Community Insect Management

Category 7D

Iowa Commercial Pesticide Applicator Manual

IOWA STATE UNIVERSITY
Extension and Outreach

CS 22 Reprinted June 2015

About this Manual

This manual was prepared for use in Iowa pesticide applicator training programs. It is intended to provide the information needed to meet the minimum U.S. Environmental Protection Agency and Iowa Department of Agriculture and Land Stewardship (IDALS) standards for certification of commercial pesticide applicators under the Federal Insecticide, Fungicide, and Rodenticide Act (FIFRA). This manual is also intended to prepare the prospective applicators for an examination to be administered by IDALS. It is intended for use as a supplement to the Iowa Core Manual (IC 445).

This manual does not provide all of the information you need for safe and effective use of pesticides. Carefully read and understand the product label for each pesticide you intend to use. Labels list directions, precautions, and health information. **If information on a current pesticide label conflicts with information in this manual, follow the label**. In addition, pesticide manufacturers supply information about products registered for use in Iowa.

Acknowledgments

This work was prepared by Ken Holscher, Extension Entomologist, and Mark H. Shour, Program Specialist, Pesticide Safety Education Program (PSEP), Iowa State University Extension.

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Issued in furtherance of Cooperative Extension work, Acts of May 8 and June 30, 1914, in cooperation with the U.S. Department of Agriculture. Cathann A. Kress, director, Cooperative Extension Service, Iowa State University of Science and Technology, Ames, Iowa.

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1
Manual Overview

Purpose of this Manual

This manual is for individuals to become certified in commercial pesticide applicator Category 7D, Community Insect Management. The purpose of this manual is to provide general information on the most common flies in Iowa communities, their biology, and current management techniques.

Information in this manual will supplement that of the Iowa Core Manual (IC 445), with specific information on pesticide safety, the environment, and equipment and application techniques. This manual should not be used for certification purposes without reference to the Iowa Core Manual.

Introduction to Community Insect Management

Mosquitoes and other flies are common in and around Iowa communities. In large numbers, these insects may become pests because they bite and are a public nuisance. Certain species of mosquitoes also may transmit diseases to humans and animals. Although individual homeowners can take steps to minimize the growth and proliferation of mosquitoes and other nuisance flies on their property, the steps they take cannot completely eliminate the problem. A community-wide management program conducted by trained personnel is most effective. The administration of such a program must be flexible and based on pest management principles, taking into account the pest's life cycle, behavior, abundance, and public health significance.

2
Mosquitoes

Learning objectives

After studying this chapter, you should be able to

- Describe how mosquitoes differ from other insects.
- Define "wigglers" and "tumblers"
- Differentiate the four important species of mosquitoes in Iowa by appearance, biology, breeding sites, nuisance, and disease transmission.
- Explain why the Asian tiger mosquito is of potential importance in Iowa.

Figure 2.1. An adult female mosquito. Credit: en.academic.ru

Figure 2.2. An adult crane fly. Credit: Piccolo Namek, Wikipedia.org

Appearance and Characteristics

Adult mosquitoes are small, fragile insects with slender bodies (Figure 2.1). They have one pair of narrow wings and three pairs of long, slender legs. Coloration is generally brown to black with some species having distinctive white markings on the thorax, abdomen, or legs. Mosquitoes vary in length from $\frac{3}{16}$ to $\frac{1}{2}$ inch (5 to 13 mm) depending on the species.

Adult mosquitoes have an elongated **proboscis** with piercing mouthparts. The female mosquito uses these mouthparts to penetrate the skin of animals and feed on the host's blood. Male mosquitoes feed only on plant nectar.

Mosquitoes are often confused with other similar insects, such as crane flies and midges (Figures 2.2 and 2.3). The presence of an elongated proboscis and scales on the veins of the wings are found only on mosquitoes.

Biology

Most insects have three body regions (**head, thorax,** and **abdomen**), three pairs of segmented legs, and one pair of antennae. An insect's leg is composed of the coxa (near body), femur, tibia, and **tarsus** (foot). Mosquitoes undergo a **complete metamorphosis** life cycle, consisting of four stages: egg, **larva, pupa,** and **adult**.

The eggs, larvae, and pupae must have standing water to complete their development (Figure 2.4). The type of standing water, however, varies with the species of mosquito. Some species prefer to develop in permanent water sources such as marshes, waste lagoons, catch basins, ponds, and the shallow margins of lakes and reservoirs. Other species prefer the water that collects in tree holes, unmounted tires, cans, clogged gutters, or other artificial containers. Still others develop in temporary pools of rainwater. Collectively, these can be called **breeding sites**.

Figure 2.3. Non-biting midge, *Chironomus plumosus*. Credit: en.academic.ru

Figure 2.4. A small body of water, such as a pond, is an ideal site for mosquito breeding. Credit: Woodcotecg.org.uk

Following a blood meal, female mosquitoes lay their eggs on the water surface or in places where water is likely to accumulate. These eggs may be laid singly or in batches of 50 to 400. Mosquito eggs are elongated, approximately 1/40 inch (0.6mm) in length, and are dark brown or black just prior to hatching. The eggs of most mosquitoes hatch in 2 to 3 days, whereas others require a drying period. These may remain dormant for many months and hatch minutes after being flooded by rain.

Mosquito larvae, or "**wigglers**," hatch from the eggs and feed on bits of organic matter in the water. Larvae also spend considerable time on the water surface where they take in oxygen through a specialized breathing tube (Figure 2.5). There are four larval growth stages called **instars**. Larvae look similar in all the instars, except for their size. Larval development can be completed in as little as 7 to 10 days during the summer, after which larvae molt into pupae.

Figure 2.5. Mosquito larva with siphon tube contacting water surface, allowing oxygen intake. Credit: FMEL IFAS.EDU

Mosquito pupae are comma shaped (Figure 2.6) and cannot feed. They are often referred to as "**tumblers**" because of their characteristic tumbling motion when disturbed. In summer, adult mosquitoes emerge from the pupal stage in 2 to 3 days. After an additional 1 to 2 days, female mosquitoes are ready to take their first blood meal.

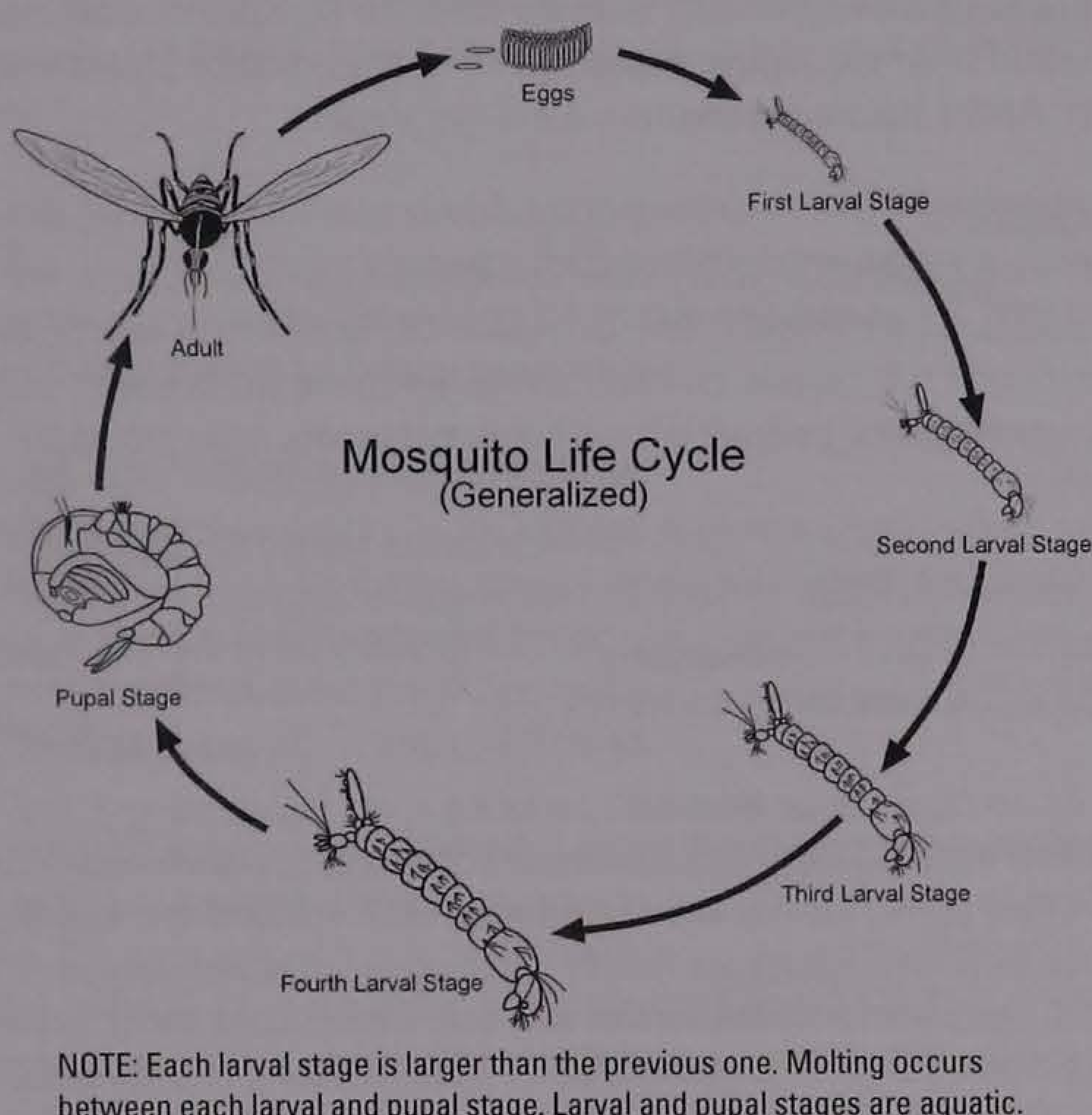

Figure 2.6. Generalized mosquito life cycle. Credit: Purdue University Entomology

Time required to complete the mosquito life cycle (Figure 2.6) may be as short as 10 days or as long as 7 months, depending on environmental conditions. Some mosquito species have a single generation each year, while other species may produce 4 or more generations each year.

Important Iowa Species

More than 40 species of mosquitoes have been recorded in Iowa. Most of these occur in relatively small numbers and pose little concern for Iowa residents. A few species, however, are of concern because they can produce large populations throughout the summer, or because they have the potential to transmit diseases to humans and animals.

Aedes vexans

Figure 2.7. Inland floodwater mosquito, *Aedes vexans*. Credit: Marlin Winfield IL, www.cirrusimage.com

This medium-sized, brown mosquito has narrow rings of white scales on the third tarsi and a V-shaped notch at the middle of each band of white scales on the upper surface of the abdomen. *Aedes vexans* breeds in rain pools, floodwaters, roadside puddles, and nearly all temporary bodies of fresh water. This is the principal pest mosquito in Iowa (Figure 2.7).

Eggs are laid on the ground above the waterline and hatch when flooding occurs. Larvae can be found in large numbers. In receding waters, 500 or more larvae may be found in each pint of sampled water. Development through the immature stages takes 10 days to 3 weeks, depending on the temperature.

Adult mosquitoes can disperse long distances from their breeding areas, with flights of 5 to 10 miles (8 to 16 km) being common. Adults are vicious biters and are especially annoying at dusk and after dark. During the day, adults rest in grasses and other vegetation. Adults live for nearly 2 months and are attracted to lights. *Aedes vexans* overwinters in the egg stage.

Culex pipiens

Figure 2.8. Northern house mosquito, *Culex pipiens*, laying an egg raft. Credit: Susan Ellis, Bugwood.org

Except for cross bands of white scales on the abdominal segments, this mosquito has no prominent markings (Figure 2.8). Breeding areas for *Culex pipiens* include rain barrels, tin cans, unmounted tires, storm-sewer catch basins, street gutters, polluted ground pools, **cesspools**, and open septic tanks.

Eggs are laid in clusters of 100 to 400 on what are known as egg rafts, which float on the water surface. Development through the immature stages requires 8 to 10 days in warm weather. This development may take 2 weeks or longer in the early spring or late fall.

Adults do not disperse far from their breeding areas except when large populations are produced. This species is active only at night and can be found resting during the day in and around houses, outbuildings, and other protected locations. Adults are readily attracted to lights and commonly enter houses. Culex pipiens overwinters as an adult. It is of public health importance because it can transmit **Flanders virus**, **St. Louis encephalitis**, **West Nile virus**, and **western equine encephalitis**.

Culex tarsalis

Figure 2.9. Western encephalitis mosquito, *Culex tarsalis*. Credit: Joseph Berger, Bugwood.org

This medium-sized, dark brown mosquito has a band of white scales at each end of the tarsal segments and a conspicuous, broad, white band at the middle of the proboscis (Figure 2.9). Breeding areas for *Culex tarsalis* include both clear and polluted water sources such as marshes, rain pools, floodwater pools, roadside ditches, cesspools, cans, rain barrels, ornamental ponds, and irrigation wastewater.

Eggs are laid in rafts of 100 to 150 eggs, which float on the water. In summer, the entire life cycle takes about 2 weeks.

Culex tarsalis adults are persistent biters and are active from dusk to dawn. During the day, adults can be found resting in sheltered areas such as vegetation, in buildings, under bridges, and in animal burrows. Adults may disperse up to 10 miles, although most remain within a mile of their breeding area. Adults are readily attracted to lights and commonly enter houses. This species overwinters as an adult. It is of public health importance because it can transmit St. Louis encephalitis, West Nile virus, and western equine encephalitis.

Figure 2.10. Adult *Ochlerotatus trivittatus*. Credit: John R. Maxwell, Marlton, NJ; BugGuide

Ochlerotatus (Aedes) trivittatus

The upper surface of the thorax of *Ochlerotatus trivittatus* is marked with two conspicuous white stripes (Figure 2.10). This species is a fierce biter and can be extremely annoying.

Larvae occur mainly in floodwater pools or temporary rain pools. Young larvae feed at the water surface, while older larvae conceal themselves in vegetation at the bottom of the pool. Larvae are seldom encountered even though adults can be present in large numbers. In summer, adults emerge 8 days after the eggs hatch.

Adults bite mainly in the evening and rest in grasses and other vegetation during the day. Adults do not disperse far from their breeding area. *Ochlerotatus trivittatus* overwinters in the egg stage. It is of public health importance because it can transmit **La Crosse encephalitis**.

Figure 2.11. Adult Asian tiger mosquito, *Aedes albopictus*. Credit: Susan Ellis, Bugwood.org

Species of Potential Importance

Society is more mobile today and, as a result, faces new threats from exotic mosquito species, such as *Aedes aegypti, Aedes albopictus,* and *Aedes atropalpus*. These mosquito species become established in new areas through the importation and subsequent distribution of articles that harbor mosquito eggs, especially in automobile tires.

Aedes albopictus, commonly referred to as the Asian tiger mosquito, is the exotic species causing the most concern among state and national health officials. The adult is a relatively small, black mosquito with a distinctive single white band down the length of the thorax (Figure 2.11). This species was first reported in the United States in Houston, Texas in 1985. Since then, it has spread to other parts of the country and is well established in most south central and southeastern states.

Figure 2.12. Tire dump, a prime breeding site for Asian tiger mosquitoes. Credit: jmctirerecycling.com

Adult Asian tiger mosquitoes are aggressive, persistent biters that prefer to feed during the day. Although they may develop in any type of artificial container, this mosquito species seems to prefer the water that collects in stacked or discarded tires (Figure 2.12). *Aedes albopictus* poses a considerable public health concern because it can transmit **dengue, dog heartworm, yellow fever**, and La Crosse encephalitis.

3
Mosquito Management Programs

Learning objectives

After reading this chapter, you should be able to

- Explain the importance of public awareness in a community mosquito management program.
- Discuss the role of surveillance in a successful management effort.
- List several practices that can be used to eliminate or reduce mosquito breeding sites.
- Differentiate between the three types of products used to control larval mosquitoes.
- Recognize the five application techniques to control adult mosquitoes by their strengths and weaknesses.
- Explain the importance of evaluation in a community mosquito management program.

Overview

Effective mosquito management requires a well-planned program. Such programs often are expensive, complex, and require the cooperation of individual property owners, industry and agriculture groups, and local and state governments.

A mosquito management program may be justified when it can be demonstrated that mosquito annoyance prevents the reasonable use of yards, gardens, and parks. Beginning a program is also justifiable when mosquito populations pose health problems beyond the reasonable control of individual property owners.

City or municipal employees, private pest control companies, or organized mosquito abatement districts may carry out mosquito management programs. The four major components of a successful mosquito management program are public awareness, surveillance, implementation of management techniques, and program evaluation.

Public Awareness

An effective community mosquito management program includes public education for the program's understanding and support (Figure 3.1). The educational program should include justification or need for a mosquito management program, the methods that will be used in the process, and the name of the agency or company that will conduct the management program. Providing the community with a contact person and telephone number is always helpful.

Figure 3.1. Public meeting. Photo credit: Yosemite EPA.GOV.

Informing the public on how they can cooperate can significantly reduce mosquito populations in the community. One key item is the elimination of mosquito breeding sites on each property. This action is important if extensive breeding of *Culex pipiens* or *Culex tarsalis* is occurring in artificial containers on private property.

Surveillance

Monitoring of breeding sites and mosquito populations is a prerequisite for any community mosquito management program (Figure 3.2). Information gathered through surveillance helps eliminate breeding sites where possible, target other breeding sites for treatment, and determine the effectiveness of the management program.

Figure 3.2. Mosquito larvae (wigglers) in sampling dipper. Photo credit: Adamweb.net.

Drawing a survey map of the area to be included in the program is the first step in surveillance (Figure 3.3). This map should include all permanent water sources that may serve as mosquito breeding sites. These water sources should be routinely monitored during the mosquito season for developing mosquito larvae. Sites should be scheduled for treatment if larvae are present in sufficient numbers.

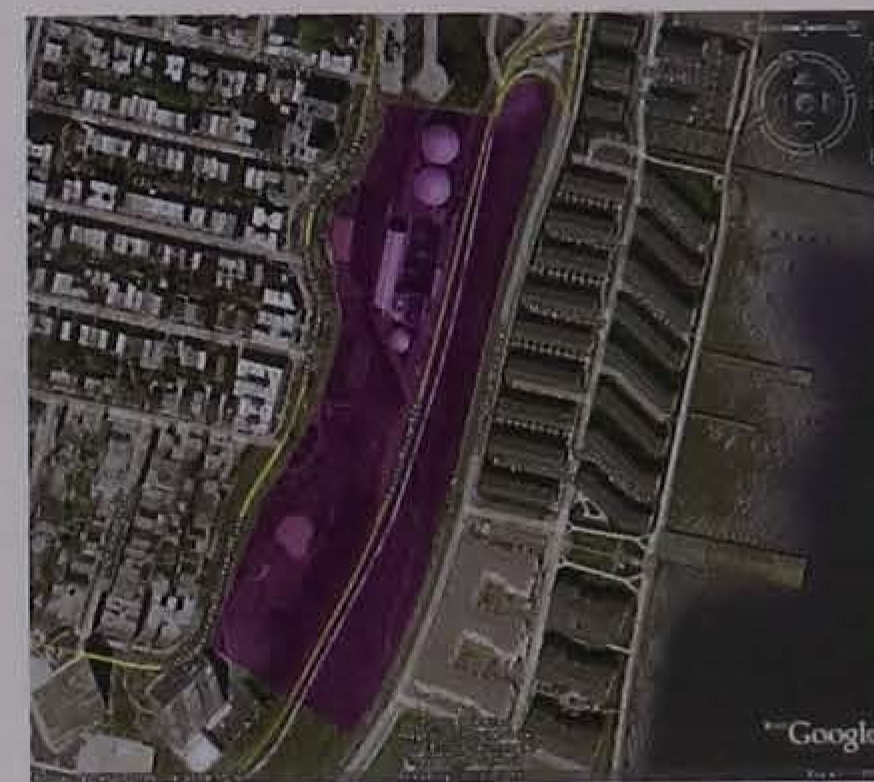

Figure 3.3. Arial treatment map. Photo credit: Armenians.net

The survey map also should indicate temporary water sources that develop following rainfall events. If possible, these sites should be eliminated. If this is not possible, these temporary water sources should be monitored 3 to 4 days following rain for mosquito larvae. If larvae are present in sufficient numbers, these sites also should be scheduled for treatment.

Survey data also can be collected on adult mosquito populations by using light traps. Ideally, adults collected in the **insect light traps** (Figure 3.4) should be identified to species. This information can provide valuable information about the potential types of breeding sites. Then the breeding sites should be located, surveyed for mosquito larvae, and either eliminated or treated.

Figure 3.4. Light trap for sampling adult mosquitoes. Photo credit: U.S. Army Photo, Sgt. Joshua Risner, 211 MPAD, MND-B

Unfortunately, most communities do not have the necessary equipment, resources, or expertise to identify mosquito species. Light-trap data, however, still can be used to determine the effectiveness of the mosquito management program. The number, not the species, caught measures a program's effectiveness. As an example, low light-trap collections indicate effective implementation of the program. In contrast, steadily or dramatically increasing light-trap collections indicate a problem in the program, which may be the result of the establishment of new breeding sites, timing of treatment, location of the treatment, improper application, improper equipment calibration, or ineffectiveness of the products used.

Management Techniques

Source Reduction and Habitat Alteration

Water management to prevent mosquito breeding is a crucial element in the success of a mosquito management program. **Source reduction** refers to the elimination of breeding sites (Figure 3.5). This is the most permanent form of mosquito management. Under no circumstances, however, should a major body of water be eliminated 1) until it has definitely been determined that mosquitoes breed there in sufficient numbers to cause problems, 2) until the impact to the environment without the water body has been determined, or 3) without a careful examination of possible state or local ordinances.

Figure 3.5. Example of a prime mosquito-breeding site. Aquatic weeds and mowing operations that discharge clippings into pond provide organic matter for development. Photo credit: Nancy Loewenstein, Auburn University, Bugwood.org

Altering the habitat to reduce mosquito breeding is an alternative when elimination of the site is not feasible. For example, clearing a shoreline of vegetation that is providing natural shelter for mosquito larvae can reduce breeding at the site. Eliminating a source of organic pollution at a breeding site deprives mosquito larvae of vital nutrients; this also provides an environment in which mosquito predators can become established.

Figure 3.6. Cleaning roadside ditch to improve water drainage. Photo credit: Destinationknowlton.com

Figure 3.7. Rainwater standing on flat-roofed building. Photo credit: M.H. Shour, Iowa State University Extension

Figure 3.8. Pond bank mowing. Photo credit: VentraCompactTractors.Wordpress.com

Figure 3.9. Bluegill, a predator of mosquito larvae and pupae. Photo credit: USBR.gov

Other examples of practices that may be used to eliminate or reduce mosquito breeding include the following:

- Clean ditches and stagnant streams to ensure a continuous flow of water, thereby eliminating border vegetation that provides habitat for larval development (Figure 3.6).
- Check flat roofs following rains, making certain no water remains for more than 1 week (Figure 3.7).
- Avoid excessive irrigation of parks, lawns, or gardens to prevent puddling in low areas.
- Eliminate water-holding tree stumps.
- Keep grass mowed around pools and other bodies of water, taking care to keep clippings out of the water (Figure 3.8).
- Maintain ponds and lakes according to good management practices. Such bodies of water should have steep, clean shoreline with as little vegetation as possible. Aquatic herbicides may be used in some cases to eliminate or prevent emergent plant growth.
- Stock ponds and lakes with any surface-feeding minnows, such as bluegills (Figure 3.9) and green sunfish.
- Clean roof gutters to prevent water accumulation (Figure 3.10 A).
- Remove and dispose of cans, old tires, buckets, jars, barrels, and other artificial containers that may fill with rainwater (Figure 3.10 B, D).
- Place tight covers over cisterns, cesspools, septic tanks, fire barrels, rain barrels, and tubs where water is stored (Figure 3.10 C).
- Drain and fill tree holes that may collect and hold rainwater (Figure 3.10 E).
- Drain or fill stagnant water pools, puddles, ditches, or swampy areas (Figure 3.10 F).
- Clean swimming pools regularly (Figure 3.10 G).
- Although the western mosquitofish, *Gambusia affinis*, has been used worldwide for mosquito control, it is invasive and consumes eggs of other fish species, as well as tadpoles of various amphibians. Check with Iowa Department of Natural Resources about the use of this species in a pond ecosystem.

Figure 3.10. This page provides examples of mosquito breeding areas that should be cleaned up to improve mosquito management. A. Clogged roof gutter; B. Stagnant water in bird bath; C. Rainwater barrel; D. Cattle watering trough, E. Tree hole with stagnant water; F. Stagnant water and sewage following a local flood; G. unkempt swimming pool. Photo credits: A-C. M.H. Shour, Iowa State University Extension; D. Galveston, TX. US. E. Shirley Apeksan, Picasa Web; F. Kingston Springs, Wordpress.com; G. Maderamosq.org

Strategies Aimed at the Larval Stage

Mosquito-breeding sites that are impossible to alter or eliminate can be treated with an approved **insecticide** to kill developing mosquito larvae. This form of mosquito management is called **larviciding**.

Figure 3.11. Larvicide treatment. Photo credit: Co.Galveston.TX.US

Larviciding is a logical management approach because it is applied at the only time in the mosquito's life cycle when it is confined, concentrated, and most vulnerable. Before applying any insecticide to a body of water, however, it should be sampled for mosquito larvae. If sufficient numbers of mosquito larvae are found, an approved insecticide should be applied immediately (Figure 3.11). If there are insufficient larval numbers, no treatment should be made and the site should be monitored weekly.

Products available for larviciding include some insecticides, insect growth regulators, and bacterial pathogens. These products differ in the speed and way that they kill mosquito larvae, and their effects on nontarget organisms.

Traditional insecticides kill mosquito larvae by direct contact. The main advantage of these products is that they produce a "quick kill" of larvae that can be observed easily when the site is sampled. Unfortunately, many of these products also have a high **toxicity** to fish and other aquatic wildlife. Products labeled with this warning should not be applied to fish-bearing waters or where other desirable aquatic wildlife is present.

Figure 3.12. Mosquito larvae at surface of water. Photo credit: Educpics.com

Insect growth regulators do not kill mosquito larvae on direct contact. These materials are taken into the larvae and inhibit development of the mosquito (Figure 3.12). Treated larvae develop normally to the pupal stage and die. Insect growth regulators do not affect fish or other aquatic wildlife and can be used safely in breeding sites containing these nontarget organisms.

Unfortunately, mosquitoes in the pupal stage at the time of the application of the insect growth regulator are not affected by this type of treatment. Another major disadvantage of growth regulators is that they do not quickly kill the larval stage, complicating surveillance of breeding sites.

Figure 3.13. Mosquito dunk. Photo credit: Blog. Oregonlive.com

Products that contain the **bacterial pathogen** *Bacillus thuringiensis israelensis* must first be ingested by the mosquito larvae to be effective (Figure 3.13). The larvae then die within 2 or 3 days. This bacterial pathogen is specific for mosquitoes and does not adversely affect fish or other aquatic wildlife. The primary disadvantage of this product is that the pathogen has limited residual activity and may require frequent reapplication during periods of high mosquito activity.

Products used in larviciding are available in several formulations. These include materials that must first be mixed with water (i.e., emulsifiable concentrates, liquid concentrates, or wettable powders) or applied as granules, pellets, and briquettes. The factors determining the formulation used include accessibility of the treatment area, size of the treatment area, amount of aquatic vegetation present, and the need for residual activity.

Larvicide treatments can be applied with either aerial or ground equipment. Aerial equipment is costly and is generally justified only under emergency conditions or if the treatment area is too large or inaccessible by ground equipment (Figure 3.14).

Figure 3.14. Helicopter pesticide application. Photo credit: John D. Byrd, Mississippi State University, Bugwood.org

The type of ground equipment used depends on the formulation of the material being applied. Liquid formulations can be applied by hand sprayers or hydraulic field sprayers. Granular and pelleted larvicides can be applied with power blowers or by crank-operated spreaders similar to those used for spreading seed and fertilizer. Briquette formulations are generally applied by hand.

The effectiveness of larvicide applications often depends on the amount of pollution, and the type and amount of aquatic vegetation present. Heavily polluted waters may require higher rates or more frequent applications. Granules or pellets are the formulations of choice when the aquatic vegetation is abundant, since they penetrate vegetation better.

Strategies Aimed at the Adult Stage

Insecticide applications used to kill adult mosquitoes are **adulticiding**. These applications are most effective when done over large areas. In general, however, adulticiding provides only temporary relief by reducing adult mosquito populations to less annoying levels.

Adulticides kill adult mosquitoes primarily by direct contact. To be effective, adult mosquitoes must come into direct contact with the insecticide as it is being applied or shortly thereafter. Thus, adulticiding may require more frequent application during periods of high mosquito activity.

The application techniques for adulticiding include thermal aerosols, cold aerosols, mist blowers, residual sprays, or aerial applications.


Figure 3.15. Adult mosquito thermal fogger in operation. Photo credit: MISTPRONC.com

Thermal aerosols (fogging). Thermal aerosols can be effective as a space treatment against adult mosquitoes. Insecticides are mixed with an approved oil base and applied through a thermal generator that uses hot gases or superheated steam to break the material into extremely small droplets. The fog is then allowed to move slowly through the target area (Figure 3.15).

Thermal fogs have no residual activity and only kill those adults directly contacting the insecticide. Thus, thermal fogs must be applied during the evening hours or early morning hours when adult mosquitoes are most active, and when there is little or no wind. Frequent reapplications may be needed during periods of high mosquito activity or if target areas become re-infested.

Follow the operating instructions for the thermal generator being used, and calibrate the thermal generator according to the manufacturer's recommendations. Thermal generators generally are calibrated to deliver 40 gallons per hour at an average speed of 5 miles per hour to cover a swath 300-feet wide.

Figure 3.16. Portable ULV fogger. Photo credit: mikesearch.com

Figure 3.17. ULV sprayer on all terrain vehicle. Photo credit: NorthernAgMistSprayer.com

Cold aerosols (ULV). Special nozzle adaptations and the development of micro metering systems make it possible to apply undiluted, specially formulated insecticides in microscopic droplets that give effective coverage for adult mosquito control. These are known as **ultralow volume (ULV)** applications (Figure 3.16). Like thermal fogs, ULV applications have no residual activity and kill only adult mosquitoes directly contacted by the insecticide droplets. Therefore, ULV applications must be made during evening or early morning hours when adult mosquitoes are most active, and when there is little or no wind. Frequent reapplications may be needed during periods of high mosquito activity or if target areas become re-infested.

ULV applications have at least three advantages over thermal fogs.

- ULV generators use less insecticide per acre than thermal generators. This results in fewer pollution problems, reduced material costs, and less time for equipment loading or travel.
- Smaller holding tanks and vehicles are needed because less insecticide is used.
- ULV generators do not produce a dense fog that may be a traffic hazard.

Ground ULV applications (Figure 3.17), however, are somewhat less effective than thermal fogs in heavy vegetation because the larger ULV droplets tend to be filtered out more rapidly.

Mist sprays. Mist spraying is the application of a very fine mist of insecticide in water using a mist-blowing machine. These machines produce an airstream across the spray material, breaking the material into droplets and blowing them into the treatment area. Mist droplets are somewhat larger than thermal or cold aerosol droplets, and they settle out faster. Thus, mist sprays do not have the "reach" available in aerosol applications. At least 3 gallons of water per acre are needed when using a mist blower for adult mosquitoes.

Apply mist sprays during the evening or early morning hours when mosquitoes are most active and there is little or no wind. Applications should be directed horizontally with slight elevation to permit the mist to move to and settle in the target area. Do not direct applications toward parked cars because the insecticide droplets may spot finishes; immediately wash off any overspray. When applied to vegetation, mist sprays give some limited residual control in addition to killing mosquitoes by direct contact.

Mist blowers must be properly calibrated according to the manufacturer's recommendations. Mist blowers are typically calibrated to deliver 60 to 100 gallons per hour, covering a swath 100 to 200 feet wide at a vehicle speed of 3 to 5 miles per hour.

Residual sprays. Residual sprays are applied in water by using hand sprayers (Figure 3.18) or hydraulic field sprayers (Figure 3.19). Compressed air in these sprayers exerts pressure on the spray material as it passes through a nozzle. This process produces larger droplets than aerosols or mists, so more material is applied to a given area.

Residual sprays are designed to remain active for several days or weeks following application. Environmental factors such as rain, high temperatures, or exposure to direct sunlight, however, may reduce this period of activity. In general, residual sprays are not cost-effective for treating large areas, but may be useful as a spot treatment for a localized area. Residual sprays help reduce adult mosquito populations when applied as a barrier zone to tall grasses, weeds, shrubs, trees, fences, and outbuildings in parks, playgrounds, and yards. For best results, treat areas before maximum use.

Aerial application. Application of insecticides by fixed-wing aircraft (Figure 3.20) or helicopter also is used to suppress adult mosquito populations. This method of application is expensive and should be used only under emergency conditions or if areas to be treated are too large or inaccessible for economical treatment with ground equipment. Most effective results are obtained in areas without dense tree cover so that spray particles can penetrate the low shrub zone, the area of greatest mosquito activity.

Observance of pre-planned flight patterns, altitudes, and air speeds ensures uniform coverage of an area. Applications should not be made over populated, food- or feed-crop areas unless the insecticide is labeled for that use. Follow label directions for applications over fish-bearing waters.

Program Evaluation

Evaluation determines the effectiveness of a community mosquito management program. Several factors can be used to develop evaluation criteria, but data gathered from surveillance activities (especially as it pertains to larval and adult abundance) will probably be the most useful and informative. These data can be used throughout the mosquito season to determine whether various aspects of the management program are performing adequately or need correction (Figure 3.21).

The data also can be used as an end-of-year evaluation to determine the program's effectiveness. Include an economic analysis of material, equipment, time, and labor costs in the evaluation. Share the results obtained with the residents of the community. Careful evaluation of all aspects of the mosquito management program can help decide its future.

Figure 3.18. Coarse spraying for mosquitoes. Photo credit: APM Pest.com

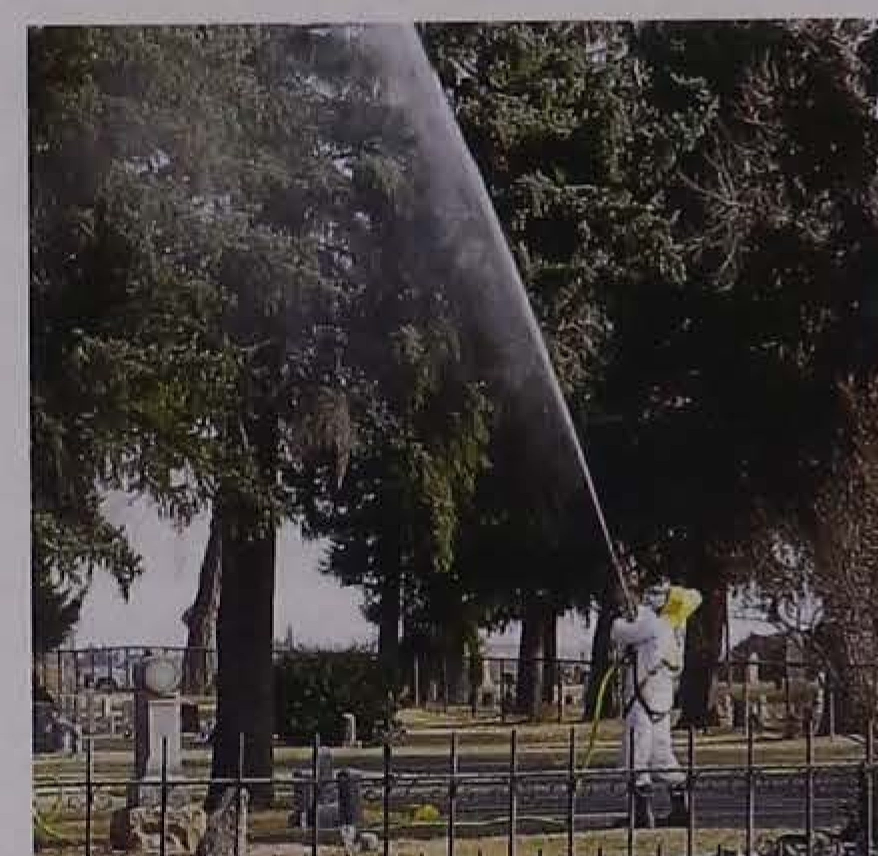

Figure 3.19. Large tree spraying. Photo credit: Cheyennecity.org

Figure 3.20. Fixed wing aircraft sprayer. Photo credit: Larry Barber, USDA Forest Service, Bugwood.org

Figure 3.21. Evaluating success of mosquito treatment. Photo credit: Christiesbrain.com

Learning objective

After reading this chapter, you should be able to

- Differentiate the three important types/species of nuisance flies in Iowa by appearance, biology, breeding sites, nuisance, and public health concern.

4 Flies

Overview

Several fly species can appear in and around Iowa communities in warm weather. Of particular importance are house flies, stable flies, and blow flies. These pests are of public health concern because they can transmit various human diseases. They also can cause considerable annoyance and irritation to community residents as a result of their behavior and feeding activity. If fly populations increase to significant numbers, a community management program may be required to reduce their populations.

Figure 4.1. *Musca domestica.* Photo credit: Juergens Peters, Diptera.info

House Fly

The house fly, *Musca domestica*, is dull gray, about ¼ inch (5 mm) in length, and has a distinctive black-and-gray striped thorax (Figure 4.1). Female flies lay eggs in garbage, animal manure, or other decaying organic matter. Eggs are laid in clusters containing 100 or more eggs. These eggs hatch in 1 to 2 days.

Figure 4.2. House fly life cycle. Photo credit: Clemson University-USDA Cooperative Extension Slide Series, Bugwood.org

Larvae, known as **maggots** for fly species, burrow into and feed on the breeding material. Larvae complete their development in 4 to 6 days and then leave the decaying organic matter, seeking a drier environment in which to pupate. Adults emerge 5 to 6 days later. The entire life cycle for the house fly can be completed in 10 to 14 days, depending on temperature (Figure 4.2).

In Iowa, house flies usually are present from May through October, during which time they produce many generations. House flies overwinter as larvae or pupae in sites where **microbial fermentation** or domestic heating prevent the breeding material from freezing.

Adult house flies are nonbiting flies that feed on liquid material through sponging mouthparts (Figure 4.3), which project downward from their head. Solid food must be liquefied with saliva secreted from the mouthparts before it can be ingested. During the day, house flies can be found near breeding sites and sources of food and moisture. At night, house flies rest on stationary objects, such as wires, fences, vegetation, and the sides of buildings.

Figure 4.3. House fly mouthparts. Photo credit: glsammy, FLICKR.com

House flies are not only considered a nuisance but also a public health hazard since they can transmit numerous human diseases. Adult flies are known to acquire and carry pathogens, both internally and externally, including the causative agents of **paratyphoid**, **salmonellosis**, and **typhoid**.

Stable Fly

The stable fly, *Stomoxys calcitrans*, is dark gray, has a checkered abdomen, and is about the size of a house fly (Figure 4.4). Female stable flies lay clusters of 80 to 90 eggs in decaying organic material such as wet hay or straw, grass clippings, and poorly managed compost piles. These eggs hatch into maggots in 1 to 3 days. Larvae complete their development in the organic matter before seeking a drier environment to pupate. In summer, the entire life cycle can be completed in 20 to 30 days. In Iowa, stable flies overwinter as larvae in breeding sites that generate sufficient heat.

Figure 4.4. Stable fly. Photo credit: Whitney Cranshaw, Colorado State University, Bugwood.org

Both male and female stable flies have piercing mouthparts and feed on blood several times each day. They prefer to feed on the lower leg of an animal and stay on the animal only long enough to complete feeding. Then the stable fly seeks shaded areas, such as the sides of buildings, fences, and windbreaks, where they digest their blood meal. At night, stable flies rest on stationary objects such as wires, fences, vegetation, and the sides of buildings.

Fortunately, stable flies are not known to transmit any human disease. The bite of this pest, however, can cause considerable irritation and annoyance to people.

Blow Fly

The term blow fly is used to describe several species of related flies, all in the family Calliphoridae. All adult blow flies are similar in size to the house fly. The color of the blow fly body, however, is a metallic green, blue, bronze, or black and is characteristic of the species (Figure 4.5).

Figure 4.5. Calliphoridae fly. Photo credit: Morten Pedersen, photo.dv.no

Adult flies are attracted to the putrefying odors of animal carcasses. Female flies lay clusters of 40 or more eggs on the carcass. Within hours, eggs hatch into larvae/maggots (Figure 4.6) that feed on and develop in the dead animal tissue. When fully developed, the larvae crawl away from the carcass and pupate in the soil, under debris or other objects. The entire life cycle can be completed in 10 to 25 days. Blow flies overwinter either as larvae, pupae, or adults, depending on the species.

Figure 4.6. Blow fly maggots. Photo credit: Susan Ellis, Bugwood.org

Adult blow flies are nonbiting flies that must feed on liquid material, using their sponging mouthparts. Like house flies, salivary enzymes from their mouthparts are used to liquefy the solid food before it can be digested. Adult flies are active only during daylight hours, when they can be found near breeding sites and sources of food and moisture. At night, these flies rest on stationary objects such as wires, fences, vegetation, or the sides of buildings.

Adult blow flies can disperse more than 10 miles in search of food and breeding sites. Under certain conditions, these flies can multiply rapidly and annoy a community's residents. In addition, their direct association with animal carcasses can constitute a public health hazard.

Learning objectives

After reading this chapter, you should be able to

- Discuss the similarities between mosquito and nuisance fly management programs.
- List several practices that can be used to eliminate or reduce larval habitats for nuisance flies.
- Explain why pesticide applications for larval and adult flies are not an effective, long-term management solution.

5
Fly Management Programs

Overview

Effective fly management requires a well-planned, flexible program based on the biology and behavior of the fly species. Unlike mosquitoes, fly populations may develop quickly and be limited to certain areas of the community. Management techniques, therefore, may need to be specifically targeted and immediately implemented to reduce fly populations.

The techniques used in a mosquito management program also can be incorporated into the management of fly populations. These techniques include source reduction, larviciding, and adulticiding. It is important to adapt these techniques to the biology and behavior of the fly species.

Source Reduction

Because it is impossible to eliminate adult flies, the most effective management technique is the elimination or reduction of larval habitats by using source reduction practices. Sanitation and waste management are the primary source reduction methods.

Figure 5.1. Trash pickup. Photo credit: AlbanyNY.org

Examples of source reduction practices include:

- Cover trash receptacles, septic tanks, and cesspools with tight-fitting lids to prevent access by adult flies.
- Collect garbage at least twice a week from residences and daily from business establishments (Figure 5.1).
- Dispose of collected garbage by burial in a sanitary landfill or by incineration.
- Collect and dispose of animal carcasses as soon as possible (Figure 5.2).
- Maintain compost piles in proper condition (Figure 5.3). The heat of decomposition prevents fly breeding.
- Collect and dispose of grass clippings and garden refuse every week (Figure 5.4).
- Ensure that municipal sewage treatment plants and waste disposal facilities are properly managed and maintained.

Figure 5.2. Collect animal carcasses to prevent their decomposition by nuisance flies. Photo credit: M.H. Shour, Iowa State University Extension

Figure 5.3. Compost bin. Photo credit: Cleveland Botanical Garden

Figure 5.4. Mowing long grass and leaving clippings in piles to decompose. Photo credit: M.H. Shour, Iowa State University Extension

Strategies Aimed at the Larval Stage

Fly-breeding sites that are undesirable or impossible to eliminate can be treated with an approved insecticide to kill larvae/ maggots. These insecticides can be applied by hand sprayers or hydraulic field sprayers, and kill larvae by direct contact. Unlike mosquitoes, a fly problem cannot be solved by larvicide treatments because:

- The treatments may not penetrate the breeding materials in quantities sufficient to kill developing fly larvae, even when high pressure is used during the treatment.
- Most insecticides break down rapidly when applied to breeding sites that contain a high concentration of organic matter.
- Continued reliance on larviciding can increase the potential of insecticide resistance in these flies.

Larvicide treatments may aid in fly management in some situations, but cannot provide effective, long-term fly management over a large area.

Strategies Aimed at the Adult Stage

Insecticides can kill adult flies. These treatments can be applied as thermal fogs, cold aerosols, mist sprays, or residual sprays. Adulticiding usually provides only a temporary reduction of fly numbers. Total reliance on adulticides without a proper sanitation and waste management program will have little effect in the long run.

Insecticides applied through thermal foggers, ULV generators, or mist blowers can kill adult flies rapidly. These applications kill adult flies by direct contact and have little, if any, residual activity. Adulticides may need to be applied several times a week for maximum effectiveness. Applications must coincide with peak activity of the adult fly. Because adult house flies, stable flies, and blow flies are active only during the day, applications made at that time may be subject to excessive drift and nontarget contamination because of the wind. In general, adulticide applications by thermal foggers, ULV generators, or mist blowers are effective only where an immediate reduction of adult flies is necessary.

Residual sprays applied to fly resting areas (Figure 5.5) with a hand sprayer can be effective in reducing adult fly populations. These materials should be applied to the point of runoff and are generally effective for 1 to 3 weeks or longer. Environmental factors such as rain, high temperatures, or exposure to direct sunlight may reduce this period of activity.

Figure 5.5. Resting house fly. Photo credit: Alec Gerry, Entomology- IPM, University of California Davis

In general, residual sprays are not cost-effective for treating large areas, but may be useful as a spot treatment. Continued reliance on residual sprays also can increase the potential for insecticide resistance. The best ways to reduce the potential for insecticide resistance among these flies is to 1) use a residual product only when necessary, 2) alternate between different chemical classes of insecticides, and to 3) use alternative management techniques, whenever possible.

Learning objectives

After reading this chapter, you should be able to

- Discuss the importance of pesticide safety in community insect management programs.
- Specify the chief culprit contributing to pesticide contamination in nontarget areas.
- Explain how phytotoxicity can be an environmental issue in community insect management programs.
- List ways to prevent insecticide resistance for insect management programs.
- Describe two precautions that a pesticide applicator must take to protect bees in Iowa.
- Discuss how the NPDES Pesticide General Permit impacts community insect management programs.

Figure 6.1. People in park near water. Photo credit: Lost in Fantasia files, wordpress.com

Figure 6.2. Family reunion at outside pavilion. Photo credit: CorpsLake.USACE.Army.mil

6
Special Considerations

Pesticide Safety

Pesticides play an important role in community insect management programs. However, these products should be used only when necessary and applied properly. Additionally, pesticides should be stored safely and disposed according to label directions. Concerns about pesticide safety are critical in community insect management programs because these products are applied around human dwellings and in public areas (Figures 6.1 and 6.2).

Take extreme care to limit the potential of pesticide **exposure** especially where children, elderly, people with illnesses, or pets are involved. Unnecessary pesticide exposure can be reduced or eliminated by 1) keeping children and pets away from areas where pesticides are stored, mixed, or applied; 2) adhering to the re-entry intervals stated on the pesticide label; and 3) limiting pesticide use in and around food-handling areas or facilities. Most importantly, choose a pesticide labeled for the intended use and carefully read and follow directions before applying any pesticide.

Nontarget Injury

Be careful not to contaminate nontarget areas when applying pesticides in a community insect management program. These areas include livestock and pet feed, vegetable gardens, surface waters, and apiaries.

Drift is probably the chief culprit contributing to pesticide contamination of nontarget areas. Apply pesticides when there is little wind so as to minimize drift, or apply when the wind is blowing away from nontarget areas. Under no conditions should pesticides be applied if the wind exceeds 10 mph.

Do not apply pesticides when heavy rain is expected because the product could be carried to nontarget areas by soil and water erosion. Avoid applying pesticides when the ambient temperature is expected to exceed 85° F (29° C), as some products may volatilize and move off target.

Phytotoxicity

Community insect management programs may involve application of pesticides to outdoor areas. Trees, shrubs, herbaceous species, and other nontarget plants occasionally may be injured through direct contact with pesticides; this is referred to as **phytotoxicity**. This nontarget damage may result from drift to nontarget areas, excessive pesticide rates, combining two or more pesticides that are not known to be phytotoxic when used alone, and the use of certain formulations (e.g., emulsifiable concentrates).

Certain weather patterns also may cause or increase the amount of phytotoxicity. For example, exceptionally bright, hot, dry weather following a period of cooler weather can increase the likelihood of this type of damage. Some minor phytotoxicity is common when pesticides are used in accordance with recommended practices, but it is unusual to have severe problems.

Avoid phytotoxicity by applying pesticides when there is little wind or when the wind direction is blowing away from nontarget plants. Apply pesticides within recommended rates and do not mix two or more pesticides unless the label indicates it is safe to do so.

Insect Resistance

Pesticides are a valuable component of community insect management programs, but overuse of pesticides may lead to insect resistance, making subsequent applications ineffective. This result is particularly true for flies that have a short life cycle and are capable of producing numerous generations each year.

To minimize insect resistance, use pesticides only when there is a threat to public health or when the insects are an acute public nuisance. Additionally, use an insecticide with a different mode of action. Most product labels have an Insecticide Resistance Action Committee (IRAC) number at the top of the label. This numerical system indicates the product's mode of action or chemical class. Following this resistance management aid will allow you to quickly determine products with the same mode of action. A third strategy is to apply the pesticide over a smaller area; this reduces the proportion of the population that is exposed to the chemical and keeps a pool of insecticide-susceptible individuals in the population to continue to interbreed with resistant ones.

Toxicity to Honey Bees

Many insecticides used in community insect management programs are toxic to honey bees (Figure 6.3). The Iowa Bee Rule establishes cooperation between pesticide applicators and beekeepers to prevent unnecessary bee kills. This rule was amended in 2009 with the following changes:

- Owners of apiaries shall register each year the location of their apiaries with the Iowa Department of Agriculture and Land Stewardship to protect their bees from pesticide applications.
- A commercial pesticide applicator shall not apply a pesticide labeled as toxic to bees to blooming crops between the hours of 8 a.m. and 6 p.m. when the applicator is within one mile of registered apiaries. The commercial applicator is responsible for maintaining the one-mile distance from apiaries that are registered and listed on the Sensitive Crops Registry of the Iowa Department of Agriculture and Land Stewardship on the first day of each month.

Figure 6.3. Honey Bee. Photo credit: David Cappaert, Michigan State University, Bugwood.org

National Pollutant Discharge Elimination System (NDPES)

Community insect management programs may involve application of an insecticide to one or more types of surface waters (Figure 6.4). In an effort to minimize water pollution from such activities and under the authority of the Clean Water Act, the National Pollutant Discharge Elimination System (NPDES) permit program controls water pollution by regulating point sources that discharge pollutants into waters of the United States.

The Iowa Department of Natural Resources, in cooperation with the U.S. Environmental Protection Agency, has developed a Pesticides General Permit to regulate discharges to waters of the United States from the application of biological pesticides and chemical pesticides that leave a residue. One of the use patterns covered under the Pesticide General Permit that directly affects community insect management is "mosquito and other flying or aquatic nuisance insect control." For more information, visit the Iowa Department of Natural Resources website: *http://www.iowadnr.gov/water/npdes/pesticides.html*.

Figure 6.4. Helicopter spraying lake. Photo credit: EagleLake-RacineCounty.org

Glossary

Abdomen. The hindmost part of an insect's body, which contains the digestive and reproductive organs. **2**

Adult. Fully grown, sexually mature insect. **2**

Adulticide. An insecticide used to kill adult insects. **3**

Bacterial pathogen. Single-celled microorganisms that are capable of causing disease in a particular species or range of species. **3**

Breeding site. A place conducive to the production of offspring. **2**

Cesspool. A place where sewage or refuse is held. **2**

Complete metamorphosis. Type of change in the shape, form, and/or size of an insect characterized by four distinct stages: egg, larva, pupa, and adult. **2**

Dengue. Also known as dengue fever. An acute, mosquito-borne viral illness of sudden onset that usually follows a course of headache, fever, prostration, severe joint and muscle pain, swollen glands, and rash. **2**

Dog Heartworm. A common parasite of dogs that is vectored by mosquitoes, when the parasite is in the microfilarial stage. **2**

Exposure. The unwanted contact with pesticides, or pesticide residues by people, other organisms, or the environment. **6**

Flanders Virus. A widely distributed rhabdovirus (rod or bullet-shaped virus) frequently found in birds and bird-feeding mosquitoes, not known to be pathogenic in humans. **2**

Head. The anterior body region of insects, bearing the mouthparts, eyes, and antennae. **2**

Insect Growth Regulator. A type of pesticide that controls insects by disrupting normal growth and development, rather than by toxic action. **3**

Instar. A developmental stage of an immature insect's life cycle between two molts. **2**

Insect Light Trap. A device used to attract and capture insects. Usually fitted with an ultraviolet or incandescent light bulb. **3**

Insecticide. Any substance or mixture of substances intended for preventing, destroying, repelling, or mitigating any insects and related forms that may be present in any environment. **3**

La Crosse Encephalitis. A viral disease transmitted to humans by the bite of an infected mosquito. It is common in the upper Midwest, mid-Atlantic, and Southeastern regions of the United States. Many people infected with this virus have no apparent symptoms. Others have fever, headache, nausea, vomiting, and tiredness. Severe cases involve an inflammation of the brain. **2**

Larva (pl. larvae). An immature stage of an insect that undergoes complete metamorphosis. **2**

Larvicide. An insecticide used to kill insects in the larval stage. **3**

Maggot. A soft-bodied legless larva of a fly, which feeds on decaying plant matter or animal flesh. **4**

Microbial Fermentation. The breaking down of a substance by the action of microorganisms. **4**

Paratyphoid. A serious, contagious disease caused by *Salmonella paratyphi* bacteria. It usually has three phases: an early stage with high fever; a toxic stage with abdominal pain and intestinal symptoms; and a recovery phase. May be mechanically transmitted to human food by flying insects feeding in/on infected feces. **4**

Phytotoxicity. Injury to plants due to exposure to a chemical. **6**

Proboscis. The tubular feeding and sucking organ of certain insects. **2**

Pupa (pl. pupae). An intermediate "resting" stage of an insect that undergoes complete metamorphosis between the larval and adult stages. **2**

Salmonellosis. An infection caused by *Salmonella* bacteria. Symptoms of the illness include diarrhea, fever, vomiting, and abdominal cramps. May be mechanically transmitted to human food by flying insects feeding in/on infected feces. **4**

Source Reduction. The process of eliminating or reducing larval habitats or breeding sites to control a pest species. **3**

St. Louis Encephalitis. A serious, mosquito-borne viral disease that can affect the central nervous system of the host. Symptoms usually include fever, headache, tiredness, and dizziness. It is widespread throughout North, Central, and South America. Usually associated with birds and bird-feeding mosquitoes; humans are accidental hosts. **2**

Tarsus (pl. tarsi; adj. tarsal). An insect's foot consisting of one or more segments. **2**

Thorax. The region of the insect body bearing the legs and wings. **2**

Toxicity. A measure of the capacity of a pesticide to cause injury. **3**

Tumblers. Common name for mosquito in the pupal stage. **2**

Typhoid. A serious, contagious disease caused by *Salmonella* typhi bacteria. Typhoid fever is characterized by a slowly progressive fever, profuse sweating, abdominal pain and intestinal symptoms, and flat, rose-colored spots on the abdomen and chest. May be mechanically transmitted to human food by flying insects feeding in/on infected feces. **4**

Ultralow Volume (ULV). A liquid pesticide formulation that is applied undiluted or with small quantities of a carrier. **3**

West Nile Virus. A mosquito-borne viral disease that can affect the central nervous system and cause a neuroinvasive disease. Can affect humans, birds, horses, and other animals. Common symptoms include fever, headache, tiredness, aches, rash, and encephalitis. Becoming widespread throughout North, Central, and South America; Africa; the Middle East; and West Asia. **2**

Western Equine Encephalitis. A mosquito-borne viral disease that can affect the central nervous system of the host (horses, humans). Symptoms are usually very mild and include headache and fever. Widespread throughout North, Central, and South America, but most cases reported from the central and western plains of the United States. **2**

Wigglers. Common name for mosquitoes in the larval stage. **2**

Yellow Fever. A tropical, viral disease spread to humans by infected mosquitoes. Many infections result in mild cases, but some can produce high fever, chills, headache, muscle aches, vomiting, backache, liver failure (giving skin and white of the eyes a yellow tint), kidney failure, and shock. **2**

Appendix A

Review Questions

Chapter 2

1. What two characteristics distinguish mosquitoes from other insects?
   A.

   B.

2. What type of mouthparts is present on female mosquitoes?
   A. Chewing
   B. Lapping
   C. Piercing
   D. Sponging

3. Which stage of mosquito feeds on blood?
   A. Larva
   B. Pupa
   C. Adult male
   D. Adult female

4. List examples of mosquito breeding sites.

5. Distinguish between "wigglers" and "tumblers."

6. Which species of mosquito found in Iowa can transmit La Crosse encephalitis?
   A. *Ochlerotatus trivittatus*
   B. *Aedes vexans*
   C. *Culex pipiens*
   D. *Culex tarsalis*

7. Which species is the principal pest mosquito in Iowa?
   A. *Ochlerotatus trivittatus*
   B. *Aedes vexans*
   C. *Culex pipiens*
   D. *Culex tarsalis*

8. Which two mosquito species commonly enter houses at night?
   A. *Ochlerotatus trivittatus* and *Aedes vexans*
   B. *Culex pipiens* and *Culex tarsalis*
   C. *Ochlerotatus trivittatus* and *Culex pipiens*
   D. *Aedes vexans* and *Culex tarsalis*

9. The Asian tiger mosquito is known to transmit the following diseases except:
   A. Yellow fever
   B. Dengue
   C. La Crosse encephalitis
   D. Paratyphoid

10. How have exotic mosquito species been introduced into new areas?
    A. Movement in cars or trucks
    B. Shipment in pallets and other products
    C. Transported via infested plant materials
    D. Distributed in automobile tires

Chapter 3

1. What is the benefit of public awareness in a community mosquito management program?

2. All of the following are parts of a surveillance program for mosquito management except:
   A. Source reduction
   B. Survey mapping
   C. Insect light trapping
   D. Larval sampling

3. Which of the following is considered the most permanent form of mosquito management?
   A. Monitoring of breeding sites
   B. Source reduction
   C. Larval control methods
   D. Adult control methods

4. List several examples of practices that may be used to eliminate or reduce mosquito breeding in a community.

5. Which type of pesticide application method would be best to control larval mosquitoes when aquatic vegetation is abundant?
   A. Hand sprayer
   B. Crank-operated spreader
   C. Hydraulic field sprayer
   D. Thermal aerosol fogger

6. Which of the following larvicides has limited residual activity and must be reapplied frequently during periods of high mosquito activity?
   A. Bacterial pathogens
   B. Insect growth regulators
   C. Systemic insecticides
   D. Traditional contact insecticides

7. List one advantage and one disadvantage of the following methods for controlling adult mosquitoes.
   A. Thermal fogging
      i. Advantage
      ii. Disadvantage
   B. ULV application
      i. Advantage
      ii. Disadvantage
   C. Mist spraying
      i. Advantage
      ii. Disadvantage
   D. Residual spraying
      i. Advantage
      ii. Disadvantage
   E. Aerial application
      i. Advantage
      ii. Disadvantage

Chapter 4

1. What is the immature, feeding stage of a fly called?
   A. Nymph
   B. Maggot
   C. Wiggler
   D. Pupa

2. All of the following are non-biting flies except:
   A. Blow fly
   B. House fly
   C. Stable fly

3. Which nuisance fly develops in dead animal tissue?
   A. Blow fly
   B. House fly
   C. Stable fly

4. Which nuisance fly is known to carry human disease pathogens?
   A. Blow fly
   B. House fly
   C. Stable fly

5. Which nuisance fly will disperse more than 10 miles in search of food and breeding sites?
   A. Blow fly
   B. House fly
   C. Stable fly

Chapter 5

1. Effective nuisance fly management differs from mosquito management in what way?
   - A. There are different techniques used for each program.
   - B. Residents are less bothered by nuisance flies than mosquitoes.
   - C. Problems are often limited to certain areas of the community.
   - D. Equipment calibration is less difficult with mosquito programs.

2. Which of the following is NOT an example of source reduction practices for nuisance flies?
   - A. Cover trash cans with tightly fitting lids
   - B. Collect and bury animal carcasses
   - C. Pick up garbage monthly from restaurants
   - D. Keep compost piles turned regularly

3. All of the following provide reasons why nuisance fly problems cannot be solved using larvicide treatments except:
   - A. Larvicides cannot aid in specific fly management situations
   - B. Treatments may not penetrate the breeding materials
   - C. High organic content of breeding sites decomposes larvicides
   - D. Continued larvicide use increases chance for resistance

4. Adulticides for nuisance fly management must be applied
   - A. At night when flies are active
   - B. Monthly or less often
   - C. Using aerial equipment
   - D. To fly resting areas

5. It is impossible to eliminate adult flies in a community.
   - A. True
   - B. False

Chapter 6

1. List four ways that unnecessary pesticide exposure can be reduced or eliminated in a community insect management program.
   - A.
   - B.
   - C.
   - D.

2. What is the chief culprit contributing to pesticide contamination of nontarget areas?
   - A. Poor storage practices
   - B. Improper location of storage area
   - C. Spills
   - D. Drift

3. Define phytotoxicity and tell how this could occur in a community insect management program.

4. All of the following are ways to reduce resistance to insecticides except:
   - A. Use only when there is a public health threat
   - B. Use only when insects are an acute public nuisance
   - C. Use only when a large area is involved
   - D. Use only if modes of action are rotated

5. According to the new Iowa Bee Rule, applicators shall not apply a pesticide labeled as toxic to bees to a blooming crop
   - A. on a cloudy day
   - B. more than 3 miles from a registered bee hive
   - C. between the hours of 8 a.m. and 6 p.m.
   - D. at the end of the month

6. Discuss one way that NPDES will impact community insect management programs.

Appendix B

Review Answers

Chapter 2

1. Mosquitoes have a) an elongated proboscis, and b) scales on the veins of their wings.
2. C.
3. D.
4. Breeding sites include marshes, waste lagoons, catch basins, ponds, tree holes, cans, old tires, clogged gutters, and floodwater puddles.
5. Wigglers are mosquito larvae; tumblers are pupae.
6. A.
7. B.
8. B.
9. D.
10. D.

Chapter 3

1. To help them understand the program and to get their support and cooperation.
2. A.
3. B.
4. Source reduction methods include: cleaning ditches and stagnant streams; draining or filling stagnant water pools, ditches, or swampy areas; removal and discarding of any artificial containers that may fill with rainwater; cleaning out roof gutters; avoiding excessive irrigation of parks and lawns; keeping pond and lake shoreline vegetation controlled; and stocking ponds and lakes with surface-feeding fish species.
5. B.
6. A.
7. Adult control strategies
   a. Thermal fogging advantage: good penetration; disadvantage: no residual activity
   b. ULV advantage: use undiluted insecticide; disadvantage: no residual, special equipment
   c. Mist sprays advantage: very fine mist blown into treatment area; disadvantage: poor penetration
   d. Residual sprays advantage: remain for several days or weeks; disadvantage: larger droplets give poor penetration
   e. Aerial application advantage: treatment of large areas; disadvantage: can drift off target

Chapter 4

1. B.
2. C.
3. A.
4. B.
5. A.

Chapter 5

1. C.
2. C.
3. A.
4. D.
5. A.

Chapter 6

1. Keeping pets and children away; adhering to re-entry intervals; limiting pesticide use around food-handling areas; selecting a product labeled for the intended use.

2. D.

3. Injury to plants due to exposure to a chemical. Could result from drift to nontarget areas, excessive pesticide rates, using certain formulations, or combining two or more pesticides.

4. C.

5. C.

6. Using biological or chemical pesticides to treat mosquitoes or other flying or aquatic nuisance insects in aquatic environments.

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http://www.extension.umn.edu/distribution/housingandclothing/dk7568.html

Books

Mallis, Arnold. 1997. Flies, Gnats, & Midges. In *Handbook of Pest Control.* Eighth Edition. Franzak & Foster Co., Cleveland, Ohio. Pages 772-835

Mallis, Arnold. 1997. Mosquitoes. In *Handbook of Pest Control.* Eighth Edition. Franzak & Foster Co., Cleveland, Ohio. Pages 836-881

Cover Images

Floodwater 2008
Sassygirl, *Flicker.com*

***Aedes aegypti* female**
James Gathany, CDC

Mosquito spraying
West Baton Rouge,
WBRcouncil.org

Mosquito sampling
Mosquito Control,
HCPHES.org

Aerial treatment map
Armenians.net

Musca domestica
Juergens Peters,
Diptera.info

Trash collection.
AlbanyNY.com

Pond bank mowing
VentraCompactTractors.
Wordpress.com

Calliphoridae fly
Morten Pedersen,
photo.dv.no

Blow fly maggots
Susan Ellis,
Bugwood.org

Aerial treatment by helicopter
CRMWA.com

Cloggged roof gutter,
a mosquito breeding site.
M.H. Shour, Iowa State
University Extension

Cleaning a roadside ditch
Destinationknowlton.com

Emergency Telephone Numbers

Regional Poison Center **1 (800) 222-1222**

For pesticide emergencies, state poison centers provide service that is free of charge to the public and is available 24 hours a day, seven days a week

Environmental Emergency Response

For pesticide spill emergencies

Iowa – Iowa Department of Natural Resources .... (515) 281-8694

Kansas – Department of Public Health Protection, Bureau of Environmental Remediation .... (785) 296-1503

Missouri – Department of Natural Resources .... (573) 634-2436

Nebraska – Department of Environmental Quality .... (402) 471-2166

National Pesticide Safety Team Network (Chemtrec) **1 (800) 424-9300**

The National Agricultural Chemicals Association has a telephone network. This network can tell the applicator the correct contamination procedures to use to send a local safety team to clean up the soil. An applicator can call the network toll-free at any time.

National Pesticide Information Center **1 (800) 858-PEST**

Call the NPIC network toll-free

U.S. Environmental Protection Agency (EPA) .... **(913) 281-0991**

All major pesticide spills must by law be reported immediately to the U.S. Environmental Protection Agency, Region VII Office, 901 N. 5th Street, Kansas City, KS 66101. The following information should be reported:

1. Name, address, and telephone number of the person reporting
2. Exact location of spill
3. Name of company involved and location. Specific pesticide spilled
4. Estimated quantity of pesticide spilled
5. Source of spill
6. Cause of spill
7. Name of body of water involved, or nearest body of water to the spill area
8. Action taken for containment and clean-up


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