Management of Biting Insects in Recreation Areas
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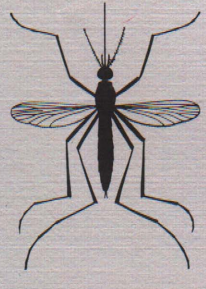


The Management of Biting Insects in Recreation Areas

by H. D. Newson
Department of Entomology

One of Michigan's most valuable resources is the extensive outdoor recreational facilities that have been developed through the efforts of national, state and local governmental agencies, private developers, and individual landowners. Our recreational areas are undoubtedly among the finest in the nation in quality, number and diversity. Michigan residents are justly proud of their lakes, streams, parks and campgrounds and have actively supported programs to expand and improve recreational opportunities for both residents and out-of-state tourists.

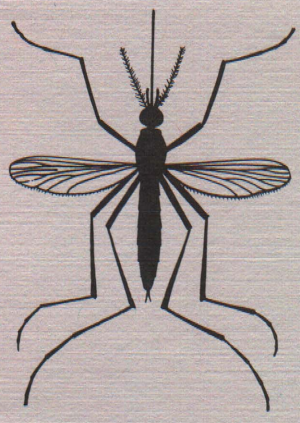
Land that can be utilized for recreational purposes is limited, and as this land is developed and used more intensively, more effort must be devoted to its proper management. Modernizing recreational areas with electricity and washing-bathing facilities results in their use by families and children's groups whose comfort and welfare require services not needed in more primitive or less intensively used areas.

Among the most important of these services is management of biting insect problems to reduce the annoyance, inconvenience and health hazards caused by biting flies, ticks, and mosquitoes. While it is not always practical to control these types of pests to the same degree as within cities or residential areas, a properly planned program will enable campers and visitors at Michigan's parks and campgrounds to fully utilize developed recreation areas.

Insect management programs should be of concern to all who plan, construct, operate or use recreation areas. Since the development of modern campgrounds and beach areas requires major expenditures, use rates must remain high for an adequate return on these investments. In most areas of Michigan, this requires some type of biting insect control program.

The most effective programs are those that prevent the development of problems. By including an entomological evaluation in site selection studies, developers can determine if a given location has inherent biting insect problems that will reduce its attractiveness, and require costly control programs. Insect problems often are the result of construction, so care should be taken to assure that existing problems are minimized and new ones are not created.

Finally, a knowledge of the habits of biting insects will enable the operators and users of recreation facilities to deal more effectively with problems. This publication contains general information about the biting insects commonly encountered in Michigan and recommendations for their control. Additional information can be obtained from your local Cooperative Extension Service Office or the Entomology Department, Michigan State University.



Mosquitoes

Mosquitoes are undoubtedly the most bothersome insect pests found in nearly all of the recreational areas of Michigan. Over 60 different species are known to be present. The individual feeding habits and seasonal abundance of these species assure the presence of mosquito problems throughout Michigan during nearly all of the months of spring, summer and fall.

All mosquitoes have four distinct stages in their life cycle and the immature stages of every species develop only in water (Fig. 1). An adult female mosquito may lay up to several hundred eggs during her lifetime. The location selected for depositing these eggs varies and is usually quite specific for any one species. Eggs deposited directly on standing water usually hatch within a short period of time. Eggs deposited in depressions on damp or dry soil subject to periodic flooding may survive for prolonged periods—up to a year or more—before they are flooded and hatch.

The larvae, often called wrigglers, emerge from the eggs and feed upon minute forms of animal and plant life and decaying organic matter in the water. When fully grown, they develop into pupae. The pupal stage of the mosquito, also called a tumbler, involves a transition from the aquatic form to the adult. When this transition is completed, the pupal skin splits along the upper surface, and the adult pulls itself up and out of the floating skin—on which it rests until ready to fly. Development time from egg to adult varies with temperature, and may be as short as 7 to 10 days in mid-summer.

Only the female mosquito sucks blood, using this nutrient for development of eggs. Feeding preferences of adult females and distances they may fly to obtain a blood meal are usually quite specific for a given species, but vary widely between species. Some feed only on birds, or wild game, or domestic animals and man. A number of species found in Michigan are such fierce biters, and appear in such large numbers, that they make some areas nearly uninhabitable. They can even pose a threat to some wildlife during the summer. Certain species fly several miles from their larval habitat while others rarely go beyond a half mile.

In addition to being nuisances, Michigan mosquitoes also transmit serious diseases such as St. Louis encephalitis, eastern and western equine encephalitis, California encephalitis and dog heartworm. Major outbreaks of St. Louis encephalitis involving humans, and eastern equine encephalitis involving horses and humans have occurred in Michigan in recent years. Dog heartworm now is a major problem in nearly every part of the state. Thus, mosquito control is a matter of both health protection and comfort.

Mosquito Control

Mosquito control operations may be directed against the larval or adult stage of the insect or, sometimes, both. For the most satisfactory and long lasting control, eliminate or modify existing water accumulations so they are not suitable for mosquito larvae. Proper management of existing or potential water breeding sites prevents development of mosquitoes within, and adjacent to, recreational areas and reduces the need for insecticide applications.

Permanent Larval Control

It is not always practical or desirable to eliminate all of the standing water suitable for mosquito breeding within or close to recreation areas. But, any reduction in either the number or size of these sites will help reduce mosquitoes. All water-holding trash, such as tin cans, old tires, containers and debris should be removed from campsites and surrounding areas. Other excellent locations for mosquito breeding: shallow, sluggish streams, ponds containing plant growth, roadside ditches, swamps or marshes, woodland pools and low areas with poor drainage in which rain or flood water accumulates and remains for prolonged periods. Sewage lagoons, catch basins under camp water faucets, and improperly constructed culverts can accumulate water and foster mosquito production within camping areas.

Many relatively inexpensive and simple modifications of potential breeding sites will greatly reduce or eliminate mosquito production. Increasing the rate of flow and reducing water surface areas will decrease mosquito breeding in streams and ditches. This is frequently less expensive than other control methods. Aquatic vegetation, particularly around the shoreline of permanent ponds, sewage lagoons, lakes and streams, protects mosquito larvae and pupae from wave action and natural enemies. Thus, elimination of this vegetation is often an essential part of mosquito control. Either chemical or mechanical removal may be used, depending upon the type of vegetation, size of the area and how the water is to be used.

Surface-feeding fish may be useful supplements to other types of larval mosquito control in permanent bodies of water. *Gambusia*, the fish most commonly used, is available from commercial sources. But, it does not survive Michigan's winters and must be restocked each year. Various top-feeding minnows native to Michigan may be alternatives to *Gambusia*, but

their effectiveness has not been demonstrated.

Ditching, filling and grading can be effective in eliminating mosquito larval sites. Culverts should be installed so that pools of water are not formed at either end, because these accumulations can produce large numbers of mosquitoes. The intake end of the culvert must be low enough to carry off all water. If rate of flow or difference in level at the lower end of the culvert is likely to create potholes, an apron should be constructed of concrete, tile, brick or other suitable material.

Small ponds, seepage areas, and undesirable swamps may be drained effectively through an underground system of drainage tiles, crushed rock or other materials. If these drainage methods are used, be careful not to create additional breeding areas. Some of the major mosquito pests in Michigan originate in water accumulated in hollow stumps or tree rot-holes. Wooded regions in, and around, the campground area should be examined carefully to locate such sites. Fill all rot-holes and hollow stumps with sand, concrete or other materials.

Table 1. Insecticides for Mosquito Control.

Method of Application	*Insecticide*	*Directions*
Larvicide spray	Malathion 57% EL	For use in standing water. Mix in sufficient water to obtain good coverage of the water surface area, and apply mixture in a uniform spray at the rate of 13 fl oz of undiluted 57% malathion/acre. Repeat as needed.
	Abate 4 E	Mix insecticide with enough water to obtain a good coverage of water surface area, and apply at a uniform rate of 1 fl oz of undiluted *Abate*/acre. (*Abate* has limited effectiveness in water containing excessive organic matter.)
	Bacillus thuringiensis var *israeliensis* (BTI)	This bacterial agent is sold under several trade names (eg. *Vectobac, Bactimos, Teknar*). Follow label directions for the product you are using. BTI is effective only against the larval stages, so applications must be made before mosquitoes have completed their larval development.
	Altocid SR-10	Shake well before mixing. May separate on standing and must be thoroughly agitated before dilution. Mix in sufficient water to obtain good coverage of the water surface area to be treated. Apply 3 to 4 fl oz of undiluted *Altocid SR-10*/acre. *Note:* this is an insect growth regulator, not a conventional insecticide. It does not kill mosquito larvae outright, but disrupts their normal development to the adult (biting) stage. Effective only against the larval stage. Applications must be made before mosquitoes have completed larval development.
Granular Larvicide—for use in breeding sites with heavy emergent vegetation	*Abate* in Celatom or Sand and Celatom	Apply evenly to water surface at .05 to 0.1 lb actual insecticide/acre. Repeat application as needed.
	Altocid in Sand or briquet formulation	Follow label directions. Briquets have an added advantage—they are a slow release formulation that can provide control for up to 30 days or more.
Larvicide for Hand Application to Small Water Accumulations	*Tossits*	Apply according to manufacturer's directions. These gelatin-like capsules rupture and release insecticide after being immersed in water.
Residual Outdoor Adulticide—for use in pressurized or power sprayers	Malathion (*Cythion*) 57% EL	Mix 4.5 fl oz/gal of water or oil suitable for insecticide use (3.5 gal/100 gal of diluent). Apply to grass, weeds, tree trunks and other vegetation as well as protected areas on outside walls and outbuildings where mosquitoes rest. ***Do not spray directly on ornamental plants.***
	Baytex 4 (Fenthion)	Apply 1½ to 3 fl oz/acre. Mix in a volume of water or suitable oil to apply as an even spray. Apply mixture to wet, grassy, bushy or wooded areas, surfaces of buildings, and other outdoor areas where adult mosquitoes rest.

Figure 1. Mosquito Life Cycle

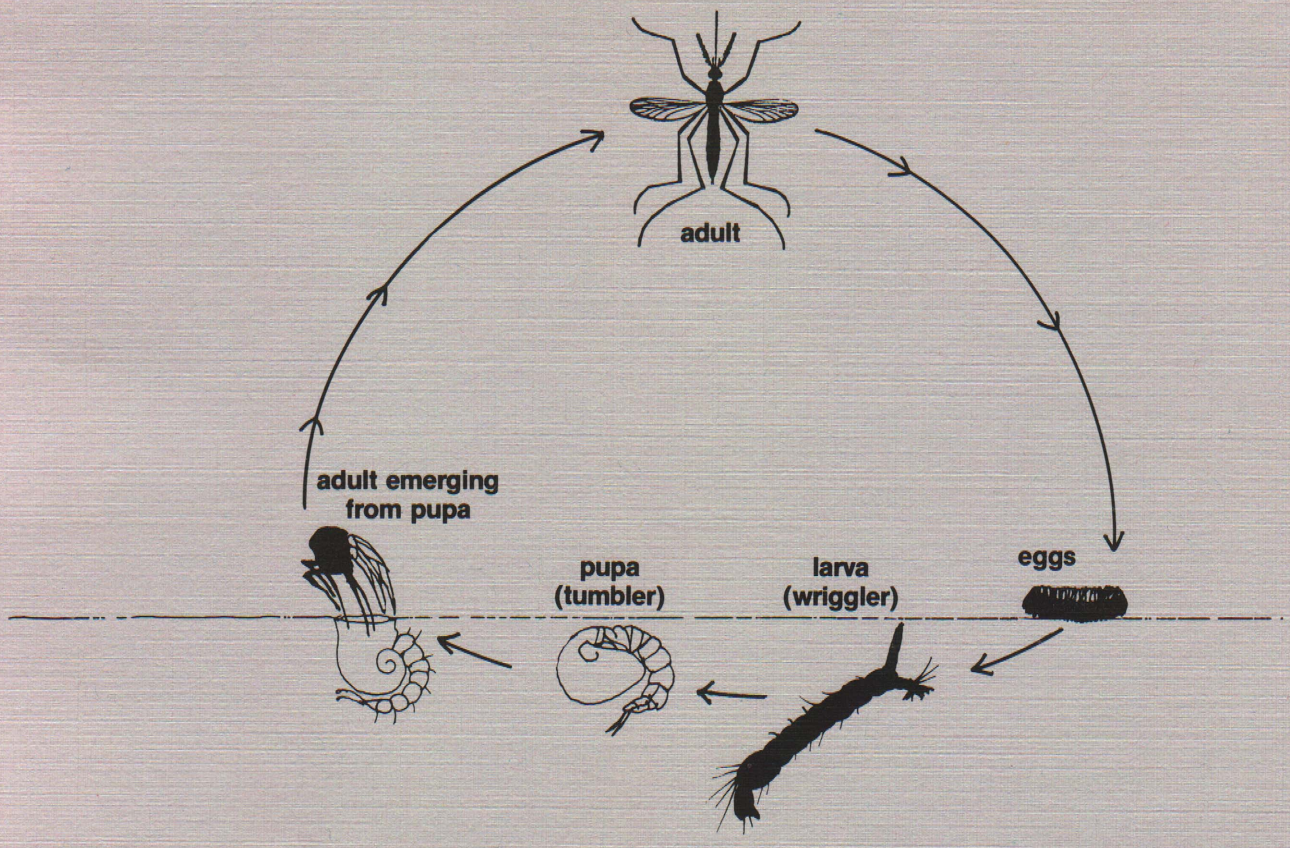


Table 1. Insecticides for Mosquito Control (continued).

Method of Application	*Insecticide*	*Directions*
Adulticide for Outdoor Mist Machines[1]	Malathion (*Cythion*) 57% EL	Mix 4.5 fl oz/gal of water (3.5 gal/100 gal of water). Direct mist into low vegetation and wooded areas. Apply 0.1 gal of mixture/ 1,000 sq ft (5 gal/acre).
	Baytex 4 (Fenthion)	Mix 1½ to 3 fl oz/gal of water (2⅛ to 4¼ gal/100 gal of water). Apply 0.05 to 0.1 lb actual insecticide/acre. Treat shrubbery and other areas where adult mosquitoes are active. ***Do not apply to bodies of water containing fish.*** Allow at least 3 weeks between applications.
Adulticide for Outdoor Thermal Fog Machines[1]	Malathion (*Cythion*) 91% Concentrate	Mix 7 fl oz of concentrate in enough fuel oil to make 1 gal (5.4 gal/100 gal of fuel oil).[2] Apply with ground equipment calibrated to deliver 40 gal/hour at a vehicle speed of 5 mph to treat a swath of 300 to 400 ft. Direct fog along ground and into low vegetation where adult mosquitoes are resting. Avoid direct application to ornamental plants—oil may injure foliage.
	Baytex 4 (Fenthion)	Mix 1 to 2 gal/100 gal of oil suitable for insecticide use. Apply mixture with standard fogging machines calibrated to deliver 40 gal/hour at vehicle speed of 5 mph to cover a swath width of up to 350 ft.
	Dibrom 14 (Naled)	Mix 3.1 qt to 100 gal of diesel or No. 2 fuel oil containing Ortho additive. See label directions for correct mixing instructions. Apply mixture with a fogging machine calibrated to deliver 40 gal/hour at a vehicle speed of 5 mph covering a 300 to 400 ft swath.

Mosquito production in lakes and ponds can also be drastically reduced by stabilizing shoreline water levels by damming or other methods. This allows natural predators of mosquitoes to become established and helps reduce the number of larvae that survive and develop into adults. Shoreline stabilization also prevents intermittent flooding (thus, hatching) of eggs laid on soil just above the water line.

Success with any of these types of permanent control measures requires an accurate knowledge of the type and location of water suitable for mosquito production. Before any mosquito control operations are begun, examine the entire recreation or campsite area to determine the location and nature of the actual and potential sites where water accumulation may produce habitats suitable for mosquito development. Only after this is done can one determine specific control procedures, permanent or temporary, that will provide the most effective and inexpensive mosquito control.

The most common methods of temporary mosquito control are the application of insecticides to kill mosquito larvae in their water habitat and use of space and residual insecticide sprays to kill adults. These types of control measures can provide relief from mosquitoes while more permanent methods are being established. Temporary control is frequently less costly than permanent control and can sometimes be used for many years at less expense than installation and maintenance of the most commonly used methods of permanent water management.

Temporary Larval Control

When used to control larvae, insecticides are commonly called larvicides. The degree of control obtained with larvicide applications often depends upon the degree of water pollution and the type and amount of vegetation cover present. If cover is heavy or organic matter in the water excessive, it may be necessary to increase the concentration or volume of insecticide. Granular insecticide formulations may be required to treat water accumulations covered with dense shrubbery, grass or other types of emergent vegetation. This is because liquid formulations are deposited on the surfaces of the plant cover and do not reach the larvae present in the water. Water in containers that cannot be drained or removed from the recreational area should also be treated with larvicide (excluding drinking water).

Frequency of larvicide application varies considerably with temperature and mosquito species, but must be often enough to prevent larvae from developing into adults. Applications each 10 to 14 days are normally adequate for Michigan summer conditions. All potential larval breeding sites within adult flight range of the controlled area must be drained, made unsuitable for mosquitoes, or treated with a larvicide for effective control. Otherwise,

Table 1. Insecticides for Mosquito Control (continued).

Method of Application	*Insecticide*	*Directions*
Adulticides for Ultra Low Volume Application[1] (Recommended for use only by commercial pest control operators or professional mosquito control personnel.)	Malathion ULV Concentrate[3]	Follow label directions
	Pyrocide Mosquito Adulticiding Concentrate	Follow label directions
	Resmethrin (*SBP 1382* or *Scourge*)	Follow label instructions
	Dibrom 14 (Naled) Concentrate	Follow label directions. ***Caution: Undiluted, material is corrosive to metals. Mixing and storage tanks should be either fiberglass or plastic lined.***
	Pyrethrum	Available in a variety of formulations. Follow label directions.
Indoor Residual Fumigation	Dichlorvos (DDVP) or *Vapona* Resin Strip	Hang strip(s) in enclosed area—1 strip/1,000 cu ft of *enclosed* space. These strips do not provide effective control outdoors or in well ventilated, enclosed areas. ***Caution: Not registered for use where infants or aged persons are exposed to the insecticide vapor, or in kitchens, restaurants or other areas where food is prepared or served.***
Indoor Adulticide Space Spray	Pyrethrum, Allethrin or Resmethrin	Available in a variety of formulations. Follow label directions.

[1]Fogs, mists and ULV applications are most effective if applied between dusk and dawn, with winds less than 4 mph. Effectiveness is greatly reduced if applied during the heat of the day or when winds exceed 4 to 6 mph. Fogs and ULV applications provide little or no residual action and must be reapplied as needed.

[2]There is a great variation in the chemical composition of oils. When mixed with malathion, some oils produce sludge and affect the solubility of this insecticide. A cosolvent or sludge inhibitor may be required. Consult your insecticide dealer for specific recommendations. Pre-mixed, ready-to-use malathion formulations also are available.

[3]Has reduced effectiveness at temperatures below 70° F.

supplemental, temporary adult control procedures usually must be employed. Table 1 gives recommended insecticides and application rates for mosquito larval control.

Temporary Outdoor Adult Control (Adulticiding)

Even though insecticide mists or fogs have been used successfully to control adult mosquitoes in recreation areas, ultra-low volume (ULV) application with ground equipment has several advantages. ULV is the method used by most organized mosquito control districts. In ULV treatments, concentrated insecticide is applied with *specially-designed ULV equipment*—at the rate of 0.5 to 3.0 ounces per acre. This is a lower rate than usually used in mist machines or foggers and reduces the cost of treatment as well as the potential for environmental contamination. It also reduces or eliminates the need for insecticide diluents and simplifies logistic support needed for control operations.

Fogs, mists and ULV applications are space treatments that depend primarily upon the wind for distribution. They should not be applied in winds of more than four mph. Optimum wind-speed is two to three mph in open areas and slightly higher in forested areas. For best results, air temperature near the ground must be cooler than at six feet or more above the ground. This condition, called a thermal inversion, assures that insecticide particles will stay close to the ground where most flying and resting mosquitoes occur. Thermal inversion occurs naturally from late evening until sunrise, so the most effective operations are conducted at night.

Fogs and ULV applications applied during the heat of the day nearly always rise rapidly, disperse in the air, and are totally ineffective in controlling mosquitoes. The effectiveness of mists is also greatly reduced when used during the day.

Insecticide fogs and ULV treatments have no lasting effect so they must be re-applied whenever the number of mosquitoes increases beyond the "level of acceptance." Mists may provide a slight residual action but their primary effectiveness results from direct contact with mosquitoes. Mists may be applied under a wider variety of atmospheric conditions than fogs or ULV, but neither mists nor ULV penetrate vegetation as well as fogs. Oil base insecticide formulations should not be applied as mists. They may burn foliage or produce objectionable residues on laundry, automobile paint and windows. Insecticide formulations suitable for fogging and misting operations are shown in Table 1.

The insecticides now approved for adult mosquito control have, at best, only a short period of effectiveness when applied as residual sprays on vegetation or areas on the outside of buildings, cabins, sheds and other locations that are exposed to sunlight, rain or dew. Residual sprays are useful as supplements to other adult mosquito control measures, but when the insecticides currently registered for adult mosquito control are used *only* as residual sprays, they usually do not provide the desired degree of control.

Temporary Indoor Adult Control

Aerosol space sprays containing either allethrin or pyrethrum (pyrethrins) are recommended for immediate control. This type of spray is usually more efficient if the treated area is kept closed for at least 15 minutes following treatment. Resin strips impregnated with dichlorvos insecticide may also help to control adult mosquitoes indoors, but are effective only if the space is enclosed and there is minimal air exchange. Specific recommendations for indoor adult mosquito control are given in Table 1.

Blackflies

Blackflies, sometimes called "buffalo gnats," are small black or gray flies with stout, humpback bodies, short, broad wings and short legs. They feed on the blood of wild or domestic animals, and birds. In some parts of Michigan, they are particularly vicious pests of humans. The blackfly season is longer than that of most other bloodsucking flies. The first adults appear late in April, reach their biggest numbers in May and June, but persist in diminishing numbers until late October.

In some areas of Michigan, blackflies become so numerous that it is nearly impossible to remain outdoors. Blood loss from their bites has resulted in death of both domestic and wild animals. Even if the blackfly is not seen while biting, its bite is readily recognized. There is no pain while the fly punctures the skin and feeds, but the site of the puncture is usually marked by a small trickle of blood which appears after the fly has finished feeding. Within an hour, the area around the bite swells and an intense itching begins that may last for several days. Some individuals become sensitized to blackfly bites and also suffer pain and severe swelling in the area of a bite. Occasionally, there are more severe reactions that require hospitalization.

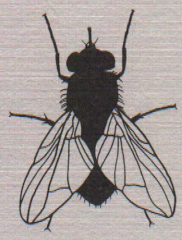
Unlike mosquitoes, blackflies bite only during the day. When feeding on animals, they crawl through the hair or feathers to the skin, or enter the ears and nostrils to bite. On man, they usually feed on exposed skin, but may crawl through openings in the clothing to bite covered parts of the body.

Blackflies lay their eggs in a variety of places, but all are either in running water or its immediate vicinity. One female may deposit as many as 500 eggs in one egg-laying period—usually in masses on stones, vegetation or other partly submerged objects—at, or near, water surfaces where they are immersed or continually wetted. Eggs hatch in 4 to 12 days and larvae attach themselves to stones or plants in the stream with a small suction disc and fine silken threads. The larva transforms to a pupa and is firmly attached within a silk pupal case spun by the larva just before pupation. Duration of the aquatic stages varies from two to three weeks to several months, depending upon species, temperature and other conditions.

Upon emerging from the pupal skin, the flies take flight immediately and may live from a few days to several weeks. While some species have only one generation each year, others have two or more. In general, southern Michigan blackflies have multiple generations each year while in the north there is only one. Generations of the various species overlap so that all stages of blackflies may be present in a given area most of the summer. Some species overwinter as eggs and others as larvae. There is little precise information concerning the flight range of adults, but one prairie species in Canada has reportedly attacked livestock as far as 100 miles from its source. The most common species in Michigan are not likely to fly this far, but they still have relatively long flight ranges.

Blackfly Control

Outdoor space sprays recommended for adult mosquito control offer some local temporary relief from blackflies, but the most effective way to prevent blackfly bites is to apply insect repellent to exposed skin areas and keep clothing tightly fastened.



Stable Flies

The stable fly is often known as the biting housefly because of its close resemblance to the housefly. The major difference between the two is the sharp "beak" of the stable fly which is used to pierce human or animal skin and suck blood. Unlike most other biting flies, both male and female stable flies feed on blood. They are often annoying summer pests at many of Michigan's beaches and recreation areas.

Females lay their eggs in moist, rotting organic matter, such as lawn clippings, manure, straw and grain wastes or piles of aquatic vegetation that accumulate along the shores of lakes. Development from egg to adult may occur in just two weeks in the hottest days of the summer, but three to four weeks is more common. Adults live up to 60 days or more and take blood meals several times daily throughout their lifetime. Stable flies usually remain outdoors but will enter animal quarters, houses and cabins, especially during cloudy and stormy summer weather.

Stable Fly Control

The only effective way to control stable flies is to eliminate favorable breeding sites. This can usually be done within developed recreational sites by the removal or drying (by spreading out) of accumulations of manure and rotting vegetation. This will reduce the pests' numbers, but their long flight range makes it difficult to completely eliminate them. Periodic removal of aquatic vegetation deposits on beaches and lakeshores will also help control stable flies. Indoor space sprays or aerosols, such as those used against mosquitoes, will control stable flies that enter animal shelters or human habitations. Skin or clothing applications of insect repellents containing diethyltoluamide (Deet) provide protection from stable flies but there are no known effective insecticide control measures that are practical for large area treatments.

Horseflies and Deerflies

A number of species in this group of flies are very common in Michigan and are bothersome pests in many low, moist, recreational areas. Some members of this group are commonly called horse or moose flies. These include a number of very large species, some with a wingspan exceeding two inches. Smaller species are called deerflies. Both horseflies and deerflies are strong fliers and commonly have brilliantly colored eyes that are banded, spotted or striped with green or purple. Only the females suck blood. They normally attack other animals more readily than man, but can also be very bothersome to humans.

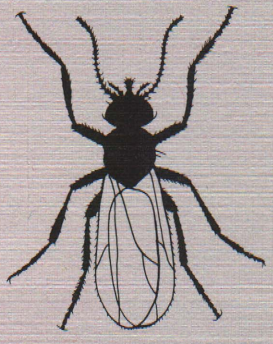
These biting flies are most abundant in swampy, forested localities, and frequently occur in large numbers in recreational areas located near extensive marshes. Adults are most active on warm, sunny days and are normally present in Michigan from late May until September.

Female horseflies and deerflies lay their eggs in compact masses of several hundred on the leaves of aquatic plants or vegetation bordering pools, swamps or other bodies of water. Eggs hatch in about one week and the immature larvae drop into the water or damp soil where they

spend one to three years completing their development to the pupal stage. Adults emerge from the pupal case in two to three weeks.

Horsefly Control

No satisfactory control for these flies has yet been developed. Their extensive breeding grounds and location of the larvae in water or moist soil makes chemical treatment and drainage impractical. Suitable clothing and an application of insect repellent containing diethyltoluamide (Deet) to areas of exposed skin will provide protection from their bites.



Biting Midges

This group of biting flies includes several types of very tiny insects known as "punkies," "sandflies" and "no-see-ums." Those that feed on humans and domestic animals bite mainly in the evening and very early morning. The burning and irritation they cause is far greater than would be expected from an insect of this small size. They are primarily pests, but some species in Michigan transmit a parasitic worm of horses.

Midge Control

Again, elimination of suitable breeding sites is the most effective method for control of these pests. Location of these areas, however, is an extremely long and tedious task, even for a trained expert. Biting midges usually develop in the bottom mud of ponds, marshes and swamps or other similar wet soils, rich in organic material. The minute size of the larvae makes it extremely difficult to locate their breeding sites. If breeding areas can be located, drainage, diking or deepening the margins of ponds and streams may provide effective control.

Due to the limited flight range of the adults, these flies can be easily controlled in localized areas with the same insecticide mists or fogs used for adult mosquito control. Biting midges are weak fliers and are greatly inhibited by even moderate to light winds. Keep grassed areas closely mowed, shrubbery and low vegetation away from human and animal habitations, and thin trees and shrubs to encourage stronger wind currents.

Biting midges are also attracted to lights. Their tiny size enables them to enter tents, cabins and cottages through average mesh screen. Indoors, an aerosol containing either pyrethrum (pyrethrins) or allethrin is effective. Most repellents will not prevent these insects from attempting to feed, but some will entrap them like fly paper and keep them from reaching the skin surface. Thick lotions or cream repellents are most effective.

Fortunately, the weak flying ability of this group of insects restricts their nuisance to very limited and localized areas.

Ticks

While ticks common to Michigan do not normally present problems, large numbers of American dog ticks, *Dermacentor variabilis*, have occurred in some recreation areas. They can usually be successfully managed without extensive use of insecticides if the habits of the tick are understood and control measures designed accordingly. Problems with this tick in Michigan recreation areas have invariably been associated with the presence of small rodents—field or meadow mice, rabbits and similar animals. Humans or dogs usually encounter ticks by passing through an area frequented by these small rodents.

Female ticks lay their eggs in protected areas of the soil and may deposit several thousand in just a few days. Immature ticks (the larvae) hatch from the eggs and climb up on low vegetation along the pathways followed by small animals. They drop onto these small animals, or grasp their hair as they pass by. Attaching itself to the animal, the tick engorges with blood, and drops to the ground after feeding. There, it develops into the next stage, the nymph. Nymphs repeat the feeding process of the larvae and again drop off the small animal host and develop into the adult stage. The adult repeats this same process of locating a suitable host and taking a blood meal.

Adult dog ticks usually attach to humans and larger wild and domestic animals, including dogs, but immature stages rarely do so. Tick larvae, nymphs and adults usually require several days of attachment to become fully engorged and complete their blood meal. The normal life cycle of this tick species is two years, but may be as long as four years. These ticks are most apparent in Michigan from late spring (when the adults emerge from their winter seclusion) through the early summer, but are rarely encountered later in the year. Ticks of this species can transmit Rocky Mountain Spotted Fever, known to occur in Michigan, but never a significant health problem here.

Tick Control

Major tick infestations in Michigan recreation areas have usually developed in the vegetation along paths or trails used by humans, and in, or adjacent to, dog exercise areas in

roadside parks or similar localities. For effective tick control in these areas, mow or remove the vegetation for several feet along each side of the path or trail. This removes the cover used by the small animals and ticks.

If it is necessary to pass through a tick infested area, insect repellents containing diethyltoluamide (Deet) can be applied to exposed skin and clothing. After passing through such an area, examine each individual carefully, and remove any tick attached to the skin or moving about the skin or clothing. To remove an attached tick, grasp it with tweezers as closely as possible to the point of attachment and pull gently and steadily to cause it to detach without breaking off the mouthparts. Portions of the mouthparts left in the skin may result in the development of a secondary infection. After removal of the tick, the bite should be treated with an antiseptic. The same procedure may also be used to remove ticks from dogs or other pets.

Another tick, the brown dog tick (*Rhipicephalis sanguinius*), has created a severe annoyance in some localities where it has infested domestic pets and become established inside buildings. This tick is brought into the building on the infested dog during the summer. Eggs laid indoors by these ticks in the summer hatch and produce the large numbers of ticks noted later in the year, usually in late winter or early spring.

The brown dog tick may be found throughout the dwelling, so examine the building thoroughly and treat all infested areas carefully. Baseboards, floor and wall crevices, window frames and other harborage sites should be treated with an insecticide spray or dust. Careful attention must also be given to treating the dog's sleeping quarters, bedding, and the dog itself. Suitable concentrations of effective insecticide dusts are available in several brands of dog flea and tick powders. With severe infestations, it may be necessary to retreat the premises and the dog one or more times at weekly intervals. Detailed control recommendations are contained in Table 2.

Table 2.
Insecticides for Tick and Flea Control.

Insecticide	*Formulation*	*Directions*
	FOR USE ON CATS AND DOGS	
[1]*Carbaryl*	2 to 5% Dust	Dust animals beginning at the top of the head and progressing along the back, undersides and legs. Rub dust thoroughly into hair. Animal bedding should be dusted, washed in hot water, or replaced.
Malathion	3 to 5% Dust	
Gardona	3% Dust	
[2]Rotenone	1% Dust	
	FOR HOUSE OR KENNEL TREATMENT	
Malathion	2% Spray	Treat baseboards, floor and wall crevices, window frames and other harborages in pet sleeping areas or elsewhere where ticks or fleas are present.
[3]*Dursban*	0.5% Spray	
Carbaryl	5% *Dust*	
[2]*Precor*	Spray or Residual Fog	Apply according to label directions. ***Note: This is not a conventional insecticide but a growth regulator effective against only the larval stage of fleas.*** It prevents their development to the adult (biting) stage. For established flea infestations, use *Precor* in combination with an insecticide to eliminate both adult and immature fleas. *Precor* has a residual action that prevents adult flea emergence for up to 90 days, so it can also be used to prevent flea infestations in the home.
	FOR OUTSIDE AREA TREATMENT	
Malathion 57% EL	Spray-mix 5 fl oz in 1 gal of water	Apply as a coarse spray to grass under shrubbery and other areas where fleas/ticks are present—especially near the house. Apply indicated volume of mixture to 1,000 sq ft.
[3]*Diazinon 4 E*	Spray-mix 1¼ fl oz in 3 gal of water	
[3]*Dursban 4 E*	Spray-mix ¾ fl oz in 2 gal of water	

[1]*Do not use on kittens under 4 months of age.*
[2]*Use only for flea control.*
[3]*Do not apply to animals. Keep humans and animals from entering treated areas until spray has dried.*

Fleas

Most flea infestations in Michigan are associated with pet dogs or cats but may also originate from rodents or rodent nests located in, or near, human habitations. Fleas lay eggs among the hairs of their animal host or in the host's sleeping places. The eggs drop or are shaken off and tiny, cylindrical, legless larvae hatch and feed on various animal and plant substances in floor cracks, under carpets, in nest materials or in other sheltered places—both inside and outside.

When mature, the larvae spin small silken cocoons and develop into the pupal or resting stage, emerging later as adult fleas. Full development from egg to adult may require several weeks or

several months, depending upon the environment.

Flea Control

To be effective, any control effort must be directed simultaneously against both the adult fleas on the animal and the adult and immature stages located throughout the area frequented by the dog, cat, or rodent host.

Frequent, thorough cleaning will help prevent outbreaks of flea infestations in buildings. Vacuum floors, carpets, rugs and upholstered furniture often, if possible. Carefully clean cracks and crevices in the floor, around furniture cushions, and sleeping areas used by cats and dogs. Locate and remove rodent nests in or near buildings occupied by humans or pets. Before removing rodent nests, treat the nest and surrounding area thoroughly with insecticide to kill all fleas.

Flea infestations on pet dogs and cats can be eliminated by applying an insecticide dust to the animal when premises are treated. Insecticide sprays and shampoos are not as effective as dusts unless the formulation is thoroughly applied to the hairs, down to and including the skin. Although outdoor fleas will not survive the first hard frost in Michigan, they may be a continuing source of dog and cat infestations during the warm months, particularly late in the summer. For this reason, effective flea control for summer infestations may also require treating outside areas frequented by pets. Specific control recommendations are given in Table 2.

Selection and Use of Insect Repellents

Insect repellents will effectively protect an individual against mosquitoes, ticks, flies and other biting insects, if used correctly. They may contain a single repellent compound or a mixture of two or more, and may be formulated as creams, lotions, solid sticks or in pressurized dispensers. Length of effectiveness after application varies with the concentration of the chemical, environmental conditions, activity of the user, amount of repellent applied, thoroughness of the application and species of insect.

After application, the repellent gradually loses its effectiveness through skin absorption, evaporation, washing off by water or perspiration, or rubbing off on foliage. Any activity that increases any of these processes will shorten the effective period of the repellent and necessitate more frequent applications. Protection may extend up to 6 to 8 hours under "ideal" conditions. However, with hot, humid conditions and heavy perspiration, repellent applied to the skin may retain its effectiveness for only 15 to 30 minutes in the presence of large numbers of mosquitoes or other biting insects. Repellent applied to clothing may continue to be effective for several weeks but is usually removed quickly by the rinsing action of water, rainfall, laundering or dry cleaning.

To be effective, the repellent must be applied thoroughly to clothing or exposed skin areas. The areas that must be treated vary with the insects involved. Mosquitoes and most biting flies attack exposed skin and are capable of biting through clothing where it adheres closely to the body—e.g., at the shoulders and waist. For a repellent to be effective against these flying insects, it must be applied to the exposed skin, to the clothing in areas where the insect can bite through, and around clothing closures where they may enter. Ticks, however, are usually encountered only in low vegetation so the application of repellent to trouser legs, socks, and clothing closures will usually provide adequate protection. Fleas most frequently bite the lower legs after crawling up from infested floors or carpets but also may be present in furniture or bedding. Thus, repellent must be applied to both exposed skin and clothing for good protection from fleas.

Most repellents will damage or dissolve many plastics and some types of synthetic fibers used in clothing. They also cause temporary irritation if in contact with the eye, mouth or inner parts of the nose, so care must be exercised in applying repellents to both skin and clothing. Pressurized spray formulations, in particular, must be used carefully to avoid skin or eye irritation or damage to plastics and synthetic materials.

Insecticide Dispersal Equipment

One of the most important considerations in any insect control program is the proper selection, use, and care of insecticide dispersal equipment. There are many kinds and sizes of equipment, ranging from small, hand-operated "flit guns" to expensive, vehicle-mounted, power equipment. Equipment needed for use in any recreational area will depend upon the types of insects, kinds of control measures, and size of the areas requiring treatment. Equipment selection should be made only after the total insect control problem has been examined and the kinds of insecticides and best methods of application have been determined.

Insecticides are effective only if applied correctly and in the proper amounts. Under-treatment will not be effective and over-treatment increases control costs and may contribute to environmental contamination by creating severe toxic hazards to nontarget plants and animals. It is important that all insecticide dispersal equipment be operated properly so that control can be achieved without unwanted side effects.

Aerosol Dispensers

Push-button aerosol dispensers (***space sprays***) are self pressurized containers that usually contain approximately one pound of insecticide solution dissolved in a liquified propellent gas. They form a fine fog

composed of minute particles of insecticide used to control flying insects within tents, cabins or other habitations. A spraying time of approximately seven seconds is usually sufficient to treat each 1,000 cubic feet of space.

A number of self pressurized insecticide dispensers for ***surface*** treatment closely resemble the aerosol containers. These dispensers produce much coarser insecticide particles and are designed to be applied directly to surfaces. They are not effective when applied as a space spray. In addition, surface formulations often contain more toxic insecticides than aerosol formulations and may be hazardous if inhaled. Container labels should be read carefully so that only aerosol formulations are used as indoor space sprays.

Hand Sprayers

Small hand sprayers of the flit-gun type usually have a capacity of one to three quarts and are used principally for application of small amounts of insecticide within buildings.

Compressed Air Sprayers

Sprayers of this type usually have a capacity of one to three gallons and are probably the most useful and versatile piece of equipment available for both indoor and outdoor insecticide application. Air is compressed in the sprayer by a built-in hand operated pump and the pressurized air forces insecticide out through the nozzle. While these sprayers may be equipped with several types of nozzles, the hollow cone nozzle is most commonly used for mosquito larviciding and other outdoor spraying. This nozzle can be adjusted to deliver sprays ranging from a solid stream to very fine particles. Frequent pumping is required during use to maintain adequate spraying pressure. A number of relatively inexpensive models of this type sprayer are available. If extensive use is anticipated, it is usually more economical to purchase a professional type sprayer with a stainless steel, welded tank and heavy duty spray trigger mechanism. With proper care and maintenance, the professional type sprayer can be used indefinitely, while cheaper models often do not withstand extensive use and must be frequently replaced.

Foggers

Fogging machines are available in a variety of sizes, from portables weighing under 20 pounds, to truck or trailer mounted units that weigh several hundred pounds. The smaller units can be powered by an electric or gasoline engine or bottled propane, while the larger ones use only gasoline motors. Insecticide fogs control adult flying insects, but have little effect on ground inhabiting pests such as ticks and fleas. They are also of little value in controlling mosquito larvae.

For a fog to be effective, an adequate amount of insecticide must be dispersed thoroughly in the treatment area. Application rate is controlled by the speed at which the fog machine is driven or by speed of passage and application rate. Regardless of equipment used, treat entire areas completely and as rapidly as possible, since re-infestation can occur quickly.

Because insecticide fogs require wind to carry them through infested areas, fogging is done on a crosswind course to allow the fog to drift downwind, away from the machine and operator. Make fog applications only between the early evening and early morning hours when air temperatures near the ground are cooler than at six feet, or more, above ground. This holds the fog close to the ground and insures maximum exposure of the insects to fog particles. Fogs applied during the warmer parts of the day normally rise quickly above the vegetation and dissipate rather than remain close to the ground where insects are located. Do not apply fogs when ground level wind speeds exceed six mph. Optimum wind speed for treatment of open areas ranges from two to three mph, while satisfactory applications can be made in wooded areas with slightly higher wind speeds.

Small areas can be treated with little effort, and control will be effective if correct application rates are used throughout. Large area treatments, however, must be planned carefully and conducted as efficiently and quickly as possible. Before treating large areas, plot and record (on a map of sufficient detail) the roads and trails that can be used by the fogging machine. The fog machine operator must know in advance which roads or trails will be used, direction of travel (based upon the wind direction prevailing at the time of treatment), and speeds and delivery rates needed to provide adequate insecticide application. The area treated and amount of insecticide applied should be carefully recorded for future reference. Systematic application makes it possible to treat the entire area thoroughly and efficiently.

Ultra-Low Volume Equipment

This type of equipment uses a relatively low tank pressure (2 to 6 psi) and is designed to produce insecticide droplets in the 5 to 27 micron range (1 micron = 1/25,000 inch). Delivery rate is less than 2 quarts (0.5 to 3.0 ounces active insecticide) per acre. The insecticide formulations registered for use in this type of equipment are much more concentrated than regular spray or fog mixtures and, therefore, must be handled and used with particular care. It is essential that the equipment be operated and maintained according to the manufacturer's recommendations. If these insecticides are applied in higher than recommended amounts or in droplets significantly larger than the 5 to 27 micron size, paint damage and other problems may occur. Techniques used for the ULV applications are

the same as those outlined for fogging. ***This method is recommended only for commercial pest control operators or professional mosquito control personnel.***

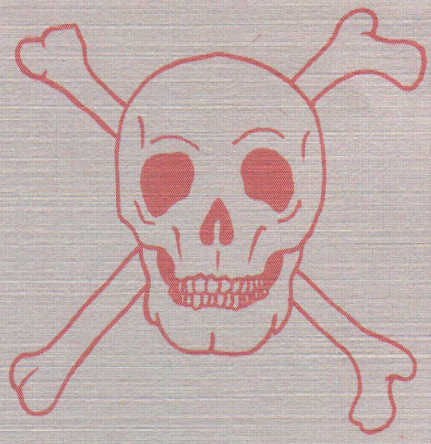
Mist Blowers

Like fogging machines, mist blowers range in size from small portable units with two to four quart capacity to truck mounted units that hold several hundred gallons of insecticide. Select your unit based on the types of control operations planned and size of the areas to be treated. Mist machines produce fine particles that are carried out in a strong blast of air. Distribution of the insecticide depends primarily upon the air blast, but may be supplemented by wind at the time of application. Insecticide mists provide some residual insect control, but, like fogs, require contact with the insect. Unlike fogs, mists can be used to control mosquito larvae. However, they are not as effective as insecticide sprays, and are not usually recommended for this purpose.

Power-Driven Hydraulic Sprayers

Large capacity power-driven sprayers are most useful for application of insecticides to large outdoor areas such as those treated in larval mosquito control. These are relatively expensive items and should be selected to provide the characteristics needed in your insect control operations.

Caution



All pesticides are poisonous and must always be handled to minimize the possibility of harm to humans and other nontarget organisms, either by contact or through contamination of food and water. Insecticides recommended in this publication are effective and relatively nonhazardous to users and the environment, *if used properly*. The key to safety with all pesticide chemicals is a knowledge of the hazards involved in handling and applying them. Know and follow these basic rules:

1. Know the material being used. Read the container label and understand the directions for preparing and applying the insecticide. Do not use more insecticide than necessary. Excessive application increases costs and may be hazardous. FOLLOW DIRECTIONS!

2. Take special care to prevent inhalation and contamination of skin and clothing when using insecticides. If insecticide is spilled on the skin or clothes, immediately remove all contaminated clothing and thoroughly wash exposed skin with soap and water. Prompt action can prevent serious poisoning or death. Always wash with soap and water after spraying or handling insecticide chemicals.

3. Avoid contaminating human and animal foods and drink with insecticides.

4. Keep spray equipment clean and in good operating condition. Rinse insecticide from equipment only where it will not affect humans, domesticated animals or wildlife.

5. Store insecticides in properly labeled, original containers, and keep out of the reach of children. NEVER store insecticides in food or beverage containers.

6. Dispose of empty insecticide containers safely (e.g. burial in an approved location); never use these containers for storing other materials.

7. In case of accidental poisoning with insecticides, get the victim to a physician WITHOUT DELAY. If possible, take the container of the insecticide involved (with label intact) to the physician so that he/she can determine the poison or poisons and prescribe the proper treatment. Immediate, proper and adequate treatment is essential.

MICHIGAN STATE UNIVERSITY

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