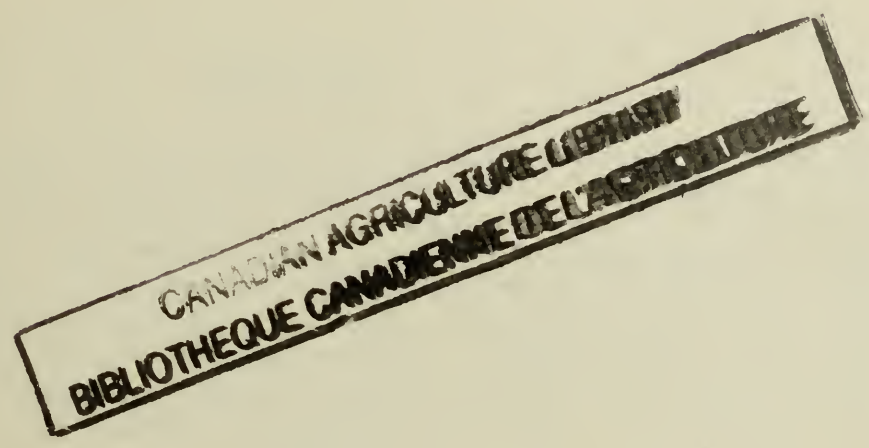
PUBLICATION 936 ISSUED JUNE, 1955

CONTROL OF MOSQUITOES IN CANADA

By

C. R. TWINN AND D. G. PETERSON



SCIENCE SERVICE, ENTOMOLOGY DIVISION
CANADA DEPARTMENT OF AGRICULTURE

10M—22742—5:57

CONTROL OF MOSQUITOES IN CANADA[1]

by

C. R. Twinn and D. G. Peterson

Veterinary and Medical Entomology Unit
Entomology Division, Ottawa

There are more than 60 species of mosquitoes in Canada. The females of most of these are blood-suckers and often cause great annoyance and discomfort to man and beast, especially in spring and early summer. Their presence may locally reduce land values, interfere with farming and lumbering operations and other outdoor employment, reduce the productivity of livestock and poultry, and interfere with recreational activities.

Although certain species are involved in the transmission of western equine encephalomyelitis in horses and man in Canada, mosquitoes are relatively unimportant as disease carriers in this country. However, in many other parts of the world they are of paramount importance because the females of a number of species serve as the intermediate hosts of several serious diseases of man, such as malaria, yellow fever, filariasis, and dengue, or breakbone fever.

Life-History

Mosquitoes develop only in water and pass through four distinct life-stages: namely, egg, larva, pupa, and adult (Figure 1). The eggs, of which one female may lay several hundred, are deposited on water or in low places where water collects. The small, active larvae that hatch from the eggs are commonly known as "wrigglers". The larvae feed on minute forms of animal and vegetable life and decaying organic matter in the water. The more common species breathe largely through a tubular organ at the end of the body that is thrust at frequent intervals through the surface of the water. When full-grown, the larvae transform into pupae. The pupa, which is somewhat similar in shape to a large-headed comma, does not feed but is able to move actively in the water. It breathes through two respiratory "trumpets" on the thorax applied to the surface of the water. The insect transforms into the winged adult within the pupal skin. When the mosquito is ready to emerge, air is taken into the pupal case, causing it to float. The skin then splits along the upper surface and the mosquito emerges, resting on the water or nearby vegetation until ready to fly away. The aquatic life-stages of mosquitoes vary considerably, depending on species, temperature, and other conditions, and may be as short as one week or as long as several weeks or even months. The winged forms live from a few days to several months. Both sexes feed on the nectar of flowers, but the females of most Canadian species also suck blood and attack man and other warm-blooded animals, including poultry and other birds.

---

[1] Revision of Canada Department of Agriculture Circular 172.

89619—1½

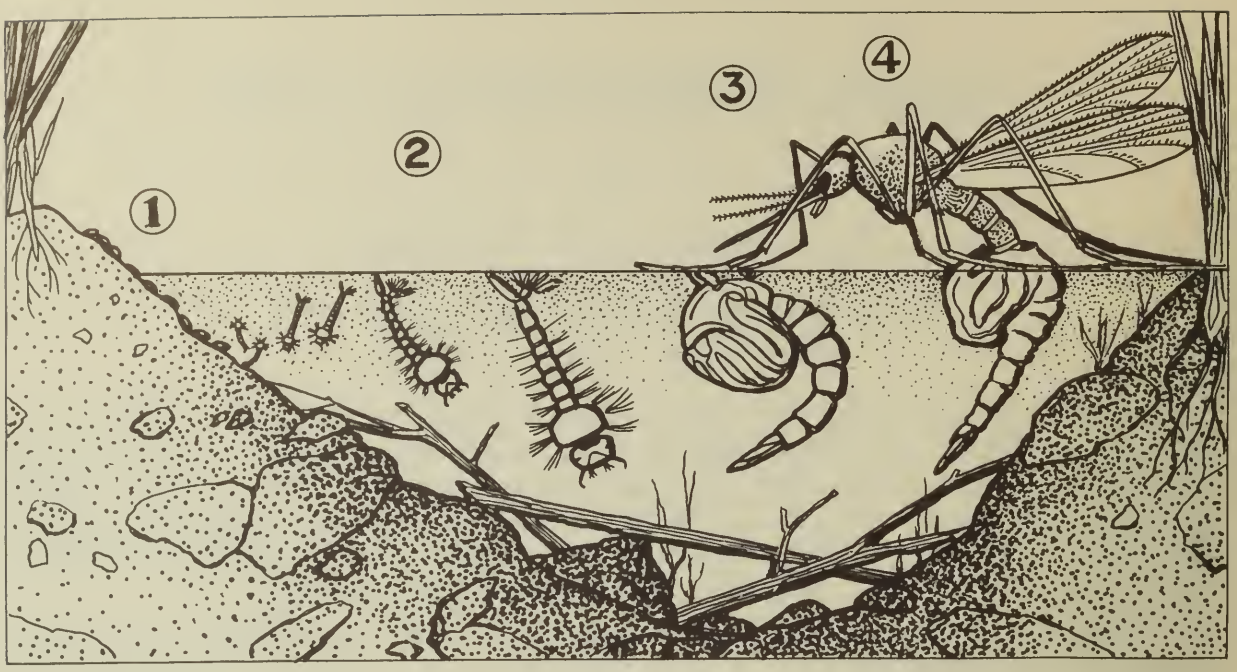


Figure 1. Life-stages of an *Aedes* mosquito: 1, eggs; 2, larvae; 3, pupa; 4, adult emerging from pupal case.

Species in Canada

In various parts of the country different species are most numerous and, as their breeding places, life-stages, and habits may vary considerably, it is important when planning control measures to know the species involved. For instance, depending on the species, the breeding places may be river flood-waters, snow- and rain-pools in woods or in open fields, salt marshes near the sea, sluggish polluted streams, or rain-water barrels under eaves of buildings. Some species may disperse or migrate considerable distances, whereas others remain near their breeding places. Some are persistent in entering houses and others are rarely found indoors; some bite in the daytime, and others at night. The most common mosquitoes[1] in Canada have only one generation each year. They breed largely in temporary bodies of water. Their eggs are laid in places left moist by receding floods and drying pools, and hatch when submerged in the spring. Less common mosquitoes[2] have more than one generation a year and pass the winter as adults, in such places as cellars, outhouses, and hollow trees. They emerge from hibernation in the spring and usually lay their eggs on water bodies of a more or less permanent character. The larvae and pupae of another species[3] develop entirely under water, attached by their air tubes to the roots and stems of aquatic plants. This species passes the winter as larvae.

Control

In dealing with a mosquito control problem, it is first necessary to locate the mosquito breeding areas. Systematic and periodical collections of larvae and adults must be made so that the important pest species may be identified. Secure a large-scale map of the district, divide the territory into numbered sections, and work systematically over each at intervals from the spring thaw

[1] *Aedes* spp.
[2] *Culex, Culiseta,* and *Anopheles* spp.
[3] *Mansonia perturbans* (Wlk.).

until the end of the breeding season. Examine all pools, ditches, flooded areas, and other likely bodies of water, especially temporary ones. To find whether larvae or pupae are present, pass a small-mesh strainer through the water and place it in a white dish containing water. For identification purposes, transfer a representative sample of the larvae by means of a medicine dropper from the dish to a vial containing 70 per cent alcohol, or, if this is not available, four per cent formalin. Write in pencil the locality, date, and collector's name on a slip and insert this in the vial for reference. Collect adult mosquitoes in an insect net and transfer them to a killing jar, or trap them by placing the jar over them when they alight. A safe and simple killing jar may be prepared by placing pieces of rubber bands in the bottom of the receptacle and covering them with chloroform or carbon tetrachloride. The rubber absorbs the chemical and may be held in place by a disk of blotting paper. Keep the jar tightly corked when not in use. Address specimens to be identified to the Head, Veterinary and Medical Entomology Unit, Entomology Division, Ottawa.

When the troublesome species have been identified, their breeding places located, funds provided, and a competent person appointed to supervise the project, the control work may be initiated. Temporary measures, such as spraying with insecticides, are usually initially less expensive and more productive of immediate results, but measures of a more enduring character should be included.

Permanent Control Measures

Drain or fill low areas where water collects and mosquitoes develop. These are measures that can best be dealt with by competent sanitary or drainage engineers. However, simple drainage systems often prevent water from collecting in low places and, if properly maintained, are of great value in reducing the pest. If city garbage is used for fill, dump it during the winter and cover it well with soil in the early spring to prevent the breeding of house flies and other vermin.

Control lake or river levels to prevent seasonal flooding. Dyke and pump the water from inundated areas both inland and on salt marshes near the sea, and transform low, mosquito-breeding places into permanent areas of deep water.

Temporary Control Measures

Use insecticides when permanent control measures are not feasible or are insufficient. DDT and related insecticides will kill both the larvae and the adults of mosquitoes and provide an effective and economical means of control. Local circumstances, conditions of terrain, types of breeding area, climate, available funds and manpower, must be considered in the selection of the method or equipment used in the application of the insecticides.

Control of Larvae

Commence a systematic application of larvicide as soon as possible after the spring thaw. An early treatment of the breeding places with DDT is often sufficient to prevent larvae from developing in the treated areas during the remainder of the season. Apply DDT in No. 2 fuel oil, diesel oil, or kerosene solution to all breeding areas at the rate of about 0·25 pound of the active ingredient per acre of water surface. Three gallons of one per cent, or five pints of five per cent, DDT in oil solution per acre gives a dosage of

approximately 0·25 pound of the active ingredient. For economy on large-scale projects, purchase a concentrate consisting of 25 or 30 per cent DDT in methylated naphthalenes or other suitable solvents and dilute it with oil as required for application. Other chlorinated hydrocarbon insecticides that may be used as substitutes for DDT in the control of mosquito larvae are: TDE, applied at the same dosage as DDT; lindane, at 0·1 pound per acre; toxaphene, at 0·4 pound; and dieldrin, at 0·1 pound. Dieldrin is more toxic to human beings than the other chemicals and should be used only by experienced operators.

Examine flood-waters shortly after they form, and spray any found to contain larvae; deal similarly with rain-pools that appear later in the season. Several treatments may be necessary during a season against salt-marsh mosquitoes. Apply the initial application at the first appearance of the immature stages and continue periodic inspections and additional treatments as required.

Mosquito larvae can also be controlled by a pre-hatching treatment of the breeding areas. Apply DDT as an oil solution, water emulsion, or wettable powder suspension at the rate of 0·5 pound of the active ingredient per acre to breeding areas in the late fall before the ground is covered by snow, or in the early spring before the snow melts.

Hand sprayers (Figure 2), portable compressed-air sprayers, power sprayers, mist blowers, and aircraft are available commercially for applying larvicides. The size of the area and the nature of the terrain will suggest the type of equipment to be employed.

Figure 2. A hand sprayer.

The portable compressed-air sprayer (Figure 3) is the mainstay of most control projects, because of its simple design and operation, and its relatively low cost and flexibility. The capacity of these sprayers ranges from one to five gallons and they are usually carried by the pump handle or a shoulder

strap. The sprayer is filled only three-quarters full and the air in the remaining space is compressed by means of a built-in plunger-type air pump. Various spray patterns of the coarse spray type may be produced by the assortment of nozzle disks that are normally supplied.

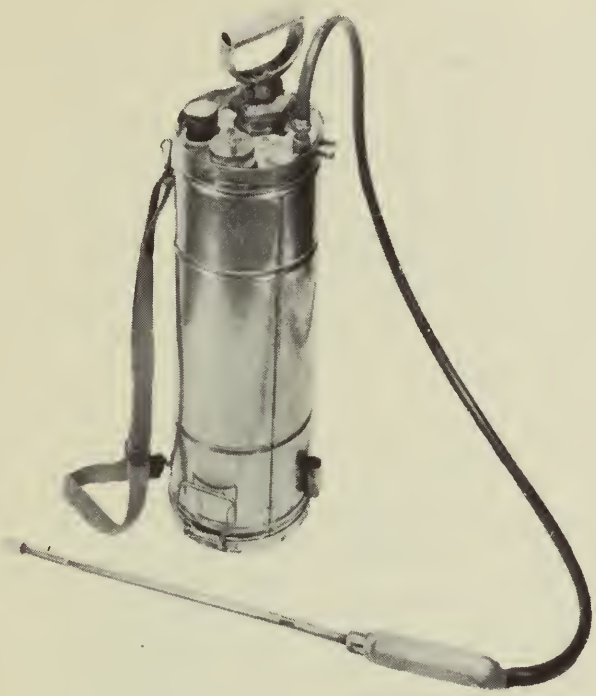


Figure 3. A portable compressed-air sprayer.

Power-operated sprayers (Figure 4), including both pneumatic and hydraulic types, have greater capacity and pressure than the portable compressed-air sprayers. They range from those with a 10-gallon capacity, operated by one-horsepower engines, to those with 200- to 600-gallon capacity and operated by 20- to 45-horsepower engines.

Figure 4. A small power sprayer applying residual spray.

TABLE 1.

EQUIPMENT AND INSECTICIDES FOR CONTROLLING MOSQUITO LARVAE, ACCORDING TO SITUATIONS

Situation	Equipment	Insecticide	Dosage
			0·25 lb. of active ingredient per acre
Floodwaters, rain-pools, and permanent pools.	Portable compressed-air sprayer...	1% DDT in No. 2 fuel oil	3 gal. per acre.
	Power sprayer.....		
	Mist blower.....	5% DDT in No. 2 fuel oil	5 pints per acre.
	Aircraft.....	10% DDT in No. 2 fuel oil	2½ pints per acre.
			0·5 lb. of active ingredient per acre
Any breeding area in late fall or early spring before eggs hatch.	Portable compressed-air sprayer	2% DDT in oil solution or water emulsion or suspension.	3 gal. per acre.
	Power sprayer.....		
	Mist blower.....	5%DDT in oil solution or water emulsion or suspension.	10 pints per acre.
	Aircraft.....	10% DDT in oil solution	5 pints per acre.
Ornamental pools and rain-barrels	Hand sprayer.....	0·01% pyrethrins in water emulsion	14 fl. oz. per 100 sq. ft.

TABLE 2.

EQUIPMENT AND DDT FORMULATIONS FOR THE CONTROL OF ADULT MOSQUITOES IN VARIOUS SITUATIONS

Situation	Equipment	Insecticide	Dosage
Space spraying inside homes and other buildings.	Aerosol bomb	2-3% DDT plus pyrethrins and piperonyl butoxide in oil solution.	3 grams per 1,000 cu. ft. (spray for 6 to 8 sec. per 1,000 cu. ft.)
	Hand sprayer	0·5% DDT plus pyrethrins and piperonyl butoxide in kerosene.	Approx. ½ fl. oz. per 1,000 cu. ft.
Space spraying outdoors	Aerosol generator	5% DDT in oil solution	2½ to 5 pints per acre (0·1 to 0·2 lb. of active ingredient).
	Aircraft	5 or 10% DDT in oil solution	5 or 2½ pints per acre.
Residual spraying inside homes and other buildings.	Hand sprayer Portable compressed-air sprayer Small power sprayer	5% DDT in oil solution	1 gal. per 1,200 sq. ft. (200 mg. of active ingredient per sq. ft.)
Residual spraying outdoors (on vegetation).	Portable compressed-air sprayer Power sprayer Mist blower	1% DDT in water emulsion or suspension.	10 to 20 gal. per acre (1 to 2 lb. of active ingredient).
Residual spraying outdoors on buildings (not on vegetation).	Portable compressed-air sprayer Power Sprayer Mist blower	5% DDT in oil solution	1 gal. per 1,200 sq. ft. (200 mg. of active ingredient per sq. ft.)

Mist blowers (Figure 5) are low-volume and low-pressure power-sprayers equipped with an engine-driven fan or blower. The oil solution is discharged into the air stream created by the blower. These machines have an effective range of 50 to several hundred feet. Small models of mist blowers are commonly mounted on a wheel-barrow or cart chassis for movement by hand. Others are skid-mounted for transport by truck or trailer. Tank capacities range from 50 to several hundred gallons.

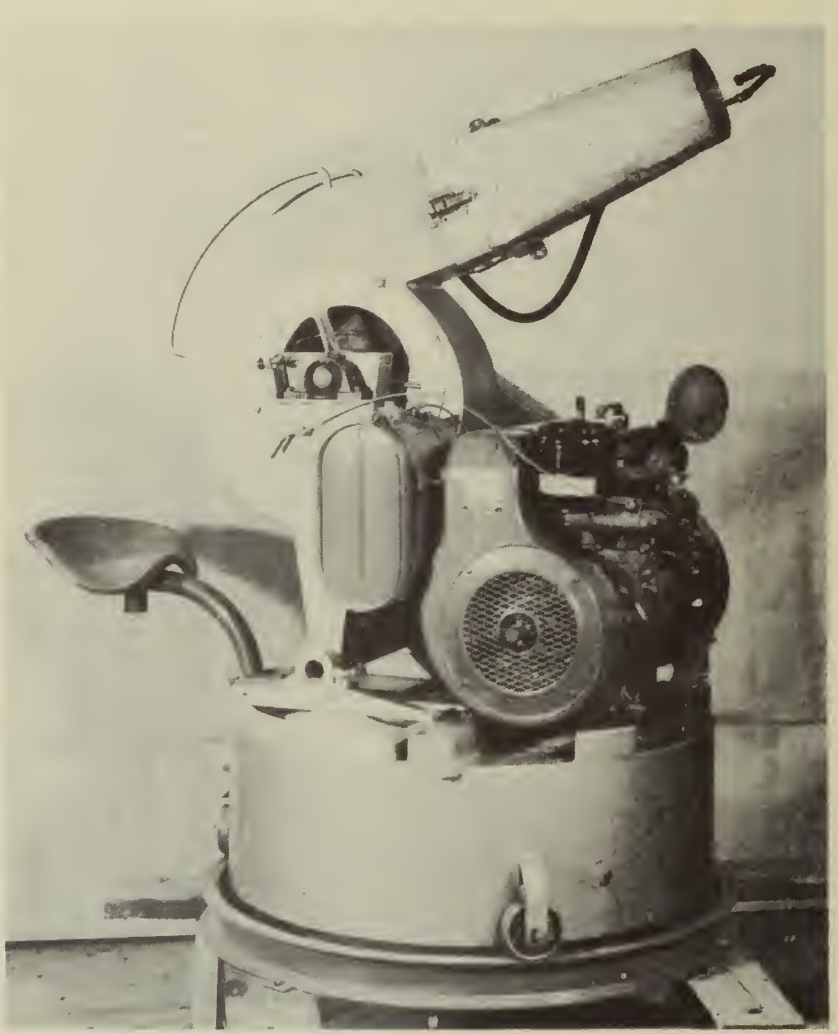


Figure 5. A mist-blower.

Control of Adults

Mosquitoes may become a nuisance in an area in spite of measures against the larvae. Use space, residual, or aircraft sprays, or a combination of these, to obtain local relief.

Space Sprays.—A space spray is a fine spray, mist, or aerosol consisting of very small droplets of insecticide solution; indoors the droplets become evenly distributed throughout the enclosed space and outdoors they are dispersed by movements of air. The droplets come in contact with the adult insects in flight or at rest. A space treatment is a temporary measure, as re-infestation may occur when mosquitoes are abundant outside the treated enclosure or area, and repeated applications may be required. Space sprays usually do not produce an effective residual deposit of insecticide.

In homes and other enclosures, release space sprays from aerosol bombs, suitable types of aerosol generators, or hand sprayers for immediate relief from mosquitoes. Use sprays or aerosols containing DDT, methoxychlor, lindane, pyrethrins, or certain organic thiocyanates.

Around camp sites, gardens, home grounds, and other small areas reduce the mosquito nuisance by space sprays applied with a compressed-air sprayer fitted with a fine-spray nozzle, or with an aerosol generator.

In extensive areas effective control of mosquitoes can be maintained by the proper use of aerosol generators (Figure 6). These generators produce an aerosol cloud of very fine droplets that are light enough to be carried by the wind. The machines range in size from those with a capacity of 45 gallons or more and an output of 45 gallons per hour to those with a capacity of one gallon and an output of two gallons per hour. Equipment is also available or may be constructed for installation on the exhaust of tractor or other gasoline engines for the production of heat-generated aerosols.

Apply an aerosol during the hours between sunset and sunrise, when adult mosquitoes are most active and meteorological conditions are usually suitable, so that the wind rolls the aerosol close to the ground and does not disperse it into the upper air. Overcast days may also provide suitable conditions for applying an aerosol. Wind speeds of two to four miles per hour are most satisfactory for the dispersion of aerosols over open ground. In forest areas, wind velocities up to 10 miles per hour are satisfactory.

Figure 6. A thermal aerosol generator in operation.

Operate vehicles carrying aerosol generators at speeds of two to four miles per hour along parallel lines across the area to be treated, at right angles to the direction of the wind, and in a shingle fashion. This ensures that the entire area is covered by the aerosol. The effective distribution of an aerosol downwind from the emission line varies with atmospheric conditions,

direction and velocity of the wind, delivery rate of the generator, density of vegetation, and other factors. Allow approximately 200 feet between emission lines to ensure a sufficient concentration of aerosol.

Use a five per cent solution of DDT in No. 2 fuel oil, diesel oil, or special fogging oils in aerosol generators and apply it at the rate of 0·1 to 0·2 pound of DDT, or approximately one to two quarts of the solution per acre. Applying 0·5 to 1·0 gallon of solution to each 100 yards of emission line gives the correct dosage.

Residual Sprays.—Residual sprays of insecticides are applied to surfaces on which the adult mosquitoes may rest. The treated surfaces remain effective for long periods, but do not provide relief against mosquitoes that are in constant flight. Use a combination of residual and space sprays for the greatest degree of protection.

Indoors, apply a five per cent solution of DDT in deodorized kerosene or other suitable solvent to surfaces at the rate of one gallon per 1,200 square feet.

In camp sites, parks, and gardens, apply a DDT spray to ground surfaces, and to buildings and vegetation up to a height of 10 feet, at the rate of two pounds of the active ingredient per acre. Lindane, applied at the rate of 1·5 pounds per acre, may also be used as a residual spray outdoors. An oil solution or emulsion is preferred, but use the latter or a wettable powder suspension if vegetation is to be sprayed, as the oil may wilt or burn vegetation.

Residual sprays outdoors may also be applied as barrier strips. Establish these by spraying a strip of vegetation, 10 to 20 feet wide, around the area to be protected, at a dosage of two pounds of DDT, or five gallons of a five per cent DDT solution, emulsion, or suspension, per acre. Destroy adult mosquitos in the area within the barrier by a space spray. The barrier may prevent or retard re-infestation.

Hand sprayers, portable compressed-air sprayers, and small power sprayers are preferred for indoor spraying. Power-sprayers and mist blowers are required for extensive residual applications outdoors.

Aircraft Sprays.—Aerial spraying is effective and economical for treating extensive areas to control both larvae and adults. A DDT solution is dispersed from the aircraft as an atomized spray. Against the larvae this should consist of small droplets sufficiently numerous to ensure that, under suitable meteorological conditions, the breeding areas are covered by an even deposit. Against adults a more finely atomized spray is required so that all adult insects in the area are hit by enough insecticide to kill them.

Including aerial spraying in a mosquito control program requires consideration of a number of factors, including the nature of the terrain, type of breeding area, species of mosquitoes, location of airfields, cost, and available funds and manpower. Aerial spraying is seldom employed alone, but is usually integrated into a program that includes the use of ground equipment. The following are the advantages of spraying from aircraft:—

1. Extensive breeding areas that may be inaccessible for ground application are within easy reach by air.

2. Scattered and widespread breeding areas can often be treated more rapidly, effectively, and economically than with ground equipment.

3. Sudden and widespread infestations of adult mosquitoes can be rapidly controlled.

4. Commercial operators may be hired, avoiding a large investment in equipment.

The following are disadvantages of aerial spraying:—

1. Aerial spraying is restricted to overcast days and the hours between sunset and sunrise, when meteorological conditions are usually such that the spray can be properly distributed.

2. The distribution of the spray from an aircraft is more difficult to control than from ground equipment.

3. Small, scattered breeding areas can be treated more economically with ground equipment.

A variety of aircraft are employed for aerial spraying, including biplanes, e.g., the Stearman; light monoplanes, e.g., the Cub type; twin-engined monoplanes, e.g., the Dakota DC-3; helicopters; and autogyros. The light planes are operated at low cost, manœuvre well, and do not require long runways. The twin-engined airplanes have longer range and greater load capacity. Helicopters are expensive, but they do not require runways and the rotors help to force the spray down.

A variety of equipment is available for installation on aircraft for aerial spraying. This includes boom-and-nozzle assemblies, straight emission pipes, and a rotary-brush assembly, all of which may be operated with gravity flow or a pump to give an even output. Efficient equipment should release the insecticide at a uniform and adjustable rate and spread the spray in wide and even swaths.

Select the aircraft to hire after considering the following points:—

1. Extent of the breeding or infested area that is to be sprayed.

2. Nature of the terrain over which the aircraft must fly.

3. Distance from an airfield and the load that the aircraft can carry. A low capacity increases the cost of a large-scale operation.

4. The spraying equipment with which the aircraft is fitted.

Plan and organize the aerial spraying program with care. The pilot should follow the directions prepared for him, and the success of the application depends upon how well the operation is planned. Remember the following important points:—

1. Familiarize the pilot with the area to be sprayed. This should avoid costly delay and waste of material.

2. Proper timing of applications is very important in the control of both larvae and adults.

3. Ascertain the success of the operation by pre- and post-spray assessments of the numbers of mosquitoes in the treated areas.

4. Prepare adequate mixing and loading facilities for the insecticide solution, unless these operations are the responsibility of the commercial operator.

Obtain a large-scale map of the locality and mark on this the area to be sprayed and the spray plan. A pattern of parallel spray runs, the pilot flying back and forth across the area, is the normal spray plan. The spray runs should be approximately at right-angles to the direction of the wind so that it will spread the spray in a wide swath. The swath width, i.e., the distance between the parallel spray runs, is determined by the height of the aircraft, the wind speed and direction, and the type of spray equipment. As a rule

the aircraft should be flown at approximately 100 feet to obtain the maximum effective swath width. If possible, place a visible marker at the start of each spray run to act as a guide for the pilot.

To apply a dosage of 0·25 pound of DDT per acre use a 10 per cent solution of DDT in No. 2 fuel oil at the rate of 2·5 pints per acre, or five per cent at five pints. As the oil solution may cause some damage to standing crops in agricultural areas, take care in spraying near such areas.

Study the legal aspects of aerial spraying in your community. There are provincial and federal regulations that may apply to these operations. Insurance is necessary for protection from possible loss of life, or injury, or damage to property.

Protection From Mosquito Bites

Proper screening of dwellings is essential to comfort where mosquitoes are troublesome. To exclude the smallest species, the screens should not have less than 16 meshes to the inch.

Personal protection for those engaged in outdoor work or recreation may be obtained by applying a mosquito repellent. Repellents, when properly applied to exposed skin, should give protection for about two hours under most conditions. If the mosquitoes are very plentiful and are biting intensely, the best of the repellents may require renewal at least as often as once an hour. Outstanding among the repellents are dimethyl phthalate, dimethyl carbate, ethyl hexanediol (Rutgers 612), Indalone, and certain cyclohexanols. These chemicals and mixtures of them have been incorporated into numerous proprietary preparations now being widely sold across Canada, both in liquid and in ointment form. Typical formulae include (1) dimethyl phthalate alone, (2) a 6:2:2 mixture of dimethyl phthalate, either Rutgers 612 or dimethyl carbate, and Indalone, and (3) a 7:3 mixture of 2-phenyl cyclohexanol and 2-cyclohexyl cyclohexanol. Twelve drops of repellent should be sufficient for the face, neck, and both hands. One should avoid getting the repellent in the eyes or on the lips as it causes a temporary stinging sensation.

On clothing, these repellents retain their effectiveness for much longer periods than on the skin. Applying them by hand or by sprayer to the outside of the clothing, particularly across the shoulders, around the waist, on the seat of the trousers, and on the socks, has definite protective value.

Many repellents are solvents of paints, varnishes, and plastics and should be kept from contact with such surfaces or materials, including nylon.

For further information write to the Veterinary and Medical Entomology Unit, Entomology Division, Science Service Building, Ottawa.

EDMOND CLOUTIER, C.M.G., O.A., D.S.P.
QUEEN'S PRINTER AND CONTROLLER OF STATIONERY
OTTAWA, 1957