COMPARISON OF AN EXPERIMENTAL UPDRAFT ULTRAVIOLET LIGHT TRAP WITH THE CDC MINIATURE LIGHT TRAP AND BITING COLLECTIONS IN SAMPLING FOR *ANOPHELES ALBIMANUS* IN HAITI[1]

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ABSTRACT. Three methods of capturing *Anopheles albimanus* mosquitoes were compared during a field study in four villages in northern Haiti. Updraft ultraviolet (UV) light traps proved to be more effective than biting collections, regardless of season or whether the tests were done indoors or outdoors. Biting collections were in turn more effective than the Centers for Disease Control (CDC) miniature light traps. Updraft UV light traps and biting collections yielded more *An. albimanus* outdoors than indoors; the reverse was found for the CDC miniature light traps. The updraft UV light traps caught *An. albimanus* on 86% of the occasions used outside and 75% of the occasions inside. The biting collections were equally as successful as the traps in catching mosquitoes outside but caught *An. albimanus* only on 64% of the occasions when used inside houses. The CDC miniature light traps were successful in collecting *An. albimanus* on 33% of the occasions outside and 60% of the occasions inside.

INTRODUCTION

For many years, the New Jersey light trap and the CDC miniature light trap have been used for sampling certain mosquito species. Both these traps employ incandescent light. In recent years ultraviolet (UV) light traps have also been used with some success in mosquito studies. Service (1970) described mosquito capture studies with the Monks Wood downdraft trap and the CDC miniature light trap. Service used fluorescent white and ultraviolet light in the Monks Wood trap in Nigeria and Kenya and found that more *Anopheles funestus* Giles and *An. gambiae* s.l. were caught with the UV light than the white light. The CDC miniature light trap was found to be the least effective in capturing these mosquitoes.

Wilton and Fay (1972), who developed both experimental updraft and downdraft UV traps, demonstrated in laboratory studies that the updraft model was superior to the downdraft model in capturing of *An. albimanus* Wiedemann and *An. stephensi* Liston. In field studies in El Salvador, Wilton (1975a) experimented with another ultraviolet light trap developed at the U.S. Public Health Service Technical Development Laboratory, which he called the TDL/UV Trap. Although this trap could be operated in an updraft or downdraft position, the data indicated that the updraft position was superior in capturing *An. albimanus*. In comparing the TDL/UV updraft light trap with the New Jersey light trap and the CDC miniature light trap, the updraft UV trap was found to be the most effective and the CDC miniature light trap the least. Wilton (1975b), in another study, demonstrated that dry ice did not affect the number of mosquito species captured in the experimental TDL/UV updraft trap and the CDC miniature light trap, but did increase the total number of mosquitoes caught. Yet, the TDL/UV updraft trap without dry ice captured larger numbers than the CDC trap with dry ice. Taylor et al. (1975) further demonstrated the effectiveness of the TDL/UV updraft trap for capturing adult *An. albimanus* during a malathion ultralow volume (ULV) spray trial for controlling this mosquito in Haiti. Wilton (1984, personal communication) stated that he considered biting collections better than traps in capturing *An. albimanus*.

This study was part of a longitudinal study of the behavior of *An. albimanus*, in support of the Service National des Endemies of Haiti. Its purpose was: 1) to compare the effectiveness of another CDC experimental updraft UV light trap with those of the CDC miniature light trap and biting collections in capturing *An. albimanus* in northern Haiti, and 2) to determine whether this updraft UV light trap and/or the CDC light trap would be suitable replacements for biting collections when only density data are required. If traps, especially on all-night surveys, could replace biting collections, then such factors as fatigue, falling asleep, boredom, differences in human attractiveness, and supervision could be eliminated and the collectors used for other productive entomologic activities.

METHODS

CDC miniature light traps (Sudia and Cham-

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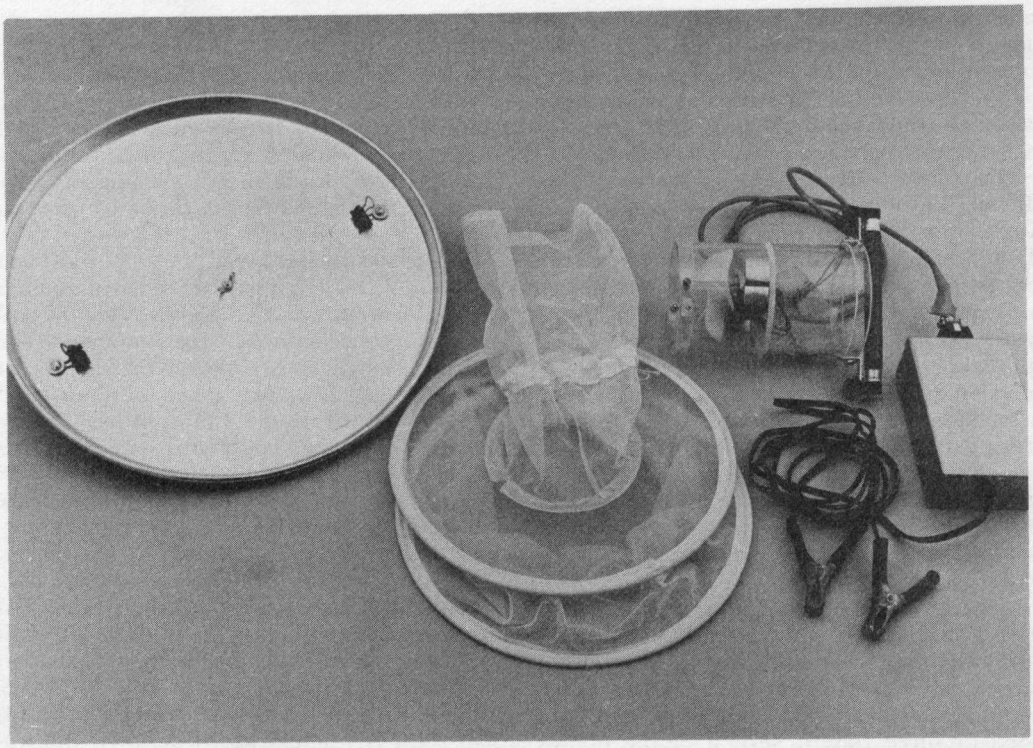

Fig. 1. Updraft ultraviolet light trap. Left to right: lid, catching bag, plastic trap body with motor and UV light, and ballast with battery leads.

berlain 1962) as modified by Johnston et al. (1973) for use with four D-size 1.5-volt dry cell flashlight batteries were used in the study.

Prototypes of the experimental updraft UV light traps used in the study were developed by D. P. Wilton at the Centers for Disease Control in 1979 but were never tested in the laboratory or used in the field for *An. albimanus* captures. This experimental model (Fig. 1) is a further simplification in construction of the traps described by Wilton and Fay (1972) and Wilton (1975a). Additional traps based on the prototype were constructed by J. D. Sexton. The trap body of the prototype was 8.3 cm in diameter and 15.2 cm long and made from a Plexiglas® cylinder. Slots and holes were cut into this body to hold the motor and frame for the lamp and for support rings. Subsequently, the body of the CDC miniature light trap was used. To use the CDC trap body, the D-size battery packs were cut off, the lamp mount was removed, and the 6-volt DC motor was taken out, reversed, and replaced so that the propellers created an updraft instead of a downdraft. Brackets were added to the bottom of the body so that a 15.2 cm 4-watt blacklight fluorescent lamp (peak emission near 3650 A) could be mounted horizontally across the entrance. The CDC trap lid was adapted for use with the UV trap by drilling two 0.3 cm holes, one on each side of the lid, approximately 2.5 cm in from the edge, and mounting two small binder clips with bolts and nuts on the inside of the lid. The bottom of the catching bag of the CDC trap was then placed against the inside of the lid and the two clips were snapped over the edge of the sack bottom. The bag opening was then slipped over the top of the trap body and tightened with the drawstring of the bag. The current for the 6-volt DC motor and fluorescent lamp was supplied by a 12-volt motorcycle battery of either 7 or 9 ampere. The fluorescent lamp was operated with a Trans-Bal[3] inverter ballast, and a 75-ohm resistor was used so the 6-volt motor could operate off the 12-volt battery.

The heavy-duty D-size dry cell batteries used in the CDC light traps were capable of running the traps all night (1800–0600 hr). New batteries were used for each all-night trial, but for the evening (1800–2100 hr) studies, the

[3] Model 12RS4CB/P, the Bodine Co., Collierville, TN 38017. The use of trade names and commercial sources is for identification only and does not constitute endorsement by the Public Health Service or the U.S. Department of Health and Human Services.

batteries were changed after 9 hr of use. Although normally capable of running the UV traps all night, the 12-volt motorcycle batteries for the updraft UV light traps were changed halfway through the night and recharged after each survey to eliminate possible problems.

The study area consisted of four villages (St. Michel, Lafond, Belle Hotesse and Morne Anglais) located near Cap Haitien in northern Haiti. St. Michel, Lafond and Belle Hotesse are located between the coast and the mountains, and Morne Anglais lies on a plain near the coast. These four villages have a population of approximately 2,000 people. The villagers depend on agriculture for their living (potatoes, vegetables, maize and rice). The mean annual precipitation for the Cap Haitien area is 1,684 mm. The rainfall patterns indicate two peaks, one in May and the other in November, but these peaks can be advanced or delayed depending on the weather patterns of that particular year.

In each village, 16 houses were chosen to serve as trap or biting collection sites based on their proximity to breeding areas. Most of the houses were constructed of mud over stick framing, had corrugated tin roofs, and consisted of three rooms. Several of the houses were constructed only of stick walls and thatch roofs. Four houses were randomly assigned for use as biting collection capture sites. Two of the houses were used for inside biting collections and two for peridomiciliary biting collections. Four houses were used for the updraft UV light traps, traps being placed indoors in two houses and outside of the other two houses. The remaining eight houses were used for the CDC miniature light traps, and four of these served as inside trap stations, and four as out of door trap sites. All inside traps were placed in bedrooms; the exterior traps were hung from a house rafter or in trees that were within 3 m of the house. All traps were hung so that their light source was approximately 1.5 m from the ground. The interior collectors sat approximately 1 m from the front door opening, while the exterior collectors sat within 1 m of the house, usually close to the front door. The inside and outside collectors exchanged places each hour to alleviate fatigue and boredom and to reduce any difference in the individual attractiveness. The collectors were protected by weekly chemoprophylaxis with chloroquine. The traps and collectors were located so that they did not interfere with each other. The same houses were used for the same activities throughout the study. The villages were visited bimonthly from September 1983 through September 1984.

RESULTS AND DISCUSSION

Twenty-one evening and 17 all-night observations were carried out during the year-long study. Three of the 4 study villages each had 4 all-night observations; the fourth had 5 observations. Two villages had 6 evening observations, one had 5, and the fourth had 4 observations.

COMPARISON OF THE THREE CAPTURE METHODS. Table 1 summarizes the total number of *An. albimanus* captured and the ratio of outside and inside captures by the 3 methods. The updraft UV light traps captured 6,258 (76%) of the 8,263 *An. albimanus* taken outdoors and 1,424 (48%) of the 2,969 captured inside houses. The biting collections accounted for 1,672 (20%) of the outdoor captures and 535 (18%) of the inside, and the CDC miniature light traps accounted for 333 (4%) of the outdoor collections and 1,010 (34%) of the *An. albimanus* caught inside. Analysis of these data by the Wilcoxon matched pairs signed rank test indicated that, exteriorly, the updraft UV light traps were significantly better ($p=0.014$) than the CDC miniature light traps and the collectors, while the collectors were better ($p = 0.014$) than the CDC light traps. Interiorly, the updraft UV light traps and CDC light traps were similar ($p = 0.173$) in catching *An. albimanus*, and both were better ($p = 0.014$) than the collectors. Table 1 also indicates the ratio of exterior to interior captures for the three methods. When the data for the evening and all-night collections were summarized, it was noted that the UV light traps and the human collectors captured 4.4 and 3.1 *An. albimanus* outside for every one inside, respectively, while the CDC trap information indicated the opposite. Only 0.3 *An. albimanus* were catpured outside for every one taken inside. Individually, the evening and all-night surveys showed similar results.

In El Salvador, Wilton (1975b) also found that the CDC trap captured more *An. albimanus* inside than outside, and suggested that this probably is related to the contrast between the light emitted by the trap and background illumination. Outside there is little contrast between the CDC light and background light, especially on moonlit nights. However, in a dark room the CDC light is attractive to mosquitoes. Yet, Odetoyinbo (1969) reporting on his work in the Gambia stated that the CDC light trap: 1) could be used to sample both endophilic and exophilic anophelines, 2) has an effective range of only 5 meters, 3) is effective because of the light source and not the air current, and 4) is effective only when the traps are placed close to

Table 1. Total number of *Anopheles albimanus* collected, and ratio of exterior to interior catches, Haiti, 1983–84.

Type of survey and date	Sampling method								
	UV light traps			CDC light traps			Biting collections		
	Total mosq.		Ratio ext. to int.	Total mosq.		Ratio ext. to int.	Total mosq.		Ratio ext. to int.
	Ext.*	Int.*		Ext.	Int.		Ext.	Int.	
Evening									
Sep. 1983	192	34	5.6	1	9	0.1	47	6	7.8
Dec. 1983	379	106	3.6	12	44	0.3	244	74	3.3
Feb. 1984	127	98	1.3	6	31	0.2	147	46	3.2
May 1984	94	29	3.2	41	18	2.3	68	19	3.6
Jul. 1984	100	60	1.7	1	7	0.1	73	67	1.1
Sep. 1984	120	13	9.2	4	4	1.0	0	0	0.0
Totals	1,012	340	3.0	65	113	0.6	579	212	2.7
All night									
Sep. 1983	71	21	3.4	0	20	0.0	19	4	4.8
Dec. 1983	579	105	5.5	88	273	0.3	465	75	6.2
Feb. 1984	251	47	5.3	13	70	0.2	12	5	2.4
May 1984	1,573	671	2.3	53	234	0.2	187	144	1.3
Jul. 1984	1,681	137	12.3	69	183	0.4	290	73	4.0
Sep. 1984	1,091	103	10.6	45	117	0.4	120	22	5.5
Totals	5,246	1,084	4.8	268	897	0.3	1,093	323	3.4
Summary of both surveys									
Sep. 1983	263	55	4.8	1	29	0.03	66	10	6.6
Dec. 1983	958	211	4.5	100	317	0.3	709	149	4.8
Feb. 1984	378	145	2.6	19	101	0.2	159	51	3.1
May 1984	1,667	700	2.4	94	252	0.4	255	163	1.6
Jul. 1984	1,781	197	9.0	70	190	0.4	363	140	2.6
Sep. 1984	1,211	116	10.4	49	121	0.4	120	22	5.5
Totals	6,258	1,424	4.4	333	1,010	0.3	1,672	535	3.1

* Exterior of house.
Interior of house.

the hosts or in the flight path of the anopheline seeking the host. As the UV light traps captured more *An. albimanus* than the CDC light traps inside as well as outside, and as the traps are similar in size, then the difference may be related to the light emitted and/or in the updraft or downdraft movement of the air current through the traps.

Table 2 compares the *An. albimanus* captured per trap/hour or man/hour by the updraft UV light traps, the CDC miniature light traps, and biting collections. The data indicate that the updraft UV light traps, both outside and inside, from both the evening and all-night captures, were better than the biting collections, and both these methods were superior to the CDC miniature light traps.

TRAP AND COLLECTOR EFFICIENCY IN CAPTURING *An. albimanus*. Table 3 indicates the number of occasions (%) the traps and collectors captured *An. albimanus* out of the total occasions used. The exterior updraft UV light traps and the collectors caught at least one *An. albimanus* on 86% of the occasions, while *An. albimanus* were found in the exterior CDC miniature light traps on 33% of the occasions. Inside houses the updraft UV light traps, CDC miniature light traps, and collectors captured *An. albimanus* on 75%, 60% and 64% of the occasions employed, respectively.

Chi square analysis at the 5% level showed that the efficiency of the updraft UV light traps and biting collections were similar, but both were significantly different ($p < 0.01$) exteriorly from the CDC miniature light traps. Interiorly, the UV light traps were significantly different ($p < 0.035$) from the CDC light traps, but the biting collections were not different.

MALE *ANOPHELES ALBIMANUS* CAPTURES BY THE TRAPS. Although it was not a study objective, neither trap proved effective for capture of male *An. albimanus*. Some 840 males were taken in the updraft UV light traps and 59 in the CDC miniature light traps. Sixty-three percent of the males caught in the CDC miniature light trap and 88% of the males caught in the updraft UV trap were collected outside. Of the 739 males taken outside by the updraft UV light traps, 83% were captured during only 5 of the 17 all-night collections.

The survival of the male and female *An. albimanus* taken by the traps was high. Although it was not quantitated, the survival rate was important, as many of the female mosquitoes were dissected for malarial oocyst and sporozoite detection.

CONCLUSIONS

The experimental updraft ultraviolet light trap used in this study proved to be a very effective means of collecting female *An. albimanus* mosquitoes. The results obtained with this trap, when compared with the standard biting collection method normally used in the malaria program in Haiti, demonstrated its superiority for vector density determinations. In addition, the high survival of the mosquitoes in the updraft UV trap would allow the use of

Table 2. *Anopheles albimanus* hourly catch rate in northern Haiti using updraft UV light traps, CDC miniature light traps and biting collections.

Type of survey and date	Sampling method: UV light traps, Mosquitoes/trap/hr, Ext.*	UV light traps, Int.*	CDC light traps, Mosquitoes-trap/hr, Ext.	CDC light traps, Int.	Collectors, Mosquitoes/man/hr, Ext.	Collectors, Int.
Evening						
Sep. 1983	4.9	0.8	0.01	0.1	1.2	0.2
Dec. 1983	24.5	6.7	0.4	1.3	20.3	6.2
Feb. 1984	5.1	4.0	0.1	0.6	8.2	2.6
May 1984	7.5	2.4	1.6	0.7	7.6	2.1
Jul. 1984	5.7	3.4	0.03	0.2	5.4	5.0
Sep. 1984	19.7	2.1	0.4	0.4	0.0	0.0
Totals	8.7	2.8	0.3	0.5	5.9	2.4
All-night						
Sep. 1983	0.8	0.2	0.0	0.1	0.3	0.06
Dec. 1983	8.0	1.4	0.6	1.9	8.6	1.4
Feb. 1984	5.2	1.0	0.1	0.7	0.3	0.1
May 1984	32.7	13.9	0.6	2.4	5.2	4.0
Jul. 1984	24.5	2.0	0.5	1.3	5.4	1.4
Sep. 1984	15.1	1.4	0.3	0.8	2.2	0.4
Totals	13.1	2.7	0.3	1.1	3.6	1.1
Summary of both surveys						
Sep. 1983	2.0	0.4	0.004	0.1	0.6	0.1
Dec. 1983	10.9	2.4	0.6	1.8	10.7	2.3
Feb. 1984	5.2	2.0	0.1	0.7	2.9	0.9
May 1984	27.5	11.6	0.8	2.1	5.7	3.6
Jul. 1984	20.7	2.3	0.4	1.1	5.4	2.1
Sep. 1984	15.4	1.4	0.3	0.8	2.1	0.4
Totals	12.1	2.7	0.3	1.0	4.2	1.4

* Exterior of house.
Interior of house.

Table 3. Effectiveness of traps and collectors in capturing *Anopheles albimanus* in the study villages near Cap Haitien, Haiti, 1983–84.

Survey method	Total occasions* method could have collected *An. albimanus*	Total occasions method actually captured *An. albimanus*	% of occasions *An. albimanus* collected
UV trap-ext.	76	65	86
UV trap-int.	76	57	75
CDC trap-ext.	152	50	33
CDC trap-int.	152	91	60
BC-ext.**	76	65	86
BC-int.	76	49	64

* Each trap or collector utilized on 38 occasions. There were a total of 2 UV traps outside and 2 inside, 4 CDC traps outside and 4 inside and 2 collectors outside and 2 inside.
** BC = Biting collections.

these mosquitoes for other purposes (e.g., dissection for sporozoites and oocysts) The CDC miniature light trap was the least effective method for *An. albimanus* collection and cannot be recommended for density studies of this species in Haiti.

The updraft UV light trap requires maintenance, possibly infrequent replacement of parts and a rechargeable battery. Nevertheless, the updraft UV light trap is still preferable to biting collections in catching *An. albimanus* as the traps do not require the supervision collectors do, and allow a program to use collectors for other purposes such as mapping breeding sites, larviciding and laboratory activities.

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