Part II

Control Measures for Specific Vectors

Chapter 5

Aedes Aegypti

Aedes aegypti is the vector of dengue, dengue hemorrhagic fever and urban yellow fever. It is a domestic mosquito that breeds in artificial containers in and around human dwellings. As containers proliferate, the species achieves high levels of density. This mosquito has also been known to breed in artificial containers placed some distance from human dwellings, and in natural containers, such as tree holes, bamboo, coconut shells and large snail shells. Any given area has slightly unique breeding habits, due to differences in the habitats and lifestyles of humans. In areas where water is stored or collected, open containers furnish ideal habitats. Such breeding sites should be given extra attention after a natural disaster, especially if the normal water supply is disrupted. Cisterns, cans, bottles, cemetery urns, tires and almost any discarded container that holds fresh water may also become infested.

The adult female mosquito deposits its eggs singly on the side of the container at, or immediately above, the waterline. Rains associated with some disasters provide the needed water to allow hatching, because the eggs are able to withstand drying for several months. Excessively heavy rains quite often wash away much of the initial egg deposition. However, large numbers of *Aedes aegypti* are quickly produced in numerous new oviposition sites. When conditions are favorable, hatching can occur within two or three days after ovipositioning.

Larval development, under favorable conditions, can be completed in five to seven days. The fourth instar larva molts to a pupal stage, and transformation to an adult is completed during the two to three day pupal period. Consequently, the life cycle can be completed in about ten or more days.

The emerging adults usually do not disperse more than a hundred meters and the females will readily enter nearby houses or any other man-made dwelling. In order to develop eggs, females require a blood meal for which humans are the preferred host. Biting usually occurs during, but is not limited to, daylight hours. In many cases humans are not aware of being bitten. The adult may live for six to eight weeks and, once infected with the viruses of yellow fever or dengue, remains so for life.

Surveillance

If the country has an eradication or control program for *Aedes aegypti*, baseline information on population densities in the affected or adjacent areas should be available. Wherever there is no control program, the distribution of the vector should be mapped, its favorable larval habitats should be determined and adult population densities should be studied by determining land rates and the distribution and examination of oviposition traps.

Initiation of new or additional control activities should be related to the prevalence of *Aedes aegypti* or virus activity in the immediate and nearby areas. The epidemiologist should be responsible for determining the presence or likelihood of the introduction of diseases.

Recruitment and training of new vector control personnel may be problematic and depends in part on the budgetary priorities of the government. Even with assistance from external sources, tremendous strain is placed on budgets during natural disasters. If paid personnel are unavailable during emergencies, military recruits, school children, boy scouts and other volunteers may be used.

Backup availability of laboratories is necessary for identification of mosquitoes. This may be available from an *Aedes aegypti* or malaria control service. Universities and other research institutions might have a professional entomologist or student biologists capable of making taxonomic identification All surveillance programs must have maps, office space, and clerical and other technical and administrative assistants to organize and evaluate field data. Information from the program should be made available to vector control and epidemiological personnel as soon as possible.

Estimates of Larval Populations

Even though adult populations are the most important of the populations of *Aedes aegypti*, when personnel trained to make species identification are available, the surveillance of larval populations is easier and more reliable than that of adults. The systematic collection of larvae serves to determine the presence, distribution and relative abundance of *Aedes aegypti*.

Estimates are usually limited to those obtained when the frequency of *Aedes aegypti* larvae in water-filled containers in the vicinity of occupied buildings is assessed. Larvae can, however, be found in containers in vacant lots and along roadsides.

Surveys can be rapidly performed in several manners Biases in information gained can be minimized if: (1) blocks to be surveyed are selected by a randomized procedure and then all houses on the selected blocks are investigated, (2) every third (or some other ordinal number) house is systematically investigated, and (3) fifty or more houses per subdivision are placed randomly in the sample.

One or more collectors, who search for and examine all water-filled containers in the vicinity of occupied buildings, take part in surveys for larvae. During the initial survey, the species composition should be determined through the collection for laboratory identification of one larva from each positive container ("single-larva-per-container survey"). Simple inspection,

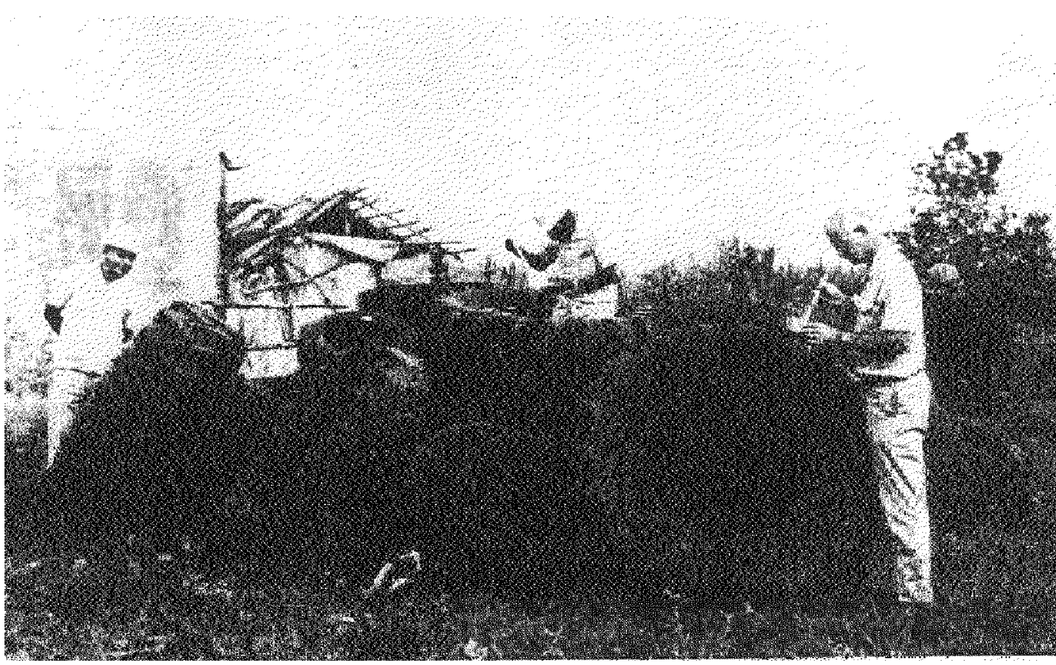


Photo courtesy L. Scholdt

The surveillance of larval populations is easier and more reliable than that of adults. Larvae are collected with a white enamel dipper, white enamel pans or other water containers, or a siphon. Flashlights or mirrors can be used to illuminate breeding places and to locate water and evidence in breeding.

or "visual larvae surveys," may suffice thereafter. Each individual who participates in the survey will need the following:

(1) Forms and pencils
(2) A flashlight
(3) A small mirror
(4) A dipper (if possible made of white enamel)
(5) A squeeze-bulb syringe or medicine dropper for transferring larvae
(6) A tea strainer to remove larvae from debris or dark water
(7) Collection bottles and a wax or grease marking pencil
(8) A container or bag to carry the instruments and equipment.

The results of the surveys are usually expressed in terms of one or more of the following indices:

(1) The House Index (or premises Index), in which the percentage of the houses examined and found positive for *Aedes aegypti* larvae is reported
(2) The Container Index (or receptacle Index), in which the percentage of the water-holding containers that were examined and found positive for *Aedes aegypti* larvae is reported
(3) The Breteau Index, in which the total number of containers with *Aedes aegypti* larvae is described per hundred houses.

Criteria for interpreting the probability of the transmission of yellow fever by *Aedes aegypti*, from the results of such surveys, have been published in the *World Health Organization Weekly Epidemiology Record* (49, 1971:493-500). Urban transmission of yellow fever is unlikely if the Breteau Index is less than five, the House Index less than four and the Container Index less than three. But where these figures are, respectively, greater than fifty, thirty-five and twenty, there is a high risk of transmitted yellow fever. Comparable criteria have not yet been established for dengue, but a similar interpretation of the indices may also be valid. In both cases, the indices of *Aedes aegypti*, the transmission of virus and the level of immunity in a population are related.

Estimates of Adult Populations

Adult surveillance is particularly appropriate in areas where it is necessary to quickly assess the effect of an emergency adulticiding operation. There are both direct and indirect methods of sampling adult *Aedes aegypti* populations. The direct methods vary in their degree of difficulty in interpretation of data. Three direct methods may be employed: resting, landing and sheet drop collections.

Resting collections may be recommended over landing counts, especially if dengue has been reported to a substantial extent in the area. Resting collections consist of search for adults in bedrooms, and other rooms in houses, garages and outbuildings. They may also be performed in yards, cemeteries, tires and junkyards. The adults are captured with small vials, hand sweep nets, or mouth or battery powered aspirators. The adults usually rest in shaded places and dark corners on walls, clothing, or mosquito nets, and under tables, chairs, or beds. *Aedes aegypti* can be found resting throughout the day so there is no restriction on time of day in which they may be collected. The collector should spend a certain standardized period of time, such as 20 minutes, in each house. This allows density to be expressed in catch-per-house and catch-per-man-hour. Mosquitoes are identified by species and sex. Collection stations can be selected at random, or they can be located at predefined sites. It should be remembered that collecting depletes the population and thus, that the same house should not be sampled every day.

Landing counts are made on humans. Thus, a collector can collect either from his own body or that of a second person, if collectors are working in pairs. Trials should be made before initiating this type of survey *and the methods to be used should be standardized* because individuals vary in attractiveness to mosquitoes. It is recommended that a twenty-minute collecting period be made in each house, between the hours of 0900 to 1100, and that the results be expressed in terms of catch per man hours.

The following items of equipment are required for adult surveys:

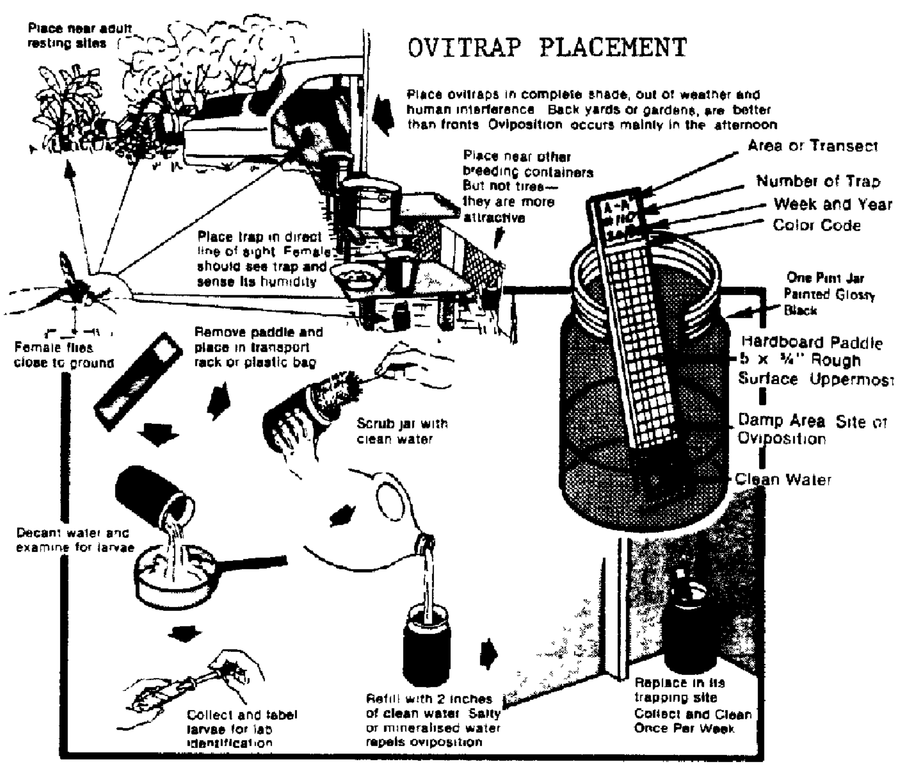
(1) Forms and pencils
(2) Flashlight
(3) Vials
(4) Aspirator
(5) Sweep net.

If a knockdown aerosol is available, the *sheet drop technique* is a quick and easy method of obtaining a representative sample of adult mosquitoes inside dwellings. In this technique, a white sheet is spread out on the floor and over the furniture of an occupied room, and then the occupants are asked to leave for approximately fifteen minutes. The room, made as airtight as possible, is sprayed with the knockdown aerosol After having left the room for ten minutes, the collector enters again to collect all the mosquitoes that have dropped on the sheet.

It is important to make certain that collection procedures are standardized; otherwise, results that should not be compared will cause incorrect conclusions to be drawn about changes in populations. Collections at a simple location should be performed by the same individuals, in a uniform manner, and at the same time of day. The number of houses to be sampled can be decided on-site.

Ovitraps provide an indirect method of assessing the presence and size of the adult *Aedes aegypti* population after a natural disaster. This method is particularly good for detecting the presence of *Aedes aegypti* where the density is so low that larvae are difficult to find Ovitraps cannot be used to effectively measure adult population densities, but if they are used routinely they can indicate changes in the population.

Ovitraps consist of black-enamelled, one-pint glass jars (of 130 mm height and 75 mm diameter). Almost any wide-mouthed glass jar with a glossy black ceramic paint on the outside can be used. Tin cans, beer cans or bamboo pots can be substituted for glass jars, but the same type of container must be used throughout the study. Clean water is added to a depth of two to three cm and a paddle is clipped vertically to the inside of the jar. The paddle should be made with an absorbent material; porous hardboard is recommended, but heavy cardboard, heavy velour paper or cloth can be used. When it has absorbed water, the paddle is an attractive surface on which mosquitoes deposit eggs. The size of the paddle should be standard, for example, 2 cm by 13 cm. The rough surface of the paddle should face the center of the jar. Paddles are usually changed at intervals of five or seven days; however, the exact schedule that should be used depends upon the number of positives identified per collection.



Courtesy Dr M. Giglioli, Cayman Islands

To obtain the full benefit of ovitrap surveys, the area should be fairly extensively covered Maps should be consulted for deciding locations in which to place the traps, and visits should be made to the area for selecting the sites. Transects or grids should be used in the survey. It is recommended that sites should be from one to two hundred meters apart, and that the traps are placed within thirty meters of the grid line.

Points to be considered are:

(1) The traps should be placed at or near ground level because females usually fly near the ground
(2) Traps should be visible to the female mosquitoes that fly over them
(3) Traps should not be placed where they will fill by rain
(4) All traps should be placed where children, cats, dogs and other small animals do not have access to them
(5) Ovitraps should be located in partial or total shade, in adult resting places such as shrubbery or junk. Placing them in the rear of a house is preferable to placing them in the front
(6) Females tend to prefer tires to ovitraps, so ovitraps should not be located in tire yards or near other locations where tires are piled.

When the paddles are collected, the water should be changed and the inside of the jar should be wiped clean. Ovitrap jars should be assigned numbers or otherwise marked with an identifying code. Paddles should be dated and should

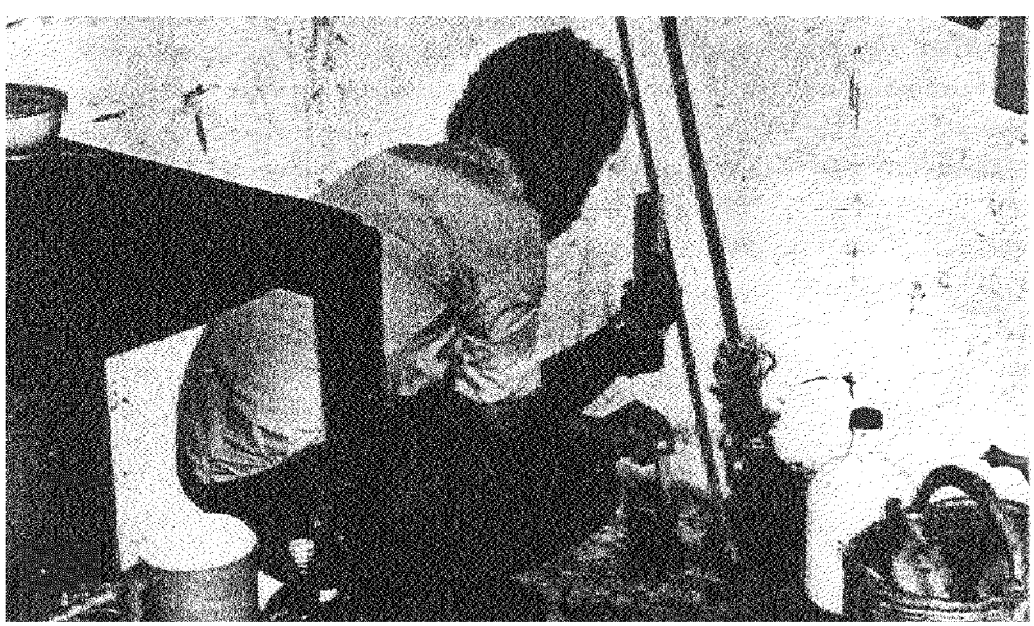


Photo J Moquillaza

A vector control worker in Honda, Colombia, checks ovitrap for evidence of *Aedes aegypti* infestation.

also be marked according to the code. If collectors miss a site, the date will help the laboratory technician in recording information. When transported to the laboratory, paddles may be placed in a plastic bag or wrapped in toilet tissue or other soft paper. Some workers have designed carrying cases similar to microscope slide boxes for the transporting of paddles.

The occurrence, distribution and changes in population density of *Aedes aegypti* in an area are revealed by the presence of its eggs on ovitrap paddles. All mosquito eggs found on the paddle might not, however, be *Aedes aegypti*.

If there is a question concerning accuracy of identification of the eggs, they should be hatched so that the larvae can be identified. Some workers recommend counting all of the eggs on the paddle; however, for disaster followup the mere recording of the presence or absence of *Aedes aegypti* eggs should be sufficient.

Control of Aedes aegypti

Ideally, *Aedes aegypti* populations are controlled through rigorous environmental sanitation and the availability of a piped water supply that eliminates many of the man-made habitats of the species. In a postdisaster period, the disruption of existing water supplies causes people to store increased quantities of water in containers, thereby increasing the availability of man-made habitats.

The appropriateness of measures for the emergency control of *Aedes aegypti* that should be taken after a natural disaster depends upon the presence or absence of dengue or yellow fever in the affected area, and upon the population density of the vector. As stated previously, larval habitats may be flushed out or destroyed during a disaster. Nonetheless, if rains occur during or after the disaster, new larval habitats may be created. However, it may take several weeks before the mosquito populations reach such a level that there is concern that disease will be transmitted. This lag in time should be sufficient for the initiation of routine control activities and for sanitation crews to haul away or empty many of the potential larval habitats. Through health education, the public should be asked to cooperate in a source reduction campaign especially since community involvement may be at a high level after a disaster. This is a key ingredient in a successful *Aedes aegypti* borne disease prevention program.

Larval Control

If the risk to health is immediate prior to the emergence of appreciable number of adults, source reduction will be recommended. The success of this type of campaign will depend upon the extent of organization, discipline and adequacy of number of staff members, and upon the completeness of the treatment of potential larval habitats. The Pan American Health Organization *Manual of Operations for an Aedes aegypti Eradication Service* can be consulted for basic organization of a campaign.

There are two insecticides that can be used for treating containers which hold potable water: one percent temephos (Abate[R]) sand granules and methoprene (Altosid[R]) miniquets. In many parts of the world temephos has been used as a larvicide for a number of years. Its effectiveness usually lasts from one to three months; an eight-week treatment cycle is recommended. The treatment dosage of temephos is 1 ppm. There may be objections made to the taste of the treated water, but these may be counteracted through public relations efforts.

Methoprene, an insect growth regulator, has been placed on the market only recently. Odorless and tasteless, methoprene is considered to be safe for use in potable water. It has been successfully used in Thailand, Indonesia, and Venezuela. The label must be consulted to determine proper dosage of the miniquets, which are available in a number of sizes. Since the period in which methoprene remains effective is considered to be shorter than that of temephos, a four-week treatment cycle may be necessary.

Both the temephos and methoprene insecticides can be used to treat watering containers used by animals. In many cases, however, it is unnecessary to treat containers used by animals with insecticides because frequent cleaning and changing of the water leads to effective control over the mosquito.

Other insecticides or formulations can be used for the treatment of larval habitats that are not in close association with man. As a temporary measure, tin cans and other containers can be treated before they are removed with emulsifiable concentrates and wettable powder insecticides applied with hand-operated compression sprayers and power spray equipment Insecticides such as fenthion, temephos, pirimiphos-methyl, malathion, fenitrothion, chlorpyrifos, and methoxychlor may be used as well as diesel fuel, kerosene, and proprietary mosquito-control oils. The product label should be consulted about the rate of application and the safety recommendations. Since some of the products are highly toxic to mammals, operators should strictly observe the precautions. It is essential to prevent toxic or ecological accidents by very clearly defining the dosage to be used and the places to be treated.

Adulticiding

Efforts to control adult populations of *Aedes aegypti* in dwellings with residual sprays are not generally effective since as few as ten percent of the adults rest

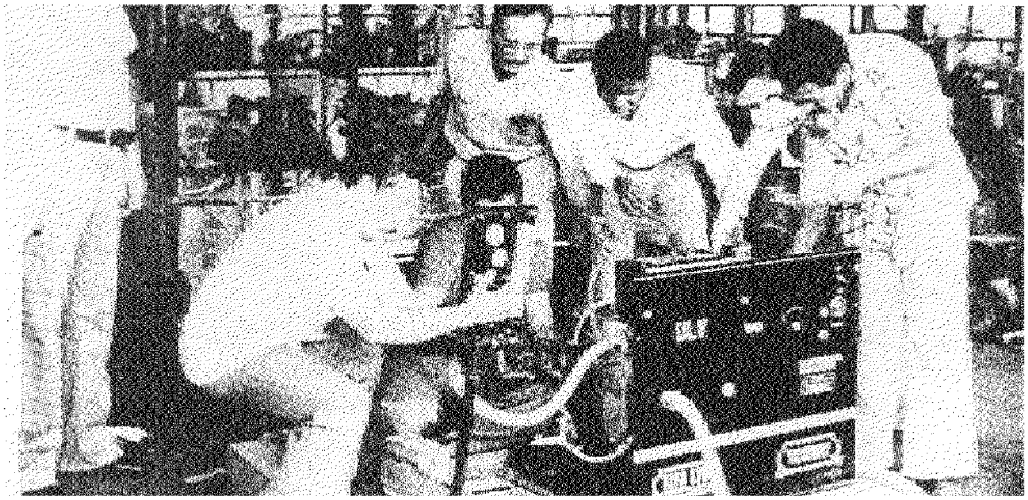


Photo: J. Moquillaza

Vector control team assemblying ULV equipment in Venezuela. Ultra-low volume space spraying can be used to control urban and salt marsh pest mosquitoes as well as *Aedes aegypti* and malaria vectors. ULV applications are rapid, and are also less expensive than thermal fogs.

on the walls at any point in time: most rest on clothes, pictures, bedspreads, mosquito net poles and other objects. Residual spraying is also slow. As an effective means of *Aedes aegypti* control in urban areas it is, therefore, of doubtful value. However, it may be of greater usefulness in refugee camps. There, pirimiphos-methyl, malathion, resmethrin and synergized pyrethroids can be used. Again the manufacturer's instructions should be strictly followed.

Adulticiding, in conjunction with larviciding, will more rapidly cause decrease in the population. Use of modern application equipment can increase coverage and should be considered when (1) either dengue or yellow fever is endemic to the area, or at epidemic levels in the vicinity, (2) there is already an *Aedes aegypti* operational program in which this equipment is used and has effectively brought the *Aedes aegypti* populations under control, and, (3) the larviciding program is ineffective.

One problem that use of modern equipment poses is logistical. If the equipment is not readily available, considerable time may be lost while waiting for its arrival. Vehicles are usually taxed to the limit after a disaster, and unless vector-borne epidemic is imminent, they are usually put to other more urgent purposes than transporting modern equipment. Other problems posed by the use of modern equipment, especially in newly created programs, concern the lack of trained staff, inadequate organization and the tendency to attempt too much with limited equipment and resources. Use of modern equipment does not always entail simply negative aspects, however; it may create beneficial psychological effects, and the use ultra-low volume aerosols and thermal fogs is speedy and efficient.

A number of companies manufacture ground and portable space-spray equipment (see Annex IV). When these are utilized, the manufacturer's instructions for the operation, maintenance and calibration of the equipment should be followed. Usually, aircraft equipment that is used in agricultural work is adapted to public health use.

Thermal fogging is the oldest of the two space spray methods. The equipment used for thermal fogging can be vehicle-mounted and portable. The portable equipment should not be used in indoor applications because it can create fire hazard. The outdoor machines are rather noisy and the fog can create a traffic hazard. There are also the disadvantages of the need to purchase and transport large quantities of nonactive oil carriers and the possible thermal decomposition of the insecticides. Despite these problems the machines are popular and provide an acceptable level of control. Thermal fog applications of chlorpyrifos, fenthion, fenitrothion, malathion, naled and pyrethroids have all shown promise in the control of *Aedes aegypti*. Concentrations, dosages and safety handling procedures should follow the recommendations on the label of the manufacturer.

In emergencies, one or two portable thermal foggers can be mounted on a vehicle, which serves as a mobile unit. The sizes of *Aedes aegypti* populations generally decline sharply within a few hours of fogging; the adults, however, reappear within a day or two. Treatment schedules should be adjusted accordingly.

The use of ultra-low volume equipment for the application of low dosages and volumes of undiluted, or partially diluted, insecticides has steadily increased. Ultra-low volume applications are rapid, and are effective against *Aedes aegypti*. They are also less expensive than thermal fogs because the cost of the solvent or carrier and of the transportation of thermal fogs is unnecessary.

Many control programs have had good results with vehicle-mounted, ultra-low volume cold aerosols, which are available from a number of companies (see Annex IV). Chlorpyrifos, fenthion, fenitrothion, malathion, naled, pirimiphos-methyl, and pyrethroids such as resmethrin have been used. Although initially expensive, these are relatively free of problems, and they can be operated for several years. The generator can be mounted on any one of a number of different types of vehicles. The type of vehicle that should be used will depend upon road conditions, which also determine whether or not a heavy-duty, four-wheel drive or a light, two-wheel drive vehicle should be used.