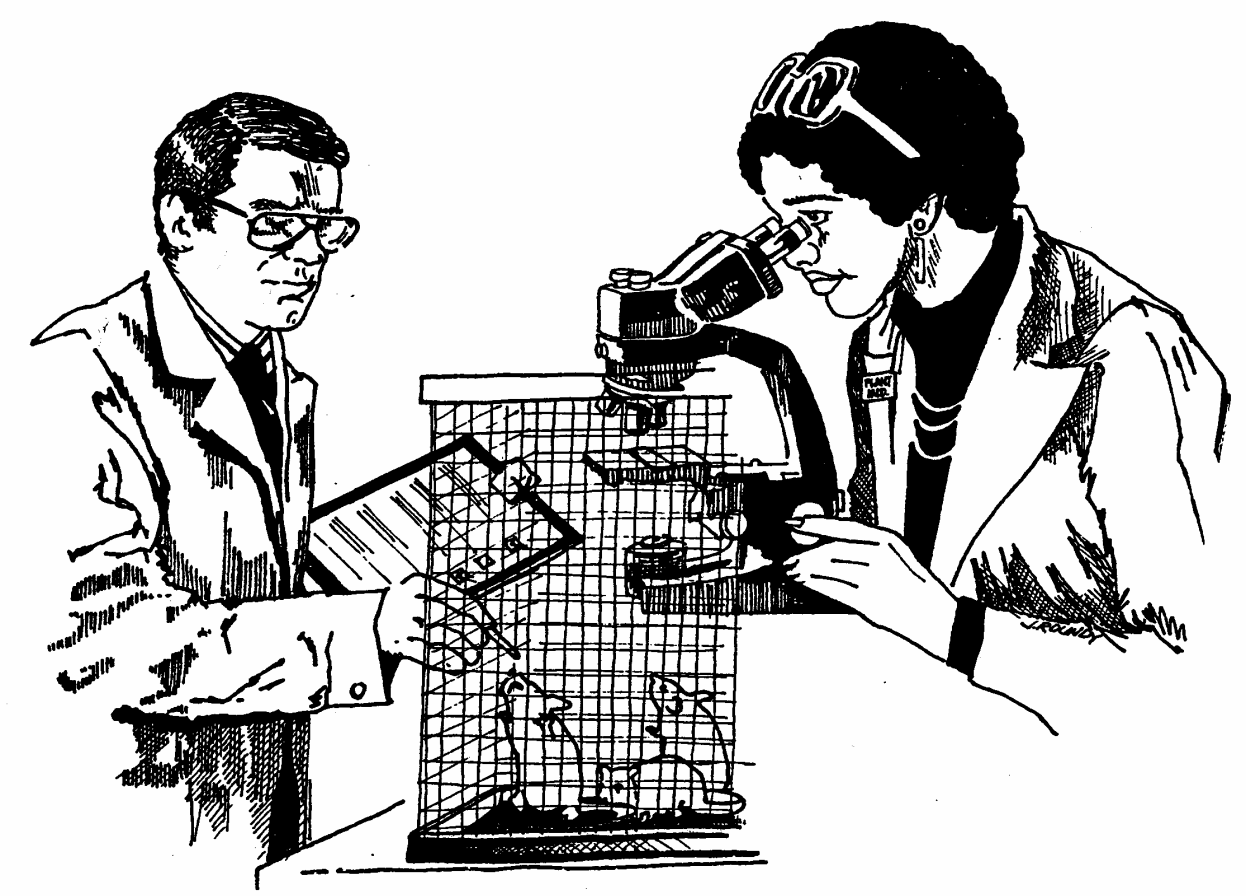
PUBLIC HEALTH PEST MANAGEMENT

Study Guide for Pesticide Application and Safety
Category 8



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STUDY GUIDE FOR
PUBLIC HEALTH
PEST MANAGEMENT

The educational material in this study guide is practical information to prepare you to meet the written test requirements. It doesn't include all the things you need to know about this pest-control subject or your pest-control profession. It will, however, help you prepare for your test.

Contributors include the Utah Department of Agriculture and Utah State University Extension Service. This study guide is based on a similar one published by the Colorado Department of Agriculture. Materials for that guide were prepared by Colorado State Extension Service. Other contributors include: University Extension Service personnel of California, Kansas, Nebraska and Wyoming. The U.S. Department of Agriculture and U.S. Environmental Protection Agency, Region VIII Office.
The information and recommendations in this study guide are based on data believed to be correct, however, no endorsement, guarantee or warranty of any kind, expressed or implied, is made with respect to the information contained herein. Additional topics that may be covered in your examinations include First Aid, Personal Protective Equipment (PPE), Protecting the Environment, Pesticide Movement, Groundwater, Endangered Species, Application Methods and Equipment, Equipment Calibration, Insecticide Use, Application, Area Measurements, and Weights and Measures. Information on these topics can be found in the following books:

1. National Pesticide Applicator Certification Core Manual, Published by the National Association of State Departments of Agriculture Research Foundation.

2. The Workers Protection Standard for Agricultural Pesticides – How to Comply: What Employers Need to Know. U.S. EPA, Revised September 2005, Publication EPA/735-B-05-002.
These books can be obtained from the Utah Department of Agriculture or Utah State University Extension Service. Please contact your local Utah Department of Agriculture Compliance Specialist or Utah State University extension agent.

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I. INTRODUCTION

TOPIC PAGE

STUDY GUIDE

This study guide provides information specific to the control of common pests related to public health. These pests include mosquitoes, ticks, spiders, other biting or stinging pests, stored food pests, and domestic rodents. This guide does not discuss the many desirable attributes of insects and insect relatives.

Public health pest management involves the control of insects or other animals that transmit diseases to man. The animals that are capable of carrying a disease organism or parasite from one host to another are called vectors. Public health pest management programs are usually directed against these vectors with the belief that controlling the vectors will control the disease. The success of this approach is evident by the eradication of malaria and yellow fever from many parts of the world through control of the mosquito vectors.

Public health considerations remain the basis for most vector management programs, but other factors may also be important. Voters approving taxes to support a pest management program may place greater importance on the immediate control of nuisance mosquitoes, flies, and rodents than on the more remote public health implications. Severe nuisance problems may have economic effects such as discouraging tourism or outdoor activities. Damage to agriculture may result when vectors weaken livestock or transmit disease to the animals.

Successful control of a vector pest involves several steps. The pest must first be correctly identified and its biology understood. Next, the pest infestation should be evaluated and finally, the selection of a control strategy may be implemented. If pest control is to be successful, it must be based on knowledge

and understanding of the pest's biology, pest management technology, and environmental safety concerns.

The communities supporting a vector management program will be more cooperative if they understand the general methods and goals of the program. A mosquito control program must reflect current legal conditions and community concerns. Community concerns should be reflected in vector control and public opinion should not be ignored.

BASIC STRATEGIES

INSPECTION

Inspection includes asking questions, inspecting the structure or structures, and inspecting other areas thoroughly to learn as much as possible about the pest problem. During the inspection an applicator should look for locations where conditions favor infestations. Note the presence of food and/or water that will attract pests and structural defects or openings that may serve as a means of pest entry. Also, look for evidence of infestation such as structural damage and pest droppings or tracks.

The inspection process should provide some idea of the control measures to use, safety precautions that may be necessary during the control effort, and the best time and method of control. Thoroughness during the inspection is a critical component of effective pest management.

DIAGNOSIS

Diagnosis includes identifying the pest and any factors contributing to infestation such as spilled food or the presence of other items that attract pests. Once the pest is located, it must be positively identified to proceed effectively. Many times identification must be made from indirect clues such as damage or droppings. After the pest is identified it is easier to identify shelter areas and the means by which the pest gained entry. Some knowledge of the biology of the pest is very useful for thorough diagnosis. Failure to properly identify the pest can result in wasted time, money, pesticides, and labor.

PRESCRIPTION

Prescription includes how, when, where, and what control techniques are needed to control the pests. Effective prescriptions are determined only after inspection and diagnosis are completed. The prescription should include the appropriate control strategy and any modifications to the existing habitat that will need to occur. People should clearly understand that the effectiveness of any control strategy is reduced if problems such as sanitation, ease of entry, and re-infestation are not addressed.

Successful pest control strategies commonly include a pesticide application combined with other control measures such as habitat adjustments. Habitat adjustments should include sanitation efforts to remove sources of food, water, or other attractants that the pest needs to survive. Exclusion of pests to prevent re-infestation is a necessary part of any prescription. Exclusion can involve screening openings and caulking cracks and crevices. Closing small openings in buildings can insect and rodent proof structures. Habitat manipulation is an effective management strategy for excluding many public health pests.

APPLICATION

Pesticides should be used to supplement other control methods against public health pests. When pesticides are used they should target areas visited and inhabited by pests. To minimize potential hazards the choice and application of a pesticide depends on the characteristics of the site such as closeness to human food, access by children or pets, and air movement or ventilation.

EVALUATION

Effective pest control programs should include ongoing evaluation. Pests changes, a pests susceptibility to pesticides change, and manufacturers change the formulation of the pest products sold. Periodic inspections to assess the effectiveness of management strategies are critical.

INSECTS AND INSECT RELATIVES

Insects comprise one group of animals within a larger group called arthropods. Arthropods have specific characteristics that make them distinctive. They have segmented bodies, jointed appendages, an exoskeleton, and their growth involves molting.

Insects, as a distinct class of arthropods, have the following characteristics. They have three body regions that include the head, thorax, and abdomen. They also have three pairs of legs on the thorax, one pair of antennae, and wings usually present during the adult stage.

Arachnids include spiders, ticks, mites, and scorpions. They have four pairs of legs, no antennae, and two body regions known as the cephalothorax and abdomen.

Crustaceans include crayfish, shrimp, sowbugs, and pillbugs. They have 5 to 7 pairs of legs, 2 pairs of antennae, and a cephalothorax and abdomen that are the 2 parts of the body region.

Diplopods are millipedes and they have elongate, usually rounded bodies. Typically their bodies consist of 50 body segments, and appear to have 2 pairs of legs at each body segment.

Chilopods are centipedes and they have elongated, flattened bodies, consisting of 14 to 20 body segments. They appear to have one pair of legs at each segment.

INSECT GROWTH

All insects begin their development as eggs produced by the adult female. Although a few species, such as aphids, may also appear to give live birth, this occurs from the eggs hatching inside the mother.

After the egg hatch, insects grow in a series of distinct stages. Each stage, known as an instar, is separated by a period when the insect sheds or molts. An insect's exoskeleton is produced during molting and each new exoskeleton is larger than the previous one. A few hours after a molt, the new exoskeleton becomes hardened, and there is no further change in body size until the following molt. Body parts that remain soft, such as the thorax and abdomen of caterpillars, may expand to a limited extent during the course of an instar. All growth ceases following the final molt to the adult stage of the insect.

As insects develop, there are also changes in form know as a metamorphosis. The kinds of changes may vary among different insect groups, but the two common types of metamorphosis are simple and complete metamorphosis.

During simple metamorphosis insects pass through three basic life forms that include egg, nymph, and adult stages. The nymphs typically pass through three to five instars. Nymphs and adults often live in the same habitat, with the principal changes during metamorphosis being body size, body proportions, and the development of wings. Some of the insects that undergo simple metamorphosis are grasshoppers, crickets, earwigs, and aphids.

During complete metamorphosis insects pass through four basic life forms that include egg, larva, pupa, and adult. Caterpillars, maggots, and grubs are typical examples of larvae. During the larval stage, there may be 3 to 7 instars, during which the larvae usually feed. The pupal stage occurs within a cocoon, puparia, or chrysalid and is a non-feeding stage.

During the pupal stage insects change into the adult form. Adults are usually winged and differ from the larvae in a number of ways, including type of legs, mouthparts, and feeding habits. After adult insects complete metamorphosis, they are very different than their larvae stage and may be found in nonsimilar habitats. Insects that undergo complete metamorphosis include butterflies, moths, beetles, flies, and lacewings.

HOW INSECTS AFFECT HUMANS

Insects are probably the most successful of all animals. They live in every type of habitat and in all locations of the world. Insects feed on almost everything that contains plant or animal material. For centuries, insects have been identified as major cause of diseases transmission. Insects compete with people and other animals for food, but the majority of them are beneficial to humans.

TRANSMISSION OF HUMAN DISEASE

Fleas, lice, and mosquitoes infect man and domesticated animals directly or indirectly with the organisms of many dangerous diseases. Insect stings or bites are occasionally fatal to humans and their germ laden saliva or contaminated bodies can also be routes of disease transmission. Insects are often involved in the transmission of diseases to humans.

MECHANICAL TRANSMISSION OF DISEASE

Mechanical transmission of disease occurs when the insect transports organisms such as dysentery bacteria on their feet, body hairs, and other body surfaces to humans. There is no multiplication or development of the disease causing organism within the insect's body. The house fly is a passive transmitter of bacillary dysentery. This mechanical transmission is considered to be accidental. That is the insect does not seek out the disease organism and does not intentionally transmit the disease to humans.

OBLIGATORY VECTORS

Obligatory vectors of disease include those insects in which the disease will develop from one stage to another while inside the insect. Malaria is an example of a disease which must be transferred by a mosquito to a human for the malaria organism to develop from one stage to another. Without the mosquito vector, the malaria organism would die. Mosquitoes are obligatory vectors of diseases.

RESERVOIR HOSTS

Reservoirs are defined as one or more hosts harboring a disease causing organism over an extended period of time without showing symptoms of the disease. Disease transmission occurs when an insect feeds on a host that has the disease agent. The insect can then transmits the disease to another host at a later feeding. Birds are an example of reservoirs for mosquito borne West Nile virus that affects humans and horses.

It is often important to understand how a disease is transmitted and the involvement of insects in the transmission. This allows a public health person to design and manage the control program for a particular problem without extending unnecessary efforts.

BIOLOGICAL TRANSMISSION OF DISEASE

Disease organisms need assistance to move from one host to another. Most disease organisms cannot stand exposure to sunlight or air. Biological transmission of disease occurs when an arthropod like a tick or mosquito picks up the disease from one host, the disease develops in the arthropod's body, and then the arthropod transmits the disease to another host. While within the arthropod, the disease may reproduce or the disease may remain as it was first picked up. Many ticks and insects are important vectors of biologically transmitted diseases.

HOST AND VECTOR RELATIONSHIP

In considering insect transmission of disease causing organisms, it is important to understand the relationships between the vector insect and the host human or animal. The disease organism can undergo certain life changes while in the insect or it may remain the same. In either case, the insect transfers the disease from one host to another. If a disease must change life stages while in the insect and before being transmitted a human, the absence of the insect vector breaks the life cycle and the disease organisms dies.

Some diseases requiring an insect host may require several hosts before completing the disease life cycle. These hosts may be the same type of animal or may be different animals. Infected host animals do not show signs of the disease are reservoirs of the disease.

VENOM IRRITATION AND ALLERGY

Many insects, some spiders, scorpions, and centipedes have developed venomous mechanisms to use as self defense or to paralyzing their prey. Stings and bites seldom result in human death, but the bite or sting can be intensely painful and sometimes requires hospitalization. Individuals allergic to certain venoms may have a fatal reaction to the sting of certain insects.

PESTICIDES

Pesticides include a variety of chemical products designed for the management of pests. The term pesticide refers to products such as herbicides and insecticides that are

used to kill or control harmful organisms such as insects, weeds, or microorganisms. The following list includes numerous pesticides and the target pests they control.

Acaricide: mites and ticks
Adulticide: adult pests
Algicide: algae
Aphicide: aphids
Attractant: insects and vertebrates
Avicide: birds
Bactericide: bacteria
Defoliant: foliage removal
Desiccant: water removal from plant foliage
Disinfectant: microorganisms
Fumigant: insects, rodents, and weeds
Fungicide: fungi and other plant pathogens
Germicide: germs
Growth regulator: insects and plants
Herbicide: weeds
Hormone: insects and plants
Insecticide: insects
Larvicide: larval pests
Miticide: mites
Molluscicide: snails and slugs
Nematicide: nematodes
Ovicide: eggs
Pediculicide: lice
Pheromone: insects
Piscicide: fish
Predacide: predators
Repellent: insects and vertebrates
Rodenticide: rodents
Sanitizer: microorganisms
Silvicide: trees and woody vegetation
Slimicide: slime molds
Sterilizer: microorganisms
Wood preservative: fungi and insects

PRECAUTIONARY STATEMENT

Pesticides offer both benefits and risks. Benefits can be maximized and risks minimized by reading and following label directions. Pay close attention to the directions for use and the precautionary statements. The information on pesticide labels contains both instructions and limitations. Pesticide labels are legal documents and it is a violation of both federal and state laws to use a pesticide inconsistent with its labeling. The pesticide applicator is legally responsible for proper use. Read and follow the label instructions.

II. MOSQUITO PESTS

MOSQUITOES

BIOLOGY AND BEHAVIOR

Mosquitoes belong to the order Diptera and the family Culicidae. They are pests to humans and other animals, acting as vectors for malaria, filariasis, yellow fever, dengue fever, West Nile virus, several other types of encephalitis, and dog heartworm. In the larval stage, mosquitoes are aquatic and the adults differ from all other stages by having scales on their wings and usually on their body.

Most mosquitoes belong to five genera, *Anopheles, Aedes, Psorophora, Culiseta* and *Culex*. Mosquitoes belonging to the genus *Psorophora* are generally vicious biters and behave like the floodwater species of the genus *Aedes.*

Members of the genus *Anopheles* are vectors of malaria and are known as "malaria mosquitoes." Although all species of this genus are believed to transmit malaria, only two species are known to transmit it in the United States.

The floodwater mosquito, genus *Aedes*, is an important pest mosquito, some being vicious biters. *Aedes* is the most common pest mosquito in Utah.
The mosquito *Aedes aegypti* is a potential carrier of yellow fever and dengue fever, but this species does not occur in Utah.

Culex tarsalis feeds on the blood of birds, large mammals, and humans and is the most

important vector of Western equine and St. Louis encephalitis. This mosquito will feed on birds in the spring and on mammals during the summer.

Female adult mosquitoes of most species suck blood, and these species require a blood meal for egg production. Adult females of a few species and males of all species feed on nectar and other plant juices.

Eggs

Generally the female lays her eggs on or near water. The eggs of genus *Aedes*, which are laid separately near water, only hatch when they are flooded. Eggs that have been dry more than two years may still hatch. Incubation periods vary, depending on species and temperature, but generally are 16 to 24 hours.

The eggs of *Anopheles sp.* are laid separately directly on the water surface and are provided with floats on the sides of each egg. The genus *Culex* lays its eggs stacked vertically in rafts, which float on the surface of the water.

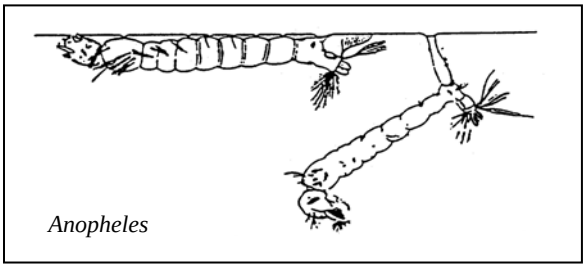
Aedes ***Anopheles*** ***Culex***

Eggs Laid Singly or Stacked Vertically

Larvae

The mosquito larvae, also called wigglers, of most species feed on algae and other organic materials. A few larval species are predaceous and feed on other mosquito larvae. Most larvae breathe at the surface of the water through a breathing tube or siphon, with the exception of genus *Anopheles*, which achieves breathing through a pair of spiracular plates.

Larvae of the genus *Anopheles* may be distinguished from the larvae of other genera because they lay parallel to the surface of the water while breathing. The larvae of other genera of mosquitoes hang down at an angle from the surface of the water.
Mosquito larvae grow by a series of four molts, where the entire skin is shed. After the fourth molt the pupa appears. The period of time between molts varies and is largely dependent on the quantity and quality of food and environmental conditions. Warmer water temperatures shorten this period of time.

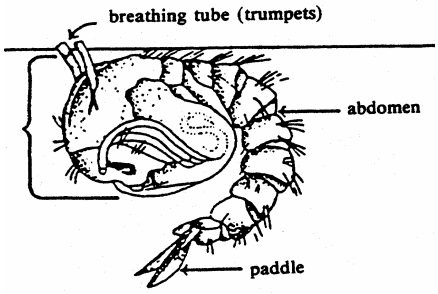


Anopheles

Mosquito larvae do not depend on the aeration of the water for survival and a very large number of larvae can live in a relatively small amount of water, even if it is foul.

Pupae

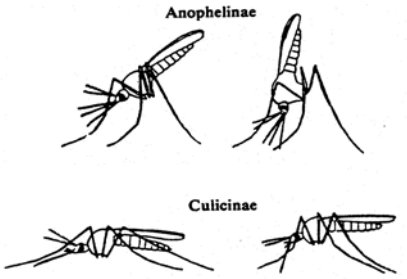
Mosquito pupae, also known as tumblers, are comma shaped and have a pair of breathing tubes or trumpets near the head rather than the single siphon near the tail like the larvae. Pupae do not feed but remain quite active. Unless disturbed, this stage remains at or near the water surface. The pupal stage lasts from 2 to 4 days, depending on temperature. During this time, the adult mosquito is developing within the pupal skin.



When emergence time approaches, the pupa becomes less active. Within a short period of time the pupal skin splits and the adult mosquito emerges, rests on the water surface until the skin hardens, the wings dry, and it is able to fly.

Adults

Mosquitoes act as vectors of several important human diseases such as malaria, yellow fever, filariasis, dengue, and encephalitis. The adults of the two major groups *Anopheles* and *Culicinae* may be identified by the angle their bodies make with the surface on which they are resting. The *Anopheles* rest with their proboscis and abdomen aligned, and suspend at an angle to the resting surface. The *Culicinae* rest with their proboscis and abdomen at an angle, and their abdomen parallel with the water's surface.



There are three primary factors that attract mosquitoes to their host. In order of importance, they are carbon dioxide, warmth, and moisture. Amino acids and estrogen are capable of enhancing these primary factors. This is thought to be why some people seem to be more attractive to mosquitoes than others.

The flight range of mosquitoes is important to mosquito control districts because it helps them determine the possibility of re-infestation from an area outside the district where control measures are not taken. The flight range varies with species, time of year, wind direction, and the distance the mosquitoes must fly to find warm blooded animals on which to feed.
Studies have been done that determined dispersion takes place in all directions if the wind speed is less than two miles per hour. The greatest distance of recapture upwind was 2.75 miles. If the wind speed was above 4 miles per hour, the dispersion is downwind with very little movement upwind. If the wind is more than 6 miles per hour, the effective distance of dispersion does not increase appreciably because such winds discourage flight. Studies have recorded mosquito flights as far as 17.5 miles and such travel distances makes control difficult.

SURVEY METHODS

One of the most important elements of a successful control program is the survey. Surveillance is the detection of the mosquito problems, the species involved, their numbers, and their location. The information provided by survey programs and a thorough knowledge of the mosquito's biology, habits, and habitats will provide a sound basis for control. Each problem is different and requires a different approach. Survey data provides immediate information on whether the particular problem warrants control and the methods of control to be employed. Also analysis of survey data on a long term basis will provide evidence of the control program's effectiveness. The decision of

where to apply the control measures should always be based on pest surveys.

LARVAL SURVEYS

Since the larval and pupal stages of mosquitoes live in water, it is customary to examine the water to determine the abundance and species of immature stages. A record of the life stages present when surveys are made is important, because pupae and eggs are not readily controlled by insecticides. A long handled water dipper is used to survey for larvae and pupae. The surveys must be made to determine where larvae are present in water. The presence of water does not mean mosquito larvae are present. When larvae are present in water, treatment should occur.

Survey frequency depends on the season and length of time necessary for larvae to mature. During the early spring, larval development may take from two to three weeks. During warm summer months, eggs may hatch and adults emerge in seven to ten days. The larvae grow rapidly and the timing of surveys is critical. As soon as there is standing water from melting snow or ice, the over-wintering eggs hatch into larvae. Mosquito larvae from these eggs can develop into adults as early as February in Southern Utah or March in Northern Utah.

ADULT SURVEYS

There are several methods of surveying adult mosquito populations. They include light traps, carbon dioxide traps, Gravid traps, a variety of artificial and natural traps, and landing counts, resting stations, and truck mounted traps transported through mosquito areas.

When surveying mosquitoes for vector potential or for further identification, the mosquitoes that land may be captured with a killing tube or an aspirator. A killing tube is merely a tube or vial whose bottom inch is filled with a killing agent such as ethyl acetate and covered with cotton. When the mosquito lands, the killing tube is placed over the mosquito and held in place until it dies. When mosquito populations are high, capturing specimens with an aspirator is a quicker and more effective method than using a killing tube.

An aspirator consists of a 12-inch long, ½ inch diameter tube with a siphon hose attached to one end. A screen is fitted between the tube and the hose to prevent inhalation of the specimens. Mosquitoes are drawn into the aspirator as the collector draws air through the hose. Specimens are then transferred to a killing tube or container for further identification. The landing count method samples that portion of the female mosquito population which is seeking blood.

Light traps are a typical method of making a mosquito adult survey. This is a metal cylinder with a protective metal cap and containing a light bulb, which serves as an attractant. A fan inside the cylinder blows the insects down into a killing jar or other collecting container. Both males and females are collected. The number of individuals and species collected gives an index to mosquitoes present in a given area. Not all species are attracted to the light, so the light trap method has limitations.

Carbon dioxide ($C0_2$) traps are similar in construction to the light trap. The difference is that an insulated container with small holes in the bottom is used either in addition to or in place of the light. The blood meal seeking female follows the $C0_2$ trail

produced by the conversion of dry ice into carbon dioxide gas.

Examples of natural and artificial mosquito traps include plastic containers, tarpaulins, tires, bird baths, barrels, tubs, holes, catch basins, pools, and depressions.

Landing counts involve rolling up a pant leg or shirt sleeve and collecting the number of mosquitoes that land during a given period of time. These collections give an index of the numbers of the biting population and identify the species causing the most annoyance.

CONTROL

Once the pest infestation has been surveyed, a management plan may be formulated. The term abatement is often used to describe the control program since it is designed to reduce the number of mosquitoes to an acceptable level, rather than an attempt to kill all of the mosquitoes. Complete extermination would be very expensive as well as environmentally unacceptable because of the quantity and concentration of pesticides required.

An abatement situation may be simple or complex, depending on the scope of the problem. There may be a localized adult problem at a large outdoor gathering, where the adult mosquitoes emerged from pools of water that have since dried up. A good residual application of pesticide may be all that is necessary. In other situations, a community may be surrounded by grass meadows that are flood irrigated. In this case, an integrated abatement program, including water management, physical changes, biological control, and pesticide applications, are required.

Total reliance on pesticides is seldom the best approach. Each situation may differ and must be handled appropriately. One applicator may handle a small area, while large scale abatement programs must be supervised by trained personnel that carefully monitor the complete management strategy.

Larval Control

Under most conditions, mosquito control is most effective and economical when designed to eliminate larvae. Since mosquito larvae live only in water, water management is an important means of control. In situations where water cannot be managed, pesticide control may be the primary control method. Water management is thought to be a more permanent control measure, whereas pesticide control is normally only a temporary measure. The presence of water does not mean that mosquito larvae are present.

Water management on a large scale involves modifying the land surface, drainage ways, and/or ponds and lakes to eliminate excess surface water which may serve as mosquito breeding habitats. Such large scale modifications should be considered when a mosquito problem requires many pesticide treatments each year. Although the initial cost of water management is high, it can prove more effective and economical over a long period.

The control of mosquito populations with water management techniques is directed at the aquatic stages of life. The basic principles involved in water management are:

1. The removal of excess surface water within five days, thereby eliminating the mosquito breeding habitat.

2. Increasing the amount of standing water to create a suitable habitat for predaceous fish and/or creating a means of access for fish into mosquito breeding areas.
3. Increasing the movement of water in the mosquito breeding area and thus creating stress conditions for the larval and pupal mosquitoes.

Water management on a small scale involves the individual homeowner because large numbers of mosquitoes can be produced in small water accumulations. Involving the homeowners will contribute to the success of community pest management program. This is especially true for mosquito species that fly only short distances. Homeowners may be able to alleviate their own and their neighbors' problem with the following steps:

1. Eliminate all temporary water containers such as tin cans and old tires.
2. Tightly cover all cisterns, water barrels, cesspools, and septic tanks. Do not allow sewage or other liquid wastes to collect on the ground.
3. Empty, wash, and refill bird baths and animal watering containers at least once each week.
4. Keep rain gutters clean and flat roofs dry.
5. Drain or fill stagnant pools or swampy places.
6. Make weekly examinations of the containers where plants are grown in water. If larvae are seen, dump the water, wash the plant roots and the containers, and refill the containers with clean water.
7. Keep the margins of small pools or ponds clear of plants that emerge through the water.
8. Fill tree holes to prevent water from collecting.

Water management includes the regular maintenance of drainage ditches, streams, and rivers and is essential in any upland water management program. The elimination of debris that normally accumulates in these watercourses is necessary to avoid creating mosquito breeding habitats.

Restoration of some rivers, streams, and ponds is important in maintaining a system that is free of mosquitoes. Many rivers and streams have a flood plain which may accumulate standing water after a heavy rain, thereby providing suitable mosquito breeding habitats. Successful restoration projects involve the removal of any excess surface water by providing outlets to and for tributary streams. Restoration of ponds usually entails the removal of aquatic vegetation and/or the excavation of silt to a depth that will maintain an adequate population of fish and other mosquito predators.

Landfills and junkyards can also serve as a breeding ground when water is allowed to accumulate in containers, tires, discarded automotive parts, and other such materials. Elimination of such situations can substantially reduce mosquito breeding sites. Around dwellings, mosquitoes may be reduced by periodically removing and/or replacing the water in birdbaths, wading pools, or other receptacles that hold water.

Biological control involves the use of predators such as fish. Mosquito fish, *Gambusia affinis*, are predatory on larvae and pupae and can be introduced into breeding areas, where the fish will reproduce rapidly. State and local fish and wildlife agencies should be involved before relocation or placement of nonnative fish occurs. Other naturally occurring predators such as diving beetles and dragonfly larvae can be preserved by careful planning and reduced chemical application.

LARVICIDES

Insecticides that kill larvae can be applied to water where the aquatic stages live. Different formulations are used depending on the situation and application equipment. Mosquito larvicides are available in numerous formulations such as granules, oils, and emulsifiable concentrates. Application equipment can vary from handheld granular spreaders to aerial applications, depending on the situation and level of pest infestation.

Extreme care and adequate supervision are essential when using chemical pesticides to control mosquito larvae. In some areas, water containing mosquito larvae in the early spring may produce only one brood. In such cases, a single well timed application of a suitable pesticide in the spring is sufficient. In some communities, other species produce several broods throughout the summer months and a pesticide may be required to control each brood. These differences in mosquito biology require regular surveys throughout the season to determine when the larvae are present in sufficient numbers to justify control procedures.

Treatment of storm sewers and water drain basins is an important part of a community mosquito abatement program. In cities with drain basins along the edges of streets, surveys indicate that many of these drainage areas hold enough water to produce large broods of house mosquitoes.

The application of larvicides to these catch basins is useful but is not always the complete answer to this type of mosquito control. If rain water runoff or irrigation water flushes a treated catch basin, the larvicide can be washed away, leaving untreated water that will allow mosquito larva to mature.

In large ponds and lakes almost all larvae are found among the marginal emergent vegetation, so little is gained by treating the open water. In such cases, the pesticides should be applied only to the weedy margins. By limiting the treatments to these areas, the danger of harming fish and other desirable organisms is reduced.

GRANULAR LARVICIDES

Granular larvicides may be formulated using solid materials such as clay, sand, corn cob, or dissolvable paper to provide weight. Such materials, when scattered over water, will sink to the bottom of larval breeding areas and release the toxicant into the water. Granular formulations can also be applied as a pre-hatch treatment over ice in marshes or pool areas in the very early spring. When the ice and snow melts, the insecticide is released. Some wet areas are accessible when the ground is frozen, but they become difficult to access after the ice melts.

Granular materials are also advantageous for spot treating small pools in sensitive areas such as bird sanctuaries, where a broadcast treatment would be environmentally unacceptable. When aerial applications must be made to large areas under heavy foliage, granular formulations are especially effective since they do not stick to the foliage, but will fall down through it and land in the water. Most of the granular pesticide will reach the target instead of remaining on the leaves, as would be the case with a liquid spray.

SURFACE FILMS

Light, highly refined oils and monomolecular films designed especially for mosquito control are applied to the water surface and spread as a thin film over the water. They act on both larvae and pupae either by suffocating the insects or by poisoning them as they take in toxic vapors through their breathing tubes.

These oils are relatively safe to other forms of wildlife, but they can be hazardous to other insects. Oils are primarily used to control pupae and are usually applied by compressed air sprayers, power sprayers, or aerial equipment.

Oil solutions are often supplied by the manufacturer in highly concentrated forms. Many of the insecticides used against mosquitoes are so effective that only a small amount is required for control. It is hard to apply this small amount uniformly over an area, so the concentrate is further diluted with compatible oils for easier handling. Oil based solutions do not evaporate as quickly as water emulsions, so they are preferable when the applicator depends on drift to help cover the area treated.

Oil solutions are often applied to small breeding areas with compressed air sprayers or portable mist blowers and to larger areas with mist blowers or aerial equipment.

EMULSIFIABLE CONCENTRATES

Emulsifiable concentrates are designed to be diluted with water. The insecticide will mix with the water in the breeding area and control larvae present. They can be applied with hand equipment such as compressed air sprayers or with power sprayers. Aerial application can also be used, but the tiny droplets of water evaporate quickly and are generally unsatisfactory for mosquito control.

GROWTH REGULATORS

Growth regulators are similar in formulation and application techniques to other larvicides, but they differ in their mode of action. Other pesticides usually kill the mosquito larvae or pupae, while growth regulators interfere with the normal development of the insect. The mosquito larva may never transform to a pupa, or molting may be affected. Growth regulators are desirable in that they have little or no effect on other wildlife; however, they can be hazardous to other insects.

BACTERIAL LARVICIDES

Bacterial or microbial larvicides have bacteria that are registered as pesticides for the control of mosquito larvae in water. These larvicides do not pose risks to wildlife, non-target insect species, or the environment, when used according to label directions. Microbial larvicides will kill susceptible larvae in outdoor aquatic locations such as irrigation ditches, standing water, ponds, pools, irrigated pastures, and marshes.

APPLICATION EQUIPMENT

Granule applicators, whether large or small, all work on the same principle. They are containers with adjustable openings in the base through which a controlled amount of granular insecticide may pass. They may be manually operated or power assisted. Some may be equipped with agitators or auger feeds to help produce a uniform flow.

HORN SEEDERS

The horn seeder is the simplest device for applying granules. It is comprised of a canvas bag which is slung over the shoulder with a tapered, telescoping wand or tube located at the lower front corner of the bag. Granules are dispersed as the operator's arm and wand move in a horizontal figure eight fashion. Application rates may be altered by adjusting the opening at the base of the wand or by changing the speed at which the operator walks.

CYCLONE TYPE SPREADERS

The cyclone type spreaders are also granular applicators. They can be used with a hand crank or powered with a battery pack or ATV electrical connection. Cyclone spreaders have cylinders with an adjustable slot in the base through which gravity fed granules fall onto a rotating disc and are dispersed by centrifugal force. The rate of dispersal is varied by adjusting the size of the slotted opening or by changing the travel speed of the operator.

Both the cyclone type spreader and the horn seeder are commonly used in treating small, isolated breeding areas such as woodland pools.

BLOWER TYPE APPLICATORS

The power assisted blower type granular applicators have feed tubes which meter the granules into the blast of an air blower. The blower type spreaders may be backpack size or truck mounted. The speed of the air blast ranges from 75 to 150 miles per hour.

Similar blower type spreaders are used in helicopter delivery systems where the forward air speed of the aircraft is not high enough to provide adequate pressure for proper distribution of the granules. In fixed wing aircraft, where the payload is greater, ram air type spreaders are used which require no power other than air turning a propeller.

The liquid larvicides most often used are oils, oil solutions, or emulsions. The choice of formulation is influenced by the application equipment, the distance the material is expected to drift, the safety of the formulation, and other such factors.

COMPRESSED AIR SPRAYERS

Handheld and backpack compressed sprayer are the most commonly used compressed air sprayers. One of the most common sprayers for treating small areas is the one to three-gallon compressed air sprayer. The air in the upper portion of the spray tank is put under pressure by a hand pump, and the pressure created forces the spray through the nozzle. Compressed air sprayers are used for applying larvicides to small breeding areas such as water catch basins or pools.

HYDRAULIC SPRAYERS

In hydraulic sprayers, the spray mixture is taken into the rotary or piston pumps, placed under pressure, and forced through spray nozzles. In some sprayers, pressures of up to 600 pounds per square inch may be reached. Hydraulic sprayers range in size from backpack style to large truck mounted units. Large equipment is most often used for treating larger mosquito breeding areas.

AERIAL SPRAYERS

Liquid spray systems can be mounted on either fixed wing or rotary wing aircraft and make larvicide applications to large areas that may otherwise be inaccessible or cost prohibitive to treat. Traditional aerial spray

delivery systems can be equipped with special low volume nozzles that release the small quantities of insecticide needed per acre.

ADULT CONTROL

While larval control is the preferred method of treatment when possible, there are situations where adult control is required. Sometimes a larval population escapes control and the biting adults must be reduced. If a small community is surrounded by many acres of breeding area, usually larvicide applications are not economically possible. The same holds true for small areas such as outdoor theatres, campgrounds, racetracks, parks, and individual properties. Sometimes an adult population that has been only a nuisance will become a public health problem as vectors of disease and must be drastically reduced. All of these situations require adult mosquito control.

SPACE TREATMENTS

Insecticides used in space treatments are applied as fine droplets in the form of fogs, mists, or fine sprays. The droplets float about in the air, settling very slowly and, depending on their size, drifting over long distances to expose adult mosquitoes to the insecticide.

Drift is both a help and a hindrance. It helps control mosquitoes over a large area, but the application must be planned to avoid highly sensitive areas, for instance bee yards, fish ponds, or parking lots, especially if the droplets are large enough to settle into these areas.

Space treatments are temporary, becoming ineffective when wind has carried the droplets out of the area. Winds exceeding five to six miles per hour or temperatures of more than 85°F often reduce the effectiveness of the insecticide.

Application is best made in early morning, early evening, or at night, when the air is calm and cool. These are also the times when mosquitoes are actively flying and many beneficial insects are not flying. Generally the spray treatments are for the control of flying mosquitoes, but larger spray droplets that are deposited on foliage may give short residual action.

Application equipment for space treatments varies from hand carried equipment to truck mounted or aerial delivery systems. Different types of units include ultra low volume (ULV) applicators, thermal foggers, cold foggers, mist blowers, and aerial dispersal systems.

1. In ULV equipment, liquid insecticide concentrates are introduced into a swirl chamber, where shearing action of the air produces extremely fine droplets. Droplet size is relatively uniform and controllable. ULV with ground equipment is becoming increasingly popular for space treatments. Units are either portable or truck mounted. Treatments rely on gentle wind speeds of one to five miles per hour to carry pesticide to the target area.

2. Thermal foggers produce an insecticidal fog formed by momentarily exposing the spray concentrate to heat. A heavy cloud of smoke is produced, which contains very fine particles of insecticide. Thermal fogs are very susceptible to wind and thermal air currents. If applied during unfavorable conditions, such as during a hot day, the fog may be carried up and over the target adults and be ineffective. It is usually better to do

applications during the evening or at night, when the fog is more likely to be held close to the ground. Thermal fogging was once the main form of adult mosquito control, but because the thick clouds can be hazardous to traffic, it has been replaced with ULV. Foggers range from small hand held units that use blowtorch propane bottles for their heat source to larger units that must be carried in a pickup truck. Units that use the hot exhaust gases from jeep, truck, or helicopter exhausts have been successfully used.

3. Cold foggers have characteristics similar to thermal foggers, except that the fog results from a mechanical breakup of the spray concentrate.
4. Power sprayers or hand held compressed air sprayers are used to apply residual adulticides to perimeter vegetation. This is sometimes referred to as barrier spraying.
5. Aircraft can quickly and effectively apply sprays over large areas. This is desirable if a public health problem such as encephalitis suddenly appears or if a large population of nuisance mosquitoes occurs. ULC can be applied at high speeds, but such speeds can result in drift problems.

Adulticide ground applications are much more effective when a temperature inversion exists in the lower 30 feet of the atmosphere. Such inversions are not more effective during aerial applications.

Dilute residual sprays can be applied with compressed air, backpack, or powered hydraulic sprayers. Concentrated residual sprays are applied by mist blowers.

WEST NILE VIRUS

West Nile Virus (WNV) has killed thousands of crows and equines, and caused hundreds of human deaths in North America since it first appeared in New York City in 1999. It has been detected in more than 284 species of wild and captive birds, in at least 30 species of mosquitoes, as well as in horses, bats, cats, rabbits, and other animals.

Birds carry the virus and mosquitoes spread it to other birds, horses, or humans. Birds serve as the reservoir of the virus, mosquitoes serve as the vector, and horses or humans are the host. Other animals rarely show illness from the infection.

The appearance of this disease is very unpredictable because of the great distances that infected birds can travel. Mosquitoes become infected after biting infected birds, the primary host of the virus. The virus multiplies inside the mosquito and accumulates in the salivary glands.
Mosquitoes are capable of transmitting the virus 10 to 14 days after feeding on an infected bird. They salivate every time they bite, injecting saliva into the wound. Only female mosquitoes bite and female mosquitoes require a blood meal before they can lay eggs. They bite every few days during their entire adult lives, which may last several months.

HUMANS

Although most people infected with West Nile virus show no signs of illness, approximately 20 percent of those infected will get West Nile fever. The symptoms associated with West Nile fever include fever, headache, body aches, occasionally a skin rash on the trunk of the body, and swollen lymph glands. These symptoms typically last from two to seven days.

More severe forms of the illness are West Nile meningitis and West Nile encephalitis. Approximately one out of 150 individuals infected with WNV will develop one of these neurological illnesses. The symptoms of West Nile meningitis include fever, headache, neck stiffness, and nausea. All of these symptoms are also present with West Nile encephalitis in addition to altered mental status such as confusion and irritability. People over 50 years of age and immune-compromised individuals are at greater risk of developing these more severe forms of West Nile infection.

In the United States in 1999, there were 62 human cases and seven deaths reported in the state of New York. In 2000, there were 21 cases and two deaths reported in New Jersey, New York, and Connecticut. In 2001, there were 66 cases and nine deaths in 27 states and Washington, D.C. In 2002, there were 4,156 cases and 284 deaths in 40 states and D.C. In 2003, there 9,862 cases and 264 deaths in 46 states and D.C. In 2004, there were 2,470 cases and 88 deaths in 40 states and D.C.

To decrease the risk of becoming infected with WNV, the following precautions are recommended. Use screens to block door and window openings, avoid mosquito infested areas from dusk to dawn, wear a long sleeved shirt and long pants when outdoors, and apply DEET containing repellants as needed.

BIRDS

West Nile virus is not likely to be a problem for indoor birds because mosquitoes are normally excluded, but birds in zoos and aviaries are at risk. Corvids and raptors are two types of birds most commonly affected by WNV. Corvids are large perching birds with strong bills like ravens, crows, jays, and magpies. Raptors include eagles, hawks, falcons, owls, and other birds of prey. These birds have long curved talons and strong hooked beaks.

When handling a dead bird, use appropriate personal protection equipment to avoid exposure to disease. If WNV is suspected, it is recommended that a facemask also be worn. All dead birds should be double bagged prior to disposal in a covered outdoor waste container to prevent access by scavenger animals.

Birds that have been dead less than 24 hours may be tested for WNV. To do so, contact your local Health Department or call the Utah Department of Health. The deceased bird should be double bagged and placed in a refrigerator or a cooler with ice for transport to the laboratory.

Although most WNV positive birds have been American crows, infections have also been confirmed in 283 other avian species. There has been no evidence of WNV virus in commercial poultry flocks in affected states, but poultry producers may want to implement mosquito control measures.

The extent to which WNV may be present in wild game birds is unknown. Surveillance studies are currently underway in collaboration with the U.S. Geological Survey's National Wildlife Health Center and with state and local wildlife biologists and naturalists to answer this question. It is important to remember that even though there is no evidence that birds can transmit WNV to humans, latex protective gloves should be worn when handling any dead bird or mammal.

Game hunters may be at risk if they are bitten by mosquitoes because of their outdoor exposure in areas of WNV activity. Hunters should follow the usual precautions when handling wild birds and animals.

Wear gloves when handling and butchering animals to prevent blood exposure to bare hands. Game meat should be cooked thoroughly. As an additional precaution, hunters should not harvest or consume any animal that exhibits unusual behavior, appears to be ill, or is in poor physical condition prior to harvesting.

HORSES

In the United States, there were 25 horse cases in 1999, 60 horse cases in 2000, 738 cases in 2001, 15,257 cases in 2002, 5,181 cases in 2003, and 1,341 cases in 2004. Data from the last several years indicates that approximately 25 percent of the horses infected with WNV die or require euthanasia.

Clinical signs in horses are related to encephalitis and the effects of the virus on brain function. These signs may include loss of appetite, depression, circling, staggering, fever, weakness or paralysis of the hind limbs, hyper-excitability, head pressing, convulsions, inability to swallow, or coma.

Vaccines are available for use in horses to protect them against WNV. They are available through veterinarians. They have been used widely in horses the past few years with minimal reactions or problems. The vaccine effectiveness is currently calculated to be 94%, which is high for any vaccine. Vaccination of all accessible horses is recommended. Give the first dose at least two months prior to the expected mosquito season. Give a second dose three weeks later. Realize that the horse will not likely achieve a protective level of immunity until two to three weeks after the second dose of vaccine.

If WNV activity is high during the summer, a third booster dose could be given 3 to 4 months after the second dose. If a horse's immunity had begun to decrease or was never optimal, this extra vaccination may boost it to the protective level. Additional measures to protect horses include reducing the mosquito population and protecting horses from mosquitoes.

Both pregnant mares and foals can be vaccinated without causing harm. The important decision is about the timing of the vaccination to give the best protection to both mares and foals. It is best to discuss this with your veterinarian as you make the decision for your horses. Realize that young foals may not develop immunity through vaccination. It is important that the dams be vaccinated to allow antibodies to pass to the nursing foal. Antibodies transferred in this manner may interfere with the foal's response to vaccination and delay the effectiveness of the foal's vaccination. Another option to consider is that of giving the foal a series of three vaccinations instead of the usual two. Discuss the appropriate inoculation strategy with a veterinarian.

DOGS AND CATS

West Nile virus is not likely to be a problem for dogs and cats, although it has apparently caused a few rare cases of illness. Dogs and cats can be carriers of WNV, but they do not transmit it to humans or other animals. WNV is transmitted by infected mosquitoes. There is no documented evidence of person to person, mammal to mammal, or animal to person transmission of WNV. It is quite unlikely that dogs and cats could become infected by eating dead animals that are infected.

Veterinarians and owners should take normal infection control precautions when

caring for an animal suspected to have this or any viral infection. There is no reason to destroy a dog or cat just because it has been infected with WNV. Full recovery from the infection is likely. Treatment should be supported and consistent with standard veterinary practices for animals infected with a viral agent.

REDUCE MOSQUITO NUMBERS

Home and land owners can have an impact on mosquito numbers by reducing the amount of standing water available for mosquito reproductive sites. Mosquitoes require water on which to lay their eggs and for the new larvae to develop. Even small amounts of water are sufficient, such as that in birdbaths, small plastic wading pools, containers, or used auto tires. Clogged roof gutters, wheelbarrows, boats, ornamental pools, or plastic covers may collect enough water to allow mosquito reproduction. Eliminate these potential sites or clean them out at least once a week.

Farms or ranches with ponds or waste lagoons may need to implement control methods to reduce the mosquito reproduction. Management practices include eliminating weedy growth along lagoon shorelines, mowing bank vegetation every one to two weeks, regularly cleaning floating debris from the lagoon surface, and applying approved larvicides if pupae numbers become high.

Rubber tires used to hold down plastic covers on silage pits should be modified or stored so they cannot hold water for mosquito breeding sites.

Mosquito abatement personnel are excellent resources for assistance in mosquito management. Some areas or communities that regularly experience high populations of mosquitoes have established mosquito control or abatement districts. Such agencies rely heavily on larvicide applications in the early spring and regular survey programs to reduce the fogging required for adult mosquito control.

Additional protection for animals can be provided by keeping animals stabled or housed from dusk to dawn when mosquitoes are most active. Screens should be used to block open windows and lights should remain off when possible so mosquitoes are not attracted. Mosquito repellent can be used to reduce contact and fogging of the premises will reduce the local mosquito population.

CONTACTS

If you have questions about animals and West Nile virus contact your veterinarian, the local county Extension Office, or a Utah State University Extension Veterinarian.

If you have questions about human health and West Nile virus, contact your health provider, the local Health Department, or the Utah Department of Health.

III. TICK PESTS

TOPIC **PAGE**

TICKS

BIOLOGY AND BEHAVIOR

From a public health standpoint ticks are important as vectors of disease to humans and other animals. Many species are quite resistant to environmental stresses and may live for many years. They have few natural enemies and have a wide range of hosts.

Ticks attach themselves to some people while other people are seldom or never bitten. After exposure to ticks, the body should be carefully searched, including the scalp.

Ticks have three characteristics which distinguish them from insects: (1) The head, thorax, and abdomen are all connected; (2) They have no antennae; and (3) In the nymph and adult stages they have four pairs of legs. In contrast, true insects have three distinct body regions known as the head, thorax, and abdomen; they have a single pair of antennae; and they have three pairs of legs.

The four life stages of ticks include: egg, 6 legged larvae, 8 legged nymph, and adult. Ticks typically take one blood meal in each of the three parasitic stages of larvae, nymph, and adult. In adult ticks, both sexes are blood feeders, but only the female becomes greatly distended with blood after mating with a male. Most ticks feed on a different host during each parasitic stage.

Ticks are known vectors for Rocky Mountain spotted fever, Colorado tick fever, tick borne relapsing fever, tularemia, and Lyme disease. Also, some species are capable of producing a toxic paralysis. Ticks are divided into two main groups, the hard ticks, family Ixodidae and the soft ticks, family Argasidae. The hard ticks possess a dorsal shield called a scutum. This distinguishes them from the soft ticks, which lack this structure.

REMOVING TICKS

Do not force the tick to let go by placing a heat source against its body or covering the tick's body with a chemical irritant. The tick will respond by regurgitation into the wound before it pulls out. A pair of fine tipped forceps should grasp the tick where

the tick contacts the skin and then the entire tick can be gently pulled out.

The portion of a tick's mouthpart that penetrates the skin is long in certain ticks and may break off from the tick body if the tick is forcibly pulled loose. This results in a continuous itching. The inflamed condition is relieved only when the mouthparts are removed. Secondary bacterial infections may occur at the bite site.

HARD TICKS

Hard ticks (Ixodidae) create problems for humans in Utah, either through disease transmission or through discomfort caused by their bites. They are present from spring through summer in a variety of outdoor habitats. They rest on grasses and low vegetation, where they attach themselves to animals or people that brush against the plants.

The female takes a blood meal, drops from the host, and deposits several thousand eggs on the ground, few of which survive to adults. The six legged larvae hatch within a couple of weeks and locate a small animal host. After obtaining a blood meal, the larvae drop from the host, molt, and emerge as eight legged nymphs. The nymphs repeat the process of feeding and molting until they become adult ticks.

The adult ticks of both sexes require larger animals or humans as hosts. This life cycle usually requires two or more years to complete, and each stage normally feeds on a different host. These species are most abundant in brushy areas along trails and along abandoned roads. Temperature and humidity play a significant role in tick development and activity.

ROCKY MOUNTAIN WOOD TICK

The Rocky Mountain wood tick (Dermacentor andersoni) is the major vector of Rocky Mountain spotted fever, a rickettsial disease of humans. It is the most common tick in Utah and is found throughout the western states and in southwestern Canada. It is a vector of bovine anaplasmosis and canine babesiosis that are blood parasites of animals. The tick injects toxins as it feeds and may cause host paralysis. Adult ticks emerge in the spring. They climb on low vegetation along trails in pasture or forested areas and attach to passing animals. These ticks mate during feeding.

After feeding the female detaches from the host and deposits several thousand eggs over a time period of about a month. Ticks hatched from these eggs attach to small rodents, feed, detach, and develop into the nymphal stage. Nymphs seek shelter and remain inactive until the following spring. They then attach to another animal, feed, drop off and molt into the adult stage. The adults over-winter. The following spring, they attach to a large animal, feed, and start the life cycle over. The entire life cycle can take 3 to 4 years to complete.

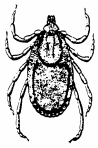
ROCKY MOUNTAIN WOOD TICK CONTROL

Effective tick control can be obtained by use of repellents and by mowing or removing the vegetation for several feet along the sides of paths or trails. Mowing removes vegetation cover that protects small animals and ticks from sun exposure. Acaricide applications may be needed if the infestation

is particularly heavy and troublesome to humans or dogs. Such control measures allow the public health applicator a better opportunity to manage the tick population.

BROWN DOG TICK

The brown dog tick (Rhipicephalus sanguineus) can create a severe annoyance if it infests domestic pets and becomes established inside buildings. Brown dog ticks can be indoor ticks in Utah. The brown dog tick is capable of reproducing indoors.



Brown
Dog Tick

Almost invariably, dogs must be present for the ticks feed and reproduce. It is the most widely distributed tick in the U.S. Humans are rarely bitten by this species. It is not known to transmit human diseases.

The brown dog tick is a subtropical and tropical tick that is not thought capable of over wintering outdoors in Utah. Most infestations originate by direct contacts with infested dogs or during warmer months, when dogs travel through areas previously frequented by an infested dog. Kennels are a common location of brown dog tick contact.

The egg stage of the brown dog tick occurs within a large mass, usually numbering several hundred eggs. Eggs hatch in about two weeks, and the small six legged seed ticks move about to find dogs or rodents on which to feed. After feeding on the blood of the host animal for a few days, the young ticks drop off and hide in cracks or similar protected areas usually near where the dog commonly rests. They then shed their skin, known as molting, and reappear in a slightly larger form with eight legs. Another feeding cycle is then completed and the third adult stage appears.

Adult brown dog ticks typically feed between the toes, near the ears, or around the anus of the dog. During the final blood feeding, the ticks may remain attached for 1 to 5 weeks. After becoming fully engorged, they drop from the dog. At this time, the ticks may be almost 1/3 inch in size and bloated. Grown ticks show a tendency to climb and can be found in the cracks of kennel ceilings.

Under favorable conditions the entire life cycle of the brown dog tick may be completed in as little as two months. When temperatures are cool or the ticks do not find a host for feeding, the life cycle may extend as long as a year.

BROWN DOG TICK CONTROL

Brown dog tick control can be a difficult and lengthy process. If a host animal is to remain in the infested area, insecticides must be selected and applied in a manner that will not endanger the animal. Several products are registered for use as pet shampoos, sprays, or dips to kill ticks present on the animal. It is desirable to get the help of a veterinarian since some dog breeds are especially susceptible to insecticide products. Insecticides used on dogs mention that they are not to be used on puppies, convalescing or sick dogs, or nursing mother dogs.

Attention must also be given to the areas where ticks molt or lay eggs. Often these are located near the area where the dog

usually rests. Insecticides with residual effects must be applied to these areas for effective control. Removal of dogs from infested locations can cause infestations to eventually die out. However, ticks can survive for six to eight months without feeding and re-infestation is possible if a susceptible host animal is present.

SOFT TICKS

The preferred hosts for most species of soft ticks (Argasidae) are birds and small mammals. These ticks feed often but for brief periods of time and are usually found in the nests of their hosts. Some species are nocturnal feeders. Humans are most likely to come in contact with this group when occupying cabins or buildings where small mammals have their nests or when camping in the immediate vicinity of animal burrows, nests, or bedding areas.

The female of the soft tick may lay several small groups of eggs, with a blood meal needed before each ova-position. In some species, the larvae molt to the nymphal stage without feeding. Five to six nymphal molts occur before the adult stage is reached.

SPINOSE EAR TICK

The spinose ear tick (Otobius megnini) is named from its habit of larvae and nymphs infesting the ears of cattle, horses, mules, and other animals including people occasionally. This tick uses only one host. It is uncommon in Utah and has only been reported a few times over the last 20 years.

IV. SPIDER PESTS

TOPIC PAGE

SPIDERS

BIOLOGY AND BEHAVIOR

Spiders are a group of animals classified as arachnids. They are not insects, instead being more closely related to mites and ticks. Spiders are characterized by having eight legs and the two distinct body regions of the cephalothorax and abdomen.

All spiders feed only on insects and other small arthropods. Their activities are highly beneficial since they help control many pest species in yards and in and around homes. Unfortunately, there is a widespread fear of spiders by people. Spider fears also exist because of a few venomous species such as the black widow.

Many spider species occur throughout Utah. They begin life as eggs laid in egg sacs that are bound by silk. These sacks may be guarded or even carried by the female. The young spiders are known as spiderlings. Many spiders disperse by ballooning. Spiders do this by producing silken threads that are caught by the wind and transport the spider. Spiderlings have been carried hundreds of miles on wind currents.

The developing spiders feed and grow over a period of several months. Spiders molt several times before becoming fully grown. Many common spiders have one generation per year and become full grown in late summer. Life cycles vary by species and mating and egg laying can occur during almost any time during the year.

All spiders can produce silk. Many of the more conspicuous species build webs to capture prey. Some spiders do not produce a web, but instead hunt their prey. These spiders ambush prey and use their silk for building egg sacs or retreats. Spiders eat live prey. Victims are killed by venom that the spider injects through fangs.

Spiders may survive for months without food. Most species of spiders found in homes are attracted to water sources. Water pipes, floor drains, and plumbing fixtures commonly attract spiders. Some spiders prefer warm, dry, undisturbed sites and can be found in air vents or room corners. Spiders found indoors often hide in cracks, darkened areas, or silken retreats they have built. Movement of spiders into homes greatly accelerates after cool weather arrives in early fall. Also, male spiders of most species are often highly mobile and range widely while searching for mates.

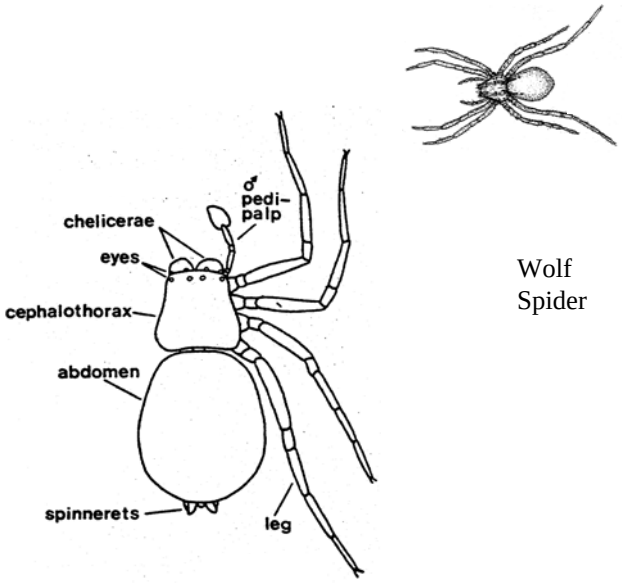
Although all spiders bite and produce venom, few pose any health threat. The venom of most spiders is not very toxic to humans and many smaller spiders cannot break the skin. Also, spiders are not usually aggressive and only bite when accidentally handled or trapped. Two venomous species of spiders do occur in Utah, the black widow and the hobo spider.

COMMON UTAH SPIDERS

Wolf Spiders

Wolf spiders are fairly large hunting spiders that often cause alarm because of their appearance. Most are gray or brown and fast moving. Many species exist and most are about 1/2 inch in length. One genus of wolf spiders, the giant burrowing spider, may be 1-1/2 inches.

Wolf spiders most commonly enter homes late in the season. They hide in cracks and do not produce webbing. Larger species can produce a mildly painful bite, but symptoms do not last long.



Wolf Spider

JUMPING SPIDERS

Jumping spiders are brightly colored active spiders. Their bodies are often densely covered with colored hairs and some may appear iridescent. They have a stout body and large eyes. They are active during the day and may jump or move sideways with ease. They rarely reproduce in homes and often appear as late season invaders after frosts.

ORB WEAVERS

Orb weavers produce characteristic large webs that have radiating threads from a central point. Some of the orb weavers become quite large, such as the common garden *Argiopes* and the monkey faced or cat faced spiders. They attract attention because of their conspicuous size and web. They rarely enter homes.

FUNNEL WEAVERS

Funnel weavers are medium sized spiders varying from 1/8 to 3/4 inch in length. Their funnel webs are easily seen on lawns in late summer. Funnel weavers may also inhabit corners of cellars or outbuildings. Egg sacs are often laid in a cocoon that remains attached to the web.

COBWEB SPIDERS

Cobweb spiders are very common in homes and many are well adapted to survival indoors. These are small to medium sized spiders that typically are found hanging upside down from irregular webs in corners of rooms and other darkened areas. When prey is tangled in the web, they throw anchoring silk strands over it. They do not completely wrap the prey, as do the orb weavers. Although almost all cobweb weavers are harmless, the black widows also belong to this family of spiders.

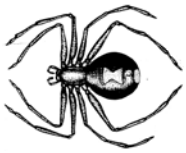
VENOMOUS SPIDERS

BLACK WIDOW SPIDERS

The black widow is a common species in many parts of Utah. Black widows produce a loose web and prefer to inhabit dark, undisturbed areas. Typical locations of black widow nests include locations such as shrubbery, around log piles, in crawl spaces, under porches, in garages, and around piled debris.

Essentially, all human bites occur from the female black widow, often as she is guarding her egg sac. A grown female is about 1/2 inch in length and appears shiny

black or dark brown with a spherical abdomen. Most black widows also have orange-red markings on the underside of the abdomen, sometimes appearing as an hourglass. However, these markings may be reduced and even absent among many of the black widows.



Black Widow

The venom of the black widow spider is a nerve toxin that produces distinctive symptoms. Often the original bite is not painful. It then produces a burning sensation with local swelling and redness. Pain may become intense in one to three hours and last up to 48 hours. Cramping of the legs, arms, and chest may follow. The abdominal muscles become rigid in many cases.

Black widow bites should receive prompt medical attention. Although fatalities are very rare, symptoms are very painful. Antiserums are available and injections of calcium gluconate can help to relieve symptoms. When possible, transport the spider and the victim to the doctor. This will allow proper identification and treatment. If a spider is crushed during capture it may not be recognizable.

THE HOBO SPIDER

The hobo spider, sometimes called the aggressive house spider, was first identified in Utah in 1990. The hobo spider is of importance because its bite causes necrotic wounds similar to those of the brown recluse spider.

The hobo spider builds funnel or tube shaped webs. It is a long legged and swift running spider. It has a brown cephalothorax and brown legs. The abdomen has a distinctive pattern of yellowish markings on a grayish background, although this pattern may be hard to see without a microscope.

The complete life cycle of the hobo spider lasts for two years. Hobo spiders prefer to use habitats that have holes or cracks to support their funnel like webs. They are poor climbers and are rarely seen above ground level.

Hobo spiders are most commonly encountered from June through September when males wander in search of females. For this reason, most bites occur during July through September. Males generally have a more toxic bite than females, while

Hobo Spider Dorsal Marking

Hobo Spider Ventral Marking

immature hobo spider bites seem to produce the most serious wounds. Females of the species tend to stay in their webs and are not usually found running about.

The hobo spider is medically important because of its ability to cause necrotic wounds. Necrotic spider bites have been reported in Utah for many years and are usually blamed on the brown recluse spider. As of 2003, only a few specimens of the brown recluse spider have been documented in Utah and these were imported.

The bite of the hobo spider is relatively painless and is reported to feel like a pinprick. Within fifteen minutes of the bite,

numbing sensations may occur at the bite site and other areas of the body and dizziness may occur. After about one hour, reddening around the bite begins and enlarges in area. The bite site becomes hardened and swollen within about 18 hours. Blistering at the bite, visual or auditory disturbances, severe headache, weakness, and joint pains may occur within the first 36 hours.

Within 24 to 36 hours, a discharge of fluids and blistering may occur. After two or three days, the area around the wound may blacken. After seven to ten days, the necrotic area will usually take on a characteristic elliptical shape. Spells of nausea and sweating often persist through this time period and headaches may persist even longer. If a bite is suspected to be that of a hobo spider, seek immediate medical attention. The treatment for all necrotic spider bites is similar.

SPIDER CONTROL

Control methods for spiders are most effective if they include habitat elimination, exclusion, avoidance of risk, and chemical control. Keep shelter materials such as rocks, debris, and trash away from building foundations. Seal cracks and other openings. Apply insecticides to exterior foundations. In cases of interior infestation, insecticides should be selected and applied according to label directions. Sticky traps and glue-boards can be used to detect spiders and provide some degree of control.

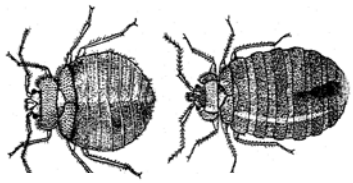
V. OTHER BITING AND STINGING PESTS

TOPIC **PAGE**

BEDBUGS AND BAT BUGS

BIOLOGY AND BEHAVIOR

The human bedbug and its relatives form a small group of bloodsucking pests. Bat bugs are rare in Utah. Bat bugs and bedbugs are characterized by short broad heads. The head is attached to the prothorax and an oval body. The body, as a whole, is broad and flat, enabling the bugs to crawl between narrow crevices. The adults are 1/4 to 3/8 inch long, brown, and wingless. After taking a blood meal, bedbugs change enough in size, shape, and color so as to make them look like an entirely different insect. The immature stages, known as nymphs, resemble the adults in shape, but are yellow-white in color.



Bedbug Bat Bug

The adult female deposits eggs in cracks, crevices, behind woodwork, and in similar locations. Eggs hatch in six to 17 days with 10 days being the average. The newly hatched nymphs feed as soon as food is available. The average time for complete development of bedbugs and bat bugs is 1-1/2 months. Adults can then live for a year or more. The bite of these bugs is often painless, but toxic saliva injected during the bite will later cause severe itching and a large inflamed area often called a weal. This bite can be distinguished from a fleabite by the absence of a red surrounding halo and the presence of a red central area within the inflamed area.

Bedbugs commonly move from one location to the next in infested furniture and bedding. Bedbugs also relocate by way of water pipes, gutters, through windows, along walls, and other such paths. Migrations often occur if a structure is vacated and their food supply is cut off. Populations of bat bugs usually develop on nesting bats, birds, or small mammals before invading living areas through cracks and crevices. Typically, bat bug infestations originate from animal populations established in the attics.

Problems with bat bugs are often severe for a few days or weeks before dying down. This time is short because survival is poor without the natural animal hosts. As an infestation increases, bat bugs and bedbugs will infest other areas of the home or structure.

Indicators of an infestation may also include bloodstains on walls and bed linens, excrement spots, and cast skins from immature stages. An odor resembling the smell of fresh red raspberries is associated with bedbugs but not with bat bugs.

BEDBUG AND BAT BUG CONTROL

Where bedbugs and bat bugs are a problem, the original sites of infestation should be treated. Applications should be concentrated on living areas by treating cracks and crevices and areas around light fixtures and any other place the bedbugs and bat bugs may use to migrate or hide. With bat bugs, exclusion and removal of bats and other hosts in the home or structure should also occur. This last step should be coordinated with insecticide treatments, since an increased movement of bat bugs into the living area may occur after removal of the animals.

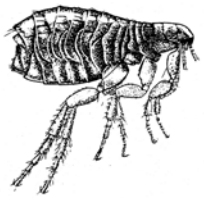
Follow up bedbug and bat bug control with a thorough examination to find hiding places of the insects. Any place offering darkness and protection such as areas behind baseboards, under loose rugs or wallpaper, and in mattresses should be checked. Also examine folds in chairs, beds, and couches. Barn swallows and

their nests are protected by federal and state laws and control of such pests must take into account these regulations.

FLEAS

BIOLOGY AND BEHAVIOR

Fleas are small, wingless insects with a narrow, laterally compressed body. Through their bites, they cause severe annoyance to people and their pets. The majority of the species infest smaller mammals, and while most have developed a high degree of host specificity, a few are found on a variety of hosts.



Flea

A flea's life cycle involves complete metamorphosis and varies with environmental factors. It may be completed in as few as two weeks or as long as a year or more. Females oviposit on the host, where the eggs soon drop, or they deposit eggs directly onto nesting material. The wormlike larvae feed on debris in nests or in animal quarters. Adult fleas can survive long periods without feeding. Flea species which may be found in Utah include the cat and dog flea, the human flea, and the northern rat flea. Problems with fleas are often intensified when pets are removed from the premises.

The human flea and a closely related species have been found in Utah. Their bites can cause dermatitis. Besides feeding on humans, they attack a wide variety of hosts, including swine, dogs, and ground squirrels. The northern rat flea is the species most often found on domestic rats and mice in Utah. It does not readily feed on humans.

Fleas serve as the alternative host for the dog tapeworm. Many of the flea species that infest sylvan animals transmit the plague organism from animal to animal and from animal to man. Thus, they play a role in maintaining a low level of plague in wild rodent populations. The most significant plague hosts in Utah are rock or ground squirrels. Their principal flea is *Diamanas montanus.* It is an aggressive parasite and will readily bite other animals and people.

Pets such as dogs and cats and wildlife, especially ground dwelling rodents, can occasionally develop seriously annoying infestations of fleas. Fortunately, problems in Utah are less frequent than in more humid areas of the country and are usually of short duration. However, a more serious concern in some areas of the state is the ability of fleas to transmit bubonic plague.

Fleabites to humans appear as itchy, red spots, usually surrounded by a red halo. Bites often occur in clusters, especially at the edges of tight fitting clothing. Some individuals are extremely sensitive to fleabites, while others are fairly immune. Humans are not a favored host of fleas and most bites occur when the fleas are starved, such as following a long absence of a pet.

Adult fleas are 1/13 to 1/8 inch in length, reddish-brown, and flat. They are wingless but they can jump. The adult stage of this insect feeds on blood.

Flea eggs are usually laid around areas used by pets. The eggs hatch and a wormlike larval stage follows. It feeds on organic matter such as hair, skin flakes, or blood excreted by the adult fleas. Several months are required for the larvae to complete development. Low humidity prolongs flea development.

FLEA CONTROL

Flea control measures should be directed at all stages of the flea's life cycle. Control of the egg

and larval stages include washing pet bedding and thoroughly cleaning areas where pet hair accumulates. Larval control can further involve use of insecticides applied to cracks and crevices in locations where the pet lives. Among the more effective chemicals are newer insecticides that affect flea growth (insect growth regulators).

The adult fleas on pets can be controlled by use of insecticides applied in shampoos or powders, in collars, and skin applications. There are flea strains that are difficult to control because they have developed insecticide resistance.

In areas where wild rodents harbor fleas that may carry the plague disease organism, control involves dusting of rodent burrows. Rodents such as ground squirrels and rock squirrels that have died suddenly may indicate plague outbreaks. Suspected plague incidents should be reported to the Utah Department of Public Health, Epidemiology.

FLIES

BIOLOGY AND BEHAVIOR

Flies belong to the order Diptera and have two distinguishing characteristics in the adult: (1) one pair of wings (or none) and (2) halteres, which are small knob like structures located behind the wing. Flies undergo complete metamorphosis during their life cycles.

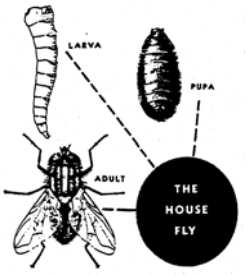
The winged adult stage is most commonly observed feeding on liquids that are usually sponged with their mouthparts. Larval stages of flies are pale legless maggots. After becoming fully grown, maggots often wander from the breeding site in search of a place to pupate. Many flies complete development, egg to larva to pupa to adult to egg, in as little as 7 to 14 days, and numerous generations are completed during a typical season.

Flies are a nuisance during the warm seasons and some flies, such as the cluster fly and face fly, over winter in buildings and are a problem year round. Through sheer numbers, domestic non-biting flies can be a nuisance to people in their work, home, or recreational environment.

Flies that develop in manure or filth, such as houseflies, face flies, and blowflies, are commonly contaminated and can transmit disease causing bacteria. The movement of flies between filth and human food has been associated with several diseases. Besides being annoying, fly species that do bite may transmit diseases such as tularemia. Many species of flies deposit eggs or larvae on the flesh of living animals. These larvae invade the flesh of the host, producing a condition known as myiasis. Myiasis occurs commonly in some wild and domestic animals but not often in humans.

HOUSE FLIES -- *Muscidae*

These are the best known of the domestic flies. They are generally gray in color, with the thorax marked with broad dark strips. Often there is some yellow coloring along the sides differentiating them from the face flies. The adult of this non-biting species occurs commonly in homes. The time for development from egg to adult is from 8 to 20 days, depending on a variety of environmental conditions.



Houseflies are intimately associated with humans and larvae almost always develop in manmade sources of food. The larvae are

found in many types of moist, warm organic material, such as animal manure, human excrement, or garbage that may rot.

The adult flies feed on a wide range of liquid waste. Houseflies can also feed on solid foods, such as sugar, by regurgitating and liquefying the food. Houseflies can be serious health threats because they transmit disease organisms. During mild winters houseflies may continue to fly and breed. Adult flies are usually found within one mile of their larval habitat, although they are capable of dispersing over greater distances. Temperature, light, and humidity all affect fly activity.

LESSER HOUSE FLIES – *Muscidae*

These species of house flies are generally the most prevalent flies found within the home. The adult flies hover in midair in the center of a room or enclosure, lending the name "hover fly" to this group. The larvae live in decaying vegetable and animal matter, including human excrement, animal manure, and rotting grass piles. The average time for larval development is seven days. The larvae of this genus have caused myiasis in humans.

STABLE FLIES – *Muscidae*

This biting fly is found wherever humans and domestic animals occur, attacking both. Larvae are found in decomposing straw, hay, or weeds but rarely in human excrement or animal manure. The time for larvae development averages three to four weeks.

BLOW AND BOTTLE FLIES – *Calliphoridae*

These are metallic green, blue, or black flies that are common throughout Utah. The adult flies of this widespread group enter homes, especially in the fall, where they create a nuisance. The larvae usually feed on animal tissue, but they will infest fresh and decaying plant refuse when animal tissue is not available. Blowflies tend to breed on decaying carcasses and dog droppings. Occasionally, blowfly maggots are found within home if they are present on a dead rodent or bird present in the home. The larvae of many species cause myiasis in animals and humans.

BLACK FLIES -- *Simuliidae*

Only the females in this group are capable of taking a blood meal. The larvae and pupae are found clinging to rocks in the rapids of clear streams. This group occasionally causes severe annoyance to animals (rarely to man) in the vicinity of fast-moving streams. At least one species is known to be a mechanical vector of tularemia. Suitable survey techniques are adult landing or biting counts on animals and larval counts from fast- flowing streams.

DEER AND HORSE FLIES – *Tabanidae*

Like the mosquitoes and black flies, only the females of this fly family feed on the blood of man and animals. Their bites inflict painful injuries. The eggs are deposited near water, allowing the larvae to mature in damp soil and litter. Species of at least one genus serve as mechanical vectors of tularemia. Suitable survey techniques are adult landing or biting rates on animals and soil larval sampling.

FLESH FLIES – *Sarcophagidae*

The adult flies of this large group normally don’t enter homes. The larvae of most species live in animal tissue, although some live in animal manure, especially dog feces.

BITING MIDGES – *Ceratopogonidae*

These tiny adult flies, sometimes referred to as "no seeums or punkies" occasionally cause severe annoyance to man and animals. The larvae live in aquatic or semi aquatic situations or in moist soil. One species is a vector of blue tongue in cattle and sheep. Other species may be vectors of tularemia

FLY CONTROL

Sanitation practices that remove breeding areas are fundamental to control filth breeding flies, such as houseflies and blowflies. Garbage should be regularly removed or covered. Spilled animal feed and manure should be cleaned up.
Screening and other exclusion techniques can be very important to management of indoor fly problems. Openings into homes should be caulked, blocked, or covered to prevent flies from entering. Efforts to exclude flies must be done prior to periods when they enter.

Use of insecticides for fly control should only be considered supplemental to other controls. Insecticide resistant flies are a widespread problem and many fly populations are poorly controlled with insecticides. Spot treatments of insecticides applied to areas of high fly activity are most efficient. Flies that tend to rest in dark corners can be controlled by applications to these areas.

Several types of traps for flies are also available and can supplement other controls. Flypaper and electrocution light traps can kill flies, but these should only be considered for sites where exclusion and sanitation efforts have reduced the fly populations to low numbers. Various bait traps are also offered for sale and can supplement other controls.

LICE

BIOLOGY AND BEHAVIOR

The two species of lice (*Anoplura*) that infest humans are the head or body louse (*Pediculus humanus*) and the pubic or crab louse (*Phthirus pubis*). Other lice species infest other animals, but do not occur on people. Lice that infest humans are small, grayish white ecto-parasites. They spend their entire life cycle on their host except for the body louse, which stays in the seams of clothing when it is not feeding.

Lice undergo incomplete metamorphosis with three stages in their life history: egg, nymph, and adult. They possess piercing, sucking mouth parts which are used to obtain blood meals from their hosts.

LOUSE CONTROL

Louse management requires close, frequent personal attention and rigorous hygiene practices. Commercially prepared remedies are available for elimination of lice. Consult a physician if infestation persists. Head and body lice can exist away from the host for a few days so there is a danger of re-infestation from surfaces of furniture or clothes. Vacuum furniture and dry heat or freeze clothes to remove lice infestations.

This characteristic of the body louse creates the potential for widespread infestations under unsanitary conditions. Head lice may be spread by the shared use of items used or worn on the head. The crab or pubic louse is transmitted primarily through intimate personal contact. Positive identification of lice or their eggs is imperative for effective control.

WASPS, HORNETS, AND BEES

BIOLOGY AND BEHAVIOR

Several different wasps, hornets, and bees are found in Utah and the majority is highly beneficial. Bees, such as the honeybee and leafcutter bee are essential to the pollination of many crops and native plants. Most wasps and hornets are predators of pest insects, feeding them to their developing young. Problems with these insects occur when nests are located near high traffic areas or in buildings. Late summer foraging by yellow jacket wasps can be a serious nuisance problem for outdoor restaurants and other areas where food is served outdoors. Also, wasps and hornets may enter homes and buildings during fall in search of over-wintering shelter.

Honey Bee

Yellow Jacket

SOCIAL WASPS AND HORNETS

Almost all nuisance problems involve social wasps within or adjacent to structures. Social wasps include yellow jackets, European paper wasps, and others. These insects produce new paper colonies or nests each year. Those produced by yellow jackets and European paper wasps are usually located under eves of structures, in holes, or in wall voids.

Bald face hornets make large paper nests among tree branches. Fertilized females over-winter in protected areas, including buildings, and begin to build nests in the spring. As the season progresses, more workers are present to help with colony development and nests rapidly increase in size. By late summer colonies may house hundreds of insects. At this time, the colony starts to break up and many of the large females leave.

Following several hard frosts the nests are completely abandoned. Nests are not reused the following year. Social wasps feed their young protein rich foods consisting mainly insects. Late in the season, food preferences switch to include more sugary materials and they are attracted to soft drinks, syrup, and other materials. During this period, they can be extremely annoying. Almost all stings involve social wasps and hornets.

SOCIAL WASP CONTROL

Destruction of wasp and hornet colonies is fairly easy if the nest can be located. Insecticide dusts are usually most effective for ground nesting yellow jackets, since dust is readily tracked into the colony. Aerial nests are best controlled with use of directed sprays forced into the opening. It is best to use an aerosol formulation that includes a fast acting insecticide such as pyrethrins to knock the insects down, combined with a more persistent insecticide. Colonies often are not completely killed for at least a week after application, since developing wasps and hornets remaining in rearing cells continue to emerge for several days. Early in the morning or in the evening wasp and hornet activity is reduced and this is the safest time to treat their colonies.

Light colored protective clothing is best to avoid stings. In some cases it is safer to wait out wasp and hornets infestations. Colonies are abandoned at the end of the season and if the insects are not too much of a nuisance, problems can be resolved without treatment.

SOLITARY WASPS

Several wasps do not produce a social colony and instead individually rear their young in nests of mud or in tunnels underground. These are

hunting wasps that collect spiders, cicadas, caterpillars, and other prey for their young. Many are highly beneficial. Although the solitary wasps sometimes appear rather fearsome, they rarely sting, and their sting is less painful than the social wasps.

SOLITARY WASPS CONTROL

If necessary, colonies of mud nesting species can be controlled simply by pulling down nests. Residual insecticide sprays can also prevent wasps from nesting.

HONEYBEES

Unlike the social wasps and hornets, honeybees form a semi-permanent colony. Nests are constructed of wax and most colonies are maintained by beekeepers. Honeybees feed on nectar and pollen, which they feed their young and use to produce products such as honey and beeswax. Honeybees also may collect water to cool the hive and plant sap to help seal cracks.

Periodically, overcrowded colonies form swarms that leave the hive. The swarms rest temporarily on a tree or shrub while scout bees search for a nesting cavity. Although the swarms are very striking, the bees are very docile at this time. Most beekeepers are willing to collect honeybees in a swarm.

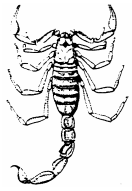
HONEY BEE CONTROL

Problems with honeybees occur when swarming bees find a building wall opening and construct nests in buildings. These nests can sometimes get very large over several years and the removal becomes difficult. Although colonies can be relatively easily killed with insecticides, the wax, honeybee debris, and other hive debris remain behind. The wax can melt with high temperatures and old colonies attract rodents and other pests. As a result, the old colony must be removed, which can require tearing out parts of the wall.

SCORPIONS

BIOLOGY AND BEHAVIOR

Scorpions are easily distinguished by their lobster like appearance with a tail that terminates in a bulbous sack and prominent stinger. The larger front pincers are modified mouthparts and are used to capture and hold prey while feeding. The stinger is used to subdue prey and for defense.
Scorpions are not common in Utah, but they can be found. Scorpions are typically encountered around rocks or debris where scorpions hide during the day. Occasionally scorpions enter homes. Scorpions can produce a painful sting when handled or disturbed. Fortunately, the venom of local species is not considered to be highly dangerous.

Scorpion 

Scorpions have a life cycle of two to five years. They do not lay eggs and the females bare live young seven to 12 months after mating. A female may produce litters of 14 to as many as 100 and the young are carried on the back of the mother until they have molted. The immature scorpions then leave the mother and become mature in about one year.

Scorpions spend the daytime under cover or in burrows in the ground. At night, they emerge to defend their territory and to feed. Since scorpions have poor eyesight, they do not stalk their prey. They lie in wait to ambush insects, spiders, millipedes, and small vertebrate animals.

SCORPION CONTROL

During dry weather, scorpions are attracted to moisture. Scorpions can be discouraged from areas around homes by removing potential cover, such as stones, lumber, and other debris. Sealing entrances into homes can also exclude scorpions. Scorpions fluoresce brightly when exposed to ultraviolet or black lighting. They can be easily spotted from several yards away using this technique.

Outdoor applications of residual insecticides can reduce scorpion problems. Applications should be directed to harborage areas, such as stone piles. It is not necessary to treat grass lawns. Exterior foundation treatments can also help provide additional control.

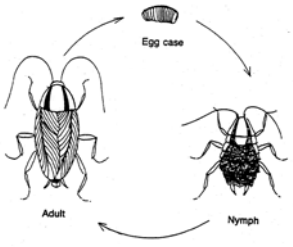
VI. COCKROACH PESTS

COCKROACHES

BIOLOGY AND BEHAVIOR

Cockroaches are oval, flattened, fast moving insects. They have long, hair-like antennae and a broad, saddle-like plate called a pronotum that covers the head. Adult stages of most species have wings, with the front pair of wings being thick and leathery.

Cockroaches go through gradual metamorphosis during their three life cycle stages of egg, nymph, and adult. The eggs are laid in beanlike egg capsules called ootheca, which may contain several dozen eggs. These egg capsules are often dropped around food sources or secured to surfaces. Some cockroaches carry the ootheca during its development.



Cockroach Life-Cycle

The immature stages are called nymphs. Several nymphal stages occur, each separated by a molt. The nymphs generally appear similar to the adult stage, but they lack wings and are smaller. Typically it requires two to three months to complete a life cycle.

Cockroaches are among the oldest known insects, with fossils dating back 200 million years. As a group, cockroaches have shown an exceptional ability to adapt to and survive in a wide range of environments. Most cockroaches can develop on a wide range of food and their flattened body form allows them to move into most areas. Cockroaches have also developed a resistance to many insecticides.

Cockroaches can enter buildings and containers of all kinds. They also may enter around loose fitting doors, windows, through utility lines, and they travel through sewers. Once inside a home, cockroaches

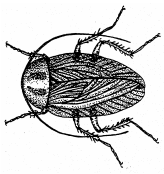
prefer warm, dark, moist shelters and are often found near kitchens and food handling areas. Since cockroaches are nocturnal, they are rarely seen during the day.

Aside from their importance as a household nuisance, they may soil areas with their salivary secretions and excrement, leaving an unpleasant odor. Cockroaches and cockroach parts also produce allergic reactions in some humans. Cockroaches have not been found to be direct carriers of human disease. However, their feeding on filth or disease organisms is why they often contaminate food and utensils. They are suspected of helping to spread diseases such as dysentery, diarrhea, and food poisoning.

Most cockroaches are tropical or subtropical in origin and possess generally harmless habits. A few have developed into serious pests, including several species of cockroaches that have been introduced into Utah.

GERMAN COCKROACH

German Cockroach



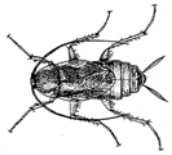
German cockroaches are the most common species in Utah. Adults are pale brown to tan and about 1/2 inch in length. Adults have wings and are distinguished by having two dark stripes that run lengthwise along the pronotum that is located at the back or top of the head. This species has the highest reproductive potential, meaning it is capable of laying the greatest number of eggs in the shortest life cycle, of all the house infesting cockroaches.

Females carry their egg capsule protruding from their abdomen until the eggs are ready to hatch. Females produce four to eight capsules in their lifetime. Each capsule contains 30 to 50 eggs, which hatch in about 28 days at room temperature. The eggs usually die if the mother is killed. Females live an average of 250 days.

German cockroaches are generally found close to moisture and food, such as in kitchens and other food areas, restrooms, and around plumbing fixtures. Infestations found scattered throughout a building, including nonfood areas, indicate very high populations.

BROWN BANDED COCKROACH

Brown Banded Cockroach



Brown banded cockroaches are slightly smaller than the German cockroach and are the smallest cockroach found in Utah, brown banded cockroaches vary from light tan to glossy dark brown in color. The adult stages are marked with two light colored bands at the base of the wings. Brown banded cockroaches usually secure their egg capsules to surfaces in dark areas such as cabinets, chairs, boxes, drawers, and high areas of a building. This is why the eggs are easily transported to new buildings.

Females produce about 14 capsules during their lifetime, averaging 18 eggs in each capsule. Eggs hatch in about 50 to 75 days. The adult female may typically live about 200 days. Brown banded cockroaches tend to scatter thoroughly throughout a building. They prefer areas with temperatures of 80°F or higher. Brown banded cockroaches tend to occur more often in homes, apartments, hotels, and hospitals than in stores or restaurants.

ORIENTAL COCKROACH

Oriental cockroaches are not as common in Utah as the brown banded cockroach and the German cockroach. Adults are about 1 inch in length and dark brown or black in color. Wings of the oriental cockroach are short. Females only have small wing pads, while males have wings that only cover about 3/4 of their abdomen.

Oriental Cockroach

Females drop egg capsules in warm, sheltered areas near a food supply. Each female produces an average of eight egg capsules, each containing about 160 eggs. Under room temperature conditions, eggs hatch in about 60 days. Adult females may live about 180 days. Oriental cockroaches are almost always found around moist, dark sites. Common habitats include floor and storm drains, water meter boxes, around plumbing fixtures, moist crawl spaces, sewers, and around garbage.

Oriental cockroaches are referred to as water-bugs and may be found outdoors during the warmer months of the year. Oriental cockroaches are rather sociable and are often found in clusters. They are seldom found on the upper floors of buildings, high on walls, or in high cupboards.

COCKROACH CONTROL METHODS

The control of cockroaches requires care and planning on the part of the pest manager. Cockroach control also requires that a business or homeowner change the environmental conditions that contribute to infestations.

An infested site should be thoroughly surveyed to determine the extent of infestation and to identify the type of treatments that will be required. Fundamental to this is determining the cockroach species present. Since different cockroach species have differing habits, this will allow treatments to be better targeted. A search should be made of all suspected hiding places. Since cockroaches are rarely active during the day this can be difficult.

Sticky traps can be used to detect cockroach hot spots. Several different types of traps exist and some also contain the sex attractant chemicals used by certain cockroach species. These traps should be placed in areas where cockroach activity is suspected and they should be checked frequently. Traps can also be used to help control cockroaches, but they are not a substitute for other control practices.

Sanitation is fundamental to cockroach control. Any methods that can be used to deny cockroach's food, water, and shelter will greatly aid in control. Cleanliness is essential. Food should be kept in tightly closed containers and should not be left exposed. This includes garbage, food scraps, and pet foods.

Cockroaches need water. Dripping faucets, leaking pipes and other sources of moisture should be eliminated. Bottles and cans collected for recycling should be stored outdoors. Sewer openings should be screened.

It is also important to bar the potential paths of re-infestation. Cracks, crevices, and other

openings should be sealed. Openings should be caulked, blocked, or screened. Items moved into building should be checked for evidence of cockroach infestation.

Several approaches to chemical control are possible. Regardless of the chemical or formulation chosen, applications made near regular hiding places are most effective. Chemical controls usually provide only temporary suppression, especially when they are not combined with a vigorous sanitation effort. Flushing infected sites with pyrethrin sprays can irritate the cockroaches and cause them to move.

Another serious limitation of insecticides is that cockroaches have developed resistance to some of them. Many populations of German cockroaches are no longer susceptible to the insecticides formerly used. Furthermore, cockroaches are repelled by some insecticides and will avoid treated surfaces.

Initial treatments should include a thorough cleanup combined with insecticide spray or dust treatments. Follow up treatments are often required because some cockroaches and cockroach eggs may not be eliminated by a single treatment.

Control chemicals can be oil based sprays, water emulsion sprays, dusts, tracking powders, or baits. The type of treatment should be matched to the conditions of the infestation site. Most treatments involve sprays in order to provide a residual effect. These applications leave a toxic residue on the treated surface that cockroaches pick up when moving across it. The length of time that treatments remain effective varies. It depends on such factors as the concentration of chemical applied, choice of insecticide, and application surface. Two to four weeks of residual activity is fairly typical.

Sprays should be applied to cockroach harborages with emphasis on cracks and crevices. If exposed surfaces are treated, a low pressure spray should be used. Oil based sprays should not be applied near open flames, to tile floors, or onto plants. Water based sprays should not be used near electrical outlets.

Several precautions should be taken when making insecticide applications for cockroach control. Pets should be removed from the treatment areas and aquariums covered. If sprays must be applied to areas where food, cooking utensils, or dishes are stored, these items should be covered or removed prior to spraying. Furthermore, applications around these sites must be limited to cracks and crevices, avoiding exposed surfaces. Also, treatments made near air ducts and ventilation systems should be done with extreme care to avoid air contamination.

Dusts and tracking powders can penetrate hiding areas that sprays may not reach. They are also useful on very rough surfaces or on surfaces that would absorb liquid sprays. Dusts and powders kill by penetrating the insect body or when ingested as the cockroach cleans its antennae and legs. Dusts should be applied as thin films since concentrations may repel cockroaches. Some dusts, such as boric acid, may be applied in water, which quickly dries. To be effective, dusts must remain dry. Dusts are not appropriate for use in areas where they would be unsightly or cause contamination.

Baits are generally long lasting and can be applied to areas that cannot be treated with sprays or dusts. Baits may include an attractant such as peanut butter or syrup in combination with a non-repellent type of

insecticide, such as boric acid. Often, baits may be placed inside small containers to help keep them away from pets and humans. To be effective, baits should be used in small amounts placed in many locations. The effectiveness of baits is dependent on the amount of competing food sources available. If sanitation efforts have not been thorough baits perform poorly.

VII. DOMESTIC RODENT PESTS

TOPIC **PAGE**

The three main domestic or commensal rodents found in Utah are the Norway rat, the house mouse, and the deer mouse. Domestic rodents are the chief vertebrate pests of humans because of their great reproductive capacity and their ability to adapt to new environments.

NORWAY RATS

BIOLOGY AND BEHAVIOR

The Norway rat is the common domestic rat in Utah. It has coarse hair, close set ears, and its muzzle is blunt. The tail is dark on the top and light on the under side. The tail is shorter than the combined length of the head and body.

The fur is gray brown on the back, and gray white on the belly. The adults weigh between 12 and 20 ounces and the combined length of the head and body is 7.5 to 10 inches long. The tail length is between 6 and 8.5 inches. The feces are capsule shaped and about 0.75 inch long.

Norway rats can be found in warehouses, farm buildings, houses, sewers, rubbish, dumps, woodpiles, and building foundations. They are good climbers and they can jump 24 inches vertically. The Norway rat has poor vision but keen senses of smell, touch, taste, and hearing. Long whiskers on the snout serve the sense of touch. Their home range is commonly no more than 100 to 200 feet.

Norway rats and other domestic rodents are mainly nocturnal, but they may go about in undisturbed places during the day. They feed on virtually anything edible, are unable to vomit, and must drink water to survive.

HOUSE MICE

BIOLOGY AND BEHAVIOR

The most common household rodent is the house mouse. Typically this mouse is uniformly gray, has large ears, a pointed muzzle, and a slender body. The tail is uni-colored, has little hair, and is about as long as the head and body combined. Adults weight 0.5 to 0.75 ounce and the combined length of

the head and body are 2.5 to 3.5 inches long. The tail measures between 3 and 4 inches long. The feces are rod shaped, 1/8 to 1/4 inch long.

Although house mice are commonly found living in structures built by humans, they are also well adapted to living outdoors. They are common inhabitants of grassy fields and cultivated grain crops. Wild populations often move into buildings when weather becomes severe. The house mouse has poor vision and is colorblind. Mice have keen senses of smell, taste, hearing, and touch. They use their sense of smell to locate food items and recognize other individual mice.

Mice use their long, sensitive whiskers on the nose and above the eyes as tactile sensors. The whiskers and guard hairs enable the mice to travel easily in the dark. House mice feed on a wide range of foods, although cereals seem preferred over other items. Most mice favor grains. Supplemental food items include foods high in fat and protein, such as lard, butter, nuts, and dried meats.

The two main feeding periods of mice are at dusk and dawn. Because of their small size, mice must feed several times during a 24-hour period. This means that they are active day and night. Their range is normally 10 to 30 feet from the nest.

DEER MICE

BIOLOGY AND BEHAVIOR

The native deer mouse occasionally invades buildings adjacent to fields or woodlands. Deer mice are slightly larger than house mice, ranging from 4.5 to 8 inches in length. Deer mice can be differentiated from house mice by a distinct, bi-colored tail with the darker upper portion being brown or gray and the underside white. Deer mice have a darker upper bodies and lighter undersides, with ears larger than house mice.

The deer mouse is the most common host of the Hantavirus, but other small animals may carry the disease. Hantavirus is a viral illness that is transmitted from saliva, stool, or urine of infected animals. Once these waste products dry, the virus can become airborne. Infection usually results when the virus is inhaled. The illness is described as a severe respiratory illness that results in death for about 50 percent of its victims. Avoid exposure to mouse droppings.

Domestic rodents contaminate food by defecation, destroy structures by gnawing, transmit diseases, and harbor parasites hazardous to humans and animals. Some of the diseases that rodents convey to humans are plague, murine typhus, infectious jaundice, food poisoning, rat-bite fever, and rabies.

PHYSICAL CAPABILITIES OF RODENTS

The Norway rat can:
Gain entrance through any opening that is larger than 0.5 inch square.
Crawl horizontally on any pipe or conduit.
Climb both horizontal and vertical wires.
Climb inside pipes that are 1.5 to 4 inches in diameter and outside of pipes up to 3 inches.
Climb vines, shrubs, and trees or travel along telephone or power lines.
Climb brick or other rough exterior walls that offer footholds.
Jump vertically as much as 36 inches.
Jump horizontally as much as 48 inches.
Jump a gap of 8 feet and greater from an elevation of 15 feet.
Drop 50 feet without being seriously injured.
Burrow vertically in earth to a depth of 4 feet.
Swim as far as 0.5 mile in open water, travel submerged under water, and in sewers.
Gnaw through a wide variety of materials, including lead, adobe brick, cinder block, and aluminum sheeting.

The house mouse can:

Gain entrance through openings slightly larger than 0.25 inch in diameter.
Jump 12 inches horizontally.
Jump against a vertical surface and use it as a springboard to gain additional height.
Jump from a height of 8 feet without injury.
Run up almost any rough vertical surface, including weathered sheet metal and cables.
Run horizontally along wires and small rope.
Travel upside down along hardware mesh.
Swim if needs to, but does not dive below the surface as do rats.

DOMESTIC RODENT CONTROL METHODS

Rodent control may involve the use of several control measures, including cleanup or sanitation, rodent proofing, and the use of toxicants and traps. Sanitation is important for rodent control. The elimination of shelter, food, and water is also important.

Keep grass, weeds, and other vegetation away from buildings. Piles of lumber, rocks, rubbish, and old equipment should be located away from buildings. Information specific to the control of domestic or commensal rodents in and around structures is covered in the Study Guide for Structural Pest Control.

Rodenticides

Both single dose and multiple dose anticoagulant rodenticides are available for rat and mouse control. Finished baits are available in a wide assortment and rodenticide concentrates can be purchased to prepare poison baits.

Pre-baiting

Mice and rats are cautious feeders and may reject new foods or eat only small amounts for the first several days. Conditioning rats to feed on a nontoxic version by pre-baiting can increase acceptance of toxic bait. If acceptance of pre-bait is poor, the bait should be changed. After a pre-bait is accepted the toxic bait should be used.

Single Dose Rodenticides

Single dose rodenticides will give a quick knockdown of rat and mouse populations, and they may be preferred where rats and mice are abundant or where it is hard to get

rats and mice to accept bait for several days in succession because of competing food items.
When rats or mice consume a sub-lethal amount of an acute toxicant, "bait shyness" or "poison shyness" may result. Because of bait rejection problems, single dose poisons should not be used more than twice a year at a given location, and preferably only once.

Multiple Dose Rodenticides

Multiple dose anticoagulant rodenticides are generally considered much safer than single dose rodenticides. When anticoagulant baits are properly formulated bait shyness does not occur. Most anticoagulant rodenticides cause death to mice and rats after several days of feeding. When using anticoagulant rodenticides, fresh bait should be made available for at least two weeks or until all signs of feeding cease.

Bait Selection and Placement

Anticoagulant baits are available in several types. Grain baits in a meal or pellet form are packaged in small plastic, cellophane, or paper packets. These packets keep baits fresh and make it easy to place baits into burrows, walls, or other locations. Rats and mice will readily gnaw into these bags to get at the bait.

Anticoagulant baits that have been formulated into paraffin blocks are also available. These blocks are useful in sewers or where moisture
can cause loose grain baits to spoil. Acceptance of the paraffin-block baits by rats and mice is usually less than acceptance of loose grain baits.

Sodium salts of anticoagulants are available to be mixed with water. Since rats require water daily, they can be drawn to baited water stations. Although mice require little water to survive, water baits used where moisture is scarce can be an effective supplement to other control measures.

The use of bait stations or boxes protects rodenticides from weather and provides a safeguard to people, pets, and other animals. Bait stations should have at least two openings and be large enough to accommodate several rats or mice at one time. Bait boxes should be placed where rats or mice are active. All bait boxes should be clearly labeled "Rat Bait" or "Mouse Bait," as the case may be.

Pest control professionals should keep a written record of the locations of all bait stations so that another person can inspect and replace baits as needed. Records should be kept of activity indicating whether baits have been disturbed, if dead rodents were found, and the observation of droppings or tracks.

Fumigants

Fumigants are often used to control rodents in their burrows in outdoor situations, sometimes in rail cars, and on ships. Fumigants are highly toxic to people and animals and they must not be used in any situation that might expose the occupants of a building to the vapors. Because of the hazards involved with fumigants, only persons licensed for fumigation pest control should use fumigants.

Rodenticide Safety Precautions

All rodenticides present some degree of hazard to animals other than rodents. Persons who formulate rodent baits for their own use should use extreme care in handling the materials. Follow the label directions when handling rodenticide formulations. Wash

thoroughly after preparing baits, using soap and water. Ready to use baits are safer to handle because they reduce risks involved in handling concentrated toxicants.

The carcasses of poisoned rats and mice should be collected using tongs or rubber gloves. The bodies should be disposed by incineration or burial. In instances where there are only a few, they can be placed in a plastic bag and dispose of with other refuse. Remove and destroy all uneaten bait at the end of the poisoning period.

Traps

Trapping can be an effective method of controlling rats and mice. Trapping is recommended where poisons seem inadvisable and it is the preferred method for areas where only a few rodents are present.

Trapping has several advantages:
1. It does not rely on rodenticides.
2. The effectiveness can be observed.
3. Rodent carcasses can be removed, thus eliminating odor problems.

Snap traps are generally more effective than cage traps. Bait rattraps with peanut butter, chocolate candy, dried fruit, or a small piece of bacon tied securely to the trigger. For mice, use bacon, nuts, hard sugar candy, gumdrops, or peanut butter. Leaving traps unset until the bait has been taken at least once reduces the chance of rats or mice becoming trap shy.
Place the traps so that the rats and mice following their natural course of travel will pass directly over the trigger. Use enough traps to make the campaign short and decisive.

Since mice seldom venture far from their shelter and food supply, traps should be placed from 3 to 10 feet apart in areas where mouse activity is noted. Place traps within 20 feet of each other for rats.

Glueboards

Glueboards are an alternative to traps. Glueboards catch and hold mice and rats that step on the surface. Like traps, glueboards need to be placed along the travel path of mice and rats. Glueboards should not be used where children, pets, or desirable wildlife can come in contact. Glueboards lose their effectiveness in dusty areas and temperature extremes may affect the tackiness of the adhesive.

VII. WORKER PROTECTION STANDARD

The U.S. Environmental Protection Agency's Worker Protection Standard (WPS), as revised in 1992, must be complied with when pesticides are used on agricultural establishments, including farms, forests, nurseries, and greenhouses, for the commercial or research production of agricultural plants. The WPS requires employers to provide agricultural workers and pesticide handlers with protections against possible harm from pesticides. Persons who must comply with these instructions include owners or operators of agricultural establishments and owners or operators of commercial businesses that are hired to apply pesticides on the agricultural establishment or to perform crop-advising tasks on such establishments. Family members who work on an agricultural or commercial pesticide establishment are considered employees in some situations.

WPS requirements for employers include:

- **Displaying information** about pesticide safety, emergency procedures, and recent pesticide applications on agricultural sites.
- **Training** workers and handlers about pesticide safety.
- Helping employees get **medical assistance** in case of a pesticide related emergency.
- Providing **decontamination sites** to wash pesticide residues off hands and body.
- Compliance with **restricted entry intervals** (REI)– the time after a pesticide application when workers may not enter the area.
- **Notifying** workers through posted and/or oral warnings about areas where pesticide applications are taking place and areas where REI are in effect.
- Allowing only **trained and equipped workers** to be present during a pesticide application.
- Providing **personal protective equipment** (PPE) for pesticide handlers and also for workers who enter pesticide treated areas before expiration of the REI.
- **Protecting pesticide handlers** by giving them safety instructions about the correct use of pesticide application equipment and PPE and monitoring workers and handlers in hazardous situations.

One of the provisions of the WPS is the requirement that employers provide handlers and workers with ample water, soap, and single use towels for washing and decontamination from pesticides and that emergency transportation is made available in the event of a pesticide poisoning or injury. The WPS also establishes REI and the requirements for PPE. PPE requirements are specified for all pesticides used on farms and in forests, greenhouses, and nurseries. Some pesticide products already carried REI and PPE directions. This rule raised the level of protection and requirements for all pesticide products.

Other major provisions require that employers inform workers and handlers about pesticide hazards through safety training. Handlers must have easy access to pesticide label safety information and a listing of treatment sites must be centrally located at the agricultural facility. Handlers are prohibited from applying a pesticide in a way that could expose workers or other people.
References: *The Worker Protection Standard for Agricultural Pesticides–How to Comply: What Employers Need to Know.* Web site <www.usda.gov/oce/oce/labor-affairs/wpspage.htm>.

VIII. PROTECTING GROUNDWATER AND ENDANGERED SPECIES

INTRODUCTION

Federal and state efforts to protect groundwater and endangered species have resulted in special requirements and restrictions for pesticide handlers and applicators. Pesticides that are incorrectly or accidentally released into the environment can pose a threat to groundwater and endangered species. Whether pesticides are applied indoors or outdoors, in an urban area or in a rural area, the endangered species and groundwater must be protected and state and federal agencies rigidly enforce this requirement.

The need for special action by the pesticide handler/applicator depends on site location. Groundwater contamination is of special concern in release sites where groundwater is close to the surface or where the soil type or the geology allows contaminants to reach groundwater easily. In the case of endangered species, special action is normally required in locations where the species currently live or in locations where species are being reintroduced. The product labeling is the best source to determine if pesticide use is subject to groundwater or endangered species limitations.

The U.S. Environmental Protection Agency (EPA) establishes the specific limitations or instructions for pesticide users in locations where groundwater or endangered species are most at risk. These limitations and instructions may be too detailed for inclusion in pesticide labeling. In such cases the labeling will direct the applicator or handler to another source for instructions and restrictions. The legal responsibility for following instructions that are distributed separately is the same as it is for instructions that appear on the pesticide labeling.

PROTECTING GROUNDWATER

Groundwater is water located beneath the earth's surface. Many people think that groundwater occurs in vast underground lakes, rivers, or streams. Usually, however, it is located in rock and soil. It moves very slowly through irregular spaces within otherwise solid rock or seeps between particles of sand, clay, and gravel. An exception is in limestone areas, where groundwater may flow through large underground channels or caverns. Surface water may move several feet in a second or a minute. Groundwater may move only a few feet in a month or a year. If the groundwater is capable of providing significant quantities of water to a well or spring, it is called an aquifer. Pesticide contamination of aquifers is very troubling, because these are sources of drinking, washing, and irrigation water.

Utah has implemented a comprehensive and coordinated approach to protect groundwater from pesticide contamination. Formulation of the Utah Groundwater and Pesticide State Management Plan is a cooperative effort between federal, state, private agencies, producers, and user groups. It provides a basis for continuing future efforts to protect groundwater from contamination whenever

possible. Furthermore, this plan provides agencies with direction for management policies, regulations, enforcement, and implementation of groundwater strategies.

Utah recognizes that the responsible and wise use of pesticides can have a positive economic impact, yield a higher quality of life, enhance outdoor activities, and give relief from annoying pests. The EPA has authorized the Utah Department of Agriculture and Food (UDAF) to enforce the protection of groundwater from pesticides.

The UDAF, in concert with cooperating agencies and entities, demands strict compliance with all pesticide labels, handling procedures, and usage to protect groundwater in the state.

Prevention of groundwater contamination is important, because once the water is polluted, it is very difficult and costly to correct the damage and in some instances impossible. City and urban areas contribute to pollution because water runoff can contain pesticides. Shallow aquifers or water tables are more susceptible to contamination than deeper aquifers or water tables. Sandy soils allow more pollution than clay or organic soils, because clays and organic matter adsorb many of the contaminants. For more information about what groundwater is and where it comes from, read the study manual

The Federal Insecticide, Fungicide and Rodenticide Act (FIFRA), as amended, establish a policy for determining the acceptability of a pesticide use or the continuation of that use, according to a risk/benefit assessment. As long as benefits outweigh adverse effects, the EPA can continue to register the pesticide. Although the intent of a pesticide application is to apply the pesticide to the target or pest, part of the pesticide will fall on the area around the target or pest. Rain or irrigation water then can pick up the part that is not degraded or broken down and carry it to the groundwater via leaching.

There are many factors that influence the amount of pesticide contamination that can get into groundwater. The major factors are the soil type, soil moisture, persistence in soil, placement of the pesticide, frequency of application, pesticide concentration and formulation, pesticide water solubility, and precipitation. Each of these factors will influence the amount of pesticide that can penetrate the soil surface, leave the root zone, and percolate into groundwater.

Although some pesticides may have a high adsorption quality, when they are applied to sandy soil, they may still migrate to the water table because there are few clay particles or little organic matter to bind them. The management and use of pesticides is up to the individual applicator and/or landowner as to whether safe practices are used. Groundwater is a very valuable resource and it must be protected from pesticide contamination.

PROTECTING ENDANGERED SPECIES

The Federal Endangered Species Act lists the three classifications as endangered, threatened, and experimental. Endangered has the highest level of protection. The phrase “endangered species” is used when referring to these classifications. This Act was passed by Congress to protect certain plants and wildlife that are in danger of becoming extinct. A portion of this Act requires the EPA to ensure that these species are protected from pesticides.

The EPA’s goal is to remove or reduce the threat to endangered species that pesticides pose.

Achieving this goal is a portion of the larger

continuing effort to protect species at risk. Normally these restrictions apply to the habitat or range currently occupied by the species at risk. Occasionally the restrictions apply where endangered species are being reintroduced into a habitat previously occupied.

Habitats are the areas of land, water, and air space that an endangered species needs for survival. Such areas include breeding sites, sources of food, cover, and shelter, and the surrounding territory that provides space for normal population growth and behavior.

Utah's endangered species plan is a cooperative effort between federal, state, private agencies, producers, and user groups. This plan provides agency direction for regulations, enforcement, management policies, and implementation of threatened and endangered species protection strategies.

The EPA launched a major project known as Endangered Species Labeling (ESL). The goal is to remove or reduce the threat to endangered species from pesticides. The EPA has the responsibility to protect wildlife and the environment against hazards posed by pesticides. The ESL program is administered by the U.S. Fish and Wildlife Service (FWS) in the U.S. Department of Interior. The FWS reports to the EPA concerning endangered species. The EPA and the FWS work cooperatively to ensure that there is consistency in the pesticide restriction information provided to agencies and pesticide users.

The UDAF acts under the direction and authority of the EPA to carry out the ESL project as it relates to the use of pesticides in Utah. Many states have web sites with maps designating the habitat boundaries and listings of endangered plants and wildlife.

X. CALIBRATION INFORMATION

Conversion:

Units

One acre = 43,560 square feet square feet	**Example: ½ acre = 21,780**
One mile = 5,280 feet	Example: ¼ mile = 1320 feet
One gallon = 128 fluid ounces	Example: ½ gallon = 64 fluid ounces
One quart = 2 pints = 4 cups = 32 fluid ounces	Example: 2 quarts = 64 fluid ounces
One pint = 2 cups = 16 fluid ounces	Example: ½ pint = 1 cup = 8 fluid ounces
One tablespoon = 3 teaspoons = 0.5 fluid ounces	Example: 2 tablespoons = 1 fluid ounce
One pound = 16 ounces	Example: ¼ pound = 4 ounces
One gallon = 231 cubic inches	Example: 2 gallons = 462 cubic inches

Weights

1 ounce = 28.35 grams
16 ounces = 1 pound = 453.59 grams
1 gallon water = 8.34 pounds = 3.785 liters = 3.78 kilograms

Liquid Measures

1 fluid ounce = 2 tablespoons = 29.573 milliliters
16 fluid ounces = 1 pint = 0.473 liters
2 pints = 1 quart = 0.946 liters
8 pints = 4 quarts = 1 gallon = 3.785 liters

Lengths

1 foot = 30.48 centimeters
3 feet = 1 yard = 0.9144 meters
16 1/2 feet = 1 rod = 5.029 meters
5280 feet = 320 rods = 1 mile = 1.6 kilometers

Areas

1 square foot = 929.03 square centimeters
9 square feet = 1 square yard = 0.836 square meters
43560 square feet = 160 square rods = 1 acre = 0.405 hectares

Speeds

1.466 feet per second = 88 feet per minute = 1 mph = 1.6 kilometers per hour (kph)

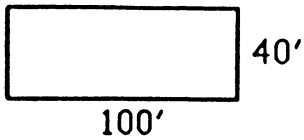
Volumes

27 cubic feet = 1 cubic yard = 0.765 cubic meters
1 cubic foot = 7.5 gallons = 28.317 cubic decimeters

Area and Volume Calculations:

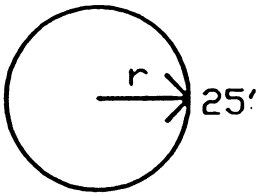
Area of Rectangular or Square Shapes

The area of a rectangle is found by multiplying the length (L) times the width (W).
(Length) x (Width) = Area
Example: (100 feet) x (40 feet) = 4000 square feet



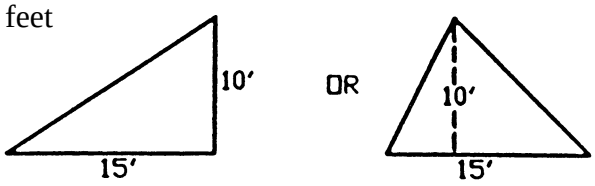
Area of Circles

The area of a circle is the radius (radius = one-half the diameter), times the radius, times 3.14.
(radius) x (radius) x (3.14) = Area
Example: (25 feet) x (25 feet) x (3.14) = 1962.5 square feet



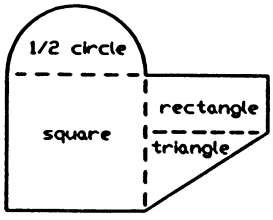
Area of Triangular Shapes

To find the area of a triangle, multiply ½ times the width of the triangle's base, times the height of the triangle.
(½) x (base width) x (height) = Area
Example: (½) x (15 feet) x (10 feet) = 75 square feet

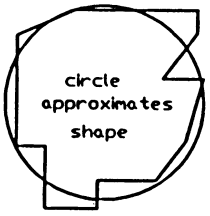


Area of Irregular Shapes

Irregularly shaped sites can often be reduced to a combination of rectangles, circles, and triangles. Calculate the area of each shape and add the values together to obtain the total area.
Example: Calculate the area of the rectangle, triangle, square, and one-half of a circle.



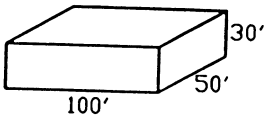
Another method is to convert the site into a circle. From a center point, measure the distance to the edge of the area in 10 or more increments. Average these measurements to find the radius, then calculate the area using the formula for a circle.
Example: Approximate the area by calculating the area of a similarly sized circle.



Volume of Cube and Box Shapes

The volume of a cube or box is found by multiplying the length, times the width, times the height.
(Length) x (Width) x (Height) = Volume

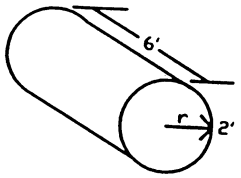
Example: (100 feet) x (50 feet) x (30 feet) = 150,000 cubic feet



Volume of Cylindrical Shapes

The volume of a cylinder is found by calculating the area of the round end (see formula for circle) and multiplying this area times the length or height.

Example: (radius) x (radius) x (3.14) = Area of Circle
(Area of Circle) x (Length) = Volume of Cylinder
(2 feet) x (2 feet) x (3.14) x (6 feet) = 75.36 cubic feet



Sprayer Calibration Formulas:

To Calculate Travel Speed in Miles Per Hour

The travel speed of a sprayer is determined by measuring the time (seconds) required to travel a know distance (such as 200 feet). Insert the values in the following formula to determine the miles per hour.

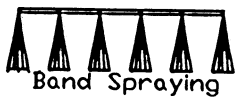
$$\frac{\text{Distance in Feet x 60}}{\text{Time in Seconds x 88}} = \text{Miles Per Hour}$$

Example: $\frac{\text{(200 feet) x (60)}}{\text{(30 seconds) x (88)}} = \frac{12{,}000}{2640} = 4.55 \text{ mph}$

To Calculate the Gallons Per Minute Applied During Broadcast Spraying

The application rate in gallons per minute (GPM) for each nozzle is calculated by multiplying the gallons per acre (GPA), times the miles per hour (MPH), times the nozzle spacing in inches (W); then dividing the answer by 5940. For small adjustments in GPM sprayed, operating pressure is changed. For large adjustments in GPM sprayed, travel speed (miles per hour) is changed or nozzle size is changed.

$$\frac{\text{GPA x MPH x W}}{5940} = \text{GPM}$$



Example: $\frac{\text{(12 GPA) x (4.5 MPH) x (24”)}}{5940} = \frac{1296}{5940} = 0.22 \text{ GPM}$

To Calculate the Gallons Per Minute Applied During Band Spraying

Broadcast spraying applies chemicals to the entire area. Band spraying reduces the amount of area and chemicals sprayed per acre. To use the above formulas for band sprayer applications, use the band width (measured in inches) rather than nozzle spacing for the “W” value.

Pesticide Mixing:

Terminology

The ***active ingredients*** of a pesticide are the chemicals in a formulation that control the target pests. The ***formulation*** is the pesticide product as sold, usually a mixture of concentrated active ingredients and an inert material. Restricted use pesticides are purchased in formulations requiring ***dilution prior to application***. Formulations are diluted with inert substances such as water. The ***percentage of active ingredients*** in a pesticide formulation directly affects dilution and application rates. Given two pesticides, A = 50% active ingredients, B = 100% active ingredients; twice as much pesticide A formulation is required to equal pesticide B formulation.

To Determine the Total Amount of Pesticide Formulation Required Per Tank

To calculate the total amount of pesticide formulation needed per spray tank, multiply the recommended dilution, ounces/pints/cups/teaspoons/tablespoons/etc. of pesticide per gallon of liquid, times the total number of gallons to be mixed in the sprayer. A full or partial tank of pesticide spray may be mixed.

(Dilution Per Gallon) x (Number of Gallons Mixed) = Required Amount of Pesticide Formulation Example: (3 ounces per gallon) x (75 gallons) = 225 ounces

Note: 1 gallon = 128 ounces; through unit conversion 225 ounces = 1.76 gallons

To Calculate the Amount of Pesticide Formulation Sprayed Per Acre

The calculate the total amount of pesticide formulation sprayed per acre is determined by multiplying the quantity of formulation (ounces/pounds/pints/cups/teaspoons/tablespoons/etc.) mixed per gallon of water, times the number of gallons sprayed per acre.

(Quantity of Formulation Per Gallon) x (Gallons Sprayed Per Acre) = Formulation Sprayed Per Acre
Example: (1/2 pound per gallon) x (12 gallons per acre) = 6 pounds per acre

To Calculate the Amount of Active Ingredients Sprayed Per Acre

To calculate the total amount of active ingredients (AI) applied per acre, multiply the amount (pounds, gallons, ounces, etc) of pesticide formulation required per acre, times the percentage of active ingredients in the formulation (100%, 75%, 50%, 25%, etc.), and divide the value by 100.

$$\frac{\text{(Amount of Formulation Required Per Acre) x (Percentage of AI)}}{100} = \text{Active Ingredients Per Acre}$$

Example: $\frac{\text{(4 pounds formulation sprayed per acre) x (75\% AI)}}{100} = 3$ pounds of AI sprayed per acre

Note: 75 % = 0.75

To Calculate the Gallons of Pesticide Mixture Sprayed Per Acre

To calculate the total amount of pesticide mixture sprayed per acre is determined by dividing the number of gallons sprayed by the number of acres sprayed.

$$\frac{\text{Gallons Sprayed}}{\text{Acres Sprayed}} = \text{Gallons Sprayed Per Acre}$$

Example: $\frac{\text{200 Gallons Sprayed}}{\text{10 Acres Sprayed}} =$ 20 gallons of pesticide mixture sprayed per acre

GLOSSARY OF TERMS

A

ACTIVE INGREDIENT - The chemicals in a pesticide responsible for killing, poisoning, or repelling the pest.
ACUTE TOXICITY - Injury within 24 hours following exposure.
AEROSOLS - An extremely fine mist or fog consisting of solid or liquid particles suspended in air. Also, certain formulations used to produce a fine mist or smoke.
ANTICOAGULANT - A chemical that prevents normal blood clotting.
ANTIDOTE - A treatment to counteract the effects of poisoning.
APPLICATION - The process of spreading something on or over the surface of objects or materials.
ARTHROPOD - Invertebrate animals such as insects, spiders, ticks, and crayfish of the phylum Arthropoda. They have segmented bodies and jointed appendages.
ATTRACTANT - A substance or device that will lure pests to a trap or poison bait.

B

BACTERIA - Microscopic organisms, some of which are capable of producing diseases in plants and animals.
BAIT - A food or other substance used to attract a pest to a pesticide or trap.
BIOLOGICAL CONTROL - Control of pests by means of predators, parasites, disease-producing organisms or competitive microorganisms.
BIOLOGICAL TRANSMISSION - Biological transmission of disease occurs when an arthropod like a tick or mosquito picks up the disease from one host and transmits the disease to another host.

C

CAST SKIN - The shed skin of a nymph or larva also called an exoskeleton.
CEPHALOTHORAX - The combined head and thorax of spiders.
CHRONIC TOXICITY - Injury or illness beyond 24 hours following exposure due to prolonged or repeated exposure.
COMPLETE METAMORPHOSIS - Insect stages in life cycle are: egg, larva, pupa, and adult. The larva does not look like the adult and often has a different food source than the adult.
CONCENTRATION - The amount of active material in a given volume of diluent.
CONTACT REPELLENT - A compound that the pest must make contact with for the substance to repel pest.
CONTAMINATION - The presence of an unwanted substance in or on plants, animals, soil, water, air, or structures.
CULTURAL CONTROL - A pest control method that includes changing sanitation and/or work practices.

D

DECONTAMINATE - To remove or break down a chemical from a surface or substance.
DEFECATE - To discharge feces from the anus.
DERMAL TOXICITY - Injury when absorbed through the skin.
DIAGNOSIS - The identification of the nature or cause of problem or fault.
DOSE OR DOSAGE - Amount or rate of chemical applied to a given area or target.
DUSTS - Pesticides that are non-liquid and comprised of fine particles

E

ECOSYSTEM - The physical and biotic factors that allow infestation by pests.
ECTOPARASITE - A parasite that lives on the outside of its host.
ENDANGERED SPECIES - Legally classified as a species in danger of extinction.
ENDOPARASITE - A parasite that lives inside its host.
ERADICATION - Pest management strategy that attempts to eliminate all members of a pest species.
EVALUATION - To examine or investigate for the purpose of judging the value, extent, or success.
EXPOSE - To be subjected to or come in contact with a material.
EXPOSURE ROUTE - The dermal, oral, or inhalation (respiratory) route by which a substance may enter an organism.
EXTERNAL PARASITE - An animal smaller than its host that lives upon the outside of its host for at least part of its life cycle.

F

FOGS - Pesticide sprays composed of very fine droplets from 0.1 to 50 microns in diameter. Fogs remain suspended for a long period of time.
FORMULATION - Pesticide as prepared by the manufacturer.
FUMIGANT - Pesticide that controls by giving off fumes.

G

GRADUAL METAMORPHOSIS - Insect stages in life cycle are: egg, nymphs, and adult. The nymph often looks like the adult but the nymph is wingless. Also, the nymph often feeds on the same foods as the adult.
GROUNDWATER - Water sources located beneath the soil surface from which water is obtained.

H

HARBORAGE - A site that shelters and provides the food and water required for a particular organism to survive.
HARD TICK - The most common ticks in Utah. These ticks have a hard top side which can expand when feeding.
HOST - Plant or animal that is invaded by a parasite and from which the parasite gets its nutrients.

I

INERT INGREDIENT - In a pesticide formulation it is an inactive material without pesticidal activity.
INHALATION TOXICITY- Injury when inhaled.
INSECT - Any of the class Insecta of arthropods with well defined head, thorax, abdomen, 6 legs, and typically 1 or 2 pairs of wings.
INSPECTION - A critical examination and evaluation aimed at forming a judgment or determination.
INTEGRATED PEST MANAGEMENT (IPM) - A planned pest control program in which various techniques are used to keep pests from causing economic, health related, or aesthetic injury.
INTERNAL PARASITE - An animal that lives within the body of its host for at lease a portion of its life cycle.

L

LEACHING - Process by which some pesticides move through the soil.
LEGAL STATUS - Classified such that it is permitted or allowed by law.

M
MECHANICAL TRANSMISSION - Occurs when the insect transports disease organisms on their feet, body hairs, and other body surfaces. There is no multiplication or development of the disease causing organism within the insect's body.

MIST - Pesticide sprays composed of droplets 50 to 100 microns in diameter. Particle size is sufficient to settle fairly rapidly, but still remain suspended long enough to be effective.
MOLT - Molting in insects is the shedding of the outer skin or exoskeleton in order for the insect, usually a nymph or larva, to grow bigger or become an adult. The shed skin is called a cast skin.

N

NONLETHAL – Not capable of causing death.
NONTARGET ORGANISM - Any plant or animal other than the intended target of a pesticide application.
NYMPH - An immature insect with gradual metamorphosis. The nymph will likely feed on the same food as the adult, will likely look like the adult but will not have wings and be smaller. The nymph will go through two or more molts, becoming larger with each molt, and reach adulthood and adult size.

O

ORAL TOXICITY – Injury when taken by mouth.
OVIPOSITOR - Egg laying organ of the female insect.

P

PARASITE - An organism that lives on or in a living host and that gets all or part of its nutrients from the host.
PASSIVE TRANSMISSION - The passing of disease vectors occurring without being active or direct.
PATHOGEN - Any organism capable of causing disease.
PERCOLATE - To pass slowly through a material or spread throughout a place.
PERSISTENCE - To have a continued or prolonged effect after treatment.
PESTICIDE - Any substance or mixture of substances intended for defoliating or desiccating plants, preventing fruit-drop, inhibiting sprouting, or for preventing, destroying, repelling, or mitigating any insects, rodents, fungi, bacteria, weeds, or other forms of plant or animal life or viruses, except viruses on or in living man or other animals.
PHOTOLYTIC DECOMPOSITION - Chemical decomposition or breakdown by sunlight.
PHYTOTOXICITY - Injury to plants by a chemical.
POLLUTION - The act of polluting or contaminating the environment with harmful chemicals or waste products.
PRECIPITATION - The formation of a suspension of an insoluble compound by mixing two solutions.
PREDATOR - An animal that attacks, kills, and feeds on other animals.
PRESCRIPTION - A proven formula for the control of pests.
PREVENTION - An action that makes it impossible or very difficult for an unwanted activity to happen.
PROBOSCIS - Any extended structure of the mouthparts.

R

RATE OF APPLICATION - The amount of pesticide applied, usually measured as per acre, per 1,000 square feet, per linear foot, or per cubic foot.
RE-ENTRY INTERVAL - The length of time following an application of a pesticide when entry into the areas is restricted.
REPELLENT - A compound that keeps pests away.
RESERVOIR - An organism in which a parasite that is pathogenic for some other species lives and multiplies without damaging its host.
RESERVOIR HOSTS - One or more hosts harboring a disease causing organism over an extended period of time without showing symptoms of the disease.
RESIDUAL - Leaving a residue that remains effective for some time.
RESIDUAL SPRAY - A pesticide spray that leaves a residue that remains effective for some time.
RISK - A probability of an adverse effect in a given situation.

S

SIGNAL WORDS - Required word(s) that appear on every pesticide label to denote the relative acute toxicity of the product.
SOFT TICK - Ticks without a hard top such as the spinose ear tick.
SOLUBILITY - The extent to which one substance is able to dissolve in another.
SURFACE WATER - Water on the earth's surface in rivers, lakes, ponds, streams, etc.

T

TARGET - The plants, animals, structures, areas, or pests at which the pesticide or other control method is directed.
TOXIC - Poisonous to living organisms.
TOXICITY - The degree or extent to which a chemical or substance is poisonous.
TUMBLERS - Mosquito pupae that tumble to the bottom of their liquid habitat when disturbed or to flee predators.

U

ULV - Ultra Low Volume - This type of spraying is the application by aircraft or ground equipment of technical insecticide at a dosage rate specified on label.

V

VECTOR - An animal that can carry and transmit a pathogen.
VECTORIAL CAPACITY - The potential of a vector to transmit disease pathogens.
VERTEBRATE ANIMAL- Animal with a segmented backbone and spinal column.
VIRUS - Ultramicroscopic parasites that can multiply only in living tissues and cause many animal and plant diseases.

W

WATER TABLE - The upper level of the water saturated zone in the ground.
WIGGLERS - Mosquito larvae that wiggle through the water.