PROTECTION AFFORDED BY THE INSECT REPELLENT JACKET AGAINST FOUR SPECIES OF BITING MIDGE (DIPTERA: *CULICOIDES*) [1,2]

C. E. SCHRECK, D. KLINE AND N. SMITH

Insects Affecting Man and Animals Research Laboratory, Agricultural Research, SEA, USDA, Gainesville, Florida 32604

ABSTRACT. Light weight net jackets treated with *N,N*-diethyl-*m*-toluamide (deet) were field tested in Florida, South Carolina, and Puerto Rico against 4 species of biting midge, *Culicoides furens* (Poey), *Cu.mississippiensis* Hoffman, *Cu.hollensis* (Melander and Brues), and *Cu.barbosai* Wirth and Blanton. The deet-treated jacket provided 98 to 99% protection against all species except *Cu.barbosai*. It gave only about 59% protection against *Cu.barbosai*. As many species as possible should be tested in evaluating personal protection methods.

The effectiveness of repellent-treated net jackets for personal protection has been evaluated against various biting flies including: blackflies (McAndless 1974, Frommer et al. 1975 and Lindsay 1975); mosquitoes, (Gorham 1974 and Grothaus et al. 1976); the so-called valley black gnat, *Leptoconops carteri* Hoffman (=*tarrens* (Townsend)) (Mulrennan et al. 1975); tsetse fly, *Glossina morsitans* Westwood (Scholdt et al. 1975). However, there is only sparse documentation (Catts 1968; Grothaus et al. 1976) concerning the effectiveness of the jackets against deer flies, *Chyrysops* spp. and biting midges, *Culicoides* spp. Because we have so little information about the effectiveness of these repellent jackets against biting midges, tests were initiated in 1977 to determine their usefulness against 4 species of *Culicoides* that commonly breed in the salt marshes and mangrove swamps found along coastal areas of the southeastern United States and Caribbean islands.

MATERIALS AND METHODS

The hooded, waist length net jackets with long sleeves used in the study were purchased from Cole Outdoor Products of America Inc., Lincoln, NE. They are made of a loose weave of cotton and polyester fibers. When approximately 60 ml of a 75% ethanol solution of deet (*N,N*-diethyl-*m*-toluamide) is added, this cotton acts as a wick and so provides spatial as well as contact repellency (Schreck et al. 1970; Grothaus et al. 1976).

The jackets were treated as follows. The liquid repellent was applied to the jackets while they were still in their respective plastic bags. After at least 12 hr the jackets were removed from the bags and aired for 1 hr so the ethanol vapors could escape. Then the jackets were stored in plastic bags except when they were not in test. Freshly treated jackets were worn in each study. Subjects wearing the jackets wore short-sleeve "T" shirts or similar short-sleeved attire beneath. Thus when the hood was in place only the face and hands were left uncovered. The check subject wore a head net and shirt with sleeves rolled to the elbows so only forearms and hands were exposed. All wore long pants, usually military fatigues.

Tests were made for 5 min, 8 to 12 times on a given day and, when possible, both early in the morning and late in the afternoon. Four to six subjects partici-

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

[2] The research reported in this manuscript was conducted in part using U.S. Navy, Naval Facilities Engineering Command Funds.

pated in each of the studies, and a total of 10 different subjects was used. During each 5 min test, the check subject counted only the midges that were biting the forearms and hands (to establish an index of biting pressure) and crushed them so they would not be counted more than once. Those midges that bit the subjects wearing jackets were also killed as they were counted. (With few exceptions bites recorded by subjects wearing jackets were on the exposed hands and face. Bites occurring on the face were observed by using a small cosmetic mirror hooked around the neck so that the hands were free.) At the end of 5 min, numbers of bites on each of the test subjects including the check were recorded. Then the subjects changed positions (moving in a clockwise direction) so no one remained at one location longer than 5 min. A different subject was used as a check in each study. Thus in a series of 4 studies at 1 location with species, 4 different check subjects were used.

At the completion of each study, the total number of bites on each of the subjects was calculated by combining all of the 5-min tests counts of that study. The bites per minute were then calculated by the following formula:

$$\frac{\text{Total no. of bites}}{\frac{\text{No. 5 = min texts}}{5}} = \text{no. bites/min.}$$

The relative effectiveness of treated or untreated jackets could then be determined by comparing the biting rates on the subjects wearing jackets with those on the check subject. From these data a coefficient of protection was calculated by using the following formula: $\frac{(A-B)\cdot 100}{A}$

where A is the average number biting the check per minute, and B is the average number biting the treatment per minute.

A variety of locations as well as species was used so as to examine the range of effectiveness of the repellent treated jackets under varying circumstances. Also, when possible, studies were scheduled to cover peak activity of species in spring and/or fall. Also during the March 1978 tests at Yankeetown, Florida, both treated and untreated jackets were tested to learn whether the untreated jacket gave physical protecction that supplemented the repellent treatment.

The location, date, time of day and predominant species for each of the studies described were as follows (see Table 1):

1. Roosevelt Roads, Puerto Rico, October 1977, AM, *Culicoides furens* (Poey).
2. Parris Island, South Carolina, November 1977, AM-PM, *Cu.hollensis* (Melander and Brues).
3. Yankeetown, Florida, March 1978, AM-PM, *Cu.mississippiensis* Hoffman.
4. Parris Island, South Carolina, April 1978, AM-PM, *Cu.hollensis.*
5. Ft. Myers, Florida, May 1978, AM-PM, *Cu. barbosai* Wirth and Blanton.

RESULTS AND DISCUSSION

The abundance of biting midges varied considerably with location and species. However, data for all locations and species showed that when the deet-treated jackets were worn, 0.04 to 6.93 bites/min were recorded. Meanwhile the check recorded 7.3 to 43.7 bites/min. Obviously the protection provided by the deet-treated net jacket was good. In fact, persons wearing the deet-treated jackets would have received an average of 2 to 22 bites/hr from all species except *Cu.barbosai; Cu. barbosai* gave 416 bites/hr. Unprotected persons would have received an average of 438 to 2622 bites/hr.

When the untreated and treated jackets were compared, no significant difference was noticed between the protection afforded by the untreated jacket (10.1 bites/min) and the check (15.9 bites/min) against *Cu. mississippiensis,* but the treated jacket allowed only 0.37 bites/min.

Thus, in tests with all species except *Cu.*

Table 1. Relative protection provided by the deet-treated net jacket against 4 species of the biting midge, *Culicoides*.

Dominant species	Location and date	No. subjects	No. 5 min tests	Avg. no. bites/min		% Protection
				Deet-treated jacket	Check	
Culicoides furens	Roosevelt Roads, Puerto Rico 10–5–77	4	48	0.14	43.7	99.7
Cu. hollensis	Parris Island, South Carolina 11–8–77	4	58	.04	7.3	99.5
Cu. mississippiensis	Yankeetown, Florida 3–6–78, 3–21–78	6	84	.37	15.9	97.7
Cu. hollensis	Parris Island, South Carolina 4–13–78	5	72	.09	9.13	99.1
Cu. barbosai	Ft. Myers, Florida 5–16–78	4	96	6.93	16.81	58.8

barbosai, the jackets provided 97% or greater protection from bites. Bites of *Cu. barbosai* were reduced only 58.8%, and these midges were observed to pass through the deet-treated net and bite in addition to biting the unprotected faces and hands of the 4 test subjects wearing the treated jackets.

Methods of personal protection against blood feeding Diptera should therefore be tested for effectiveness against a number of species and families. It cannot be assumed that a successful repellent will be effective against all species unless all species have been evaluated. This consideration apparently has not been widely held in view of the limited number of insect species tested in repellent studies published to date.

ACKNOWLEDGMENTS

We thank D. Godwin, J. Jackson, K. Posey, D. Smith, R. Roberts and R. Grothaus of this laboratory, as well as Lieutenant J. McCormick and Chief L. Wilson of the U.S. Navy Medical Dispensary, Parris Island, South Carolina, and the Chamber of Commerce, Yankeetown, Florida, for participating in the studies and/or providing access to test sites.

References Cited

Catts, E. P. 1968. Deet-impregnated net shirt repels biting flies. J. Econ. Entomol. 61:1765.

Frommer, R. L., R. R. Carestia and R. W. Vavra, Jr. 1975. Field evaluation of deet-repellent mesh jacket against black flies (Simuliidae). J. Med. Entomol. 12:558–561.

Gorham, J. R. 1974. Tests of mosquito repellents in Alaska. Mosquito News 34:409–415.

Grothaus, R. H., J. R. Haskins, C. E. Schreck and H. K. Gouck. 1976. Insect repellent jacket: Status, value and potential. Mosquito News 36:11–18.

Lindsay, I. S. 1975. Assessment of a garment for protection from biting flies. Defense Research Establishment Ottawa, DREO Tech. Note No. 75–3. 17 p.

McAndless, J. M. 1974. Personal protection against biting flies: The relative effectiveness of topical repellent and repellent-treated overjackets, collars and wrist bands. Defense

Research Establishment Ottaws, DREO Tech. Note No. 74–28, 30 p.
Mulrennan, J. A., L. A. Lewis and R. H. Grothaus. 1975. Field tests with repellent treated wide-mesh netted jackets against the valley black gnat, *Leptoconops carteri*. Mosquito News 35:228–229.
Schiefer, B. A., R. W. Vavra, Jr., R. L. Frommer, and E. J. Gerberg. 1976. Field evaluation of several repellents against black flies (Diptera, Simuliidae). Mosquito News 36:242–247.
Schreck, C. E., I. H. Gilbert, D. E. Weidhaas and K. H. Posey. 1970. Spatial action of mosquito repellents. J. Econ. Entomol. 63:1576–1578.
Sholdt, L. L., R. H. Grothaus, H. K. Gouck and C. E. Schreck. 1975. Field studies using repellent-treated wide-mesh net jackets against *Glossina morsitans* in Ethiopia. East African Med. J. 52:277–283.

LABORATORY STUDIES ON THE EFFECTIVENESS OF *BACILLUS THURINGIENSIS* VAR. *ISRAELENSIS* DE BARJAC AGAINST *SIMULIUM DAMNOSUM* (DIPTERA: SIMULIIDAE) LARVAE

ALBERT H. UNDEEN
Research Unit on Vector Pathology (RUVP) Memorial University of Newfoundland, Canada

DANIEL BERL
Institut de Recherches sur l'Onchocercose Bouaké, Côte-d'Ivoire, West Africa

A variety of *Bacillus thuringiensis* pathogenic to mosquito larvae was isolated from a mosquito larval habitat in Israel (Goldberg and Margalit 1977). It was found to be a new serotype and given the name *Bacillus thuringiensis* var. *israelensis* (de Barjac, 1978). Aqueous suspensions of this *Bacillus*, cultured on agar from an inoculum provided by Dr. L. J. Goldberg of the Naval Biosciences Laboratory, Oakland, California, proved quite toxic to the larvae of several species of Newfoundland black flies (Undeen and Nagel 1978). Arata et al. (1978) suggested that the control potential of this microbe should be assayed against other simuliid species, especially *Simulium damnosum*, the vector of West African onchocerciasis.

MATERIALS AND METHODS.

A sample of *B. thuringiensis* var. *israelensis* powder, rated at 1,000 *Aedes aegypti* units per mg, was obtained from Dr. H. de Barjac of the Pasteur Institut and bioassayed for *Simulium verecundum* efficacy in Newfoundland (Undeen and Nagel 1978). The bacterial powder, as well as some of the aqueous suspension produced in Newfoundland was taken to Bouake, Ivory Coast, for testing against *S. damnosum*.

The tests were carried out in 2 systems. (1) A portable version of the Colbo and Thompson (1978) system used in Newfoundland so that parallel investigations of *S. damnosum* could be carried out using procedures and doses described in Undeen and Nagel (1978) and (2) a concrete trough system (Berl and Prud'hom, 1979) through which water is circulated by pumps.

The *S. damnosum* tests in the magnetic stirrer system differed from the *S. verecundum* tests in that the African water temperature was 26° compared to the Newfoundland 19°C. Tetra 4-in1[R] food