REPELLENCY OF CYCLOHEXAMETHYLENE CARBAMIDE AND *N,N*-DIETHYL-*m*-TOLUAMIDE AGAINST *AEDES AEGYPTI* AND *AE. TAENIORHYNCHUS*

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The compound, "cyclohexamethylene carbamide" ("carbamide") was reported in the Russian literature (Stepanor et al. 1967) to have repellent activity against a variety of bloodsucking insects. Subsequently, Maibach et al. (1974), Shimmin et al. (1974), Khan et al. (1975), Gabel et al. (1976), and Spencer and Akers (1976) reported on studies in which this repellent was compared with *N,N*-diethyl-*m*-toluamide (deet) and other repellents. Because of the promising results with "carbamide" indicated by these investigators we conducted a series of tests comparing carbamide and a standard repellent, deet, in the laboratory against *Aedes aegypti* (L.) and in the field against *Ae. taeniorhynchus* (Wiedemann).

The test methods and data analysis were those used standardly at our laboratory (Gilbert et al. 1957 and Smith et al. 1976). The repellents were applied at varying concentrations to forearms of test subjects, and the forearms were subsequently exposed to caged or natural populations of biting mosquitoes.

The laboratory test was a round-robin series in which we used 3 concentrations (6.25, 12.5 and 25%) of each repellent in ethanol. One ml of each concentration was applied to 1 forearm of a subject (wrist to elbow), the equivalent of 62.5, 125, and 250 mg/treatment, respectively. Six subjects were used, and each concentration was tested 8 times. The treated arms were exposed to mixed populations containing ca. 1500 female laboratory-reared *Ae. aegypti* in cages 35.6 cm high × 35.6 cm wide × 45.7 cm long.

The field tests were made at New Smyrna Beach, Florida, in a location described by Smith et al. (1976) where relatively high densities of *Ae. taeniorhynchus* are present. Only one concentration (25%) of each repellent was tested in paired evaluations by applying 1 ml of repellent solution to the forearms of subjects. Three complete series of tests were conducted, 1 in 1975 and 2 in 1976.

The results of the laboratory evaluations are summarized in Table 1; the results of the field tests are reported in Table 2.

Table 1. Laboratory of "carbamide" and deet applied to the skin at various concentrations against *Ae. aegypti* mosquitoes (balanced incomplete-block design; average of 8 tests).

Conc. (%)	Protection time (min) Range	Adjusted mean	Ratio[a]
	Deet		
25	330–480	400	1.0a
12.5	180–330	240	0.6b
6.25	60–210	117	.29c
	"Carbamide"[b]		
25	30–120	70	.18d
12.5	30–90	17[c]	.04d
6.25	30–30	24[c]	.06d

[a] Significance tested at the 0.01 level. Values with the same letter are not significantly different.

[b] Supplied by the U.S. Army Environmental Health Agency, Aberdeen, MD.

[c] Due to the nature of the statistical analyses, variations in the data may cause the average protection time to fall outside the actual protection range when relatively short protection times are recorded.

In the laboratory tests with *Ae. aegypti,* deet gave significantly longer protection times than "carbamide" at all concentrations tested. Moreover, deet at 6.25% gave longer protection than "carbamide" at 25%; and at equal concentrations the protection provided by deet averaged ca. 5 to 14 times longer than that provided by "carbamide."

In the field tests with *Ae. taeniorhynchus,* the average length of protection provided by deet in series 1, 2, and 3 was 9, 1.5, and 5–7 times that provided by "carbamide." The reason for the differences in length of protection in test series 2 and 3 may be explained by the population counts made at the time of these 2 tests. Two types of counts were made: (1) by having 4 subjects walk into the test area where they stopped for 1 min and recorded the number of bites occurring in 1 min on both the bare arms of each of 4 different subjects; (2) by walking in pairs, stopping and recording the total mosquitoes landing on the untreated clothing of both subjects. The average counts in series 3 were more than 2 times those made in series 2 indicating more pressure on the repellents by

Table 2. Field evaluations of "carbamide" and deet applied to the skin as 25% solutions against *Ae. taeniorhynchus* mosquitoes (all paired tests with 4–5 subjects).

Chemical	Protection time (min) Range	Protection time (min) Mean	Ratio to deet
	Series 1 (avg. 5 tests 1975)		
Deet	317–368	351	1.0
70564 [a]	10–113	37	0.11
	Series 2 (avg. 8 tests 1976) [b]		
Deet	286–495	401	1.0
70564 [c]	83–390	274	.68
	Series 3 (avg. 8 tests 1976) [d]		
Deet	205–390	313	1.0
70564 [c]			
1st treatment [e]	23–120	65	.21
70564 [c]			
2nd treatment [a]	7–134	43	.14

[a] Supplied by the U.S. Army Environmental Health Agency, Aberdeen, MD.

[b] Series II population counts ranged from 8 to 52 and averaged 18.8 in 16 counts on 4 subjects

[c] Supplied by the Letterman Army Inst. of Research, Presidio of San Francisco, CA.

[d] Series III population counts ranged from 7 to 100 and averaged 39 in 16 counts on 4 subjects.

[e] Since the protection times in series 3 were relatively short for "carbamide" compared with those for deet, a second application of "carbamide" was applied after the first application failed.

the biting mosquito population. (The series were run 6 weeks apart.)

In both our laboratory and field tests, both "carbamide" and deet were active repellents. However, when large numbers of avid mosquitoes were present and 100% protection against biting was required, deet provided significantly longer protection than "carbamide." Although no complaints were made by any subject during the laboratory tests, all 6 subjects reported during the field tests that the "carbamide" felt warm on the skin.

Our results are therefore in apparent conflict with the results of other workers. For example, Shimmin et al. (1974) reported the "carbamide" gave about 3 times longer protection against *Ae. aegypti* in laboratory tests and gave a significantly reduced number of bites and longer protection than deet against *Ae. taeniorhynchus* in field tests. They also reported that their laboratory results appeared to predict field results. It is difficult to reconcile these differences, particularly since we used the same species of mosquitoes as they did in laboratory (*Ae. aegypti*) and field (*Ae. taeniorhynchus*) tests. In addition, the dosages applied per unit surface of forearm were similar or overlapping, i.e., Shimmin et al. (1974) used 0.31 mg/cm^2 in laboratory tests and 0.31 or 0.48 mg/cm^2 in field tests compared with the ca. 0.1 to 0.4 mg/cm^2 used in our laboratory and field tests.

Gabel et al. (1976) studied rates of evaporation and minimum effective dosages (MED) of 5 repellents including deet and "carbamide." Although MED's may be variable with test subjects, species, locations, and other conditions (Smith et al. 1963), the MED Gabel et al. (1976) reported for deet, 0.039 mg/cm^2, was in the same order of magnitude as that reported earlier by Smith et al. (1963), 0.05 to 0.08 mg/cm^2. They have proposed that differences in the protection time afforded by deet and "carbamide" might be explained on the basis of MED's and evaporation rates. For example, they reported that the MED (0.039 mg/cm^2) for deet was lower than that for "carbamide" (0.078 mg/cm^2), but that the evaporation rate of deet was greater than "carbamide." Thus, they reasoned that results of tests where repellents were applied at a dose above the MED for one compound, but below the MED for another could be misleading. They further reasoned that if both compounds were applied at a rate above their MED's, the "carbamide" would last longer than deet because of its lower rate of evaporation. However, the hypothesis has not been validated to date. In fact, Smith et al. (1963) working with loss of repellents from test subjects concluded that with 3 repellents—deet, ethylhexanediol, and dimethylphthalate—the differences in losses by evaporation from forearms were balanced by differences in absorption. As a result, the total loss by both evaporation and absorption was similar for these 3 repellents.

In any case, the hypothesis of Gabel et al. (1976) would not explain the differences in results discussed here because in both studies doses well above the MED's were evaluated. Many other variables involved in repellent testing could be considered in an attempt to reconcile the differences obtained in these 2 independent studies; for example, (1) location; (2)

quality of laboratory test insects; (3) numbers of biting females; (4) avidity of the biting females; (5) activity of the test subjects; (6) environmental influences; and (7) testing techniques.

These factors can cause considerable variability in the results of tests with insect repellents. However, it would, at this time, be only speculation to attempt to determine what factors could have caused the variance in the repellent activity of deet and "carbamide" in the 2 tests.

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AN IMPROVED BAIT TRAP FOR MOSQUITO COLLECTING[1]

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The most basic technique of catching medically important or pestiferous mosquitoes or other flying insects has been to use a suitable bait to attract host-seeking females, and human bait has been used for many years to collect anthropophilic species. Later developments included inclosing human or animal baits in nets, cages or traps which, in theory at least, permitted the unhindered entry of mosquitoes, but prevented their escape. Light traps, especially in North America, have for the most part replaced human and animal baits as routine sampling techniques. However, according to Hocking (1971) no really effective attractant has been found to replace a natural host and consequently human bait catches remain the single most useful technique to collect anthropophilic mosquitoes. Service (1976) provides the most up-to-date information on human bait catches and equipment.

The original trap utilizing animal or human bait was the Magoon (1935) trap. Various modifications of this trap have been made over the years, but basically the method of attracting the female mosquito to the bait and collecting it while feeding, landing, or resting after feeding, has not differed significantly from trap to trap. The bait trap described offers the unique potential of collecting mosquitoes attracted to humans without exposure to bites by the mosquitoes. This will allow collections to be made in areas where diseases such as malaria, mosquito-borne encephalitis, etc. are prevalent without endangering the collectors to these diseases during the sampling hours.

[1]The opinions contained herein are those of the author and should not be construed as official or reflecting the views of the Department of the Army. Mention of proprietary products is for the purpose of identification only and does not imply endorsement by the Department of the Army.