REPELLENCY OF TWO DEET FORMULATIONS AND AVON SKIN-SO-SOFT® AGAINST BITING MIDGES (DIPTERA: CERATOPOGONIDAE) IN HONDURAS[1,2]

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ABSTRACT. Two U.S. military issue deet repellent formulations (75% deet liquid and 33% deet lotion) and Avon Skin-So-Soft® were tested against ceratopogonid midges under field conditions in Honduras. Test subjects were U.S. military personnel deployed to Honduras for training. *Culicoides furens* accounted for 96.3% of all midges collected. The liquid and lotion formulations of deet and Avon Skin-So-Soft provided 97.9, 95.9 and 71.4% protection, respectively, compared with the untreated control. Both deet formulations provided significantly better protection ($P < 0.05$) than Avon Skin-So-Soft. The latter provided protection by trapping the midges in the oily film and not by repelling the insects as did the deet formulations.

INTRODUCTION

A number of field studies in the U.S.A. have evaluated the effectiveness of deet repellent applied to exposed skin against a variety of ceratopogonid midge species. Sjogren (1971) reported that alcohol base solutions containing 25, 50 and 75% deet had no repellent effect against *Leptoconops kerteszi* Kieffer in California. In contrast, Schreck et al. (1979b) reported that 25% deet in ethanol provided 84–96% protection against *Culicoides hollensis* Melander and Brues in South Carolina and 92–99% protection against *C. mississipiensis* Hoffman in Florida. Subsequently, Schreck and Kline (1981) reported that 25% deet in ethanol provided >99% protection against a mixed population containing 94% *C. barbosai* Wirth and Blanton in Florida and a mixed population containing 80% *C. hollensis* and 20% *C. melleus* (Coq.) in South Carolina.

Net jackets treated with deet also reduce the attack of various species of biting midges. Early work in California (Mulrennan et al. 1975) showed that deet-treated jackets (0.25 g deet/g of netting) provided 97% protection against *Leptoconops carteri* Hoffman. Schreck et al. (1979a) reported that net jackets treated with 60 ml of a 75% ethanol solution of deet provided >98% protection against *C. furens* (Poey) and *C. mississipiensis* and 59% protection against *C. barbosai* in Florida, 99% protection against *C. hollensis* in South Carolina and 99% protection against *C. furens* in Puerto Rico. Harlan et al. (1983), using the same type of jacket as Schreck et al. (1979a), demonstrated 87–93% protection against 5 species of biting midges, principally *C. furens* and *C. barbosai*, during field testing in Panama.

These studies indicate that deet applied either to exposed skin or to net jackets provides adequate protection against a number of biting midge species. However, these studies also show that deet provides inadequate protection against some species, such as *C. barbosai*.

Biting midges have long been known to occur along the northern coast of Honduras during certain periods throughout the year. Painter (1926) reported large populations of *C. furens* in and around the coastal area of Puerto Castilla, Honduras. Military personnel training in these areas report biting midges as the major nuisance pest. The authors have also observed large numbers of these insects, both on the mainland and on coastal islands along the northern coast of Honduras.

Unsatisfactory protection from biting midges after the use of military issue deet repellent formulations [Insect Repellent Liquid (deet liquid), national stock number (NSN) 6840-00-753-4963 and Insect/Arthropod Repellent Lotion (deet lotion) NSN 6840-01-284-3982] recently has been reported by military personnel training in Honduras. Many of these personnel reported receiving numerous bites (10 or more) within the first hour after application of these repellents. Some personnel also reported the use of Skin-So-Soft® (SSS) bath oil, marketed by Avon Products, Inc., New York, NY, as a biting midge repellent. Schreck and Kline (1981) reported that SSS was effective against biting midges in the field when 1 ml was applied evenly over the forearm. These authors concluded that this product could be used to prevent bites, not

[1] The opinions and assertions contained herein are the private views of the authors and should not be construed as official or as reflecting the views of the Department of the Army or the Department of Defense. Mention of trade names in this report does not constitute an official endorsement or approval for the use of these items.

[2] Humans subjects in this study gave free and informed voluntary consent.

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because it repels midges, but because the oil traps midges on the skin surface.

In the present paper, we report the results of a field study comparing the repellent action of deet liquid, deet lotion and SSS against ceratopogonid midges in Honduras.

MATERIALS AND METHODS

The test site was located on the southern coast of Barbareta Island, approximately 30 km off the northern coast of Honduras. A variety of ceratopogonid species are present on the island; however, *C. furens* is the major pest species. The field test was conducted during a training exercise in May 1989.

Two U.S. military issue deet formulations were tested: 1) Insect Repellent Liquid (NSN 6840-00-753-4963) containing 75% deet in ethanol, and 2) Insect/Arthropod Repellent Lotion (NSN 6840-01-284-3982) containing 33% deet and 67% inert ingredients. Deet (*N, N*-diethyl-3-methylbenzamide) is the active ingredient in both repellents. Concentrated bath oil SSS was also tested.

The test procedures were modified from those originally described by Schreck et al. (1979b). To assess the performance of the deet formulations in a field environment, label instructions were followed as closely as possible. Deet lotion label directions indicate that 2.5 ml will treat both forearms, therefore 1.25 ml was used to treat one forearm. Deet liquid directions indicate that 12 drops (0.6 ml) will treat all exposed skin (hands, head and neck). It was decided that this amount would be used to treat one forearm. The same quantity (0.6 ml) of SSS was also used to treat one forearm.

Volunteers wore either the battle dress uniform (BDU) and cap or the olive drab jungle fatigue uniform and cap with the right sleeve rolled to the elbow. Rubber gloves were worn during the tests to limit exposure to only the right forearm. Each formulation was spread evenly from wrist to elbow by each volunteer. Formulations were applied 15 min before the start of each test session. Due to insufficient numbers of headnets, treated volunteers applied an additional quantity of the same formulation being tested to the face and neck. The control wore a headnet. Treated arms were continuously exposed to the natural populations of midges. Three test sessions each consisting of ten 5-min replicates were conducted (dawn, midday and dusk) for 3 days. Dawn and dusk test sessions started 30 min before sunrise or sunset and continued until the 10 replicates were completed. Midday tests were conducted between 1130 and 1230 h. There were 9 treated people (3 each for deet liquid, deet lotion and SSS), and 1 control (untreated) for each test session. The volunteers were randomly assigned positions in a circular formation standing 8–10 m apart. Each replicate lasted 5 min, after which volunteers moved in a clockwise direction to the next position. Therefore, each subject occupied each position in the circle during a 50-min test session.

During each 5-min replicate, the control individual aspirated midges biting the untreated forearm to establish the index of biting pressure and provide specimens for later identification. After each 5-min replicate, the number of bites on the treated arms were recorded. A different individual was the control in each test session. Treated forearms were thoroughly washed with unscented soap at the close of each test.

Data were analyzed on a VAX computer using the BMDP statistical software program.[6] The differences in the numbers of bites were compared statistically using the Friedman 2-way analysis of variance test (Siegel 1956). The Friedman test is an extension of the sign test to more than 2 matched variables in which the data are arranged as a randomized block design.[6] This nonparametric statistical technique was used because the data were not normally distributed and, therefore, did not meet the distributional assumptions of standard analysis of variance procedures.

RESULTS AND DISCUSSION

Field test populations of ceratopogonid midges were found to be mixed (Table 1), but *C. furens* accounted for 96.3% of all specimens collected during the test sessions. Biting activity was low (<14 bites/h for the control subject) during the 3 midday test sessions. During the daylight hours a strong breeze (>20 kph) was always present. Linley and Davies (1971) report that there is total cessation of all *C. furens* biting activity at wind speeds >10 kph. *Culicoides furens* is crepuscular and nocturnal in its biting activity, with pronounced dawn and dusk peaks of activity (Linley and Davies 1971).

There was no significant difference between the effectiveness of the 2 deet formulations, and both deet formulations were significantly more effective ($P < 0.05$) than SSS (16.8 bites/h, 71.4% protection). Deet liquid was most protective with 1.2 bites/h (97.9% protection) and deet lotion was also effective with 2.4 bites/h (95.9% protection). These findings contrast somewhat with Schreck and Kline (1981) who reported that SSS was up to 6 times more effective than

[6] BMDP Statistical Software Manual, Volume 1. 1990. BMDP Statistical Software, Inc., Los Angeles, CA.

Table 1. Mean number of bites/h* from ceratopogonid midges** and percent protection obtained with deet liquid, deet lotion and Avon Skin-So-Soft® (SSS).

Treatment	Mean no. bites/h***	% protection
Deet liquid	1.2[a]	97.9
Deet lotion	2.4[a]	95.9
Avon SSS	16.8[b]	71.4
Control	58.8[c]	0.0

* Means in the same column followed by different letters are significantly different at the $P < 0.05$ level using the Friedman 2-way nonparametric analysis of variance procedure.

** Species identified in biting collections were 96.3% *Culicoides furens*, 3.4% *Leptoconops becquaerti* Kieffer and 0.3% *Culicoides diabolicus* Hoffman.

*** Means of 27 tests (270 replicates) for each formulation and 9 tests (90 replicates) for the control.

deet against *Culicoides* spp. when used at ca. twice the dosage that was used in this study. Skin-So-Soft significantly decreased ($P < 0.05$) midge biting compared with the untreated control (58.8 bites/h). However, during 2 test periods with low biting activity (morning and midday), the subjects treated with SSS averaged more bites than did the control subject. The reason for this apparent failure in protection of SSS is unclear. The individuals treated with SSS and reporting more bites than the control may have had dry skin allowing the SSS to be absorbed at an increased rate, thus reducing the amount left on the skin surface to trap midges in the oily layer.

Observations of midge behavior during the test sessions confirmed that deet acts as a repellent by preventing midges from landing on the treated skin. As previously indicated (Schreck and Kline 1981), SSS does not appear to repel biting midges. It acts as an oily barrier and physically traps the midges on the sticky surface of the skin. No midges were trapped by the deet formulations, whereas hundreds of midges were trapped in the oily SSS.

These studies show that both U.S. military issue deet formulations effectively repelled *C. furens* in Honduras. Avon SSS provided some protection, but the level of protection would probably not be acceptable to many people. Because the biting counts reported in this study were taken from only one exposed forearm, troops in a similar field environment could expect to receive several-fold more bites/h due to more exposed skin area (i.e., head, neck and both forearms). Although deet may provide >95% protection against these species of biting midges in the field, at issue is the number of bites/day that can be perceived as being tolerable. For some individuals who are allergic to biting midges (Machuca 1966) this may be a serious problem.

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