REPELLENCY DETERMINATIONS OF FOUR COMMERCIAL PRODUCTS AGAINST SIX SPECIES OF CERATOPOGONID BITING MIDGES[1, 2]

C. E. SCHRECK AND D. L. KLINE

Insects Affecting Man and Animals Research Laboratory,
Agricultural Research, Science and Education Administration,
USDA, Gainesville, Florida 32604

ABSTRACT. In a series of field tests in which several commercial products were evaluated in paired tests with a deet (*N, N*-diethyl-*m*-toluamide) standard against 6 species of *Culicoides* biting midges, all materials including deet were very effective. The products tested were Avon's Skin-So-Soft®, Johnson's™ Baby Oil®, Claubo® and mineral oil. In the absence of a suitable repellent, these products could be used to prevent bites, not because they repel midges, but because their oiliness traps midges on the skin surface.

The primary mission of our research unit at the Insects Affecting Man and Animals Research Laboratory is personal protection from the bites of blood-feeding arthropods. A significant portion of the research has been concerned with topical and clothing repellents. In the course of these investigations, we have become aware of a number of different methods and materials that might be termed "home remedies," which are firmly endorsed by their advocates as to their effectiveness in preventing insect bites. Many have been tested by our laboratory, and though some materials were initially effective, protection in most cases was found to be of short duration when compared with the better, commercially available formulations containing deet (*N,N*-diethyl-*m*-toluamide). Deet is an effective repellent by both its contact and vapor action and is relatively long-lasting because of its resistance to loss by abrasion (Smith et al. 1963).

Recently, we have learned from a number of sources, including the U.S. Navy (Cdr. L. L. Sholdt, of the Navy Disease Vector Ecology and Control Center, Naval Air Station, Jacksonville, Florida, personal communication), that the concentrated bath oil Skin-So-Soft® (SSS) marketed by Avon™ Products, Inc., New York, New York is widely used full strength as a skin application to protect against biting midges (*Culicoides* spp.). Another product, Johnson's™ Baby Oil® (JBO), marketed by Johnson & Johnson, New Brunswick, New Jersey, has also been reported as being used often for this purpose. A third product, Claubo®, distributed by Claubo Corporation, Savannah, Georgia, has been formulated and sold as a repellent against these species.

Subsequent investigation revealed that an ingredient common to all these products was mineral oil. JBO is mineral oil plus a fragrance. Claubo and SSS were found to contain nearly identical ingredients as is shown in the following comparison:

SSS	*Claubo*
Mineral oil	Mineral oil
Isopropyl palmitate	Palmitate*
Diisopropyl adipate	
Fragrance	Fragrance
Dioctyl sodium sulfosuccinate	Dioctyl sodium sulfosuccinate

[1] This paper reports the results of research only. Mention of a pesticide in this paper does not constitute a recommendation for use by the U.S. Department of Agriculture nor does it imply registration under FIFRA as amended. Also 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.

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Benzophenone-11	Benzyophenone-11
	Isopropyl stearate
	Isopropyl myristate
	Bensy* alcohol

* As found on the label.

Their physical appearance, including color, viscosity, and odor, are unmistakably similar. The important difference between the 3 products is that Claubo is being marketed specifically as a repellent for "gnats," mosquitoes, and flies, whereas the word "gnat" is commonly used to characterize *Culicoides* spp.

In the present paper, we report the results of experiments designed to compare these products to deet in terms of effectiveness and mode of action. Tests were designed to evaluate SSS, JBO, Claubo, and mineral oil, and included deet as a standard repellent.

MATERIALS AND METHODS

Three test sites were included in the studies. The first test area was at Yankeetown, Florida in June 1979, a time of year when a mixed population of *Culicoides furens* Poey, *C. barbosai* Wirth and Blanton, *C. floridensis* Beck, and *C. mississippiensis* Hoffman occur. The second test area was at Ft. Myers, Florida in September 1979, a time of year when *C. barbosai* occurs in large numbers. The third test area was at Parris Island, South Carolina in April 1980, when *C. hollensis* (Melander and Brues) and *C. melleus* (Coquillett) are the major pest species.

The test procedures were described by Schreck et al. (1979). The formulations and mineral oil were applied at full strength, whereas a deet standard was applied as a 12.5 or 25% ethanol solution. All applications were made in 1-ml aliquots and spread evenly over the forearm of a subject from wrist to elbow. Six subjects participated in each of the studies.

All subjects wore a headnet and shirt with sleeves rolled to the elbow, and gloves were worn permitting exposure of only the forearms on treated subjects, while exposure of the hands of the check subject allowed extra freedom for killing and counting biting midges. All subjects wore long pants, usually military fatigues. Treated arms were continuously exposed to the natural populations of midges. Tests were made in units of 5 min each because of the fluctuating activity of the midges. Up to twenty-one 5-min tests were made in 1 replication of a test series depending on fly activity and weather conditions at each location.

The purpose of the 5-min test was to establish an index of biting pressure with the untreated check subject as an indicator of activity while the other subjects exposed treated arms to the midge population. At the end of 5 min, the number of bites on each of the test subjects and the check were recorded. The subjects (each separated by 8–10 m) then changed positions, moving in a clockwise direction, so that no one remained at a location longer than 5 min. A different subject was used as a check in each replication of the study. During each 5-min test, the check subject counted only those midges that were biting the forearms and hands, and these were crushed so that they were not counted more than once. Each material was paired directly on one forearm with deet on the other forearm in each test series. The forearms were thoroughly washed with unscented castile soap between tests.

At Yankeetown, the materials (mineral oil was not included in this study) were applied at 1840 h and tested until dark at 2045 h. Four to 6 replications of each treatment were made.

At Ft. Myers and Parris Island, tests were made at dawn and at dusk, and all formulations were applied 1 hr before testing. Tests began with the onset of biting activity and continued until daylight; light intensity, heat, or wind conditions (depending on species) caused biting to cease 60–90 min later. Evening tests were conducted in the same manner beginning with start of biting activity and ending when biting ceased 60–90 min later. Two or 3 replications of each treatment were made in each study.

Since it was not always possible to distinguish species when they were biting, collections were made by aspirating midges in the act of biting the untreated check subject during tests. Subsequent determination of species composition of the biting population was then made.

RESULTS AND DISCUSSION

Results of the studies at each location are given in Table 1. At Yankeetown, Florida, against a mixed population containing 58% *C. mississippiensis*, no bites were recorded on the 25% deet treatments, and biting rates on the candidate treatments were quite low, except for Claubo at ca. 23 bites/hr.

At Ft. Myers, Florida, against a mixed population containing 94% *C. barbosai*, SSS was ca. 6X and Claubo 3X more effective than deet. Johnson's Baby Oil was least effective at ca. 120 bites/hr when paired with deet at ca. 8 bites/hr. However, when these results are compared with the untreated check at ca. 2511 bites/hr on 1 arm, it must be concluded that considerable protection was afforded by all treatments in these tests. Unfortunately, due to weather and limited time for testing, only 2 replicated tests could be made on Claubo, JBO, and mineral oil.

At Parris Island, South Carolina, against a mixed population containing 80% *C. hollensis* and 20% *C. melleus*, <1 bite/hr was recorded for the JBO treatment in 3 tests, and no bites were recorded with the other candidates. The deet standard averaged ca. 2 bites/hr during the same period, while the check averaged 351 bites/hr. Again, the data show that considerable protection was provided by all treatments.

Observations made by all test subjects in these studies revealed that the mode of action of deet was to repel attacking midges, whereas the other materials did not repel at all but merely trapped the insects on the oily skin surface, thus preventing bites. No midges were observed trapped by the deet standard application, while hundreds were found stuck to the candidate applications.

These studies show that SSS, JBO, Claubo, and mineral oil are effective as protective applications for the prevention of bites from at least 6 species of the genus *Culicoides*. Certainly, in the absence

Table 1. Mean numbers of bites/min received from *Culicoides* spp. in paired tests with a deet standard as a 12.5 or 25% ethanol solution and the candidate materials at full strength.

Pairings of candidates and standard	Yankeetown, Fla.[a] No. of replications	Yankeetown, Fla.[a] Mean[d] no. of bites	Ft. Myers, Fla.[b] No. of replications	Ft. Myers, Fla.[b] Mean[e] no. of bites	Parris Island, S.C.[c] No. of replications	Parris Island, S.C.[c] Mean[d] no. bites
Deet	6	0	3	87.6	3	0.42
Skin-So-Soft®	6	3.6	3	15.	3	0
Deet	4	0	2	7.8	3	.42
Johnson's® Baby Oil®	4	0.6	2	120.	3	.18
Deet	4	0	2	45.	3	5.58
Claubo®	4	22.8	2	15.	3	0
Deet			2	15.	3	.18
Mineral Oil			2	22.8	3	0
Check	3	384.0	2	2511.0	3	351.0

[a] Species identified in biting collections were 58% *C. mississippiensis*, 17% *C. barbosai*, 13% *C. floridensis* and 12% *C. furens*.

[b] Species identified in biting collections were 94% *C. barbosai*, 5% *C. furens* and 1% *C. floridensis*.

[c] Species identified in biting collections were 80% *C. hollensis* and 20% *C. melleus*.

[d] Deet tested at 25% in ETOH.

[e] Deet tested at 12.5% in ETOH.

of a suitable repellent, any of these commercial materials might serve as useful substitutes to mechanically prevent bites. As a caution, however, it must be noted that the sale and recommended use of SSS is not as a skin application at full strength but rather as a dilution as a bath oil at the rate of ½ capful in a bathtub of water. It would therefore be prudent to investigate what effect, if any, long-term applications to the skin might have on the potential user of this and the other materials tested.

A possible cause for dissatisfaction in some users might be both the oiliness of these products and the numbers of midges stuck to the skin after long-term exposure to high populations.

An interesting observation made as a result of these studies showed that biting rates could be determined with any of the oily preparations on the forearm. Five-minute interval counts of attacking *Culicoides* species stuck on the oily surface of the treated skin equaled those biting an untreated check in the same period. Such a method could possibly be used to determine biting rates of known and/or suspected disease vector species with minimal hazard of disease transmission to the investigator.

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