CONTROL OF *ANOPHELES* MOSQUITOES BY ULTRA-LOW VOLUME APPLICATIONS OF *d*-ALLETHRIN AND *d*-PHENOTHRIN IN COMBINATION WITH LARVICIDINGS OF FENITROTHION IN TANZANIA

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Ultra-low volume (ULV) application of insecticide is widely recognized to be effective against adult mosquitoes. Hobbs (1976) reported that ULV applications of synergized pyrethrins applied with ground equipment reduced the natural population of *Anopheles albimanus* Wied. during a heavy malaria transmission season. However, a single ULV application cannot be expected to provide lasting effectiveness. This suggests the necessity of ULV applications at appropriate intervals together with larviciding to aquatic breeding sites. In the present paper, a preliminary trial of ULV applications with a pyrethroid formulation containing *d*-allethrin and *d*-phenothrin with larvicidings by fenitrothion was carried out in an urban area of Tanzania for control of *Anopheles* mosquitoes.

The experimental area, Buguruni Malapa village, was situated in the city of Dar es Salaam, in Tanzania, East Africa. The area was about 36 ha, and included about 10,180 inhabitants and 400 houses. The average temperature and relative humidity during the trial period (June 29 to August 11, 1987) were 28.8°C and 53.0%, respectively. The rain season occurs twice a year, from March to June and October to December. In the trial area, there were 6 primary *Anopheles* breeding sites including an open drain, a swamp, two rice fields, a ridge and a shallow well. The untreated area was set up 0.75 km from the trial area. This area included 12,798 inhabitants and 610 houses.

For the ULV applications, an emulsifiable concentrate formulation containing *d*-allethrin and *d*-phenothrin at a w/v ratio of 6/14% (Pesguard® PS201, Sumitomo Chemical Co. Ltd.) was used. One liter of Pesguard PS201 was diluted with 2 liters of water. The diluted solution was sprayed at one week intervals, July 2, 9, 16 and 23, 1987, by a sprayer mounted on a pick-up truck (Semco® ULV applicator, Model ENCF-E 250U2, Semco Co. Ltd.) at a discharge rate of 500 ml/min with a vehicle speed of approximately 10 km/hr. Every application was started on the downwind side of the spray area. The dosage of Pesguard PS201 per ha was calculated to be 200 ml per ha when the effective range of the ULV aerosols was 50 m downwind to the route of the vehicle. Every application was carried out from 1800 to 2000 hr. For larvicidings, a fenitrothion 50% (w/v) emulsifiable concentrate (Sumithion® 50EC, Sumitomo Chemical Co. Ltd.) was used. One liter of Sumithion 50EC was diluted with 99 liters of water. The diluted solution was applied to the breeding sites of *Anopheles* mosquitoes with a Hudson® X-pert compression sprayer (H. D. Hudson Manufacturing Co., Shawnee Mission, KS) on July 2, 23 and August 1, 1987. Spray volume was adjusted to give the concentration of active ingredient at 1 ppm.

Adult mosquito density was assessed in the treated and untreated areas by 2 different methods, i.e., indoor resting collections (pyrethrum spray catch) (Taylor et al. 1981) and outdoor man-biting collections. For the indoor resting collections, the density was determined by counting the number of mosquitoes collected in 5 selected houses in each area at 2 or 3 day intervals during the trial period. The collections were carried out in the morning (0600 hr) after spraying with pyrethrum. For outdoor man-biting collections, 15 volunteers were used for each area. The density was determined by catching biting mosquitoes from 1800 to 0600 hr of the next day. Three volunteers were seated at fixed sites outside each house selected for indoor resting collection. The collected adults of *Anopheles* mosquitoes were identified and sexed. Larval density was assessed by counting the number of larvae collected by 10 repeated dips at 5 designated breeding sites at 2 or 3 day intervals during the trial period.

The results of the mosquito density assessment are shown in Table 1. In the assessment of larval density, the number of larvae decreased to zero on July 3 after the first larviciding and

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Table 1. Influence of ULV applications of *d*-allethrin and *d*-phenothrin in combination with larvicidings of fenitrothion on population density of *Anopheles* mosquitoes in Tanzania.

Date	Larval density[a]		Man-biting collection[b]				Resting collection			
	Untreated	Treated	Untreated		Treated		Untreated		Treated	
			A.g.[c]	A.f.[d]	A.g.	A.f.	A.g.	A.f.	A.g.	A.f.
June 20	—[e]	—	13	12	21	0	12/49[f]	3/6	1/38	0/3
July 1	61.3	39.4	39	19	42	0	31/35	0/0	10/22	0/1
3	31.8	0.0	8	15	3	1	8/52	9/5	2/3	0/1
5	29.6	0.0	—	—	—	—	31/124	4/4	0/12	0/1
7	32.5[g]	0.0[g]	34	27	8	3	25/93	12/20	1/13	0/1
10	29.0	18.8	20	21	4	0	2/12	0/1	0/1	0/1
12	32.0	20.5	—	—	—	—	25/87	6/13	0/9	0/5
14	22.0	9.3	21	27	10	0	22/77	2/10	0/23	0/2
17	31.8	2.8	21	0	1	0	49/100	5/10	0/4	0/0
19	41.2	4.5	—	—	—	—	52/66	3/1	0/5	0/2
21	29.5	2.0	13	15	8	0	27/57	1/4	3/13	0/1
24	34.8	4.3	7	9	1	0	19/23	2/2	2/4	0/0
30	53.2	2.3	27	3	0	1	110/24	15/22	1/1	4/0
Aug. 5	22.4	11.0	18	11	5	0	124/45	7/12	14/1	3/0
11	33.2	3.0	51	9	4	0	204/23	4/4	14/3	9/0

[a] The number of larvae per a designated breeding site, [b] The number of female adults, [c] *Anopheles gambiae* s.l., [d] *Anopheles funestus*, [e] Not observed, [f] Left; Male, Right; Female. [g] Data on July 9. ULV application date; July 2, 9, 16 and 27, 1987. Larviciding date; July 2, 23 and August 1, 1987.

remained there until July 9. From July 9 to 12, it gradually increased, but then decreased and remained low. The number of larvae collected by 10 repeated dips in the treated area never exceeded 20 during the remaining trial period. In the untreated area, the number of larvae collected by dipping was over 20 at all collection sites. Pretreatment outdoor man-biting collections of adults before starting the trial indicated that *An. gambiae* s.l. was the dominant species in the treated area, and *An. funestus* Giles and *An. gambiae* s.l. were more evenly distributed in the untreated area. However, the pretreatment sampling of the indoor resting collection differed from the results mentioned above. *Anopheles gambiae* s.l. was the dominant species in both the treated and untreated areas. This would indicate that *An. gambiae* s.l. was more endophagic than *An. funestus*. In a man-biting collection, the number of both mosquitoes decreased dramatically in the treated area on the day after the initial ULV application (July 3). The number of female mosquitoes caught did not exceed 10 per night for the whole trial period. The total number of mosquitoes from July 3 to August 11 was 49 and 357 in the treated and untreated areas, respectively. In the resting collection, both mosquitoes also decreased indoors on the day after the first ULV application (July 3) and the number of the female adults caught did not exceed 23 per night for the whole trial period. The total adults caught from July 3 to August 1 were 106 and 891 in the treated and untreated areas, respectively.

The immediate reduction of the mosquito adult density after the first ULV application was evidence of direct impact of the application on the population of *Anopheles* mosquitoes. However, subsequent low density of the adults during the remaining period may have been derived from the combined efficacy of the ULV and larvicide applications. The present trial revealed that ULV applications of *d*-allethrin and *d*-phenothrin combined with fenitrothion larvicidings can reduce population of *Anopheles* mosquitoes, and that these methods are useful for *Anopheles* mosquito control under the conditions of Dar es Salaam in Tanzania.

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