Volume

4

ATLANTIC CANADA PESTICIDE APPLICATOR TRAINING MANUAL SERIES

Biting Fly Training Manual

New Brunswick NEWFOUNDLAND & LABRADOR NOVA SCOTIA Environment and Labour Prince Edward Island CANADA

Cooperatively developed by the Atlantic Working Group for Pest Management Education and Training Standards

ATLANTIC CANADA PESTICIDE APPLICATOR TRAINING MANUAL SERIES

Biting Fly

This manual can be obtained from the following Provincial Agencies:

Government of Newfoundland & Labrador	**Government of Nova Scotia**	**Government of New Brunswick**	**Government of Prince Edward Island**
Queens Printer P.O. Box 8700 St. John's, NL A1B 4J6	**Environment & Labour P. O. Box 697 Halifax, Nova Scotia B3J 2T8**	**Environment& Local Government Fredericton, NB.**	**Department of Environment, Energy and Forestry, PO Box 2000, Charlottetown, PE C1A 7N8**
Tel: 709-729-3649	**Tel: 902-424-3170**	**Tel: 506 453 2098**	**Tel: 902- 368-5474**

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The Atlantic Working Group is composed of representatives from the regulatory department that maintains responsibility for pesticide licensing/certification programs within each Atlantic Canada province. The mission of the AWG is to develop and maintain high quality pesticide education and training materials that meet or exceed the national *Standard for Pesticide Education, Training and Certification in Canada*. The development of this manual will promote consistency and harmonization of pesticide education, training, and licensing/certification programs, thereby allowing for greater reciprocity within Atlantic Canada.

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PREFACE

The basic knowledge requirements for pesticide application education in Canada consist of information covering the following topics:

General	Environment
Labelling	Emergency Response
Regulations	Pest Management
Human Health	Application
Safety	Public Relations

The *Applicator Core Training Manual* provides the basic information all applicators need to know about applying pesticides safely and effectively. There are 10 category specific modules that provide further information for applying pesticides in specific areas. The applicator core plus a specific module will provide full information for applying pesticides within a given area. The 10 specific areas are:

Aerial	Greenhouse
Agriculture	Industrial Vegetation
Aquatic	Landscape
Forestry	Mosquito and Biting Fly
Fumigation	Structural

To obtain a licence or certificate in pesticide application you must write a pesticide applicator exam. This exam consists of information found in the *Applicator Core Training Manual* as well as a specific category manual. **NOTE: For agricultural applicators, the applicator core and agriculture category exams have been combined.**

The following manuals are currently available in Prince Edward Island from the PEI Pesticide Regulatory Program at (902) 368-5474 or pesticideinfo@gov.pe.ca

Volume 1 *Applicator Core Training Manual*
Volume 2 *Landscape Training Manual*
Volume 3 *Agriculture Training Manual*
Volume 4 *Biting Fly Training Manual*
Volume 5 *National Aerial Training Manual*

DISCLAIMER

The information in this manual is supplied with the understanding that no discrimination is intended, and that listing of commercial products implies no endorsement by the authors or the Prince Edward Island Department of Environment, Energy and Forestry.

Due to changes to laws and regulations that occur over time, the Prince Edward Island Department of Environment, Energy and Forestry assumes no liability for the suggested use of pesticides contained herein.

No pesticide can be used unless it is registered in Canada for the intended use and has a *Pest Control Products Act* registration number. At all times, pesticides must be applied according to the label directions on the pesticide container.

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ORGANIZATION OF MANUALS

To complete the mosquito and biting fly exam; to obtain a Mosquito and Biting Fly Class Certificate/License in Atlantic Canada, it is advisable to have the following two training manuals:

The Applicator Core Manual

The Mosquito and Biting Fly Manual

The Applicator Core Manual and the Mosquito and Biting Fly Manual have been divided into sections, each with learning objectives, text, exercises and review questions.

The Mosquito and Biting Fly certificate/license authorizes the use by ground of insecticides for control of mosquito or black fly larvae or their adult stage.

Chapter

2

PEST MANAGEMENT

Learning Objectives

When you have completed this chapter, you should be able to:

- **Describe why mosquitoes and black flies (biting flies) can be pests**
- **Describe the biology of mosquitoes and black flies**
- **Identify mosquitoes and black flies to genus**
- **Describe the control measures used to manage these pests**

Note: Mosquitoes are not biting flies; black flies, etc. are biting flies.

The biting activities of mosquitoes and black flies may result in significant effects on human health. Intense scratching of black fly and mosquito bites may result in open wounds and secondary infection. In addition, some mosquitoes are capable of transmitting West Nile virus (WNv) to humans and heartworm to dogs. Dog heartworm is a nematode that resides in the heart of dogs, resulting in restricted blood flow, reduced endurance and reduced longevity. West Nile virus is a bird virus that is spread by mosquitoes that have fed on the blood of infected birds. Occasionally human infection occurs when a mosquito infected with the virus takes a blood meal from a human.

While preventing the transmission of mosquito-transmitted diseases is important, any mosquito/biting fly program must be seriously evaluated before it is used. Mosquito and black fly larvae may be a food source for other animals, including fish, amphibians, and other insects. Applications of inappropriate amounts of pesticide to standing or flowing water may harm other organisms living in the water and alter the ecosystem. It is necessary to be able to identify the larval and adult stages as well as understand the biology of these pests to select and use appropriate control measures.

Most mosquito and black fly control in Atlantic Canada is conducted to reduce the annoyance caused by blood feeding. Populations of these pests may be reduced using a variety of control techniques discussed in this module.

Integrated Pest Management

The use of a variety of techniques to manage pests is known as Integrated Pest Management (IPM). A typical mosquito control program employing IPM principles first determines the species list and abundance of mosquitoes through larval and adult surveys. IPM then determines the most efficient and effective means for control. In some situations, water management programs or sanitation programs can be started to reduce breeding areas. When this approach is not practical, then a larviciding program may be used to treat specific breeding areas. Where larviciding is not effective adulticides may be used. The choice of larvicides and adulticides used is based on the species targeted for control and other restrictions such as environmental.

This section does not include identification of individual mosquito species. However, the identification and biology of the most significant mosquito genera will be outlined here since the timing and type of control measures vary among different genera.

A Note on West Nile Virus

Note: The scientific knowledge concerning West Nile virus continues to evolve. It is the responsibility of the applicator to contact the various regulatory agencies for up-to-date information.

West Nile Virus (WNv) is a type of flavivirus. Other viruses in this family include dengue virus, yellow fever virus, and the viruses responsible for St. Louis encephalitis and Japanese encephalitis. Most people infected with WNv will experience no symptoms at all. About 20% of those infected with WNv will develop mild flu-like symptoms lasting a week or less. Symptoms typically include fever, headache, and body aches; a rash on the trunk of the body and swollen lymph glands may also be present. In less than one percent of cases, WNv can cause meningitis (inflammation of the lining of the brain and spinal cord) or encephalitis (inflammation of the brain). For unknown reasons, people over 50 years of age are most at risk for severe illness.

WNv is widespread in parts of Africa, Western Asia and the northern Mediterranean area. Outbreaks have been reported in Egypt, Israel, India, France, Romania and the Czech Republic. In September of 1999, New York City (NYC) reported the first outbreak of West Nile Fever in North America. In the summer of 2000, a second outbreak occurred in NYC and surrounding counties, northern New Jersey, and Connecticut. WNv has since been detected in dead birds, mosquitoes, horses and other animals in most of North America.

WNv is a mosquito-borne virus. In nature it is normally passed between mosquitoes and birds (Figure 2-1). The usual way for humans to get WNv is through the bite of an infected mosquito. However, a very small proportion of cases may become infected with WNv in other ways. These include infection through blood transfusion or organ donation and infection of laboratory staff working with the virus, transmission through the placenta from mother to child and transmission through breast milk.

In North America, WNv transmission is most likely to occur during mosquito season, usually from mid-May until hard frost (late September-October).

Even in areas where mosquitoes do carry the virus, very few mosquitoes are infected. If the mosquito is infected, less than 1% of people who get bitten and become infected will get severely ill. The chance you will become severely ill from any one-mosquito bite is extremely small.

Only certain types of mosquitoes can transmit WNv. There are many different "types" or species of mosquito. The species of mosquito primarily responsible for WNv transmission belong to the "group" or genus *Culex*. Many species of birds can become infected with WNv during the cycle of transmission; members of the crow family (crows, ravens, magpies, nutcrackers and blue jays) are particularly sensitive to the virus and have high death rates if infected. Evidence suggests that crow die-offs precede an increased risk for human illness by 2-6 weeks. Monitoring of dead crows may provide an early warning signal that WNv is moving into an area.

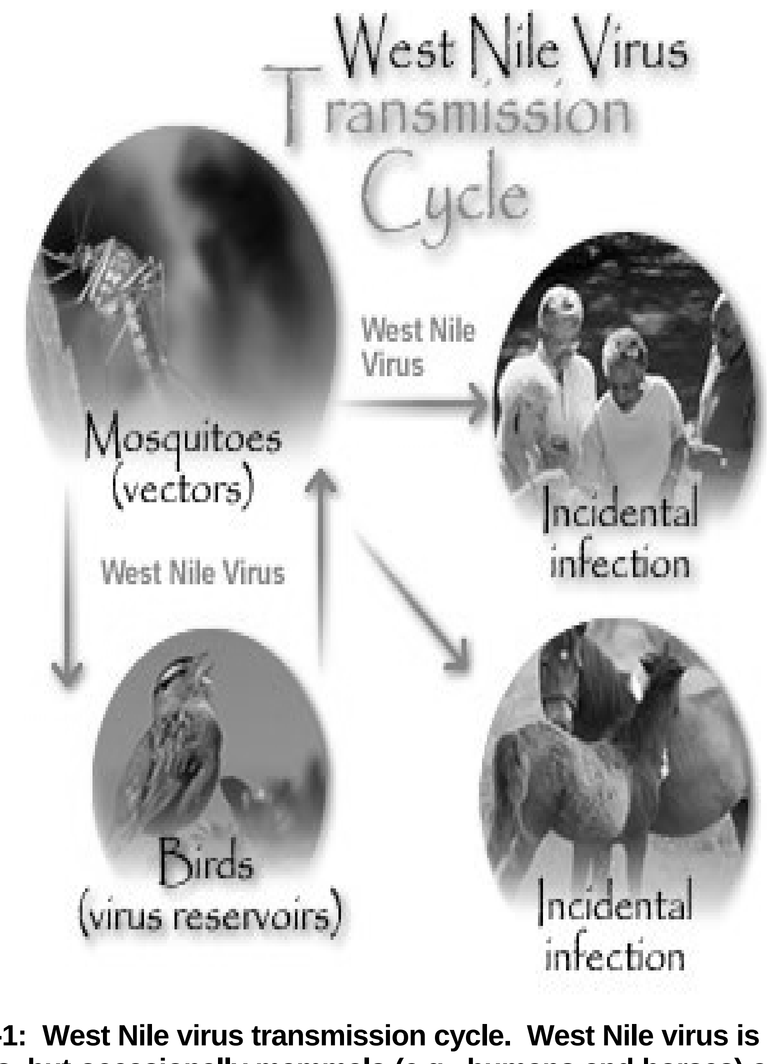


Figure 2-1: West Nile virus transmission cycle. West Nile virus is primarily a bird virus, but occasionally mammals (e.g., humans and horses) are infected (Health Canada website, 2004).

Mosquitoes: Biology, Collection and Identification

Introduction to the Mosquito

Mosquitoes belong to the family Culicidae. All members of this family have piercing and sucking mouthparts, fine scales on their body and wings, and setae (fine hairs) on the thorax. There are over 70 species of mosquitoes in Canada. Approximately 40 of these species are found in the Maritime Provinces: Nova Scotia has recorded 27 species, Newfoundland 26, Labrador 29, Prince Edward Island 34, and 25 in New Brunswick. Each species may differ in size, colour, and body features. Each of these characteristics is used to distinguish between genera (groups) as well as species. Identification of pest species and an understanding of mosquito biology is an essential part of selecting and using appropriate control measures.

The body of mosquitoes and black flies, like other insects, has three major sections (head, thorax, and abdomen). Attached to the thorax are six legs and a set of wings. Like other insects belonging to the Order Diptera, mosquitoes and black flies have a pair of membranous wings in the adult stage. On the thorax, behind the wings, is a set of knobby structures called halteres, halteres are the remnants of the second set of wings. Attached to the thorax, mosquitoes have a large set of compound eyes (Figure 2-2).

The mouthparts of the mosquito are adapted for piercing and sucking fluids, including nectar and blood. The saliva exits through one tube, and the blood or nectar comes up another tube. Male mosquitoes do not take blood meals; they feed only on nectar, while females feed on both nectar and blood. A female mosquito must take a blood meal in order to obtain the nutrients necessary for egg development. When feeding on a host, the saliva of the mosquito is pumped into the wound to prevent coagulation or clotting of the blood, and stimulates blood flow. The mosquito saliva causes the local allergic reactions including redness, swelling, discomfort and pain at the bite. The saliva is the medium that disease-causing organisms, like heartworm and WNv, are transmitted from the mosquito to the host.

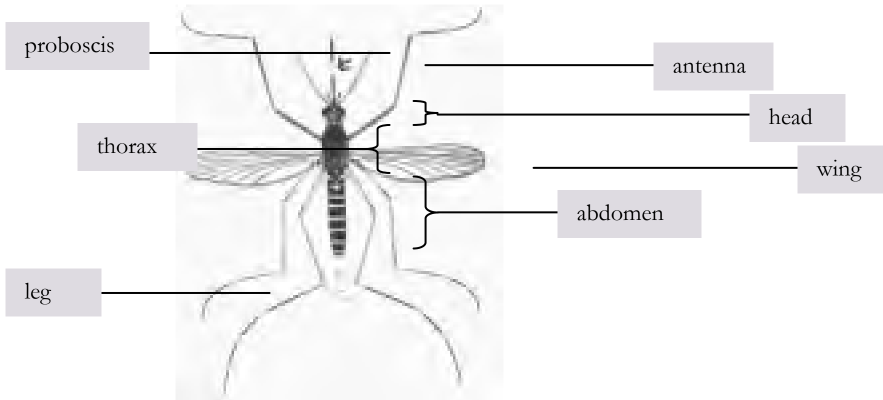


Figure 2-2: The general mosquito body.

Mosquito Lifecycle

Mosquitoes have four stages in their development, namely the **egg**, **larva**, **pupa** and **adult**. The egg, larval, and pupal stages occur in water.

After a female mosquito has taken a blood meal, it can take several days for her to digest the blood meal. After the blood meal has been digested, the adult female mosquito deposits her eggs in a suitable habitat (e.g., damp soil or water). Under suitable conditions, the eggs hatch into larvae, also known as "wrigglers." During the larval stage the mosquito feeds on detritus, algae and other microorganisms. Standing (or very slow moving) water that is high in organic matter is best for egg laying and larval growth. Examples include:

- Edges of swamps
- Flood pools
- Shallow ponds
- Weedy margins of deeper ponds
- Woodland pools

Woodland pools are common sites for larval development.

Mosquitoes may also develop in standing water around culverts and highways, and in storm water catch basins; eaves troughs; discarded tires; tin cans; bird baths, and ornamental pools.

Mosquitoes develop only in stagnant water. They cannot survive the wave action of open water or the movement of water in flowing streams. Large ponds and lakes are not suited for breeding. The only exception would be the shallow edge of a pond where plants reduce water movement.

The larval stage goes through 4 different stages, called **instars**. With each instar, the larva gets bigger. Larvae can be identified in the fourth instar. The size of the larvae can range from 1-15 mm through the four different instars. It is the larval stage that is usually treated first in mosquito control with a **larvicide**, a pesticide designed to attack the larval stage of the mosquito.

Following the larval stage is the **pupal stage**. The pupa floats at the water surface to exchange oxygen and does not feed. The pupal stage is similar to the cocoon stage of a butterfly. In this stage, the shape of the pupa resembles a large-headed black comma. During this time the mosquito gets ready to turn into an adult. Larvicides do not affect mosquitoes in this stage. The adult emerges from the pupal case shortly thereafter. Once mosquitoes emerge as adults, they can be treated with airborne pesticides called **adulticides**.

See Figure 2-3 for an illustrated version of the general lifecycle of the mosquito.

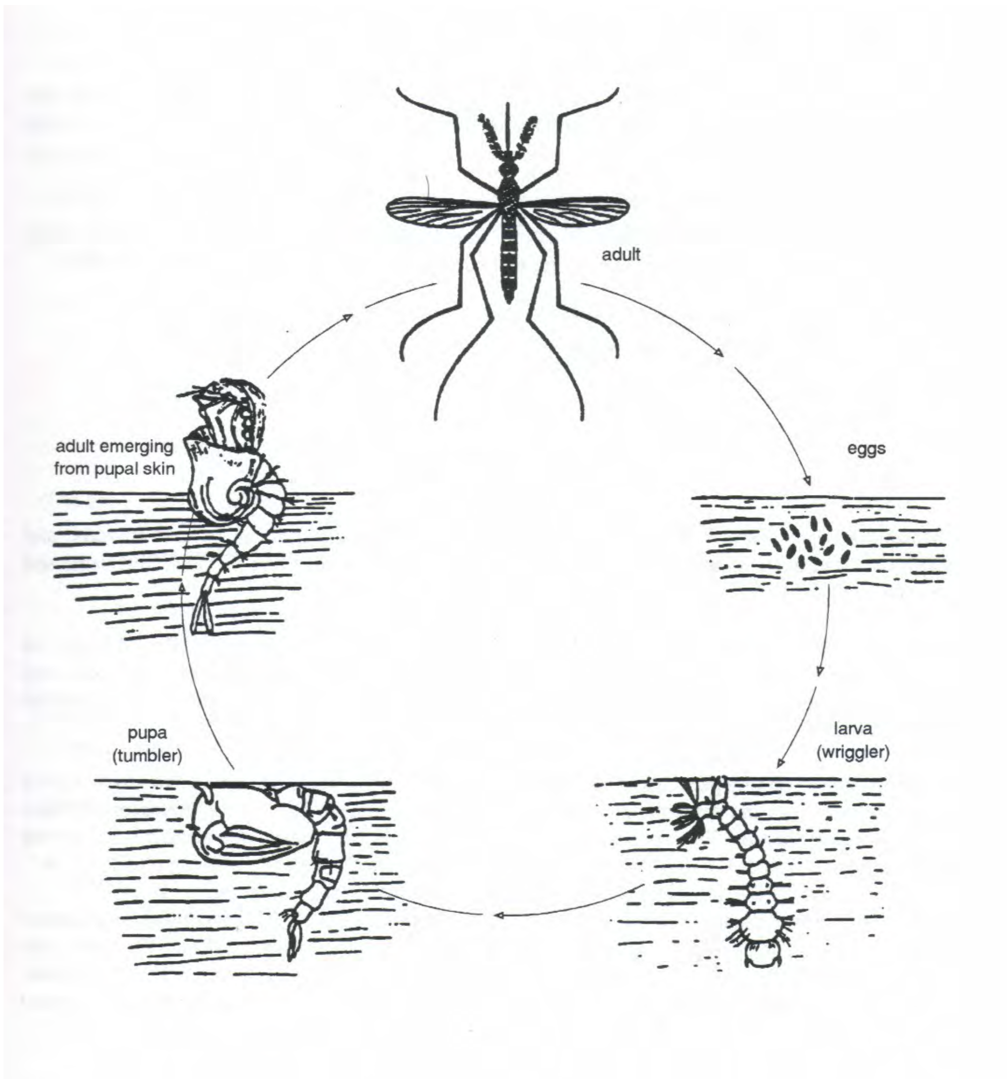


Figure 2-3: The general mosquito lifecycle.

Biology and Behaviour

The genera of mosquitoes found in the Atlantic Provinces that are of annoyance to humans and/or may carry disease, belong to the genera *Aedes, Culex,* and *Coquillettidia* (formerly known as *Mansonia*). These groups, and the species within each group, may differ in many ways, including:

- Their preferred source of blood meal (e.g., human or bird)
- The number of generations in a year
- Which stage (egg, larval, pupal, or adult) and where they survive the winter
- The type of habitat preferred for larval development
- Their ability to carry and transmit disease-causing organisms

These factors influence the **necessity** for control, the **timing** of control methods, the **habitats** that are controlled, and the selection of the **control method** that is most appropriate.

Genus Aedes: Spring

This is the most common group of mosquitoes found in Atlantic Canada

Spring *Aedes* include:

Aedes communis ***Ae. canadensis***

Ae. excrucians ***Ae. punctor***

Ae. fitchii ***Ae. provocans***

Ae. stimulans

Spring *Aedes* survive the winter as eggs in damp depressions containing decaying vegetation, most often deciduous leaves. These locations are typically in a deciduous woodlot or forest. In the spring, the eggs hatch as snowmelt creates water pools over the eggs (snowmelt pools). These mosquitoes may also be referred to as "snowmelt *Aedes*." The eggs may hatch as early as April or as late as June, depending on the local weather conditions.

The larvae of spring *Aedes* mosquitoes grow from 1st to 4th instar in 3 to 8 weeks depending on the temperature conditions. Snow or colder weather will slow down the metabolic rate of the larvae, so they will develop slowly. Unfortunately the cold does not kill them; they usually survive even if the water freezes.

The adult females take blood from a wide variety of animals: humans, pets, other mammals and birds. This means that they have a broad feeding spectrum. Biting activity from this group typically reaches its maximum in June with adult populations declining markedly by late July. After the female has taken a blood meal, she rests in areas of high humidity, until she has digested the blood and is ready to deposit her eggs. She will then lay her eggs in damp soil and leaf litter where they will stay until the next spring snowmelt, when hatching will occur. Spring *Aedes* only have one generation per year.

GENUS AEDES: SUMMER

Aedes cantator, Ae. sollicitans, and *Ae. vexans* are examples of summer *Aedes*. They are common to the Atlantic Provinces, especially where drainage is poor. This group can carry heartworm to dogs and cause significant annoyance to humans. Like spring *Aedes,* they survive the winter as eggs in moist depressions containing decaying vegetation. Typical habitats for summer *Aedes* includes golf course "roughs," powerline rights-of-way, and grassed ditches that are flooded following precipitation.

Eggs hatch as a result of being wetted, dried, and wetted again. Spring snowmelt can be considered the first "wetting" after a dry spell. A subsequent heavy rain in late May or June can cause eggs to hatch. Usually 2.5 cm of rain within 24 hours will cause eggs to hatch. *Aedes cantator,* and *Ae. sollicitans* prefer roadside ditches where salinity from the winter road salt is present, and natural salt marshes. *Aedes vexans,* on the other hand, prefers any area with grassy vegetation and frequent summer flooding.

The larvae develop from 1^{st} to 4^{th} instar in 10 days or less, depending on water temperature (they develop more quickly when it is warmer). If the larval habitat dries within this time, as commonly occurs, the larvae will be killed. Pupation occurs and lasts for a maximum of 3 days, often less. Adult mosquitoes may emerge within a week of the eggs hatching. The adults mate, and the females obtain blood from a variety of hosts, often mammals, including humans. After the eggs have been deposited, they will hatch after 2 consecutive wettings during the same summer.

The number of generations per year for this group is related strictly to weather conditions. There may be one to many generations per year. More precipitation would result in more generations. Biting activity from this group may be at a maximum anytime from June through September. However, if precipitation is common through the summer, populations of adults will increase through the summer and into September until there is significant frost.

GENUS CULEX

Culex pipiens and *Cx. restuans* prefer to feed on birds, *Cx. territans* prefers amphibians and reptiles, but all 3 species will occasionally feed on mammals, including humans. These mosquitoes are of greatest significance as carriers of WNv to birds. They amplify the virus in the bird population and may act as a bridge vector to mammals (e.g., humans and horses). These mosquitoes do not usually reach nuisance levels and are rarely found biting humans.

WNv is known to be primarily a bird virus. Once a mosquito has fed on an infected bird, and the virus has multiplied in its body, the mosquito remains infective for the rest of its life.

Culex mosquitoes survive the winter as adults, under houses, in barns, sewers, and road culverts as well as natural sites such as caves and hollow trees. They leave their overwintering sites once the average daily temperatures reach 21°C (usually mid-May). The adult females take blood, develop eggs and lay them in early June. The eggs are laid in boat-shaped rafts that float on the water surface. Each raft is the result of one blood meal and contains several hundred eggs. Eggs are laid in habitats that are high in organic content that contain water for an extended period of time. These habitats are typically:

- Storm sewer catch basins
- Sewage lagoons
- Abandoned tires
- Swimming pool covers
- Small containers such as tin cans, birdbaths, rain barrels, etc.
- Dyke-land ditches
- Check-dams

When populations are high, flooded ditches may also be used for larval development. The eggs hatch 24 to 48 hours after being laid. The larvae develop from 1^{st} to 4^{th} instar in 7 to 21 days depending on temperature. Pupation occurs, and the pupal stage lasts several days. Adults emerge, mate, take a blood meal and return to lay egg rafts in the same type of habitat.

While they typically have three generations per year, there is significant overlap in the development of these generations. Eggs, the four larval instars and the pupal stages can all be found in the same breeding site at the same time. Biting activity from this group typically is maximum in late July and late August. From early August on, some emerging adults will not seek a blood meal to develop eggs, but rather begin to prepare to go into "hibernation" by feeding on nectar to develop fat bodies. These adult mosquitoes will enter overwintering sites and survive until the next spring.

GENUS COQUILLETTIDIA PERTURBANS (FORMERLY KNOWN AS MANSONIA PERTURBANS)

This is a single species that is known as either *Mansonia perturbans* or *Coquillettidia perturbans*. The adults of this species are strong fliers and voracious biters. They can be an extreme nuisance in areas adjacent to larval habitats. This species survives the winter as larvae buried in the mud, attached to the roots of emergent vegetation in permanent freshwater marshes. The larvae breathe air by inserting specially adapted siphons into the roots of emergent aquatic vegetation such as cattails and bulrushes. The larvae remain attached to the roots from the first to the fourth larval instar as well as the pupal stage. When fully developed, the pupae detach from the roots, swim to the surface, and emerge as adults from July through August. Several emergences may occur during the summer. This is a result of larvae overwintering in different instars and requiring different development periods to complete development the next spring and summer.

After mating and taking blood, the female lays eggs on the water surface in boat-shaped rafts, similar to those of *Culex*. After hatching, the first instar larvae swim down to the mud substrate in the marsh and attach themselves to the roots of aquatic plants with their siphon. They will remain attached to the roots until the next summer when they pupate and emerge. *Coquillettidia perturbans* has one generation per year with most biting activity occurring in July through August.

This species is very difficult to control with larvicides or biocontrol agents focused against the larvae because they are buried in the mud for most of the year. Control of this species usually focuses on control of the adult stage.

OTHER GENERA

There are other mosquito species in Atlantic Canada that can be a nuisance. These include species in the genera *Culiseta*, and *Anopheles*. They are rarely a large-scale problem.

Monitoring Mosquito Populations

During the planning phase of a mosquito control program, it is necessary to monitor mosquito populations to establish the:

- Mosquitoes of significance in the area
- Proximity of larval habitats to humans
- Relative importance of each species
- Presence or absence of disease-carrying mosquitoes
- Size of the larval habitats that require treatment
- Control methods most suitable to the situation
- Type and amount of application equipment required
- Type and amount of control agent required

During the control program, monitoring information is used to establish the:

- Timing of control methods
- Effectiveness of control methods
- Most effective components of the program

Monitoring Mosquito Larvae

A well-planned pest control program should include knowledge of the types of mosquitoes breeding in the control area. Monitoring larval populations includes:

- Identification of the larvae present in the area
- Surveys to establish where the larvae are found
- Development of site maps indicating where control measures should be used

A larval survey can either be subjective to determine the location and kind of mosquitoes present, or objective to determine the relative abundance of each species present. A subjective survey requires much less sampling and time than an objective survey, but it is not as accurate. In either case, the survey must be systematic to insure that no areas will be missed.

Larval Surveillance Equipment

Surveying larvae requires simple equipment. Here is a list of some equipment used to conduct a larval survey:

- A white dipper (500 ml capacity) made of metal or plastic
- Small dip nets to collect larvae for preservation
- Containers to hold larvae (e.g., polystyrene or paper cups with lids)
- Maps to record the location of the larval habitat
- Pen and paper to record the information
- Boots or hip waders

Collecting Larvae

Larvae have no legs, but they swim by wriggling their body from side to side. It is this movement from which their common name of "wrigglers" was derived. Some mosquito larvae feed mainly at or near the surface, whereas others feed mainly at or near the bottom (Wood et al. 1979). Mosquito larvae can be found in almost every type of standing water habitat, from the marshy edges of large lakes, provided that fish are not present; through swamps and marshes of all types and sizes; to small collections of water in rock crevices, tree or stump holes, leaves of pitcher plants, and artificial containers (e.g., pet dishes and bird baths) (Wood et al. 1979).

Larvae are usually collected from large ground pools and marshes by using a white enameled dipper. Some larvae seek the protective cover of floating or emergent vegetation, where they are difficult to collect (Wood et al. 1979). When larvae are disturbed in the water, they swim to the bottom. You may have to wait quietly again until they return to the surface.

Larval monitoring should occur regularly at designated locations. The scheduling of observations depends on the species of mosquitoes present.

Spring Aedes

Monitoring for Spring *Aedes* requires the regular sampling of snowmelt pools from the time when snow-melt begins until the mosquito eggs have hatched and developed into second or third instar larvae. At this point, treatment should occur. Sites that melt early, and those that contain snow and ice for an extended period should be monitored to ensure that all eggs have hatched before treatment occurs. Similarly, monitoring should insure that the larvae are treated before pupation otherwise larvicides are not effective.

Summer Aedes

Monitoring for summer *Aedes* requires sampling of sites that are likely to hold water for a minimum of four days following summer rains. They should be sampled 24 hours after a significant rainfall. A significant rainfall is considered 2.5 cm or more of rain within 24 hours. Flat clay terrain will not permit much water percolation so summer *Aedes* eggs may hatch when there is less than 2.5 cm of rain. Grassy ditches and ditches associated with multilane highways should be checked after every summer rainfall to see if sufficient precipitation has occurred to hatch eggs. Similarly, check around the edges of ponds receiving water from urban storm sewer ditch system for *Aedes vexans* production. Monitoring should occur after hatching to ensure that treatment occurs before pupation.

Culex mosquitoes

Monitoring for *Culex* requires sampling of storm sewer catch basins, and permanent water ditches especially those high in organic content. These areas should be checked from June 1st on a weekly basis for production of *Culex* and *Culiseta* mosquitoes. Containers such as rain barrels, birdbaths, flat roofs, discarded pans, swimming pool covers and old rubber tires should also be monitored at least twice per month during the summer season. Monitor sewage lagoons containing stagnant water for production of *Culex* and other mosquito species. Larvae can be removed from most of these containers by removing or changing the water (e.g., birdbaths and old rubber tires).

You should indicate the location of larval habitats, as well as the type of mosquito present, on a topographical map or aerial photograph. In large control programs the control area should be divided into sections with each potential mosquito habitat indicated and numbered on the map. If possible, the pools should be coded to indicate the types of mosquitoes present.

Records on mosquito species should include the following:

- The species present (Collect larvae to identify later.)
- Their numbers
- When larvae were present
- The presence of natural enemies

Other site data can include:

- Site permanency (spring snowmelt, summer intermittent, summer permanent)
- Substrate type
- Average depth
- Area of the site
- The type and amount of plants present

To collect and preserve larvae for identification, skim the surface of the water with a dipper or dip net. Collect where water plants or floating debris offer cover for the larvae. When disturbed, larvae of many species quickly sink to the bottom and remain there for a number of minutes. You may need to wait for them to return to the surface to collect them.

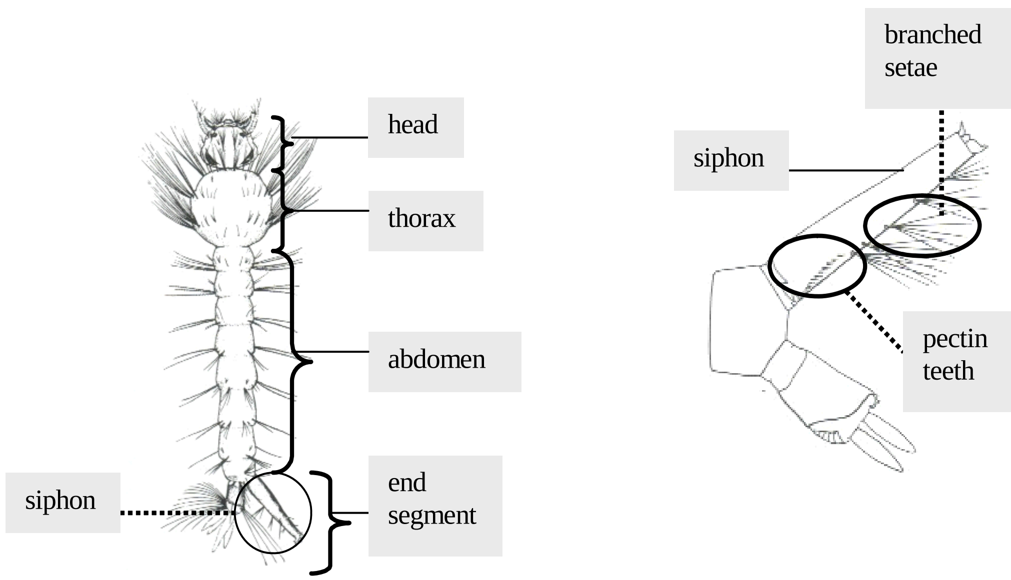
The key given in this section is for mature (fourth instar) larvae. You can collect younger larvae and raise them to fourth instar. Keep them in containers at room temperature and feed them small amounts of fish food.

Place mature larvae in small vials of 70-95% ethanol to preserve them. No more than 25 larvae should be placed in one vial. Place a label that gives the place, date and name of collector inside the vial. Use waterproof paper and a pencil to make records. The vial should be tightly sealed with a stopper.

Identification of Mosquito Larvae

It may be necessary to identify the exact species of mosquito present. In these instances it is strongly recommended that you consult a specialist in insect identification to help identify the mosquitoes.

Once the mosquito larvae have been collected, they should either be reared to identify them as adults, or they should be placed in ethanol and then identified under a microscope. Figures 2-4 and 2-5 show the general mosquito larval body and the end segment of the mosquito larva. Like the adult mosquito body, the larval body is divided into the head, thorax, and abdomen. Although the entire larval body is used to identify the mosquito to species, the key in this manual focuses on the end segment only to identify each larva to genus.



2-4 2-5

Figures 2-4, 2-5: General body of mosquito larva; end segment of mosquito larva, showing the siphon with 5 groups of branched setae above the pectin teeth.

The larvae of mosquitoes can be identified to genus using the following key:

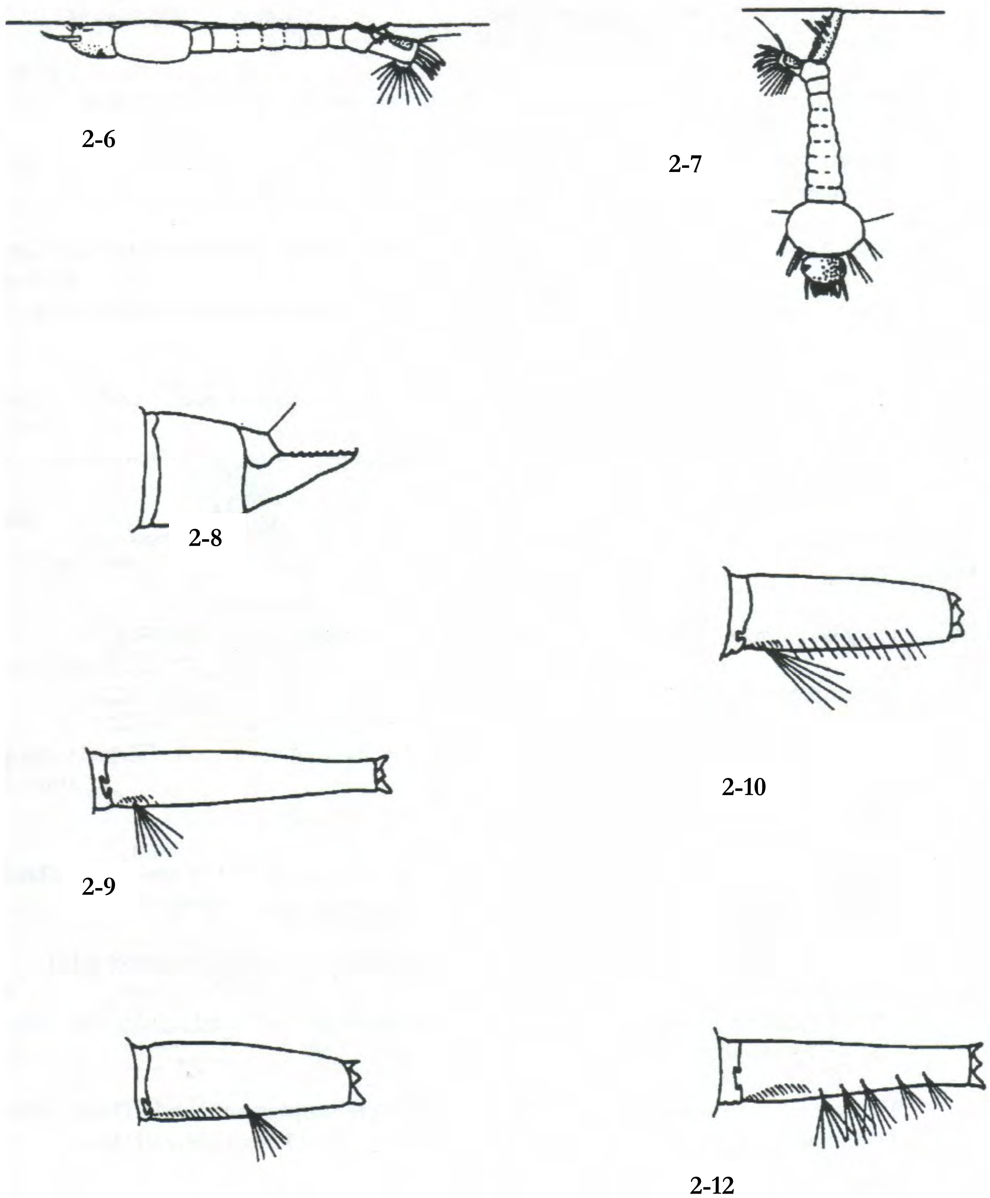
Key to Mature Larvae (fourth instar)

1) Siphon absent (Fig. 2-6); larvae floating horizontally when at water surface …………………………………………………………………………………….*Anopheles*
Siphon present; larvae hanging vertically down when at surface (Fig.2-7)….. …………………………………………………………………...…...2

2) Siphon is short and conical, serrated at tip (Fig. 2-8); larvae buried in mud, attached to aquatic plants………………………………………………………………….…*Mansonia*
Siphon at least twice as long as wide; larvae free-swimming ………….…………………3

3) Siphon with a pair of branched setae at base, beneath or within the pectin teeth of the siphon (Figs. 2-9 and 2-10)…. ……………………………………………...…..*Culiseta*
Siphon with setae at or beyond midlength, not at base of pectin teeth (Figs. 2-11 and 2-12)……. ………………………………………………………………………... 4

4) Ventral surface of siphon with one pair of branched setae beyond the pectin teeth (Fig. 2- 11) ……………………………………………………………………….*Aedes*
Siphon with 4 or more pairs of branched or unbranched setae beyond the pectin teeth, with at least three of the pairs located on the ventral side of the siphon (Fig. 2-12) ……………………………………………………………………………………..*Culex*



Figures 2-6, 2-7, 2-8, 2-9, 2-10, 2-11 & 2-12:
2-6, Anopheles larva; 2-7, larva with siphon; 2-8, siphon of Mansonia perturbans; 2-9 – 2-12, side view of various mosquito larva siphons.

This figure is from the publication Ontario Pesticide Training and Certification Manual: Mosquito and Biting Flies Module. Section 2., p. 5.

Monitoring Adult Mosquitoes

Monitoring adult populations are an important part of any mosquito control program. It allows you to identify the types of mosquitoes that are out and biting in the area. Monitoring of adult populations includes:

- Identification of adult mosquitoes to establish the species that are actually causing the biting activity in the area
- Surveys to establish where biting activity is more severe
- The development of thresholds to establish when control measures should be taken

Adult mosquito populations should be monitored in areas where information on annoyance levels is being collected (usually in residential areas). A good spot is the backyard of a home on a quiet street away from highly illuminated areas and close to shrubbery. The proximity of larval breeding sites will significantly influence the data.

NOTE: DO NOT PRESERVE ADULT MOSQUITOES IN LIQUIDS such as ethanol because the scales cannot be easily seen, making the species identification impossible. Instead place mosquitoes in a soft packing material (e.g., tissue paper) and place in a protective container.

Adult Surveillance Equipment

There are many methods of surveying adult mosquito populations. Surveys in Atlantic Canada have used:

- New Jersey Light Traps
- CDC Miniature Light Traps Baited with Dry Ice
- CDC Traps baited with compressed Carbon Dioxide

The methods used to measure adult mosquito populations are not without bias. The number of mosquitoes collected will depend on:

- The time of day when monitoring is conducted
- The duration of monitoring
- Location of the trap
- Weather conditions (temperature, wind, humidity)
- Attractiveness of the trap for each species of mosquito

The best means is to use a combination of monitoring methods that will overcome any one bias. Some of the advantages and disadvantages of the most commonly used methods are discussed below.

New Jersey Light Traps

These traps are standard traps, which have been used for many years to monitor adult mosquito populations. They use a light bulb to attract mosquitoes and an electric fan to draw them into a container. A 25 or 40 watt electric light bulb supplies light. Do not use a stronger wattage.

Advantages

- Traps can be set up and run 24 hours a day, or on a timer
- Collections can be made on a daily, 2-, 3-,4-, or 7-day cycle
- Its rugged construction minimizes breakdown, vandalism and theft
- Traps only require light, no dry ice or carbon dioxide tanks required
- It is effective for monitoring many different species of mosquito

Disadvantages

- The trap must be located within 30 metres of a hydro outlet
- It collects a wide variety of insects as well as mosquitoes, and much labour is required to sort the mosquitoes from the other insects
- Mosquito specimens are often damaged in the trap or during sorting
- The traps cost several hundred dollars

CDC Miniature Light Traps

These traps use a combination of light, and a carbon dioxide source to attract mosquitoes and a fan to suck the mosquitoes into a mesh bag. Dry ice or compressed carbon dioxide is usually used as the carbon dioxide source. The trap can also be used with the light alone or with the CO_2 alone. Because of the differences in the attractiveness of this trap and that of the New Jersey trap, the data from these two traps cannot be compared.

The trap should be set out between 6:30 and 7:30 p.m. It should be disassembled the next morning between 6:30 and 7:30 a.m. The trap should be suspended from a tree, 1.5 metres from the ground, at the edge of, or inside a wooded area. It should not be visible from any well-traveled road or theft will be likely.

Advantages

- Traps can be set up and operated away from sources of electricity because the power source is a portable battery
- At morning pick-up, the specimens are usually still alive and may be used for encephalitis surveillance
- Only minimal sorting of collected insects is required

Disadvantages

- The apparatus is quite portable and easily stolen
- When collections are made over more than 12 hours, the specimens become badly damaged
- Traps should be baited with dry ice as the light source alone is not an effective attractant
- While less expensive than New Jersey light traps, the CDC traps may be costly

Collecting Adult Mosquitoes

Adult mosquitoes collected in a CDC trap can be killed with minimal damage by placing the collective vial or bag in a freezer for several hours. Provide a label, which defines when the sample was collected, location of collection, and the name of the collector.

Identification of Adult Mosquitoes

It may be necessary to identify the exact species of mosquito present. In these instances it is strongly recommended that you consult a specialist in insect identification to help identify the mosquitoes.

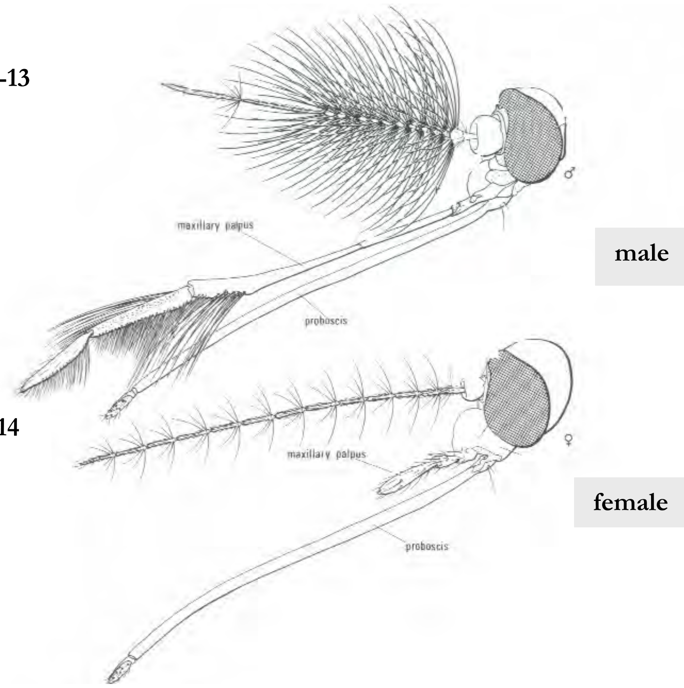
Adult mosquitoes can be identified to genus using the following key:

Key to the Adult Mosquitoes

Male mosquitoes can be distinguished from females by their long, plumose antennae (Fig. 2-13) (Wood et al. 1979).

2-13

2-14



Figures 2-13, 2-14: Side view of mosquito head: 2-13, male; 2-14, female.

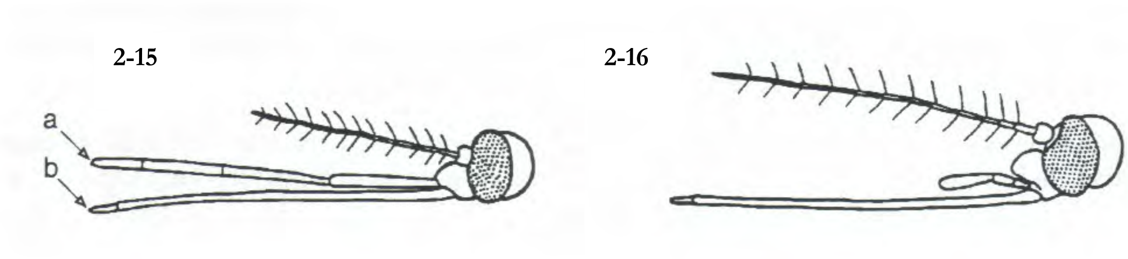
Figures 2-13 and 2-14 are from the publication **The Insects and Arachnids of Canada Part 6: The Mosquitoes of Canada Diptera: Culicidae; Agriculture Canada. Wood, Dang, and Ellis, p. 29.**

1) Palps of the female mosquito are as long as the proboscis (Fig. 2-15); wing scales of most species aggregated into dark spots; body held at an angle to the skin surface when biting…..…………………………………………………………….……..*Anopheles*
Palps are much shorter than the proboscis (Fig. 2-16); body held parallel to the skin when biting …………………………………………………………………...…………2

2) Post spiracular setae present (Fig. 2-17); the end of the abdomen is pointed (Fig. 2-20) …………………………...………………………………………………..………*Aedes*
The end of the abdomen is blunt (Fig. 2-21); postspiracular setae absent …………..……3

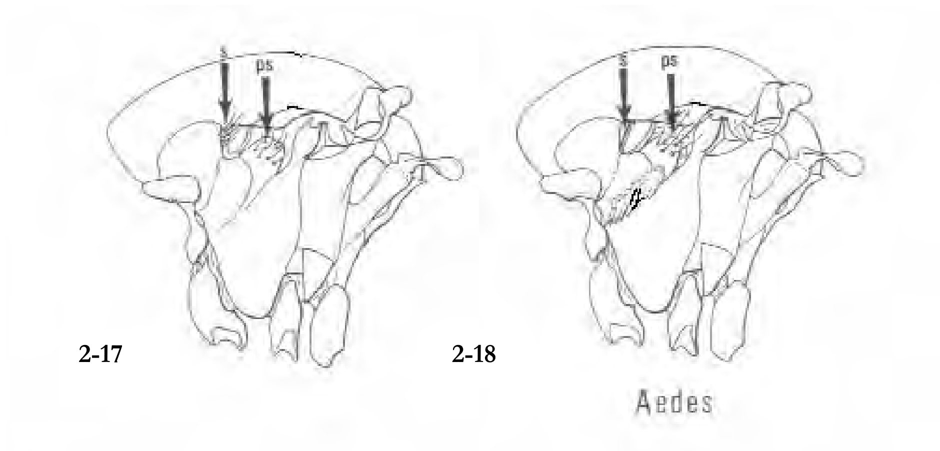
3) Hind tibia with a wide ring of yellow scales near midlength (Fig. 2-19); first tarsal segments each with rings of light-coloured scales at the base and apex; all remaining tarsal segments have a ring of light-coloured scales at the base; wing scales are ……*Coquillettidia*
First hind tarsal segment dark-scaled or if banded, not at midlength; wing scales are narrow ………………………………………………………………………………4

4) Spiracular setae present (Fig. 2-17); most species large-bodied with wing scales that are aggregated into dark spots ………………………………………………………...*Culiseta*
Spiracular setae absent; small-bodied mosquitoes with unspotted wings ………..…...*Culex*

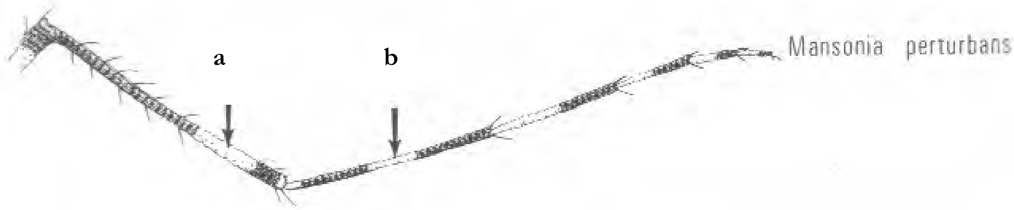


Figures 2-15, 2-16

Figures 2-15 and 2-16 are from the publication Ontario Pesticide Training and Certification Manual: Mosquito and Biting Flies Module; section 2, p. 4.



Figures 2-17, 2-18: Left lateral view of thorax: spiracular setae (s); and post spiracular setae (ps).



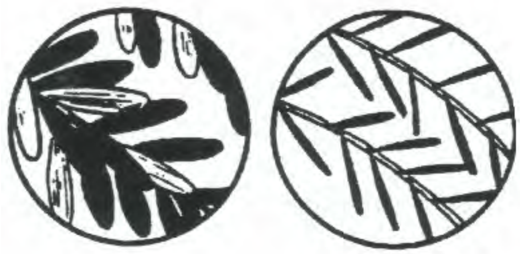
Figures: 2-19. Hind tarsus of *Mansonia perturbans*. (a) distinguishing light-coloured band on the hind tibia; (b) light-coloured band at midlength of first tarsal segment.

Figures 2-17, 2-18 and 2-19 are from the publication **The Insects and Arachnids of Canada Part 6: The Mosquitoes of Canada, Diptera: Culicidae; Agriculture Canada. Wood, Dang, and Ellis. p. 31.**

2-20

2-21

Figures 2-20, 2-21: Dorsal view of mosquito abdomens.



a b

2-22

2-23

Figures: 2-22, 2-23. Wing Scales a) broader, flat scales as seen on _ Coquillettidia**_ _**perturbans**_; b) narrow, thin scales. Figure 23 shows the dorsal view of a right wing.**

Figures 2-20 2-23 are from the publication **Ontario Pesticide Training and Certification Manual: Mosquito and Biting Flies Module;** section 2, p. 4.

Mosquito Control

The selection of a control method or a combination of control methods for mosquito control depends on:

The size of the area to protect

- Financial resources
- Acceptability of the control method to the public
- Availability of application equipment
- Effectiveness of the control method

These factors are critical in deciding which combination of control measures should be used. With few people and limited financial resources, personal protection methods are the most feasible method of control. However, if a large area is to be protected and sufficient financial resources are available, a much greater variety of control measures with greater effectiveness are possible. An integrated mosquito control program may involve a combination of the following techniques:

Habitat Modification

Virtually all mosquito larval habitats have one factor in common, standing water. The elimination of water from the site will result in complete control. However, the practicality and environmental effects of such activities rarely makes this a viable option on a large scale.

Low areas and ditches where water accumulates in the spring, or after precipitation during the summer may be dredged to ensure that they drain quickly.

All provincial governments of Atlantic Canada require an Approval for the alteration of a watercourse (ponds, rivers, lakes, etc.) or water resource (wetland, marsh, bog, etc.), including infilling or draining the water therein. The draining or infilling of a watercourse or water resource is not permitted for the purposes of "private gain".

Plans that involve drainage of wetlands should also consider the effect on fish, waterfowl, other wildlife and the environment in general. Natural swamps are important as reservoirs; they help to maintain adequate water levels in tributaries and streams over dry summer periods. Manipulating drainage systems may also have a significant impact on the availability of water for recreation, domestic water supplies and agriculture. Therefore, all of these factors must be considered before significant changes in drainage of natural swamps are attempted.

Habitat Modification on a Smaller Scale

Property owners should be encouraged to eliminate sites that may be mosquito larval habitats such as:

- Abandoned swimming pools
- Precipitation and snowmelt left on swimming pool covers
- Ornamental ponds
- Rain barrels
- Troughs
- Other small containers and debris

Old tires often contain water and an excellent habitat for the development of several mosquito species. Storm water retention ponds, dugouts and ornamental ponds should be kept free of emergent aquatic vegetation. If possible, no vegetation should be present around the edges of these ponds in order to discourage female mosquitoes from laying eggs.

Mechanical Exclusion (protective clothing, building maintenance)

If people must be in areas with high mosquito populations, they should wear clothing designed to exclude mosquitoes, e.g., long-sleeved shirts, light coloured jackets, trousers and socks. Some clothing (often available in fishing and hunting stores) is specifically designed to exclude mosquitoes and black flies. Remember that lighter coloured clothing is less attractive to biting flies than dark clothing.

The use and maintenance of screens on windows and doors, door closures, and proper building maintenance will reduce the number of mosquitoes entering buildings. If a shipping door must be left open for a long period, an air curtain or plastic strip curtain will reduce the number of mosquitoes and other flying insects from entering the building.

Reducing the number of and type of lights used in the evening, in areas frequented by people, will reduce the number of mosquitoes attracted to an area.

Light traps

Many varieties of light traps are now being marketed as a method of insect control. Although two types of light traps (CDC and New Jersey Light Traps) are commonly used in monitoring mosquito populations, neither of these, nor any light trap is particularly effective for reducing mosquito populations outdoors. Studies conducted in Ontario indicated that less than 4.1% of insects killed in these traps were mosquitoes. These devices do not reduce the number of mosquitoes biting people in yards. The operation of these devices for several days does not reduce the mosquito populations. These traps are designed to take only a sample of the mosquitoes in the area.

BIOCONTROL AGENTS

Biological control or biocontrol includes the use of predators, parasites and pathogens for control. The only commercially available biocontrol agent for mosquitoes in Atlantic Canada is the bacterium *Bacillus thuringiensis israelensis* (BT H-14).

Commercial formulations of BT H-14 contain the bacterial spores and crystalline endotoxins that are toxic to larvae of mosquitoes and black flies. Applied as a liquid solution or granules, BT H-14 is active against the larvae. There is no significant residual activity. While BT H-14 is highly effective against spring and summer *Aedes*, it may not be the product of choice to control *Culex* mosquitoes because of its brief residual activity.

REPELLENTS

A variety of effective mosquito repellents are available. How long the repellent works depends on:

- The active ingredient in the repellent
- The concentration of the active ingredient in the formulation
- The completeness of the application
- Any factor that will dilute or cause the repellent to evaporate faster

Please note: the fact sheet from the PMRA on the use of insect repellents can be found at:

http://www.hc-sc.gc.ca/pmra-arla/english/pdf/pnotes/deet-e.pdf.

Compare the concentrations of the effective ingredients listed on the label of different brands. A repellent should be applied thinly and evenly to all exposed skin. **Keep it out of your eyes.** Treat your clothing, especially, around the collar, cuffs and front openings on shirts or jackets. Always read the instructions on the label before use. For children, remember not to place repellent on their hands as they may accidentally put it in their eyes.

Remember that all repellents are solvents of plastics and can damage eyeglass frames, watch crystals and synthetic fabrics such as nylon. Repellents with a high percentage of active ingredient tend to have more of an effect on plastics than formulations that are less concentrated.

Any physical activity that results in perspiration will shorten the effective life of the repellent.

Swimming, bathing or exposure to precipitation will quickly remove most repellents.

NOTE: Sonic repellers do not repel mosquitoes.

Larvicide Application

Generally, most mosquito control programs rely on larvicides (chemical or BT H-14). Since the larvae can live only in water, they are easier to control than the adults, which are free to fly about over a wide area.

Larvicides are available in a variety of formulations (Table 2-1). These formulations are better adapted to some situations than others.

Table 2-1: Group and method of application of mosquito larvicides

COMMON NAME	*CHEMICAL GROUP**	*FORMULATION***
BT (H14)	Bacteria	S, G
Methoprene	IGR	S, B
Diflubenzeron	IGR	WP
Chlorpyrifos	OP	EC, G
Malathion	OP	EC

* OP=organophosphate; B=botanical; IGR=insect growth regulator

** S=solution; G=granular; B=briquette; WP=wettable powder; EC=Emulsifiable Concentrate; C=capsules

Capsules

Capsules contain an active ingredient held inside a covering. The covering breaks open after several hours of exposure to water releasing the active ingredient into the larval habitat. These are useful when a small area needs treatment. No application equipment is needed and they can be easily applied.

Briquettes

This type of formulation results in the active ingredient being slowly released into the larval habitat over a period of time. The residual activity of this formulation depends to a significant extent on the change over of water in the site because of precipitation. Briquettes are especially useful in a situation such as the control of *Culex* larvae found in small containers, or catch basins.

Emulsifiable Concentrates, Wettable Powders, Solutions

The control of larvae in sites with no or minimal vegetation (catch basins, open ditches etc.) can be conducted with any of these formulations. They are mixed in water and applied with a variety of equipment ranging from backpack sprayers through skid-truck-mounted sprayers and mist blowers.

If there is a significant amount of vegetation in the treated sites, the insecticide may adhere to the vegetation and not reach the standing water. Off target drift may also be a problem and limit work when winds are significant. You must ensure that wettable powder formulations receive sufficient agitation for the product to remain in suspension during application.

Granules

Granular formulations are commonly used for the control of spring *Aedes* mosquitoes. The larval habitat is often under vegetation. The granules are used so that the active ingredient does not adhere to the vegetation, but falls to the standing water below. The use of granules minimizes drift and reduces user exposure during mixing and loading. Because the granules are very visible, it is easy to distinguish between treated and untreated sites. Granules can be applied with manual, powered backpack blowers or vehicle-mounted equipment.

Larvicides should be applied when the majority of larvae are mid-way through their development (second and third instar). **Because larvicides do not control pupae, treatment must be made before the pupal stage.** The treated sites should be surveyed 24 to 48 hours after the application to establish whether the larvicide has been effective.

If there is significant precipitation immediately following the larvicide application, effectiveness may be reduced. Also, additional precipitation may cause another hatch of mosquito eggs that may not be controlled by the initial larvicide application. A second treatment may be required to control these mosquitoes.

Adulticide Application

A properly conducted larvicide program will reduce the mosquito population so that killing adults may not be required. However, occasionally adults may migrate into the area from untreated locations, or it may not be practical to conduct a larviciding program. The latter situation may occur in small northern communities or at work camps, summer camps, tourist resorts and cottages. Adulticiding alone is an activity, which provides only temporary relief. Within a few hours, or perhaps a few days if the treated area is large, re-infestation will take place from the surrounding area.

Table 2-2: Chemical group and method of application of mosquito

COMMON NAME	*CHEMICAL GROUP**	*APPLICATION METHOD***
Dichlorvos	OP	TF, ULV
Propoxur	C	RS, TF, ULV
Chlorpyrifos	OP	RS
Naled	OP	RS, TF, ULV
Permethrin	SB	RS
Malathion	OP	F, ULV
Pyrethrin	B	F, ULV
methoxychlor	CH	RS, TF

*OP=organophosphate; CH=chlorinated hydrocarbon; B=botanical; SB=synthetic botanical; C=Carbamate.

** RS= residual spray; TF=thermal fog; ULV=ultra low volume; F=Fog

Mosquito adulticides may be applied as residual sprays, thermal fogs or as ultra low volume applications. The products available for use are listed in Table 2-2. The following provides a discussion of these application techniques:

Residual Spray

A backpack, truck-mounted mist or high-pressure sprayers are used to deliver a variety of insecticides (Table 2-2) to kill mosquitoes where they rest during the day. This equipment typically produces a droplet size of 50 to 400 microns depending on the pressures and nozzles used. This droplet size is significantly greater than that used for thermal fogging or ULV applications described below. Therefore, drift is usually a less significant problem with this type of application.

Residual sprays may be applied where specific areas are to be protected, or as a barrier treatment to prevent the migration of mosquitoes into an area. Areas such as industrial work areas, private yards, playing fields, parks and golf courses are areas where such sprays can be effective.

Areas where mosquitoes rest during the day should be treated. This is typically in areas of dense vegetation with high humidity. For greatest effectiveness, applications should be done in late afternoon or early evening shortly before mosquitoes become active. Some emulsifiable concentrate formulations may be phytotoxic. Avoid direct application of these formulations to foliage and consult the label as to whether or not foliage should be treated.

Thermal Fog

Thermal fogs are produced by introducing an insecticide mixed with diesel fuel, fuel oil or kerosene onto a warm manifold and subsequently into a stream of air. This results in the production of a dense grey fog consisting of droplets ranging in size from 0.5 to 50 microns. This fog or cloud of extremely fine spray droplets lingers near the ground, penetrating the area inhabited by adult mosquitoes. The insecticide enters the mosquito through the exoskeleton or through the breathing system. Residual deposits are minimal and insufficient to kill mosquitoes landing later on. Thermal fogging will reduce biting activity for several hours to several days depending on the environmental conditions during and following the application, the size of the mosquito population, and the effectiveness of the active ingredient chosen.

Experience has shown that mosquitoes must be in a fairly dense fog for a minimum of 20- 30 seconds to be killed. If the fog is intermittent and the mosquitoes are exposed to it for a lesser period of time, they are likely to survive. Fog density and exposure time are the two important factors. Unless atmospheric conditions (wind and temperature), and the fog produced are such that a dense fog moves slowly through the area to be protected from 0-5 m above the ground, the effectiveness of the treatment will not be satisfactory.

Fogging is most effective when conducted during the evening or early morning hours.

At this time a temperature inversion may occur and is desirable (cooler air at ground level with a warmer air above). Fogs tend to rise and are dispersed too rapidly during the heat of the day. An inversion causes the warm fog containing the insecticide to stay near the ground.

Although some air movement is desirable to carry the fog through the area, the wind should not be greater than 15 kph and ideally should be 5 - 8 kph.

An additional advantage to fogging during the evening is that, at this time, usually the greatest number of mosquitoes are starting to move from their resting places and thus more likely to be contacted by fog.

The fogging machine should be moved in a direction at right angles to the wind direction.

Additional passes should be made through the area, still moving across the direction of the air movement. The distance between passes is governed by the necessity that all parts of the area should be exposed to a dense fog for the required period of time. This will regulate the rate of travel of the fogging machine.

The best results are produced from fogging machines when the instructions for operating, cleaning and maintaining the particular machine are followed. It is preferable to have one person responsible for operating and maintaining the machine. Straining the insecticide as it is poured into it may avoid clogging. It may also be advantageous to flush out the machine at the end of each fogging season by running fuel oil through it.

Problems associated with the use of thermal fogging include:

- Weather conditions that are inappropriate for the fogging (often wind speed is too high)
- Inadequate access to the area where most of the mosquitoes are resting
- It may be impractical to apply the fog at right angles to the wind
- The swath width is too wide because of dense vegetation
- The fog produced may impair the safe driving of vehicles
- "Wet fog," which may be phytotoxic, can be produced if the thermal fog generating equipment is not "warmed up"
- Fogging may have an adverse effect on off target drift

Ultra Low-Volume

Ultra low volume machines break specially concentrated formulations of insecticides into very small droplets and disperse them by means of a powerful air blast system. The formulations used have a relatively high percentage of active ingredient and are often used undiluted. This significantly reduces the size of the tank required on the sprayer. The size of droplets produced is in the 5 to 20 micron range. The ideal range for mosquito control is 5-15 microns. This technology was developed in part to eliminate some of the problems associated with the use of thermal fogs. The aerosol produced is almost invisible, and drift is more controlled than with thermal fogs.

The insecticide droplets kill mosquitoes by direct contact and should be applied in the late afternoon and early evening hours when mosquitoes are active. A low wind velocity usually aids in dispersing ULV aerosols.

Types of Larvicides and Adulticides

Mosquito larvicides and adulticides may be divided into four groups:

- Insect growth regulators
- Botanical and synthetic botanical
- Chlorinated hydrocarbo
- Organophosphate and carbamate

Insect Growth Regulators

Methoprene is an insect growth regulator used to control mosquito larvae. It causes abnormal development in larvae, pupae and adult insects when applied during the larval stage. Death usually occurs when the pupa attempts to moult to the adult. Methoprene itself has a residual life of only several hours. Therefore the formulations sold, slowly release methoprene into the larval habitat. It is sold in a slow release liquid formulation or as briquettes. The briquettes are especially suited for the control of *Culex* mosquitoes in permanent water sites (e.g., catch basins) while the liquid formulation is effective against *Aedes* larvae.

Diflubenzuron is an insect growth regulator that prevents the chitin from forming in the insect's exoskeleton. As a result the mosquito is killed at its next moult. It is not effective against pupae or adult mosquitoes. The residual life is a maximum of several days. It has little residual activity and is not suitable for the control of *Culex* mosquitoes in its wettable powder formulation.

Botanical and Synthetic Botanical

Pyrethrins (the pyrethrum extracts from chrysanthemums) are the only botanical insecticides used for mosquito control. Various formulations of pyrethrins are available for the control of many insect pests, including larval and adult mosquitoes. They are often formulated with piperonyl butoxide, a synergist, or other active ingredients to increase their insecticidal activity. They work faster at lower temperatures, a property known as a negative temperature co-efficient.

Capsules containing pyrethrins are used to treat small, mosquito larval habitats. They are easy to apply with no application equipment and are ideal for the treatment of small spring or summer *Aedes* sites. The negative temperature coefficient results in pyrethrum being especially effective against spring *Aedes* mosquitoes.

Both thermal fog and ultra low volume formulations of pyrethrin are available for the control of adult mosquitoes.

Chlorinated Hydrocarbons

Methoxychlor is the only chlorinated hydrocarbon used to control mosquitoes. It is available as an emulsifiable concentrate for the control of adult mosquitoes.

Organophosphates and Carbamates

Two organophosphate insecticides are currently used to control mosquito larvae, namely:

chlorpyrifos and **malathion.** In mosquito larval habitats chlorpyrifos has a residual life of several weeks; malathion shows residual activity for several days. Chlorpyrifos is available in granular formulations that make them especially suitable for use in habitats that have dense vegetation. Malathion does not show sufficient residual activity to control *Culex* mosquitoes. However, chlorpyrifos with a longer residual life may be an effective agent for the control of mosquitoes in this genus.

Four organophosphate and one carbamate insecticide are used to control adult mosquitoes (Table 2). These vary in residual activity from virtually none to several days, depending on the method of application and product used.

Record Keeping

The collection of data and accurate record keeping provides information that will help to:

- Identify areas consistently requiring treatment
- Monitor costs and develop future budgets
- Establish the effectiveness of the program
- Identify where improvement may be made
- Defend any liable action directed at the program

Detailed records should be maintained concerning:

Larval Surveillance: The maps, aerial photographs, and related information discussed in the monitoring should be maintained on an ongoing basis.

Larval Treatment: Details of the control method used together with data on effectiveness should be kept with the pond number. This includes information concerning any habitat alteration that has been done, and the use of biocontrol agents and insecticides, etc.

Adult Surveillance: Records concerning all the monitoring of adult mosquito populations should be maintained.

Application Equipment: Type and number of equipment used, repair or replacement time and costs; vehicle allocation and depreciation should all be recorded to help plan budgets and maintenance schedules.

Notification: Records must be maintained concerning the methods of notification used to inform people regarding the details of the mosquito control program.

Black Flies: Biology, Collection and Identification

Black flies belong to the family *Simuliidae*. Black flies are also known as buffalo gnats, turkey gnats, ear flies and sand flies. Adult female black flies feed on blood, causing irritation and discomfort to humans, domestic and wild mammals and birds.

Female black flies have short, piercing-rasping mouthparts, which slash the skin before sucking blood. The males, who do not feed on blood, have sponging mouthparts. They feed on the nectar of flowers to meet their energy requirements. Both sexes of black flies feed on moisture released through pores on the underside of leaves. The female starts looking for her blood meal approximately two weeks after emerging. Unlike the mosquito, the black fly bites only during the day. On animals they bite not only the exposed skin but also invade the ears and nostrils.

On humans, in addition to biting exposed areas, they also crawl through openings in clothing. Although the actual bite may not be painful, swelling may occur later and the area may remain sore and itchy for several days. Some species that seldom bite can nevertheless be very annoying because of their habit of flying about the head and face.

Identification

Adult black flies are small (1-5 mm in length), stout-bodied, hump-backed flies with short, broad wings and short legs. They have short, thick antennae with 9-11 segments. There are about 150 species of black flies in Canada. Only 6 or 7 species are major pests of humans.

In Eastern Canada, only two species complexes are severe pests. The first of these to appear (with the bursting of the buds of forest trees) is the *Prosimulium fuscum-mixtum* species complex. Adults are pale to dark brown and have uniformly brown legs, without white bands. The species of *Prosimulium* last only 1-2 weeks before being largely supplanted by the *Simulium venustum-verecundum* species complex, a group of blacker species with black and white banded legs. The peak of abundance of the *venustum* species complex is in June or early July, depending on latitude. Thereafter, the problem usually subsides, although a few species continue to create local problems. *Simulium decorum* may become noticeable in autumn (though present all summer, this species either does not attack humans or is so outnumbered by the *venustum* complex that it escapes detection).

Many black fly genera do not bite humans and do not need to be controlled. Proper identification will minimize the number of sites requiring treatment. A key to help identify the larvae and adults of the major genera of black flies is included on the following pages. The groups that do not bite humans are indicated on the key.

It is strongly advised that you consult a specialist in this field if you need to identify black flies to species.

Life Cycle and Behaviour

Like the mosquito, the black fly also has four life stages: egg, larva, pupa, and adult (Figure 2-24). The first three stages are found in fast-flowing water. They are in rapids, beaver dams and even below waterfalls. In the spring, every stream and rivulet is a potential breeding place for black flies. Unlike the mosquito that breathes at the water surface, the black fly larva and pupa obtain their oxygen directly from the water. This explains the need of black fly larvae for flowing water that is well aerated, while the mosquito larvae live in standing waters.

Different species of black flies differ greatly in details of their development including:

- The stage in which they overwinter
- Preferred water temperature for development
- Types of streams in which they live
- Number of generations per year

Depending on the species, black flies may have one or several generations per year. In the latter case, the number of generations may overlap so that at a given time any of the four life stages of a species may be present.

The adult females lay eggs on or in moving water, or on rocks, weeds or other materials at or just under the water's surface. Depending on species, each female can lay 200 to 500 eggs. The eggs may hatch within a few days or several months. Some species overwinter in the egg stage.

The eggs hatch into larvae, which attach to stones, sticks or vegetation under the water. The larvae may be dark brown, green or pale in colour. When very numerous, they cause the object to which they cling to have a slimy appearance. The larvae feed by filtering organic matter from the passing water. The larvae moult 5 to 8 times before pupating and when full grown are about 1 centimetre long. The larval period varies from 2 weeks to several months depending on the species and water temperatures. Some species may overwinter in the larval stage.

The larvae spin cocoons, which are attached to objects in the water. Cocoons vary in form. In some species they may be of loosely woven silk-like material; in others they may be firmer and slipper-shaped. The larvae change into pupae within the cocoons. The adult emerges from the pupal skin, rises to the water surface and takes flight almost immediately. Mating usually occurs soon after emergence. The females then begin to search for a blood meal.

The adult black fly may live for a few days to several weeks. For some species several generations may occur in one year. Biting activity may continue into October.

Some black fly species are very active fliers commonly dispersing 30-40 km. They may be carried by the wind more than 100 km.

Black flies are most active when the wind is less than 5 km/h. They will attack during daylight with more activity at dawn or dusk. They become more aggressive on cloudy days and when storms are approaching. They usually do not bite when in buildings, tents or vehicles.

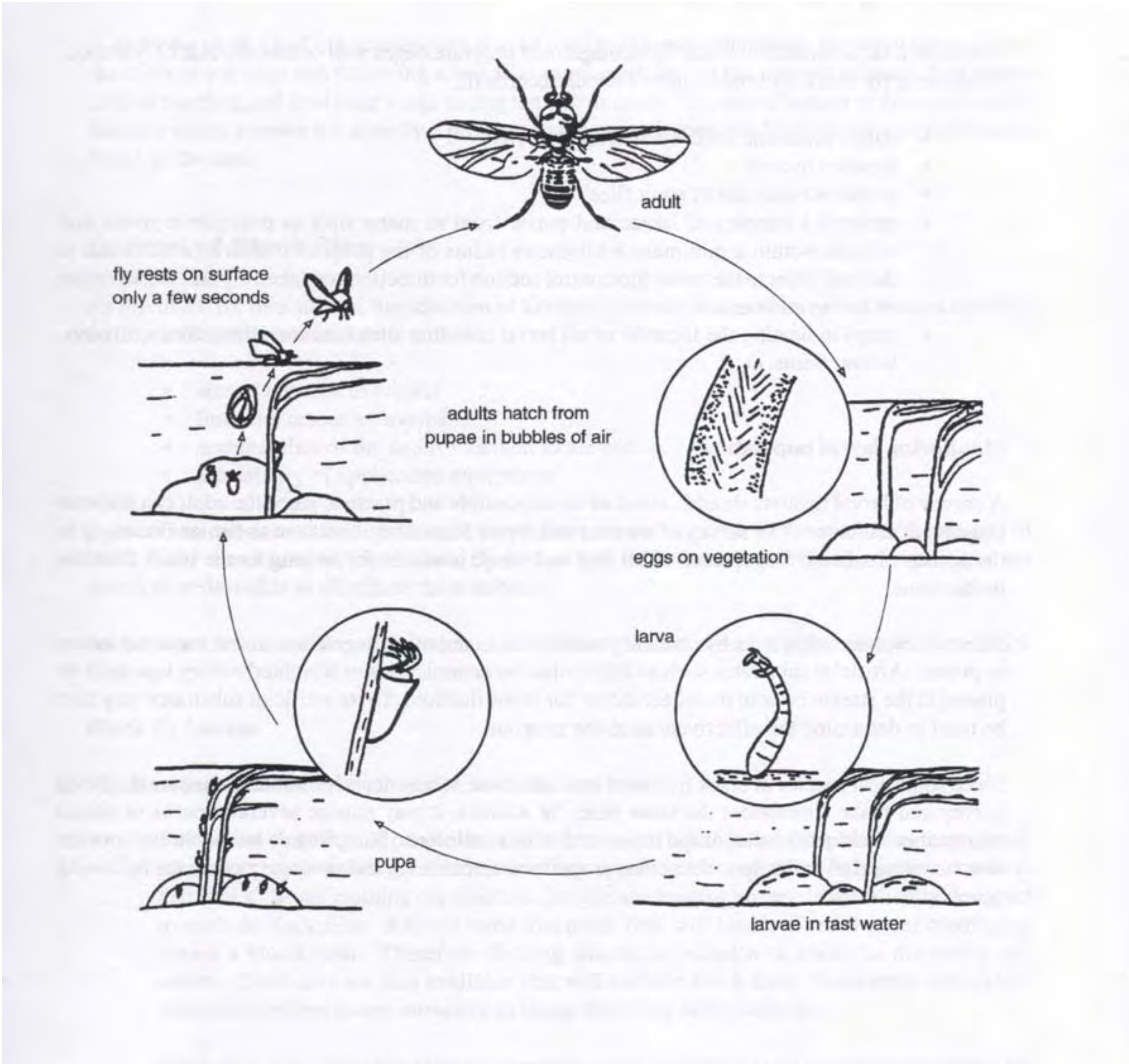


Figure 2-24: Generalized lifecycle of black flies.

Monitoring Black Fly Populations

Preparation for a successful black fly management program must begin well before the black fly season. Monitoring for black fly control must include records of:

- Dates, times and severity of biting activity
- Weather records
- Preserved samples of adult flies
- Preserved samples of larvae and pupae from as many sites as possible in rivers and streams within a minimum 8 kilometre radius of the proposed areas where control is desired (refer to the mosquito control section for directions on labeling and preservation of larvae and pupae)
- Maps indicating the location of all larval breeding sites (stream riffles, dam spillways, beaver dams, etc.)

Monitoring Larval Populations

A survey of larval habitats should extend as far as possible and practical since the adult can disperse significant distances. The survey of streams and rivers should begin as soon as the ice breaks up in the spring. It should be repeated at 10 day to 2-week intervals for as long as the black flies are bothersome.

Survey larval breeding sites by checking rocks, twigs, and other vegetation in the water for larvae or pupae. Artificial substrates such as light coloured ceramic tiles or weighted survey tape may be placed in the stream bottom to collect larvae for identification. These artificial substrates may also be used to determine the effectiveness of the program.

Since some pest species of black fly overwinter as larvae, it may not be possible to conduct the larval survey and make a treatment the same year. In addition it may require several months to obtain proper species identification of the larvae and adults collected. Sampling of larvae throughout the first survey season will help to determine proper treatment timing and site locations for the following year.

Monitoring Adult Populations

Surveys of adult black fly populations may be made using a sweep net. Use the sweep net to gather resting black flies in vegetation near larval breeding habitats or where significant adult biting activity is present. The sweep net can also be used to collect adult black flies that are flying around your body, especially your head.

A dark blue cloth (30.5cm square) may also be used to estimate adult black fly populations. Place the cloth in your lap and following a two-minute interval, record the number of black flies that land on the cloth and fold their wings during the two minutes. The identification of these adults will indicate which species are actually a problem in the area. It may not be the most common larvae found in the area.

Key to the Adult Black Flies

1) Dorsal surface of stem of wing vein R with no setae (Fig. 2-25)
. . . . …… . biting species of *Simulium*
Dorsal surface of R with setae . . . . … 2

2) Rs wing vein deeply forked; stem same length as or shorter than branches (Fig. 2-26)
. . . . ….3
Rs unforked or shallowly forked; stem much longer than branches (Fig. 2-27)*non-biting spp. of *Simulium, Greniera, Cnephia, Mayacnephia, Metacnephia, Stegopterna, Ectemnia*

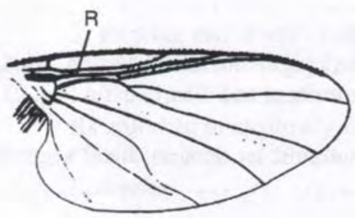
3) Wing smoky brown, opaque . . . . … . . . . ….**Gymnopais*
Wing clear or, if tinted, transparent 4

4) Antennal flagellum 7-segmented, 9 segments in all (Fig. 2-29)….... . . . . ….5
Flagellum 9-segmented, 11 segments in all . . . . … . . . . most spp. of *Prosimulium*

5) Vein R1 joining C at or beyond midlength of wing. Vein C extending around margin of wing well beyond its junction with R4+5. Setae on C and all branches of R as long as cross vein r-m (Fig. 2-28) . . . . …... . . . . . …**Parasimulium*
Vein R1 joining C beyond midlength of wing. Vein C ending close to junction with R 4+5.
Setae on veins much shorter than length of r-m 6

6) Shiny spherical protrusion behind eye (Fig. 2-29,a) . . . . … . . . . . . **Twinnia*
No-shiny spherical protrusion behind eye . . . . ……... . . . . *Prosimulium gibsoni*

***Genera not known to bite humans** These keys are from the publication Insect Identification; Supplement No.1; Third Edition; To Canadian Forces Manual On Pest Control (A-MD-115-001/FP-Z01) 94 pp.



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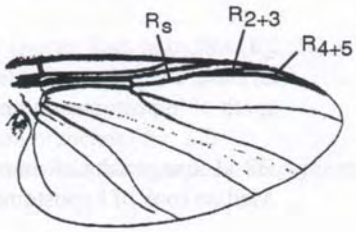

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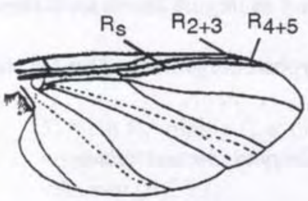

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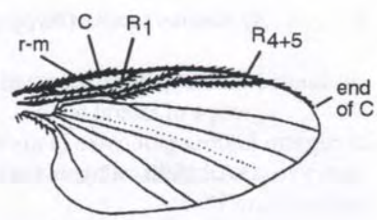

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Figures 2-25, 2-26, 2-27, 2-28, and 2-29.

These previous figures are from the publication Ontario Pesticide Training and Certification: Mosquito and Biting Flies Module. Section 2, p. 32.

Key to the Late-stage Larvae of Black Flies

1) Lateral margins of head capsule convex, labral fans absent (Fig. 2-30)
. . . . *Gymnopais, Twinnia*
Lateral margins of head capsule more or less parallel, labral fans present (Fig. 2-31)
. . . . 2

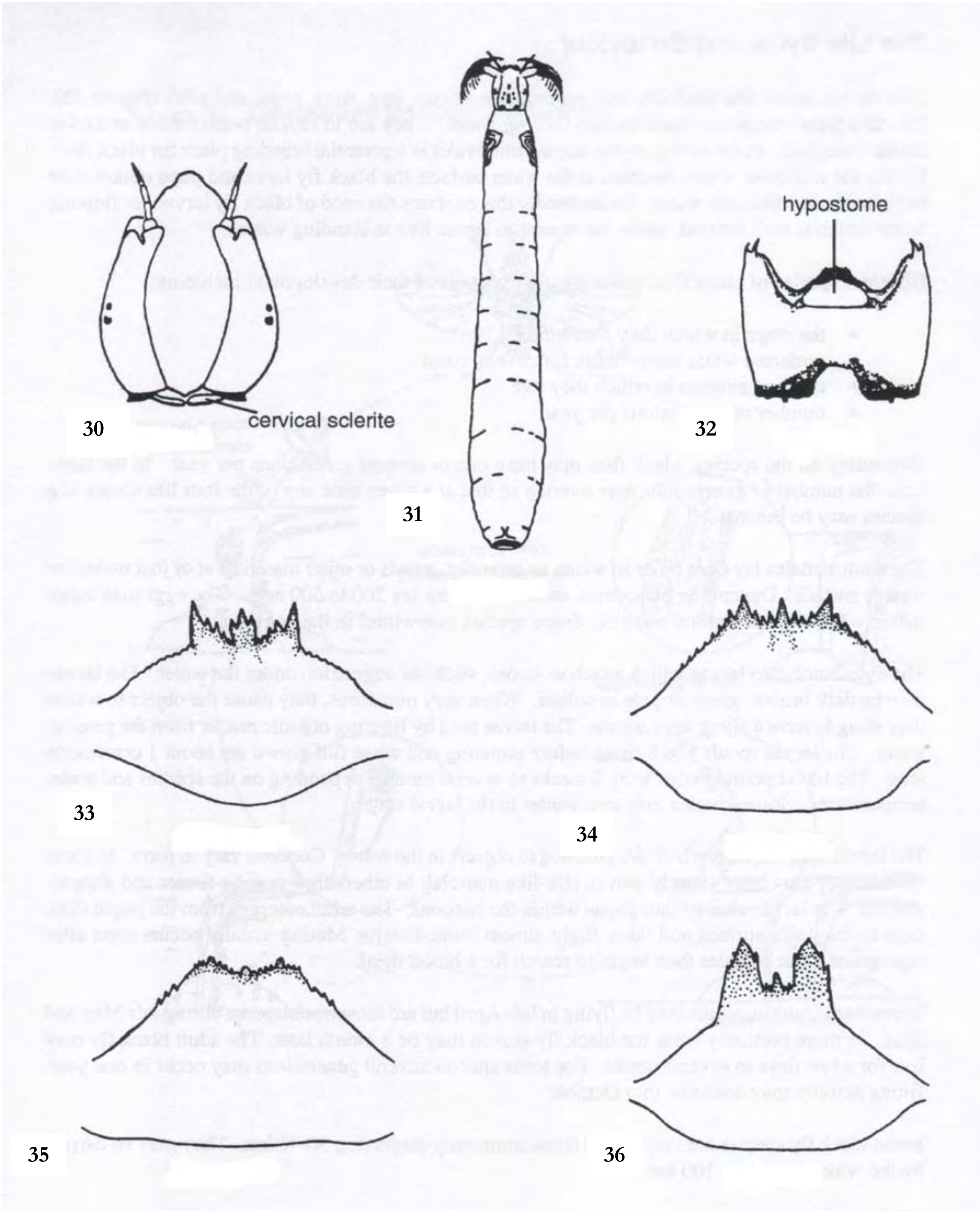
2) Basal 2 segments of antenna pale, contrasting with dark pigmenteddistal portion. Median tooth of hypostome, on underside of head (Fig. 2-32), prominent and clearly trifid (Fig. 2-33)….. 3
Basal 2 segments of antenna pigmented, as dark or almost as dark as distal segments. Median took of hypostome not trifid 4

3) Cervical sclerites strap-shaped (as in Fig. 2-32) ………. . . . . *Prosimulium*
Cervical sclerites reduced to dots of pigmented cuticle . . . …….. . . . . *Stegopterna mutate*

4) Median tooth of hypostome projecting as far anteriorly as largest lateral teeth (Fig. 2-34)…….... . . . . ……… *Simulium*
Median tooth either small and similar to other teeth of hypostome or flanked by 2 prominent groups of lateral teeth 5

5) All teeth on hypostome small (Fig. 2-35)….. ………….. **Ectemnia, Cnephia, Metacnephia*
Lateral teeth of hypostome in prominent groups, projecting much further forward than median tooth (Fig. 2-36)…………...……….…….. **Greniera, Mayacnephia, Stegopterna emergens*

*Genera not known to bite humans



Figures 2-30, 2-31. 2-32, 2-33, 2-34, 2-35, 2-36: Features of black fly larvae.

These figures are from the publication Ontario Pesticide Training and Certification Manual: Mosquito and Biting Flies Module. Section 2, p. 33.

Control of Black Flies

As discussed for mosquitoes, the selection of a control method or a combination of control methods for black flies depends on the:

- Size of the area to protect
- Financial resources available
- Acceptability of the control method to the public
- Availability of application equipment

Some of the options available to control mosquitoes are not effective or practical for the control of black flies. For example, since black fly larvae live in fast-moving streams or rivers, it is not practical or desirable to eliminate these habitats.

As discussed for mosquitoes, light traps are not effective for the control of either mosquitoes or black flies.

Black Fly Larvae Control

The most practical control methods for black flies include**:**

PROTECTIVE CLOTHING

If people must be in areas with high black fly populations they should wear clothing designed to exclude black flies, e.g., long-sleeved shirts, light jackets, trousers and socks. Some clothing (available in fishing and hunting stores) is specifically designed to exclude black flies. Keep in mind that black flies will land and crawl under clothing to obtain a blood meal. Therefore clothing should be sealed with elastic at the wrists and ankles. Head nets are also available that will exclude black flies.

Remember that lighter coloured clothing is less attractive to biting flies than dark clothing.

Black flies will rarely bite indoors; therefore, work indoors if at all possible when black fly populations are severe.

BIOCONTROL AGENTS

This includes the use of predators, parasites and pathogens for control. The only commercially available biocontrol agent in Canada is the bacterium *Bacillus thuringiensis israelensis* (Bt H-14). It is a highly effective and selective biocontrol agent. The application methods discussed for chemical larvicides apply to BT H-14.

REPELLENTS

The same repellents used against mosquitoes will work against black flies. However, they are usually effective for a shorter period. The following factors are important in the use of biocontrol agents and larvicides:

TIMING

Since the recommended larvicides are effective only against the larvae, treatment should be made when the greatest number are in the larval stage. This may be immediately after ice starts to leave, or as late as mid-May depending upon species, and local weather. Thus, to ensure the best timing, monitoring of breeding sites should begin early in the spring. Treatment should be timed for when the larvae are very numerous and are about 6 mm long. Treatments are not effective against pupae; therefore, application must occur before pupae are present.

APPLICATION

In general, the larvicide should be applied to the streams or rivers at intervals of 400-800 metres. However, the optimum spacing should be determined by past experience. Where possible, treatment sites should be located above rapids, below dams, or pond or lake outlets where the water is highly oxygenated. Stream turbulence is needed to ensure adequate mixing. Wide streams will need more than one injection point across their width. Back-pack sprayers or other application devices may be used to apply the larvicide and ensure good mixing of the larvicide in the water.

Because black flies are excellent fliers, the area in which larvae should be controlled may be significantly larger than that required for mosquito control. It is not possible to state the area required for good control. Certainly, the larger the area treated, the lower the biting activity in the treated area. Cost usually limits the amount of time and labour available, and thus the size of the area in which larvae can be controlled.

ASSESSMENT

The effectiveness of the treatment should be assessed 24 to 48 hours after application by counting the number of larvae remaining on natural stream substrates or artificial substrates used in the initial surveys. Several treatments may be required in one year depending on the species present. Species with several generations each summer may re-infest a larval breeding habitat.

The effectiveness of the control program should also be monitored on the basis of adult populations within the control area. This could be done using sweep nets or monitoring biting activity. However, the biting activity of adult black flies is very weather dependent and assessments of biting activity difficult.

Black Fly Adult Control

Black flies bite only during daylight hours. Usually the peak time of activity is during the late afternoon and evening. However, in wooded areas especially on cloudy warm days, they bite throughout the day. Winds of 5 kph or more, especially in open areas, suppresses black fly activity.

Methoxychlor and **propoxur** are the only registered black fly adulticides. The formulations that are available are the same as mosquitoes (Table 2). Refer to the discussion of these active ingredients and their formulations in the mosquito section of this module.

Similar to mosquitoes, black fly adulticides may be applied as:

- Residual sprays
- Thermal fogs
- Ultra low volume applications

Refer to the discussion of these application methods in the mosquito section.

The control of adult black flies usually provides only several hours, or at best several days of reduced biting activity. Application should be done when the black flies are most abundant, i.e. early morning or during the late afternoon or throughout warm, still, overcast days. Generally adult black fly control must be conducted on a consecutive daily basis over a large area to reduce biting activity significantly. Repeat applications at dawn and dusk are necessary if adults continue to emerge and move into the treated area.

Record Keeping

As discussed with mosquito control, the collection of data and accurate record keeping provides information critical to the success of your program. Refer to the discussion concerning mosquitoes for what types of information should be recorded.

Review Questions

Answers are located in Appendix A of this manual.

1. What do adult male mosquitoes and black flies feed on?

   ____

2. What do adult female mosquitoes and black flies feed on?

   ____

3. Where are the larvae of mosquitoes found?

   ____

4. List the three genera of mosquitoes commonly found in the Atlantic Provinces?

   ____

   ____

   ____

5. What stage of the life cycle of the *Culex* mosquito survives the winter?

   ____

6. How much precipitation is usually required for a hatch of summer *Aedes* mosquitoes?

   ____

7. What stage of the life cycle of the *Coquillettidia perturbans* survives the winter?

8. Why is it necessary to monitor mosquito populations during the planning stage?

9. List seven methods of controlling mosquitoes.

10. List three methods of applying mosquito adulticides.

11. What are the major species of black flies in the Atlantic Provinces?

12. What is the duration of the larval stage of black flies?

13. When is the maximum biting activity from black flies in your area?

14. When should stream surveys for black fly larvae begin?

15. List the five methods of black fly control.

16. What biocontrol agent is available for both black fly and mosquito control?

17. How long will black fly adulticides reduce biting activity?

Chapter

3

PESTICIDES AND THE ENVIRONMENT

Learning Objectives

This chapter will allow you to:

- **Understand the relative residual activity of pesticides used for mosquito and black fly control.**
- **Name the pesticides with the least impact on non-target species.**

Environmental Impact

Products used to control larval mosquitoes and black flies tend to cause less environmental harm than those used to control adults. Larvicides tend to be more specific and are applied to a smaller area. This minimizes effects on non-target species. Adulticides are less specific. These are applied in a way that may result in drift to areas that should not be treated. **Use larvicides rather than adulticides (if possible).**

Bacteria

Bacillus thuringiensis israelensis (Bti) poses little risk to human health from direct handling or indirect exposure. Bti toxins are only active in alkaline conditions that exist only in certain insect digestive systems. The acidic stomachs of humans and animals do not activate Bti toxins. To date, there are no known cases of Bti toxicity or endocrine trouble in humans or other mammals around the world. Studies have shown that if Bti spores are ingested or inhaled, they will be removed without causing harm. Bti poses little threat to other vertebrates, beneficial insects, and most non-target aquatic life. For a few days after treatment, Bti may harm chironomids and some insects in the Order Diptera during the larval stage. There is no residual activity. Bti is one of the most selective and environmentally benign controls for mosquitos or black flies.

Insect Growth Regulators

Methoprene has little toxicity to mammals and birds. It will only affect insects in their larval stage at the time of treatment. It is somewhat toxic to shrimp, crabs and fish, but only at rates well above those used for mosquito control. Methoprene is easily broken down in the bodies of vertebrates.

Methoprene has a very short half life (hours). It must be formulated to increase residual activity (slow release or briquette). The slow release formulation may provide a number of days of residual activity. The briquette releases methoprene over a number of weeks.

Botanical and Synthetic Botanical

Pyrethrum is used to control many insect pests in Canada. This includes larval and adult mosquitoes. Pyrethrum is quickly broken down outdoors by light and air. It has a short residual life. Pyrethrum has little toxicity for mammals. It is toxic to fish.

Chlorinated Hydrocarbon

Methoxychlor has long residual activity (days to weeks). It is both a contact and stomach insecticide. Methoxychlor tends not to be stored in body fat. It is quickly broken down and expelled from the body. Methoxychlor may be used as a residual spray to control adult mosquitoes in yards and recreational areas. It has low toxicity to warm-blooded animals (e.g., humans). Methoxychlor is rarely phytotoxic. It is used on a very wide range of crops as seed treatments or foliar applications.

Organophosphates and Carbamates

A number of organophosphate and carbamate insecticides, are used to control larval and adult mosquitoes. Most of these have little residual activity (several days). **Chlorpyrifos** may be active for a number of weeks in larval habitats.

Chlorpyrifos is toxic to crustacea and fish. Care must be used when it is applied to aquatic habitats.

Propoxur is a carbamate insecticide. It may be toxic to bees at rates used to control adult mosquitos.

Review Questions

Answers are located in Appendix A of this manual.

1. What insecticide may harm bees at rates used to control adult mosquitos?

2. What organophosphate larvicide should not be used in areas with fish and crustacea?

3. Which larvicide must be formulated to increase its residual life?

4. Which chlorinated hydrocarbon insecticide is used as a residual spray to control adult mosquitoes?

5. Bacillus thuringiensis israelensis (BT H14) may harm what other insects?

Chapter
4

LEGISLATION

Learning Objectives

This chapter will allow you to identify and interpret legislation that relates to the control of mosquitoes and black flies.

Legal Requirements

As an applicator, you must understand the Provincial legislation that applies to pesticide applications for mosquitoes or black flies. In the Atlantic Provinces the appropriate certificate/license and Approval/Permit must be obtained prior to any application. Please consult the regulatory authority in your Province for guidance.

Pesticide Legislation in Atlantic Canada

Nova Scotia

In Nova Scotia, pest control products are governed under the Environment Act and the Pesticide Regulations. Copies of the Act and regulations can be obtained by calling 1-800-670-4357.

The Environment Act can be downloaded at:

http://www.gov.ns.ca/legi/legc/statutes/environ1.htm .

Pesticide Regulations can be viewed at:

http://www.gov.ns.ca/just/regulations/regs/env6195.htm

Prince Edward Island

In Prince Edward Island, pesticides are governed under the *Pesticides Control Act*. This is administered by the Department of Environment, Energy and Forestry. The Act may be viewed at:

http://www.gov.pe.ca/law/statutes/pdf/p-04.pdf

Regulations can be obtained by contacting the Pesticide Regulatory Program: (902) 368-5474 or by e-mail at pesticideinfo@gov.pe.ca

General Regulations

http://www.gov.pe.ca/law/regulations/pdf/P&04G.pdf

New Brunswick

In New Brunswick, pesticides are governed under the *Pesticides Control Act*. The Department of the Environment and Local Government administrates this. The Act and regulations may be obtained by calling the Pesticide Regulatory Program at 506 453 2098 or by e-mail at: pesticides@gnb.ca

Newfoundland and Labrador

In Newfoundland and Labrador, pesticides are governed under the *Environmental Protection Act* and Pesticides Control Regulations. This is administered by the Department of Environment. The Act and regulations can be obtained by contacting the Provincial Queen's Printer: (709) 729-3649 or by e-mail at: qprinter@mail.gov.rtf.ca

The Act and Regulations can be viewed at: http://www.gov.nf.ca/hoa/sr/

Summary

Provincial law governs many aspects of pesticide use. These include transport, application, storage, and disposal. Users must be familiar with legislation. This ensures safe handling of pesticides and legal compliance.

Review Questions

1) When would you not require a certificate to use pesticides to control black fly or mosquito larvae?

____

____

2) In addition to a certificate/license, what else is required for commercial application of pesticides to water for mosquito and black fly control?

____

____

Chapter

5

THE LABEL

Learning Objectives

When you have completed this chapter, you should be able to interpret labels of pesticides typically used in mosquito and black fly control.

The **Applicator Core** manual has highlighted the parts of the pesticide label. This section provides you with generic pesticide labels that are similar to those used in mosquito and black fly control. Be able to answer the review questions for each of the generic labels provided. You will need to refer to **Chapter 3: The Label** of the **Applicator Core Manual.**

Sample Label #1

NET WEIGHT: 15 KG

BIO 300g

BIOLOGICAL LARVICIDE
Granule
(Bacillus ferrengis, Serotype B-112)

COMMERCIAL

GUARANTEE: Bacillus ferrengis,
Serotype B-112, 300 International Toxic Units
(ITU per milligram (0.3 billion ITU/L).

CAUTION

POISON

KEEP OUT OF REACH OF CHILDREN
READ THE LABEL BEFORE USING

REGISTRATION NO. 999, 999 PEST CONTROL
PRODUCTS ACT

LOT NO. 1146-117

E.P.A. Est. No. 1122-33-4

Chemical Products Division
X,Y,Z Limited
Montreal, Canada, XXX YYY

(BIO 300G continued)
FOR USE BY COMMERCIAL APPLICATORS IN COMMERCIAL AND MUNICIPAL MOSQUITO CONTROL PROGRAMS.

NOTICE TO USER: This control product is to be used only in accordance with the directions on this label. It is an offence under the Pest Control Products Act to use a control product under unsafe conditions.

DIRECTIONS FOR USE

MOSQUITOES

Apply Bio 300G at a rate of 3 to 10 kg/ha in temporary and permanent pools in pastures and woodlots, irrigation or roadside ditches, natural marshes or estuarine areas, catch basins and sewage lagoons. Use higher rates in deep and/or polluted water and when late 3rd and 4th instar larvae predominate

Apply recommended rate by conventional ground equipment or measure required amount and broadcast over water using a can or appropriate container and a gloved hand. Uniform coverage is necessary for best results.

A 3 to 14 day interval between applications should be employed. Monitoring will indicate the appropriate retreatment interval. BIO 300G does not affect non-target, aquatic, invertebrate predators and parasites that are non-filter feeders. Therefore, longer periods of suppression may result since these beneficials would be conserved to aid in mosquito population management.

LIMITATIONS:

Do not apply to water that will be used for drinking by humans.

PRECAUTIONS:

Avoid contact with skin and eyes. May cause irritation. In case of contact, flush eyes with plenty of water. If irritation persists, contact a physician.

STORAGE AND DISPOSAL:

Storage: Tightly re-close containers of unused Bio 300G. Store in a cool, dry place.

Disposal: Empty container thoroughly. Follow provincial instructions for any required additional cleaning of container prior to its disposal. Render empty container unsuitable for any additional use. Dispose of container in accordance with provincial requirements.

For information on the disposal of unused, unwanted product and the cleanup of spills, contact the regional office of the Environmental Protection Service, Environment Canada.

LIMITATION OF WARRANTY

Seller's guarantee shall be limited to the terms set out on the label and subject thereto, the buyer assumes the risk to persons or property arising from the use or handling of this product and accepts the product on that condition.

Sample Label #2

MOSE 30EC

INSECTICIDE

EMULSIFIABLE CONCENTRATE

For Control of Mosquito Larvae and Black Fly Larvae

RESTRICTED

GUARANTEE:..menetos 30 g/L

REGISTRATION NUMBER: 11111 PEST CONTROL PRODUCT ACT

CAUTION

POISON

KEEP OUT OF REACH OF CHILDREN
READ THE LABEL BEFORE USING

NET CONTENTS: 10 L

Manufactured By:
Meno Inc.,
234 Inger Street,
Orangeville, Ontario
Z1T G1G

NOTICE TO USER: This control product is to be used only in accordance with the directions on this label. It is an offence under the Pest Control Products Act to use a control product under unsafe conditions.

NATURE OF RESTRICTION: This product is to be used only in manner authorized, consult local Pesticide Regulatory authorities about use permits that may be required.

RESTRICTED USES:

USE LIMITATIONS: Do not use on crops grown for food or forage or pasture or allow spray drift to contaminate these crops.

When small areas are treated, do not allow livestock to drink water for 72 hours after application.

MOSQUITO LARVAE CONTROL: Apply MOSE 30EC Insecticides as a uniform spray in sufficient water for good coverage at the rate of 35 to 100 millilitres per hectare. Apply to standing water in pools, shallow ponds, swamps, marshes, catch basins and similar areas where mosquitoes breed. Use 35 mL per hectare to clean open water and 70 to 100 mL per hectare in waters high in organic matter content. The higher rate should be used in areas known to have organophosphate resistant mosquitoes. Repeat applications as necessary.

BLACK FLY LARVAE CONTROL: Use MOSE 30EC insecticide to treat black fly breeding sites in fast flowing water. Treatment should be made when there are numerous larvae from one half to one centimetre long. Repeat applications may be necessary to control larvae of later generations. Treatment sites should be located below beaver dams or other obstructions to the flow of water and below the outlets of lakes. Longer fast flowing streams may require treatment sites at one half to one kilometre intervals.

Apply MOSE 30EC insecticide into the water at a concentration of 0.3 parts per million (ppm). The amount of chemical required is dependent on the volume of water being treated. The rate of stream flow (in cubic metres per second) is calculated by multiplying the average depth (in metres) of the stream by the average width (in metres) of the stream by the average velocity (in metres per second).

It is necessary to maintain the required concentration of MOSE 30EC insecticide for 15 to 20 minutes in the water. The following chart can be used as a guide:

Average Stream Flow	Amount of MOSE 30EC insecticide (cubic metres per second) (millilitres) required for 30 minute dispensing for a concentration of 0.3 parts per million	
0.5	600	
0.6	1.0	1200
2.0	2400	
3.0	3600	

The MOSE 30EC insecticide should be mixed with water and the mixture dispersed into the stream from a container with an adjustable valve set to empty within the required 30 minute period.

Better mixing with the water in the stream will be obtained if the MOSE 30EC insecticide is introduced at a turbulent spot in the stream, or from more than one container if the stream is fairly large.

PRECAUTIONS: Keep out of reach of children. Do not expose product to excessive heat or direct sunlight. Do not apply to crops used for food, forage or pasture. Harmful if swallowed or absorbed through skin. Causes skin and eye irritation. Do not get on skin, in eyes or on clothing. Wash thoroughly after handling, and avoid breathing vapour or mist. Do not contaminate food or feed products.

FIRST AID: In case of contact, flush skin or eyes with plenty of water. Call a physician immediately in all cases of suspected poisoning.

TOXICOLOGICAL INFORMATION: This product may cause cholinesterase inhibition. Atropine is antidotal. Pralidoxime chloride (2 PAM) may be effective as an adjunct to atropine. Use according to label directions.

THIS PRODUCT IS TOXIC TO BIRD AND BEES. It should not be applied when bees are actively visiting area. Do not contaminate water by cleaning of equipment or disposal of wastes.

RINSE AND DISPOSAL PROCEDURE: Drain the container completely into the spray tank for dispensing container. Then rinse with water draining the rise water into the spray tank. Dispose of container in a method approved by the Ministry of Environment.

NOTICE TO BUYER: Seller's guarantees shall be limited to the terms set out on the label and subject thereto the buyer assumes the risk to persons or property arising from the use or handling of this product and accepts the product on that condition.

1% BEGONE RESIDUAL INSECTICIDE

DO NOT STORE BELOW FREEZING TEMPERATURES

READ THE LABEL BEFORE USING

GUARANTEE:
Proposty 1%
REGISTRATION NO. 1156543
PEST CONTROL PRODUCTS ACT

DANGER

POISON

Net Contents **4 LITRES**

ACME Pest Control Ltd.

235 Bromwell Drive,
Rexdale, Ontario
M9Q 1Z7

COMMERCIAL
1% Begone (continued)

Kills: Brown Dog Ticks, Centipedes, Cockroaches, Clover Mites, Earwigs, Millipedes, Mosquitoes, Paperlice, Punkies, Sandflies, Scorpions, Silverfish, Sowbugs, Spiders and Wasps. Exposed Stages of: Angoumois Grain Moth, Cigarette Beetles, Drugstore Beetles, Indian Meal Moths, Saw-Toothed Grain Beetles and Weevils.

Acme 1% Begone residual insecticide is a ready to use formulation for control of the insects listed including those resistant to certain chlorinated hydrocarbon and organophosphorus insecticides. This product drives insects from their hiding places, gives rapid kill and long residual activity.

Directions For Use
General: For use in areas of industrial, institutional, and commercial locations where treatment will present no human hazard or contamination of food.

Apply with a low-pressure sprayer equipped with a coarse spray nozzle. Spray surfaces only until wet. Avoid excessive run-off. Apply to all insect breeding sites . Also treat adjacent exposed surfaces where insects may crawl when they come out of hiding. Repeat treatment as necessary.

Cockroaches: Thoroughly treat the infested area. Spray baseboards, cracks and crevices; around window and door frames; the under surfaces of shelves, drawers and work areas; behind and beneath cabinets, refrigerators, sinks and stoves; in and around waste containers, switch panels, junction boxes, floor drains and other places where cockroaches hide or rest.
Ants: apply to trails and places where ants enter premises such as window and door sills, Spray hills and runways outdoors.

Hornets and Wasps: Spray directly to the nest after dark when all of the insects have returned to the nest.

Exposed stages of Angoumois Grain Moth, Cigarette Beetles, Drugstore Beetles, Indian Meal Moths, Saw-toothed Grain Beetles and Weevils. Thoroughly treat floors and the walls of the infested area with attention to cracks, crevices, corners and perimeters. Sanitation and dust control are of primary importance. Fumigate or destroy infested products.

Silverfish: Apply to localized areas infested by these insects.

Brown Dog Ticks: Spray sleeping quarters of pets around baseboards, window frames, wall cracks and local areas of floors. Repeat as needed. Fresh bedding should be placed in animal quarters after spraying. Do not spray animals.

Clover Mites, Crickets, Earwigs, Millipedes, Sowbugs, Sowbugs, Scorpions and Spiders. Thoroughly spray the interior and exterior perimeter of the infested premises. For Clover Mites give special attention to window sills.

Fleas, Flies, Gnats, Mosquitoes, Punkies and Sandflies (outdoors only). Spray infested areas thoroughly, including outside surfaces of screens, doors window frames, foundations, patios and other areas where insects may enter.

For use in Meat Packing and Food Processing Plants. Obtain a fine flat fan spray patterns. Use only in the inedible product areas of meat packing plants, including those that are federally inspected. Any exposed food products, equipment, or packing materials must be removed or covered before spraying. Rinse all equipment with water before resuming operations canning or other processing begins. Repeat applications, if necessary, when plant is not in operation. Spraying where insects congregate will aid in preventing re-infestation. Good sanitation and proper disposal of waster in essential in any effective insect control program.

Restrictions: Do not use a space spray. Provide adequate ventilation of area being treated. Do not allow children to contact treated areas until surfaces are thoroughly dry. Do not store near feed or food products. Avoid contamination of feed, food processing equipment and food handling and packaging surfaces. Do not apply to animals. Remove pets and cover fish bowls before spraying. DO not spray plants.

PRECAUTIONS: KEEP OUT OF REACH OF CHILDREN. May be harmful if swallowed, inhaled, or absorbed through the skin. Avoid breathing of spray mist. Do not get in eyes, on skin, or on clothing. Wash hands, arms and face thoroughly with soap and water after using and before eating or smoking. Wash all contaminated clothing with soap and hot water before reuse.

Flammable: DO not spray near open flame. Do not smoke while using. Avoid excessive heat.

RINSE & DISPOSAL PROCEDURE: Drain the container completely into the spray tank for dispensing container. Then rinse with water draining the rise water into the spray tank. Dispose of container in a method approved by the Ministry of Environment.

FIRST AID & INSTRUCTION: This product contains Petroleum Distillate. If swallowed DO NOT induce Vomiting. If patient is unconscious give him air. Obtain medical attention, if in eyes, flush with plenty of water. In case of skin contact, immediately wash skin with plenty of soap and water.

POISON: Do not swallow.

TOXICOLOGICAL INFORMATION: Atropine sulfate is antidotal.

NOTICE TO USER: This control product is to be used only in accordance with the directions on this label. It is an offence under the Pest Control Products Act to use a control product under unsafe conditions.

NON-WARRANTY: Seller's guarantee shall be limited to the terms set out on the label and subject thereto, the buyer assumes the risk to persons or property arising from the use or handling of this product and accepts the product on that condition.

65-20 Mal-dane

fogging oil concentrate

READ THE LABEL BEFORE USING

GUARANTEE:
Mal-dane................65%
Beta sutoxy beta thiocarbdile ether 20%
REGISTRATION NO. 9824
PEST CONTROL PRODUCTS ACT

DANGER

POISON

Net contents 4 LITRES

Acme Pest Control Ltd.
35 Bromwell Drive, Rexdale, Ontario M9Q 1Z7

65-20 Mal-dane (continued)

DIRECTIONS FOR USE: Kills flies, gnats and mosquitoes, for use in specialized fogging and misting equipment.

OUTDOOR FOGGING: This concentrate should be diluted at the rate of 1 litre of concentrate in 21 litres of No. 2 fuel oil. Approximately 1 part concentrate to 21 parts base oil. Then use at the rate of 14-17 litres per hectare (10,000 m^2) for control of mosquitoes, flies and black flies. For most effective treatment it is required that the fog remain close to the ground. Fogging should be done in the early morning or late evening when there are few wind currents.

IMPORTANT: Wet fog or mist can be used on dumps but care must be used on foliage. Avoid applying wet fog to valuable ornamental plants as injury may occur. When using thermo fogging generator, the equipment must be operated and maintained in accordance with the manufacturer's instruction manual.

PRECAUTIONS: KEEP OUT OF REACH OF CHILDREN. Hazardous if swallowed, inhaled or absorbed through the skin. Avoid breathing spray mist. Avoid contact with skin, eyes or clothing. Remove contaminated clothing and clean before reuse. Do not contaminate feed or foodstuffs. Avoid contaminating any body of water. Highly toxic to fish and bees.

RINSE AND DISPOSAL PROCEDURE: Drain the container completely into the spray tank for dispensing container. Then rinse with water draining the rise water into the spray tank. Dispose of container in a method approved by the Ministry of Environment.

FIRST AID: In case of exposure to Mal-dane, remove patient from area and remove all contaminated clothing. Wash all exposed skin with soap and water. If swallowed and patient is conscious induce vomiting. If breathing is weak or irregular give artificial respiration. Get prompt medical attention.

TOXICOLOGICAL INFORMATION: Symptoms of poisoning: headache, weakness, sweating, giddiness, blurred vision, nausea, abdominal cramps, diarrhea and chest discomfort. Atropine is antidotal; 2-PAM is also antidotal and may be administered in conjunction with atropine but not as a substitute.

NOTICE TO USER: This control product is to be used only in accordance with the directions on this label. It is an offence under the Pest Control Products Act to use a control product under unsafe conditions.

NON-WARRANTY: Seller's guarantee shall be limited to the terms set out on the label and subject thereto, the buyer assumes the risk to persons or property arising from the use or handling of this product and accepts the product on that condition

Review Questions

Answers are located in Appendix A of this manual.

For each of the labels, answer the following questions:

BIO-300G MOSE 30EC 1% BEGONE 65-20 MALDANE

1. What is the trade name?

2. What type of formulation is it?

3. What is/are the active ingredient(s)?

4. What is the concentration of the active ingredient in this formulation?

5. What is the federal use designation (classification)?

6. Based on hazard symbol(s) on the label, in what range is the LD_{50} of this product?

7. What is the *Pest Control Products Act* Registration Number?

8. What is the name and address of the company that produced this product?

9. If applicable, what rate is used for mosquito control?

10. If applicable what rate is used for black fly control?

11. How is the product applied?

12. What antidote should be used, if any?

13. How should empty containers be disposed of?

14. What first-aid information is available?

Chapter

6

HUMAN HEALTH

Learning Objectives

This chapter will allow you to:

- **Select pesticides for mosquito and black fly control based on their oral and dermal LD_{50} values.**
- **Describe how blood cholinesterase tests work.**
- **List pesticides for which blood cholinesterase tests should be used to establish whether poisoning has occurred.**

Reduce Risk with Least Toxic Pesticides

The Applicator Core manual states that when you have a choice of pesticides; select the product that is least toxic. To help in this, the acute oral LD_{50} values for active ingredients used in biting fly control are given in Table 6-1. **To reduce risk, choose the product with the highest LD_{50} value.**

COMMON NAME	*FORMULATION**	*ORAL LD_{50}*	*DERMAL LD_{50}*	*CHEMICAL GROUP***
Chlorpyrifos	G/EC	135-163	202	OP
Malathion	G/EC	1,375	>4,400	OP
Diflubenzuron	G/WP	4,600	4,000	P
BT H-14	G/L	>30,000	>30,000	Bacteria
Methoprene	B/L	>34,600	>30,000	FA

Table 6-1: Larvicide's LD_{50} Values, Formulation Types and Chemical Group of Insecticides Used for Mosquito or Black Fly Control.

*G=granular; L=liquid; EC=Emulsifiable concentrate; WP=Wettable Powder; B=Briquette; T=Tossits

**OP=organophosphate; CH=chlorinated hydrocarbon; B=botanical; P=phenyl-urea(insect growth regulator); FA=fatty acid(insect growth regulator)

COMMON NAME	*USE**	*ORAL LD_{50}*	*DERMAL LD_{50}*	*CHEMICAL GROUP***
Dichlorvos	TF/ULV	80	107	OP
Propoxur	R/TF/ULV	90-128	1,000	C
Chlorpyrifos	R/TF	135-163	202	OP
Naled	R/TF/ULV	430	800	OP
Malathion	TF/ULV	1,37	>4,400	OP
Pyrethrin	TF/ULV	>1,800	1,800	B
Methoxychlor	R/TF	6,000	>6,000	CH

Table 6-2: Adulticide's LD_{50} Values, Formulation Types and Chemical Group of Insecticides Used for Mosquito or Black Fly Control.

* R=residual spray; TF=thermal fog; ULV=ultra low volume

** OP=organophosphate; CH=chlorinated hydrocarbon; C=carbamate; B=botanical; SB=synthetic botanica

Organophosphates and Carbamates

The most acutely toxic insecticides used for mosquito and black fly control are in the organophosphate and carbamate groups. These inhibit the work of an enzyme called **acetyl cholinesterase** or simply **cholinesterase.** Exposure to these pesticides may lead to a sharp decline in the work of this enzyme and cause acute poisoning. It is important to know the role of cholinesterase in the function of nerve cells.

A nerve impulse travels from the brain to cause the movement of a muscle. It must pass through a number of nerve junctions. At each junction, a chemical called acetyl choline is released to carry the nerve impulse across the gap between nerve cells. When acetyl choline reaches the next nerve cell, the impulse continues down the next nerve. The acetylcholine is then quickly destroyed by the enzyme cholinesterase. If it were not destroyed, nerve impulses would continue to be sent down the nerve. If cholinesterase is not working, acetylcholine will not be broken down. Nerve impulses will be repeatedly sent down the nerve. This results in a number of poisoning symptoms that range from headache, fatigue, and dizziness, to nausea, trembling, convulsions, breathing failure, and death.

A blood test may help medical personnel tell whether symptoms are the result of poisoning by organophosphate or carbamate insecticides. When exposure occurs, cholinesterase in the blood and at nerve junctions is reduced. A reduced level of cholinesterase in the blood points to insecticide poisoning.

There is no standard level of cholinesterase in human blood. Levels vary widely from person to person. Those working with organophosphate or carbamate insecticides should have their normal cholinesterase blood levels measured before working with these pesticides. This normal level may be compared to later tests if poisoning is suspected.

Without added exposure, blood cholinesterase will return from very low to normal values in about 120 days with organophosphate poisoning. This will be faster for carbamate insecticides. Cholinesterase testing must be performed right after exposure to be of value. The test is does not work for carbamate fungicides.

Applicators who often work with organophosphate or carbamate insecticides should monitor the extent of their exposure to these compounds through a cholinesterase test program.

Contact your family doctor and plan a time for a pre-season baseline test. Also plan for one or more tests during the spray season.

Botanical and Synthetic Botanical

Botanical insecticides are derived from plants. **Pyrethrin** is the only botanical used in mosquito and black fly control. Pyrethrin comes from the flower heads of the chrysanthemum plant. It is a mixture of four compounds with similar chemical structure..

This compounds disrupts the electrical transmission of nerve impulses. This quickly paralyses muscles.

Poisoning by this group is rare because of the low level of active ingredient in products and their high LD_{50} values. Mild symptoms of poisoning include lack of coordination, tremors, salivation, and irritability to sound and touch. Severe poisoning symptoms include nausea, vomiting, and diarrhea.

Chlorinated Hydrocarbon

Methoxychlor is the only chlorinated hydrocarbon insecticide used to control mosquitoes and black flies. Chlorinated hydrocarbon insecticides disrupt electrical transmission of nerve impulses. Methoxychlor does not behave like many other chlorinated hydrocarbons. It is not persistent, and does not bioaccumulate or biomagnify. It has a high $LD_{50,}$ and poisoning is rare. Symptoms of mild poisoning include dizziness, sweating, headache, muscle twitching, fatigue, nervousness, nausea, convulsions, and vomiting.

Other Products

Methoprene and **diflubenzuron** are new products that do not affect the nervous system. Methoprene mimics the action of juvenile hormone in insects. Methoprene kills the insect when it attempts to moult from the pupal to the adult stage.

Diflubenzuron disrupts the forming of **chitin** in the insect exoskeleton. Diflubenzuron and methoprene are virtually nontoxic to mammals.

<u>Bacillus thuringiensis israelensis</u> (H14) is a bacterium that controls larvae of mosquitoes and black flies. When eaten by larvae, it produces a toxin in their stomachs and kills them. It is virtually nontoxic to mammals.

Review Questions

Answers are located in Appendix A of this manual.

1. What is the most toxic larvicide based on the oral LD_{50}?

   ____

2. What is the most toxic adulticide based on the oral LD_{50}?

   ____

3. In general, oral LD_{50} values are ________ than the dermal LD_{50} values.

   ____

4. Which group of insecticides have the lowest LD_{50} values?

   ____

5. What is cholinesterase?

   ____

6. When should cholinesterase tests be done?

   ____

7. Cholinesterase tests will help show if poisoning has occurred from which group(s) of insecticides?

____

8. List the symptoms of poisoning associated with an organophosphate or carbamate insecticide?

____

____

____

9. List the symptoms of poisoning associated with a botanical or synthetic botanical insecticide?

____

____

10. List the symptoms of poisoning associated with a chlorinated hydrocarbon insecticide?

____

____

Chapter

7

SAFETY

Learning Objectives

This chapter will allow you to minimize pesticide exposure to applicators and bystanders.

Applicator Risk

Pesticide Safety

The greatest risk of human exposure to large amounts of pesticides is during mixing and loading.

- Mixing and loading should not be done at the water's edge. Spills of insecticide concentrate may enter the water.
- Mixing and loading should never be performed on a boat. A boat is very unstable. Working with concentrated insecticide in a boat greatly increases the chance of spills, human exposure and poor measurements. These spills may be impossible to clean up. Spilling of concentrated insecticide may cause much more harm than even application of insecticide over a large area.
- Mixing and loading should be performed in a well-ventilated area, away from water.

Water Safety

When working near or in an aquatic environment, the risk of drowning always exists. **The applicator should never work alone**. If applying insecticide from the shore or walking through the site, the extra weight of the application equipment and the insecticide may increase the risk of stumbling and falling into the water. This risk may be increased if you are busy with the application. It may be hard to get up after falling if you are laden with application equipment. You may strike a hard object and be knocked out. The results may be grave if you are alone.

If you are using a boat for application, follow safe boating procedures. Do not work alone. It is not possible for one person to operate a boat and apply insecticide. Examine the area before treatment. Look for hazards such as rocks, submerged logs etc. Do not overload the boat.

Reducing Bystander Exposure

The application of pesticides in populated areas may cause public concern. Be aware of nearby human activity before and during application.

To reduce bystander exposure:

- Perform applications, if possible, when human activity is reduced (e.g., after dark or early morning).
- Take action to ensure that bystanders do not come in direct contact with the spray or applied substance.
- Inform the public when, where and what pesticides will be applied to an area.

Review Questions

Answers are located in Appendix A of this manual.

1. Why should you not work alone?

____

____

____

2. Why is it important to examine the treatment area before application?

____

____

____

3. Why should pesticide mixing and loading never be done on a boat?

____

____

____

Chapter

8

APPLICATION TECHNOLOGY

Learning Objectives

This chapter will allow you to:

- **Choose equipment to apply mosquito and black fly larvicides and adulticides.**
- **Calibrate equipment and find the amount of product required to complete the application.**

Control of Mosquito Larvae

A host of equipment may be used to apply mosquito larvicides. The equipment used depends on the type of formulation and the size of the area to be treated.

Capsules and Briquettes

Capsules and Briquettes are often applied by dropping the capsule or briquette into the larval habitat. No application equipment, only a gloved hand, is needed. The application rate on the pesticide label is stated as the number of capsules/briquettes per 375 litres of water, or per 10 square metres of surface area.

To find the number of capsules/briquettes to use, based on surface area:

Measure the width and length of the pond (in metres) at a number of places. Find the average width and length of a site. The area in square metres is calculated as follows:

Average width (m) X average length (m) = area (square metres or m^2)

For example, if the average width of a site is 7.8 m, and the average length is 4.5 m, the area is calculated as follows:

$$(7.8) \times (4.5) = 35.1 \text{ m}^2$$

If the application rate is one capsule per 10 m^2, add 3 to 4 capsules/briquettes to the site.

Volume of Water

To find the volume of water at a site, calculate the area as above. Measure the depth of the pond at a number of places. Find the average depth. The volume in cubic metres is calculated as follows:

Depth (m) X area (square metres) = volume (cubic metres or m^3)

For example: if the surface area is 1050 m^2, and the average depth is 0.65 m, the volume is calculated as follows:

$$(0.65)\ (1050) = 682.5 \text{ m}$$

If the application rate calls for one capsule/briquette per 375 m^3, apply two briquettes to the area.

Granular Formulations

Hand Application: Granular formulations may be applied to small areas by spreading with a gloved hand. It is very hard to obtain an even application or maintain the proper application rate using this technique.

To hand apply granular formulations, find the surface area as described in the section on **Capsules and Briquettes**. Refer to the label to find the application rate. The rate will often be shown as kg product/ha. Small sites are often measured in m^2. The application rate will have to be converted to m^2. One hectare is 10,000 m^2. For example, if the application rate on the label is 6.0 kg product/ha, this is the same as 6.0 kg/10,000 m^2 or 0.0006 kg/m^2 or 0.6 g/m^2.

For example, for a site that is 35.1 m^2, apply:

(35.1) x (0.6) = 21.1 g of product to the site.

Manual Spreaders: Granular formulations are often applied over larger areas with seed and fertilizer spreaders. These have a bucket or sack that holds several kilograms of granules. The operator rotates a handle. This spins a plate under the bucket or sack that hurls falling chemical outwards in all directions. Although they are hard to calibrate, manual spreaders will do when there are few resources.

To calibrate a manual spreader for granular formulations:

1. Load the bucket/sack half-full with the chosen granule formulation.

2. Walk at the speed you will use during application. Open the flow lever and turn the handle at a constant rate to make sure the swath width is constant.

3. Measure the swath width.

4. Find the distance needed to walk to treat a tenth of a hectare using the following:

   1,000/(swath width in metres from Step 3) = the number of metres that must be walked to treat one tenth of a hectare

5. Select the rate from the label. This will allow you to find how much product is needed to treat a tenth of a hectare. For example, if the label rate is 5.0 kg

product/ha, divide the 5.0 by 10 to find the amount that should be used on one tenth of a hectare. In this example it would be 0.5 kg or 500 g.

6. Place the amount of product required to treat one tenth of a hectare in the bucket/sack. Adjust the flow lever so that granules run out when you walk the distance calculated in Step 4. This will take a number of tries and adjustments. Once you have figured how far to open the flow lever, mark this adjustment on the spreader. This may then be easily used during application.

It is very hard to walk at a constant rate through mosquito larval habitats. This is more so for spring Aedes sites.

Motorized Spreaders: Motorized backpack spreaders with two-cycle engines may be used to apply granular formulations. These use an air blast to spread granules. Motorized Spreaders are more expensive than manual spreaders. These spreaders are fairly heavy. This must be taken into account for walking through mosquito larval habitats.

Calibration is similar to that of manual spreaders.

1. Set the throttle at the normal running speed for the machine. Mark this position on the machine.

2. Half-fill the reservoir with the granules that you will be using. Use the spreader while walking at the speed to be used during application.

3. Measure the swath width.

4. Find the distance needed to walk a tenth of a hectare using the following:

   1,000/(swath width in metres from Step 3) = the number of metres that must be walked to treat one tenth of a hectare

5. Select the rate from the label. This will allow you to find how much product is needed to treat a tenth of a hectare. For example, if the label rate is 5.0 kg product/ha, divide the 5.0 by 10 to find the amount that should be used on one tenth of a hectare. In this example it would be 0.5 kg or 500 g.

6. Place the amount of product required to treat one tenth of a hectare in the reservoir. Adjust the flow so that granules run out when you walk the distance calculated in Step 4. This will take a number of tries and adjustments. Once

this adjustment has been found, mark it on the spreader so that it may be used during application.

Liquid Sprayers

Formulations such as emulsifiable concentrates, solutions and wettable powders may be applied with a range of equipment. This choice depends on the size and finances of the program.

Backpack Sprayers

Backpack Sprayers are used to apply liquid or wettable powder formulations in small mosquito control programs. They often work well in sites with few plants in the water. If there are a lot of plants, the spray may not pass through and get into the water.

Backpack sprayers often use compressed air above the spray mixture to push it out of the tank, through a hose and nozzle. Sprayer output depends on the pressure used, the nozzle type, and walking speed during application. The compressed air above the spray mix is supplied by a manual pump. The pump is powered with one hand while the hose and nozzle are held with the other. This may make walking awkward.

To calibrate a backpack sprayer:

1. Measure and mark an area that is 100 square metres (e.g., 10 m by 10 m; 20 m by 5 m).

2. Make sure that the sprayer is working well. Fill the spray tank with water. Mark the water level on the outside of the tank, or mark the water level on a dipstick.

3. Pump until air pressure reaches the point that will be used during application. Keep the pressure constant to maintain an even application rate. A pressure gauge on the wand may help.

4. Spray the marked area. Walk at the pace to be used during application.

5. Measure the amount of water required to refill the spray tank to the mark on the dipstick or on the tank. This gives the output per 100 square metres.

6. Find the total area one tank will treat as follows:

$$\frac{\textbf{tank capacity in litres}}{\textbf{amount added to the tank in litres}} \times 100 = \textbf{number of square metres treated by one tank}$$

The 100 in this equation is the area measured in step 1. When using a larger or smaller area, replace the 100 in the equation with the area used (measured in m^2).

For example, the amount of water required to treat 100 m^2 is 5.5 litres. Find the area one full tank will treat as follows:

$$\frac{25}{5.5} \times 100 = 454 \text{ square metres}$$

7. Use the following to find how much product should be added to the tank if the label provides a rate per 100 square metres:

$$\frac{\textbf{Total area one tank will treat in } m^2}{100} \times \textbf{rate}/100m^2 = \textbf{amount of product to add to the tank}$$

For example, you are using a backpack sprayer to treat 454 m^2. The label calls for a rate of 50 ml/100 square metres. The amount of product to be added to the full tank is:

$$\frac{454}{100} \times 50 = 227 \text{ ml of product}$$

8. Use the following to find how much product should be added to the tank if the label provides a rate per hectare:

$$\frac{\text{Total area one tank will treat in } m^2}{10{,}000} \times \text{rate/ha} = \text{amount of product to add to the tank}$$

For example, you are using the backpack sprayer to treat 454 m^2. The label calls for a rate of 5.0 l/ha. The amount of product to be added to a full tank is:

$$\frac{454}{10{,}000} \times 5.0 = 0.227 \text{ l of product}$$

Power Sprayers

Power sprayers are comprised of a tank, pump, handgun or wand, check valve, pressure regulator, pressure gauge, and hose. These may be mounted on an all terrain vehicle or truck. Power sprayers are calibrated in the same way as backpack sprayers. The area that you treat may have to be larger than 100 square metres. The larger the area treated during calibration, the more accurate the result.

Control of Black Fly Larvae

The amount of product required to treat a site is based on the flow rate of the stream. To find the amount of product needed:

- Find stream flow in cubic metres per second (m^3/sec)

(m^3/sec=average depth (m) x average width (m) x average velocity (m/sec);

- Measure average stream depth.
- Measure average stream width.
- Measure average velocity using a flowmeter or by timing a floating object for at least 3 metres. When timing a floating object, the average velocity is roughly 0.67 of the surface velocity for streams with rocky bottoms, and 0.9 for those with mud bottoms. Multiply the surface velocity by either 0.67 or 0.9 to find the average velocity.

For example, the average width of a stream is 2.5 m. The average depth is 0.5 m. It takes 5 seconds for a small object to float 7 metres. The surface velocity is found as follows:

$$\frac{7}{5} = 1.4 \text{ m/second}$$

The bottom of this stream is rocky, therefore the average stream velocity is:

$$(1.4)\ (0.67) = 0.94 \text{ m/second}$$

The stream flow in m^3/second is:

$$(2.5)\ (0.5)\ (0.94) = 1.18 \text{ m}^3\text{/sec}$$

- Find the pesticide application rate from the label (mls of product needed/m^3/sec).
- Multiply the rate from the label by the stream flow to find the total amount of product needed.

For example, if the application rate from the label calls for 100 ml/m^3/sec, apply:

$$(1.18)\ (100) = 118 \text{ ml of product}$$

- Dilute the larvicide with water to provide a total volume needed for an injection period of 15-30 minutes.

- The diluted larvicide may be applied with a variety of spraying equipment. A compressed air sprayer such as a backpack sprayer is often the best. These apply product across the entire stream. This ensures good mixing and proper timing of application.

Control of Mosquito and Black Fly

Residual Sprays

Residual treatments are applied to foliage and structures where mosquitoes rest during the day. Products may be applied using backpack compressed air sprayers or power sprayers. This equipment is described in the mosquito larval control section above.

Most products registered for this use give application rates as a percentage. For example, the label will call for a 0.5 to 1.0% active ingredient spray. To find the amount of product to add to the tank, use the following:

$$X = \frac{(S)\,(A)}{C}$$

X = the amount of concentrate required;

S = the percent active ingredient in the spray;

A = the amount of spray to be prepared;

C = the percent of the active ingredient in the concentrate.

For example, you have a concentrate with 25% active ingredient. You wish to make 40 litres of 1.25% active ingredient spray solution. How much concentrate would you put in the tank?

$$X = \frac{(1.25)\ (40)}{25}$$

$$X = 2 \text{ litres of concentrate}$$

Application rates can also be expressed as a proportion. For example, the label may call for 2L of concentrate in 25 litres of water. To find the amount to put into the tank if the tank holds 125 litres:

$$\frac{125}{25} \times 2 = 10 \text{ L}$$

Thermal Foggers

Thermal foggers have engines that force a mixture of pressurized diesel fuel and insecticide into a mixture of hot engine gases. The mixture is broken into small particles, vaporized and discharged into the cooler air. The vapour then condenses into fine particles or fog. The fogger must be warmed up before opening the insecticide/diesel flow line. Many formulations are premixed and may be added directly to the tank of the thermal fogger. Follow instructions that come with the thermal fogger to calibrate it. The amount of concentrate used is often calculated as a percentage or proportion as described above.

Ultra Low Volume Application

Ultra Low volume sprayers dispense insecticide droplets at a low volume. Droplets measure less than 20 microns. The concentrated insecticide is forced through an air stream where the insecticide is sheared into very fine droplets.

Before calibrating an ultra low volume sprayer, take a sample of droplets to measure and ensure that they are within the proper range. Check the manufacturers guidelines for droplet collection and measurement. Most formulations for ultra low volume applications come ready-made and do not have to be diluted. If dilution is required, use the calculations for percentage or proportion described above.

Review Questions

Answers are located in Appendix A of this manual.

1. You are using a capsule formulation to control mosquitoes. The site measures an average of 12 m wide and 17 m long. The label calls for one briquette per 100 m^2. How many briquettes would you use?

____

____

2. You are using a briquette formulation to control mosquitoes. The site measures 30 m wide and 5 m long. The average depth is 0.7 m. The application rate on the label calls for 1 briquette for every 375 m^3 of water. How many briquettes should be used?

____

____

3. You have been asked to calibrate a backpack sprayer. You measure an area as 5 metres wide and 20 metres long. To treat that area, you find that you require 7 L of water. The total tank capacity of the sprayer is 25 L. How much area will one full tank treat?

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4. Using the backpack sprayer calibrated in question 3, how much product would you add to the full tank if the label calls for 45g/100 m^2?

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5. Using the backpack sprayer calibrated in question 3, how much product would you add to the full tank if the label calls for 3.7 kg/ha?

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6. You wish to control black flies in a stream that is 3.5 m wide and 1.7 m deep. You have measured surface velocity and found that a floating object travels 10 m in 5 seconds. The bottom of the stream is mud. What is the stream flow in cubic metres/second?

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7. The pesticide label calls for 356 ml/m^3/second to control black flies. How much product would you use to treat the stream in question 6?

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8. You have been asked to control adult mosquitoes with a residual spray. The pesticide label states that the percentage of active ingredient in the spray should be 0.75%. The pesticide concentrate you are using is 33.3% active ingredient. How much pesticide concentrate do you need to make 250 L of spray mix?

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9. You have been asked to control adult black flies using a thermal fog. The label calls for 0.5 L of pesticide concentrate for 10 L of diesel fuel. The tank on the thermal fog machine holds 22 L. How much concentrate is required for 22 L of mix?

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APPENDIX A:

ANSWERS TO SELF-TEST QUESTIONS

ANSWERS TO SELF-TEST QUESTIONS

Chapter 2: Pest Management

1. Nectar

2. Blood

3. Standing water

4. *Aedes* (spring and summer)
   Culex
   Coquillettidia or *Mansonia*

5. Adults

6. 2.5 cm

7. Larvae

8. To establish timing and effectiveness of control methods. To find the most cost effective parts of the program.

9. Habitat modification
   Mechanical exclusion
   Light traps
   Biocontrol agents
   Repellents
   Larvicides
   Adulticides

10. Residual spray
    Thermal fog
    Ultra low volume

11. Simulium venustum
    Prosimulium

12. 2 weeks to several months

13. Late May and June

14. As soon as the ice breaks up in the spring

15. Protective clothing
    Biocontrol agents
    Repellents
    Larvicides
    Adulticides

16. *Bacillus thuringiensis israelensisi* (Bt H-14)

Chapter 3: Pesticides and the Environment

1. Propoxur

2. Chlorpyrifos

3. Methoprene

4. Methoxychlor

5. Chironomids and dipterans

Chapter 4 Legislation

1. When applying a Domestic pest control product.

2. You would also need an Approval or Permit.

Chapter 5: The Label

Trade Name	BIO-300G	MOSE 30EC	1% BEGONE	65-20 MALDANE
Formulation type	granule	emulsifiable concentrate	liquid	fogging oil concentrate
active ingredients (a.i.)	*Bacillus ferrengis,* Serotype B-112	menetos	proposty	Mal-dane, beta sutoxy beta thiocarb dile ether
concentration of a.i.	300 ITU per milligram	30 g/L	1%	65% Mal-dane, 20% Beta sutoxy beta thiocarb dile ether
federal use designation	Commercial	Restricted	Commercial	Commercial
Range of LD50s	1000-2000 mg/kg oral 1000-2000 mg/kg dermal	1000-2000 mg/kg oral 1000-2000 mg/kg dermal	<500 mg/kg oral, <500 mg/kg dermal	<500 mg/kg oral, <500 mg/kg dermal
PCP #	999999	11111	1156543	9824
name/address of company	X,Y,Z Limited Montreal, Canada XXX YYY	Meno Inc., 234 Inger St. Orangeville, ON Z1T G1G	ACME Pest Control Ltd. 235 Bromwell Dr. Rexdale, ON M9Q 1Z7	ACME Pest Control Ltd. 235 Bromwell Dr. Rexdale, ON M9Q 1Z7
mosquito control rate	3-10 kg/ha	35 to 100 mL per hectare	ready to use spray	14-17 L of mixed product per hectare
black fly control rate		apply to a concentration of 0.3 ppm		14-17 L of mixed product per hectare
application method	ground equipment or by hand	apply as a uniform spray	low-pressure sprayer with coarse spray nozzle.	fogging or misting equipment
antidote	none	Atropine, Pralidoxime chloride as an adjunct	Atropine sulfate	Atropine, Pralidoxime chloride (2-PAM) as an adjunct
disposal methods	follow provincial requirements (see core)	follow provincial requirements (see core)	follow provincial requirement (see core)	follow provincial requirement (see core)
first-aid methods	none	flush skin or eyes with water, call physician	do not induce vomiting. Obtain medical attention. Flush eyes with water, wash skin with soap and water	remove contaminated clothing, wash exposed skin with soap and water. Induce vomiting if swallowed. Get medical attention

Chapter 6: Human Health

1. Chlorpyrifos
2. Dichlorvos
3. Lower
4. Organophosphates
5. Enzymes that control nerve impulse transfer
6. Before using pesticides, right after exposure
7. Organophosphates and carbamates
8. Headaches, fatigue, dryness, trembling, convulsions, respiratory failure, and death
9. Lack of co-ordination, tremors, salivation, and irritability to sound and touch
10. Dizziness, sweating, headache, muscular twitching, fatigue, nervousness, nausea, convulsions, and vomiting

Chapter 7: Safety

1. The risk of drowning and pesticide exposure.
2. To identify any hazards such as rocks or submerged rocks.
3. Boats are very unstable.

Chapter 8: Application Technology

1. 2
2. 0.28
3. 357.1 m^2
4. 160.7 g
5. 132.1 g
6. 10.71 m^3/sec
7. 3812.8 ml
8. 5.6 L
9. 1.1 L

APPENDIX B

GLOSSARY

GLOSSARY

Adulticide
A pesticide used to kill adult mosquitoes or black flies.

Aedes
A genus of mosquitoes that uses temporary water areas to complete its life cycle. There are both spring and summer species in this genus that attack humans. This genus is a biological vector for dog heartworm.

Anopheles
A genus of mosquitoes rare in Atlantic Canada This genus spends the winter as eggs or adults, depending on the species. Anopheles is rarely a major problem in Atlantic Canada. They are worldwide biological malaria vectors.

Biological vector
An insect in whose body the infective agent develops or multiplies, and is then transmitted.

Catch basin
A shallow shelf basin covered by a storm grate. It receives run-off water from roadways, and is joined by pipes to a larger network of sewer pipes. The catch basin is often clogged with debris, organic matter and a small amount of water that cannot flow freely into the system. This is an ideal breeding site for mosquito larvae, particularly Culex mosquitoes.

Culex
A genus of mosquitoes that often completes its larval development in permanent water sites, such as catch basins. There are a number of generations each year.

Encephalitis — An inflammation of the brain. Symptoms include headache, drowsiness, fever and nausea. There are a number of kinds of encephalitis, one of which is the St. Louis strain.

Larvicide — A pesticide that is used to kill the larval stage of an insect.

Mechanical vector — An insect which transmits an infective organism from its contaminated parts, e.g. from contaminated mouthparts.

Percolation — Action by which water moves through ground or soil to the underground water table.

Permanent water — Water in a land depression or containment from melted snow or rainfall. This often lasts for more than three weeks and may never dry up. Birdbaths, sewage lagoons, rain barrels and marshes contain permanent water. These are common breeding sites for Culex, Culiseta, and Anopheles mosquitoes.

Pupicide — A pesticide that is used to kill the pupal stage of an insect. No pupicides are available for mosquito or black fly control at this time.

Self-contained water — In reference to breeding sites, these areas do not have drainage. Water loss only occurs through ground percolation or evaporation.

Siphon — The tube through which mosquito larvae breathe.

Temperature inversion — Where warm light air moves over cool dense air. Smoke or fog discharged at ground level will tend not to rise from where it is discharged.

Temporary water — Water that remains long enough to be a breeding site for floodwater mosquitoes (e.g., Aedes spp.). Water may remain from three days to three weeks, depending on time of year. Over time the water, and mosquito eggs deposited there, will dry up.

Vector — A carrier of disease that transfers an infective agent from one person or animal to another.

Woodland pool — Depressions in mixed leafy woodlands. Melted snow in the spring provides a breeding site for spring Aedes mosquito larvae.