

AN EXPERIMENTAL PLEXIGLAS® MOSQUITO TRAP UTILIZING CARBON DIOXIDE¹

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ABSTRACT. A promising new octagonal mosquito trap is constructed of Plexiglas® and has three funnel openings in each of four opposite sides to allow air movement. When the trap was field-tested against natural populations of *Culex salinarius* Coquillett, *Mansonia perturbans* (Walker) *Aedes taeniorhynchus* (Wiedemann), and *Aedes sollicitans* (Walker) at Gainesville and New Smyrna Beach, Florida and with *Anopheles quadrimaculatus* Say and *Psorophora confinnis* L. in Stuttgart, Arkansas, *A. quadrimaculatus* was the only species that did not respond.

Carbon dioxide (CO₂) provided by a steel tank is released into the trap at the rate of 1 liter per minute. The effectiveness of the design in the field prompted construction of duplicate traps of wood and glass, but tests with these traps showed them to be one-half to one-fourth as effective as the Plexiglas trap.

Part of our work at the Insects Affecting Man Research Laboratory at Gainesville, Florida has been directed toward the collection, isolation, and identification of the factors responsible for the attraction of mosquitoes to humans. Acree *et al.* (1968) found that L-lactic acid in combination with carbon dioxide (CO₂) was one of these factors in studies with *Aedes aegypti* L. made with the olfactometer described by Schreck *et al.* (1967). The role of lactic acid and CO₂ as mosquito attractants for *A. aegypti* was then studied further by Smith *et al.* (1970). However, no field studies have yet been undertaken of lactic acid alone or combined with CO₂ as an attractant for other species of mosquitoes. We therefore decided to develop a trap to evaluate lactic acid in combination with CO₂ as an attractant. A number of preliminary experiments were made with several thousand laboratory-reared *A. aegypti* of mixed sexes that had been re-

leased into a large outdoor cage 4.88 m. wide by 12.2 m. long by 3.66 m. high. The trap proved to be highly effective in catching female mosquitoes during both daylight and evening hours. On the basis of these results, several more traps were made for field evaluation.

Over the years, a persistent search has gone on for more effective trapping devices for mosquitoes so that better methods will be available for determining the kinds of mosquitoes present in an area and their relative abundance. Three major types have been designed: The Malaise trap is used to obtain a relatively unbiased population sample since there is no attractive element to select one species over another (Townes, 1962; Gunstream and Chew, 1967). The light trap, in contrast, is selective because it causes varying degrees of phototactic response among mosquito species (Clements, 1963; Gunstream and Chew, 1967; and Carestia and Savage, 1967). Finally, traps baited with CO₂ and animals are used to attract what are assumed to be the host-oriented segment of the population, the females (Reeves, 1951, 1953; Thompson, 1967), and in fact, CO₂ traps have demonstrated greater efficiency in trapping large numbers of mosquitoes than traps without CO₂ (Newhouse *et al.*, 1966; Carestia and Savage 1967).

TRAP DESIGN. The trap is octagonal, 39.8 cm. wide by 45.7 cm. high, and constructed of 0.63-cm. Plexiglas® (polymethyl methacrylate; Rohm and Haas Co.) except for the 12 funnels (see Figs. 1 and 2). The top is removable for transferring trapped insects. The panels forming the octagon are 15.2 cm. wide, and in 4 panels (one in the center of each side), there are three openings, 10.2 cm. in diameter. The openings allow easy

¹ Mention of a proprietary product in this paper does not constitute an endorsement of this product by the USDA.

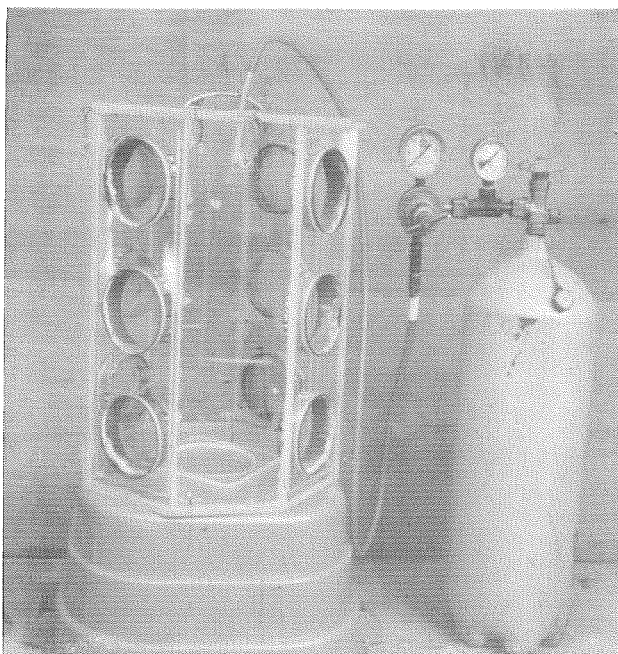


FIG. 1.—Assembled Plexiglas trap showing manner of dispensing CO_2 for a field test.

movement of air and the mosquitoes enter the trap through the screen wire funnels placed in the openings without apparent difficulty in spite of changes in wind direction. (The mosquitoes were most often observed to enter from the down-wind side.) Once inside, the insects tend to fly upward because of the transparency of the sides and top and thus are unable to escape. The trap has been operated 25 to 50 cm. above the ground and has proved quite effective at these heights. After a test, the funnel openings are stoppered while the mosquitoes are transported in the trap to the laboratory for identification and counting.

CO_2 from a steel cylinder is released via a regulator, an SS-2SA Nupro Fine Metering Valve, and a rubber hose at the rate of 1 liter/minute (determined by a Fisher and Porter tri-flat variable area flowmeter tube type FP- $\frac{1}{8}$ -20-G-5) into the top of the trap through a short

length of 0.63-cm. diameter polyethylene plastic tubing. This method of delivery provides a constant flow of CO_2 to the trap. The flowrate was considered near optimum based on reports by Reeves (1953), Carestia and Savage (1967), and Gillies and Snow (1967).

TESTS OF NEW CAGE. Several types of traps (modifications of Malaise trap, cylinders of various sizes, and a variety of materials such as wood, aluminum, plastic, and cloth coated with sticky materials) were prepared that used CO_2 as an attractant and/or carrier gas for lactic acid, but they did not prove satisfactory. Finally, a trap constructed entirely of Plexiglas was tested. Then the trap's effectiveness with natural populations of *Culex salinarius* Coquillett, *Mansonia perturbans* (Walker), *Aedes taeniorhynchus* (Wiedemann), and *Aedes sollicitans* (Walker) was tested in Gainesville and New Smyrna Beach, Florida and other tests were made with

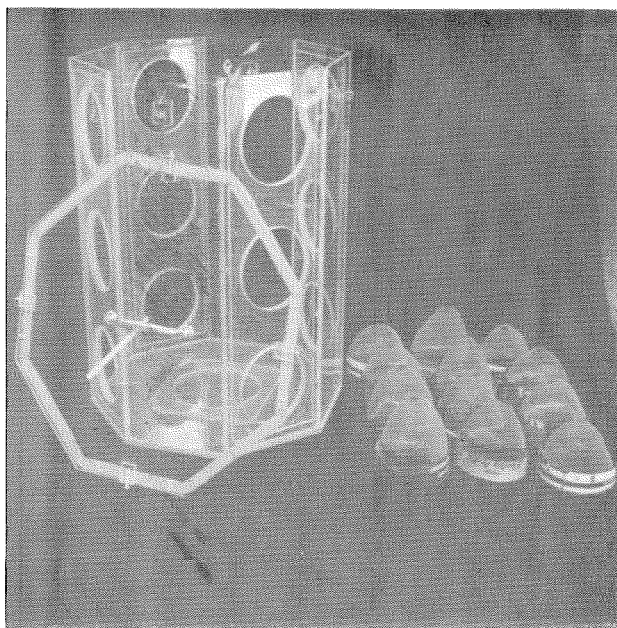


FIG. 2.—Disassembled Plexiglas trap showing the top and screen wire funnels (12).

Anopheles quadrimaculatus Say and *Pso-rophora confinnis* L. in Stuttgart, Arkansas. All tests were made from dusk to 7:30–8:30 a.m., a 10 to 12-hour time span.

In the 22 trapping tests made in the spring of 1969 at Gainesville, the traps captured an average 1,280 female *C. salinarius* (almost all this species) per trap night (Table 1). The range was 332 to 3,366. In 10 of the 22 traps, the catches per trap per night were 1,200 or more. Also, a trap placed in an area where *Mansonia perturbans* was common yielded total catches of 485 and 164 *Mansonia* in May 1969.

At Stuttgart, Arkansas, where very heavy mosquito populations occur throughout the summer, the trap had little success against *Anopheles quadrimaculatus*, but great numbers of *P. confinnis* were trapped. A single trap yielded a total of over 102,000 *P. confinnis* (and very few other species) in five nights (Table 2).

Further tests at New Smyrna Beach, Florida to evaluate the efficiency of the experimental trap with salt-marsh mosquitoes proved that it was satisfactory for trapping this species (Table 2). One trap that captured 7,619 specimens on August 5 took totals of seven species as follows: *Aedes sollicitans* 1,212, *Aedes taeniorhyn-*

TABLE 1.—Number of mosquitoes (mostly *Culex salinarius*) caught each night in an experimental Plexiglas trap at Gainesville, Florida 1969. (CO₂ added at the rate of 1 liter/minute).

Date (May)	Number trapped	Date (June)	Number trapped
14	332	2	1,236, 1,529 ^a
15	3,366	7	972
19	685	8	803
21	2,063	9	717
22	1,453	10	1,142
23	1,058	11	1,279
26	1,280	12	1,491
27	642, 637 ^a	13	1,301
28	915, 1,710, 2,514 ^a	17	1,043

^a Numbers caught in several (2 and 3) traps at locations about 30 meters apart.

TABLE 2.—Number of mosquitoes caught in an experimental Plexiglas trap (CO₂ added at the rate of 1 liter/minute) in 1969.

Date	Number trapped	
Stuttgart, Arkansas ^a		
July	11	19,702
	14	19,000
	15	24,609
	16	25,179
	16	14,197
New Smyrna Beach, Florida ^b		
July	22	480
	29	5,403
August	5	7,617
	19	15,131
	27	3,872

^a Species trapped: about 98% *P. confinnis*.

^b Species trapped: mostly *Aedes taeniorhynchus* and *Aedes sollicitans*.

chus 4,718, *Aedes* sp. 6, *Anopheles crucians* 17, *Culex* sp. 231, *Psorophora ciliata* (F.) 6, and *P. confinnis* 1,427.

There was not time to count and identify all species trapped in each test; however, the figures in the two tables are accurate counts of the species named except that some of the larger collections of salt marsh mosquitoes and *P. confinnis* are estimates. The number of male mosquitoes trapped in all tests was negligible.

The results obtained when CO₂ was used alone in the traps in the field tests described above, and the results obtained in the laboratory by Smith *et al.* (1970) showing that CO₂ and lactic acid combined were attractive though neither was attractive alone, prompted us to test combinations of CO₂ and lactic acid in the field with this trap. However, in the several field tests in which we used L-lactic acid and CO₂ in the Plexiglas trap vs. the Plexiglas trap with only CO₂, the numbers caught did not differ. This result does not discount the effectiveness of L-lactic acid as an attractant; we may not have presented the L-lactic acid in a suitable manner for it to be effective, and we did not test lactic acid without CO₂.

TRAPS OF OTHER MATERIALS. The effectiveness of the new trap in the field was such that we also constructed traps of the same design from 0.63-cm. plywood

or 2-mm. single-strength glass to determine whether the Plexiglas trap had any advantage. Also, a Plexiglas trap was lined with brown wrapping paper. With all four traps, CO₂ was supplied at the rate of 1 liter/minute.

In all competitive tests at Gainesville, the traps were placed about 12 meters apart, and their positions were reversed each time they were tested. Also, in two instances, a 15-watt incandescent light was operated inside the plywood trap. In the tests at New Smyrna Beach, the four types of traps were spaced about 91 meters apart, and the positions were reversed after each test.

The results were unexpected (Table 3). At Gainesville, we again trapped mostly *C. salinarius*. However, when the Plexiglas trap was compared with the plywood trap by averaging the catches over 7 nights, the Plexiglas trap had caught 6.8 times as many mosquitoes as the plywood trap. Also it had caught 2.4 times as many mosquitoes as the glass trap and 14.4 times as many mosquitoes in 2 nights as the Plexiglas trap covered with paper. The wooden traps with the 15-watt lamp caught more mosquitoes than the wooden trap without a light but only about half as many as the Plexiglas trap. At New Smyrna Beach, the Plexiglas trap caught 2.1 times as many *A. taeniorhynchus* and *Aedes sollicitans* in 3 nights as the glass trap.

It is difficult to find reasons for the differences in catch which, however, were consistent: the numbers trapped in Plexiglas were twice those trapped in glass and 6 to 14 times those trapped in nontransparent traps (plywood and paper covered Plexiglas). The construction materials were not attractive to mosquitoes by themselves and were not contaminated by attractive materials. CO₂ and the currents of movement of the CO₂ were the only known attractants added. Thus the differences in numbers trapped (we do not know whether or not there were differences in the numbers approaching) may have been related to visual sensing, to

TABLE 3.—Number of mosquitoes caught (mostly *Culex salinarius* except where noted) in a Plexiglas trap vs. duplicate traps constructed of plywood, glass, or paper covered Plexiglas in Florida in 1969. (CO₂ added at the rate of 1 liter/minute).

Date	Number trapped in Plexiglas trap	Number trapped in duplicate trap
Plexiglas Trap vs. Plywood Trap, May, Gainesville		
19	685	5
21	2,063	73
22	1,453	151
23	1,058	11
26	1,280	542 ^a
27	390	4
29	637	334
Total	7,566	1,120
Avg.	1,080.9	160
Plexiglas Trap vs. Paper-Covered Plexiglas Trap, June, Gainesville		
7	972	36
8	803	135
Total	1,775	171
Avg.	887.5	85.5
Plexiglas Trap vs. Glass Trap, September, Gainesville		
2	40	20
3	56	16
4	76	53
5	72	41
8	89	3
10	48	21
11	159	72
Total	540	226
Avg.	77.1	32.3
Plexiglas Trap vs. Glass Trap, September, New Smyrna Beach ^b		
9	12,720	4,758
16	4,203	2,531
22	2,125	1,915
Total	19,048	9,204
Avg.	6,349.3	3,068

^a Plus 15-watt incandescent bulb.

^b Mostly *Aedes taeniorhynchus* and *Aedes sollicitans*.

the sensing of some irradiation, or to an interaction between CO₂ and the trap material that affected attraction or trap entry. The mechanism is unknown, but

an understanding would increase our knowledge of attraction and trapping of mosquitoes.

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