Field Studies on Carbon Dioxide as a Possible Host Simulant to Mosquitoes.* (18679)

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It has been known for a number of years that certain materials provoke a positive chemotropic response in mosquitoes(1), yet little application has been made of this knowledge in developing new technics for the collecting or study of mosquitoes in nature. Rudolfs(2) demonstrated that mosquitoes were strongly "activated" by an atmospheric increase of carbon dioxide and ammonia, and he believed that these stimuli played an important role in attracting mosquitoes to their hosts. Subsequently, studies have been reported in which this knowledge was applied by using dry ice as an adjuvant with mosquito light traps(3-5). Although the number of mosquitoes collected was increased, knowledge of mosquito behavior was not amplified, nor was the technic practical for general use.

These observations led in the present study to the use of carbon dioxide alone as a mosquito attractant to determine the applicability of such a stimulus in studying the apparent feeding preferences of different mosquito species. Data from preliminary field investigations on the role of mosquitoes in the epidemiology of virus encephalitis in Kern County, California, during 1950 indicate that a valuable technic for such studies may be developed. A recent report(6) on field studies of the various factors which may serve to attract mosquitoes to man substantiates the importance of carbon dioxide as one of the stimuli.

Methods. Two stable traps of the design described by Bates(7) were employed as the standard apparatus to collect the mosquitoes. In preliminary trials, the 2 traps were comparable in parallel trials using dry ice baits. Under these conditions, variations in the number of mosquitoes collected in the 2 traps were those expected by chance. Dry ice was the source of carbon dioxide. A 7 to 9 lb. piece of dry ice, wrapped in 2 thicknesses of heavy paper with a single longitudinal slit through both layers, was placed in a 6-gallon can with a screen top. This can was suspended in the trap at the level of the ingress baffle. For animal bait a single calf or 3 to 5 chickens were used in each test. Each trap was baited shortly before or at sunset. In comparative tests with dry ice and animal baits, the two traps were baited at the same time and were run in the same area, usually separated by a distance of 10 to 20 yards. Some dry ice remained the following morning. On the morning following trials, all mosquitoes were removed from the traps and transported to the

TABLE I. Species and Number of Female Mosquitoes Collected in 49 Trials with Dry Ice Bait.

Mosquito	No. collected: Total	Mean per trial	Median per trial
Culex tarsalis	9036	184	178
Culex quinquefasciatus	578	12	1
Aedes dorsalis	175	4	1
Aedes nigromaculis	4477	91	20
Others*	11	0.3	—
Total	14277	291	220

* Species included *Anopheles franciscanus, Culex erythrothorax.*

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TABLE II. Species and Number of Female Mosquitoes Collected in 8 Trials, Comparing Dry Ice and Calf Baits.

	Species and No. of mosquitoes collected									
	C. tarsalis		*C. quinquefasciatus*		*A. dorsalis*		*A. nigromaculis*		All species	
Bait	Total	Mean per trial	Total	Mean per trial	Total	Mean per trial	Total	Mean per trial	Total	Mean per trial
Dry ice	1291	161	62	8	4	.5	764	96	2121	265
Calf	879	110	43	5	4	.5	400	50	1326	166

TABLE III. Species and Number of Female Mosquitoes Collected in 7 Trials, Comparing Dry Ice and Chicken Baits.

	Species and No. of mosquitoes collected									
	C. tarsalis		*C. quinquefasciatus*		*A. dorsalis*		*A. nigromaculis*		All species	
Bait	Total	Mean per trial	Total	Mean per trial	Total	Mean per trial	Total	Mean per trial	Total	Mean per trial
Dry ice	2350	336	195	28	19	3	335	48	2799	400
Chicken	780	111	120	17	2	0.3	21	3	923	132

laboratory for identification and counting.

Results. In 49 trials employing dry ice as an attractant, a total of 14,277 female mosquitoes of 6 species were collected (Table I).

In 8 trials to compare the attractiveness of dry ice and calf baits, the 4 principal mosquito species of the area were collected. The dry ice bait consistently attracted more mosquitoes than did the animal bait (Table II).

In 7 trials to compare the values of dry ice and chicken baits, dry ice again consistently attracted larger numbers (Table III).

On 3 occasions small numbers of female mosquitoes (2, 6, and 13) were found in unbaited traps.

Male mosquitoes were seldom found in unbaited traps or in traps baited with dry ice or animals. With dry ice, males of the following species were collected: *Culex tarsalis,* 3; *Culex quinquefasciatus,* 2; and *Aedes nigromaculis,* one. With calf bait, 2 male *C. tarsalis* were collected, and with chicken bait, one male *C. tarsalis.*

Discussion. The results of these preliminary trials indicate that carbon dioxide alone can be used to attract female mosquitoes. This method of collecting samples of mosquitoes has been of value in areas where electricity or experimental animals are not available. Mosquito samples collected in this fashion were satisfactory in disease vector studies. Because of the open construction of the trap, the mosquitoes are not asphyxiated by the carbon dioxide, and there is no reason to suspect that disease agents such as viruses are affected by it in the living vector. Another definite advantage over collections from animal-baited traps is that few of the mosquitoes are freshly engorged with blood meals which may include disease agents or immune bodies, either of which would be misleading in interpretation of field data.

These findings seem to warrant further studies in which the volume of carbon dioxide released is carefully controlled. It would seem appropriate in such studies to use the average amount of carbon dioxide produced by bovine, human, avian, and amphibian hosts. This would represent a wide host range and markedly different volumes of carbon dioxide and possibly would clarify the unexplained host preference of different mosquito species.

If a carbon dioxide chemotropism is a major attracting force, one might hypothesize that the chemotropism of different mosquito species differs. *Culex apicalis,* for example, might be extremely sensitive to a small amount of carbon dioxide, such as is given off by amphibians, but be repelled by the higher concentrations excreted by larger vertebrates. Other species such as *Culex tarsalis* and *Culex quinquefasciatus,* known to have a wide host range

from small to large vertebrates(8,9), could be expected to exhibit a broad chemotropic sensitivity. Many species of *Aedes, Anopheles,* and other genera which feed predominantly on large mammals(10,11) would respond only to relatively high concentrations of carbon dioxide.

The observation that carbon dioxide specifically attracted female mosquitoes may be further evidence that this chemotropism is closely allied to search for a blood source.

The significance of host body temperature as an attracting force appears to be eliminated. However, dry ice materially reduces temperature and increases relative humidity in the immediate area of the tests. Therefore, in future studies, some other source of gas such as a portable carbon dioxide generator should be used to obviate these objections.

It would be of interest to test the attractiveness of carbon dioxide in areas inhabited by species such as *Aedes varipalpus, Aedes triseriatus,* or *Aedes albopictus.* Males of these species are frequently observed in the vicinity of animal hosts supposedly for the purpose of coming in proximity to females for mating. Demonstration that these males are attracted by carbon dioxide could serve as further evidence of the specificity of this chemotropism.

Summary. Carbon dioxide alone was a mosquito attractant in disease vector studies. Large numbers of female mosquitoes of several species were attracted into a trap baited with carbon dioxide. It consistently attracted more mosquitoes than calf or chicken baits. This chemotropism may be a major factor in controlling host selection by various species of mosquitoes.

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Effect of ACTH and Cortisone on Homogenous Kidney Transplants. (18680)

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The reported efficacy of ACTH and cortisone in states of hypersensitivity(1) and in antigen-antibody reactions(2) has led to a reconsideration of the possibility of influencing the biological incompatibility of homogenous renal transplants(3-5) by the use of these agents.

Method. Sterile technic was employed. A donor kidney was obtained from a healthy heparinized dog. The pedicle was cleared of extravascular tissue and its vessels anastomosed to the common carotid artery and external jugular vein of the recipient dog by direct end-to-end union with continuous everting sutures, or by the use of vitallium tubes(6). Anastomosis by direct suture required 20-25 minutes; by the use of vitallium tubes, less than 10 minutes. After fixing the kidney to prevent rotation, the ureter was brought out through a stab wound in the opposite side of the neck with care to avoid kinking. Urine collection was facilitated by

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