TRIALS WITH GROUND APPLICATION EQUIPMENT USING ULTRA LOW VOLUME APPLICATION OF INSECTICIDES FOR MOSQUITO CONTROL

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The Mosquito Research and Control Unit was set up with the aim of carrying out a program of research leading to the control of mosquitoes on Grand Cayman. The main pest mosquito on Grand Cayman is *Aedes taeniorhynchus*, and the main control scheme is a physical scheme based on dyke construction and the control of water levels in the extensive mangrove swamps. A chemical control program is being developed to provide relief in the form of fogging to the residential areas and to control localized outbreaks by larviciding. With the extreme flatness of the island a heavy rain will result in the flooding of many acres of agricultural land which form a habitat for *Aedes sollicitans* and these areas can be treated with ground application equipment. During the final stages of the control program on the whole island there will probably be an aerial application scheme and in the open areas ultra low volume application of larvicides might be feasible.

Grand Cayman has a total area of only 70 square miles; the highest ground is only 60 feet above sea level and yet even with the relative smallness and flatness of the island, there is a great variation in rainfall. Frequently the rain showers cover a front only one-half mile wide. This variability in rainfall pattern results in a "patchy" larval development which, in the case of a mosquito such as *A. taeniorhynchus,* can cause great inconvenience to people living within, or close to, the rainfall area.

To provide protection from these localized outbreaks, ground application equipment in the form of a Buffalo Turbine Model FS sprayer-duster, and a Four Oaks Back Pack sprayer were purchased. With the aim of improving the efficiency of the operation, of extending the spray-time in the field and, in the case of the Back Pack sprayer, of lightening the load of the spray-man, both machines were modified for ULV spray application.

BUFFALO TURBINE, MODEL FS. A complete ULV dispersion system was purchased from the manufacturer. The system chosen was the electrically driven, variable speed Mini-spin, and a Sigmamotor pump to deliver the insecticide. The standard volume liquid pump was removed from the Buffalo turbine and on the mounting bracket was placed the Sigmamotor pump and the solenoid control valve. The solenoid valve was wired with the control switch on a panel in front of the operator's seat. A 24-inch-long, one-quarter-inch diameter copper tube was connected to the insecticide suction line which could be inserted into the insecticide drum. A needle valve to control delivery rate was also connected on the suction side of the insecticide line. The

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solenoid valve was inserted on the delivery side of the insecticide line with a return line to the insecticide tank. With the solenoid turned "on" insecticide was pumped to the Mini-spin; with the solenoid turned "off" insecticide was recirculated back to the insecticide tank. The Mini-spin was wired with an "on-off" switch on a panel at the operator's seat. On the panel was also mounted a rheostat and a voltmeter; these were connected to the electrical circuit to the Mini-spin. In this way the Mini-spin could be set to run at a fixed rate of speed.

The data on Mini-spin revolutions per minute according to a voltmeter reading as supplied by the manufacturer was accepted for calibration trials with No. 2 fuel oil and in all trials the Mini-spin was set to run at 10,000 rpm. The delivery of the Sigmamotor pump with the turbine at full throttle was determined with No. 2 fuel oil. The line of the Mini-spin was disconnected and the No. 2 fuel oil was collected in a 1,000 ml graduated cylinder. Two readings of number of mls per minute for each needle valve setting were taken and average determined.

The minimum delivery rate of the machine was 40 mls per minute, and the maximum was 380 mls per minute. A plot of needle valve setting vs. volume delivered, over a range of 6 settings showed a straight line relationship.

The effective coverage of the Buffalo Turbine operating in a 3–5 m.p.h. cross-wind was next determined. Oil sensitive cards, as supplied by Home and Farm Chemical Supplies Limited, were set out on the ground at 100-foot intervals from 0 to 500 feet down-wind of, and at right angles to, the line of movement of the machine. The delivery rate of the machine was set at 380 mls per minute. The Buffalo Turbine was started 300 feet from the line of cards, and driven at 3 m.p.h. to a point 300 feet beyond the line of cards. To permit the smaller droplets time to drift to the 500-foot card there was a 15-minute time lapse between completion of the run and collection of the cards. A new set of cards was set out for each run and the coded cards were returned to the laboratory for drop counting. Trials were carried out with the nozzle pointing vertically up (90°) and at an angle of 45° and pointing down-wind of the machine.

The average number of droplets per square centimetre was determined from a count of 21 one-centimetre square units on each card. Equipment to determine droplet diameter was not available and it was not possible to ascertain drop distribution and mass median diameters for the droplets on each sample. The results are shown in Table I.

TABLE I.—Droplet deposition by a model FS Buffalo Turbine fitted with a ULV Mini-spin delivering No. 2 fuel oil, delivery rate 380 mls/min., 3–5 m.p.h. cross-wind.

	No. of feet down-wind				
Position of nozzle	100	200	300	400	500
Nozzle at 90° (vertical)	7.3*	5.3	2.9	2.9	3.1
Nozzle at 45°	6.9	2.3	1.2	1.2	0.5

* Number of droplets per square centimetre.

These results show that the most effective complete down-wind coverage was produced with the nozzle vertical. The maximum deposit was at 100 feet down-wind of the machine; there was then a decrease to just under half at the 300 foot mark and the deposit was then uniform up to 500 feet from the machine. With the nozzle inclined to an elevation of only 45° the deposit at 100 feet was about the same as with the nozzle vertical. However, at this elevation there was then a rapid decrease in deposit to the 500-foot mark. As mentioned it was not possible to determine droplet distribution, but presumably the deposit at the greater distances would be made up of the smaller droplets.

A field trial was then set up using Abate emulsifiable concentrate. The site chosen was in the West Bay area of Grand Cayman where there were many flooded pastures. Based on the assumption of coverage to 500 feet down-wind of the machine in a 3–5 m.p.h. cross-wind, the speed of the vehicle and the delivery rate of insecticide were adjusted to give 4 ounces of active ingredient per acre. It is admitted that across the 500-foot range there was a twofold variation in amount of insecticide. Two blocks were treated; prior to application of the insecticide a check was made to determine the larval density in each area. Collections were made at approximately 10-yard intervals while walking across the flooded fields. At each sampling spot the collector paused to allow any larvae which may have been disturbed to rise to the surface. Ten dips were then made at each point. The average larval density ranged from 0.1 to 0.2 larvae per dip.

During the second trial the Mini-spin started to run slow; adjustment of the rheostat to give a higher voltage did not result in a speed-up of the Mini-spin and shortly after, the Mini-spin stopped. Examination showed that spray liquid had run back into the motor which had burnt out. In correspondence with the Buffalo Turbine company we were informed that the Mini-spin should never be run pointing vertically up.

The post spray check of larval density, made 48 hours after the application showed a reduction in larval density to 0.01 to 0.05, indicating a population reduction of from 50 to 95 percent. This variation in reduction is attributed to the range in number of droplets deposited (see Table 1) plus a change in the spray characteristics as the Mini-spin began to run slow.

Four Oaks Back Pack Sprayer. This machine was modified to deliver ULV amounts of insecticide following the technique described by Buzicky at the AMCA meeting in 1968. A line strainer and a tube to hold a metal restrictor plug were fitted into the insecticide line. A series of restrictor plugs with orifices of different sizes was obtained, and the delivery rate of the machine was determined using water. In Table 2 are shown the rates of flow at each of the different drill size orifices.

Table 2.—Delivery rate of a ULV modified Four Oaks Back Pack sprayer using water.

Drill size orifice	Number of mls per minute
80	14
77	38
73	54
67	94
56	214

The coverage down-wind of the machine was determined. Oil sensitive cards were set out at 25-foot intervals from 0 to 125 feet down-wind of the line of movement of the machine. The operator walked at right angles to, and up-wind of the zero line starting 200 feet from the cards continuing to a point 200 feet beyond the cards. The cross-wind was 3–4 m.p.h. and the delivery rate of the machine was 214 mls per minute; the liquid used was No. 2 fuel oil. A fresh set of cards was set out for each trial. Three trials were carried out: (a) Nozzle at 90° (vertically up); (b) Nozzle at 45° and pointing down-wind, i.e. across the line of movement; (c) Nozzle at 45° and pointing cross-wind; and (d) Nozzle at 0° (horizontal) and pointing ahead of the operator. Again the average number of droplets per square centimetre was determined based on a count of 21 one-centimetre square areas on each card. The results are shown in Table 3. In the last line is shown a hypothetical deposit produced if the nozzle was swung continuously from the vertical to the horizontal position and back again as quickly as possible as the operator walked along.

With the nozzle held vertically up there were two peaks of deposit; one at 50 feet down-wind, and the other at 125 feet. Presumably the first peak was made up of large droplets and the second was comprised of smaller droplets which were carried farther by the wind. Elevating the nozzle to only 45° and directing the spray down-wind, i.e. towards the target, resulted in a steady increase in deposit from 25 to 125 feet. With the nozzle elevated to 45° and directed cross-wind

TABLE 3.—Droplet deposit by a ULV modified Four Oaks Back Pack sprayer using No. 2 fuel oil, delivery rate 214 mls/min., 3–5 m.p.h. cross-wind

Position of Nozzle		No. of feet down-wind 25	50	75	100	125
Nozzle at 90° (vertical)	(a)	2.0*	44.0**	6.0	19.5	32.0
Nozzle at 45° (down-wind)	(b)	2.0	no card	7.0	no card	14.0
Nozzle at 45° (cross-wind)	(c)	3.0	4.5	32.5**	2.5	3.5
Nozzle at 0° (horizontal)	(d)	41.3**	6.5	6.0	1.5	1.0
Theoretical (a)+(c) +(d)÷3 (Nozzle swung)		15.4	18.3	14.8	7.8	12.1

* Number of droplets per square centimetre.
** Maximum deposit.

there was a peak at 75 feet (32.5 droplets/sq. cm.). Holding the nozzle horizontal resulted in a maximum deposit at only 25 feet from the operator, and then a rapid decrease in deposit as the distance from the operator increased. With the exception of the trials in which the nozzle was directed down-wind, these trials show that, working in a cross-wind, the greater the height to which the spray can be directed the greater the spread of coverage. In effect, the wind is having more of an effect on the spray output. The theoretical deposit is based on the assumption that the operator can swing the nozzle as quickly as possible as he walks along. The average deposit calculated indicates a surprisingly uniform deposit out to 75 feet, and even at the 100-foot point the decrease is not too great. The increase at 125 feet will be the result of the smaller droplets being carried farther.

A field trial was carried out on a pond approximately one acre in size, and flooded to an average depth of one foot. The borders were grassy and on about three-quarters of the border the pond was overgrown with high brush extending out about 20 feet into the pond. Abate emulsifiable concentrate was diluted to a 10 percent solution and applied to give a nominal dosage of 4 ounces active ingredient per acre. The operator walked through the brush on the border and on two transects across the pond.

In a prespray assessment III and IV instar larvae of *A. taeniorhynchus* were collected in large numbers. The larvae were found in concentrations ranging from only a few inches across to about one foot in diameter, and in bands along the grassy borders. Many larvae were also found within the high brush area of the pond. With these great variations in number of larvae an estimation of the number of larvae per dip was of no value. Control was estimated by searching the same areas after application of the insecticide.

A search 24 hours after treatment indicated 95 to 99 percent control. Dead larvae were seen along the grassy borders and in the overgrown area. The few areas with the live larvae were those with thick high grass or under clumps of brush which presumably shielded the particular areas from the insecticide.

These trials show that ground equipment, modified to deliver ultra low volumes of insecticide, will give good enough coverage to provide effective larval control.