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FIELD EVALUATION OF HEAT AS AN ADDED ATTRACTANT TO TRAPS BAITED WITH CARBON DIOXIDE AND OCTENOL FOR *AEDES TAENIORHYNCHUS*

DANIEL L. KLINE[1] AND GENE F. LEMIRE[2]

ABSTRACT. Collection size of 3 species of mosquitoes (*Aedes taeniorhynchus, Anopheles atropos,* and *Culex nigripalpus*) and a species of biting midge (*Culicoides furens*) in CDC-type traps baited with carbon dioxide and octenol were significantly increased with the addition of heat. The presence of heat also significantly reduced collection size of the tabanid *Diachlorus ferrugatus.*

INTRODUCTION

Aedes taeniorhynchus (Wied.) is the dominant salt marsh mosquito species in coastal areas of Collier County, FL. It is a serious pest of humans and other vertebrates. Currently Collier Mosquito Control District (CMCD) operational personnel rely solely on aerial sprays of Baytex® (fenthion) to control this species. Given the present-day political climate towards the use of broad-spectrum insecticides spawned by the concerns of various segments of the general public and environmental groups (Kline 1994), this strict reliance on aerial sprays needs to be reassessed.

This increased concern about use of insecticides has provided the impetus to conduct a cooperative research effort on Key Island, located southwest of Naples, FL, to evaluate the potential role of attractant-baited traps/targets in an integrated management strategy to protect a resort area located on the north end of the island from populations of *Ae. taeniorhynchus* believed to be migrating in from the south. A research project was initiated in the spring of 1993 to develop an effective barrier perimeter of baited traps/targets around the resort area. The first step was to select a baited trap/target. The selection of our initial baited-trap setup was based on recent studies showing that carbon dioxide (CO_2) and 1-octen-3-ol (octenol) are good attractants for *Ae. taeniorhynchus* in south Florida (Takken and Kline 1989; Kline et al. 1990, 1991b). Used together these 2 attractants have demonstrated a synergistic effect on collections of this species made with an unlighted model 512 Communicable Disease Center (CDC)- type trap (John Hock, Gainesville, FL). Although this trap–bait combination has resulted in large collections of *Ae. taeniorhynchus* under field conditions, mark–release–recapture studies with known numbers of laboratory-reared 3–4-day-old adult female mosquitoes of this species conducted in a large outdoor cage resulted in a recovery rate of 50–75% with this same trap–bait combination (Kline, unpublished data). These latter data indicate that our selected trap–bait combination might be improved. In recognition of this possibility an ongoing search for additional attractants and/or improved trap/target design was initiated simultaneously with the beginning of the overall project. As part of this search, a literature review revealed several studies conducted on other *Aedes* spp. (e.g., *Aedes aegypti* [Linn.]) in which heat in the presence of CO_2 resulted in increased landing responses of female mosquitoes (Clements 1963, Khan and Maibach 1966, Khan et al. 1966). Because similar studies have not been reported for *Ae. taeniorhynchus,* the objective of the present study was to determine whether the addition of heat to our previously selected trap–bait combination would result in increased trap collections of *Ae. taeniorhynchus* under field conditions.

MATERIALS AND METHODS

Field studies were conducted during 8 trap-days between April 27 and May 19, 1993, in Collier Seminole State Park. Each trap-day consisted of a *ca.* 24-h period beginning at *ca.* 0800 h Eastern Daylight Savings Time (EDST) one day and ending at *ca.* 0755 h the following day. Two densely vegetated trap sites located *ca.* 30.5 m apart were selected. These sites were selected because a New Jersey light trap nearby indicated an abundance of the target species, and it was near the employees' compound where a source of 110-V electricity was readily available for the heating pads. A single battery-powered model 512 CDC-type trap was hung at each site from a metal pole at a height of *ca.* 1.2 m above ground level, and operated without light. Each trap was equipped with a source of CO_2, octenol, and heat. The CO_2 was metered from a 9-kg compressed gas cylinder at 200 ml/min using a

[1] United States Department of Agriculture, Agricultural Research Service, Medical and Veterinary Entomology Research Laboratory, P. O. Box 14565, Gainesville, FL 32604.

[2] Collier County Mosquito Control District, P. O. Box 7069, Naples, FL 33941.

Table 1. Effect of heat on the mean number (±SE) of mosquitoes and other biting Diptera into model 512 CDC-type traps baited with CO_2 + octenol (n = 8 nights).

Species	No heat	Heat	Critical t-value	$P > t$
Aedes taeniorhynchus	14,698 ± 3,324	27,958 ± 7,543	1.99	0.04
Anopheles atropos	711 ± 445	1,390 ± 516	2.65	0.02
Culex nigripalpus	117 ± 30	624 ± 138	3.55	0.005
Culicoides furens	9,354 ± 4,950	26,688 ± 9,175	2.19	0.03
Diachlorus ferrugatus	135 ± 15	69 ± 19	−4.15	0.002

Victor (Model VTS 453B) double-stage regulator (Victoria Equipment Company, Denton, TX) and micrometering valve (Series M, Nupro, Willoughby, OH). Gas flow was monitored using a compact #12 flow meter (Gilmont Instruments, Barrington, IL) and was delivered to its release point *ca.* 5 cm from the top trap entrance via polyethylene tubing. Octenol was supplied from 5-ml microreaction vials (Supelco, Bellefonte, PA) fitted with plastic lids and neoprene septa using a wick (Dills® 15-cm pipe cleaner) system (as illustrated by Kline et al. [1991a]). The pipe cleaner was doubled over with *ca.* 2 cm protruding above the septum. The microreaction vial was placed adjacent to the CO_2 release point. Heat was supplied by attaching a 50-W Sunbeam® model 734 moist heating pad (Sunbeam Home Comfort, Chicago, IL), wrapped in black polyester cloth, to the underside of each trap lid. This resulted in a heated surface area of 95.8 cm^2. When turned on, the heating pads were operated on the high setting, which resulted in a surface temperature of 46°C.

Collections were made into 568-ml (1-pint) Mason jars containing a small piece of resin strip (Industrial Strip™, Bio-Strip, Inc., Reno, NV) impregnated with dichlorvos as the killing agent. All tabanids were removed, identified, and their number recorded before the sample was thoroughly mixed, weighed, and a 1-g subsample removed for identification of biting midge and mosquito species. Estimated collection size of each species was extrapolated based on the number found in each subsample.

Paired comparisons were made between CO_2 + octenol-baited traps, with and without heat. This was achieved by continuously dispensing the CO_2 + octenol at both trap sites, and on alternating trap-days turning on the heating pads at either one trap site or the other. Statistical analyses of these data consisted of the one-tailed t-test for paired comparisons utilizing Statistical Analysis System's (SAS) PROC UNIVARIATE (SAS Institute 1985).

RESULTS

An estimated total of 364,830 mosquitoes was collected. The collections consisted of 5 species of mosquitoes, which in descending order of abundance were *Ae. taeniorhynchus* (93.5%), *Anopheles atropos* Dyar and Knab (4.6%), *Culex nigripalpus* Theobald (1.6%), *Mansonia* spp. (0.1%), and *Aedes infirmatus* Dyar and Knab (0.1%). Due to their low numbers the latter 2 species were not included in the statistical analyses. The biting midge, *Culicoides furens* (Poey), and the tabanid, *Diachlorus ferrugatus* (Fabr.), were collected in sufficient numbers for statistical analyses. These data indicate that heat significantly increased the collection size of all species analyzed, except *D. ferrugatus,* which was significantly decreased (Table 1). The average ambient temperatures were *ca.* 30.6° C and 21.1° C at the beginning and ending of each trap day, respectively.

DISCUSSION AND CONCLUSIONS

The attraction of host-seeking mosquitoes to humans has been attributed to factors such as variations in skin temperature, skin color, sex, age, and body odor, and to other factors such as moisture (Khan 1977). However, the unique role, if any, of each of these factors in the mosquito response is not understood and is the subject of debate. Obtaining information on the role of various factors in mosquito attraction is essential for the development of traps/targets for use in an attractant-based surveillance and/or control program. Wright (1975) described mosquito attraction as a response to warmth and humidity but doubted the need to search for a particular skin emanation as a mosquito attractant. In contrast, Schreck et al. (1990) reported that heat was not necessary to elicit an attraction response in mosquitoes to substances collected from human skin and placed on glass Petri dishes. Unhandled heated control dishes did not evoke this response. Heat did, however, increase the attraction response of laboratory-reared *Ae-*

des albopictus (Skuse), *Ae. aegypti* (in most but not all trials), *Ae. taeniorhynchus, Anopheles albimanus* Wied., *Anopheles freeborni* Aitken, and *Anopheles quadrimaculatus* Say, but not field-collected *Culex quinquefasciatus* Say or *Culex salinarius* Coquillett. Field-collected *Anopheles crucians* Wied., *Coquillettidia perturbans* (Walker), *Culex nigripalus,* and *Mansonia* spp. did not respond to either heated or unheated handled or control dishes.

Although heat is not essential to attract *Ae. taeniorhynchus, An. atropos,* or *Culex nigripalpus* to CO_2 + octenol-baited traps, the presence of heat enhanced the ability of the traps to attract mosquitos, as demonstrated by the significantly increased collection size of all 3 species. This was an important finding to us because these are the 3 most abundant mosquito species attacking people on Key Island (Kline and Lemire, unpublished data). Based on these results, if a practical way can be found to add heat to our baited trap stations located on Key Island, the efficiency of our barrier perimeter traps in intercepting migrating populations of host-seeking mosquitoes will be enhanced.

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