A CRITICAL REVIEW OF CERTAIN GROUND EQUIPMENT AND INSECTICIDES FOR AEDES AEGYPTI CONTROL

by

C.Y. Chow, Ph.D. ¹

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¹WHO Regional Adviser on Vector Biology and Control
A CRITICAL REVIEW OF CERTAIN GROUND EQUIPMENT AND INSECTICIDES FOR AEGYPTI CONTROL

Recently, outbreaks of dengue fever/dengue haemorrhagic fever have been reported in many countries and areas in the Western Pacific Region. Very few of them have equipment and insecticides suitable for control of Aedes aegypti, the primary vector. During the Technical Discussions on "Control of vector mosquitoes of dengue haemorrhagic fever" at the 25th session of the Regional Committee Meeting held in Kuala Lumpur, Malaysia, in September 1974, the participants requested that WHO provide guidance on the equipment and insecticides needed to control Aedes aegypti. To ensure that these items would be available at short notice in the case of outbreaks, further information was also requested on where, particularly within the Region, they could be purchased.

1. EQUIPMENT AND INSECTICIDES

It is well known that source reduction by basic sanitation and health education is the fundamental measure for controlling vector mosquitoes. However, application of insecticides is still required particularly during outbreaks. Aerial spraying may be necessary under certain conditions and for coverage of a large area. In general, ground application will serve the purpose. The present review relates, therefore, to ground equipment only.

Details of certain equipment and insecticides are given in Annexes I and II together with names and addresses of suppliers. It is impossible to list all available equipment and insecticides. Those items mentioned in the present paper were in most cases tried by the WHO Aedes Research Unit. It must be emphasized, however, that the mention of manufacturing companies or of their proprietary products does not imply that they are recommended or endorsed by the World Health Organization. The details are intended solely for easy reference of the government authorities concerned.

The following comments may be made on some of the items. For this purpose, information provided by Drs C.P. Pant and L.S. Self of Vector Biology and Control, WHO Headquarters, Geneva, was taken into account.
1.1 Equipment

1.1.1 Cold foggers and aerosol/mist applicators

(a) "Fontan"

There are two models (R 11 and R 12) of knapsack sprayers with ULV attachment. The former has a net weight of 9.3 kg and an insecticide tank of 10 l. The latter has a net weight of 13.4 kg and an insecticide tank of 10 l. One machine can cover about 25 ha/day.

It is a good machine but is rather heavy for an average Oriental worker. Because of the weight (more than 20 kg with insecticide), it might also be operated from the back of an open vehicle by several spraymen.

One or two of the sprayers are now in use in American Samoa, Fiji, Malaysia and the Solomon Islands.

(b) "Leco"

There are two vehicle-mounted models, heavy-duty and standard. The former has a net weight of 202 kg, with an insecticide container of 13 gallons. The latter is lighter and cheaper (US$2000), with a six-gallon container.

With one machine it is possible, at a vehicle speed of 5 km/hr and applying a dosage of 438 ml/ha (6 fl oz/acre), to cover 250 ha/day (approximately 1 sq. mile), or 3000 houses/day, if applications are made on an adequate road system.

In this Region about 15 H-D models are in use in Malaysia, and one each in Fiji and the Solomon Islands.

The ULV mini II model is portable, being mounted on a tricycle arrangement of two large wheels and a caster. It is also a cold aerosol generator with a net weight of 53 kg. One has been tried in Malaysia, where it was found clumsy and hard to push around, especially when the road surface is not smooth.

(c) "Mity Moe"

Its net weight is 6.6 kg. Breakdowns are common (Pant et al., 1974). Due to a low tank capacity (32 oz) the machine requires constant refilling with insecticide. It has proved difficult to treat more than 200 houses per machine per day, with two men.
1.1.2 Thermal foggers

(a) "Dynafog"

This is a thermal fogging machine. One vehicle-mounted unit can treat about 150 ha/day. A portable model is also available. Several types of "Dynafog" are in use in the Republic of Korea for control of mosquitoes, mainly of the Japanese encephalitis vector species.

(b) "Swingfog"

The heavy-duty model (SN 100) weighs 50 kg, and has an insecticide tank of 40 l. The portable (SN 11) unit weighs 9 kg and has an insecticide tank of 4.5 l. Insecticides used should be diluted with an oil; for example, 4% malathion oil solution. One portable unit can treat about 5 ha/day, and a vehicle-mounted one about 150 ha/day.

Despite the obvious economy of ULV application, thermal fog is still very popular. Today, the "Swingfog", with a good record of dependability, is the most commonly used portable space spray machine available. In 1973-1974, Malaysia imported a considerable number.

1.1.3 Others

The reviewer has not yet had any personal experience of the following equipment:

"Gutbrod" - This unit is being tried in Thailand.

"London Aire" - Model H (vehicle-mounted ULV aerosol generator) has a net weight of 100 kg and an insecticide tank of 50 l. The hand-carried fogger has a net weight of 11 kg and an insecticide tank of four l.

"Micro-Gen" - The hand-carried type has a net weight of 8.2 kg and an insecticide bottle of one l. There is also vehicle-mounted model IS 2-15 (ULV cold aerosol generator) which has a net weight of 102 kg and an insecticide drum of 60 l.

"Microsol" - Model 202 (hand-carried aerosol generator) has a net weight of 6.3 kg and an insecticide container of 1.9 l. While operating, it has to be plugged into an electric outlet.

"Tifa" - Recently, the dual ULV-thermal fog generating system has become available. "Tifa 100-ULV" has a net weight of 260 kg. During the forthcoming WHO workshop on anti-mosquito measures to be held in Kuala Lumpur, Malaysia, in August 1975, "Tifa" and "Microsol" units will be demonstrated by an engineer from Tifa Ltd.
1.2 Insecticides

(a) Abate

Abate at the target dosage rate of 1 ppm has no taste effects, and the treated portable water is completely safe (Brown, 1972). Due to its safety in use, long residual effectiveness and very low cost, the Abate 1% sand granules formulation can be used for long-term control of *Ae. aegypti* larvae.

(b) Fenitrothion and malathion

Technical grade is used for ULV application, and 4% oil solution for thermal fogging. The odour of malathion may be objectionable to inhabitants.

(c) Bioresmethrin

This is a synthetic pyrethroid. Its toxicity is much lower than that of chlorinated hydrocarbon and organophosphorus compounds. On the other hand, the cost is rather high. "Reslin 10/10" diluted 1:49 in a suitable base to give a 0.2% bioresmethrin solution has been used in thermal fogging with success in Singapore, when applied indoors with all the windows and doors closed for ten minutes. Average cost of fogging per house was about US$0.20. No encouraging results have so far been obtained in Bangkok, Jakarta and Kuala Lumpur, when this insecticide is used in aerial spraying, outdoor space spraying, and indoor spraying when the windows and doors are not closed.

(d) Others

Mention may be made of some other insecticides, which have not yet been tried for *Ae. aegypti* control in the Region, such as naled (Dibrom). A large amount of this insecticide has been in use in the Republic of Korea for insect control. Control trials of *Culex tritaeniorhynchus*, the vector mosquito of Japanese encephalitis, were made by aerial and ground applications. "Dibrom" is a product of Chevron Chemical Co., 200 Bush St., San Francisco, California 94120, U.S.A.

2. CONTROL OF AEGEDES AEGYPTI

WHO has just issued a booklet, "Technical guides for diagnosis, treatment, surveillance, prevention and control of dengue haemorrhagic fever", which gives methods for vector surveillance and control.

A brief review is made of recent trials, mainly undertaken by the WHO Aedes Research Unit in Bangkok, Thailand, with some of the equipment and insecticides mentioned above (Annex III).
For ready reference, a review of the recently developed ULV technique is given in Annex IV.

3. SUGGESTIONS ON PURCHASING EQUIPMENT AND INSECTICIDES

It is suggested that both vehicle-mounted and portable equipment be made available for the control of *Ae. aegypti* to obtain complete coverage because of the inaccessibility of some areas by motorable roads. It is further suggested that the ULV equipment for applying aerosols and mists of insecticides (such as technical grade malathion or fenitrothion) be purchased because the ULV application is more economical than thermal fogging. However, in some cases, thermal fogs may be applied as the inhabitants can see for themselves that their neighbourhood has been covered.

It is difficult to make suggestions on the amount of equipment and insecticides to be purchased for a country. Generally, two to four vehicle-mounted units and 20 to 40 portable units should be available; and 200 to 500 litres of ULV grade insecticide should be kept in stock for immediate use.
REFERENCES


ANNEX I

CERTAIN GROUND EQUIPMENT FOR INSECTICIDE APPLICATION IN AEDES AEGYPTI CONTROL

(1) "Dynafog" 400 (heavy-duty, vehicle-mounted thermal fog)

Price: US$2000

Head office: Curtis Dyna Products Corporation, Box 297, Westfield, Indiana 46074, U.S.A.

(2) "Fontan" R-11 (backpack ULV mistblower)

Price: US$700

Head office: Motan Gessellschaft MBH, D-7972 ISNY/Allgäu, Federal Republic of Germany

Philippines: Pharma Industries, Inc., Zuellig Building, Buendia Avenue, Makati

(3) "Gutbrod" ATO 77 (knapsack mistblower)

Price: Not known

Head office: Gutbrod S.A., 44 Rue Rambuteau, 71 Macon, France

(4) "Leco" H-D (heavy-duty, vehicle-mounted ULV cold aerosol generator)

Price: US$3000

Head office: Lowndes Engineering Co., Inc., 125 Blanchard St., Valdosta, Georgia 31601, U.S.A.

Australia: Lane Ltd., Rural Division, P.O. Box 335, Hamilton Central, 4077, Pinkenba, Brisbane.

Singapore: The Wellcome Foundation Ltd., Zone Office-South East Asia, 33 Quality Road, Singapore 22

(5) "London Aire" (vehicle-mounted ULV aerosol generator)

Price: Not known

Head office: London Fog Co., Crystal Bay, Minn. 55323, U.S.A.
ANNEX I (cont'd)

(6) "Micro-Gen" HCS1-2A (hand-carried ULV machine)

Price: US$350

Head office: Micro-Gen Equipment Corporation, 8127 Vidor Drive, San Antonio, Texas 78216, U.S.A.

(7) "Microsol" 202 (hand-carried ULV mechanical aerosol generator)

Price: US$350

Head office: Tifa Limited, 1390 Valley Road, Stirling, N.J. 07980, U.S.A.

(8) "Mity Moe" (hand-carried ULV machine)

Price: US$150


(9) "Swingfog" SN 100 (Heavy-duty, vehicle-mounted thermal fog generator)

Price: US$2900

"Swingfog" SN 11 (portable thermal fog generator)

Price: US$380

Head office: Same as for "Fontan"

(10) "Tifa" 100-ULV (vehicle-mounted ULV cold aerosol)

Price: US$3450

Head office: Same as for "Microsol"

Note: The price is only approximate and does not include freight costs.
ANNEX II
CETAIN INSECTICIDES FOR Aedes Aegypti CONTROL

(1) "Abate" 1% SG

Price: US$0.60 per lb

Head office: American Cyanamid Co., P.O. Box 400, Princeton, New Jersey 08540, U.S.A.

Australia: Agricultural Manager, Cyanamid Australia Pty. Limited, P.O. Box 584, Crows Nest, N.S.W. Sydney

Hong Kong: Cyanamid (Far East) Limited, G.P.O. 14217

Malaysia: Zuellig, P.O. Box 255, Petaling Jaya

Philippines: Cyanamid Philippines, Inc., P.O. Box 60, Makati, Rizal D-708

Singapore: F.E. Zuellig, P.O. Box 725

(2) Fenitrothion ("Sumithion") ULV grade (95%)  

Price: US$5.60 per kg

Head office: Sumitomo Chemical Co., Ltd., 15 5-Chome, Kitahama, Higashi-ku, Osaka, Japan

Hong Kong: Sumitomo Shoji Kaisha, Ltd., G.P.O. Box 13619

Malaysia: Agricultural Chemicals, 962, MK 1, Prai Industrial Complex, Seberang Prai Tengah, Penang

Philippines: Sumitomo Shoji Kaisha, Ltd., Manila Branch, 8th Floor, Bank of the Philippine Islands Bldg., Corner Herrera St. & Ayala Ave., Makati, Rizal (P.O. Box 4279)

Singapore: Sumitomo Shoji Kaisha, Ltd., 1st Floor, Hong Bldg., 144-A Robinson Road

(3) Malathion, ULV grade 96%

Price: US$3.20 per litre

Head office and agencies in the Western Pacific Region are the same as for "Abate"
(4) Bioresmethrin ("Reslin 10/10", containing 10% bioresmethrin and 10% piperonyl butoxide)

Price: US$12 per litre

Head office: The Wellcome Foundation Ltd., London, England

Singapore: The Wellcome Foundation Ltd., Zone Office-South East Asia, 33 Quality Road, Singapore 22

Note: The price is only approximate and does not include freight costs.
ANNEX III

RECENT TRIALS OF AEDES AEGYPTI CONTROL

For easy reference, recent trials of Ae. aegypti adult and larval control, conducted mainly by the WHO Aedes Research Unit in Bangkok, are reviewed below:

1. Abate as larvicide

(a) Bangkok, Thailand

Abate 1% sand granules at 1 ppm was used. An average of 100 g of insecticide was needed per house. One man could treat 40-50 houses per day. A barrier zone of about 50 metres was adequate. Two applications seemed sufficient, one just before the rainy season and the other within two months. Retreatment was indicated when the Breteau index reached 10 or when adult density was one mosquito per man-hour as determined by the collection of resting and landing mosquitos of both sexes (Bang & Pant, 1972).

(b) Brunei

Abate 1% sand granules at 1 ppm was applied to nearly 20,000 water containers in about 4,000 houses in two localities. After three rounds of treatment at an interval of three months, the Breteau index of Ae. aegypti dropped from 266 to 0.35 in one locality and from 67 to 4.7 in another. The average time taken to treat one house was seven minutes by a team of two persons, and the number of houses treated per day was 30-35. The average cost of the insecticide used per house was Brunei $0.05 - 0.11 (US$1 is equivalent to approximately Brunei $2.50) (Zachariah & Noordin, 1974).

(c) Saigon, Viet-Nam

A small-scale trial with Abate 1% sand granules at 1 ppm showed that the effectiveness lasted at least three months. The average amount of the insecticide used was 67 g per house, and an average of 15 houses were treated per man-day (Nguyen-Dang-Que et al., 1974).

2. ULV aerial spray

A C-47 aircraft with a fuselage-mounted spraying boom, fitted with ten tee-jet nozzles and No. 8008 flat-fan tips, was used. The aircraft flew at a height of 150 feet and a speed of 150 miles/hour, with a swath of 500 feet. Technical malathion at 6 oz/acre was used. Two treatments at four days' interval reduced the adult density of 95-99%, and this effect lasted for ten days after treatment (Lofgren, C.S. et al., 1970).
3. ULV spray by a portable non-thermal fog applicator

Two thorough treatments of Sumithion mist were applied by "Mity Moe" at a dosage of 0.1 ml/m². Individual houses were usually treated from the doorway by slowly swinging the nozzle for about 20 seconds. Complete control lasted from 6 to 7 months after the two treatments at an interval of about two weeks. These good results can be attributed to the immediate reduction of adult mosquitoes, plus limited residual and larvicidal effects. The equipment used and the method of application still need perfection (Pant et al., 1974).

4. ULV spray by a backpack mistblower

Through six applications of Sumithion ULV aerosols by "Fontan" at 856-1364 ml/ha, at 13-69 day intervals, a very high degree of control was maintained for 7-8 months (Samutrapongse & Pant, 1973).

5. ULV spray by a vehicle-mounted aerosol generator

Two treatments of technical malathion (96%) were applied by a vehicle-mounted "Leco" cold aerosol generator at 438 ml/ha at a three-day interval. The adult mosquito population was reduced by 99%, and it took about two weeks to regain its pre-treatment level (Pant et al., 1971).

Five sequential treatments of fenitrothion applied by "Leco" at 511-1095 ml/ha (7-15 oz/acre) at 11-49 day intervals provided 4-5 months' control of Aedes aegypti (Pant et al., 1973).

6. Combined application of adulticide and larvicide for emergency control

Two days after treating all larval habitats with Abate 1% sand granules at 1 ppm, 4% malathion thermal fogs were applied by "Swingfog" at 420 ml/ha to front doors and the areas between houses. The length of this combined effect varied from 6 to 24 weeks, depending upon the surroundings of the treated area (Bang et al., 1972).

During an epidemic of dengue haemorrhagic fever in Thailand in 1973, two ground ULV applications of malathion concentrate by "Leco", "Fontan" and "Mity Moe" mistblowers were combined with applications of Abate 1% sand granules at 1 ppm. The adult mosquito population was reduced to 70% for two months (Phanthumachinda et al., 1974).
ANNEX IV

ULTRA-LOW-VOLUME (ULV) APPLICATION OF INSECTICIDES

Using the ULV technique, a small quantity of technical grade insecticide in liquid concentrate form may be applied from the air or the ground. Lofgren (1970) made a critical review of this recently developed technique. ULV cold aerosol spraying is generally more effective against adult mosquitos than high-volume thermal fogging.

ULV application has resulted in substantial savings in vector control operations, through economy of insecticides and transportation, and non-requisite of diluents. Moreover, it does not produce a dense fog that may constitute a traffic hazard, and the size of the insecticide droplets can be controlled reasonably well to give an effective compromise between the biologically optimum droplet size spectrum and that which allows maximum control of the dispersal within the target area.

It was reported that car spotting or damage to some automobile finishes occurs occasionally because of the solvent or the corrosive properties of some of the insecticides. But such damage is noticeable only when large droplets (larger than 100 micra) are present in the spray (Lofgren, 1970). Drift of ULV sprays can be a serious problem if dosages substantially above recommended amounts are used. One should always consider that aerosol clouds may be carried long distance with the wind and may cause exposures beyond the limits of the target area.
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Regional Adviser on Vector Biology and Control, WHO/WPRO, Manila,
Philippines.
A CRITICAL REVIEW OF CERTAIN GROUND EQUIPMENT AND INSECTICIDES FOR Aedes aegypti CONTROL

Recently, outbreaks of dengue fever/dengue haemorrhagic fever have been reported in many countries and areas in the Western Pacific Region. During the Technical Discussions on "Control of vector mosquitoes of dengue haemorrhagic fever" at the 25th session of the Regional Committee Meeting held in Kuala Lumpur, Malaysia, in September 1974, the participants requested that WHO provide guidance on the equipment and insecticides needed to control Aedes aegypti, the primary vector. To ensure that these items would be available at short notice in the case of outbreaks, further information was also requested on where, particularly within the Region, they could be purchased.

1. EQUIPMENT AND INSECTICIDES

It is well known that source reduction by basic sanitation and health education is the fundamental measure for controlling vector mosquitoes. However, application of insecticides is still required particularly during outbreaks. Aerial spraying may be necessary under certain conditions and for coverage of a large area. In general, ground application will serve the purpose. The present review relates, therefore, to ground equipment only.

Details of certain equipment and insecticides are given in Annexes I and II together with names and addresses of suppliers. It is impossible to list all available equipment and insecticides. Those items mentioned in the present paper were in most cases tried by the WHO Aedes Research Unit. It must be emphasized, however, that the mention of manufacturing companies or of their proprietary products does not imply that they are recommended or endorsed by the World Health Organization. The details are intended solely for easy reference of the government authorities concerned.

The following comments may be made on some of the items. For this purpose, information provided by Dr C.P. Pant, Dr L.S. Self and Mr J.D. Parker of the Division of Vector Biology and Control, WHO Headquarters, Geneva, was taken into account.

1.1 Equipment

1.1.1 Cold foggers and aerosol/mist applicators

(a) "Fontan"

There are two models (R 11 and R 12) of knapsack sprayers with ultralow-volume (ULV) attachment. The former has a net weight of 9.3 kg and an insecticide tank of 10 l. The latter has a net weight of 13.4 kg and an insecticide tank of 10 l. One machine can cover about 25 ha/day.
It is a good machine but is rather heavy for an average Oriental worker. Because of the weight (more than 20 kg with insecticide), it might also be operated from the back of an open vehicle by several spraymen.

A few are now in use in American Samoa, Fiji, Malaysia, New Hebrides and the Solomon Islands. Six are kept in the WHO Regional Office for the Western Pacific, Manila, and available on loan to governments in this region for emergency use. Five have been ordered for the Republic of South Viet-Nam.

(b) "Leco"

There are two vehicle-mounted models, heavy-duty and standard. The former has a net weight of 202 kg, with an insecticide container of 13 gallons. The latter is lighter and cheaper, with a six-gallon container.

With one machine it is possible, at a vehicle speed of 5 km/hr and applying a dosage of 438 ml of technical or ULV grade insecticide per hectare (6 fl oz/acre), to cover 250 ha/day (approximately 1 sq. mile), or 3000 houses/day, if applications are made on an adequate road system.

In this Region about 15 H-D models are in use in Malaysia, and one or two each in Fiji, French Polynesia, New Hebrides, Papua New Guinea, the Solomon Islands and the Republic of South Viet-Nam.

The ULV mini II model is portable, being mounted on a tricycle arrangement of two large wheels and a caster. It is also a cold aerosol generator with a net weight of 53 kg. One has been tried in Malaysia, where it was found clumsy and hard to push around, especially when the road surface is not smooth.

(c) "London Aire"

There are four types of vehicle-mounted ULV aerosol generator, Model A, H, XK and XW. Model H has a net weight of 100 kg and an insecticide tank of 50 l. Model XK has a net weight of 140 kg and an insecticide tank of 42 l. The hand-carried fogger has a net weight of 11 kg and an insecticide tank of four l.

(d) "Micro-Gen"

The hand-carried type has a net weight of 8.2 kg and an insecticide bottle of one l. There is also vehicle-mounted model LS 2-15 (ULV cold aerosol generator) which has a net weight of 102 kg and an insecticide drum of 60 l. Five machines of the hand-carried type are in use in French Polynesia.

(e) "Microsol"

Model 202 (hand-carried aerosol generator) has a net weight of 6.3 kg and an insecticide container of 1.9 l. While operating, it has to be plugged into an electric outlet.
Its net weight is 6.6 kg. Due to a low tank capacity (32 oz) the machine requires constant refilling with insecticide. It has proved difficult to treat more than 200 houses per machine per day, with two men.

1.1.2 Thermal foggers

(a) "Dyna-Fog"

The heavy-duty model (DH 440) weighs 50 kg and has an insecticide tank of 208 l. There are manual shut-off control model and remot shut-off control model.

The portable model (DH 90) weighs 8.2 kg and has an insecticide tank of 3.8 l. The other type (DH 180) has double the fog output of the DH 90, with an empty weight of 10 kg and an insecticide tank of 7.6 l.

Several types of "Dyna-Fog" are in use in the Republic of Korea for control of mosquitos, mainly of the Japanese encephalitis vector species.

(b) "Swingfog"

The heavy-duty model (SN 100) weighs 50 kg, and has an insecticide tank of 40 l. The portable (SN 11) unit weighs 9 kg and has an insecticide tank of 4.5 l. One portable unit can treat about 5 ha/day, and a vehicle-mounted one about 150 ha/day.

Despite the obvious economy of ULV application, thermal fog is still very popular. Today, the "Swingfog", with a good record of dependability, is the most commonly used portable space spray machine available. In 1973-1974, Malaysia imported a considerable number.

(c) "Tifa" 100-E

It has a net weight of 260 kg, and produces dense aerosol fog at 10-100 gal/hr. A ULV conversion kit is available for this model for changeover from thermal fogging to ULV fogging. Recently a ULV model ("Tifa" 100-ULV) is also made available; it has a net weight of 260 kg.

1.2 Insecticides

(a) Temephos ("Abate")

Temephos at the target dosage rate of 1 ppm has no taste effects, and the treated portable water is completely safe (Brown, 1972). Due to its safety in use, long residual effectiveness and very low cost, the temephos 1% sand granules formulation can be used for long-term control of Ae. aegypti larvae.
(b) Fenitrothion and malathion

These are employed for the control of Ae. aegypti adults with good results. Technical or ULV grade is used for ULV application, and 4-5% oil solution for thermal fogging. The odour of malathion may be objectionable to inhabitants.

(c) Bioresmethrin

This is a synthetic pyrethroid. Its toxicity is much lower than that of chlorinated hydrocarbon and organophosphorus compounds. On the other hand, the cost is rather high. "Reslin 10/10" diluted 1:49 in a suitable base to give a 0.2% bioresmethrin solution has been used in thermal fogging with success in Singapore, when applied indoors with all the windows and doors closed for ten minutes. Average cost of fogging per house was about US$0.20.

(d) Others

Information on some other insecticides, which have not yet been tried for Ae. aegypti control in the Region, is available in a document prepared by Chow (1976).

2. CONTROL OF Aedes aegypti

WHO has issued in 1975 a booklet, "Technical guides for diagnosis, treatment, surveillance, prevention and control of dengue haemorrhagic fever", which includes methods for vector surveillance and control.

A brief review is made of trials, mainly undertaken by the WHO Aedes Research Unit in Bangkok, Thailand, with some of the equipment and insecticides mentioned above (Annex III).

For ready reference, a review of the recently developed ULV technique is given in Annex IV.

3. SUGGESTIONS ON PURCHASING EQUIPMENT AND INSECTICIDES

It is suggested that both vehicle-mounted and portable equipment be made available for the control of Ae. aegypti to obtain complete coverage because of the inaccessibility of some areas by motorable roads. It is further suggested that the ULV equipment for applying aerosols and mists of insecticides (such as technical grade malathion or fenitrothion) be purchased because the ULV application is more economical than thermal fogging. However, in some cases, thermal fogs may be applied as the inhabitants can see for themselves that their neighbourhood has been covered.
It is difficult to make suggestions on the amount of equipment and insecticides to be purchased for a country. Generally, two to four vehicle-mounted units and 20 to 40 portable units should be available; and 200 to 500 litres of ULV grade insecticide should be kept in stock for immediate use.
REFERENCES


Pant, C.P. et al. (1973) Sequential application of ULV ground aerosols of fenitrothion for sustained control of *Aedes aegypti*. *Bull. Wld Hlth Org.*, 48, 455-459


ANNEX I

CERTAIN GROUND EQUIPMENT FOR INSECTICIDE APPLICATION IN AEDES AEGYPTI CONTROL

(Note: The FOB price is only approximate)

(1) "Dyna-Fog"

Price: Unknown

Head office: J. Hofman Overseas USA, Inc., P.O. Box 318, Carmel, Indiana 46032, U.S.A.

(2) "Fontan" R-11 (backpack ULV mistblower)

Price: US$170

Head office: Motan Gessellschaft MBH, D-7972 ISNY/Allgäu, Federal Republic of Germany

Philippines: Pharma Industries, Inc., Zuellig Building, Buendia Avenue, Makati

(3) "Leco" H-D (heavy-duty, vehicle-mounted ULV cold aerosol generator)

Price: US$3200

Head office: Lowndes Engineering Co., Inc., 125 Blanchard St., Valdosta, Georgia 31601, U.S.A.

Australia: Lane Ltd., Rural Division, P.O. Box 335, Hamilton Central, 4077, Pinkenba, Brisbane

Singapore: The Wellcome Foundation Ltd., 33 Quality Road, Singapore 22

(4) "London Handy Fogger"

Price: US$335

"London Aire ULV Aerosol Generator"

"Model H": Price - US$2050

"Model XK": Price - US$2395

Head office: London Fog Co., Crystal Bay, Minn. 55323, U.S.A.
(5) "Micro-Gen" HCS1-2A (hand-carried ULV machine)

Price: US$350

Head office: Micro-Gen Equipment Corporation, 8127 Vidor Drive, San Antonio, Texas 78216, U.S.A.

Philippines: Fedco Import & Export, Inc., 659 Carlos Palanca Sr. Street, San Miguel, Manila

(6) "Microsol" 202 (hand-carried ULV mechanical aerosol generator)

Price: US$350

Head office: Tifa Limited, 1390 Valley Road, Stirling, N.J. 07980, U.S.A.

(7) "Mity Moe" (hand-carried ULV machine)

Price: US$150


(8) "Swingfog" SN 100 (Heavy-duty, vehicle-mounted thermal fog generator)

Price: US$1400

"Swingfog" SN 11 (portable thermal fog generator)

Price: US$310

Head office: Same as for "Fontan"

(9) "Tifa" 100-ULV (vehicle-mounted ULV cold aerosol)

Price: US$3500

"Tifa" 100-E (vehicle-mounted thermal fog generator)

Price: US$7500

"Tifa" ULV Conversion Kit for Model 100-E

Price: US$1300

Head office: Same as for "Microsol"

Singapore: Gulf International Trading (Far East), P.O. Box 641
ANNEX II

CERTAIN INSECTICIDES FOR Aedes Aegypti CONTROL
(Note: The FOB price is only approximate)

(1) "Abate" 1% SG

Price: US$0.75 per kg

Head office: American Cyanamid Co., P.O. Box 400, Princeton, New Jersey 08540, U.S.A.

Australia: Agricultural Manager, Cyanamid Australia Pty. Limited, P.O. Box 584, Crows Nest, N.S.W. Sydney

Hong Kong: Cyanamid (Far East) Limited, G.P.O. 14217

Malaysia: Zuellig, P.O. Box 255, Petaling Jaya

Philippines: Cyanamid Philippines, Inc., P.O. Box 60, Makati, Rizal D-708

Singapore: F.E. Zuellig, P.O. Box 725

(2) Fenitrothion ("Sumithion") ULV grade (95%)

Price: US$6.00 per kg

Head office: Sumitomo Chemical Co., Ltd., 15 5-Chome, Kitahama, Higashi-ku, Osaka, Japan

Hong Kong: Sumitomo Shoji Kaisha, Ltd., G.P.O. Box 13619

Malaysia: Sumitomo Shoji Kaisha, Ltd., P.O. Box 297, Kuala Lumpur

Philippines: Sumitomo Shoji Kaisha, Ltd., Manila Branch, 8th Floor, Bank of the Philippine Islands Bldg., Corner Herrera St. & Ayala Ave., Makati, Rizal (P.O. Box 4279)

Singapore: Sumitomo Shoji Kaisha, Ltd., 1st Floor, Hong Bldg., 144-A Robinson Road

(3) Malathion, ULV grade 96%

Price: US$2.10 per litre

Head office and agencies in the Western Pacific Region are the same as for "Abate"
(4) Bioresmethrin ("Reslin 10/10", containing 10% bioresmethrin and 10% piperonyl butoxide)

Price: US$26.40 per litre

Head office: The Wellcome Foundation Ltd., London, England

Singapore: The Wellcome Foundation Ltd., Zone Office-South East Asia, 33 Quality Road, Singapore 22
ANNEX III

RECENT TRIALS OF Aedes aegypti CONTROL

For easy reference, recent trials of Ae. aegypti adult and larval control, conducted mainly by the WHO Aedes Research Unit in Bangkok, are reviewed below:

1. "Abate" as larvicide

(a) Bangkok, Thailand

"Abate" 1% sand granules at 1 ppm was used. An average of 100 g of insecticide was needed per house. One man could treat 40-50 houses per day. A barrier zone of about 50 metres was adequate. Two applications seemed sufficient, one just before the rainy season and the other within two months. Retreatment was indicated when the Breteau index reached 10 or when adult density was one mosquito per man-hour as determined by the collection of resting and landing mosquitoes of both sexes (Bang & Pant, 1972).

(b) Brunei

"Abate" 1% sand granules at 1 ppm was applied to nearly 20,000 water containers in about 4000 houses in two localities. After three rounds of treatment at an interval of three months, the Breteau index of Ae. aegypti dropped from 266 to 0.35 in one locality and from 67 to 4.7 in another. The average time taken to treat one house was seven minutes by a team of two persons, and the number of houses treated per day was 30-35. The average cost of the insecticide used per house was Brunei $0.05 - 0.11 (US$1 is equivalent to approximately Brunei $2.50) (Zachariah & Noordin, 1974).

2. ULV aerial spray

A C-47 aircraft with a fuselage-mounted spraying boom, fitted with ten tee-jet nozzles and No. 8008 flat-fan tips, was used. The aircraft flew at a height of 150 feet and a speed of 150 miles/hour, with a swath of 500 feet. Technical malathion at 6 oz/acre was used. Two treatments at four days' interval reduced the adult density of 95-99%, and this effect lasted for ten days after treatment (Lofgren, C.S. et al., 1970).

3. ULV spray by a portable non-thermal fog applicator

Two thorough treatments of "Sumithion" mist were applied by "Mity Moe" at a dosage of 0.1 ml/m². Individual houses were usually treated from the doorway by slowly swinging the nozzle for about 20 seconds. Complete control lasted from 6 to 7 months after the two treatments at an interval of about two weeks. These good results can be attributed to the immediate reduction of adult mosquitoes, plus limited residual and larvicidal effects. The equipment used and the method of application still need perfection (Pant et al., 1974).
4. **ULV spray by a backpack mistblower**

Through six applications of "Sumithion" ULV aerosols by "Fontan" at 856-1364 ml/ha, at 13-69 day intervals, a very high degree of control was maintained for 7-8 months (Samutrapongse & Pant, 1973).

5. **ULV spray by a vehicle-mounted aerosol generator**

Two treatments of technical malathion (96%) were applied by a vehicle-mounted "Leco" cold aerosol generator at 438 ml/ha at a three-day interval. The adult mosquito population was reduced by 99%, and it took about two weeks to regain its pre-treatment level (Pant et al., 1971).

Five sequential treatments of fenitrothion applied by "Leco" at 511-1095 ml/ha (7-15 oz/acre) at 11-49 day intervals provided 4-5 months' control of *Aedes aegypti* (Pant et al., 1973).

6. **Combined application of adulticide and larvicide for emergency control**

Two days after treating all larval habitats with "Abate" 1% sand granules at 1 ppm, 4% malathion thermal fogs were applied by "Swingfog" at 420 ml/ha to front doors and the areas between houses. The length of this combined effect varied from 6 to 24 weeks, depending upon the surroundings of the treated area (Bang et al., 1972).

During an epidemic of dengue haemorrhagic fever in Thailand in 1973, two ground ULV applications of malathion concentrate by "Leco", "Fontan" and "Mity Moe" mistblowers were combined with applications of "Abate" 1% sand granules at 1 ppm. The adult mosquito population was reduced to 70% for two months (Phanthumachinda et al., 1974).
ANNEX IV

ULTRA-LOW-VOLUME (ULV) APPLICATION OF INSECTICIDES

Using the ULV technique, a small quantity of technical grade insecticide in liquid concentrate form may be applied from the air or the ground. Lofgren (1970) made a critical review of this recently developed technique. ULV cold aerosol spraying is generally more effective against adult mosquitoes than high-volume thermal fogging.

ULV application has resulted in substantial savings in vector control operations, through economy of insecticides and transportation, and non-requirement of diluents. Moreover, it does not produce a dense fog that may constitute a traffic hazard, and the size of the insecticide droplets can be controlled reasonably well to give an effective compromise between the biologically optimum droplet size spectrum and that which allows maximum control of the dispersal within the target area.

It was reported that car spotting or damage to some automobile finishes occurs occasionally because of the solvent or the corrosive properties of some of the insecticides. But such damage is noticeable only when large droplets (larger than 100 micra) are present in the spray (Lofgren, 1970). Drift of ULV sprays can be a serious problem if dosages substantially above recommended amounts are used. One should always consider that aerosol clouds may be carried long distance with the wind and may cause exposures beyond the limits of the target area.