# INDUSTRIAL, INSTITUTIONAL, STRUCTURAL, AND PUBLIC HEALTH PEST TRAINING MANUAL






STATE OF MONTANA
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# PREFACE

This manual was prepared as a study guide for pesticide applicators involved in community health pest control, and control of pests in businesses, institutions, food producing establishments, and homes. Discussions of Montana pests that are most common in all of these situations are included. This manual can be used to study for the examinations in Public Health Pest Control, Food Manufacturing and Processing, Industrial, Institutional, Structural and Health Related and also Regulatory Mosquito Abatement.

To simplify information, trade named products and equipment have been mentioned. No endorsement is intended, nor is criticism implied of similar products or equipment which are not mentioned.

We wish to acknowledge the help of personnel of the Environmental Management Division, Montana Department of Agriculture in preparing this manual.

CHAPTER I

# COMMUNITY PEST CONTROL

## A. Introduction

This Chapter will deal with insects, and other arthropods, rodents, birds and animal pests affecting man's health, structures, fabrics and foods. The type of applications concerned with these pests include: pest control applicators (PCA'S), institutional and public school personnel, public health sanitarians and related personnel.

## B. Nuisance Arthropods

Ants - Class:Insecta Order: Hymenoptera Family: Formicidae

Ants are social insects consisting of workers (nonreproductive females), reproductive females and reproductive males. Ants have a narrow waist between the thorax and abdomen called the pedicel. Ants are divided into two groups on the basis of a pedicel consisting of one or two nodes. Ant groups are known either as "single-node" or "double-nodes".

Ants develop by complete metamorphosis. The worker ant is the adult normally seen as a pest. Workers do the work for the colony such as nest construction and gathering food. It is in gathering food they become pests. Food preferences differ as to species but for the most part ants are attracted to sweets, fats and proteins. Some species like only one kind of food; others will eat several kinds. The reproductive females are usually larger than the workers.

Ants which may be encountered in and around buildings include:

1. Field Ant (Formica spp)-single-node, may be brown, black, red, or combination thereof and vary in size from 1/8 to 3/8 inches. They prefer sweets but also feed on other insects. Nests are commonly found along sidewalks, fences, and flower beds.

2. Adorous House Ant (Tapinoma sessile (Say) - Single-node, small (1/8 inch) varying from dark brown to black. They frequently nest in walls and underneath floors. When crushed these ants give off an unpleasant odor. They prefer sweet foods such as sugar, syrup, fruit juices, secretions of plants and honeydew from other insects.

3. Pharaoh Ant (Monomorium pharaonis) - a tiny, two-node, yellowish-red ant, 1/12 to 1/10 inch. This species generally nests around fountains and in walls of buildings. They prefer sweets and protein foods including syrups, fruit juice, cakes, greases, dead insects and meat.

4. Small Honey Ant (Prenolepis imparis) - a tiny, single-node, shiny black ant, 1/16 to 1/8 inch, is attracted to sweets.

5. Thief Ant (Solenopsis molesta)- a very small (1/16 inch) reddish, yellowish or pale brown, shiny ant. Attracted to fatty foods, such as bacon, other fatty meats and cheese but may feed on sweets at times. Their name results from the frequent practice of living in nests of larger ants, feeding on the larvae.

Suggested Control Methods

The best method for control of ants is to locate the nest and treat them directly. It is often difficult to locate the ant nest if the colonies are situated in walls, under pavement, in stone cracks or other secluded places. To prevent ants from entering a building, spray insecticide on the outside walls from the ground up to the windows; or the foundation and adjacent four inches of soil; under porches; around doors and windows; and in cracks and perimeters of cement walk ways. Ants indoors can be controlled by treating base boards, moldings, around plumbing and heating pipes, around sinks and bathtubs and in kitchen cupboards. Commercial bait formulations (such as Kepone) may be effective. Workers will carry the bait back to the nests where it is fed to larvae and reproductives. However, baits may be ignored because of more attractive foods.

Silverfish and Firebrats - Class: Insecta Order: Thysanura Family: Lepismatidae

Silverfish and firebrats (also called "bristletails", because of the three slender appendages at the rear of their bodies) are about 1/2 inch long. Silverfish are distinguished from firebrats by their shorter appendages and antennae and their uniform silver to brown color. Firebrats are a mottled grayish brown. Silverfish prefer 70 to 80 degree temperatures, whereas firebrats prefer temperatures $90^{0}$ or higher. Both like moist locations. Both feed on starches and proteins and can damage fabrics, paper, books, and furnishings.

Applications of residual insecticide sprays or dusters should be in and around heaters, warm pipes, storage areas, along floor-wall junctures, cracks and crevices in basements and other hiding places. Damp areas under building should be treated.

Springtails - Class: Insecta Order: Collembola

Springtails are small, usually less than two millimeters, vary from white to gray and are without wings. A forked appendage attached to the lower side of the abdomen can be released suddenly causing the springtail to leap into the air, hense his name. Springtails are usually found in damp places around plumbing, in kitchens, in bathroom and around window jams. They do not cause damage but are a nuisance when in large numbers.

Elimination of damp places through construction or ventilation are good control measures. In the home trash piles should be removed and compost piles located away from the building.

Dusts or emulsions should be used if chemicals are believed to be needed since oil won't adhere to the damp surfaces. Bathroom overflow drains, water pipes and other moist surfaces where springtails can be seen should be treated; outside granular treatment of Sevin and Malathion is effective.

Earwigs - Class: Insecta Order: Dermaptera

Although earwigs cause great concern because of their appearance, they are harmless to humans. The pinchers of larger earwigs may cause painful pinch to humans.

The European earwig (Forficula auricularia) is the common earwig in most areas of the United States. It is dark reddish-brown and is about 1/2 to one inch in size. Earwigs develop by simple metamorphosis. Although they have wings, they are relatively poor fliers and rarely fly.

Earwigs are active at night and usually hide during the day. Earwigs prefer moist hiding places such as under debris, boxes, and similar materials. Good yard sanitation, particularly near the building, and good housekeeping inside, such as in basements, has much to do with effective control. Well maintained structures, including tight windows and sealed foundations, are important to preventing earwigs from entering buildings.

Chemical control of earwigs in buildings must include control outside of buildings. Commercially prepared baits in plant beds around the building provides control in these areas, reducing the numbers which might enter the building and preventing damage to the plants. Application of sprays or dusts outside and along floor-wall junctures or other hiding places inside buildings will give effective control. Dusts and sprays such as Chlordane should be applied in the opening soon after the young earwigs come out of the soil.

Crickets - Class: Insecta Order: Orthoptera Family: Gryllidae

Both the field and the house cricket will enter buildings. They can be a nuisance and damage fabrics. Crickets develop by simple metamorphosis. The field cricket is larger than the house cricket. Its wings extend beyond the wing covers. The house cricket remains hidden during the day. It will eat or drink most anything and thus may damage clothes, paper, fruits and vegetables. Chemical control of crickets usually involves application of residual insecticides to foundations, window wells, damp areas in basements and potential hiding places.

Centipedes - Class: Chilopoda

Centipedes have a flattened worm-like body with head and abdominal regions. Centipedes vary from brown to grayish-yellow to green and they may have as many as one-hundred pairs of legs,

one pair to each body segment. The appendages of the first body segment behind the head are clawlike and function as poison jaws. In reality, they are modified legs.

Centipedes other than the house centipede, live outdoors in moist areas under leaves, stones and trash. They often enter buildings at night and can be found most any place providing cover.

The house centipede may live in damp areas of a building. They feed on small insects, their larvae, and on spiders. Since they are beneficial, control is not necessarily desirable. If present in large numbers, building occupants may feel that control is mandatory. Chemicals may be applied outdoors to their hiding places. Diazinon, Sevin, Chlordane, and Dylox are often recommended for control. Indoors, centipedes may be controlled with a vacuum.

Millipedes - Class: Diplopoda

Millipedes are worm-like in appearance and are 1/2 to three inches in size. They have short antennae and two pair of legs on most abdominal segments.

Millipedes live in moist, decaying material. Their diet consists of decaying organic matter and green leaves. They usually do not damage plants or lawns nor do they damage food supplies or structures. Millipedes do not bite or sting humans. For this reason, control is seldom required.

Millipedes may enter buildings but are not a problem if harborages are removed from around a building. An application of a residual insecticide, if necessary, around the foundation of the building should give adequate control.

Sowbugs and Pillbugs - Class: Crustacea Order: Isopoda

Sowbugs and pillbugs are segmented, oval, brown or grayish in color and about 1/2 inch long. Sowbugs have tail-like appendages but pillbugs do not. Pillbugs also roll up into a ball when threatened.

Sowbugs and pillbugs feed primarily on decaying organic material and are normally found outdoors but migrate indoors occasionally. They require moist conditions and are most active at night. Outside they will be found under rocks, debris and decaying vegetation. Inside they will seek crevices such as in basement floors.

Removal of decaying vegetation from around the foundation of a building and dry basements are deterants to sowbugs and pillbugs and should be adequate for control. If they are present in basements, residual insecticide dusts or sprays may be applied around floor drains, in floor crevices, or other floor openings or voids at or near grade level. Outside treatments should be made

to and near foundation walks, around and beneath door steps and porches, subfloor crawl spaces and damp areas immediately around the structure.

Clover Mites - Class: Arachnida Order: Acari Family: Tetranychidae

Clover mites are reddish-brown and about the size of a printed period. They are not a public health hazard but can be a nuisance inside buildings. They are normally associated with healthy lawns (particularly new lawns) and well fertilized old lawns. They migrate into buildings through openings around windows when weather is favorable. This is particularly true in the spring and in the fall since they are relatively inactive during very hot or cold weather. They migrate from lawns because of population pressures or because of unfavorable lawn conditions. They frequently overwinter in outside building walls.

A two foot bare soil barrier around a building helps to prevent clover mites from reaching the outside walls. Many varieties of flowers and shrubs can be planted in these soil barriers. Application of an oil-base insecticide to the outside foundation is effective. If mites are already on the wall, then application of the same type of insecticide around the window helps to prevent entrance into the building. If the mites have entered the building, wiping off surfaces with a detergent-disinfectant solution is effective and is recommended over the application of insecticides.

C. Fabric Insects

There are many insects capable of damaging fabrics. Only those insects which feed on fabrics and specifically the protein "keratin" are included in this guide. Keratin, a major constituent of animal hair, horns, hoofs and feathers is digestable by only a few insects (primarily fabric insects). Fabric insects also need vitamins and amino acids normally found on contaminated fabrics. Such contamination is inevitable through handling and thus contamination is always sufficient to support fabric pests.

The two groups of fabric pests are moths (Order: Lepidoptera, Family: Tineidae), and beetles (Order: Coleoptera, Family:Dermestidae).

Clothes Moths

There are three moths which are called clothes moths: the webbing clothes moth (Tineola bisselliella), the casemaking clothes moth (Tinea pellionella) and the tapestry moth (Trichopaga tapetzella). The most common moth in northern states is the webbing clothes moth.

The body and wings of the webbing clothes moth are uniformly buff colored. The wings when extended measure less than 1/2 inch. The larvae, which causes the damage, are a creamy-white and about 1/2 inch long. Although the larvae feed primarily on fabrics made of animal products, they will at times incidentally damage other fabrics while feeding on their natural food.

Fabric Beetles

The most common fabric beetles are the black carpet beetles (Attogenus piceus), the varied carpet beetle (Anthrenus verbasci), the common carpet beetle (Anthrenus scrophulariae) and the furniture carpet beetle (Anthrenus flavipes). Adult carpet beetles can be seen in windows in the spring or early summer if an infestation exists in a building.

The adult black carpet beetle is oval, dark brown to black and 1/8 to 3/16 inches long. The larvae are carrot-shaped, grow up to 1/2 inch in length and are shiny brown to black, with long tail bristles resembling a paint brush. Larvae prefer temperatures around 80°F. and a high relative humidity but may exist in a wide environmental range. Larvae shy from light and are commonly found in closets, under basemolding or in furniture. Larva food consists of protein containing substances including animal products and cereals.

The varied carpet beetle adults are about 1/8 inch long, slightly oval shaped and mottled with white, brownish and yellowish scales on the back. Larvae are about 1/4 inch long with three dense tufts at the rear. Food of the larvae consists of animal fabrics and almost any plant or animal food. Larval skins and feces can be found near feeding locations.

The adult common carpet beetle is about 1/8 inch long, oval shaped, gray to black in color with orange scales down the middle of the back. Larvae are not more than 1/4 inch long, are reddish-brown in color and covered with black and brown hairs. Larvae feed on wool carpets and other materials of animal origin.

The furniture carpet beetle adults are more rounded and slightly larger than the varied carpet beetle. They are black with mottling of yellow and white scales. The larvae have an elongated oval shape and are covered with brown hairs. The larvae often attack upholstered furniture, feeding on fibers of animal origin and fibers contaminated with animal excreta.

Control of Fabric Insects

The prevention of fabric damage from these insects by use of Paradichlorobenzene or Naphtalene (moth balls or crystals) is a common and effective practice. Good housekeeping practices such as vacuuming basemoldings and edges of carpets, good cleaning and storage practices with clothing, and storage of cereals in covered containers help prevent damage as well as control fabric insects. Chemical control measures involve application of residual insecticides, with wetting agents, to the edges of carpets, to other carpet areas not subject to traffic, to areas around heating units, baseboards and to the bottom of furniture.

D. Mechanical Transmitters of Disease

## Domestic Flies

Flies belong to the Class Insecta and to the Order Diptera. The flies ordinarily considered to be "domestic" belong to the Families Muscidae (housefly and related species) and Calliphoridae (bottle flies and blowflies). All flies undergo complete metamorphosis.

The above families have been associated with mechanical transmission of some human diseases. Mechanical transmission involves the transporting of organisms associated with plant and animal wastes on the body of flies to surfaces which come in contact with food or the mouth. Domestic flies reproduce as well as feed on or in plant and animal wastes.

Members of the Family Muscidae lay their eggs on such organic matter as animal manure, human excrement and garbage. Adult flies are attracted to a large variety of food materials. This group of flies increases the possibility of disease transmission through their need to ingest only liquid materials. In liquidizing solid foods by means of regurgitated saliva, they may transfer organisms acquired from filth to clean food.

Bottle flies and blowflies feed and reproduce in animal and plant wastes (primarily animal wastes). These flies are particularly abundant in populated areas near meat processing plants and garbage dumps. Eggs are usually laid on meat or dead animals but are also laid on decaying vegetable matter. Adults are usually large flies with a metallic blue or green color.

The most effective and principle control measure of domestic flies is good premise and community sanitation. Good sanitation eliminates or isolates wastes and thus prevents access to reproductive sites. Screening of buildings to prevent fly entrance, storing garbage in fly-tight containers, twice a week garbage collection, landfill disposal of refuse and sanitary disposal of other community organic wastes are all important sanitation measures.

When breeding areas are not eliminated, it becomes necessary to chemically control adult flies. Baits are sometimes very effective, particularly when placed around garbage storage areas. The most effective chemical control is the application of residual surface sprays to garbage storage areas inside a building.

Misting or fogging with an insecticide of low toxicity may be necessary for severe infestations.

## Domestic Cockroaches

Cockroaches belong to the Class Insecta, to the Order Orthoptera and to the Family Blattidae. Roaches develop by simple metamorphosis. The female produces a purse-shaped egg case, called an ootheca, containing two rows of eggs. The oothecae can be used for species identification.

Roaches usually prefer a warm, moist environment. They are nocturnal and thus are not seen in daylight unless the population is large. Those which live in buildings are scavengers and feed on a wide variety of foods. They give off odorous secretions causing off flavor in foods. When populations are large the secretions cause an odor in the area of infestation.

Although cockroaches at one time were major transmitters of gastro-enteritis, particularly salmonellosis, the incidence of those diseases have been reduced by controlling roaches by sanitary and chemical methods. Roaches remain a potential for transmitting enteric illness through food.

Three species of cockroaches are commonly found in Montana: the German (Blattella germanica), the American (Periplaneta americana), and the Brown-banded (Supella supellectilium).

The German roach is the most common. Adults are about 1/2 inch in length and are light brown with two dark longitudinal stripes on the upper surface of the first thoracic segment (pronotum). Both sexes have wings but rarely fly. The female carries the egg capsule protruding from her abdomen until the eggs are ready to hatch. This characteristic enhances reproductive potential. German roaches are carried from place to place on or in food packages and cases, and may move from one location to another. They are found in dark, warm moist locations near water and food. Thus, hiding places in kitchens are ideal locations for German roaches.

The American roach is reddish-brown and grows to about one and one-half inches in length. Both male and female are winged. The male is more apt to fly or glide. The American roach also prefers warm, moist locations and may be found in food establishment basements.

The Brown-banded cockroach is 1/2 inch or shorter, is light brown with light colored transverse stripes across the base of the wings and abdomen. They are very active insects. Both male and female have wings and the male flies readily when disturbed. They prefer warmer and drier places than the German roaches. Brown-banded roaches are difficult to control because they are found throughout a building; in furniture, along picture moldings, in pantries and in closets. The female leaves her egg capsules in furniture allowing infestations to be transferred when furniture is moved.

Because cockroaches require water, food and a place to hide, environmental sanitation which makes these needs unavailable to roaches provides basic control. Environmental sanitation practices include: frequent disposal of garbage, storage of garbage in vermin-proof containers, storage of food in protective containers, maintaining water and sewer lines in good repair, proper building maintenance, housekeeping, and construction which precludes hiding places for roaches. Once a roach infestation has been established, good sanitation and chemical methods must be combined to give complete control.

Application of a residual insecticide spray to all potential hiding places is needed. These include behind appliances, in cracks and

crevices, under sinks, basemoldings, under furniture, in closets, in cabinets and any place which is warm and moist. Application of dusts with synetetic pyrethrum to difficult to treat areas (wall voids, behind built in ranges, etc.) and the placement of baits at suspected points of entry in combination with residual sprays provides effective control.

E. Venomous and Biting Arthropods

Spiders - Class: Arachnida Order: Araneae

There are many species of spiders. Two of primary concern because of their bites are; the blackwidow (Latrodectus mactans) and the brown recluse (Loxosceles reclusa). Neither of these spiders are aggressive and tend to retreat when disturbed. They may bite when threatened. Bites occur when a human and a spider attempt to occupy the same space. This occurs when people put on clothes in which the spider is hiding or when they roll onto the spider in a bed. People should be cautioned against putting on clothing that have been hanging for sometime in areas where spiders frequent without first checking them. Beds and bedding should also be checked if spiders are prevalent.

The female black widow has a shiny black body about 5/8 inch long with a red "hour-glass" on the underside of the abdomen. The male is smaller, lighter colored and usually has a red or yellow mark on the upper side of the abdomen. Webs can be found under buildings, in corners of basements, under furniture or other shaded areas which are resting places for insects. When the web is jarred, the black widow will rush out and sting that which causes the vibration.

Localized pain, often spreading throughout the body and limbs may result from a black widow bite. The reaction usually isn't fatal unless a person is particularly sensitive. Treatment by a physician is recommended.

The body of the brown recluse is about 1/2 inch long, light brown in color, with a fiddle-shaped area on the cephalothorax (joined head and thorax). Pain from the brown recluse bite may be immediate or delayed several hours. Usually after a few hours the pain becomes quite intense. Over a period of a few days the bite area becomes blistered, then swollen and red, developing into an ulcerous sore, with a final sloughing of dead tissues, resulting in a sunken scar. Treatment immediately after the bite by a physician is recommended.

Chemical control has its place in spider control but it is usually not as effective as environmental control. Besides the personal precautions mentioned earlier, prevention of human contact involves discouraging the presence of spiders in and around buildings. Control of other insects through good premise sanitation, general house cleaning and exclusion will reduce or eliminate the food supply for spiders and thus create an unsuitable habitat. Webs should be removed and the spider destroyed possibly with the use of a contact spray, such as (Chlordane, Lindane or Diazinon). Residual insecticide treatment outdoors to cracked, crevices, corners and surfaces where webs are built may be effective. Indoors the use of Paradichlorbenzene or similar materials

in storage areas for clothing and bedding will exclude spiders from these areas.

Stinging Hymenoptera

The order Hymenoptera includes bees, wasps, ants, sawflies, parasite wasps, and others. Most Hymenoptera are beneficial to humans but some groups live in close proximity to humans and can be hazardous. These latter groups are called the stinging Hymenoptera and include the bees, wasps and yellowjackets. The hazard to humans is the venom (protein material) injected by these species. Some people are extremely sensitive to such material may have severe allergic as well as toxic reactions. Persons in this category need immediate care and should be prepared for such emergencies. The Allergy Foundation of America recommends a kit for such persons containing prescriptions from their physicians.

Members of the Family Vespidae (paper wasps) are probably the severest stingers of the Hymenoptera. Most species of this Family are banded with yellow and black or brown bands on the abdomen. This family includes the genus Vespula (yellowjackets and hornets) and the genus Polistes (single comb wasps). Vespids are large wasps (1/2 to one inch long). Impregnated queens formed late in the season over winter and start a colony the following spring. Once a colony is started, workers take over duties of nest building and gathering food, and the queen devotes full time to egg laying. The nests are of paper, made first by the queen then by the workers from plant fiber, rotten wood, etc. Queens of yelowjackets and hornets over winter in the ground, under bark of trees, or sometimes in buildings.

Most species of yelowjackets build nests in the ground but some build nests in trees, shrubs or in the eaves of houses. Hornets build the well-known hanging grayish-brown structure with a size and shape somewhat like a football. The Polistes wasps build simple, single layer nests under horizontal surfaces, such as under eaves and window ledges. Polistes are distinguished from the Vespula by having a more constricted waist and a slimmer abdomen.

Mud daubers, (Family Sphecidae) recognized by the narrow "waist", construct their nests of mud, often in attics of old buildings. The danger of being stung by mud daubers is not as great as with the Vespidae.

Some species of bees, including honey bees, can be pests around residences if they establish a nest in the area. As a rule, bees do not ordinarily present a structural pest problem as do the wasps. When honey bees establish their nests in buildings they are best removed by a beekeeper.

There are several approaches to vespid control. (1) If possible, locate nests and then apply insecticide dusts (such as Chlordane, Lindane) directly into nests when it is dark. Cover ground nests with dirt after treatment. Follow up succeeding nights until all wasps are

dead. Entry areas should be kept well treated. Persons allergic to the sting should not attempt control; protective clothing should be worn. (2) Place a bait consisting of a fish product and insecticide in cages scattered throughout an infested area. Cages should have a 1/4 inch mesh screen to keep out birds, animals and children. (3) Cleaning of outside garbage containers reduces their attraction. After garbage containers have been cleaned application of 0.75% DDVP to the inner surface garbage containers may be made.

Bedbugs - Order: Hemiptera Family: Cimicideae

The food of bedbugs is blood. There are several known to bite humans but it is human bedbug, Cimex lectularius, which lives close to humans and feed on their blood. Other species feed on bats, swallows and other birds. Species which feed on bats and swallows may become a problem for humans if bats or swallows make their home in buildings used by humans (bat bugs may switch to human hosts if bats are excluded or when bats move to their winter colonies). The human bedbug is about 1/4 inch long, wingless, flat, and reddish-brown in color. Its glands produce a characterictic odor similar to almond. Eggs are attached to most any available surface, even to the host. Growth is by single metamorphosis. Nymphs as well as adults feed on blood. Adults can survive a year or longer without food. The time period is somewhat shorter for nymphs. Humans are a preferred host but they will also feed on household pets and on rats and mice. Bedbugs are not known to transmit diseases.

Although building construction, housekeeping and personal hygiene can have some effect on bedbug control, chemical control is the only positive control measure. A single application of a residual insecticide to mattresses, bed parts and cracks and crevices in wall surfaces is standard chemical control procedure. Sprays containing Trichlorofon (0.1%), Ronnel (1%), or Malathion (0.5 to 1.0%) are commonly used. Special care should be exercised in the treatment of mattresses and upholstery; only a light application should be made and under no circumstances should mattresses be soaked with spray. Infant bedding, including the crib, should not be treated. Spray only tufts and seams of mattresses and air dry at least 4 to 8 hours before reuse. If the infestation persists, treat again at not less than two week intervals. Fogging or misting of a room with synergized pyrethrum may be used to speed control or to aid in the effectiveness of residual control.

Modified from: Public Health Pesticides, 1973, Center for Disease Control, Public Health Service, Health Services and Mental Health Administration, U.S. Department of Health, Education and Welfare, Savannah, Georgia 31402.

Conenose Bugs - Order: Hemiptera Family: Reduviidae

This group includes the kissing bugs and assassin bugs. Most of the Reduviidae feed on insects but a few feed on humans by sucking blood. The bite of the conenose is painful. Some species have known to transmit Chages Disease. Conenose bugs live in warm climates but

may be transported north. They are similar in appearance to squash bugs. The conenose bugs, common in Southwestern United States, are brown to black and measure about 3/4 inch in length.

Ticks - Order: Acarina Suborder: Ixodides

Ticks are arachnids. Although the order Acarina includes both mites and ticks, because of their size, ticks are the most conspicuous. All ticks feed on the blood of vertebrates. Most species belong to two families; the Ixodidae (the hard tick) and the Argasidae (the soft ticks). Although members of both families will bite humans, certain species of hard ticks are the ticks usually associated with humans. Some species in addition to being biting pests, transmit Colorado tick fever and Rocky Mountain spotted fever, from which there is full recovery if the tick is removed in time. Tick paralysis most often observed in children under seven years old, has a high fatality rate.

The body of ticks, prior to feeding, is flattened and tapered toward the head. After feeding, the tick, particularly the female, becomes greatly distended. The ticks leathery body covering (cuticle) is capable of considerable distension.

Ticks have four stages in their life cycle: egg, "seedtick" (intermediate larval stage), nymph and adult. The seedtick has six legs and feed on small vertebrates, particularly rodents. The nymphs have eight legs like the adults and usually feed on small animals. The adults, who feed to reproduce, normally feed on large animals including humans. Most hard ticks do not dwell in nests but wait on vegetation and drop on passing hosts. This is particularly true of the Rocky Mountain wood tick which transmits spotted fever. The dog tick on the other hand, may be brought to humans by their pet. Soft ticks are almost always associated with the nests of their immediate host and for this reason humans are less likely to come into contact with them.

Removal of an attached tick is usually the most immediate control measure. A slow steady pull should remove the tick without breaking off the mouth parts. Application of alcohol, vaseline, or fingernail polish will help remove the tick. An antiseptic should be applied to the bite wound and the persons hand should be washed after the tick has been removed.

Other important control measures include avoidance of tick infested areas, wearing protective clothing, clearing of brush and weeds around homes and recreation areas, and well-kept yards. When ticks are brought into homes it may be necessary to use chemical control. Application of residual insecticide along basemoldings, floor and wall crevices and similar hiding places is recommended.

F. Human Ectoparasites

Human Lice - Order: Anoplura

There are three kinds of human lice: the body louse (Pediculus

humanus humanus), the head louse (Pediculus humanus capitus) and the crab louse (Phthirus pubis). All three kinds are found in close association with humans and depend on human blood for sustenance.

The control of body lice involves personal hygiene and sanitation. It is these lice that can be involved in the transmission of three human diseases: typhus, trench fever, and relapsing fever. Infestations of body lice may be transferred from infested persons to others through bedding or clothing or personal contact. Lice will normally die if the infested bedding or clothing is not used for several days. Laundering with hot water will destroy all stages of lice. Dry cleaning will destroy lice on clothing or bedding which cannot be laundered. The control of head lice usually involves shampooing the hair with a shampoo insecticide which is prescribed by a physician. Control may also involve lightly spraying upholstered chairs and couches with an approved insecticide. Cleaning brushes, combs, and articles of apparel that contact the head and neck are necessary.

The control of crab lice (which are spread chiefly by sexual contact) involve washing the infested area with a shampoo containing insecticide.

Fleas - Order: Siphonaptera Family: Pulicidae

There are five fleas which are known to bite humans and which can be a problem in northern states: the human flea (Pulex irritans), the dog flea (Ctenocephalides canis), the cat flea (C. felis), the Oriental rat flea (Xenopsylla cheopis), and the northern rat flea (Nosopsyllus fasciatus). The preferred host of each flea is indicated by their common names. However all of them will bite humans if provided the opportunity. Humans may become infected when playing with pets. The dog and cat fleas and the Oriental rat flea can be sources of disease to humans as well as being a pest. The dog and cat fleas are known to transmit tapeworms to their hosts. The Oriental rat flea is known to transmit bubonic plague and murine typhus and is most common in coastal regions. Humans are incidental hosts of cat and dog fleas. In the absence of the cat and dogs, fleas will more readily attack humans.

Control of fleas on pets should be according to the recommendation of a veterinarian. Likewise, a physician should be consulted if a human flea infestation is suspected. Control of rat fleas must be coordinated with the control of rodents and will be discussed under rodent control.

Control of fleas involves the premises as well as the host. Good housekeeping practices are very important. Infestations on dogs and cats will be concentrated in their sleeping places. Infested bedding should be laundered or destroyed. Floor-wall junctures should be vacuumed. Application of an insecticide in areas frequented by pets should be correlated with flea control measures on the pets.

Control of human flea infestations should include laundering or dry cleaning of bedding, vacuuming of upholtered furniture and application of an insecticide to upholstered furniture.

G. Insect Pests of Stored Foods and Grains

General

There are a wide range of pests which cause damage to stored products. Stored food insects feed primarily on such items as dried fruits, grain, cereal products, flour, and nuts. Candy and cheese may also be involved. Discussion here will involve those pests found in mills, elevators, warehouses, processing plants, homes, and retail stores.

Most insects involved with stored products require a warm environment for reproduction. Most do not lay eggs below temperatures of $60^{o}F$ to $65^{o}F$. Almost all stored food insects are adopted to living on food with a low moisture content.

Insects attacking stored grain include many of the same species attacking these products stored under processed conditions. Their populations are dependent upon; (1) numbers present in the bin before harvest, (2) temperature of grain going into storage, (3) length of time grain retains heat after going into storage (weather influence). (4) moisture content of the grain. To prevent high moisture spots, grain from the field must be less than 13 percent of saturation and the bin must be made tight against rain and snow. When grain retains summer heat in storage, some stored grain insects may produce a new generation in a month or less.

Insect Types Found in Stored Products

Common insects found in stored product situations can be separated into four groups according to feeding habits: internal feeders, external feeders, scavengers, and miscellaneous pests.

1. Internal Feeders

The larvae of internal feeders feed entirely within grain kernels. Examples are the rice weevil, the granary weevil and the Angoumois moth. Weevils belong to the Order Coleoptera and to the Family Curculionidae. The Angoumois grain moth belongs to the Order Lepidoptera and the Family Gelechiidae.

Adult rice weevils, considered to be the most destructive pest of stored grain, are reddish-brown and 1/8 inch long. They infest grain in the field as well as in storage. Larvae are short, stout, with a whitish body and a tan head. Both adults and larvae feed on a wide variety of grains. Infestation of grains can be detected through staining which reveals the gelatinous egg plugs, not visible to the naked eye. Although infestations are usually confined to whole grain, they can be found in solidified milled products such as macaroni or caked flour.

Adult granary weevils resemble the rice weevil but are dark brown to black in color. Since they have no wings they are transported by humans through food supplies. Although reproduction

involves stored grain, not field grain, their life style is much the same as the rice weevil. The adults hibernate in cold weather.

Eggs of the Angoumois grain moth are laid on or near grain. The larvae bore into the grain kernels and feed within, leaving a thin layer of outer seed coat intact. These moths are frequently found in homes, warehouses and stores. The adults are yellowish-white and are about the size of clothes moths (1/2 inch wing span). The larvae are minute and white.

2. External Feeders

Insects which feed through the outer coat of a grain kernal into the kernal are called external feeders. Examples are the drug store beetle, the tobacco beetle, cadelle beetle and the Indian meal moth. The beetles belong to the Order Coleoptera. The drug store and tobacco beetles belong to the Family Anobiidae and the cadelle beetle belongs to the Family Ostomatidae. The Indian meal moth belongs to the Order Lepidoptera and the Family Phycitidae.

The drug store beetle feeds on flour, dry cereals, red pepper and other dry foods. The adult is brown, 1/10 inch long and cylindrical. The larvae are white and about 1/4 inch long.

The tobacco beetle, besides being an important pest of stored tobacco, is found in spices, dried plants, seeds and rice. The adults are light brown and about two to three millimeters long. The adults fly readily. The larvae are white with light brown markings on the head.

The adult cadelle is shiny black and about 1/3 inch long. The larvae are almost 5/8 inches long, dirty white with a dark brown head. The larval prothorax (just behind the head) has a dark-brown hardened plate covering. This beetle is commonly found in packaged cereals, nuts, spices and fruits but is very common in grain storage and flour mills. Eggs are deposited in crevices of food materials. The larvae feed on the above foods and tobacco. They usually only eat the germ portion of grains and thus not only have the potential of damaging large numbers of kernels but also provide entry for other insects.

The adult Indian meal moth has a wing spread about 3/4 inch. The front wings are tan in front and reddish-brown in back. In the home they are often mistaken for clothes moths. The larva is about 1/2 inch long with a dirty white color, sometimes with a green or pink tint. The larvae feed on almost any dried food.

3. Scavengers

Examples of the scavengers are the saw-toothed grain beetle, the confused flour beetle, the red flour beetle, and the Mediterranean flour moth. Scavangers feed on grain which has the seed coat broken, either by another insect or by mechanical

damage. These beetles are also able to work their way into packaged foods.

The adult saw-toothed grain beetle (Family Cucujidae) is brown and about 1/10 inch long, with six saw-like projections on the thorax. The larva is less than 1/2 inch long and has a narrow body with a dirty white color. Eggs are usually laid in crevices or in a food supply such as flour. This beetle is found in dry cereals, dried fruits, dried meat and other dry foods. The adults are small enough to penetrate into packaged foods. The larvae eat finely divided food particles hence this beetle is often found with other grain insects or in spilled flour.

The adult confused flour beetle (Family Tenebrionidae) is reddish-brown, and about three and one-half millimeters long. Like the saw-toothed beetle, it is able to work its way into packaged foods. It is an important pest in flour but may be found in a variety of dried foods. The larvae are about 1/4 inch long and yellowish-white.

The red flour beetle is similar in appearance and habits to the confused flour beetle. It belongs to the same family. They are strong fliers which may explain why they are frequently found in stored grain.

The adult Mediterranean flour moth has a wing span of about one inch. The pale gray wings have wavy black lines across them. It infests most dried foods. Females lay eggs in flour or other milled products. The larvae are white or pink, with a few black spots on the body. Mats of silken threads left by the larvae are good indications of infestations.

4. Miscellaneous Pests

Frequent pests of stored food include the meal worms (Order Coleoptera, Family Tenebrionidae); the spider beetles (Family Ptinidae); the psocids (Order Psocoptera); and grain mites (Class Arachnida, Order Acarina). These insects are often found in stored products, but only occasionally in sufficient numbers to warrant control.

## Prevention and Control of Stored Food Infestations

Food housekeeping practices are very important in the prevention and control of stored food infestations. Such practices include clean storage facilities, cool storage conditions, storage of packaged foods off of the floor and away from walls, and limiting storage time for foods through rotation. Grain bins should be kept clean of debris both inside and in the area outside around the bin. Bins may be sprayed with insecticides such as Malathion, or Diazinon two or three weeks before harvest.

When an infestation is detected, the first step in control is to locate the source of the infestation. Once located, remove and destroy the source and all infested materials. Thoroughly clean and remove all loose materials from the premises. Vacuuming cracks and crevices and scrubbing of floor and wall surfaces with a detergent-disinfectant solution may be as effective as an insecticide. The application of contact, residual or space spray insecticides may be desirable following sanitation practices. It is essential that insecticides, whether space sprays or residuals, be kept from contacting food. Care must be used in application of insecticides. NO INSECTICIDE SHOULD BE CONSIDERED "NONTOXIC" AND THUS SUITABLE FOR USE ON FOOD. All food stuffs must be removed before treatment and all food contact surfaces covered and/or washed after treatment. (Refer to Chapter 27 Part H for use of pesticides in food establishments and food processing plants.)

Pest control in grain storage areas may involve the application of insecticides like Malathion, or Pyrethrin, plus a synergist, as the grain is going into storage for protection against insect pests for one season.

Infested grain can be fumigated to destroy troublesome insect pests. Various compounds are recommended for grain fumigation; example: carbon tetrachloride, carbon bisulfide, ethylene dichloride. Select the right one for your job, follow labeling directions and pay attention to these precautions:

(1) Level the top of grain surface.
(2) Apply fumigant uniformly over the entire surface.
(3) Wear a gas mask with proper canister and filters.
(4) Apply recommended dose - do not under dose.
(5) Make bin as air tight as possible.
(6) Do not smoke near treatment area or while handling the fumigant.
(7) Do not enter bin until odor is gone (may be a week or more).
(8) Post a DANGER sign so that no one will enter fumigated premises.

Some grain storage bins are equipment with aeration ducts making it possible to cool the grain by forcing air through it. A fumigant may be applied by adding it to this air system.

## H. Pesticide Use in Food Plants and Food Handling Establishments

### Introduction

The use of pesticides in food handling areas and processing plants is a sensitive subject and one of considerable confusion. The general public shares common views toward the use of pesticides in food areas, particularly when the use is visual or odors are detectible. The misuse of pesticides in food processing plants and food handling areas may result in serious pesticide contamination of food. These adulterated foods can subsequently be disseminated to a large population of of people or livestock for consumption.

Pest Control

Pest control in food handling areas is essential for protection of the public's health from foods contaminated by insects and vermin. When pesticides are used for pest control the following principles must be adhered to:

(1) Pesticides play only a secondary role in achieving pest control in these establishments. Pesticides are not substitutes for good sanitation and construction.

(2) The best pest control is keeping pests out of structures by exclusion and proper building design--"pest proofing."

(3) The next best method is to remove those conditions pests require for survival and reproduction, food, shelter, moisture or water, and warmth. This is called environmental sanitation. If the desirable habitat is eliminated, the pest population will decline.

(4) Pesticides should only be applied in conjunction with good sanitation and housekeeping practices. More frequent pesticide applications are required if environmental factors responsible for maintenance of pest populations are not removed.

(5) Pesticide use should be minimized by encouraging routine local sanitary inspections and by education on proper sanitation and other non-pesticide approaches to pest control (traps, attractants, devices).

(6) When pesticides are used, a method of application should be chosen which most effectively minimizesthe pest as well as prevents the pesticide from reaching food or food contact surfaces.

(7) Selection of a pesticide should be based upon a benefit - risk evaluation.

(8) Only pesticides which are registered for use in food establishments can be utilized.

Methods of Insecticide Application

(1) Space treatment

This method involves the dispersal of insecticides into air by foggers, misters, aerosol devices, and vapor dispensers. Products and their uses currently registered by EPA and MDA for this type of application are summarized at the end of this section.

(2) Contact (non-residual) treatment

This method includes an application of wet spray applied to kill pests on contact. Only insecticides which do not persist may be used. Products and their uses currently registered by

EPA and MDA are summarized at the end of this section.

(3) Residual treatment (liquid sprays)

Application of an insecticide leaving a deposit that kills insects which later rest or crawl on the treated surfaces comprises a residual treatment. Such treatments are applied to breeding places, harborages, and areas where pests are present or anticipated to visit. Residual insecticides are not to be applied to food or food contact surfaces. Residual insecticides applied indoors should be made with brushes or with sprays operated at low pressures and in such a manner as to avoid spattering or drifting spray mist. Residual treatments may be of three types:

a. General Treatment - the application of pesticides over surfaces such as walls, floors, and ceilings, or as outside treatment to walls, eaves, lawns, and shrubs. General treatment should be confined to outside areas and non-food areas indoors. Under certain conditions, food storage areas may be treated.

b. Spot Treatment - a restrictive application confined to two square feet or less of the floor or lower wall surface. Spot treatment applications are limited to selected surfaces, or cracks and crevices where pests have been seen or are suspected of visiting or occupying. Spot treatment of residuals should be confined to outside areas, non-food areas, and in some cases food storage areas. Spot treatment should only be used in food processing areas in cases of extreme infestations.

c. Crack and Crevice Treatment - the application of small amounts of insecticides in a careful and precise manner into cracks and crevices in which insects hide or through which they may enter the building. Such openings commonly occur at expansion joints, between different elements of construction, and between equipment and floors. These openings may lead to voids such as hollow walls, equipment legs and bases, conduits, motor housings or junction switch boxes. Treatment should be carried out to thoroughly cover all cracks and crevices, and other concealed pest entries and harborages, and to minimize any potential for contamination of exposed portions of floors, walls, food contact surfaces, food, and food containers. Crack and crevice application can be made in both the food and non-food areas of establishments.

(4) Other Materials Used in Residual Treatments

a. Dusts - are finely divided solid particles of a toxicant, with or without an inert carrier. Dusts are useful in treating switch boxes and electrical motors, or to treat

recesses such as wall voids. Dust must not be placed where they are likely to be transferred to food, containers, or food contact surfaces. Dusts should be avoided where there is wind, sweeping, foot traffic, and other activities causing the dust to be transferred or become air-borne. Any dust left in the open after application must be removed. Dusts should not be used in or near processing areas.

b. Granules - are coarse particles of an inert carrier impregnated or coated with a toxicant. Granules are used in outdoor applications for insects living in or on the soil. They should not be applied in areas where they could become tracked indoors.

c. Baits - may be used only in confined and enclosed spaces or at and below floor level. They should not be used in situations where they may contact food products or containers. They can be used outside for controlling crawling and flying insects.

Method of Rodenticide Application

Only rodenticides of low and medium hazard classification should be used in or around food handling and food preparation establishments. Low hazard rodenticides include the anticoagulants, red squill and ANTU. Medium hazard rodenticides include strychnine. Bait mixing and placement should be done in areas where food is not stored, prepared or served. Tracking powder rodenticides should not be used in food establishments. Refer to the summary of registered products at the end of this section.

Guidelines for Use of Pesticides in Food Handling and Food Processing Plants.

1. Outdoor Area Food Establishment

Pest problems usually begin outside. With proper sanitational practices and prudent pesticide applications to outside resting, harborage, and breeding areas, pests can be destroyed or discouraged, and migration to indoor areas prevented. Special attention should be given to washing outside and inside surfaces of garbage cans; washing outside walls and vents; routine removal and litter pick-up; washing down outside pavement; maintaining healthy vegetation and lawns, and other practices which would ultimately reduce odors and harborage sites. A good exclusion program using such barriers as self-closing doors, screens, air-curtains, rodent-proofing, and traps, should be encouraged.

a. Insecticides - if required, must be applied so they neither contact food products stored outdoors, nor enter or are carried into the establishment. Special care is required in making applications around windows, doorways, ventilators,

and other openings leading to the inside. Insecticides should not be applied in or around serving windows. Insecticides outdoors can be applied as a space treatment, contact treatment, or residual treatment, or dusts and baits.

b. Rodenticides - may be used outside as attractive food baits or in water solutions to intercept rodents before they gain entry into the establishment. Such baits require adequate bait boxes to protect animals and children and to void contamination of food. The use of rodenticides outdoors is considered in two categories:

(1) Public - areas not enclosed and readily accessible to the public. Only low hazard rodenticides should be used.

(2) Restricted - not accessible to the public. Fenced or other barriers. Such areas include power stations or refuse areas. Medium or low hazard rodenticides may be used.

2. Non-Food Areas

These areas include offices, locker rooms, toilets, machine rooms, boiler rooms, rubbish rooms, and garbage. Control efforts in these areas are directed at pests which may wander into or breed in these non-food areas, and subsequently migrate into food areas. Non-food areas should be neat, free of litter and debris and well lighted. Restrooms should be kept clean and odorless.

a. Insecticides can be applied in non-food areas as space treatments, contact or residual sprays, dusts, and as baits. However, it is imperative that prior to the selection of a pesticide or its method of application, thoughtful consideration be given to the size and layout of the establishment, foot traffic, or any other items which (through transferral or air currents) could contribute to product contamination. Dusts may be used only where conditions preclude their being tracked or carried by air currents into food areas (e.g. switch boxes, wall voids are examples). Space treatment is determined by the size of the establishment, construction, ventilation, etc., which would contribute to contamination of stored foods or food processing surfaces. Contact sprays and residual sprays can be applied as conditions dictate. These sprays, if properly applied, will stay where directed.

b. Rodenticides should be placed in concealed locations, in special bait containers and bait boxes, containing a warning statement. Use of rodenticides in these areas should be dictated by the conditions of exposure:

(1) Public - access by the general public. Use low hazard rodenticides.

(2) Employee only - only authorized persons allowed. Use low hazard rodenticides.

(3) Restricted - physical location and construction can be used, e. g. crawl spaces and wall voids.

Baits in public areas should be placed during off hours only and picked up and destroyed at the beginning of each day's operation. Dead rats and mice should be picked up and discarded.

3. Food Storage Areas

These areas vary from shelf storage, open floor storage to sealed tanks and are for the storage of new commodities, intermediates, finished products as well as containers and packaging materials. Food materials may be stored in bulk, bags, cases, boxes or cans. Pest populations can be controlled with proper environmental management of stored food areas. Bulk foods should be stored in rodent-proof containers. Stacked foods should be stacked in orderly rows and up off the floor to facilitate inspection and other non-pesticidal control methods. All spilled materials should be cleaned up and not allowed to remain on the floor or shelves. All windows and doors should be tight fitting and walls should be of sound construction. Pesticides are applied in food storage areas to prevent pests from contaminating a raw product, the finished product, or its container. Their use helps to avoid infestations which could spread to other processing areas.

a. Insecticides can be applied as space treatments, contact or residual sprays, baits, and dusts. Consideration, should first be given to the type of packaging used. All precautions must be taken to avoid treatment that would cause food to be contaminated when it is removed from the container and to avoid the potential for migration of the chemical through the packaging material. Pesticide applications should not be made where stored foods are open. Food containers such as burlap should be considered "open-food".

b. Rodenticides Use of rodenticides in food storage areas depends upon the exposure of foods and the resulting potential for contamination by rodenticides. Rodenticides should not be used in storage areas where food is left uncovered, or so packaged that it could become accidentally contaminated. Storage areas are not considered as exposed food areas if food is packaged in cans, jars, or other materials impervious to rodenticides. Any storage facility may contain both exposed and non-exposed foods. Rodenticides in these areas should be placed in bait containers in labeled bait stations. Exposed rodenticides should not be allowed to remain out during working hours. Rodenticides should be colored to distinguish them from other food stuffs and placed at or below floor level to prevent contamination of food stuffs. Only low hazard rodenticides should be used in food storage areas.

4. Food Processing Areas

These areas may be completely enclosed systems of conveyance and processing, or those in which foods are exposed for varying periods of time. The latter are areas of a food establishment requiring the greatest care to avoid exposure of food to pesticides. Pest problems in this area can be largely eliminated if environmental sanitation practices are exercised to reduce or eliminate pest habitat outside, in non-food areas, in food storage areas, and in food processing areas. Odors, food material, and dust can be easily eliminated through regular clean-up and washing of appliances and machines, food preparation surfaces, waste cans, floors, walls, and windows. Surfaces which can collect organic debris should be cleaned and kept free of cracks and joints. Careful consideration should be given to the use of pesticides in this area if a pest problem exists in spite of good environmental sanitation. If the pest problem is of a minor nature, a mechanical means of control should be considered.

a. Insecticides - if required, should be used with extreme caution.

(1) Food Contact Surfaces - pesticides should not be used on any food contact surfaces if at all possible. Under conditions which may warrant their use, Allethrin, Pyrethrim, and similar non-residual pesticides may be used. The food contact surface must be cleaned after their use.

(2) Non-food contact surfaces of equipment--Non-residual contact insecticides may be applied in small amounts. Care must be taken not to contaminate food contact surfaces. Certain residual pesticides may be applied to cracks and crevices.

(3) Floor and lower walls--Selected treatments can be made using contact or residual insecticides applied in cracks and crevices. Applications should be restricted to cracks and crevices unless the infestation is unusual. Spot treatments, should be restricted to areas below food contact surfaces such as lower portions of walls, undersides of shelving, and the bases of equipment. Special care should be exercised in avoiding drift into food contact surfaces or into food itself.

(4) Overhead areas-- Care is needed in treating upper walls and overhead objects to prevent contamination of food products or food contact surfaces. During any treatment of overhead areas, exposed food or food contact surfaces should be removed or covered. Residual sprays can only be used in cracks and crevices and should be confined to walls. Application should generally be restricted to non-residual contact sprays.

(5) Space Treatment--Food must be removed or covered and all food contact surfaces covered and cleaned after use. Space treatment application should be made when the establishment is not in operation and only when infestations are of an unusual and persistant nature.

b. Rodenticides--are not to be used when foods are exposed or during working hours. Bait containers and bait stations should be restricted to the floor and picked up at the beginning of each days work. Only rodenticides of a low order of hazard should be used.

Pesticide Materials Registered For Use

Residual, non-residual and bait-type insecticides currently registered for use in food processing plants, restaurants, or other areas where food is commercially prepared or processed are listed below (prepared by the Criteria and Evaluation Division, EPA (Revised 2/9/73).

Group I:

The following insecticides are currently registered for use as residual insecticides in the inedible product areas of food processing plants, restaurants, or other places where food is commercially prepared, or processed. These materials must not be used in any areas where food is exposed.

Baygon
carbaryl
Chlordane
Diazinon
dicapthon
dichlorvox (DDVP)
dimethoate
Dipterex
Dursban
Fenthion
heptachlor
Lindane
Malathion
methoxychlor
Naled
Perthane
Ronnel
Rotenone
Strobane
toxaphene

Products registered for this use must bear the following precautionary labeling: "Do not use in the edible products area of food processing plants, restaurants or other areas where food is commercially prepared or processed. Do not use in serving areas while food is exposed."

Group II.

Residual-type insecticides which are also registered for use as space-sprays only, in the edible product areas of food processing plants, restaurants, or other areas where food is commercially prepared or processed:

dichlorvos (DDVP)
Malathion
methoxychlor
Naled
Ronnel

Products registered for this use must bear the following precautionary labeling: "Food should be removed or covered during treatment. All food processing surfaces should be covered during treatment or thoroughly cleaned before using. When using the product in these areas, apply only when the facility is not in operation."

If any products of this type are to be applied in such a manner as to leave a residual deposit, they automatically fall under Group I and are subject to that precautionary labeling.

NOTE: The Montana Department of Health and Environmental Sciences does not approve the use of residual type space sprays in edible product areas of establishments, unless after all environmental sanitation efforts have been made, a severe pest infestation persists.

Group III.

Non-residual type insecticides and synergists which are currently registered for use as space and contact treatments in the edible products areas of food processing plants, restaurants or other areas where food is prepared or processed:

| | |
|---|---|
| Allethrin | Pyrethrin |
| d-trans allethrin | Rotenone |
| Lethane 384 | SBP-1382 |
| MGK-264 | Thanite |
| piperonyl butoxide | Tropital |

Products registered for these uses must bear the following precautionary labeling: "Food should be removed or covered during treatment. All food processing surfaces should be covered during treatment or thoroughly cleaned before using. When using the product in these areas, apply only when the facility is not in operation."

Group IV.

Non-residual type insecticides and synergists which are currently registered for use in automatic activation devices in the edible product areas of food processing plants, restaurant or other areas where food is prepared or processed:

| | |
|---|---|
| d-trans allethrin | Pyrethrin |
| MGK-264 | Stabiline |
| piperonyl butoxide | Tropital |

Products registered for this use must bear the following precautionary labeling: "Food should be removed or covered during treatment. All food processing surfaces should be covered during treatment or thoroughly cleaned before using. When using the product in these areas, apply only when the facility is not in operation."

Currently registered products of this type are awaiting a final decision from the Environmental Protection Agency.

Group V:

Bait-type products prepared and applied in separate containers which are permitted with directions for use in exposed food areas during periods when operations are shut down and all food and food handling surfaces are removed or well protected. Cleaning procedures are required before operations are resumed. All bait containers should be removed and accounted for at this time.

Baygon
Kepone

Products registered for this use must bear the following precautionary labeling: "Use only when the facility is not in operation and food is not exposed. Use only in bait boxes where bait in each box can be accounted for. Remove and account for all bait prior to resuming food processing."

Group VI:

Vaporizing type insecticides which are currently registered for use in the inedible areas of food processing plants, restaurants, or other areas where food is prepared or processed:

Allathrin (vaporizers)
Lindane (vaporizers)
Vapona (DDVP) (strips)

Products registered for this use must bear the following precautionary labeling: "Do not use in kitchens, restaurants or areas where food is prepared or served," or "Do not use in the edible products areas of food processing plants, restaurants, or other areas where food is prepared or processed."

Group VII:

Dry, powdered type products such as silica aerosol gels, boric acid, pyrethrum, borax, and other powders may be used in the inedible product areas of food processing plants, restaurants, or other areas where food is commercially prepared or processed.

Products registered for this use must bear the following precautionary labeling: "Do not use in the edible product areas of food processing plants, restaurants, or other areas where food is commercially prepared or processed. Do not use in serving areas while food is exposed.

Group VIII:

An additional specialized usage includes concentrations of sodium fluoride (40% or less) which are restricted to areas which are inaccessible to children and pets. Any powder visible after application is completed should be carefully brushed into cracks and crevices or else removed.

Products registered for this use must bear the following precautionary labeling: "Do not use in the edible product areas of food processing plants,

restaurants, or other areas where food is commercially prepared or processed. Do not use in serving areas while food is exposed."

No attempt has been made to cover all powders, specific products, or unusual formulations or mixtures of pesticides.

This information is subject to periodical revision and updating as a result of the addition of new or cancellation of old insecticide products, or the issuance of food additive tolerance regulations which could relax the present precautionary statements governing the use of these materials in food handling establishments.

Group IX:

Residual insecticides authorized by EPA for careful and precise crack and crevices treatment in food areas (Federal Register, August 2, 1973).

borax (finely divided powder)
boric acid (finely divided powder)
carbaryl
Chlordane
chlorpyrifos
DDVP
Dipterex
Diazinon
Fenthion (Baytex) Entex
Baygon
Malathion
MGK-264
piperonyl butoxide
Pyrethrin
Ronnel
silica gel (finely divided powder)

Application of these insecticides must be made after operating hours. Food should be removed or covered during treatment. All food processing surfaces should be covered during treatment or thoroughly cleaned before using. These residuals can be used in "areas of receiving, serving, boxing), preparing (cleaning, slicing, cooking, grinding), edible waste storage and closed processing systems (mills, dairies, edible oils, syrups)."

## I. Structural Pest Control

### Introduction

Insects of various types often attack wood and other structural materials. Agents such as lightening, wind, water, fungi, birds, rodents, and insects may damage structural materials allowing secondary insects and fungi to invade them causing further damage and decay. Weakening structural supports by wood destroying insects may present a hazard to building occupants. Some of the more common structural pests are:

#### 1. Termites

##### a. Subterranean Termites:

In Montana, one termite species, Reticulitermes tibialis, is native. Except for a few areas in Montana, subterranean termites are not a structural problem as they are found in areas removed from urban centers. Subterranean termites have been found in the Bitterroot Valley, near Fromberg south of Billings, Billings and in Helena, and periodically in the Sidney, Glendive and Terry areas.

Subterranean termites are social insects that live in nests or colonies in the ground. Each colony is made up of three forms or castes i.e. reproductives, workers, and soldiers. Each individual of each caste passes through three stages - egg, nymph and adult.

The principle food of termites is cellulose obtained from wood and other plant tissue. Subterranean termites are the most distructive species of termites in North America. They commonly infest wood in the soil or wood that can be reached from the soil by means of covered runways. Serious damage results to wood buildings, fence posts, telephone poles, paper and fiberboard.

Subterranean termites prefer moist, warm soil containing an abundant supply of wood, roots and other wood debris. Most termite infestations in buildings occur because wood touches or is close to the ground. Cracks and voids in concrete foundations make it possible for termites to reach wooden structures that do not reach the soil. Termite activity is prolonged or increased in northern areas when soil around basements is heated or kept warm.

Good sanitation, design and building construction is the best way to prevent termite infestations (e.g. removal of wood in soil, drainage, ventilation beneath buildings, breaking contact between soil and wood by 18 inches, and use of treated lumber for maintenance, repair, and in new construction).

Chemical control is most effective when used in conjunction with basic sanitation and structural control methods. The soil most frequented by termites must be found. An application of a chemical soil barrier can be made as required. The soil, between the foundation and the termite nest may be dug and treated with a residual insecticide. Chemicals may also be applied to the bottom of a trench along the inside and outside of the foundation and then filled with dirt. Mud tubes where termites go from soil to wood should be broken.

b. Carpenter Ants

Unlike termites, carpenter ants do not feed on wood but merely excavate wood to provide their home. Carpenter ants forage principly for dead insects and aphid honeydew. Carpenter ant infestations are often first recognized by the piles of "sawdust" excavated by the ants from their tunnels. Carpenter ant tunneling can present serious structural damage in wooden or wooden frame buildings. Chlordane to is an effective insecticide for controlling carpenter ants and should be placed in or near the site of infestation.

c. Powder Post Beetles

There are three families of powder post beetles that commonly infest wood products and structures. Beetles in the family Lyctidae reduce wood to a fine powder, while beetles in the family Anobiidae and Bostrichidae produce coarse sawdust or fass. Wood infested with powder post beetles will exhibit small circular holes 1/32 to 3/8 inch in diameter. Because of the wide variety of materials attacked by these beetles, chemical control often requires special techniques. Insecticides recommended for use against powder post beetles must be carefully selected for each treatment area.

d. Buprestids and Cerambycids

These beetles commonly attack seasoned wood and wood in service. Larvae of Buprestids (flat head borers) bore into both living and dead wood forming eliptecal exit holes. These beetles may survive in cured wood for twenty years or more. Cerambycid (round headed borers) larvae also attack living and dead wood but their exit holes are more round then those of Buprestids.

Control is much the same as for other wood boring beetles. Chlordane and Lindane have been used effectively, but selection of the proper insecticide is governed by the treatment situation.

J. Animal Pests

Birds

Anyone who plans to control bird populations must be informed as to federal and state laws, local ordinances and attitudes of local groups. Birds which are apt to be pests are the common pigeon (Columbia livia); the English sparrow (Passer domesticus);the European starling (Sturnus vulgaris), and the barn swallow (Hirundo erythrogaster)

1. Common Pigeons

The common pigeon also called the rock dove, is familiar to most persons. Their defecation on buildings and sidewalks are problems in most cities. They nest on ledges and in open portions of the upper levels of buildings. They can contaminate grain if storage facilities are not properly constructed. Several fungus diseases, including ornithosis, are transmitted by pigeons. The potential for transmission increases as humans are exposed to pigeon's droppings and resultant dusts.

2. English Sparrow

Family Ploceidae

The English sparrow or house sparrow builds nests in and around buildings and may cause such problems as plugged roof drains and fire hazards as well as contamination of stored foods and other stored goods.

3. European Starling

Family Sturnidae

This bird is a greater problem in rural areas than in cities, particularly in stock feeding locations. They may become a problem in cities when they seek the warmth and shelter of buildings during cold weather.

4. Barn Swallow

Family Hirundinindae

This swallow may build nests on the sides of public buildings. They are nuisances because of their droppings but their nests are also of concern since they usually contain swallow bugs which are closely related to bedbugs. These bugs live on the blood of the swallow but when the nest is abandoned in late summer, the bugs may move into a building and feed on humans.

5. Control of Birds

Pest bird control in and around buildings primarily involves good sanitation (reduction of food sources) and construction of structural features which discourage nesting (exclusion and bird proofing). Repelling devices such as sound devices, bird glues or jellies and ammonia water mists can be effective. Trapping is effective for removing pigeon populations. Removal of nests will discourage continued residence. Killing programs should be a last resort, and merit considerably more information than can be provided here. Only pesticides registered for use on specific birds are permitted. Migratory birds are protected and killing is illegal. The Pesticide Control Division, Department of Agriculture should be contacted for recommendations or consultation.

Rodents

1. Bats: Order: Chiroptera

Bats in Northern states feed on large numbers of insects and therefore are beneficial to humans and the environment. Bats sometimes cause annoyance in homes and buildings because of offensive odors or noises; fecal droppings may deface buildings and sometimes rabies infestations cause community concern. The part played by bats in the overall ecology of rabies is not understood. Rabies can be transmitted to man by a bite of an infected bat or less commonly by urine aerosol in caves. Histoplasmosis, while rare in Montana, can be transmitted through dust of bat droppings in caves.

Bats are occasionally a problem when they fly into open windows at night. They are easily removed by hands protected with a leather glove or a towel. Screens or hardware cloth keep bats out of buildings. Openings larger than 1/4 inch should be closed. Bat-proofing should be accomplished between November and early March when bats have migrated out of the state or are hibernating in caves. If a colony should establish itself in an attic or some other part of a building, they can be driven out by such chemicals as naphtalene or paradichlorobenzene. Several pounds of these chemicals may be required. They dissipate on exposure to air allowing the bats to return in one or two weeks or the next season. Chemicals will substitute for bat-proofing. The use of repellents or bat-proofing while flightless young are in the nest will cause young to starve to death, decompose and produce offensive odors.

2. Domestic Rodents: Order: Rodentia Family: Muridae

The term "domestic rodents" refer to three rodents introduced into North America from Europe. These rodents are the Norway rat (Rattus norwegicus), the roof rat (Rattus rattus), (not present in the state), and the house mouse (Mus musculus). These rodents can cause a great amount of destruction of food and property. They can also be a source of such human diseases as plague, murine typhus, leptospirosis, rat bite fever and trichinosis. Mice are known to transmit rickettsialpox. Rats in slum areas are known to kill or maim babies in their beds.

Successful control of domestic rodents is only achieved by preventing their access to food and harborage. This is accomplished primarily through good premise sanitation and building construction, as well as through good community sanitation.

Rodent populations are suppressed with trapping, fumigation poison baits, tracking dusts and glue boards. Rodenticides are supplemental to and not a substitute for good management. Poisons used for rodents are two types: multiple dose (the anticoagulants) and the single dose (such as strychnine).

a. Norway Rats

A number of baits are used for Norway rats: grain, seeds, legumes, bacon, fish, sugar, corn, fruits, (e.g. apples and tomatoes), vegetables, mineral, peanut and salad oils are frequently used. Wheat, corn, oats, and barley are most commonly used in poison baits. Baiting problems may be related to food availability rather than the rodenticide employed. Improper placement and distribution may be responsible for control failure. In food warehouses cereal baits may not be accepted and liquid baits may be desirable. In extremely moist areas (indoors or outdoors) paraffin treated baits may retard the deteriation of the baits, prolonging its acceptability.

b. House Mice:

Mice do not forage widely, therefore, the use of many well distributed small anticoagulant baits is preferable. Because mice nibble when feeding, a high concentration of anticoagulant is required to reduce control failures. Frequent renewal of baits is a must since mice reject old baits. Liquid baits are usually not desirable because mice have low water requirements. Rodent ectoparasites can be controlled at the same time as rodents. Spreading insecticide dust in runways or in burrows is the recommended procedure.

c. Skunks:

Skunks usually live in underground burrows, rock piles or hollow logs, and may be found under buildings if construction permits entry. Besides the odor associated with skunks they are also carriers of rabies. Rabid skunks can become very aggressive and easily transmit rabies to domestic animals or humans. Large skunk populations may be a potential threat to domestic animals and to humans.

Control of skunks includes preventing entrance to buildings, trapping, shooting and denning. Trapping, while fairly nonspecific can be effective but includes the potential of scent release. Quick acting poisons such as strychnine treated eggs are very effective but can only be used by certain government agencies.

d. Trapping:

Traps are a preferred method of control where rodenticide use should be avoided, when dead animals may die in an inaccessible area and cause annoying odors, or where a few surviving rodents become poison bait shy. Both wood base and steel traps are effective; mice are more easily trapped with snap traps and rats tend to be more wary of traps.

Mouse traps must be set close together (3-4 foot intervals) against baseboards, boxes and platforms. Baits for house mice include rolled oats, peanut butter, gum drops, raisin bread, bacon and nut meats. Traps for rat control should be placed in rat runs. Baits for rats include bacon, fish, ground meat, raisin bread, nut meats, prunes and apples.

e. Fumigating:

Fumigation provides a quick kill. However, rodents will die in inaccessible areas and decompose and produce odors. For these reasons it is not recommended for general rodent control. Unless a situation absolutely warrants their use fumigants should not be considered. Fumigants should be applied only by trained personnel.

f. Poisons

(1) Multiple-Dose (anticoagulant) Rodenticides

Anticoagulant poisons include pivalyn, warfarin. diphacinone, Fumarin,and chlorophacinone. Anti-coagulants are the safest of the rodent poisons. They must be eaten by rodents over a period of several days and should be made available for a period of 10-20 days. Establishment of permanent bait stations in places subject to continued reinfestation gives good control, provided old baits are periodically replaced by fresh ones. Liquid baits work best where the rodent's water supply can be controlled. Anticoagulants work best for Norway rats, less so with roof rats and house mice. For house mice, fresh bait should be made available for a minimum of 14 days.

(2) Single-Dose (acute poisons) Rodenticides

Single dose rodenticides including sodium fluroa-cetate (1080), fluroacetamide, (1081), norbormide, red squill, ANTU and zinc phosphide. Pre-baiting (offering plain bait for several nights prior to adding poison) will greatly increase the effect-iveness of acute poisons.

a. Norbormide is a specific poison used to kill Norway rats. It is very erratic with roof rats

and has no effect on house mice. Norbormide kills Norway rats in 15 minutes to one hour.

b. ANTU is very effective against Norway rats but has little effect on roof rats or house mice. It may be mixed with regular food baits or used as a tracking powder.

c. Red Squill is a red powder, effective in baits against Norway rats and as a tracking powder against house mice.

d. Strychnine is effective only against house mice; rats quickly detect its presence because of its bitter tastes. Strychnine baits (0.3-0.5% strychnine) are sometimes used against mice, baits should be handled with care.

e. Zinc Phosphide is effective against all three domestic rodents. Zinc phosphide is moderately fast acting. The powder releases phorphine gases when it contacts stomach acids. Both the powder and gas are extremely toxic.

f. Fluoroacetamide (1081) and sodium fluoracetate (1080) Both 1081 and 1080 are so highly toxic and hazardous that their use is restricted to special situations, and to professionally trained personnel. There are no known antidotes for either of these poisons. Both 1080 and 1081 are effective against Norway rats, roof rats and house mice.

1080 and 1081 should be placed in locked bait boxes and all precautions taken to protect the skin from contact with the chemicals.

g. Tracking Powder Non-Toxic tracking dusts (flour or talc) should only be used to check rodent activity in food areas and areas where pets or children may be exposed.

Tracking dusts may also be used to get a rodent to ingest materials they would normally not eat in a food bait (e.g. reg squill).

h. Baits The acceptability of a bait is a critical factor in controlling rodent populations. Often a "trial and error" approach in finding a bait acceptable to specific rodent populations is necessary.

## References


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4. Insecticides in Food Handling Establishments. Federal Register, Vol. 38, No. 154, August 10, 1973.

CHAPTER II

MOSQUITOES AND THEIR CONTROL

A. Philosophy

It is necessary to understand the life cycle and habits of mosquito species in order to effectively and efficiently control mosquito populations. Detailed surveys are essential for the planning, operation and evaluation of control programs. Survey and evaluation are continuing processes that must accompany control. A basic tenet for mosquito control is that only by treatment of cause (larval mosquito habitat) rather than effect (mosquito populations) can a problem become less severe. For this reason and since mosquitoes require shallow standing water for development, good water management practices/source reduction methods are the preferred approaches in mosquito control. As a practical matter, the use of chemicals will be required for the temporary suppression of mosquito populations. Chemical control should assume less importance as source reduction programs develop. In all cases, the least environmentally disrupting approach to mosquito control should be used.

Control programs conducted by mosquito control districts organized under state enabling legislation (R.C.M. 1947, 16-4201 through 16-4214) have been the most effective. Districts thus organized have more program continuity, higher levels of financing and a more reliable source of financial support. These advantages make environmentally sound source reduction and larviciding programs easier to attain.

The vector control specialist of the Environmental Services Bureau may be contacted for technical advice, information or assistance in forming mosquito control districts or for reviewing and consultation upon mosquito control programs and problems.

B. Mosquito Biology

There are 43 species of mosquitoes in Montana distributed among six genera (Aedes, Anopholes, Culex, Culiseta, Coquilletidia and Psorophora). Vector Control Bulletin #1, Montana Mosquitoes, Part I, Identification and Biology (obtainable from the Department of Health) may be consulted for detailed information. The most common mosquitoes are Aedes species. Most control efforts are directed at this group. The other common genera are Culex and Culiseta. The mosquito species Culex tarsalis is of public health importance in Montana because it is the principle vector of human and equine encephalitis. Other species have also been found to be naturally infected with the virus causing this disease.

All mosquito species have four distinct stages in their life cycle:(complete metamarphosis) the egg, the larva (wiggler), the pupa (tumbler) and the adult. The first three stages require water for development. Eggs of all species (except Aedes and Psorophora) and all larvae and pupae will die out of water. (Pupae can survive for

short periods in moist environments).

Aedes and Psorophora species normally lay their eggs in the mud along receding waters. (One rare Aedes species lay its eggs above the water line in tree holes or containers). Eggs of some Aedes species will hatch if the site is flooded again that season. Others must be subjected to cold before hatching. Hence, some species have only one generation each year; others may have several generations. Aedes are a temporary water mosquito, implying that they are produced in water which is retained on the surface for a minimum of about 7 days but which normally disappears during the course of the season. They may also be found in permanent or semi-permanent bodies of water which have periodic fluctuations in water levels. Eggs of some Aedes species retain the ability to hatch if flooded even after a peroid of 5 years on dry land. Aedes overwinter in the stage.

Eggs of the Culex and Culiseta species are laid in rafts on the surface of permanent or semi-permanent bodies of water. Eggs of Anopholes (which are not too common) species are laid singly on the water surface. Eggs of these permanent water mosquitoes must have water continuously to remain viable. While Coquilletidia overwinter in the larval stage, the Culex, Culiseta, and Anopholes species overwinter in the adult stage in sheltered sites. Since there is a high mortality of adults of these species during the winter, their populations do not usually build up until later in the season. The permanent water mosquitoes typically have several generations each year.

Water temperature is the most critical factor in the hatching of eggs and in the time required for development. Eggs of the predominant Aedes species may hatch when the daily average water temperature reaches about 50°F. but they do not hatch in large numbers until the daily average water temperature approaches 70°F. Besides water temperature, the rate of larval development depends on the species and amount of nutrients available. Larval and pupal development may be completed in as little as 5 days (more likely 7 to 8 days) in hot weather or development may take 3 weeks when the water temperature is cooler. All larvae (except Coquilletidia, which is fairly rare) must come to the surface to breathe; hence the effectiveness of oils which foul the breathing apparatus and cut off the air supply.

The adult mosquitoes feed mainly at night, being most active at dawn and at dusk. A few Aedes species will attack during broad daylight (especially if distrubed) but most prefer shaded situations if they bite at all during daylight hours. Different mosquito species show different host preferences. Culex tarsalis, the common encephalitis mosquito, readily bites man but prefers to feed on birds. Culex territans feed exclusively on reptiles and amphibians.

The normal flight range of most Anopholes, Culex and Culiseta species is usually considered to be one mile or less. However, studies have shown that Culex tarsalis commonly fly from 3 to 10 miles, especially when seeking shelter in the fall. Most Aedes species are strong

fliers and range several miles from their breeding places. Individuals have been recaptured over 20 miles from their release site but most range three miles or less. Mosquitoes will normally fly no further from their breeding sites than is necessary to feed.

C. Classification of Mosquito Breeding Places

Mosquito breeding places may be classed as temporary, permanent or semi-permanent. Temporary breeding pools remain for a limited period of time following each flooding. Permanent water remains throughout the year. Semi-permanent water areas remain throughout most or all of a mosquito season following an initial flooding.

Mosquito breeding places may also be classified as to their location. They may be classified as on field (including surface pools, irrigation laterals and drains) or off field (including road side ditches, or borrow pits, waste land areas, abandoned canals and laterals, drainage ditches, natural waterways, oxbows, sloughs and distribution systems). Over 95 percent of the total breeding area was associated with "on field" mosquito breeding places in one irrigated area studied in Montana. These accounted for over 70 percent of all mosquito production during the entire season. Thus in most areas suffering from severe mosquito infestations, more than 90 percent of all mosquito production may be associated with the use of water for irrigation. In non-irrigated areas, spring run-off and a rising water table account for higher percentages of mosquitoes produced.

D. Mosquito Surveys

Two types of survey are widely used: The original basic survey and the operational survey

Original Basic Survey

The original basic survey determines the species of mosquitoes, their source, location and seasonal density. Mosquito control maps are used for orientation and locating larval breeding places and adult sampling stations. When making the original basic survey, it is advisable to record the type of breeding place and if known, the number of expected generations of mosquitoes (e.g. temporary, on-field (alfalfa), 3 generations). This information is of value for estimating the expected seasonal breeding acreage that would have to be treated each year (as opposed to the amount of acreage that can produce mosquitoes) and for estimating the types of control measures that may be used, the number of personnel needed, type of equipment and amount and type of insecticide required.

Operational Surveys

The operational survey is a continuing evaluation of the mosquito control program and is extremely valuable in daily operations. Through operational surveys, one refines information on control efficiency, the times that larvae appear in each source, and the

significance of each larval source according to the production indexes. Such surveys determine the population index (showing general fluctuations rather than determining the actual numbers of mosquitoes present). Operational surveys may be larval or adult mosquito surveys.

1. Larval Surveys

In conducting larval surveys, a dipper approximately 4 inches in diameter is scooped fairly rapidly through the water surface near emergent vegetation. Aedes larvae are collected by a rapid skimming movement of the dipper with one side depressed below the water surface, ending the stroke just as the dipper is filled. Where clumps of emergent vegetation are present, it is easiest to collect Anopholes larvae by pressing the dipper into such clumps with one edge depressed so that the water flows from the vegetation into the dipper. A quicker motion is required for collection of Culicine larvae (Aedes, Culex, Culiseta and Psorophora) than for the collection of Anopholes larvae since they are more likely to dive below the surface when disturbed by shadows or movement. The number of dips made and the number of larvae found are recorded in order to calculate a breeding index. The breeding index may be defined as the number of larvae per square foot of water surface. Therefore, the number of larvae collected divided by the number of times that 4 dips are taken equals the breeding index ($BI = \frac{\#\ \text{larvae}}{\#\ \text{dips}\ (1/4)}$). Unless the mosquito production source is very large, a mosquito breeding index of less than 1 is not normally controlled. One can determine the relative importance of each breeding site or station by calculating the production index (Breeding Index X the Area = Production Index of the site or station). Both pre-treatment and post treatment larval counts should be made when possible in order to determine control efficiency.

2. Adult Surveys

Adult surveys may include biting collections, resting collections, light trap carbon dioxide or baited collections. Adult mosquito surveys provide information on :

(1) the species present,

(2) the mosquito population density,

(3) the effectiveness of the control efforts throughout the season and

(4) a means of evaluating the effectiveness of specific treatments.

Adult light trap collections depend upon a phototropic response. Mosquito species differ in their response to light; some being attracted readily, others poorly. After being attracted to the

light, fan is usually employed to blow the mosquitoes into a bag or killing jar. Biting collections are carried out by capturing the adult female mosquito with an aspirator as she attempts to obtain a blood meal from a host. When making population estimates with the bite count method, a predetermined time period is established. The count per given time period that will be tolerated by residents in an area varies from region to region and must be determined for each area. Biting and light trap collections are the most common forms of adult surveys. Resting station collections are made by aspirating the adult which remains inactive during the day, resting in cool, humid places. Resting stations may be in such sites as stables, chicken houses, culverts, and so forth. Egg samples or egg-sod surveys are not typically made in Montana but have been employed in large districts as a part of pre-larviciding operations.

E. Methods of Control

All methods of mosquito control require surveys to insure success. A number of general methods are employed. In order of preference, they are good water management, source reduction, biological control, pre-larviciding, larviciding, and adulticiding. The one instance in which adulticiding pre-empts other control methods is in the event of an outbreak of mosquito-borne diseases, such as St. Louis encephalitis or Western equine encephalitis.

(1) Source Reduction. Source reduction is accomplished by the removal of free, shallow, standing water contributing to mosquito production or by the elimination of harborage present within the water. Source reduction or permanent control may involve diking, ditching, draining, dredging, deepening, filling or water level management.

(2) Biological Control. Most forms of biological control remain in the experimental stage. The use of the mosquitofish Gambusia affinis has been effective in Montana on a limited basis. Other experimental efforts to use fish for mosquito control should be attempted whenever possible. The Fish and Game Department should be notified prior to such attempts. Algae, protozoa (particularly microsporidia), nematodes, fungi (e.g. Coeleomomyces), irridescent viruses and the crystaloid toxicant produced by the bacteria Bacillus thuringiensis are examples of experimental control efforts not yet reaching field use.

(3) Pre-larviciding. Prelarviciding consists of applying approved insecticides to areas known to produce mosquitoes but which contain no larvae at the time of application. Granules of either the coated or clay type and containing 1 to 2 percent concentrate (e.g. Abate, Chlorpyrifos or Fenthion) may be applied to the ice of snow melt pools or to low spots that collect the annual run-off and which are known to produce an early hatch of mosquiotes. Precisely

outlining this area depends upon experience, accurate surveys and records. Areas to be treated by pre-larviciding should be carefully selected to insure that the insecticide will not be flushed from the area and contaminate potable water supplies or water containing valuable resources.

(4) Larviciding. It is at the larval stage of development that mosquitoes are most effectively controlled. More mosquitoes are killed per given quantity of insecticide by larviciding than adulticiding because mosquito larvae are concentrated in a restricted location and less toxicant is needed to affect control. Since insecticide is applied over given areas at approximately the same dosage whether adulticiding or larviciding, more insecticide is required after adults disperse. Larviciding should not be conducted without surveying a site and establishing that mosquito larvae are present in sufficient numbers to merit control. Larviciding is conducted by the application of fuel oil, fuel oil plus spreader, highly refined oils, insecticide granules, emulsifiable concentrates or solutions to a body of water. The choice of approach and chemical depends upon the registration of the chemical, its directions for use and the environmental conditions present.

Besides being of value in pre-larviciding, granules are an excellent means for applying insecticide through heavy foilage. They will tumble through the vegetation to the water surface rather than being deposited upon the surface of vegetation as liquid formulations are: (The use of liquid formulations in heavy cover may result in ineffective control from the application of less than toxic amounts of insecticide to both the water and the foliage ).

The use of fuel oil should be restricted to waste land areas not possessing valuable vegetation. Fuel oil applied at the rate of 15 to 20 gallons per acre may burn vegetation and leave an unsightly appearance. Fuel oil with a spreading agent applied at 2 to 3 gallons per acre is slightly less objectionable. The more highly refined mosquito control oils have not been reported to have this toxic effect.

When applying an insecticide for mosquito control, the applicator must insure that the insecticide is also registered for application to crops in that area. For example, a flooded alfalfa field containing mosquito larvae should be treated with a chemical registered for both mosquito control and for use on alfalfa pests.

(5) Adulticiding. Adulticiding is conducted through the use of thermal fogging, misting or ULV equipment. Adulticiding is the most difficult form of mosquito control to practice in terms of applying the correct dosage and obtaining the proper coverage that is necessary for efficient control. Disadvantages are that there is less control of exposure to non-target organisms, more insecticide is used per

mosquito killed, the effect is more temporary than it is with other forms of mosquito control and a repellent effect may occur. Routine adulticiding or adulticiding only on the basis of telephone complaints can be a useless and expensive procedure. None-the-less, adulticiding can be a valuable supplement to other forms of mosquito control. It is widely used to combat outbreaks of mosquito-borne disease.

Mists, fogs, and ULV applications depend upon direct contact of the insecticide with the adult mosquito. For this reason, they are most effective while the mosquito is on the wing in the early morning or early evening hours. Under ideal conditions the wind should not exceed five miles per hour, temperature should be between 65 and 75°F and the relative humidity should be 60 to 80 percent. ULV application of Malathion should not be made if the temperature exceeds 82°F. Space spraying is conducted as near as possible at right angles to the wind. Low wind currents are depended upon to disperse the insecticide over 300 to 400 foot recommended swath width.

The movement of the extremely small thermal fog particles is very unpredictable. These particles are more subject to climatic conditions than are the larger ULV or mist particles.

ULV adulticiding (the application of 1/2 gal. or less of undiluted concentrate per acre) results in the distribution of more uniform particle sizes which are of a size sufficient to kill the adult mosquito. It is the cheapest form of adult mosquito control (about 1/4 that of thermal fogging) and results in less environmental contamination. The use of diesel fuel is eliminated and it is only necessary to apply approximately 1/2 to 2/3 the dosage needed for thermal fogging. However, since pure or concentrated insecticide is dispensed, chemical and equipment use directions must be followed rigorously and the performance of the machine must be continually assessed to assure that accidents do not occur. The hazard of spotting of automobile paint increases with droplet size.

Misting machines disseminate a wide array of different size particles. This may result in wastage of some chemical but enables applicators to use the machine during daylight hours and under more adverse wind and temperature conditions. Misters can be used for short term residual mosquito control in parks and in bushes and trees in rural or urban residential areas. Under these conditions the mist is directed at a lower angle than the customary 45° above the horizontal that is used when space spraying. If vegetation is tall, the mist should be directed at the upper part. The vehicle speed should be 5 mph or less when treating low sparse vegetation and 3 mph or less when vegetation is dense. In the latter case or under hot, dry conditions, the effective swath width may not exceed 100 feet. Under more ideal conditions, it may be 200 feet. Although one can larvicide with misters, it

is usually best to larvicide with equipment designed for that purpose rather than attempt to employ adulticiding equipment in this fashion. If equipped with a granule hopper, however, mist blowers can be used to effectively larvicide with granules.

F. Chemicals for Mosquito Control

A variety of insecticides are registered for mosquito control. Since registrations are periodically reviewed and certain restrictions may be imposed, applicators should consult with the State Department of Agriculture and State Department of Health and Environmental Sciences prior to using them. Label directions should be followed. Table 19 indicates pesticides currently used in mosquito control.

TABLE 1

PESTICIDES CURRENTLY EMPLOYED IN MOSQUITO CONTROL[a]

| Type Application | Toxicant[b] | Dosage | Remarks |
|---|---|---|---|
| Residual Spray | malathion | 100 - 200 mg per square ft. | For use as an interior house treatment. Effective for 3-5 months on wood surfaces. |
| Continuous Vapor Treatment | dichlorvos | 1 dispenser per 1,000 cu. ft. | In resin; dispeners hung from ceilings. Gives 2 1/2-3 1/2 months control. Do not use where infants, ill or aged are confined or in food preparation or serving areas. |
| Outdoor, Ground Applied, Space Spray | chlorpyrifos[e] (Dursban) | lb/acre 0.0125 | Dosage based on estimated 300 foot swath width. Mists and fogs are applied from dusk to dawn. Mists are uaually dispersed at 7 to 25 gal/mi. and at a speed of 5 mph. Fogs are applied at a rate of 40 gal/hr @ 5 mph (occasionally at higher rates and greater speeds). Finsihed sprays have 0.5 - 8 oz/gal actual insecticide in oil or (with non-thermal foggers) water. In Ulv ground applications[d] technical grade malathion is used at 1-1.5 fl. oz/min. at 5 mph or 2-3 fl. oz/min @ 10 mph; some ULV pyrethrins at 2-2.25 fl. oz/min @ 5 mph or 4-4.5 fl. oz/min @ 10 mph; chlorpyrifos fog concentrate at 2/3 - 1 1/3 fl. oz/min @ 10 mph. |
| | fenthion[c] (Baytex) | 0.001-0.1 | |
| | malathion | 0.075-0.2 | |
| | naled | 0.02-0.1 | |
| | pyrethrins (synergized) | 0.002-010025 | |
| Larvicide | abate | 0.05-0.1 | Apply by ground or air at up to 10 quarts finished spray/acre depending on concentration used. Use oil or water emulsion formulations in areas with minimum vegetation cover; granular formulations where vegetative cover is heavy. Fenthion provides longer residual in contaminated water at 5 times the dosage listed. Chlorpyrifos has long residual toxicity in water with a high organic content (e.g. 12 weeks |
| | chlorpyrifos[c.e] | 0.0125-0.05 | |
| | fenthion[c.e.f] | 0.05-0.1 | |
| | malathion | 0.2-0.5 | |
| | pyrethrin tossits | 1/100 sp.ft. | |

cont'd

| | | |
|---|---|---|
| | | in septic tanks) while abate is fairly labile |
| fuel oil | 2 to 20 gal/A | in polluted water. Apply fuel oil at 15-20 gal/A in open water courses or with 0.5% |
| Flit MLO | 1 to 5 gal/A | spreading agent (e.g. T-Det-MC, Dal-Com W) apply at 2-3 gal/A. |

a Modified from "Public Health Pesticides" Technical Development Laboratories, Center for Disease Control, U.S. Department Health, Education and Welfares (1973)

b Other compounds such as Lethane 384 and ronnel may have uses in some categories. If so follow label directions.

c For use by trained mosquito control personnel only.

d Adhere STRICTLY to all label specifications and directions.

e Do not apply to waters with valuable fish.

f Label requires 3 week interval between applications except for adulticiding.