ANALYSIS OF COMPARATIVE EFFECTS OF SELECTED CO_2 FLOW RATES ON MOSQUITOES USING CDC LIGHT TRAPS

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The use of carbon dioxide as an attractant in light traps to determine adult mosquito population indices and to collect large numbers of species associated with disease transmission has been previously studied. Headlee (1943), Reeves (1951), and Reeves and Hammon (1942) made field studies showing that various mosquito species were attracted to carbon dioxide gas. Results of tests reported by Newhouse *et al.* (1966) indicated that the total number and variety of mosquitoes collected with light traps baited with carbon dioxide were significantly greater than those unbaited. A subsequent study by Carestia and Savage (1967) confirmed that carbon dioxide increased the total number of mosquitoes caught and provided a greater variety of species. A more extensive and precise study was undertaken to determine the minimum flow rate of carbon dioxide needed to effect an increase in mosquito collection rate.

The evaluation was divided into three replicate experiments (Phases I, II and III) conducted near the Van Bibber Water Treatment Plant, Edgewood Arsenal, Md. from May 1 through August 3, 1967. Each phase consisted of twelve "trap nights," with traps operated from 4:30 p.m. to 8:00 a.m. the following day. The trap sites were adjacent to wooded lots of a

seepage swamp and flood plain succession. Twelve CDC Miniature Light Traps, of the type used by Sudia and Chamberlin (1962) were employed; however, they were modified by removing the motors and replacing them with 6-volt motors.[1]

Traps were placed in two parallel rows, 30 yards apart (Fig. 1). The distance

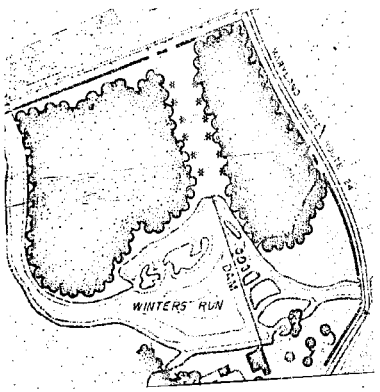

FIG. 1.—Van Bibber water treatment plant, wood Arsenal, Maryland, showing light trap sites (*).

between adjacent light traps in each row was 30 yards. Carbon dioxide was supplied by 50-pound compressed gas cylinders and released through a regulator;[2] the flow was further reduced and controlled by a micro-needle valve with a hose connection. Tygon tubing, 5/16 inch ID, conveyed the carbon dioxide gas to the mouth of the trap. Flow rates selected were 25, 50, 125 and 500 cc per minute. Variations in flow rates during Phases I and II were minimized by placing a Matheson 410x check valve between the regulator and micro-valve. All traps were powered by 6-volt wet cell batteries. A 1-pint mason jar with potassium cyanide was used as a killing container on all traps. Five traps without light and five traps with light were baited with carbon dioxide, while two traps, one with light and one without light remained unbaited. Variables of light and carbon dioxide flow were applied to trap sites by randomization. Each morning the flow rates were calibrated with a Matheson Flowmeter[3] and a F&P Precision Bore Flowerater.[4] The mean flow was obtained from the average of the original and final flow. (Table 1).

TABLE 1.—Calculated mean flow rates of carbon dioxide

	Release rate (cc/minute)				
	25	50	125	250	500
Phase I	15	33	76	156	377
Phase II	20	36	85	179	391
Phase III	25	50	121	242	490

Data obtained on nights that equipment failed to function properly were excluded.

Tables 2 and 3 show that all light traps baited with carbon dioxide attracted a greater number of adult mosquitoes than unbaited traps. During Phase I, 254 specimens comprising six species, *Aedes canadensis* (Theobald), *Aedes cantator* (Coquillett), *Anopheles punctipennis* (Say), *Culex erraticus* (Dyar and Knab), *Culex restuans* Theobald and *Culex salinarius* Coquillett, were collected. Mosquito populations during this period, May 1–May 12, were at their lowest levels. During Phase II, June 5–June 16, 15 species were trapped and 5 of these species were caught every night. They were: *A. canadensis, A. cantator, Aedes vexans* (Meigan), *C. restuans* and *C. salinarius*. The total catch for this period was 5,427 mosquitoes. Mosquito populations during Phase III, July 17–August 3 were at their highest peaks and 18 species were collected, of which *A. vexans, An. punctipennis, Culex pipiens* Linnaeus, *C. restuans* and *C. salinarius*, were caught on all

[1] Barber Coleman Motor (Model #BYQM 2184).

[2] Matheson, single stage, general purpose regulator (Model #1P—320).

[3] The Matheson Co., Inc. tube size R–2–15–AA.

[4] Fischer and Porter Co. Flowrator tube #01–150/S–51801.

TABLE 2.—Total number of female mosquitoes collected at calibrated flow rates of CO_2 per minute.

Species	0	25cc	50cc	125cc	250cc	500cc
Aedes						
canadensis	6	14	32	86	364	424
cantator	46	137	311	605	755	1603
mitchellae	..	..	1	..	..	..
triseriatus	1	3	1	8	5	8
vexans	62	124	282	455	1011	1752
Anopheles						
barberi	..	..	..	1	..	..
crucians	..	..	..	1	6	..
punctipennis	25	20	37	57	207	336
quadrimaculatus	8	1	8	9	11	21
walkeri	..	..	..	1	2	..
Culex						
erraticus	..	..	..	..	1	..
pipiens	32	62	71	150	163	149
restuans	94	112	139	174	210	205
salinarius	574	870	1434	2432	3926	4530
Culiseta inornata	..	1	..	..	..	..
Mansonia perturbans	..	1	1	2	..	7
Psorophora						
ciliata	..	..	..	..	..	1
confinnis	1	..	..	..	1	1
ferox	2	..	3	11	13	28
howardii	4	1	1	3	4	5
Uranotaenia sapphirina	..	..	1	..	2	..
Total:	855	1346	2322	3995	6681	9070
Mean per trap	23.8	37.4	64.5	111.0	185.6	251.9

nights. A total of 18,507 mosquitoes were trapped. Five species, *Aedes mitchellae* (Dyar), *Anopheles walkeri* Theobald, *C. erraticus, Psorophora howardii* Coquillett and *Uranotaenia sapphirina* (Osten Sacken) were collected exclusively in lighted traps.

Throughout the evaluation the significance of carbon dioxide was shown at the 5 percent level and in Phases II and III also at the 1 percent level. During Phase III traps with light showed significance at the 1 percent level (Fig. 2).

TABLE 3.—Significance of variables applying latin square.

Source of variation	Degrees of freedom	Phase I	Phase II	Phase III
Treatments	11	1.35	5.62**	9.02**
Light	1	0.16	1.25	22.98**
CO_2	5	2.51*	11.46**	13.75**
Interaction	5	0.44	0.67	1.49

* Significance at the 5% level.
** Significance at the 1% level.

The minimum flow rate of carbon dioxide needed to obtain the maximum mosquito collection rate was determined by using the standard deviation method. These calculations demonstrated that a CO_2 release rate of 125 cc per minute was significant at the 5 percent level in all phases and significant at the 1 percent level in Phases II and III. Considering the variation in flow in Phases I and II, the minimum flow which attracted a significant increase of mosquitoes lies between 75 and 125 cc per minute.

It is important to note that all light traps baited with carbon dioxide without a light source trapped only mosquitoes, whereas all other lighted traps collected a variety of insects, i.e., beetles, moths and flies (sandflies, midges, gnats).

CONCLUSIONS. The total number of mosquitoes trapped in the CDC Miniature Light Trap may be significantly increased

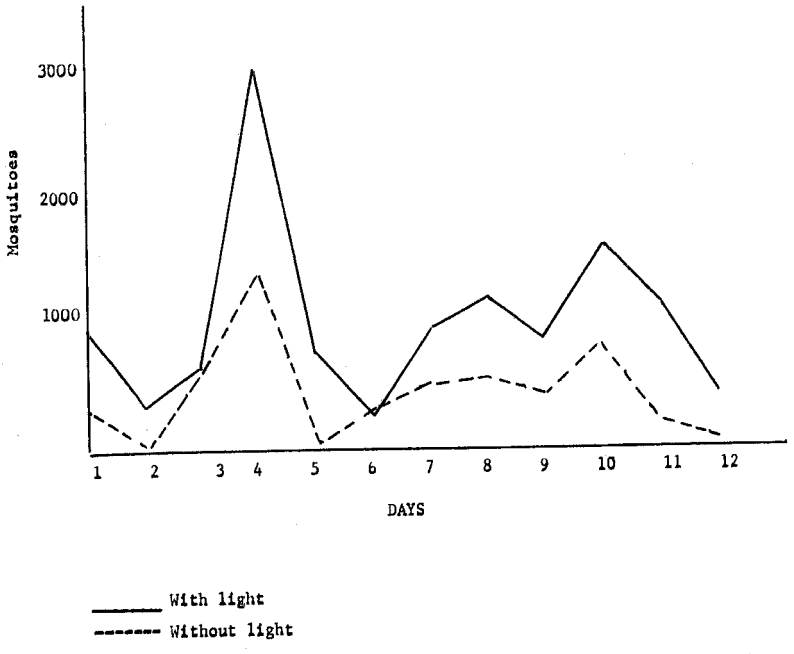

FIG. 2.—Comparative numbers of female mosquitoes caught in lighted and unlighted CO_2 baited traps during Phase III.

by the addition of carbon dioxide at the minimum flow rate of 125 cc per minute. The use of carbon dioxide in conjunction with light in the traps resulted in an increase in the number of species of mosquitoes collected. Mosquito separation and identification can be simplified tremendously using a trap with carbon dioxide and no light.

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