THE RANGE OF EFFECTIVENESS AND TRAPPING EFFICIENCY OF A PLEXIGLASS MOSQUITO TRAP BAITED WITH CARBON DIOXIDE[1]

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ABSTRACT. When ramp-traps were used to intercept mosquitoes flying toward a plexiglass trap baited with carbon dioxide, the plexiglass trap proved to be effective in an area about 120 feet in radius. Also, the mosquitoes generally flew upwind to the baited traps. The carbon dioxide attracted mosquitoes to within a few feet of its source, and the plexiglass trap caught them; a duplicate wooden trap did not.

The mosquito species collected were predominantly *Culex salinarius* Coquillett, *Coquillettidia perturbans* (Walker) and *Psorophora confinnis* (Lynch-Arribálzaga).

At some time the inventiveness of many an entomologist has been tested when he tried to build a better mosquito trap, and consequently, much has been published on the subject.

Unfortunately, our knowledge about why a trap catches mosquitoes is still quite meager. In the present paper, we attempt to contribute to that knowledge. Our study was inspired by the experiments of Gillies and Wilkes (1969, 1970) and by observations we made when we tested a plexiglass mosquito trap in 1969 (Schreck *et al.* 1970). The objectives were three-fold: to determine how large an area the plexiglass trap sampled; to establish whether some mosquitoes approached the trap but did not enter; and to determine what effects wind and weather have on trapping studies.

MATERIALS AND METHODS

All tests were made on an open grassy field on the grounds of the Insects Affecting Man and Animals Laboratory at Gainesville, Florida.

Either a plexiglass or a wooden trap was used as the center point of the study area. Then 16 ramp-traps (constructed of wood with green fiberglass screening as described by Gillies (1969)) were arranged around the center trap. See Figures 1 and 3.

The ramp-traps were used to collect mosquitoes flying toward the centrally located attractive source. Since only one side (approximately 12 feet^2) of these unidirectional traps is open to receive flying insects, and since the openings faced out from the center of the circle (to within 4½ feet of the ground), insects flying toward the center encountered the trap opening and were caught. For example, a mosquito flying out of the east in a straight path toward the center of the circle would encounter a ramp trap and be caught before reaching the trap at the center. However, if the mosquito missed the ramp-trap, it would probably be caught in the center trap.

A wind direction indicator and recorder (Taylor Windscope® No. 3105 and Rustrak miniaturized chart recorder) together with a hygrothermograph were set up within 150 feet of the center of the test area so that an hour to hour monitoring of temperature, relative humidity, and wind direction was obtained during the test. All tests were started at 1630 and continued until 0800 hours the following day. Carbon dioxide was released into the central trap at the rate of 1 liter per minute. Also, a plexiglass check trap similarly baited with carbon dioxide was operated about 200 yards from the test area during all tests.

Mosquitoes were collected from all traps

[1] This paper reflects the results of research only. Mention of a commercial or proprietary product in this paper does not constitute a recommendation or an endorsement of this product by the U. S. Department of Agriculture.

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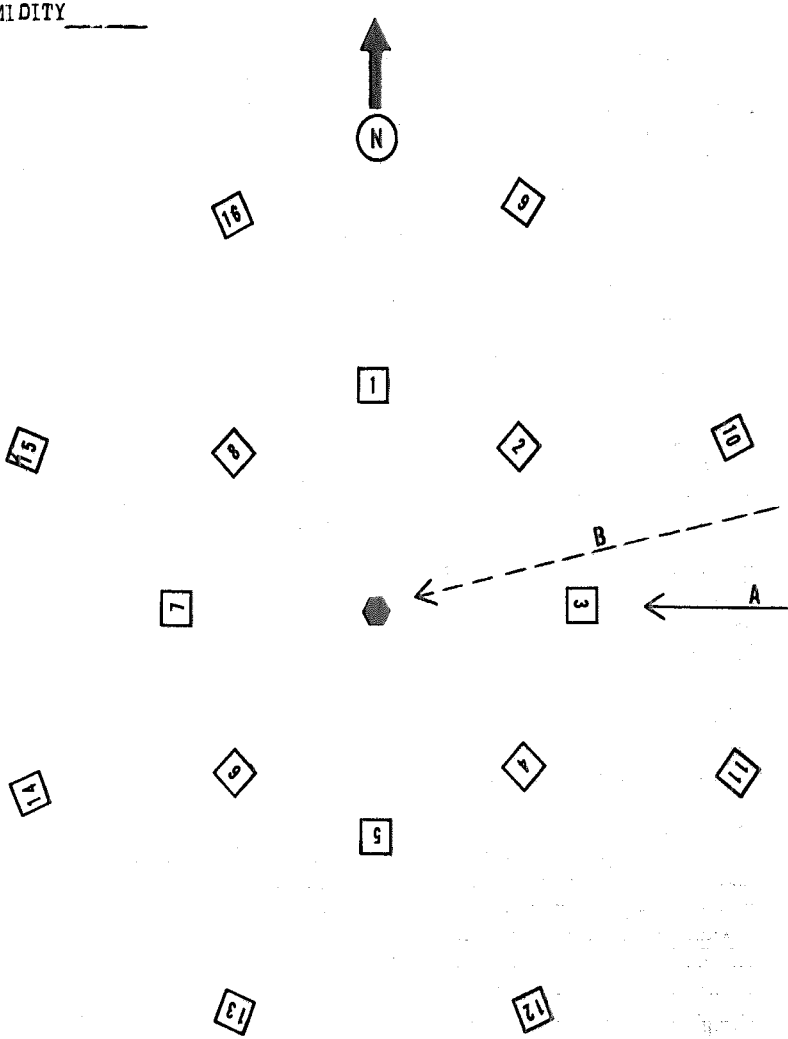

FIG. 1—Arrangement of traps for Series I showing center trap and location of ramp-traps around it. Arrow A shows path of a mosquito flying out of east on a direct path to the center circle; it would be caught by ramp-trap 3. Arrow B shows that a mosquito flying a few degrees north or south of trap 3 would miss the ramp-trap and be caught in the center trap.

with an aspirator and placed in numbered containers. Collections from each ramp-trap and from the test and the check plexiglass traps were counted and identified in a low-temperature room in the laboratory.

RESULTS AND DISCUSSION

The predominant species present in the study area were *Culex salinarius* Coquillett, *Coquillettidia perturbans* (Walker) and *Psorophora confinnis* (Lynch-Arribálzaga). When the center traps were operated without carbon dioxide, they caught no mosquitoes and only a very few (average of 0.34 per trap for 10 tests) were caught in the ramp traps. Thus, random flight of mosquitoes in the test area was of little consequence in this study, and background activity was not taken into account in this study as it was in tests reported by Gillies and Wilkes (1969).

SERIES I. In the Series 1 tests (made in April and May 1971) identical wood or plexiglass traps (Schreck *et al.* 1970) were tested on alternate or successive nights at random and regardless of weather, in an attempt to assure an unbiased sample. The test with each trap was replicated 10 times. The 16 ramp-traps were arranged in two circles of eight traps, one at 15 and one at 30 feet from center of the circle. The inner circle was arranged so that the traps were situated at compass directions north (N), northeast (NE), east (E), south (S), southeast (SE), southwest (SW), west (W), and northwest (NW) of the center trap; the outer circle was arranged so the traps did not block one another, i.e., NNE and ENE, etc. (Fig. 1). With this configuration, the traps were able to sample mosquitoes in a circle 60 feet in diameter. Results are given in Table 1.

Although the total numbers of mosquitoes (number in test trap plus number in ramp-traps) caught when the wood and plexiglass traps were used were about the same as the number caught in the check, the distribution of trapped mosquitoes differed considerably. The wood trap was ineffective (an average of one mosquito was trapped per test in the 10 replications), but the ramp-traps caught 135. Thus, the average total (136) was slightly lower than the total from the check (163). The plexiglass trap caught an average of 97 mosquitoes, about half the average number (199) caught in the ramp-traps; thus the total number trapped (296) averaged slightly higher than the average for the check (268). Apparently, the plexiglass check trap caught nearly all the mosquitoes that came within its range. The data also indicated that the species caught in both areas were comparable though *C. perturbans* and *Anopheles crucians* Wiedemann were caught more readily in the ramp-traps, and that the plexiglass trap provided a reliable sample of the mosquito species in the area.

TABLE 1.—Mosquitoes trapped in competitive tests with wood and plexiglass traps baited with carbon dioxide and ramp-traps (average of 10 tests). Series I.

Test trap	No. of mosquitoes trapped	
	Average	Range
Center plexiglass trap		
Plexiglass trap	97	7–265
16 ramp-traps	199	91–359
Total	296	
Check (plexiglass trap)	268	49–596
Center wood trap		
Wood trap	1	0–6
16 ramp-traps	135	68–208
Total	136	
Check (plexiglass trap)	162	36–336

SERIES II. Since the wood trap was ineffective, Series II was made to determine how close mosquitoes approached the wood trap and whether all those that approached the plexiglass trap were actually caught. To accomplish this, four box-traps (similar in design to the ramp-trap) were constructed of wood and green fiber-glass screening (Fig. 2); each trap was 46.5 inches wide by 49 inches high and 10 inches deep, and each had a ramp and baffle. These traps were positioned

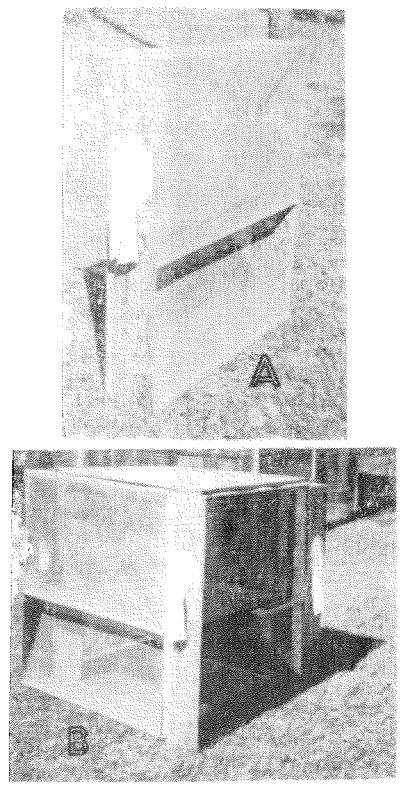

FIG. 2.—Box-traps. A—single box; B—4 box traps assembled around center trap.

upright in a square around the central trap (backs 28 inches from it) with the four fronts facing the four points of the compass. Also, the central trap was enclosed with a cover of screen and wood. Thus, mosquitoes attempting to get to the baited test trap were caught in the box-traps.

In addition, the ramp-traps were rearranged because the Series I tests had shown that the prevailing winds were SSW, SW, and WSW. Therefore, to obtain best use of the test area and to determine the distance mosquitoes can detect the carbon dioxide baited plexiglass trap, we used five new ramp-traps and relocated the seven in the SW quadrant of the circle. Thus, 12 more ramp-type traps were placed in the NE quadrant in three additional concentric rows so five concentric rows of ramp-traps were arranged in a wedge-shaped pattern in this quadrant (Fig. 3). The first and second rows were still 15 and 30 feet from the center point, but rows 3, 4, and 5 were 60, 90, and 120 feet distant, respectively. The tests were made in late June and July as in Series I. The results of the nine replications are given in Table 2.

The average total number of mosquitoes (test trap plus ramp-traps) caught in the wood or plexiglass configurations were somewhat higher than the average caught in the check. Thus, some mosquitoes may fly by or the additional ramp-traps located at a greater distance from the attractive source may be more efficient in removing the mosquitoes before they reach the center trap. However, the average number of mosquitoes caught in all tests in Series II (Table 2) was much less than in Series I, presumably because Series II was conducted when the mosquito population had declined from the earlier peak in April and May.

The results indicated that the wood trap baited with carbon dioxide did attract

TABLE 2.—Mosquitoes trapped in competitive tests with wood and plexiglass traps baited with carbon dioxide and enclosed with 4 box traps (average of 9 tests). Series II.

Test trap	No. of mosquitoes trapped	
	Average	Range
Center plexiglass trap		
Box-traps around plexiglass trap	25	2–45
21 ramp-traps	14	6–28
Total	39	
Check (plexiglass trap)	29	5–48
Center wood trap		
Box-traps around wood trap	19	0–57
21 ramp-traps	17	3–36
Total	36	
Check (plexiglass trap)	25	6–36

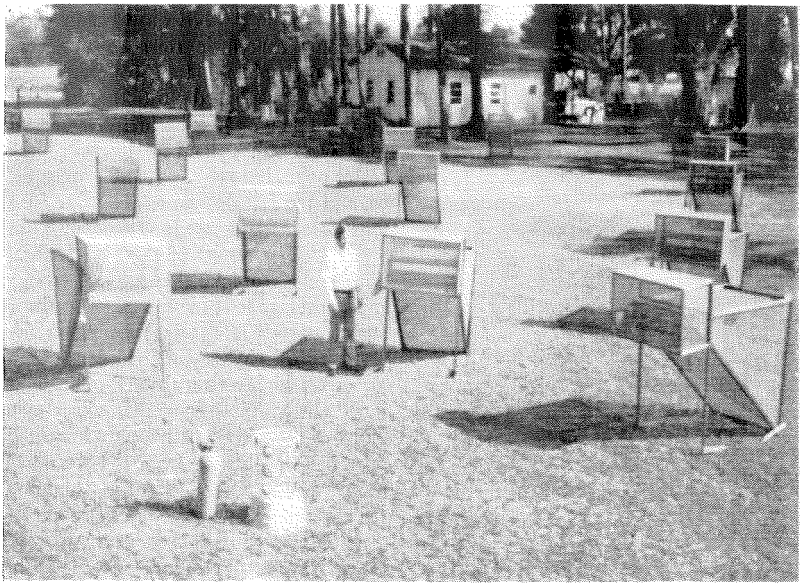

FIG. 3.—Ramp-traps arranged in wedge-shaped pattern.

the mosquitoes but that they turned away within the last 2 feet or less and did not enter the trap. The mosquitoes did not turn from the plexiglass trap and were caught.

An analysis of 22 tests selected from Series II (during favorable wind direction since all points of the compass were not covered) showed that 92 percent of the mosquitoes were trapped within 60 feet of the source of carbon dioxide, 5 percent were caught at 90 feet, and 2 percent were caught at 120 feet. Furthermore, analysis of all data (including preliminary tests) collected March 1971 through August 1971 (78 replications) showed that collections in all ramp-traps plus those in the plexiglass trap baited with carbon dioxide averaged 165.46 mosquitoes per test; the average for the baited plexiglass check was 164.09 mosquitoes per test (Table 3). The area of effectiveness around a plexiglass trap baited with carbon dioxide is therefore not much more than 120 feet in diameter. This result is in general agreement with results reported by Gillies and Wilkes (1970).

TABLE 3.—Total numbers of mosquito species caught in baited plexiglass and wood traps, in ramp-traps, and in check (baited plexiglass) traps (total of 78 tests).

Mosquito species	Trap type: Plexiglass or wood [a] (at center)	Ramp	Check
Culex salinarius	3414	5501	9911
Psorophora confinnis	1231	148	1131
Coquillettidia perturbans	201	973	417
Anopheles crucians	20	61	19
Anopheles quadrimaculatus	3	1	4
Aedes infirmatus	6	18	3
Psorophora ciliata	4	1	1
Average no. trapped	69.70 + 95.76 = 165.46		164.09

[a] Data for plexiglass and wood traps were combined since wood trap catches were so low (average 9.9) though concurrent ramp-trap catches were comparable to the catches in the plexiglass check.

Finally, the studies demonstrated that with average conditions of temperature and humidity, the mosquitoes made a predominantly upwind fight to the baited traps, regardless of the wind direction.

Heavy rain, high winds, or low temperature curbed activity, and a drop in temperature below 56° F reduced activity markedly. However, some activity was still evident on cool nights. For instance, on March 31, 1971, NNW winds produced temperatures of 58, 55.5 and 54.0° F at 1900, 2000, and 2100 hours, respectively, and the overnight low was 36° F. Still, 27 *C. salinarius* and one *A. crucians* were trapped. Also, there was evidence that the distribution of the catch in the ramp-traps showed some variability and slightly less correlation with wind direction when the plexiglass trap was used. With the wood trap, the distribution showed more directed upwind flight toward the carbon dioxide source. Although not conclusive, the results indicate that factors other than olfaction may be used by mosquitoes to detect the plexiglass trap emitting carbon dioxide.

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OBSERVATIONS OF GROUND ULV APPLICATIONS IN CHATHAM COUNTY, GEORGIA

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Recent studies of mosquito adulticiding indicate that ground ultra low volume (ULV) cold aerosol applications have great promise. Mount *et al.*, (1970) obtained higher kills with ULV than with conventional high volume thermal aerosols using malathion as a toxicant. Certain nontoxic advantages make this concept even more desirable and subject for consideration. Lower cost, less traffic hazard, and less environmental contamination, which the machines contribute (Taylor and Schoof, 1971), are of vital concern to those involved in mosquito control.

The success of earlier tests led the Chatham County Mosquito Control Commission to evaluate ULV cold aerosols for use in its program. The Commission has a continuing adult salt-marsh mosquito problem due to man-made breeding sites which permit only limited source reduction. Adulticiding applications are a very necessary part of the mosquito control program in areas affected by these salt-marsh mosquitoes. The availability of a tested production model ULV aerosol generator, coupled with the labeling of malathion for use in ground ULV work by the Environmental Protection Agency, encouraged the Commission to make final plans for ground ULV usage in 1971.

METHODS AND MATERIALS. The Chatham County Mosquito Control Commission, since its inception in 1957, has used thermal aerosol generators, employing