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EVALUATION OF LIGHT TRAPS COMBINED WITH CARBON DIOXIDE AND 1-OCTEN-3-OL TO COLLECT ANOPHELINES IN VENEZUELA

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ABSTRACT. A 6-month study was carried out in northcentral Venezuela to evaluate the efficiency of the CDC light trap and the updraft ultraviolet (UV) light trap combined with carbon dioxide (CO_2) or 1-octen-3-ol (or both) and human baits to sample outdoor *Anopheles aquasalis* and *Anopheles albimanus* populations. The human baits caught far more mosquitoes than did any of the other trapping methods. Comparing each of the trapping methods to the human bait catches, UV light trap + CO_2 gave a closer correspondence of the ratio of *An. aquasalis* to *An. albimanus* compared with the ratio found in human baits than did any of the other trapping methods. The mean parous rate was significantly lower in human bait catches than in all of the trapping methods except for *An. aquasalis* in UV light trap with CO_2. We consider the UV light trap with CO_2 to be the most reliable substitute for human bait catches.

INTRODUCTION

Anopheles aquasalis Curry and *Anopheles albimanus* Wied. are primary malaria vectors in tropical and subtropical coastal areas of the Americas (Rubio-Palis and Zimmerman 1996). Both species are exophagic and are most active between 1800 and 2100 h (Zimmerman 1992).

The most widely used methods for sampling adult females of *An. albimanus* have been animal-baited traps and nocturnal collections of resting mosquitoes in corrals (Lowe and Bailey 1981). More recently, Sexton et al. (1986) and Mekuria et al. (1990) found that ultraviolet (UV) light traps were superior to human bait catches and CDC light traps for catching *An. albimanus*. Wilton (1975) demonstrated that the updraft UV light trap was the most effective method of trapping *An. albimanus* in El Salvador compared with a downdraft UV light trap, a New Jersey light trap, and a miniature CDC light trap. Only one comparable study has previously been carried out on *An. aquasalis*, the mosquito being collected on human baits (Berti et al. 1993).

In entomological studies on malaria transmission and evaluation of vector control programs, it is necessary to estimate the human biting rate, i.e., the number of female mosquitoes per person per night. Thus, when evaluating trapping methods for anophelines, one must consider them in relation to human bait catches. There are ethical and practical reasons for wishing to minimize the use of human landing catches (Rubio-Palis and Curtis 1992).

In a search for a satisfactory method for sampling *An. albimanus* and *An. aquasalis* that would reduce the need to use human landing catches, a CDC light trap and an updraft UV light trap combined with carbon dioxide (CO_2) or 1-octen-3-ol (octenol) or both were compared with human landing catches of these anophelines in Venezuela.

MATERIALS AND METHODS

Study area: The study was carried out on a farm in Puerta Negra (10°06'N, 67°36'W), 20 km south of Maracay city on the eastern shore of Valencia Lake, Aragua State, in northcentral Venezuela. This area has an altitude of 442 m, an annual rainfall of 835 mm, a mean temperature of 25.6°C, and 75% RH (Fuerza Aérea Venezolana 1995[1]). The area is characterized by large sugar cane and banana plantations as well as cattle ranching.

Mosquito collections: Collections were carried out between 1830 and 2130 h, 3 nights per week every month between September 1994 and February 1995. Six collection stations, located 100 m apart and forming a cross with the farmhouse at the center, were established outdoors to test the following methods: 1) landing catches on 2 human baits, 2) a 12-V rechargeable-battery-operated updraft UV light trap (John W. Hock Co., Gainesville, FL), 3) UV light trap + CO_2, 4) UV light trap + octenol, 5) UV light trap + octenol + CO_2, and 6) a CDC light trap (Sudia and Chamberlain 1962). Each method was rotated each night with the intention that each collection method was tested at each site in each month, i.e., a total of 36 tests for each method. Dry ice (300 g) wrapped in newspaper and hung approximately 50 cm away from the

[1] Fuerza Aérea Venezolana. 1995. Datos Climatológicos. Base Aérea de Palo Negro, Estado Aragua.

Table 1. Number of anophelines collected in the locality of Puerta Negra, Aragua State, Venezuela during September 1994–February 1995 using 6 different methods (number of nights in parentheses).

	Method[1]					
	1 (36)	2 (35)	3 (35)	4 (34)	5 (27)	6 (34)
Anopheles albimanus	4,475	356	331	712	793	10
An. aquasalis	4,231	52	194	67	273	10
An. apicimacula	16	6	5	5	5	1
An. punctimacula	1	0	1	0	0	1
An. pseudopunctipennis	1	1	0	1	2	0
Unidentifiable	2	26	30	29	56	2
Males of *An. albimanus* and/or *An. aquasalis*	0	170	57	36	63	28

[1] 1, human baits; 2, updraft ultraviolet light trap (UVLT); 3, UVLT + CO_2; 4, UVLT + octenol; 5, UVLT + CO_2 + octenol; 6, CDC light trap.

UV light trap was used as a CO_2 source. The octenol (1 ml) was placed in a 2-dram vial and attached to the UV light trap near the entrance. The vial was open in order to allow the evaporation of the octenol at an estimated rate of 92 ± 15 µl/h under field conditions (mean temperature 23.2°C and 91% RH). The following morning mosquitoes were killed, identified, counted, and dissected for parity by the Detinova (1962) technique, i.e., presence or absence of tracheolar skeins.

Analysis of data: Correlation analysis and unconditional logistic regression analysis were carried out on data transformed to $\log(n + 1)$ using the program GLIM 4 (Royal Statistical Society, London).

RESULTS

Anopheline catches: During the study, 5 species of anophelines were collected: *An. aquasalis, An. albimanus, An. apicimacula* Dyar and Knab, *An. punctimacula* Dyar and Knab, and *An. pseudopunctipennis* Theobald (Table 1). About 5% of the females caught in the different traps were unidentifiable because they were damaged by the trap

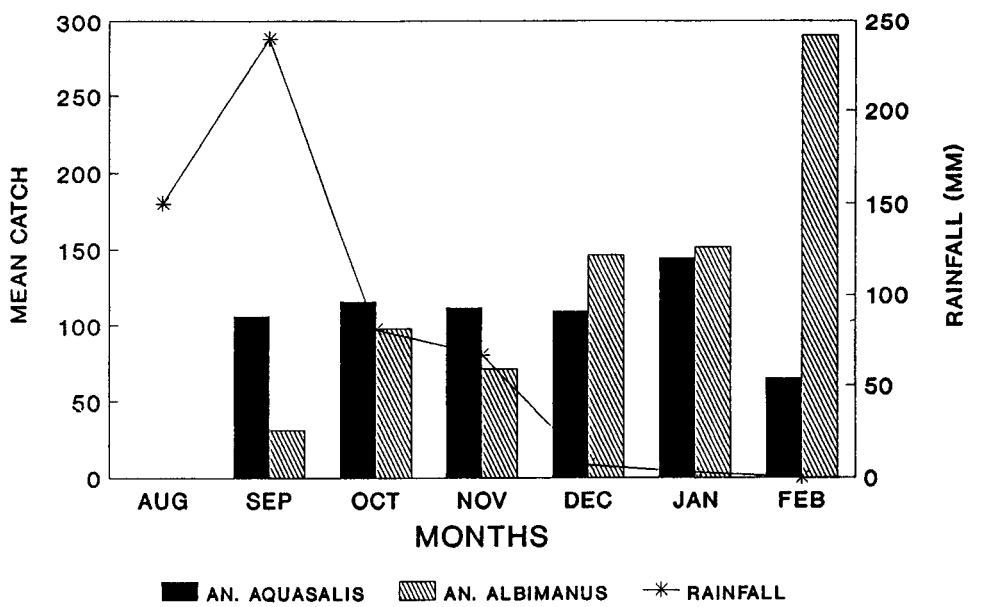

Fig. 1. Catches of *Anopheles aquasalis* and *An. albimanus* on human bait in relation to rainfall between August 1994 and February 1995.

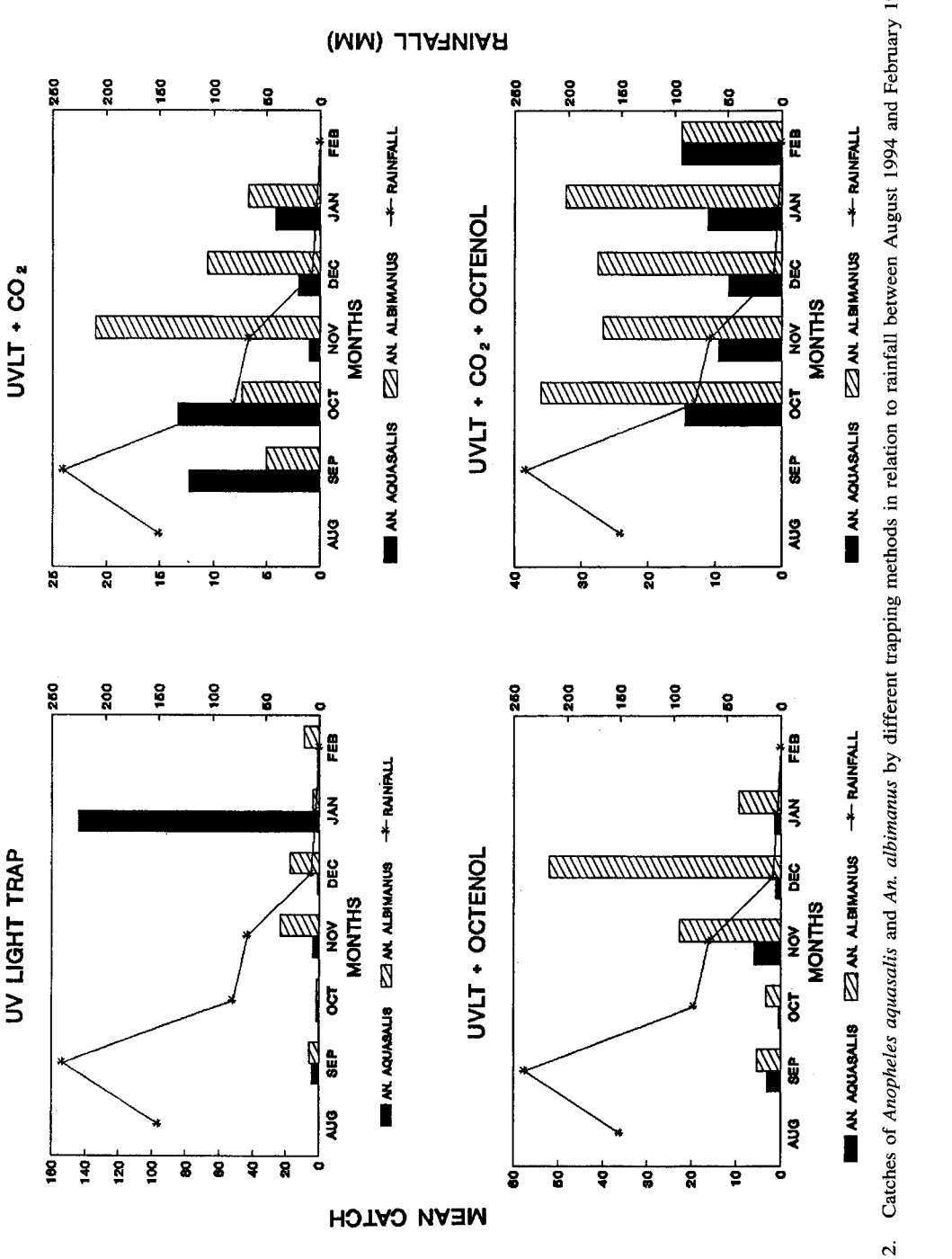

Fig. 2. Catches of *Anopheles aquasalis* and *An. albimanus* by different trapping methods in relation to rainfall between August 1994 and February 1995.

Table 2. Unconditional logistic regression of the odds ratios of the number of *Anopheles aquasalis* and *An. albimanus* caught by updraft ultraviolet light trap (UVLT), UVLT + CO_2, UVLT + octenol (oct), and UVLT + CO_2 + oct in relation to the numbers collected on human baits. Data were transformed to log(n + 1).

Method	*An. aquasalis*		*An. albimanus*	
	Odds ratios	95% confidence limits	Odds ratios	95% confidence limits
UVLT	0.040	0.038, 0.043	24.50	23.09, 26.16
UVLT + CO_2	0.619	0.606, 0.634	1.61	1.58, 1.65
UVLT + octenol	0.028	0.027, 0.029	35.20	34.17, 36.44
UVLT + CO_2 + oct	0.236	0.233, 0.239	4.23	4.18, 4.29

fans. The most common species were *An. aquasalis* and *An. albimanus*. A larger proportion of males was caught (30%) by the UV light trap alone than when used in combination with the attractants CO_2 and octenol (less than 9%), whereas 76% of the mosquitoes collected in the CDC light trap were males. Fewer anophelines were collected in any of the traps than by human landing catches. The CDC light trap collected only 24 anopheline females and was not included for further statistical analysis. There were fewer observations with light traps than with human baits because of trap failures.

Figures 1 and 2 show the mean monthly number of *An. aquasalis* and *An. albimanus* collected by each method in relation to rainfall. Correlation analysis of the log-transformed mean number caught with rainfall showed significant negative relationships for catches of *An. albimanus* on human baits ($P = 0.01$) and a significant positive relationship of *An. aquasalis* in UV light traps ($P = 0.04$). All other correlations were insignificant ($P > 0.5$).

In order to estimate the relative efficiency of each method to catch the most common species compared with human landing catches, a logistic regression model was used. With this model we estimated the adjusted odds ratios (Kirkwood 1988), i.e., $[p_2/(1 - p_2)]/[p_1/(1 - p_1)]$, where p_2 is the proportion of *An. aquasalis* or *An. albimanus* in the total female catch of these 2 species in a trap and p_1 is the corresponding proportion of catches off human baits. As shown in Table 2, the odds ratios for *An. aquasalis* were significantly less than one with the trapping methods but closest to one with UV light trap + CO_2. Conversely, the odds ratios for *An. albimanus* were significantly more than one with all trapping methods but closest to one with UV light trap + CO_2. Thus all trapping methods overrepresented *An. albimanus* relative to *An. aquasalis,* but the representation of the human bait populations was better with the UV light trap + CO_2 than with any of the other trapping methods.

The total catch of *An. albimanus* was increased by the use of octenol (Table 1 and Fig. 2), but the catch of *An. aquasalis* was unaffected by the addition of octenol.

Parous rate: A total of 6,705 anophelines collected during the study were dissected and their parity was determined (Table 3). In general, the parous rate observed was significantly higher in *An. aquasalis* and *An. albimanus* collected in the traps than on human baits, except in *An. aquasalis* collected in UV light trap + CO_2 (Table 4).

DISCUSSION

Anopheles aquasalis and *An. albimanus* are the commonest species present in the selected

Table 3. Parous rates of *Anopheles albimanus* and *An. aquasalis* caught by different methods (sample sizes in parentheses).

Method	*An. albimanus*	*An. aquasalis*
Human bait	31.6% (2,503)	32.6% (2,500)
UVLT[1]	74.5% (245)	62.1% (34)
UVLT + CO_2	59.4% (221)	26.9% (76)
UVLT + octenol	69.2% (424)	73.2% (46)
UVLT + CO_2 + octenol	59.8% (433)	44.8% (209)
CDC light trap	85.7% (7)	50.0% (7)

[1] Ultraviolet light trap.

Table 4. Unconditional logistic regression of the odds ratios of the parous rates of *Anopheles aquasalis* and *An. albimanus* caught by updraft ultraviolet light trap (UVLT), UVLT + CO_2, UVLT + octenol (oct), UVLT + CO_2 + oct in relation to the parous rate in mosquitoes caught on human baits.

Method	*An. aquasalis*		*An. albimanus*	
	Odds ratios	95% confidence limits	Odds ratios	95% confidence limits
UVLT	2.95	1.33, 6.55	5.03	3.58, 7.08
UVLT + CO_2	0.80	0.45, 1.41 (ns)	2.55	1.84, 3.54
UVLT + octenol	6.64	3.09, 14.30	4.58	3.63, 5.79
UVLT + CO_2 + oct	1.88	1.37, 2.58	2.66	2.12, 3.36

study area in northcentral Venezuela, where malaria was eradicated in the 1940s by environmental sanitation and indoor house spraying with DDT (Gabaldon and Berti 1954). At present, coastal malaria persists in the eastern part of the country where the incriminated vector is *An. aquasalis* (Dirección de Endemias Rurales 1995[2]).

The present study showed that no trapping method caught as many mosquitoes as did the use of human baits. The updraft UV light trap + CO_2 is the most promising collection method that can substitute for human landing catches for monitoring adult populations of *An. aquasalis,* however, because proportions of mosquitoes caught and their parity were more nearly comparable with those of the man-biting population. These results contrasted with those reported by Sexton et al. (1986) and Mekuria et al. (1990), who found that larger numbers of *An. albimanus* were collected in UV light traps without CO_2 than on human baits.

The use of light traps in combination with CO_2 or octenol or both to attract *An. aquasalis* failed to show the synergistic effect reported by Kline (1994) for other mosquito species. In the present trial, there was some evidence for an increase in the catch of *An. albimanus* by the use of octenol (Table 1 and Fig. 2), but the poor correspondence of the ratio of the 2 species and of the parous rates compared with those from human bait collections led to the conclusion that octenol is best omitted as an attractant when working with *An. aquasalis* and *An. albimanus.*

In a preliminary survey in a hyperendemic falciparum malaria area in the Upper Orinoco River (02°50′N, 65°14′W), an updraft UV light trap hung inside dwellings where some people were protected by bednets and run from 1800 to 0600 h collected about the same number of *Anopheles darlingi* Root as in simultaneous catches on 2 Amerindians sleeping in their hammocks. These preliminary results are encouraging for further investigations using light traps to sample populations of *An. darlingi,* the most efficient malaria vector in the Amazon Basin.

[2] Dirección de Endemias Rurales. 1995. Boletín Epidemiológico del Programa de Erradicación de la Malaria.

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