others, all the workers are approximately the same size. The worker caste performs all the labor duties within the colony including building, repairing and enlarging the nest, foraging for food and feeding the young and other adult forms within the nest.

The male ant is usually winged and maintains its wings until death. The male form is typically smaller than the queen but larger than the worker. The number of males within a colony will vary depending on the species concerned and the time of the year. The sole purpose of the male is to fertilize the queen. Correspondingly, most males will be found in the nest immediately prior to the peak mating period and are usually only found in mature or large colonies. Depending on the species, mating occurs either in the nest, on the ground or in the air. When large numbers of males and queens leave the nest for mating, it is referred to as swarming. Adult males do not remain in the nest for a long period of time. Immediately after mating, they die. If males remain unmated, they apparantly succumb to predators or elements of the environment.

The female or queen is generally the largest of the 3 castes. She normally possesses wings but loses them immediately after mating. Queens have well developed eyes, an enlarged thorax, and a greatly distended abdomen for housing large numbers of eggs. In many species, the primary function of the queen is to lay eggs, but she usually cares for and feeds the first batch of brood when a new nest is first formed. In species where there are more than one queen, as many as several hundred, the queens may perform some of the duties of the workers. The queen typically only mates once but may live and lay fertilized eggs for 15 or more years. Old queens are usually replaced by daughter queens; hence a colony may survive indefinitely provided environmental conditions remain favorable.

Ants develop with complete metamorphosis. The egg is almost microscopic in size and varies in color and shape, depending on species. The larva is white, soft bodied, legless, and lacks a prominent head. The pupae resemble the adults, but is soft, white, immobile, and does not feed. It may require from 6 weeks to 2 months or more to develop from egg to adult. As environmental conditions change within one area of the nest, the workers typically move the brood throughout the colony selecting favorable environmental conditions for development.

A new colony is usually established by a newly fertilized queen. Once finding a suitable location, she loses her wings and digs a nest or seeks a cavity under a stone, in the soil, or in wood. She then seals the cavity and rears her first brood by herself on salivary secretions. The adults formed from the first brood are usually undernourished and small, but soon open tha cavity and forage outside for food themselves, the ensuing brood and the queen. As the colony increases in size and number of individuals, new queens and males may be formed.

Although some ants have specific food requirements, most are omniverous and will feed on a variety of foods including sweets, greasy materials, starchy materials, dead and living insects, seeds and a large variety of other plant and animal matter. Many species will prefer to feed on one type of food material if given a choice but will go to other materials if the preferred food is not available. Beside feeding on matter found in the home, many species of ants obtain much of their nourishment either from sweet exudants of plants or insects. The primary diet of many species of ants is honeydew. Honeydew is a sugar based material secreted by many soft body insects including aphids, soft scales, mealy bugs, whiteflies and others. These insects feed mainly on the sap of plants. Only part of this sap is completely digested. The rest is secreted in the form of honeydew. Ants are commonly found in close association with these insects and readily lap up the honeydew as it is excreted. Many species of ants will actively tend aphids and other honeydew excreting insects. It is not uncommon to observe an ant approach an aphid from the rear and first stroke the aphid's abdomen with one

antenna then the other. Immediately following this a drop of honeydew will exude from the anus and is readily consumed by the ant.

Ants mainly locate their food byforaging at random. Their strong sense of smell probably is essential once food is in the immediate vicinity. Their eyesight is thought to be extremely poor and of little use in locating food. They forage by day, night or both, depending by the species. Once a scout locates a source of food, she carries a piece back to the nest and alerts other workers. Many species lay down a pheromone chemical along the path from the food source to the nest, thus giving alerted workers a clear odor trail to follow to the food. Most species of ants also actively seek water and if necessary, will travel a considerable distance in search of it.

Identification

There are several hundred species of ants found in the United States. Over 20 species enter structures and are of some economic concern. Because of limited space we will limit our discusion to the most common ant pests. A key to the Hawaiian species is given in Appendix A. Ants may be divided for identification into 2 groups; those with one petiole segment, hence 1 node or bump and those with 2 petiole segments, the double node ants. In the illustrations of Table 2, this seperation is used. A hand lens is needed for examining the smaller ants.

Biology

Argentine Ant (Figure 1)

The Argentine ant is well established in the southern half of the United States and occurs sporadically throughout other states. Because of the aggressive and competitive nature of this species, it tends to drive other species of ants out of areas where it has become established. Therefore, over most of its distribution, the Argentine ant is by far the commonly encountered species.

The nest of Argentine ants may be situated wherever light is excluded, including both indoor and outdoor localities. Typical nesting sites include exposed or convered soil, rotting wood, plant cavities, potted plants inside buildings, under buildings and sidewalks, and many other locations. The adaptability of this insect is the prime factor for its sucess. During the spring and summer months, the number of nests and ants gradually spread out and increase over large areas, particularly along the edges of sidewalks, under shrubbery, and other situations with adequate moisture. However, as winter approaches, large numbers of nests and ants decrease, with many nests congregating into one large nest that is usually located in a well defined locality. If located outdoors, winter nests are usually deep in the soil (up to 6 inches). Argentine ant nests frequently move indoors during the winter months, especially if outdoor conditions become too cold, wet or dry.

The Argentine ants prefer sweets but will readily feed upon meats, dead and live insects, seeds, and occasional starches. In areas where this species is found, it is undoubtedly the most common species of ant invading the home. They forage both day and night and travel in well defined trails.

The Argentine ant was first found in Hawaii in 1940. It has been found in a variety of habitats ranging from sea level to 6000 feet. Although it is often found attending honeydew producing insects it can also feed on seeds and starches. It is one of the species often found in houses, although its nests are usually established outdoors in Hawaii.

Figure 1. Argentine Ant, Iridomyrmex humilis (Mayr)

Bigheaded Ant (Figure 2)

The bigheaded ant, *Pheidole megacephala* (F.), is very common in Hawaii. It is readily recognized by its dark brown color and the presence of big-headed soldiers. The waist has 2 nodes. It is the dominent ant species in Hawaii and was first recorded in Hawaii around 1880. In the Hilo area, another *Pheidole* species, (*P. fervens*, Fr. Smith), occupies much the same ecological niche as *P. megacephala*. The soldiers of teh bigheaded ant have a smooth head while those of other species have a roughened head surface.

Figure 2. Bigheaded Ant, Pheidole megacephala (F.)

Food habits of the bigheaded ant are extremely varible. Foodstuffs include household food, honeydew, and small arthropods.

The life cycle takes about 2 months. The queens average about 7 mm and the males average 4 mm long. Workers generally forage singly and are up to 3 mm long. Mating flights occur as with other ants.

The bigheaded ant becomes a pest because of nest location and great numbers more than anything else. The workers are responsible for nest construction and are found in the soil under stones, in litter, manure piles, decayed stumps. They will pile debris next to supporting posts of lanais, often creating an unsightly mess. When located near a house they can enter through small cracks and forage inside. Control measures must be directed at the nest sites. Residual insecticides should be applied to outside walls.

Carpenter Ants

Carpenter ants are widely distributed and are among the largest of ant occuring in the United States. The workers may be as large as 5/16 inch in length and the reproductive forms grow to 3/4 inch. These ants also charteristically have smaller workers (about 1/4 inch) in the same colony. Two of the more important species found in the United States are *Componotus pennsylvanicus* (black carpenter ant), a predominantly eastern species, and *Camponotus vincimus*, a predominantly western species.

Carpenter ants commonly nest out-of-doors in fallen trees, rotten logs, tree stumps and wooden structures. However, they will travel several hundred feet in search of food or water. They typically forage at night and will readily enter the home in search of food. These ants feed upon dead and living insects, honeydew, plant sap and almost any household food. Carpenter ants do not produce odor trails, but frequently follow the trails

of other ant species.

Swarming of reproductive forms occurs in the spring or early summer months. It is not uncommon to find large numbers of these winged forms in the home at this time of the year. Although carpenter ants do not sting, they will bite. They frequently torment campers and vacationers by attacking people and getting into food.

Figure 3. Carpenter Ant, Camponotus variegatus (Fr. Smith)

The Hawaiian species of the carpenter ant, *Carponotus variegatus*, is a large, yellow to yellowish-red ant. It is the largest ant found here. Its normal nesting sites are under rocks, trash, and in dead tree branches in drier areas. However, it is often found nesting in dwellings if it can find a dark, hollow area with enough space for colony development. The most common indoor locations are in hollow doors and neglected suitcases or storage boxes. Even if the nest is in rotted wood, it will expand the cavity but will not feed directly on wood as do termites.

The reported habits of mainland carpenter ants, (Camponotus pennsylvanicus, in the east and *Camponotus vincinus* in the west), indicate that nesting occurs mostly outdoors but that they may forage for food in homes, also. Our Hawaiian species, however, prefers nesting in the home and foraging oudoors at night, primarily for honeydew.

Many people do not realize that ant reproductive forms swarm as do termites. The large size of the carpenter ant queens and kings (up to 3/4 inch) adds to the confusion.

It is reported that the mainland species bite readily and can be a pest to campers and vacationers by attacking people and getting into food. These habits are not known in our Hawaiian species. Control measures are directed at locating the nests and destroying them either by removal or chemicals.

Fire Ants (Figure 4)

Many ants of the genus *Solenopsis* are referred to as fire ants because of their painful or fiery sting. These ants typically do not nest in structures. Nests are usually located in hard or soft, dry ground and frequently with the entrance hole next to objects such as rocks, wood blocks, cow chips and other debris. The nests are usually small with small craters around the entrance and are frequently located in a series.

These ants travel in trails and are attracted to sweets and fats, as well as living animals. They may enter the home but most problems arise when these pests are located in the yard. They are very pugnacious and will rush from the nest and bite and sting upon the slightest provocation. It generally does not invade homes in Hawaii, but is a serious pest of residents on lawn, turf, and areas where people congregate. This ant is also an important agricultral pest in some areas.

Figure 4. Fire Ant, Solenopsis geminata (F.)

Miscellaneous Household Ants (Figure 5)

Although the Pharoah ant, *Monomorium pharaonis* (L.), is widely distributed on the mainland and considered a major pest species there, this small, yellowish ant is found only occasionally in Hawaii.

The crazy ant, *Paratrechina longicornis* (Latreille) (Figure 5), a robust, dark brown to black, fast moving ant, is often seen running crazily around kitchens and other areas in the home. It is about 2.5 mm long. It normally rests under rocks, in dead limbs and stalks, etc. They are carnivorous to some extent but also feed on honeydew and extrafoliar nectaries of many plants.

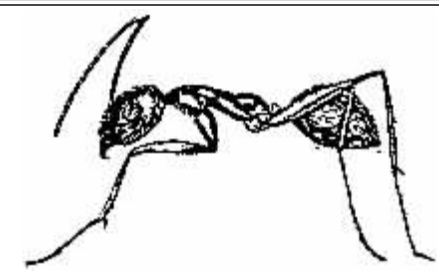


Figure 5. Crazy Ant, Paratrechina longicornis (Latreille)

Control

The control method employed may depend on the ant species involved, and more specifically, where the ants are nesting. The 3 basic methods of ant control are, the use of insecticide barriers to prevent ants from entering a structure, the use of baits to poison ants in their nests, and the direct application of toxicants to the nest.

The most reliable means of ant control is to locate and treat the nest directly. This is done most easily when ants are nesting outdoors. To treat individual mounds, spray 4 to 5 foot areas surrounding the mound and then flood the entrance of the mound with the toxicant. It will do little good just to flood the entrance, as this will not kill all the ants in the nest, and those remaining will form a new entrance. Broadcast spray of emulsions or wettable powder have been used in areas where mounds are numerous.

Direct nest treatment may also be used with indoor nesting species like the odorous house ant and thief ant if the nest can be located. Nests may frequently be located by following several individual workers, especially those carrying food. Following individual workers can be misleading; ants may disappear behind a baseboard or similar structure, and the nest may be located a considerable distance from their point of disappearance. However, if a nest is located in a wall or void similar area, a toxicant should be blown into the nest through existing openings (e.g., light switches) or through small holes drilled in the void.

If nests cannot be located or if it is not practical to treat them directly, barriers of long lasting residual chemicals can be used. Barriers are most effective if they can be placed around the entire perimeter of the nest. This may be difficult indoors if wall in question is joined by many other walls or if the nest is beneath

flooring.

A barrier can be applied to keep outdoor nesting species from entering the structure. This should be in the form of a wettable powder or emulsion of a long lasting residual chemical applied to the outside wall from the ground to the bottom of the first window. Other possible entrances into the house should also be treated and residual sprays cannot be used effectively. The principle behind baits is to place the bait where foraging workers will readily contact it and take it back to their nests to feed to their young. Baits contain an attractant and a toxicant. Since most ants have distinct food preferences, different attractants are used for different species. Some baits have a sugar base and others have an oil base and some both. Most baits used today contain a weak, slow acting toxicant. This allows the worker to injest the bait and without adverse effects before returning to the nest and dispersing it among the colony.

COCKROACHES

The cockroaches can be recognized by their oval flattened body, elongate hair-like antennae and large saddle-shaped plate (pronotum) which dorsally covers the thorax and projects forward over the head. The adults of most cockroach species have wings and are capable of flight. In those forms with wings, the front pair are leathery in texture, pigmented and serve to protect the second pair of large membranous flight wings. In some species the front pair of wings are distinctively shorter in the females than the males.

There are over 2000 species of cockroaches found in the world. Most of these are subtropical in distribution and are not found in the United States. Approximately 75 species occur in North America. Of these, only 4 or 5 commonly enter structures and are of economic concern.

Identification

It is extremely important to be able to recognize the common household infesting species as treatment should vary depending on the species. There are 4 important cockroach species in Hawaii (Figure 6): the American cockroach (*Peripleneta americana*), the Australian cockroach (*Peripleneta australasiae*), the German cockroach (*Bellatella germanica*), and the brown-banded cockroach (*Supella longipalpa*) are serious household pests in Hawaii. The specific names *americana*, *australasiae*, and *germanica* were given these pests not because they are particularly serious pests of those countries but because they the person who first gave them a scientific name examined his first specimens from those countries. See Table I for a synopsis of data on cockroaches of interest to PCO's in Hawaii. This table was prepared by Dr. W. C. Mitchell of the Department of Entomology at the Univeristy of Hawaii.

Biology

It is not only important to be able to recognize the domestic species of roaches, but a knowledge of their generalized and specific biology is extremely important as treatment will be inherently more successful if based on this information. All roaches develop with gradual metamorphosis. The eggs of the domestic species develop within a leathery case called an ootheca. The number of eggs per ootheca will vary from 8 to 48 depending mainly on the species. The ootheca may be dropped in a suitable habitat or glued to a surface soon after forming, or in some species, it is carried projecting from the tip of the female abdomen until the young are ready to hatch. Once hatched, the nymphs may require anywhere from 70 days to a year or more to reach adulthood depending on the species, prevailing temperatures or other environmental factors. The adult

roaches are typically long-lived.

Cockroaches are omnivorous feeders and have adapted themselves to feeding on just about anything that we, as people, consider edible as well as many things we don't consider edible. Cockroach infestations should be treated not only because they can be carriers of human diseases such as diahrrhea and dysentery.

Cockroaches also survive on books, wallpaper, and other materials containing starches and glue.

CONTROL

Cockroaches are normally active at night. When seen in numbers during the day it is a sign of either a very large infestation or they are not well fed. Sign of cockroach presence include (1) seeing the cockroaches, (2) fecal droppings, (3) full or empty eggcases, (4) cast skins from nymphal molting, (5) characteristic stains, and (6) strong musty odors.

Many cockroach invasions begin by introducing a few individuals with merchandise or equipment from infested locations. A thorough inspection of all such articles is worth the effort. In Hawaii, invasions can occur year-round from cockroaches flying or walking into dwellings with unscreened, or poorly screened doors and windows.

Proper sanitation is a key to control. Like other animals, cockroaches require adequate food, shelter, and water to survive. Accumulation of materials such as garbage, rubbish, boxes, sacks, newspapers, and empty pop and beer bottles and cans should be avoided. Areas of excessive moisture within a structure should be eliminated. Proper cleaning of areas where bits of food or grease may accumulate is also helpful. In general, anything whch can be done to reduce the supply of food, water, or shelter for cockroaches will reduce possible infestation.

Once a colony of cockroaches has established itself in a structure, creating proper sanitary conditions generally will not rid the premises of the entire infestation. In this case, chemical control is advisable. Since domestic cockroaches have different environmental habits and biologies, the method and extent of chemical treatment should vary with each species. Of the common household species, the German cockroach is considered the mosy severe pest. This may be directly related to its life cycle. Note in Table I that this species can complete one generation in 1/2 to 1/5 the time of the other pest species. It is on wonder that the German cockroach is found in such great abundance and can infest or reinfest a structure in a compartively short period of time. Theoretically, the fact that the female German cockroach carries the eggcase until the day before the eggs hatch makes this species easier to control than the other 3 species which drop the case the day after it is formed. Fewer treatments may be necessary with the German cockroach. With this species, if the first chemical treatment is adequately applied and the insecticide is effective, further treatment may not be necessary. Once the feamle contacts the chemical and dies, the eggs in the case protruding from her abdomen will soon die. With the other domestic species, the egg case may be deposited on a protective surface and not be reached by the chemical. In this situation, nymphs may continue to hatch from the ootheca over a 2 month period. Most chemicals used for cockroach control do not have this long residual action and retreatment is always necessary to ensure adequate control.

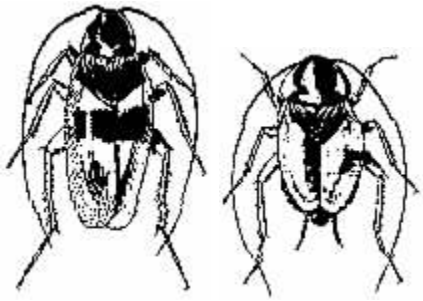
The German cockroach prefers areas of warmth and high humidity. In most residences, infestations of the German cockroach are typically confined to the bathroom and kitchen. It may be adequate to treat for the German cockroach in these confined areas. Typical resting places include under the refrigerator in the motor compartment, under sinks where it is moist, under and behind all appliances, as well as in drawers and

cupboards.

The brownbanded cockroach prefers warm areas but frequent drier locations than the German cockroach. For this reason, while German cockroaches are almost always found at floor level, brownbanded roaches tend to be found in "up" locations, such as behind mirrors, pictures, or in bureaus. This cockroach may be found in any room and infestation is frequently spread throughout a structure. This, coupled with the fact that the female carries the egg only a short period, makes control of this species difficult. It is almost impossible to control the brownbanded cockroach in a single spray application.

The American and Austrailian cockroached are found as frequently outdoors as they are indoors. This may be due to the lower heat requirements of these species. It is common to find infestations of these roaches in basements. The American cockroach is likely to be found in upper levels of basements, as between floor joists and braces. Complete elimination of these two species may require outdoor as well as indoor treatment.

<table>
<tr>
<td> 
GERMAN

Two dark longitudinal stripes on pronotum; approximately 1/2 inch in length.</td>
<td>Male Female
 
BROWN-BANDED

Two pale bands at base and tip of wings; 1/2 inch in length.</td>
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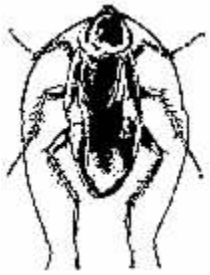
<td> 
AMERICAN

Brown to reddish brown color; wings cover abdomen; 1 to 1/2 inch in length.</td>
<td> 
AUSTRAILIAN

Reddish-brown color with yellowish markings on pronotum and lateral edges of forewing; 1 to 1 1/4 inches in length.</td>
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Figure 6. Diagnostic Characteristics of Common Domestic Cockroaches

Table I. Synopsis of Cockroach Data

Name of Cockroach	In HI since	Size	Ootheca	Egg Days	Nymphs	Adults live	No. of Egg Male Capsules	Male Egg Case Habit
American *Periplaneta americana*	1882	35-40 mm (1.5-2")	16 eggs (16-28)	30-45 days	5-15 mo. (7-13 molts)	100 days (2-3 years)	10-90	glues case to object
Austrailian *Periplaneta australasiae*	1899	27-33 mm (3/4-1")	22-24 eggs	40 days	6-12 mo. (9-12 molts)	4-6 mo.	20-30	glues case to object

German *Blatella germanica*	1899	10-15 mm (5/7")	37-44 eggs	1.5 days	30-60 days (125 days) (5-7 molts)	100 days home over a year	4-8	carries case to 1 day before hatching
Brownbanded *Supella longipalpa*	1921	10-14 mm (1/2")	16 eggs	74 days, 25 C 43 days, 27.5 C 35 days, 30 C	55 days (6-8 molts)	90-115 days 30 C	10-20	drops case
Harlequin *Neostrylopyga rhombifolla*	1882	20-25 mm (1")	22 eggs		285-302 days	156 days		
Cinerous Roach *Nauphoeta cinerea*	1899	25-29 mm (1 to 1 1/4")	36 eggs (ovovoviparous, 26-40)	35 days	87-94 days (7-8 molts)	1 year	20 (batch every 45 days)	
Burrowing Roach *Pycnoscelus surinamensis*	1822	18-24 mm (1")	26 ovoviparous	35 days	127-184 days (8-10 molts)	10 mo. about 1 year	1-5 broods 3 average interval 48-82 days	
Cyprus Roach *Diploptera lytiscoides*	1882		Ovoviviparous			feeds on plants, fruits, girdling twigs		
Pacific *Euthyrrhapha pacifica*	1882		small				active day and night	

Table II. Summary of Cockroach Information

American Cockroach: *Perplaneta americana* Size=35-40 mm Adults mate within a few days, some parthenogenetic; Ootheca, 16-28 eggs, 16 normal; egg cases glued to surface; Female produces ootheca every 4-10 days; can produce 10-90 in her lifetime; Ootheca, 30-45 days to hatch; varies from 20-100 days; Nymphs, 7-13 molts; can take 5-15 months; Adults live 100 days - some 2-3 years; Preferred temperature 28^{o}C	**Austrailian Cockroach: *Perplaneta australasiae* (Fab)** Size=27-33 mm Adults mate about 5 days after becoming adults; Ootheca, 22-24 eggs; takes 40 days to hatch; Female produces ootheca 20 days after maturation; produces 20-30 ootheca at 10 day intervals; Nymphs, 9-12 molts; 6-12 months Adults live 4-6 months; they are often found in greenhouses; Preferred temperature are warm areas, 30^{o}C (86 F)
German Cockroach: *Blatella germanica* (L) Size: 10-15 mm Adults mate within first week to 10 days of life-females mate once or twice; Ootheca (egg case) formed 2 days later, held up to 1-2 days prior to hatching; contains 37-44 eggs; 90% usually hatch. Nymphs, 5-7 molts; can take 30-60 days; can live with scarcity of food for 125 days; Adults live 100 days or more; can live over a year in home; Preferred temperature 30^{o}C (86 F)	**Brownbanded Cockroach: *Supella longipalpa* (Fab)** Size: 10-14 mm Adults mate 3-5 days after maturity; Ootheca 10 days later; Ootheca usually has 16 eggs; glued in place; hatching times: 74 days, 25^{o}C 43 days, 27.5^{o}C 35 days, 30^{o}C Nymphs go through 6-8 molts; molts take 55 days; 30^{o}C (86 F) (95-276 days);

	Adults live 90-115 days at 30°C (86 F); Bio-control, Hawaii; Fond of starch foods, paste, sizing.
Harlequin Cockroach: *Neostrylopya rhombifolia* (Stoll) Size=20-25 mm Tegmina vestigial; hind wings absent; Parthenogenetic, but nymph die; Ootheca has 22 eggs, dropped by female; Nymph's development time: 286-302 days at 27°C (80 F) Adults live 156 days (24°C); Like cinerous cockroach, found in outdoor feed lots, animal foods, etc.	**Cinerous Cockroach: *Nauphoeta cinerea* (Oliver)** Size: 25-29 mm Adults mate 6 days after adulthood; wings short, do not cover abdomen; Ootheca, 6 days after maturity; is held 35 days inside female; average 36 eggs (range: 26-40 eggs); Female produces 20 in an average lifetime; Broods nymphs 45 days apart; Nymphs go through 7-8 molts; molts take 87-94 days; (30°-36°C) (86-97 F); Adults can live one year; Outdoor species fond of feed lots, animal feeds, milling plants, fish oil, food storage sheds.
Burrowing Cockroach: *Pycnoscelus surinamensis* (dusty tail cockroach) (Bicolored Roach) Size: 18-24 mm Ovoviviparous; some bisexual, others reproduce parthenogenetic ootheca; 7 days after adulthood. Develop in 35 days at 18°-24°C; Female produces 1-5 broods; 3 average; Interval between broods: 48-82 days; Egg case: 26 nymphs; Nymphs: 8-10 molts; develop in 127-187 days at 18°-24°C; Outdoor species, found in stones, boards, litter; damage plants.	

VENOMOUS ARTHROPODS

Centipedes

Centipedes (Figure 7) generally have over 15 pairs of legs, but only one pair per body segment. The commonest centipede in Hawaii is the large brown centipede which, in addition to the normal complement of legs, bears a pair of poisonous claws on the second segment from the front. These claws can inflict a painful bite which is often very sore for several days. Bites are not known to be fatal. The large centipede present in Hawaii is a member of the genus *Scolopendra*. Its "bite" is generally similar to the sting of a wasp or bee. In addition, a number of smaller forms are encountered in the islands, generally in areas of high humidity. These smaller centipedes do not bite and are of little economic importance.

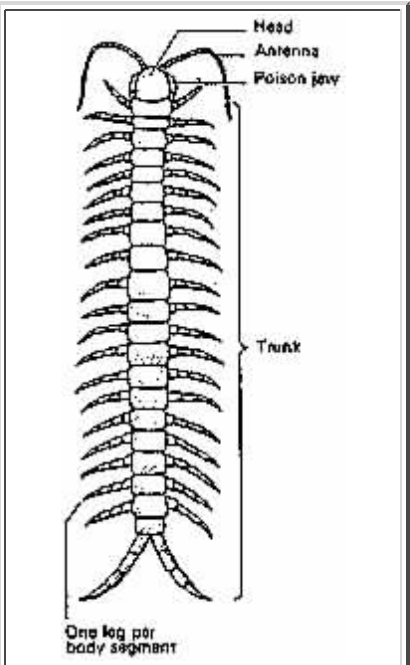


Figure 7. Centipede, Scolopendra sp.

Millipedes

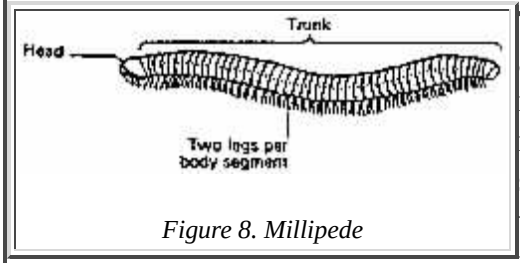


Figure 8. Millipede

The legs of millipedes (Figure 8) are arranged so that there are 2 pairs on most segments. The body is rounded rather than flat. They move about sluggishly, and feed on decaying vegetable matter. They frequently roll up into a ball when disturbed.

The female lays from 20 to 30 eggs in a cluster in the soil. The newly hatched young generally have 3 pairs of legs. There are typically 7 to 10 molts with the number of legs and segments increasing each molt.

Two species of our millipedes found in Hawaii often come to the attention of the PCO. The garden millipede reaches a length of about one inch and is a mixture of brown, white, and black. When it accidentally invades a house and is crushed underfoot on a light-colored rug, the resulting yellow stain is hard to remove.

Another common millipede grows to about 1 1/2 inches long and is solid, shiny brown or cinnamon colored. It often marches about in great numbers, accidentally invading houses.

Millipedes cannot bite and are not involved in the carrying of diseases. They are primarily nuisance pests.

Spiders

Among the spiders found in Hawaii are 4 venomous forms, the black widow spider (*Latrodectus mactans*), brown widow spider (*Latrodectus geometricus*), the pale leaf spider (*Chiracanthium diversum*), and the brown recluse spider (*Loxosceles reclusa*).

Although almost all spiders have a small amount of venom which they use to stun their insect food, the other species of spiders commonly found in Hawaii are not considered venomous. They are simply nuissance pests. The large (4 to 5 inches in dimeter) brown wolf spider (*Heteropoda regina*) may be found in homes and garages where cockroaches abound; the spinyback spider. (*Gasteracantha cancriformis*) builds an orb web in yards and is about 1/2 inch in diameter with red spines radiating from the crab-like body; and the 2 species of garden spiders (the yellow garden spider, *Argiope appensa*, and thw whitebacked garden spider, *Agriope avara*) build orb webs in yards.

The black widow (Figure 9) has a reputation for being dangerous to humans which is undeserved. It is true that when sufficiently provoked, the female will bite and that the bite, in a few known cases, has been fatal. A number of the cases involve small children. This is sufficient reason to regard this spider as dangerous, even though it is shy and retiring and will normally avoid humans. If bitten by a black widow spider you should

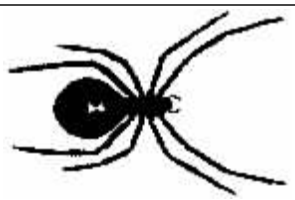


Figure 9. Vertical view of Female Black Widow

have the bite checked by your physician.

In making their irregular-shaped web, their favorite habitat in Hawaii is on Australian saltbush. It occasionally can be found in or around dwellings. It is distributed across the entire United States and is found in Canada and South America.

The males and females of the black widow are quite different. The female is shiny black with a bright red hourglass-shaped marking on the underside of the abdomen. The mature female, with legs fully extended, can reach the size of 2 inches long. The abdomen ranges from 1/4 to 1/2 inch in diameter. The male is much smaller and skinnier than the female, being less than 1 inch long overall, lighter in color and with light streaks on the abdomen. The common name of black widow arises from the fact that a hungry female is capable of eating her mate after copulation.

The web of this species is also distinctive. The strands of silk run in many directions so the web appears as concentration of irregularly-arranged threads. The silk strand of the web is considerably heavier and stronger than those of other species that form similar shaped webs.

The female hangs upside down in the web. The egg sacs are smooth on the outside while the egg sac of the brown widow spider is spiny or rough. The sac may contain up to several hundred eggs. In Hawaii, an egg parasite helps to keep the numbers of eggs that hatch to a low level. Within a few days of hatching, the young spiderlings spin strands of silk into the breeze and are carried off to establish new homes. Development from egg to adult takes a month or so and females may live a year or more after maturity.

The period of time when female spiders can be aggressive is when they are guarding their egg sacs. The bite most frequently precedes a stinging sensation. Pain at the bite site may develop in less than 1/2 hour. The pain may be quite severe for some hours subsiding after 12 to 48 hours.

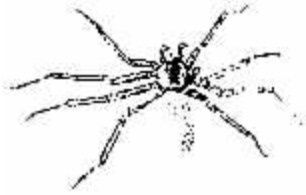


Figure 10. Brown Recluse Spider

The brown widow spider is a close relative of the black widow. It should not be confused with the brown recluse spider (*Loxosceles reclusa*). The brown widow spider can also be found in Florida on the mainland.

The brown widow has a body size of about 1/2 inch long. It has distinct, black markings on the upper side of the body and the hourglass on the underside of the abdomen of the female is tan or yellow. It has a tendency to frequent dwellings much more than the black widow.

The webs of the brown widow are fairly symmetrically shaped cones within which they retreat when disturbed. They are often found in large numbers under houses with crawl spaces beneath.

Egg sacs are similar to the black widow except they are noticeably bumpy or spiny. Egg production and development are similar to the black widow.

The brown widow can cause a very painful bite. It is not known whether or not it is as dangerous as the black widow, but probably the two are quite similar. No one in Hawaii has been known to die as a result of bites from either the brown widow or the black widow.

The brown recluse spider is a recent introduction to Hawaii (Figure 10). It can inflict a very painful bite and is considered more dangerous than the black widow spider.

It occurs throughout the mid-western U.S. from Texas to Georgia and Kentucky, and north to Illinois and Indiana. The brown recluse, as its name indicates, is a withdrawn species and is not aggressive. Adults average about 4/10 of an inch long, but they may range from 3/10 to 1/2 inch. Usually they are rich brown, but may also be light tan or cream. The cephalothorax (the section with legs) is lighter in color than the abdomen, and has a dark fiddle- or violin-shaped design on it.

Similar to the brown widow, the web is a simple cobweb type. The spider likes dimly lit areas and is usually hidden away. Bites usually occur when the spider has crawled into a bed and is squeezed by a person rolling in his sleep, or when a person is putting on clothes or shoes in which the spider is hiding.

Spiders can control the amount of venom they inject. The severity of the bite can be related to this. At first, there may be either no reaction from the bite, or a light stinging sensation. In some two to eight hours intense pain can develop. A small blister forms at the bite and a large area around the bite becomes red and swollen. Unlike the black and brown widows whose venom becomes more dispersed in the bitten person's body, the venom of the brown recluse remains concentrated in the bite area. This is the chief reason why this species is considered more dangerous.

When the period of intense pain occurs, some people feel nausea, stomach cramps, joint pains, and may develop a fever. Later the wound can become ulcerous and gangrene may result. Wounds heal slowly, sometimes taking six to eight weeks; and they leave a round, deep scar like that from a bullet wound. If bitten by a brown recluse spider, see a doctor immediately.

The pale leaf spider is also a relatively recent introduction to Hawaii. Its bite is not known to be fatal but can be very painful. It hides in folded leaves in shrubbery. Meeting up with one can be a startling and painful experience. It is common in Hawaii and bites are reported often. The spider itself is pale in color and only about 3/8 of an inch long.

Scorpions

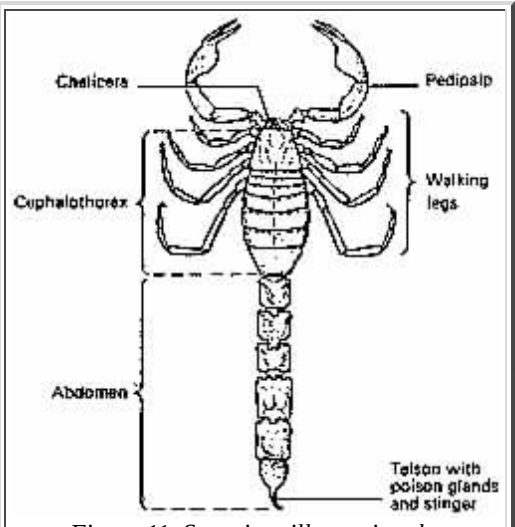


Figure 11. Scorpion, illustrating the major chelicerate features.

Scorpions are easily recognized by their more or less crab-like appearance and elongate, fleshy, five-segmented tail appendage terminating in a bulbous sac and prominent sting (Figure 11). Scorpions have 5 pairs of legs with the first pair bearing enlarged pinchers. Although these arthropods bear from 2 to 12 eyes, they have poor vision. Species in the United States range from 1 to 5 inches in length.

Scorpions commonly occur in the southern states from the Atlantic to the Pacific being most prominent in the southwest. These arthropods are nocturnal, remaining hidden during the day in a variety of locations including under loose stones, loose bark, piles of lumber, leaf litter and a variety of other places especially if moisture is present. During the night they actively prey on insects and other arthropods and are commonly found in the vicinity of lights at night feeding on attracted insects. They occassionally enter the home and may be found on the floor, walls or hidden beneath clothing and other objects.

Scorpions are greatly feared by man; however, they are not aggressive and most stings result when they are accidentally crushed or contacted. Most species are relatively non-toxic to man; their sting is no more dangerous than that of a bee or wasp. A sting may result in a sharp pain and some minor localized swelling which soon subsides.

The Hawaiian species is *Isometrus macolatus*. It is found in California and South Florida as well. The male's post-abdomen is twice as long as its body. It is relatively harmless but can give a painful sting.

Control and Safety Procedures: In areas where scorpions are prevalent, the pest control operator can provide a valuable service by advising the customer as to means of avoiding stings. Since scorpions hide in dark areas, it is advisable to avoid leaving shoes, boots, and other wearing apparel on the floor overnight. All apparel should be shaken vigorously prior to wearing. Since scorpions cannot climb on slippery surfaces, the legs of a crib can be placed in glass jars. Beds should be moved away from walls. Walking barefoot outdoors in the evening, especially around lights, may be especially risky.

Chemical control is best achieved with residual contact insecticides. Sprays may be applied to the foundation and entries into the house and to certain selected locations inside the home, chiefly around baseboards, molding, corners, and plumbing.

Mites

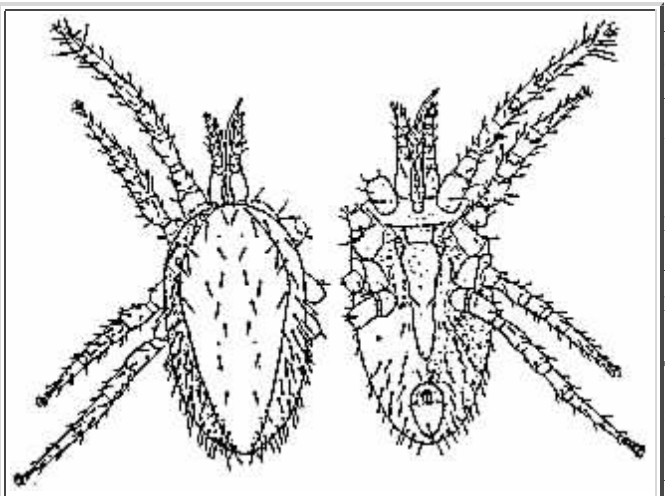


Figure 12. Ornithonyssus bursa (Berlese).
Left, dorsal view of female.
Right, ventral view of female.

A number of troublesome mites (Figure 12) are encountered by the PCO in Hawaii. Among these are the tropical fowl mite (*Ornithonyssus bursa*), the northern fowl mite (*Ornithonyssus sylviarum*), the tropical rat mite (*Ornithonyssus bacoti*), the dried fruit mite, the grain mite, the hay itch mite, the house mite, the North American house dust mite, and the European house dust mite.

These mites are all very hard to see and identify by species. They are less than 1.0 mm, colorless, and many similar looking species are involved. They are wingless, have 3 pairs of legs in the larval stage, and 4 pairs when adult. The body is short, round or oval and not divided into sections as in insects. The life cycle is short and they can increase to large numbers in a very short time. We suggest that you send or bring your specimen to an acarologist if identification is needed.

These mites can cause itchiness, scabies, dermatitis, and certain allergies such as bronchial asthma and allergic rhinitis.

The tropical fowl mite, northern fowl mite, and tropical rat mite are bloodsucking mites that live in the nests of birds and rodents. After these hosts abandon their nests, the mites may migrate in search or a blood meal. Humans are bitten during this period, although the mites cannot survive on human blood.

The dried fruit mite, grain mite, hay itch mite, and others often build up in large numbers in packaged food such as cereals, flours, dried fruit, condiments, baking mixes, and pet foods. Itch and rash result from

handling these infested products or by remaining in the vicinity of them for long periods.

The house mite, North American house mite and European house dust mite are common in homes and may become numerous in rugs, sofas, carpets, pillows and mattresses. They produce allergens which cause bronchial asthma, allergic rhinitis and dermatitis.

Ticks


Figure 13. Hard (left) and Soft Ticks (right)

Ticks are close relatives of mites. The only tick likely to be encountered in Hawaii by the PCO is the brown dog tick (*Rhipicephalus sanguineus*).

Ticks are divided into two groups: the soft ticks and the hard ticks (Figure 13). The soft ticks are not represented in Hawaii. They pass through 5 stages: egg, larva, first nymph, second nymph, and adult. The eggs are deposited in batches in the nest or living quarters of the host. The six-legged larva hatch and usually feed for several days before molting to the 8-legged nymphal stage. The nymphs and adults do not attach to the host and they take several blood meals before molting.

The hard ticks pass through only 4 states: egg, larva, nymph and adult. The brown dog tick egg mass is typically deposited after the enlarged female drops from a dog. The mass may have a thousand or more eggs. They are placed in soil or under stones and trash. The 6-legged larvae and the 8-legged nymph can live up to 8 months without food. The larvae require a single blood meal to molt into the 8-legged nymphal stage. The larvae and nymphs climb up grass stems and other exposed locations and attach themselves to any animal that passes by. The nymphs feed to engorgement and drop off the dog prior to molting. They may feed for several hours or several days before dropping off the dog. The male and female copulate on the host, feed to engorgement and then drop off. When engorged adult females drop off the dog inside the house they can oviposit their eggs under carpeting or in cracks and crevices. When the larvae, nymphs, or adults are not feeding they hide in cracks and crevices and often accumulate under pictures.

Although it is reported on the mainland that this species does not bite man, it is of relatively common occurrence in Hawaii.

Under ideal conditions, the life cycle may be completed in about 2 months.

Bed Bugs

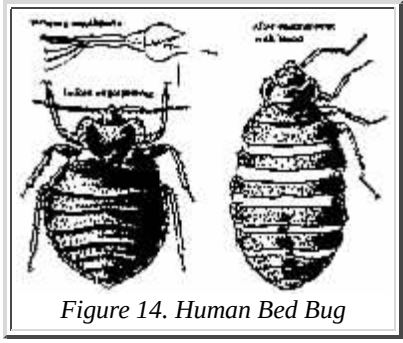


Figure 14. Human Bed Bug

There are several species of bed bugs that are known to bite man. Most of these are associated with bats or are found in nests of swallows and other birds. If these animals abandon nests that are found in attic or eaves of homes, the bed bugs may leave the area in search of food and enter the living areas of the home. The human bed bug, *Cimex lectularis*, is primarily a pest of man. This species is about 1/4 inch long, flattened dorsoventrally, reddish brown and wingless (Figures 4-5). Females are generally larger than males and the tip of the abdomen is more pointed. Having incomplete metamorphosis, the nymph looks similar to the adult.

The human bed bug has been a constant companion of man for centuries. It is nocturnal in habit, taking blood

meals at night and remaining hidden during the day, It can be found most frequently hiding in the seams and tufts in the beds. Other favored hiding places include behind wooden headboards, loose wallpaper, buttons in the bed, calendars, and in upholstered furniture, backing of pictures, and cracks in the walls and floors.

The human bed bug has glands on its body that secrete an odorous oily material. A room heavily infested with this species will usually have this characteristic odor. Another sign of the presence of bed bugs is blood spots on sheets. These may be due to the accidental crushing of partially fed nymphs or adults, or by the fact that a person bitten may continue to bleed for a short period of time. After feeding this species will defecate; this material will appear as small black spots that are usually found in the vicinity of their hiding places.

Persons bitten by bed bugs differ greatly in their reaction. I n some there is a marked irritation and localized swelling, but in others, the bite has no apparent effect. This species has been suspected of transmitting diseases of man, but has never been proven to do so.

The human bed bug requires from 4 to 6 weeks to develop from egg to adult during tavorable environmental conditions. Adults are relatively long lived and may live up to 18 months. Since this is an indoor species, infestations can normally occur in the home during any time of the year.

The importance and occurance of the bed bug has been greatly reduced since the advent of the newer synthetic organic insecticides. At one time this pest was one of the most frequently encountered insect by the pest control industry, but today infestations are only infrequently encountered.

Control

Control is usually confined to sleeping quarters in the home. Insecticides must be applied to all the hiding places to achieve good control of bed bugs. Mattresses should be sprayed lightly and allowed to dry for several hours before replacing the sheets and occupying the bed. Extra sheets might be used as a precaution. A pin stream nozzle is used for cracks and crevices and a fan or cone nozzle for mattresses. Each tuft in the mattress and the folds at the edges, as well as the bottom and sides should be treated. Hollow frames, spring coils, headboards, under loose wallpaper and in cracks around nearby doors, windows, and moldings should also receive attention. Treatment of entire rooms by fogging, misting, or vaporizing has also been recommended. Outside treatment is seldom necessary, but bird nests and bat harborages should be kept in mind as possible sources of bed bug infestation in unusual cases.

Fleas

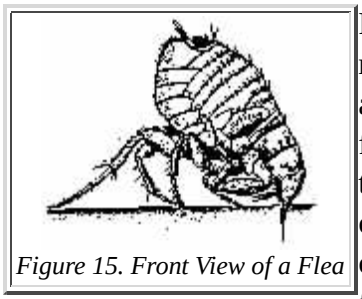


Figure 15. Front View of a Flea

Fleas are small, wingless, brown to blackish insects with piercing and sucking mouthparts designed for taking blood. Their bodies are compressed laterally to allow them to move rapidly through hair or feathers, and their legs are designed for jumping. The body, legs and head are equipped with stout spines for gripping the *Ctenocephalides felis* and *C. canis*, the cat and dog fleas, respectively, are capable of feeding on either cats or dogs and both will readily bite man. Both are cosmopolitan in distribution and are frequently found in the home. Only the cat flea occurs in Hawaii.

The life history of the cat or dog flea is quite similar to that of other fleas commonly encountered in the home. Each species passes through 4 stages; the egg, larva, pupa and adult. The eggs are laid a few at a time

although several hundred may be deposited. The eggs are seldom deposited on the heirs of the host but in the nest or sleeping quarters of the host where flea excrement occurs. If deposited on a dog or cat, the eggs fall off when the animal stretches or shakes itself. Depending on temperature and humidity, the eggs hatch in 2 days to several weeks.

Flea larvae are small, 1/8 to 1/2 inch long, somewhat worm-like and whitish in color. They move with a rapid hitching motion, using the mouthparts for grasping and 2 fleshy appendages at the tail end to push. They feed on organic debris including adult flea feces, dried blood, host feces and many other materials. When disturbed they may "flip" in circles to escape. Under ideal conditions, they may complete larval development in about 2 weeks. When mature they spin cocoons covered with grains of sand or debris and change into pupae. It may require as little as a week to complete the pupal period. Adults can live a few weeks to more than a month without food; however, food is required in order to produce eggs.

The dog and cat flea readily bite man but require a dog, cat or other animal to maintain an infestation. They tend to concentrate in bedding or sleeping places of pet dogs or cats, but sometimes an entire yard or neighborhood may be infested, especially if the pet population is high. When pets are available, flea infestations often go unnoticed. If the pet dies, or is taken away during vacations, hungry fleas emerge and become evident.

Sometimes cat or dog flea infestations are encountered where there are no pets. A check often reveals that a stray cat has had kittens under the house or in the basement, or that pets have been removed leaving fleas to develop and seek new hosts. Opossums also carry cat fleas.

The cat or dog fleas are responsible for more home infestations than are any other fleas. If present in large numbers, they will be attracted to a white hankerchief placed on the ground or floor. These species tend to bite as soon as they hop onto a person. Their bites are usually concentrated about the ankles or legs.

As a general rule, infestations of the human flea, *Pulex irritans*, are harder to find than cat and dog fleas. They do not need other animals, but can survive and reproduce on human blood alone. The larvae live on organic materials found in cracks and crevices in floors. In mild climates, they live in yards. Since the widespread use of vacuum cleaners and good tile, linoleum or hardwood floors, the human flea has become less important. Occasional large infestations are found, especially where standards of sanitation are low. Usually an infestation is small, but often it is persistent.

Human fleas tend to bite about the waist or upper trunk. These fleas are voracious feeders and one flea will bite many times. The fleas feed so rapidly and so much that they eliminate undigested blood (upon which larvae may feed). Blood spots on bed linen and underclothing offer a good clue to their presence if not caused by bed bugs.

The presence of rats on premises is enough indication that rat fleas are present. The oriental rat flea (*X. chelopsis*) is the species most frequently associated with rats in the United States. The eggs are laid in the rat's nest where hatching and development take place. However, if rats are controlled, fleas leave the nest in search of a blood meal. This exodus from the nest may continue for several weeks as the larvae already present mature and become adults.

The oriental rat flea readily bites man when rats are not available. The tropical rat mite (*Ornithonysus bacoti*) also develops in nests and will bite man if the rats are removed. For this reason, it is important that mite and flea control measures should be done before and during rat control. The oriental rat flea can pose a serious health problem under certain circumstances. It is the most important vector in the U.S. of Pasteurella pestis,

the causative bacteria of plague. Plague is endemic to certain areas of California.

Control

The control of fleas in the home and on the grounds may be broken into a number of steps. Since dogs and cats are the usual carriers of fleas, the animals should be treated with a flea powder or dip. Next, attention should be directed to those localities frequented by the pets, especially areas where animals rest or sleep. The bedding should be discarded or washed with a strong detergent and hung to dry in the sun. Collections of lint and dust should be vacuumed away, since the larvae breed in such material in cracks of the floor boards, under edges of carpet, behind and under furniture and similar places. Basements and areas under houses are havens for dogs, cats and in some areas, opossums. Also, flea larvae often breed in the soil in unexcavated or partially excavated areas in the basement. Wettable powders are applicable in this situation.

Severe infestations of human fleas indoors is usually the result of poor sanitations, since larvae feed upon organic debris. Accumulations of debris and dirt in cracks, crevices and furniture should be vacuumed or otherwise cleaned out to remove harborage and food. The pest control operator should remember that he may be attacked if the fleas are alive while cleaning is taking place, and that flea eggs and larvae can develop inside the vacuum cleaner that is used.

HYMENOPTEROUS PESTS

Honey bees, yellow jackets, paper wasps and other wasps are generally beneficial insects, but they may also be a nuisance and sometimes a serious health hazard because of their sting. In general, they are more common in rural areas as opposed to highly urbanized areas.

Honey Bee

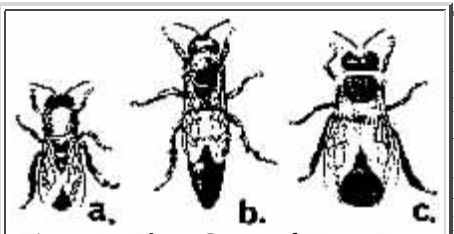


Figure 16. Three Castes of Honey Bees; Worker (a), Queen (b), and drone (c)

The honey bee, *Apis mellifera*, is undoubtedly the most beneficial insect in the world (Figure 16). Besides producing honey and wax, this is the most important insect in pollinating man's crops. There are many crops that are totally dependent on the honey bee for pollination including most pome and stone fruits (e.g., apples, pears, plums, nectarines), oranges, most seed crops, berries, melons, almonds and many others. Without cross pollination by insects, these crops could not be produced on a commercial basis. The honey bee is constantly increasing in importance as urbanization increases and nesting sites of wild bees are decreasing, and these wild pollinators are being eliminated.

Honey bee hives are kept by commercial and amateur beekeepers. For this reason, honey bees are found almost anywhere in the United States, including both agricultural and residential areas. There are also many natural hives that occur throughout the nation. Many residents become very concerned about the presence of these bees having been stung or afraid of being stung.

The reaction of an individual to a bee sting will vary greatly depending on the individual and his past history

of bee stings. In the United States, several people per year die from the sting of honey bees. Most who die from bee stings are allergic. Most people who are repeatedly stung over a period of time produce an immunity to the venom; the actual prick remains painful, but the resulting reaction is minimal. A small percentage of individuals do not develop immunity, and a few have a natural immunity. In about 2 percent of the individuals, repeated stinging results in the development of a hypersensitivity to the venom with each sting resulting in a more severe reaction. In many of these individuals, this results in an intensification of the local reaction; in others, the reaction is general and may result in a condition similar to anaphylactic shock. Death may follow within an hour after the sting in very severe cases. As would be expected, many of these deaths occur in individuals who constantly work with bees.

The sting of the honey bee is barbed and usually after the bee attacks, the sting, venom sac and part of the abdomen are torn off and left in the flesh. In this case, the bee usually dies. The sting should be removed by scraping it off with a fingernail or straightedge. Removal of the sting by pulling it out will usually result in squeezing the poison sac and forcing more venom into the flesh.

The honey bee is a social insect. All the duties within the colony are carried out by the worker caste, composed of sexually undeveloped females. A strong colony of honey bees will have as many as 60,000 workers. The colony will also have several hundred drones (males) and usually one sexually mature queen whose duty is to lay eggs. During the spring, in response to heavy nectar flows in the field, more workers are produced and the colony may become overly crowded. In response to this, a new queen will develop and either the new or old queen will leave the colony with a few hundred to over half the worker force in the form of a swarm. The swarm may travel a mile or two before finding an area that is suitable for the development of a new colony. New colonies may be formed in a hollow log, within a wall in a hollow balcony or other cavities around the home. The swarm may settle several times and rest for a day or more prior to finding a permanent home. The activity of the bees in and around the swarm are generally of considerable concern to the home owner. Generally speaking the bees in a newly emerged swarm are quite docile and will not readily sting; however, within a day or 2, the bees become more aggressive and readily sting.

Control

The honey bee collects pollen and nectar from a large number of plants including ornamentals. When a nectar or pollen source is particularly strong, large numbers of bees may visit a plant or group of plants in a relatively short period of time. If these plants are found around the home, bees may be of concern to the home owner. It is generally not advisable to try to control these bees, as they will not sting if not disturbed, and the large number of blossom visitations will generally cease in a few days.

Swarms found in a tree, bush or on some other exposed areas will not normally remain and generally will move on to a more permanent location within a few days. Unless these swarms are in an area with frequent human traffic, it may be advisable to leave them alone or have someone remove it. The University of Hawaii Extension Entomologist has a list of beekeepers who are willing to pick up swarms. Many beekeepers will pick up swarms free of charge provided the bees are in the open and of easy access. Some will charge a fee to remove more difficult to reach swarms.

If bees have settled in a wall, balcony, chimney, attic or difficult place to reach, it may be necessary to destroy the hive with an insecticide. The material should be applied as a dust directly to the swarm. This may necessitate drilling holes in walls, or blowing dust into a chimney from above. If the colony has been in the structure for a month or more, it is likely that considerable amount of wax, honey and pollen are present. These materials, plus the dead bees, are likely to attract other scavenger insects and should be removed. This

usually necessitates the temporary removal of part of the structure (siding, shingles) to gain access. After removal the area should be treated with a residual dust to discourage insect pests from being attracted to the old location.

Yellow Jackets and Hornents

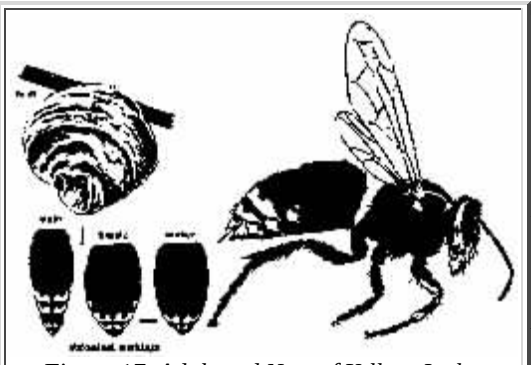


Figure 17. Adult and Nest of Yellow Jacket

There are several common species of yellow jackets and hornets found in the United States; all belong to the genus Vespula (Figure 17). The biology of these are quite similar. All are social and there may be as many as 10,000 individuals within a colony (depending on species). One species, *Vespula vulgaris*, occurs in Hawaii and that has only been reported from Haleakala on Maui. In the fall the newly emerged queen and males mate. The male and the workers die in the fall with only the young queens overwintering beneath bark or in other protected locations. The following spring the overwintering queen emerges and selects a suitable nesting site, rarely returning to its old nest. She collects materials from rotten or weathered wood, plant fiber and other cellulose material to mix with saliva and construct a small new nest. She then deposits eggs, one pa cell in the new nest. When the eggs hatch, the larvae are fed protein, mainly insects which the queen collects. Upon maturation these larvae pupate and ultimately emerge as adult workers. At this time the sole duty of the queen is to lay eggs. The newly emerged adult worker carries out all the work including enlarging and maintaining the nest and collecting food. The workers feed the larvae protein materials (insects) and in return receive sugar solutions from the larvae.

The workers are all sterile females and can sting. During the latter part of the season late summer, early fall), new queens and males are produced; egg laying is also reduced. As a result, the number of young in the nest is reduced and the workers run short of sweets. At this time the workers actively forage for sweets including nectar, fruit juices, soft drinks and other sources of sugar. They may at this time feed on whole fruits including grapes and pears and cause considerable harassment to the home owner.

Yellow jackets and hornets create problems around campgrounds, recreation areas, backyards, drive-in restaurants and other areas where food and water are found. These wasps are capable of foraging several thousand feet in search of food. The list of food material that yellow jackets and hornets feed upon is quite long. The 2 main categories being meats and liquids high in sugar.

Polistes Wasps

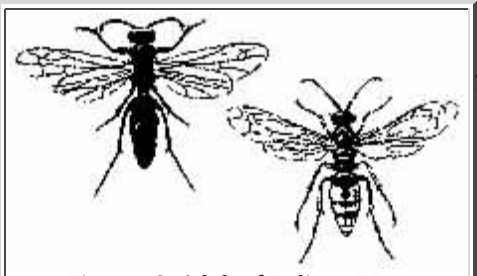


Figure 18. Adult of Polistes Wasp

The Polistes wasps are similar in appearance and habit to the yellow jackets (Figure 18). These pests at times may be exceedingly numerous, but their nests are never as large as those of yellow jackets. A large nest may consist of 100 to 200 individuals. Unlike those of the yellow jacket, the nest consists of a single more or less circular horizontal comb suspended by a slender stalk (Figure 19). Like the yellow jackets, the workers actively forage for food in the form of soft bodied insects, fruit juices and honeydew. The activity and role of the queens, males and workers and the life cycle of these wasps is very similar to that of the yellow jackets.

Figure 19. Nest of Polistes Wasp

The nests of Polistes wasps are typically located on branches of trees and backyard fences, in burrows in the ground and hollow trees, and under eaves of homes. When disturbed these wasps will readily sting. This situation frequently arises around the home when small children throw rocks at the nests or attempt to jab them with a stick. In Hawaii, we have at least 4 species, the most prevalent being the common paper wasp. In a sense, they are beneficial since one of their chief foods is caterpillars. Even in Hawaii, they respond to cooler temperatures and longer days, usually around September, and swarm actively around houses. This gives rise to an increase in calls to PCO's.

Control

These hymenopterous pests can be controlled by introducing almost any insecticide directly into their nests. This can be hazardous to the applicator if certain precautions are not taken. Some applicators prefer to wear protective clothing including heavy full-length coveralls, high top boots, gloves and a bee veil. If these are not available, it is less hazardous to treat the nest at night as these species fly less readily at this time. The probability of being stung is also reduced if the chemical can be applied from a distance using a pencil stream from power spray equipment.

Wasp Freeze is a formulation that appears to show considerable promise in control of hymenopterious pests. This product contains highly volatile solvents and a quick acting insecticide. When this material is applied, the solvent results in a quick reduction of the wasps body temperature and hence in combination with the "quick action" of the toxicant gives an instant knock down. The applicator can clear the area of flying wasps and then direct the pressurized spray into the nest. This ensures instantaneous kill and eliminates or reduces the chance of being stung when attempting to kill the pest during the day.

Indirect control in many cases can be achieved by the use of an attractant bait coupled with a toxicant. If the bait is placed in the problem area, workers pick it up, take it back to their nest and feed it to the young.

FABRIC PESTS

A number of insects will occasionally feed on different fabrics (e.g., termites, silverfish, book lice and cockroaches); however, these incidental pests seldom cause any major damage. Most damage to fabrics result from infestations of carpet beetles and clothing moths. The main fabric pests encountered in the United States are:

Clothes Moths

Webbing clothes moth - *Tineola bisselliella*
Casemaking clothes moth - *Tinea pellionella*
Carpet moth - *Trichophaga-trapetzella*

(NOTE: the webbing moth and the carpet moth are not found in Hawaii.)

Carpet Beetles

Black carpet beetle - *Attagenus piceus*
Common carpet beetle - *Anthrenus scrophulariae*
Varied carpet beetle - *Anthrenus verbasci*
Furniture carpet beetle - *Anthrenus flavipes*

The principle fabrics attacked by these insects are wool and other substances containing a tough fibrous protein called keratin, the main feeding attractant of these pests. Keratin is also the principle protein of hair, fingernails, horns, feathers and hoofs.

Although these insects commonly feed on wool and other fabrics, these materials apparently do not contain adequate vitamins and amino acids (protein) to properly sustain their development. For this reason, fabric pests do not typically feed on "clean wool" but mainly attack wool and other fabrics which have been contaminated with soilage, food spillage, urine or related nutrients. Contamination is frequently difficult to avoid and be caused by perspiration, body oils and even air borne microorganisms.

The clothes moths and carpet beetles develop with complete metamorphosis. However, the larvae are the only damaging stage of these pests. Adults of the clothes moths do not feed and are short lived. Adult carpet beetles commonly feed outdoors on pollen and enter the home to lay eggs in the spring and summer months. The clothes moths are more limited in their diet than the carpet beetles. The larvae of these moths feed mainly on contaminated wool and other materials containing keratin. Carpet beetle larvae will feed on many other materials including dried museum specimens, dead insects, nuts, leather, seeds, cereals and cereal products, and many other dried plant and animal products. Cotton, synthetics and other contaminated fabrics may also be attacked by these pests.

Identification

The clothes moths are small and delicate, rarely over 3/8 to 1/2 inch in length. Unlike most species, these moths are not attracted to lights, but prefer darkness and when disturbed will rapidly conceal themselves in folds or other secluded places. Larval identification is best based on the feeding damage rather than specific morphological characteristics. The carpet beetles can be easily identified in either the larval or adult stage. Adults can generally be separated by body shape, coloration and the presence or absence of a cleft at the rear of the forewings. The larvae are characterized by body shape and the arrangement of hairs and tufts of hairs on the body. Table 3 summarizes the diagnostic characteristics of the larval and adult stages of the carpet beetles.

Biology

Specific biological and other pertinent facts about the common fabric pests are discussed in the following section.

Casebearing Clothes Moth

The casebearing clothes moth is distributed throughout nearly all of the populated areas of the world. This species is relatively rare in northern areas of the United States. The life cycle of this species is very similar to that of the webbing clothes moth. Unlike the webbing clothes moth this species covers its body with a

portable silken case. Once covered the entire larval period is spent within, and the case is dragged behind as new feeding areas are sought. The case is often composed of dried fibers interwoven with silk, creating a multicolored effect. Also unlike the webbing clothes moth, this species does not spin copious webbing over its food material. This species eats out well defined, clean cut holes. When the larval feeding is completed, it frequently crawls up on vertical surfaces to pupate; consequently, it may be found on walls, partitions or other similar structures when pupating. Pupation occurs in the larval case.

Black Carpet Beetle

This is a serious fabric pest in the eastern states. In these areas, it is considered the most destructive of all carpet beetles. It is also common in the western states. The larvae are extremely active feeders and will readily burrow and enter food or food containers that are not perfectly sealed. The searching habits of the larvae frequently result in their appearance in containers of non-food materials. Dead bodies of insects are the preferred food of this species. For this reason, black carpet beetles are frequently found in cereals and grain that are infested with stored product pests.

Black carpet beetle infestations that are found in homes and industry frequently begin with a buildup of the population in bird nests, abandoned wasps or bees nests and dead rodent bodies that are located in attics, chimneys, wall voids or basements. Larvae initially located in these situations will freely migrate into the living quarters of the building and infest any suitable food materials.

Under ideal environmental conditions this species requires about 1 year to complete a generation. The larvae will pass through 6 to 20 molts and may require up to 650 days complete development under poor environmental conditions. The last larval instar typically does not pupate until encountering suitable environmental conditions. Pupation typically occurs in protected situations.

Furniture Carpet Beetle, Varied Carpet Beetle, Carpet Beetle

These 3 beetles belong to the same genus (Anthrenus) and are similar enough in appearance and habits that they should be considered to surface feeders. A heavy infestation will show many larvae feeding in close proximity to each other on the surface. but feeding deeply enough to penetrate woolen fabric and other materials.

The varied carpet beetle passes through about 1 generation per year. The larvae passes through 5 to 16 larval instars. The female lays an average of 30 eggs. With 1 generation per year and an average of 30 eggs per female, this species potential capacity for rapid reproduction and infestation is limited. Fortunately, this beetle has not been encountered in Hawaii.

The life cycle of the furniture carpet beetle may be complete in as little as 3 months. Under ideal conditions, this species may complete up to 4 generations per year although in the home 2 per year is the more likely situation. The females lay an average of 70 eggs each. This species is extremely destructive to carpeting, upholstered furniture, clothing and natural fiber brushes.

The carpet beetle, which has also been known as the buffalo bug, seems to be less common in the eastern part of the United States. It is still a common fabric pest east of the Rocky Mountains. The carpet beetle is capable of completing 1 generation in 78 days although the average is closer to 3 months. Thus I pair of carpet beetles

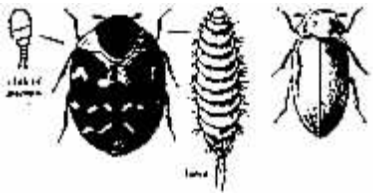
are capable of producing several thousand offspring in a 1 year period.

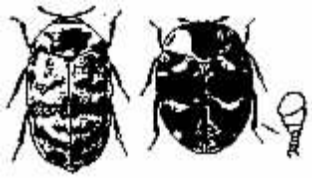
Control

Control methods for fabric pests can be divided into 2 distinct categories: prevention and elimination. Prevention is usually limited to the public. However, the pest control operator should be aware of these techniques and can function to recommend sanitary methods that reduce the chances of initial infestation and eliminates conditions that favor the development of populations in the home or industry. The following technique will minimize the chance of establishment of these pests.

1. Do not store soiled or contaminated wool garments.
2. Do not allow unwanted soiled woolen garments to accumulate in protected locations.
3. Do not allow lint or dust to accumulate in undisturbed areas.
4. Do not keep furs, feathers or woolens in storage without moth protection.
5. Woolens and other fabrics should be tightly wrapped with such repellents as paradichlorobenzene or napthalene (moth balls). Caution should be taken to sandwich these volatile substances between sheets of paper to prevent staining of these fabrics.

Table 3. Identification of Carpet Beetles

Species	**Diagnostic Characteristics**
 Black carpet beetle *Attagenus megatoma*	Adults distinctly oval, dark brown to black, about 1/6 inch long. Larvae carrot-shaped with long tail bristles. Shiny brown to black.
 Varied carpet beetle *Anthrenus vrerbasci*	Adults slightly oval shaped and mottled with white, brownish, and yellowish scales. No cleft at tip of wings. Larval body wedge-shaped with rear broader than head. Three tufts of hair on either side of rear end.
 Furniture carpet beetle *Anthrenus flavipes*	Adults mottled with yellow, black and white, more rounded than varied carpet beetle, cleft at tip of wings. Larvae torpedo-shaped, head wider than rear, darker than varied carpet beetle.

 Carpet beetle *Anthrenus scrophulariae*	Adults round-oval, about 1/8 inch long, black with orange red scales, scalloped band of orange down center of back. Larvae reddish brown, hair extending outward from entire body.

Elimination is the major phase of fabric pest control which can be offered by the pest control industry. Elimination may be effected in part by the use of sanitary methods, but basic reliance must be placed on killing the existing pests with contact and or residual chemical.

Difficulty arises due to deep-seated infestations occuring deep within carpeting or beneath or behind other infested materials. Water emulsion or even oil base sprays too often fail to reach hidden insects as wool repels small droplets of spray. Spray equipment must propel the insecticide droplets sufficiently to force them beneath the surface of fibrous materials in carpeting. The "furry" nature of the varied and furniture carpet beetle larvae, plus natural resistances of the black carpet beetle, also tend to protect these insects against most aqueous sprays. The use of wetting agents in both oil and water sprays greatly improves penetration.

Carpeting should never be "soaked" with an oil spray. Penetration should be deep enough to reach the base pile but not enough to wet the synthetic or rubberized backing, otherwise "warping" may occur. A means of assuring rapid penetration and evaporation of oil spray without damage to the carpet backing is to cut base oil by one-half with isopropol alcohol (rubbing alcohol). For the first few moments following treatment with this combination, flash point is lower and odor higher; however, both undesirables dissipate quickly in a well ventilated room. Insecticidal deposit is thus evenly distributed throughout all fiber, reaching the seat of infestation. Rapid evaporation also enables quick resumption of traffic on treated carpeting without tracking dirt on or oil off the carpet. It is not necessary to treat an entire wall to wall carpet that is walked upon and vacuumed regularly. Attention should be given to areas under stationary furniture, or around heat registers.

INSECT PESTS OF STORED PRODUCTS

There are over 100 species of insects found infesting dried plant and animal food materials. Exclusive of the cockroaches, mites and ants, the majority of these pests belong to the orders Coleoptera (beetles) and Lepidoptera (moths). The occurance of these pests in homes, restaurants or other structures usually originate from 1 of 2 sources. The majority of these pests originate from infested material brought into the residence. 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 numbers of these pests that naturally occur in and around areas where food is stored.

Most stored product insects are cosmopolitan or worldwide in distribution. One reason for the wide distribution of these pests is that grain, cereal and other dried foods and their pests have been shipped with little restriction all over the world. Another reason may relate to the 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 the reader 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 grain silo, home or warehouse in each location are likely to be similar.

It is beyond the scope of this text to attempt to discuss all the pests of stored products. We will limit our discussion to the 10 most commonly encountered pests in the orders Coleoptera and Lepidoptera. The cockroaches, mites and ants are discussed in other sections of this text.

Identification

The beetles and mites develop with complete metamorphosis. Generally the life cycle of stored product pests is short and the egg, larval, pupal and adult stages of any pest will all be present at the same time in a well established infestation. This is very convenient for identification purposes. It is almost impossible to identify any of these species with either the egg or pupal stage. The larval stage can be used in identification, but this usually requires considerable expertise and should be avoided if possible. It is easiest to base identification of the stored product pests on the adult stage. Since many of these pests are small, it may be necessary to use a 10X eyepiece magnifying glass in identification. It should be noted that the identifying characteristics given in Table 4 are only useful if the pest is found in stored products.

Biology

The feeding habits of stored product pests can be divided into 2 large categories. These are external and internal feeders. As one might expect, the external feeders will feed on the exterior of stored foods while the internal feeders bore into the food and may spend the larval, pupal or even part of the adult stage within the food. In many cases the actual amount of food consumed by a stored product pest may only be a minimal part of the damage. Some of the moth species web their food with silk. In heavy infestations, this webbing may actually clog the machinery used to process the food (e.g., flour mills). Also, governmental agencies have set limits on how much insect contamination may be present in processed food. For example, if infested grain were ground into flour, the flour may be judged unfit for human consumption if it exceeded the allowable amount of insect contamination. In this case, the contamination would be ground insect parts which were not detectable to the human eye.

Generally speaking, insects found infesting stored products will not harm animals or man if consumed. Indeed, they actually add an additional source of protein to the diet. However, the average consumer will find a few beetles in his cereal extremely repulsive and will discard this and any other infested material in the pantry. The damage caused by stored product pests is often enhanced by the mind of the consumer.

Specific biological facts about the common stored product pests are presented in Table 5.

Control

Packaging usually has little effect in preventing stored product pests from infesting food. Most methods of

packaging food can be invaded by stored product pests. Cardboard, cellophane, metal foils, various cloths and most flexible plastics are readily penetrated by the larval, adult or both stages of these pests. Metal cans and tightly sealed glass containers are generally secure. Since most packaging is penetrable, once these pests become established in an area, they will typically spread to other food materials in the structure.

The first step in control is to locate and destroy the source of the infestation. However, the bulk of the infested material is usually confined to a small area, such as a closet or cabinet in the kitchen. Once the source of infestation is located and destroyed, all penetrable food containers, sealed or not, should be inspected. Foods such as cereals, nuts, beans, peas, spices, dried bread and fruits should be checked with care. Once all suspect food is removed, the storage cabinets, pantries or other areas of storage should be thoroughly cleaned, paying particular attention to crevices. A vacuum cleaner can be used to pick up loose food particles and dirt. These areas should then be washed with soap and hot water and allowed to dry.

Chemical application is frequently very helpful. It is essential that insecticides, whether residual or space sprays, be kept from direct contact with food products. The chemical should be applied to all the shelves, drawers or benches in the general area of infestation. After the insecticide is allowed to dry, the sprayed surface should be covered with paper or other material to avoid having food or food containers come in contact with the residue. It may take several days for the insects to contact the residue and be killed. Fumigants are also commonly used in controlling stored product pests, especially in warehouses and other large scale operations.

DOMESTIC FLIES

The order Diptera (flies) is one of the largest and most diverse in the class Insecta. There are close to 17,000 species of flies in North America. Most of these flies are rarely encountered by man and are of little concern. A rather small group, which we shall term domestic flies, have evolved to live in close association with man. These flies are typically found around or within structures and can become extremely annoying by their constant presence and ability to bite and transmit diseases. This section is concerned with 9 kinds (about 20 species) that are important nuisance flies in the United States.

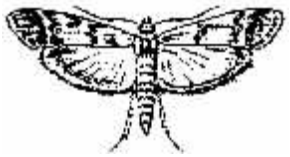
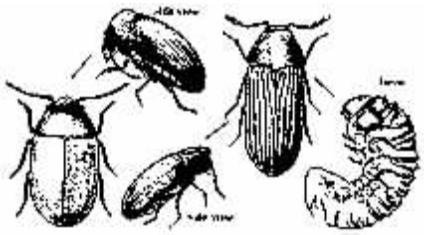
Identification

There is little or no information available on the identification of domestic flies based on the egg or pupal stage. The larval stage may be used for identification, but this is frequently difficult. Table 6 presents a synopsis of identifying characteristics of the common adult domestic flies.

Biology

The life cycle of each species of the domestic flies is quite similar. The immature stages are found in moist, solid organic matter which is usually associated with man's activities. The female deposits small (approximately 1/25-inch long), white eggs in or upon the host material. The eggs typically hatch in a day or less and are extremely susceptible to desication. The white, legless carrot-shaped larvae may reach 1/2- to 3/4-inch in length. When preparing to pupate, the larvae move to drier areas of the host material.

Table 4. Identification of Adult Stored Product Pests

Pest Species	Identifying Characteristics
 Angoumois grain moth *Sitotroga cerealella*	Wingspread 1/2 inch. Pale yellow forewings. Gray hindwings which are pointed at end resembling a pointed finger.
 Mediterranean flour moth *Anagasta kuehniella*	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 inch as well as head and thorax reddish.
 Rice weevil *Sitotroga oryzae* Granary weevil *Sitotroga granarius*	Length 1/8 inch and dark brown in coloration. Mouthparts drawn into elongate snout or beak.
 Drugstore beetle* *Stegobium paniceum* Cigarette beetle *Lasioderma serricorne*	Squat, 1/8 inch in length and reddish brown in coloration. Head retracted into thorax and not visible from a dorsal angle. Elytra of cigarette beetle with parallel lines. Drugstore beetle elytra smooth.
 Saw-toothed grain beetle *Oryzaephilus surinamensis*	Approximately 1/8 inch long, elongate, dark brown and flat. Readily recognized by 6 sawtoothed like projections, located on the lateral margins of each side of thorax.

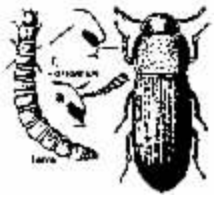
 Confused flour beetle *Tribolium confusum* Red Flour beetle *Tribolium castaneum*	Elongate, flattened, shiny reddish brown and about 1/8 inch in length. Antennae gradually enlarged to form a club.
*These 2 beetles are very similar in appearance and have similar biologies.	

Table 5. Biology of Stored Product Pests

Pest Species	**Feeding Damage**	**Developmental Biology**	**Food Infested**
Angoumois grain moth *Sitotroga cerealella*	Very important grain pest in South. Commonly found emerging from decorative corn in home. Internal feeder.	40 - 400 eggs per female. Six to 7 generations per year. Larval and pupal stage found within host.	Mainly attacks whole grain.
Mediterranean flour moth *Anagasta kuehniella*	Larvae spins large amounts of silk in and over food. Surface feeder.	360 - 600 eggs per female. Three to 4 generations per year. Larvae typically leaves area of host to pupate.	Prefers flour, also infests wheat, bran, nuts, chocolate, seeds, beans, dried fruits and others.
Indian meal moth *Plodia interpunctella*	Larvae spins 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 6 generations per year.	Same host range as Mediterranean flour moth.
Rice weevil* *Sitotroga oryzae* Granary weevil *Sitotroga granarius*	Most important whose grain infesting insects in world. Internal feeder.	50 - 400 eggs per female. Six to 8 generations per year. Larvae and pupae found within host.	Attacks whole grain or pieces of grain large enough for larvae to develop within.
Drugstore beetle* *Stegobium paniceum* Cigarette beetle *Lasioderma serricorne.*	Most common pantry pest in United States. External feeder.	20 - 200 eggs per female. Six generations per year.	Very general feeders, attacking almost all dried plant and animal including drugs and tobacco.
Saw-toothed grain beetle *Oryzaephilus*	Feeding consists of scarring and roughening of surface of food. Very common household pest.	50 - 300 eggs per female. Eight to 9 generations per year.	Very general feeding. Attacks almost all dried plant products.

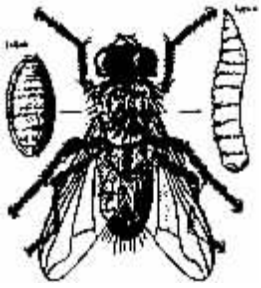
surinamensis			
Confused flour beetle* *Tribolium confusum* Red Flour beetle *Tribolium castaneum*	Feedings consists of scarring and roughening of surface of food. Usually brought into home in flour.	400 eggs per female. Six to 7 generations per year.	Common in flour, also infests cereals, nuts, chocolate, spice, peas and many others.

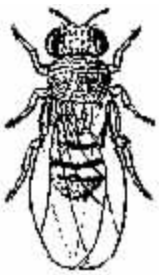
*These 2 beetles have almost identical life.

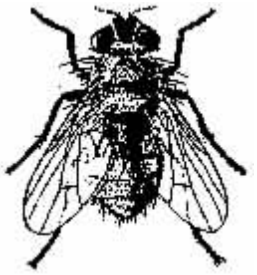
The pupa can be recognized by the hard, brown pupal case in which the larva transforms into an adult. Empty pupal cases may be found in the host material long after an infestation has ceased and are not necessarily a sign of an active infestation.

The developmental period of the domestic flies is relatively short compared to other insects. The house fly, under favorable environmental conditions, is capable of developing from egg to adult in as little as 7 days. The cycle of the other domestic flies may be completed in as short as 8 to 18 days depending on the species. This short life cycle coupled with the ability of the female flies to lay large numbers of eggs gives these pests a tremendous reproductive capacity. Under favorable conditions, large numbers of these flies can appear in a very short period of time. The specific biologies of the domestic flies are presented in Table 7.

Table 6. Identification of Adult Domestic Flies

Species	**Identifying Characteristics**
 House fly *Musca domestica*	Dull gray with 4 stripes on thorax. Abdomen lighter color than thorax. Fourth longitudinal vein sharply angled. Body 1/4 inch in length.
 Little house fly *Fannia canicularis*	Males easily recognized by habit of hovering in protected places. Dull gray with abdominal segment next to thorax yellow. Similar in size to house fly, but less robust.

 Green blow fly *Phaenicia* (2 species)	Shiny green or copper colored. Slightly larger and more robust than house fly.
 Blue blow fly *Calliphora* (several species)	Bicolored, the thorax gray with stripes and abdomen shiny blue. About size of green blow fly.
 Black blow fly *Phormia regina*	Shiny black or green and similar in size or slightly larger than house fly. Distinguished from green blow fly by presence of orange anterior spiracle.
 Stable fly *Stomoxys calcitrans*	Similar in size to house fly, but has elongate blood sucking mouthparts. When at rest, body slightly angled rather than parallel to surface.
 Vinegar fly *Drosophila* (several species)	Small (1/8 inch), yellowish brown. Typically found hovering around overly ripe or decaying fruits and vegetables.

 False stable fly *Muscina stabulans*	Similar to house fly but can be distinguished by pale or reddish color on tip of scutellum and the fourth longitudinal vein only slightly curved upward near tip of wing.
 Flesh flies (several genera)	Dull gray. Only 3 black stripes on thorax. Abdomen usually has a checkered pattern. Males of many species with red spot on tip of abdomen. Generally larger than house fly.

Control

The basis for domestic fly control is the elimnation or prevention of favorable habitats for fly production. If suitable habitats exist and environmental temperatures are favorable, a domestic fly problem will undoubtedly result. The use of insecticides is only secondary in fly control. Habitats where flies breed frequently cannot effectively be reached or penetrated by insecticides. Insecticide treatment at locations other than the site of breeding and development is at best a temporary means of control.

Some of the fly problems in urban areas and most of the problem in rural areas originate at sites other than in the immediate vicinity of homes, restaurants and similar structures. However, most flies live within 1/2 mile of where they hatch and rarely do large numbers of flies travel more than 2 miles. Nevertheless, if a large population exists around a structure, it is advisable to consider all possibilities of their origin. Common agricultural areas where large fly populations may breed include chicken ranches, dairies, beef feed lots, hog ranches, horse stables and areas of crop production where manure is used or fruits and vegetables are culled. Control or prevention of fly population in these areas is beyond the scope of this text. Adequate information is available and can be obtained from the Cooperative Extension Service.

Fly control in the urban areas follows the same principles as that in the rural areas. That is, locate the breeding place or places of the population and eliminate them. The first step is to identify the pest species. In many instances this will limit the potential breeding localities. For example, if a large number of blue blow flies are present, the operator should first expect some animal carcasses in the vicinity. Once a breeding site has been eliminated, corrective steps should be taken to prevent a recurrence of the problem. Possible breeding areas for domestic flies are outlined in the following discussion.

1. Garbage cans are probably the single most important source of domestic flies. Tight fitting lids may be of some value. Also, twice a week garbage collection and a thorough cleaning of the cans is very helpful.
2. Grass clipping may be an important source of flies if piles are allowed to accumulate and decompose

until the inner areas reach a slimy stage. If clippings are removed every other week, this should not be a problem.

3. Dog and cat droppings may sustain a fly population if they are allowed to accumulate. These materials may not only serve as a source of an infestation, but droppings also serve to attract many flies into an area in larger numbers than nominal.
4. Fertilizers (especially chicken and cow manure) may contain fly larvae which emerge after the fertilizer is applied, or flies may actually go through a complete life cycle after the manure is applied if it is not thoroughly mixed into the earth.
5. Dead snails are frequently a source of fly infestation, especially for flesh flies. Accumulations should be removed once a week.
6. Compost piles may produce flies if they are not fumed frequently and kept sufficiently dry.

Table 7. Biology of Domestic Flies

Species	**Life cycle**	**Adult occurance**	**Preferred host material**
House fly *Musca domestica*	200 - 2000 eggs per female. Egg to adult in 7 to 45 days.	Prefer warm but not too hot weather. May occur year around.	Larvae almost always occur in man-made sources, animal waste, culled fruits and vegetables are preferred.
Little house fly *Fannia canicularis*	180 - 560 eggs per female. Egg to adult in 18 to 24 days.	Males typically hover in protected locations such as garages, porches and inside houses.	Larvae develop in almost all kinds of decaying organic matter. Chicken manure usually the source of large infestations. Other types of manure also favored.
Green blow fly *Phaenicia* (2 species)	3000 eggs per female. Egg to adult in 9 to 18 days.	Frequently most common flies in urban situation. Common during summer months.	Garbage cans common source during summer months. Dog droppings also preferred.
Blue blow fly *Call iphora*	500 - 700 eggs per female. Egg to adult in 15 to 21 days.	Usually first flies to appear in the spring.	Decaying carcasses of birds and mammals. Also found in garbage dumps.
Black blow fly *Phormia regina*	200 - 400 eggs per female. Egg to adult in 10 to 25 days.	Most common blow fly in wild areas. Active in relatively cool temperatures in spring and summer.	Decaying carcasses. Also lays eggs in open wounds of animals.
Stable fly *Stomoxys clacitrans*	200 - 400 eggs per female. Egg to adult in 13 to 40 days.	Common around dairies. Occasionally attracted to and bite dogs in large enough numbers to be a problem.	Manure, especially when mixed with straw. Lawn clippings and animal feed waste also preferred.
Vinegar flies *Drosophila* (several species)	400 - 1000 eggs per female. Egg to adult in 8 to 11 days.	Most abundant around larval source and during fall, but can be present year around.	Larvae found in decaying fruit and vegetables. Garbage cans frequent source.

False stable fly *Muscina stabulans*	140 - 220 eggs per female. Egg to adult in 15 to 30 days.	Most abundant in early spring prior to peak house fly emergence. Occur in many situations.	Manure and decaying plant waste such as culled fruit.
Flesh flies (several genera)	Female deposits 30 to 60 larvae instead of eggs. Eggs held in female until they hatch. Larvae to adult 8 to 18 days.	Year around, more common in warm months.	Garbage cans, manure (especially untrampled) animal carcasses including snails.

DOMESTIC RODENTS

Domestic rodents have co-existed with man for centuries. They have eaten man's food and wastes and have shared his living quarters. They have become man's chief vertebrate pest because of their great reproductive capacity and their ability to adapt to new environments. Aside from consuming man's food, the domestic rodents are involved in contamination of foods by defecation, destruction of building structures by their gnawing habits, and transmission of diseases and parasites of medical and veterinary importance. Some of the diseases that rodents are directly or indirectly involved in imparting to man are plague, murine typhus, infectious jaundice, rate-bite fever, food poisoning, poliomyelitis, and rabies. A few examples of the parasites conveyed to man and animals are nematodes, spiny-headed worms, flukes, tapeworms, fleas, and ticks. Control measures are essential and costs of control are low as compared with losses brought about by rodents even without consideration of diseases. Rats alone generally outnumber the human population by 3 to 2. The average cost in goods damaged and food eaten by a given rat is estimated at 1/2¢ each day. This comes to over $1.80 for each rat in a year, or a total of over $250,000 for a city of 100,000 human population.

Identification

The 3 main domestic rodents found in the United States are the Norway rat (*Rattus norvegicus*), the roof rat (*Rattus rattus*), and the house mouse (*Mus musculus*). The Norway rat is distinguished from the roof rat by several factors. The Norway rat has coarser hair, close-set ears and its muzzle is blunt. Its tail color is dark dorsally and light ventrally. The tail is also usually shorter than the combined length of the head and body. The fur coloring changes from grayish brown on the back to grayish-white on the belly. Adults weigh between 12 and 20 ounces and are 7-1/2 to 10 inches in head and body length. The tail length is between 6 and 8-1/2 inches. The feces are capsule-shaped and about 3/4 inch long (Figure 20).

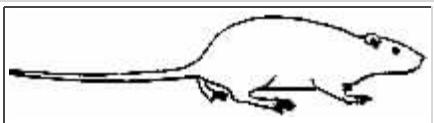


Figure 20. Norway Rat

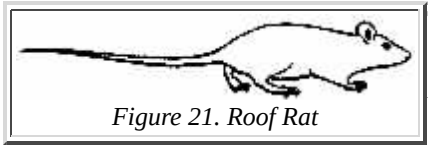


Figure 21. Roof Rat

The roof rat is smaller than the Norway rat. This rat has large, membranous ears and a sharply pointed muzzle. The unicolored tail is usually longer than the head and body. The adult head and body length is between 6 and 8-1/2 inches while the tail ranges between 7 and 10 inches. The adult weight is from 8 to 10 ounces. The feces differ from those of the Norway rat in that they are about 1/2 inch long and are spindle-shaped. The roof rat has 2 color phases. The black rat phase has a sooty black back and a gray belly. The Alexandrine rate phase is grayish-brown on the back and ranges from gray-white to yellow-white on the belly (Figure 21).


Figure 22. House Mouse

The house mouse resembles the roof rat in that they both have large ears, pointed muzzles, and slender bodies. However, the house mouse is a great deal smaller. The tail is unicolored, has little hair, and is about as long as the head and body. The adult mouse can be distinguished from a young roof rat by virtue of the head and feet of the mouse being distinctly smaller in proportion to its body size. Adults weigh 1/2 to 3/4 ounces end are 2-1/2 to 3-1/2 inches long in head and body length. The tail measures between 3 and 4 inches long. The feces are 1/8 to 1/4 inch long and are rod-shaped (Figure 22).

Biology

The specific biologies and behaviors of these rodent pests are presented in Table 8. Rodents build nest wherever security, food, and water are available. Preferred nest sites include enclosed spaces between walls and floors, under counters, machinery, or shelving, in trash piles, or in burrows in the ground. Nests are well hidden and are rarely discovered during routine inspection.

Control

There are 2 basic methods of domestic rodent control. The first method is environmental management; that is, maintaining or changing the environment such that it no longer is conducive to rodent infestation. When environmental management is achieved, it is a much more permanent form of control than is the second method: rodent extermination. Rodent extermination is the elimination of the existing population of pests. The second method of control employed alone, without preventative measures, merely invites new infestations.

Environmental Management

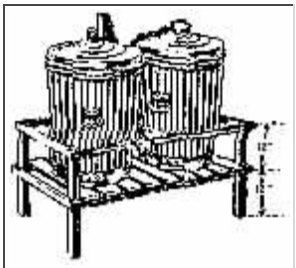


Figure 23. Elevated Rack

Environmental management uses sanitation and exclusion as keys to rodent control. Sanitation practices entail the removal of any excess material on which rodents may feed or drink. Garbage or waste areas are especially vulnerable to attack by domestic rodents. Containers should be equipped with rodent-proof, tight-fitting lids. Placing garbage cans and other containers of stored foods on elevated racks having a 6-inch clearance above the floor helps keep storage areas cleaner and easier to inspect (Figure 23). Other materials which may draw rodents are excessively available water, rotting or overly ripe fruit which has fallen from trees, or any other refuse containing food substances.

The exclusion method of rodent control involves the eradication of all possible nesting sites and avenues of entrance into buildings (Figure 24). Exclusion practices are frequently difficult because of the habits and behaviors of rodents. Rats and mice are quite agile and capable of entering through extremely small openings. In general, buildings with openings larger than 1/2 or 1/4 inch are not rat- or mouse-proof, respectively. Rodents have great climbing abilities. also. They are capable of gaining entry to a building by climbing vertical pipes up to 4 inches in diameters, climbing shrubs, trees, or vines adjacent to structures, and crossing wires to upper stories. Climbing abilities are best developed in roof rats and house mice. Rodents have evolved other adaptive skills and-behaviors. They can jump 3 feet vertically and 4 feet horizontally. They can enter a building through drains and toilets. They are able to fall 50 feet without being killed and can burrow 4 feet down into the soil. They are capable of gnawing through wood, fiberboard, and many plastics. Exclusion

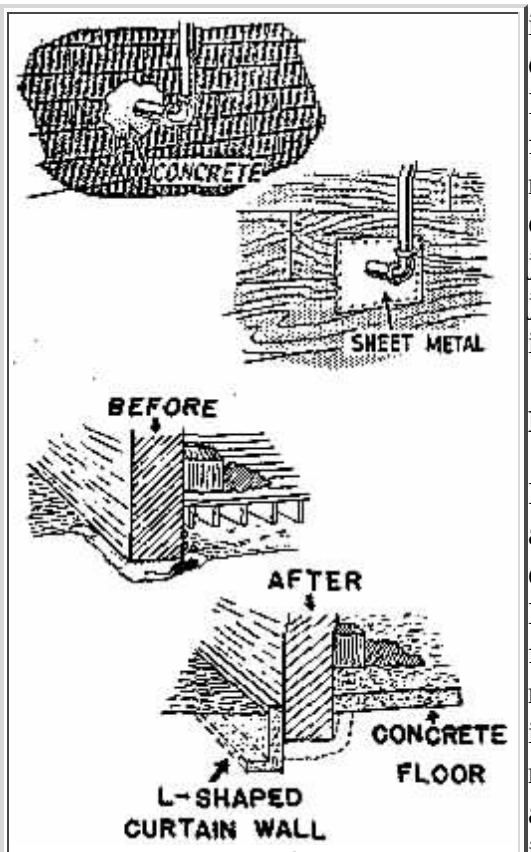


Figure 24. Methods of Preventing Rats from Entering a Structure

is therefore difficult, but can be achieved through the modification of existing buildings or in the design of buildings to be constructed. In existing buildings, enclosed spaces, such as those between double floors, under cabinets, and under stairways, should be removed or modified. Stored materials or containers should be placed on shelves or racks. Outdoor potential nesting sites, such as rubbish piles or junk piles should be removed. Entrances to buildings, such as door jams, borders of windows, house vents, and furnaces, should be inspected.

Extermination

Rodent extermination as a control method is to be considered only as a supplement to environmental management. This method merely eliminates the existing population of rodents temporarily. Extermination can be accomplished by trapping, poisoning, and fumigating. Trapping is the preferred method of control when rodenticides are prohibited or where poisoned rodents might die in inaccessible areas and cause foul odors. Snap traps are generally more effective than cage traps. They should be equipped with a large and sensitive trigger which may or may not be baited. Effective baits include meats (especially bacon), various grains, dried fruits, peanut butter, and pastries. Baits should be fresh daily. Mice are more easily trapped than rats because they tend to be less fearful of traps. Traps for mice should be spaced every 3 or 4 feet adjacent to baseboards, boxes, platforms, wall junctions, and on rafters. Rat traps should be placed along established runways (Figure 25). Rat runways can be determined by using tracking powder or looking for rat signs. All traps should be anchored well and checked daily. The reason traps are placed next to vertical objects is that rodents are highly touch sensitive in their whiskers. They appear to use this sense to guide them along vertical objects on the floor.

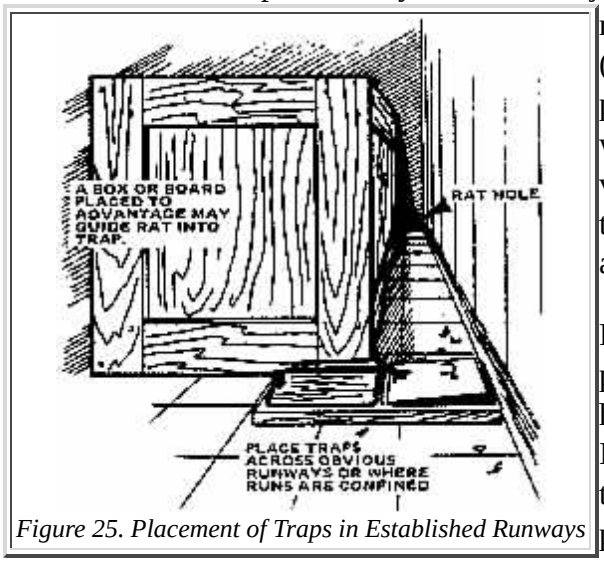


Figure 25. Placement of Traps in Established Runways

Rats typically avoid new or unfamiliar objects along their paths. This aversion is not a problem with mice, but it does hinder the effectiveness of traps and poison baits in rat control. It is often necessary to allow a familiarization period before traps or toxic baits can produce good results. Often a good place for rat traps is in surprise locations along their runways just behind an object which has been in the path for some time.

The use of poison baits is the most effective means of extermination. When using poison baits, first use an untreated bait until the rodents will freely accept it. This will also reveal which baits are more desirable. When the baits are being consumed regularly, begin treatment of the bait with a registered rodenticide. This procedure is known as pre-baiting. Untreated baits should be used from 2 to 4 nights prior to actual rodenticide treatment. Other factors which determine the success of poison baits include the choice of the proper food for bait, the correct distribution of baits over the entire home range, the proper mixture of poison in the bait, and the use of the correct rodenticide. Good baits are cereal grains, fish, meats, fruits, and

vegetables.

Rodenticides are of two types: chronic poisons (anticoagulants) and acute poisons (stomach poisons). Anticoagulants are decidedly the safest for general use. However, rodents must feed on the bait for several days for the poison to be effective. Bait stations in the form of a tunnel or box placed adjacent to a vertical surface usually increases the effectiveness of anticoagulant baits (Figure 26). Stomach poisons are sometimes laid down as a tracking powder and are ingested by the rodents when they groom themselves.

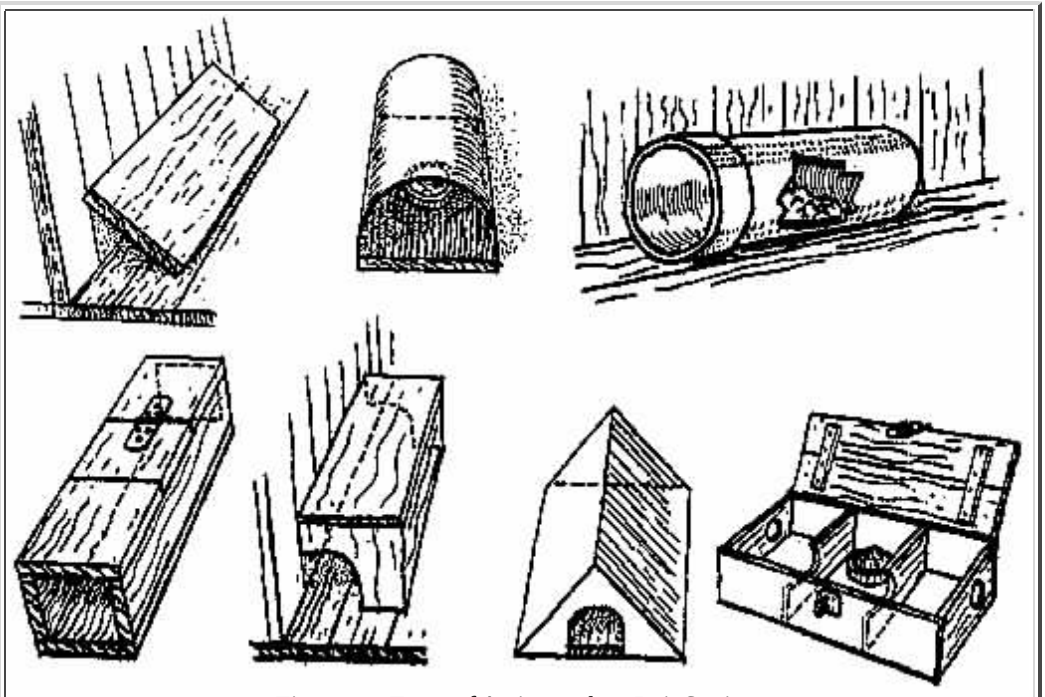


Figure 26. Types of Anticoagulant Bait Stations

Fumigation for domestic rodents is not widely used around the home but is commonly used on ships. Since the nesting sites of rats and mice are frequently in well-protected areas, fumigants will often be ineffective. Rodent fumigation requires great skill since it can be dangerous to the person handling the poisons.

Table 8. Specific Biology of Domestic Rodents

Rodent	Life Cycle	Home Range*	Food
Norway rat *Rattus norvegicus*	8 to 9 young per litter Two to 4 litters. Nine to 12 months life expectancy.	100 to 200 feet diameter.	Omnivorous; prefer garbage, meat, fish, grains. One-half 1 ounce water per day.
Roof rat *Rattus rattus*	5 to 7 young per litter. Two to 4 litters. Up to 1 year life expectancy.	100 to 200 feet diameter.	Omnivorous; prefer vegetables, fruits, nuts, grains. 1 ounce water per day.
House mouse *Mus musculus*	5 to 6 young per litter. Up to 6 litters. Up to 1 year life expectancy.	Very small; usually within or around 1 building.	Omnivorous; cereal grains preferred.

*Refers to normal distances these rodents will travel from their nesting sites in search of food, water, or other requirements.

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