STUDIES ON FLIGHT ACTIVITY AND CONTROL OF MOSQUITOES IN THE EDMONTON AREA, 1971-73

J.E. Hudson
Department of Entomology
University of Alberta
Edmonton, Alberta, Canada
T6G 2E3

Quaestiones Entomologicae
17: 179-188 1981

ABSTRACT

The effects on mosquito activity of barrier strips of dichlorvos and propoxur sprayed on the vegetation in wooded ravines, were assessed by means of insect wind traps and by landing counts on human bait. Dichlorvos at 1.12kg a.i./ha reduced trap catches by 70% for one day after treatment; bite count data were inconclusive. Propoxur at 0.34kg a.i./ha reduced trap catches by 44% and bite counts by 100% for one day after treatment. From these results a continuation of the barrier strip method could not be recommended. Many other insects (chiefly other Diptera) were caught in the traps, but there were no consistent reductions in catches in the treated strips. Catches of mosquitoes were consistently higher on the down-valley sides of the traps than on the up-valley sides, and catches were generally higher in traps in the ravines than in traps on the plain above. The effectiveness of malathion sprayed by helicopter was measured by kills of caged, wild-caught mosquitoes and by bite counts. Boom and nozzle application at 0.7kg a.i./ha killed only 27% of the mosquitoes (mostly Aedes vexans*) caged in the woods at Whitemud Creek. Ultra-Low-Volume application at 0.3kg a.i./ha killed only 8% of the caged mosquitoes (mostly* Aedes fitchii*) at Whitemud Creek, but 94% of the caged mosquitoes at Victoria Park golf course, a more open area.*

RÉSUMÉ

Le dichlorvos et le propoxur furent appliqués sur des bandes de végétation en ravin boisé, et leurs effets sur l'activité des maringouins furent étudiés à l'aide de pièges éoliens, et en dénombrant les individus atterrissant sur un appât humain. Le dichlorvos, appliqué à raison de 1.12 kg i.a./ha, réduisit les captures de 70% pendant une journée suivant le traitement; les résultats du dénombrement des piqûres ne furent pas concluants. Le propoxur en concentration de 0.34 kg i.a./ha réduisit les captures de 44%, et le nombre de piqûres de 100%, pendant une journée suivant l'application. Ces résultats ne permettent cependant pas de recommander l'arrosage de bandes de végétation pour contrôler les moustiques. De nombreux autres insectes (surtout des Diptères) furent capturés dans les pièges, mais il n'y eut pas de diminution uniforme des captures dans les bandes traitées. Les captures de moustiques furent toujours plus élevées près du fond que près du rebord des ravins, et furent généralement plus abondantes dans les pièges placés dans les ravins que dans ceux situés sur la plaine environnante. L'efficacité du malathion répandu par hélicoptère fut évaluée à partir de la mortalité de moustiques sauvages encagés, et du dénombrement des piqûres. L'épandage à l'atomiseur d'une solution concentrée à 0.7 kg i.a/ha ne tua que 27%, des maringouins (principalement Aedes vexans*) encagés dans un bois à Whitemud Creek. L'épandage à très faible volume d'une solution à 0.3 kg i.a/ha ne tua que 8% des maringouins (surtout* Aedes fitchii*) encagés à Whitemud Creek, mais tua 94% de ceux encagés au terrain de golf de Victoria Park, qui est un endroit plus découvert.*

INTRODUCTION

According to Klassen and Hocking (1964), the North Saskatchewan River valley and its tributary ravines are a major route of entry of adult mosquitoes into the city of Edmonton, because local air currents and the mosquitoes' optomotor responses bring them down from the plains into the valleys, and the prevailing winds at night are down-valley. To stop the mosquito invasions, Klassen and Hocking applied lindane by aircraft, at 0.3kg/ha, to vegetation on the sides of the river valley, in three 90m wide barrier strips at the eastern and three at the western city limits. From bite counts and observations on male swarms, it was concluded that the barrier strips were effective, (Klassen and Hocking, 1963), and the method was used, without further evaluation, by Edmonton Parks and Recreation from 1959 to 1969, when lindane was banned. This report describes attempts in 1971 and 1972 to reassess the barrier strip method of control, and to test two substitutes for lindane, using traps designed to measure insect flight activity and direction, (Hocking, 1970; Hocking and Hudson, 1974).

In the meantime, the City of Edmonton began using aerial sprays of Malathion against adult mosquitoes, and this report also describes attempts to measure the effectiveness of these sprays.

MATERIALS AND METHODS

The 1971 barrier strip experiment was performed in a wooded ravine which meets the North Saskatchewan River Valley on the south side at a point 18 km southwest of the City of Edmonton and 3 km east of Devon. The 1972 experiments were performed in the Whitemud Creek Valley, which runs North to Edmonton, at 0.8 and 1.6 km south of the city limits. The ravines at the two test sites were about 300m wide, and thickly wooded with aspen, poplar and spruce, with small streams running through.

Two insecticides, dichlorvos (Vapona 20% e.c.,[1] 2,2 - dichlorovinyl dimethyl phosphate), and propoxur (Baygon 70% w.d.p.,[2] ortho-isopropoxyphenyl methyl carbamate) were chosen for the tests because both are quick acting and have a fumigant action, properties they share with lindane. For the dichlorvos trial, a rectangular plot 150 x 70m was marked out on the west slope of the ravine near Devon, and on the 24 July 1971 all the vegetation in the outermost 10m of this plot was treated with the dichlorvos emulsion from hand compression sprayers, at a dosage of 1.11kg a.i.[3] in 200 liter/ha. An insect trap was located in an unsprayed area 130 x 50m within the plot. A similar plot on the eastern slope was sprayed with the insecticide solvent only in water. For the propoxur trial, a 200m wide strip across the Whitemud Creek ravine, 0.8km south of the city limits, was sprayed by a helicopter with boom-and-nozzle equipment, at a dosage of 0.3kg a.i. in 39 liters of water per hectare, at 22:30 hrs on the 28 May 1972. A third trial in June 1972 at Whitemud Creek to re-evaluate lindane was abandoned because of a mistake by the helicopter pilot. A fourth trial in July at the same site was to test a new variant of the trap, not an insecticide.

[1]Emusifiable Concentrate
[2]Wettable powder
[3]a.i.=active ingredient

Three variations of insect wind traps (Hocking, 1970) were used: the large ($10m^2$) and medium-sized ($2m^2$) ones were set up with one side facing up-valley and the other side down-valley, while the small ones ($0.5m^2$, pivoted and wind-vaned) were set up in small clearings in the forest so they could turn freely. For the dichlorvos trial six traps were used, one large and two small on the west (treated) and the same numbers on the east (untreated) slope of the ravine. For the propoxur trial, five traps were used: one small and two large traps on the ravine bottom (one large inside the treated strip); and two small traps on the plain above, one each side of the ravine. Traps were emptied once or twice daily, and mosquito biting counts made near the traps when they were emptied. Mosquitoes from the traps were identified with the aid of Carpenter and LaCasse (1955).

The effectiveness of the malathion sprays was assessed by putting wild-caught *Aedes* females into cylindrical cages made from 1.4mm mesh galvanized mosquito screen and 10cm plastic petri dishes and the cages were hung from trees and bushes in the areas to be sprayed. One hour after spraying, the mosquitoes were transferred to clean plastic cups and held in the laboratory for another 24h before the mortality count was made. Spray droplets were sampled by white glossy cards (Kromekote Bristol 291M), pinned to leaves near the cages, and a few cards were put into empty bioassay cages to measure the droplet penetration rate. The helicopters were fitted in 1972 with boom-and-nozzle equipment to spray malathion emulsion in drops of 500 microns at 0.7kg a.i. in 46 l of water per hectare, in 1973 with Beecomist ultralow volume (ULV) rotary atomizers to spray undiluted technical malathion in drops of 40 microns at 0.3kg/ha.

Reductions in trap catches and bite counts were calculated according to the formula:

$$\% \text{ reduction} = 100(1 - (Tn\ Co\ /\ To\ Cn))$$

where Tn and Cn are the numbers caught in the treated and untreated areas, respectively, on day n after treatment, and To and Co are the corresponding values for the day before treatment. Mortalities of caged mosquitoes in the malathion-sprayed areas (T) were corrected for mortalities of mosquitoes caged in the unsprayed areas (C) by Abbott's formula, as follows:

$$\text{Corrected mortality} = 100(T - C/100 - C)$$

RESULTS

The wind traps caught many insects (Table I), and the mean catch per m^2 at Devon was the highest obtained anywhere in the world, except Tahiti (Hocking, 1970). Of the catch at Devon, 72.4% of the total were female mosquitoes, 97.4% of them *Aedes vexans* (Meigen), the worst pest mosquito in western Canada. In the trials at Whitemud Creek, female mosquitoes, which never formed more than 15% of the total catch, were mostly *Aedes cataphylla* in May, *Aedes fitchii* in June and *Aedes vexans* again in July.

In the dichlorvos experiment there was a 69.8% reduction in trap catch in the treated plot only on the day after treatment (Table II). There was no reduction in catch in the traps up-valley and down-valley from the treated plot. The bite counts were too low to draw any conclusions about the effectiveness of the treatment.

In the propoxur experiment there was a 43.8% and 100% reduction in the trap catches and in the biting rates, respectively, in the treated strip the day after treatment (Table III). On the second day after treatment, both flight and biting activity within the treated strip returned to pre-treatment levels.

The wind traps have the advantage that they can also detect changes in the activity for non-target insects, but the results obtained in the propoxur trial were inconsistent. On the day after treatment, there was a reduction in the catch of other Diptera in the treated strip, but no reduction in the catch of Hymenoptera, and the catch of Lepidoptera actually increased.

According to Klassen and Hocking (1964) bigger catches could be expected in the traps in the ravines than on the plain, and bigger catches on the up-valley sides of the traps (i.e. mosquitoes flying down-valley) than on the down-valley sides. The $10m^2$ and $2m^2$ traps gave consistently higher catches in the ravine than on the plain, but the $0.5m^2$ traps gave higher catches on the plain, (Table IV). In three of four trials, catches were greater in the sides of the traps facing down-valley, i.e. the direction of flight was predominantly up the valley, and against the prevailing night winds, (Table V).

At Whitemud Creek in July 1972, malathion applied by boom-and-nozzle killed only 27.4% of the caged mosquitoes, 84% of which were *Aedes vexans*, (Table VI), and four hours after spraying the biting rate in the treated area (4.5/min.) was almost as high as in an untreated area nearby (5.5/min). In the 1973 tests, 97% of the caged mosquitoes used were *Aedes fitchii*. At Whitemud Creek, the average corrected mortality in treated area was only 8% (average uncorrected 26%, average for untreated area 25%), and 0.09 droplets/cm^2 were found on the test cards. At Victoria Park, the average mortality of the caged mosquitoes was 94% and 0.26 droplets/cm^2 were found on the cards. From the numbers of the droplets found on the cards inside cages, it was estimated that the penetration rate was only 35.4%. In both 1973 tests, mosquitoes bit us in the treated area less than one hour after treatment, and 23% of 48 mosquitoes caught in the treated area died after 24hr holding in the laboratory, compared with 2% mortality in 41 mosquiitoes from an untreated area.

DISCUSSION

A barrier strip of insecticide should kill all the mosquitoes attempting to cross it, for several days after treatment, but the trap catches indicated reductions in mosquito activity for only one day after treatment, and no measurable reduction in mosquito activity up-valley or down-valley from the strips. The reasons for these poor results are uncertain and require further investigation, but on this basis we could not recommend the resumption of barrier strip spraying with dichlorvos and propoxur. Both dichlorvos and propoxur have very short residual life. Lindane was more effective because of residual properties. Dichlorvos is unstable in the presence of light and water. Propoxur is more stable but the volume of spray, 39 liters/ha, was insufficient for adequate leaf coverage. Brown (1951) states that 50 gallons/acre (=562litres/ha) are required for adequate leaf coverage in woodland. Another important factor in the Edmonton region is the vulnerability of the spray deposits to the summer rains. Two attempts were made in 1972 to bioassay the residual toxicity of propoxur and lindane deposits on leaves, but on both occasions the toxicity of the deposits disappeared within 48h, after heavy rains.

The insect wind traps were chosen for the trials because of their ability to sample a wide selection of flying insects, and to measure both flight density and direction of flight. However, in practice the traps proved to be less suitable for these studies than they had seemed. The ratio of mosquitoes to other insects was low in 3 of the 4 trials. The pivoted $0.5m^2$ traps did not keep facing properly into the light winds down in the ravines, though later a lighter, more efficient wind vane was developed, (Hocking and Hudson, 1974). In studies elsewhere, Hocking found that sometimes insects which had been flying upwind were caught in the upwind, not the

downwind, sides of the traps, (Hocking and Hudson, 1974). The three variants of the trap gave different results in the same place for flight densities of mosquitoes, (see Table V), the $2m^2$ fixed, pyramidal, traps giving the highest values per m^2-hr. This was probably due to differences in area distribution with height. For future studies of mosquito dispersal it would be better to have a larger number of smaller traps, more specific for mosquitoes.

The boom-and-nozzle application of malathion was ineffective, probably because of the very large droplets produced. The low temperature at the time of spraying, 10°C, was also unfavourable. The ultralow volume equipment produced drops of around 40 microns in diameter, which is much closer to the optimum of 25 microns for adult mosquitoes, (Weidhaas *et al.* 1970). Malathion ULV sprayed at 0.3 kg/ha. gave satisfactory kills of caged mosquitoes at Victoria Park golf course, a fairly open area, but not in the thickly wooded ravine at Whitemud Creek. In both areas, mosquitoes were taken biting less than one hour after treatment. These mosquitoes may have been protected by resting deep in the undergrowth, below the level of the caged mosquitoes (about 1.5m). The ULV application of malathion was adopted as routine by Edmonton Parks and Recreation, with a higher dosage (0.5kg/ha) for thickly wooded areas.

ACKNOWLEDGEMENTS

These studies were supported by grants from the Alberta Agricultural Research Trust and City of Edmonton to the late Dr. Brian Hocking. Assistance of Hugh G. Philip, Brian M. Rolseth, Bernard Boisvert and Jacqueline Marr is acknowledged. The propoxur wettable powder was kindly donated by Chemagro.

REFERENCES

Brown, A.W.A.. 1951. Insect control by chemicals. New York, John Wiley. 817 pp.

Carpenter, S.J. and W.J. LaCasse. 1955. Mosquitoes of North America (North of Mexico). Berkeley, University of California Press. 360 pp.

Hocking, B. 1970. Insect flight and entomologists' inheritance. Ent. News 81:269–278.

Hocking, B., and J.E. Hudson. 1974. Insect wind traps: improvements and problems. Quaestiones Entomologicae 10:275–284.

Klassen, W., and B. Hocking. 1963. Control of *Aedes* dispersing along a deep river valley. Mosquito News 23:23–26.

Klassen, W., and B. Hocking. 1964. The influence of a deep river valley system on the dispersal of *Aedes* mosquitoes. Bulletin of Entomological Research 55:289–304.

Weidhaas, D.E., M.C. Bowman, G.A. Mount, C.S. Lofgren and H.R. Ford. 1970. Relation of minimum lethal dose to the optimum size of droplets of insecticides for use in mosquito control. Mosquito News 30:195–200.

Table I. Catches of mosquitoes and other arthropods in wind traps at Devon, 1971, and at Whitemud Creek, 1972.

Locality	Devon (1971)		Whitemud Creek (1972)					
Dates	19–30 July		25–31 May		24–30 June		12–17 July	
Trial	Dichlorvos		Propoxur		Lindane[1]		New trap	
Number of traps	6		5		8		4	
Total area (m^2):	22		21.5		26		24	
m^2-hours:	5515		2750		4014		3295	
Catch/m^2-hr:	5.24		2.84		2.60		1.32	
Catch composition:	No.	%	No.	%	No.	%	No.	%
Female mosquitoes:								
Aedes vexans	20446	97.4	0	0.0	43	11.2	231	58.9
Aedes fitchii gp[2]	86	0.9	400	36.1	203	52.9	74	18.9
Aedes communis gp[3]	4	0.03	474	42.8	48	12.5	7	1.8
Other species	355	1.7	233	20.9	90	23.4	80	20.4
Sub-total	20891	72.4	1107	14.2	384	3.7	392	9.1
Male mosquitoes	640	2.2	1011	13.0	159	1.5	203	4.7
Other Diptera	5788	20.1	3837	49.3	6321	60.7	2583	60.1
Lepidoptera:	734	2.5	610	7.8	1989	19.1	468	10.9
Hymenoptera	706	2.4	863	11.0	738	7.1	405	9.4
Other arthropods:	121	0.4	368	4.7	826	7.9	244	5.7
Total	28880		7796		10417		4295	

[1]Trial stopped because of pilot error

[2]In May 1972 mostly *Ae. cataphylla*

[3]*Aedes fitchii* plus *Ae. mercurator*

Table II. Catches of both sexes of mosquitoes in wind traps, and landing counts of females, in a dichlorvos treated and an untreated plot near Devon, July 1971

	Before treatment	After treatment		
	1 day	1 day	2 days	3 days
Catches in traps/m^2-hr				
Treated side	1.50	0.18	1.04	5.37
Untreated side	1.71	0.68	1.11	7.09
Landings/person/min.				
Treated side	-[1]	3	3	4
Untreated side	-	1	11	3
% reduction on treated side				
Trap catches	-	69.8	0	0

[1]Sample not taken

Table III. Catches of mosquitoes (both sexes) in wind traps and bite counts before and after propoxur spraying, Whitemud Creek, May 1972.

	Before treatment	After treatment		
	1 day	1day	2 days	3 days
Catches in traps/m^2-hr				
Inside treated strip	0.68	0.57	2.26	0.70
Outside treated strip	0.67	1.00	1.32	0.74
On plain (untreated)	1.25	0.89	0.67	1.75
Bites/persons/min.				
Inside treated strip	5.5	0.0	1.3	1.3
Outside treated strip	8.2	2.6	2.0	3.0
On plain (untreated)	5.0	1.3	1.8	3.6
% reduction in treated strip vs. outside				
Trap catches	-[1]	43.8	0	6.8
Bite counts	-	100.0	3.0	35.4

[1]Sample not taken.

Table IV. Catches of mosquitoes of both sexes, per m^2-hr, in insect wind traps in the ravine and on the plain, Whitemud Creek 1972.

Trap variant:	0.5m^2		2.0m^2		10.0m^2	
Location:	Ravine	Plain	Ravine	Plain	Ravine	Plain
May	0.30	0.50	-[1]	-	0.75	-
June	0.11	0.12	0.34	0.12	0.11	-
July	-	-	0.36	0.12	0.26	0.05
Mean	0.20	0.31	0.35	0.12	0.37	-

[1]Sample not taken.

Table V. Catches of mosquitoes of both sexes, per m^2-hr, in the large insect wind traps (10m^2 variant) sited in the ravines on the up-valley and down-valley sides of the traps

Locality:	Devon	–Whitemud Creek–		
Date:	July 1971	May 1972	June 1972	July 1972
Down-valley side	4.89	0.94	0.04	0.18
Up-valley side	3.58	0.40	0.06	0.08

Table VI. Assessment of aerial sprays of malathion against mosquitoes in the Edmonton area, 1972–1973.

Location:	Whitemud Cr.	Whitemud Cr.	Victoria Park
Date:	16/vii/72	22/vi/73	23/vi/73
Time:	06.30	22.00	04.30
Temperature (°C):	10	21	16
Spray equipment:	Boom + nozzle	ULV	ULV
Dosage, kg a.i./ha:	0.7	0.3	0.3
No. of caged mosquitoes:	307	210	424
Mean mortality, %[1]:	27.4	8.0	94.0
Droplets on cards/cm^2:	-	0.09	0.26

[1]Corrected for control mortality by Abbott's formula