Woodard, D. B. and H. C. Chapman. 1977. Effect of post-emergence age on insemination of colonized mosquitoes. Mosquito News 37: 523–524.

Young, M. D., J. K. Nayar and D. J. Forrester. 1977. Mosquito transmission of wild turkey malaria, *Plasmodium hermani*. J. Wildl Dis. 13: 168–169.

BOOM SPRAY APPLICATION OF INSECTICIDE FOR CONTROL OF ESTUARY BREEDING BITING MIDGES (*CULICOIDES*, CERATOPOGONIDAE)

K. J. FERGUSON AND J. H. CAWTHORNE

Entomological and Rodent Control Section, Health Department, Gold Coast City Council, P. O. Box 5042, Gold Coast Mail Centre, Queensland, 4215, Australia.

ABSTRACT. Temephos or Abate® insecticide emulsifiable concentrate formulation applied at the rate of 10% with a salt water carrier and discharged through a telescopic boom from apparatus fitted to a small boat has been 98% effective against *Culicoides molestus* larvae in canal banks. Equipment described enables the application of Abate® E.C. at 0.78 Kg. per ha., and 20 Km. per day are readily achieved in all weathers.

INTRODUCTION

Culicoides molestus (Skuse) has assumed major pest status on the Gold Coast of Queensland, since former wetlands were converted for residential development with artificial canals and white sand beaches. This biting midge species breeds in relatively clean flocculated sand and has effectively colonized man-made breeding places. The larval habitat extends from the 1.5m tideline to the 2m tideline, usually a distance of about 4m on the average slope of canal beaches, and adults emerge at spring tides (new and full moon).

Fox et al. (1968) and Wall and Marganian (1971) showed Abate® insecticide to be effective against *Culicoides* larvae in Puerto Rico and Cape Cod respectively. Abate® insecticide (0,0,0′0′- tetramethyl 0,0′ - thiodi-p-phenylene phosphorothiote) has been used extensively for mosquito control in this area since 1968, with minimal effects to other organisms (Kay et al. 1973), and preliminary trials indicated that it would be effective against *Culicoides* in Queensland.

A rapid practical method was required for the treatment of the 140 Km of canal banks, when the breeding zones were exposed. A boom spray was designed to fit into a small boat and has proved to be highly effective in both distribution of the chemical and reduction in labor costs.

MATERIALS AND METHODS

SPRAYING EQUIPMENT. A 3.6m aluminium boat, driven by 15 horsepower outboard motor, was fitted with a V.D.O.® sumlog and speedometer which accurately measures distance travelled and speed in knots, even at slow speeds.

A 4 horsepower air-cooled 4 stroke petrol engine fitted with a pulley and a vee belt drives a 25mm (1 in) positive displacement gear pump to produce 60 lb. pressure, and a pressure relief valve protects the system. A discharge line allows salt water to be circulated through the pump and discharged back to the sea when the insecticide flow is interrupted.

A pulley and belt fitted on the pump

shaft drives a 6.33mm (¼ in) positive displacement gear pump used to pump insecticide from a bulk container to a liter capacity header tank. From this tank the insecticide flows through a needle valve and flow meter to a venturi fitted to a 25mm (1 in) suction hose connected to the intake of the 25mm pump which draws salt water from the canal through a filter.

The Abate®/saltwater mixture is pumped through the 25mm pump and is thoroughly mixed by recirculating, then discharged through a 12.5mm (½ in) pressure hose to the boom. The boom consists of 3 aluminium tubes each 3m (10 ft) long, which telescope together. The 3 tubes 25mm, 32mm, and 38mm (1″; 1¼″ and 1½″) in diameter, are fitted to a mast 145 cm (4′9″) high, by means of a device which allows the boom to be raised, lowered and moved horizontally. (Figure 1).

The 12.5mm hose passes through the boom to 2 nozzles fitted to "Rega" hand valves individually controlled by the boatman. The nozzles are made from 25mm x 10mm stainless steel clevis pins, bored through the head with a 6mm (¼″) drill. The first nozzle has a slot 1.4mm wide and cut so as to give a 4m swath width. The second nozzle has 5 x 1.5mm holes drilled into the 6mm cavity and spaced so as to extend the swath width another 4m. Both nozzles have slots cut in the ends so that the swath widths can be varied by turning the nozzles with a screwdriver. The first nozzle covers the normal 4m swath, and the second extends the coverage for treating breeding areas with longer and more gentle slopes. The pump delivers 8 liters per min. through each nozzle. A 1 liter container fitted next to the header tank holds insecticide used when calibrating the equipment.

The equipment is calibrated by turning the 2-way cock to the metering position, and spraying the liter of insecticide on to the canal beach at the usual speed of 5 knots. The distance covered is measured in meters by a "Measure master" pedometer and the area sprayed is calculated on a 4m swath width. The insec-

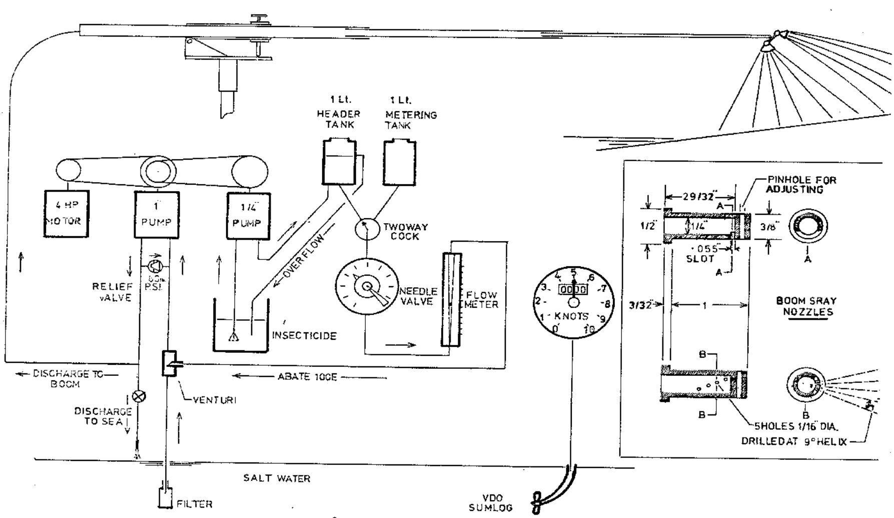

Fig. 1. Diagram showing arrangements for mixing insecticides.

ticide flow is adjusted through the flow meter to the required dose rate which is 1 liter per 1.35 ha.

Larval Sampling. Sand samples are taken at the 1.7m tide level, using a hinged sand grab (Figure 2) which takes a 5cm x 5cm x 7.5cm deep sample. Five of these samples are taken at intervals of 5 paces and combined in a 1 liter bucket to form 1 sample for processing. Twelve 1 liter samples are collected from each canal system and sampling is repeated at approximately 30-day intervals.

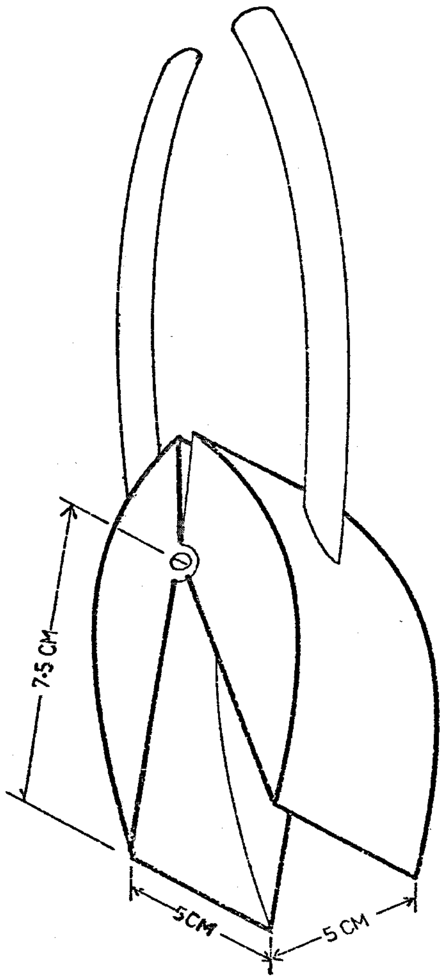

Fig. 2. Sand grab.

The larval extraction technique is a development from Bidlingmayer (1957) and modified by E. J. Reye of Queensland University.

The sand from each 1 liter bucket is transferred to a 9 liter bucket and mixed with a cane sugar syrup which has been diluted with water to produce a specific gravity of 1.3. Raw sugar is added to the sample to compensate for the water content of the sample. The sand and syrup are thoroughly mixed then transferred to 8cm diameter by 40cm high settling tubes and left to settle for 20 mins. This settling time is satisfactory for relatively clean sand, but needs to be extended for sand containing more organic matter. The surface of the tube is then skimmed with an inverted cone, and the skimmings passed through sieves of 7 and 48 meshes per cm. and washed with water. The larvae are trapped on the finer sieve and are washed into a dish from which they are extracted by pipette and counted.

RESULTS

Preliminary trials in 1972 had shown that Abate® insecticide was effective against *Culicoides* larvae at 0.78 Kg. active ingredient per ha. In vitro tests have also proved that Abate® was as effective when mixed with clean sea water as with clean fresh water. Mean pre-spraying and post-spraying larval counts for the period December 1977 to January 1978 are shown in Table 1. Regular monthly sampling between January and April 1978 has shown the larval density has been reduced by 98% in every canal system treated. Prior to larviciding canal systems, residents were being so seriously affected by biting midge infestation that some people were hospitalized, and some were forced to sell their properties and move

Table 1. Effects of Abae® insecticide on *Culicoides molestus* larvae at 0.78 kg. per ha. December, 1977–January, 1978. (Mean larval count per canal system (12 × 125 sq.cm.samples) calculated according to Williams.)

	Pre-treatment	38 days post-treatment	65 days post-treatment	108 days post-treatment
Swordfish Canal	0.73	0.00	0.00	0.00
Mackerel Canal	2.82	0.00	0.00	0.00
Dolphin Canal	3.69	0.00	0.00	1.01
Barracuda Canal	5.70	0.41	0.41	0.73
Marlin Canal	10.18	0.00	0.25	8.16
Control Endless Summer Canal	33.96	17.95	12.43	21.77

In all treated canals no pupae were found after 108 days.
In the Control pupae were present at the rate of 6.67 per sample.

away. Since this treatment began, the level of complaints from residents has shown a decrease commensurate with the reduction in larval numbers.

DISCUSSION

A single application of Abate® insecticide at 0.78 kg active ingredient per ha maintained control of *Culicoides molestus* larvae from 80 to 130 days. These results suggest that the duration of the larval stage of *Culicoides molestus* is some 8 weeks (2 to 3 lunar cycles).

The insecticide application kills most larvae present and maintains the sands free of larvae during the life of the insecticide (2 to 3 days). After this period oviposition may occur when the tidal cycle exposes the sands at dawn or dusk. The immature stages then develop so that pupation and emergence occur in phase with suitable tides, a period of 2 or 3 lunar cycles, depending on the time of application of the insecticide (Fig. 3).

To satisfy the tidal requirements, the duration of the larval stage must be greater than 1 lunar cycle. The breeding of *Culicoides molestus* in canal banks reached such proportions that some form of control became necessary. The breeding areas are more readily accessible by boat than by land. The mixing of Abate® with sea water has obviated the necessity to carry fresh water and has permitted a small boat to be used, which can easily navigate restricted waters. Four men were previously required to spray the area with a hose, and spraying was restricted to the walking pace of a man in heavy sand.

The equipment described enables the application of Abate® E.C. at 0.78 Kg. per ha. and treatment rates of 20 Km per day are readily achieved in all weathers. The equipment is operated by 2 men, with resultant saving in labor costs, and the area covered is 5 times greater than previously achieved thus allowing the total 140 Km of canal banks to be treated over a 7 day period. Larval control has been

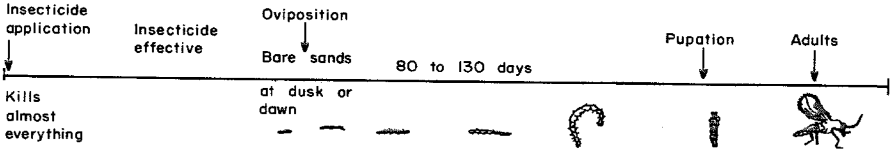

Fig. 3. Diagram to show relation of insecticide application and biting midge life cycle.

proved in biting midge producing areas in artificial canal banks with this equipment, and the equipment is suitable for distribution of any insecticide which can be mixed with sea water.

ACKNOWLEDGMENTS

The authors thank Mr. A. L. Dyce, McMaster Laboratories, Sydney and Mr. H. A. Standfast, C.S.I.R.O. Division of Animal Health, Brisbane, for their advice in preparation and criticism of the manuscript, and Mr. E. J. Blake, Gold City Council, for his assistance in sampling and processing larval samples.

References Cited

Bidlingmayer, W. L. 1957. Studies on *Culicoides furens* (Poey) at Vero Beach. Mosquito News 17:292–294.

Kay, B. H., Ferguson, K. J. and Morgan, R. N. C., 1973. Control of salt-marsh mosquitoes with Abate® insecticide at Coombabah Lakes, Queensland, Australia. Mosquito News 33:529–535.

Fox, I., Rivera, G. A. and Umpierre, C. C. 1968. Toxicity of various insecticides to *Culicoides* larvae in Puerto Rico. Mosquito News 28:68–71.

Wall, W. J. and Marganian, V. M. 1971. Control of *Culicoides melleus* (Coq.) with granular organo-phosphorous pesticides, and the direct effect on other fauna. Mosquito News 31:209–214.

GENETIC FITNESS OF THE MUTANT, CARMINE EYE, IN *CULEX TARSALIS* IN THE LABORATORY[1]

R. W. AINSLEY AND S. M. ASMAN

Department of Entomological Sciences, College of Natural Resources, and Department of Biomedical and Environmental Health Sciences, School of Public Health, University of California, Berkeley, Berkeley, CA 94720

ABSTRACT. Experiments designed to test the effect of the eye-color mutant, *car*, on mating competitiveness indicated *car* does not significantly influence mating ability. Estimates of survivorship to pupae indicate that *car* might be an overdominant gene. However, the genetic history of the stocks used indicated that a general hybrid vigor was expected and might have produced the overdominance detected.

INTRODUCTION

The development of chromosomal translocations for the genetic control of the mosquito, *Culex tarsalis*, has progressed in our laboratory to a point where assessment of the relative genetic fitness of the translocation lines is necessary. Recently visible genetic markers were incorporated into translocations generated in this species (McDonald et al. 1978). This allowed the development of selection experiments which depend upon genetic markers to assess the results. Before assessing the fitness of translocations, the fitness of populations that carry genetic markers should be determined.

Carmine-eye color (*car*) (Asman 1975b) was chosen for the first round of selection experiments because *car* can be detected in the larval, pupal, and young adult stages. This report is an assessment of the mating competitiveness of *car*-bearing adult males against wildtypes and the survivorship of *car* to the pupal stage.

[1] This research was supported in part by a U.S. Army Contract/Grant No. DAMD 17-74-C4128 U.S. Army Medical Research and Development Command, Washington, D.C. and Research Grant AI 03028, National Institute of Allergy and Infectious Diseases.