From the standpoint of potential harm to nontarget organisms, methoxychlor would be the insecticide of choice because it is biodegradable and thus less objectionable than DDT to groups concerned with birds and other forms of wildlife. However, despite 4 years of use of DDT on the Aedes aegypti Eradication Program in certain states as a premises treatment, there has not been any confirmed evidence that it has adversely affected the bird or fish life in those areas. Whether this condition would have continued will always be a moot question since the Federal program was terminated in the United States in October 1969.

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RESISTANCE TO AGING AND RAIN OF REPELLENT-TREATED NETTING USED AGAINST SALT-MARSH MOSQUITOES IN THE FIELD

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ABSTRACT. In 1967, 1968, and 1969, 4-mesh-per-inch tied cotton netting was treated with 27 individual compounds and one mixture applied at a rate of 0.5 gram (g) chemical to 1 g of net; 45 individual compounds and the same mixture applied at a rate of 0.25 g of chemical to 1 g net; and 22 individual compounds applied at a rate of 0.5 g of chemical to 1 g net. Twenty-four compounds gave 90 percent protection for more than 87 days against the salt-marsh mosquito, *Aedes taeniorhynchus* Wiedemann, and three of the 24 were still 90 percent effective after 287 days when they were applied at a rate of 0.5 g of chemical to 1 g net. Also, 28 compounds gave 90 percent protection for more than 60 days when they were applied at a rate of 0.25 g chemical to 1 g net, and 7 of the 28 were still 90 percent effective after 141 days. Two compounds were 90 percent effective after being exposed to 4.13 inches rainfall, and 6 compounds were 90 percent effective after being exposed to 2.69 inches rainfall.

INTRODUCTION. Netting treated with repellents against biting insects might be used as head nets, bed nets, and nets to cover windows or entrances where more air movement and visibility are desired or where standard screens do not deter small insects (Gouck *et al.*, 1967a). Screening tests have therefore been conducted at the Insects Affecting Man Investigations Laboratory at Gainesville, Florida, to find chemicals effective in preventing mosquito penetration through wide-mesh netting and preliminary field tests have been made with the promising compounds (Gouck *et al.*, 1967b). During 1967, 1968, and 1969, further field studies were made with 70 individual compounds and one mixture against salt-marsh mosquitoes, *Aedes taeniorhynchus* Wiedemann to find other promising compounds for more practical study and to determine the approximate duration of effectiveness with and without exposure to rain.

Methods. The tests were made in Volusia County, Florida in areas where natural populations of salt-marsh mosquitoes were available. Booth-like enclosures similar to that described by Gouck *et al.* (1967a) were used. The enclosures were collapsible for ease in handling and consisted of four equal sides (124.5 cm high x 96.4 cm wide) and a top. The sides and top were constructed of aluminum frames covered with plastic mosquito screening (18 mesh per inch) to prevent entry of mosquitoes. One side had an opening (61.0 x 83.7 cm) near the bottom of the screening where a piece of 4-mesh-per-inch tied cotton netting (untreated or repellent-treated) mounted on an aluminum frame could be inserted. The inside of this opening was covered with a collapsible screen compartment (11.4 cm deep) that trapped any mosquitoes which entered through the netting. The assembled enclosure, which had no bottom, could be fitted snugly to the ground at a site where natural populations of salt-marsh mosquitoes were high and was large enough so a man could sit inside where he served both as the attractive bait and counted the number of mosquitoes trapped in the compartment in the 15-minute test period. Each test compound (or the mixture) was applied to the piece of netting at a rate of 0.50 or 0.25 gram (g) per netting. The piece of netting was mounted on an aluminum frame so it could be placed in the opening since untreated nets were included as controls with each treatment, we could calculate the percentage reduction in mosquitoes entering through the treated netting. The trapped mosquitoes were released after each test. The number of mosquitoes entering through untreated netting during a 15-minute test ranged from 23 to 141.

In the 3 years, we tested 66 compounds applied at a rate of either 0.5 or 0.25 g per g of netting and 4 compounds and one mixture applied at both rates. Each compound (and the mixture) was tested once a week, depending on the availability of natural populations of mosquitoes, until the effectiveness of the treatment decreased to 90 percent or less, i.e., until the number entering the treated netting was more than 10+ percent the number entering untreated netting (confirmed by two successive tests). For one evaluation, the treated netting was simply stored between tests in a large well-ventilated room in the laboratory so we could determine how long it would remain effective. For the other evaluation, the panels of treated netting were placed outdoors when natural rains occurred and exposed to measured amounts of rainfall. In 1967, 27 compounds and one mixture were tested at a rate of 0.5 g of repellent per 1 g of netting; in 1968, 15 compounds and the mixture were tested at a rate of 0.25 g per g; and in 1969, 30 compounds were tested at a rate of 0.25 g per g. Also, in 1968, 10 compounds and the mixture and in 1969, 12 compounds were tested for resistance to rain at 0.5 g per g. The majority of the compounds were tested at only one rate, and tests were not replicated because of the limited amount of chemical available and the time required for testing. The dose was reduced in 1968 because of the length of time many of the compounds remained effective.

Results. The days of effective protection provided by each compound and the mixture at one or both doses, with or without exposure to rain, are given in Table 1. The compounds are listed generally in decreasing order of days of effective protection.

At a dose of 0.5 g per g, 23 chemicals and the mixture gave 90 percent protection for more than 86 days. The three chemicals that were still 90 percent effective when the tests were discontinued were: dibutyl malate carbanilate (287 days), 1-butyl-4-methylcarbostyril (293 days), and *N,N*-dibutyl-*o*-ethoxybenzamide (293 days). At a dose of 0.25 g per g 28 chemicals gave 90 percent protection

TABLE 1.—Days of effective protection (criteria = 90 percent reduction of mosquito penetration through netting) obtained with 4-mesh-tied cotton netting treated (rates of 0.5 and 0.25 g per g of netting) with repellent with and without exposure to rain.

ENT. No.	Chemical name	Days of protection from dose of— 0.5 g	0.25 g	Inches of rain reducing effectiveness below 90 percent
7627	1-Butyl-4-methylcarbostyril	293[a]		2.7[a]
19084	*N,N*-Dibutyl-*o*-ethoxybenzamide	293[a]		4.8
23483	Dibutylmalate carbanilate	287[a]		
19083	*o*-Ethoxy-*N,N*-dipropylbenzamide	240	140	4.8
20574	4-Hydroxy-4-methyl-*N,N*-dipropylhexanamide	236		
.....	M-1960[b]	213	29	0.3
20297	*o*-Ethoxy-*N,N*-diethylbenzamide	132	48	1.0
14825	1,3-Bis(butoxymethyl)-2-imidazolidinone	127	126	2.0
373	2-[2-(Cyclohexyloxy)ethoxy]ethanol	118		0.1
2065	10-Undecenoic acid	118		2.0
2220	2-(Diethylphenoxy)ethanol	118		
4203	Isobutyl mandelate (Rutgers 850)	118		
5950	2-(Phenethyloxy)cyclohexanol	118		2.7
5974	1-Butyryl-1,2,3,4-tetrahydroquinoline	118		
6365	Ethyl *N,N*-dipropylglutaramate	118		
8118	Tetrahydrofurfuryl octanoate	118		0.1
20127	Pentyl mandelate	118		0.1
20830	Diisopentyl malate	118	67	2.0
5756	*o*-Butoxybenzyl alcohol	89		
4296	Tetrahydrifurfuryl 2-methyllactate	87		
4562	3-(1,3-Dimethylbutoxy)-1,2-propanediol	87		
6168	Propyl *N,N*-diethylsuccinamate	87		
13204	2-(2-Hydroxyethoxy)ethyl hexanoate	87		
24828	2-(Octylthio)ethanol	87		
5533	4-(*p*-Methoxyphenyl)-5-methyl-*m*-dioxane	36		
22542	Deet	21	54	0.3
5540	2-Methoxyethyl 2-furanacrylate	0		
17415	Bis(2-ethylhexyl) fumarate	0		
396	Butyl tartrate		141	
80	4-Biphenylol		141	
2485	*N*-[2-(*p*-Chlorophenoxy)ethyl]cyclohexylamine		141[a]	
7198	2-Ethoxyethyl α,β-epoxy-β-methylhydrocinnamate		120	0.9
16739	*N*-Benzyl-*N*-(2 methylcyclohexyl)acetamide		141	
16750	*N*-Cyclohexyl-*N*-pentylbenzamide		141	
17928	*N*-Hexyl-4-cyclohexene-1,2-dicarboximide		120	
18059	3-Chloro-1-propanol carbanilate		120	
20573[c]	2-[(*p*-Methoxybenzyl)oxy]-*N,N*-dipropylacetamide		141[a]	0.8
20593	Ethyl 2-hydroxy-4,6,6-trimethylheptanoate		120	
20831	Bis(1-methylbutyl) malate		141	
21050	*cis*-*N*-Heptyl-4-cyclohexene-1,2-dicarboximide		141	
22851	2-Chloroethyl *m*-methylcarbanilate		120	
23773	1-Methylbutyl *m*-chlorocarbanilate		141[a]	
24090	Pentyl *m*-chlorocarbanilate		141[a]	
25209	allyl octyl sulfoxide		141[a]	
25210	2-Methylallyl octyl sulfoxide		141[a]	
25211	Butyl 2(octylsulfinyl)ethyl ether		141[a]	
20364	1-(*o*-Ethoxybenzoyl)piperidine		204	1.6
4841	2-(2-Butoxyethoxy)-*N*-cyclohexylacetamide		185	
14254	*N*-Pentylglucolamide benzoate		185	2.7
1016	*N*-Pentylbenzamide		136	2.7
20430	α-(3-Phenylpropyl)piperonyl alcohol		91	
20829	Dipentyl malate		91	1.9
20701	*m*-Chloro-*N,N*-diethylbenzamide		63	
375	2-Ethyl-1,3-hexanediol		50	<0.3
17586	*o*-Chloro-*N,N*-diethylbenzamide		50	

(*Continued*)

TABLE 1.—Days of effective protection (criteria = 90 percent reduction of mosquito penetration through netting) obtained with 4-mesh-tied cotton netting treated (rates of 0.5 and 0.25 g per g of netting) with repellent with and without exposure to rain.

ENT. No.	Chemical name	Days of protection from dose of— 0.5 g	0.25 g	Inches of rain reducing effectiveness below 90 percent
20806	*N,N*-Diethyl-2,5-dimethylbenzamide			
20128	Heptyl mandelate		50	
1789	Butyl mandelate		48	
2706	2,2,4-Trimethyl-1,3-pentanediol		36	
15482	3-(Dimethylamino)-1,2-propanediol		36	
18653	Allyl 2-biphenylcarbamate		36	
28638	4-Pentyl-2-oxetanone		36	
33062	Diheptyl fumarate		36	
262	Dimethyl phthalate		36	
15510	2-[2-(2-Butoxyethoxy)ethoxy]ethyl 3-methylcrotonate		28	0.3
6420	Tetrahydrofurfuryl 1-hydroxycyclohexanecarboxylate, acetate		27	0.6
5985	1-Ethyl-1,2,3,4-tetrahydo-2-naphthol		8	
20336	2-Methylcyclohexyl 2,2-dimethyl-3-(2-methyl propenyl)cyclopropanecarboxylate		0	
16634	Sulfoxide		0	
				3.4

[a] Chemicals were still 90% effective when testing discontinued.
[b] Composition of mixture M–1960=30% benzyl benzoate, 30% *N*-butylacetanilide, 30% 2-butyl-2-ethyl-1,3-propanediol, and 10% emulsifier.
[c] Contains 25% *ortho* and 75% *para* isomers.

for more than 60 days, and 7 were still effective at 141 days when the tests were terminated.

Thirteen chemicals gave 90 percent protection through exposure to 1 or more inches of rain. Seven of the 13 were applied at a rate of 0.5 g per g and were effective for more than 86 days; the other 6 were applied at a rate of 0.25 g per g and were effective for more than 60 days (two compounds were not tested without exposure to rain). Two chemicals, *o*-ethoxy-*N,N*,-dipropylbenzamide and *N,N*-dibutyl-*o*-ethoxybenzamide, were still 90 percent effective after 4 inches of rain, and both were among the most effective compounds applied at a rate of 0.5 g per g and tested for length of protection.

DISCUSSION. The use of repellent-treated netting as head nets, bed nets, or protective coverings to protect people from attack by mosquitoes or other biting Diptera which enter enclosures such as tents, cars, or buildings appears promising. However, effective treated netting cannot have a coarser net than 4 mesh per inch. Also, further studies of the materials found effective in these tests are needed so we can relate lower doses to protection time and determine the most effective compounds and doses.

In the present tests, we used tied cotton netting rather than the pressed cotton used by Gouck *et al.* (1967a). Therefore, the shorter protection time (19 to 56 days vs. 213 to 293 days in the present test) provided by 0.5 g per g of the one mixture and two compounds (M-1960, *o*-ethoxy-*N,N*-dipropylbenzamide, and *N,N*-dibutyl-*o*-ethoxybenzamide) may relate to the type of netting. However, deet at 0.5 g per g was effective for only 21 days in both tests so some of the variation in results may be caused by the different time when the tests were conducted.

None of the commonly used repellents—deet, 2-ethyl 1,3-hexanediol, or dimethyl phthalate—were as effective as some of the more effective test compounds, but they did provide protection for 21 to 54 days.

M–1960 applied at a rate of 0.5 g per g provided 213 days protection but was ineffective after exposure to only 0.3 inch of rain; also, it was effective for only 29 days when it was applied at a rate of 0.25 g per g.

Further studies of biological effectiveness and toxicology are needed.

ACKNOWLEDGMENT. The authors thank Nelson Smith, Daniel Smith, and Johnny Jackson of this laboratory for their assistance in the field work.

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FEEDING PATTERNS OF SIX SPECIES OF MOSQUITOES IN ARID SOUTHEASTERN CALIFORNIA [1]

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ABSTRACT. Positive precipitin tests with host antisera were obtained for the blood of 875 engorged mosquitoes. *Culex tarsalis* had fed on a variety of mammals and birds, in an annual ratio of almost 1:1; as elsewhere the dietary ratio shifted with the season. *Aedes dorsalis, Aedes vexans, Psorophora confinnis* and *Culiseta inornata,* which were collected mainly in agricultural areas, had fed predominantly on large domestic mammals. *Culex erythrothorax* collected at a seepage area isolated in the desert had fed primarily on cricetid rodents and herons. This mammal-bird feeding pattern could allow this species to be a vector of arboviruses.

Knowledge of the host-feeding patterns of mosquito species is useful in assessing their potential to serve as vectors. Such information from a wide range of geographical areas aids in explaining regional differences in disease infection rates and the basic ecology of the species.

The present study gives information on the feeding habits of six species of mosquitoes in southeastern Riverside County and Imperial County, California. Engorged females were collected by New Jersey light traps and Malaise traps from January 1969 through July 1970 at sites described in Chew and Gunstream (1970). The host sources of the blood in over 900 females were analyzed by precipitin tests in the laboratory of C. H. Tempelis by methods described in Tempelis and Lofy (1963). The results are summarized in Table 1.

The data for *Culex erythrothorax* are of special interest because of the limited information on this species. All the specimens reported in Table 1 were taken at an isolated natural seepage area in open desert about 2 miles northeast of the Salton Sea (site 84, Chew and Gunstream, 1970). No livestock was within 10–20 miles of this site, except for animals that may have been present temporarily in trucks parked at a gas station-cafe about 1 mile away. Adult *C. erythrothorax* were present from February through July; most of the engorged females were captured in March and April. Of the total feedings, 42 per-

[1] This work was supported by grant AI 08284 from the National Institute of Allergic and Infectious Diseases of the U. S. Public Health Service to R. M. Chew.

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