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A COMPARISON OF THREE MOSQUITO SAMPLING TECHNIQUES IN NORTHWESTERN NEW JERSEY[1, 2]

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ABSTRACT. The similarity of 3 mosquito sampling methods was compared in northwestern New Jersey for 2 summers. The collecting techniques were the standard New Jersey light trap, dry ice baited CDC miniature light trap and human bite count. The data indicated that the dry ice baited CDC trap closely agreed with the mosquito collections made with the bite count. Collections from the standard light trap, however, did not accurately reflect the nuisance mosquito populations at the study sites.

INTRODUCTION

The need to accurately assess mosquito population levels has long been a major component of control efforts. Early attempts at measuring mosquito populations consisted of counting, capturing and identifying the species attracted to humans (Smith 1904). Although the technique provided a useful overview of the mosquitoes causing nuisance to the residents of a given area, the results obtained were inherently variable due to differences among the collectors. The development of the New Jersey light trap marked the beginning of efforts to overcome human induced variability by using consistent, mechanical mosquito collecting devices (Headlee 1932).

Although the light trap is currently employed as a standard mosquito sampling device, critics of the trap indicate that the collections do not reflect the true mosquito nuisance levels (Huffaker and Black 1943, Service 1976). Reeves (1951) demonstrated that carbon dioxide might be a major factor in attracting mosquitoes to mechanical traps in proportion to those sampled by landing rates and animal-baited traps. Extensive research since that time has shown that adding dry ice as a source of carbon dioxide will greatly increase the number and variety of mosquito species captured (Newhouse et al. 1966, Morris and DeFoliart 1969, Magnarelli 1975). Frequently, the dry ice supplement is used in conjunction with CDC portable light traps (Sudia and Chamberlain 1962), so that collections may be made without the need for a nearby electrical outlet. The current study was undertaken to quantitatively compare mosquito collections made with 3 techniques that are commonly used to measure mosquito population levels; landing/biting rates, the standard New Jersey light trap and dry ice baited CDC light traps.

MATERIALS AND METHODS

The study was conducted in 4 state parks and forests in northwestern New Jersey. The area is characterized by gently rolling hills, mixed deciduous and pine forests, and limestone, sandstone and shale rock formations. Much of the region has an underlying clay pan, and during the spring, melting snow forms numerous woodland pools that produce sizeable populations of univoltine mosquito species. As the season progresses, the pools dry and reflood, leading to the emergence of several floodwater mosquito species.

A standard New Jersey light trap was operated nightly at each site from early June through August, 1979 and 1980. Collections

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were emptied daily and the mosquitoes were identified to species. Once each week, 2 of the recreation areas were visited for additional sampling with dry ice baited CDC traps and landing rate collections, i.e., each site was sampled biweekly.

The CDC traps were stationed approximately 30 m from the New Jersey light traps and operated from 1 hr before sunset until 1 hr after sunrise. Landing rate collections were 10 min. in length and were made twice during the evening, once 30 min. prior to sunset and again at sunset. A flashlight with a red filter was employed to make the collections possible with a minimum of interference to host-seeking mosquitoes. As the mosquitoes landed, they were aspirated from the investigator and placed in pint (0.47 liter) ice-cream containers. All CDC trap and landing rate collections were immobilized at the field site by freezing with dry ice. Only those mosquitoes positively identified in the laboratory were included in the data.

A comparison of the mosquitoes collected by the 3 sampling techniques used the similarity index of Horn (1966). The index is as follows:

$$Ro_c = \frac{\Sigma(x_i+y_i)\log(x_i+y_i) - \Sigma x_i \log x_i - \Sigma y_i \log y_i}{(X+Y)\log(X+Y) - X\log X - Y\log Y}$$

in which Ro_c is community overlap where a species (i) is represented x times in community X and y times in community Y. X and Y represent the total number of individuals in the community, or in this case, the trap. The end result is a relative scale ranging from zero when the communities are completely dissimilar to 1 when they are identical in species composition and species abundance. Tallamy et al. (1976) applied the index to compare trapping techniques for tabanids and deerflies (Diptera: Tabanidae).

RESULTS AND DISCUSSION

The first parameter for comparing the trapping methods was species richness, which is simply the total number of species collected. Light trap data are from the nights when both CDC and landing rate collections were made.

Table 1. A comparison of species richness as measured by 3 mosquito sampling techniques.

Sampling method	No. species collected		
	June	July	August
N.J. light trap	1	12	4
Landing rate	7	10	3
CO_2-CDC	12	15	10

The results are presented in Table 1 and are compiled by month. During June, the light trap collected only a single mosquito species, while the landing rate showed that 7 species were coming to bite. During the same period, the dry ice baited trap attracted 12 species, a twelve-fold increase over the trap currently used as the standard method to sample adult mosquitoes.

A summary of the mosquitoes most commonly collected is shown in Tables 2 and 3. From June 1–July 15, landing rate data indicated that *Aedes abserratus* (Felt and Young), *Ae. canadensis* (Theobald) and *Ae. excrucians* (Walker) were the principal species that were coming to bite (Table 2). Although the dry ice baited trap closely reflects these results, the standard light trap gave no indication that these 3 mosquito species were a problem in the region. Later in the summer, from July 16–August 31, the results were less consistent (Table 3). The most abundant nuisance species captured by the dry ice supplemented CDC trap were, in ascending order, *Anopheles quadrimaculatus* (Say), *Ae. trivittatus* (Coquillett), *Coquillettidia perturbans* (Walker), *Ae. vexans* (Meigen) and *An. punctipennis* (Say). Despite the reputed pest status of these mosquitoes (Carpenter and LaCasse 1955), the landing rate did not show them to be especially numerous at the times that sampling was conducted. In addition, the light trap proved to be a poor indicator of the major pest mosquitoes in the region during this sampling period.

Table 4 depicts the results of the species overlap comparison between the 3 sampling

Table 2. A comparison of the mosquito species collected by 3 sampling techniques from June 1–July 15, 1979 and 1980.

Species	No. mosquitoes collected		
	N.J. light trap	Landing rate	CO_2-CDC
Ae. abserratus	0	28	31
Ae. canadensis	0	22	70
Ae. excrucians	2	170	238

Table 3. A comparison of the mosquito species collected by 3 sampling techniques from July 16–August 31, 1979 and 1980.

Species	No. mosquitoes collected		
	N.J. light trap	Landing rate	CO_2-CDC
An. quadrimaculatus	4	5	36
Ae. trivittatus	2	4	75
Cq. perturbans	1	17	88
Ae. vexans	14	1	107
An. punctipennis	4	9	165

Table 4. A comparison of the species similarity of mosquitoes collected by 3 sampling techniques. Light trap data only from nights of CDC and landing rate collections.

Sampling method	Species overlap (0–1.0)			
	June	July	August	Entire study
N. J. light trap vs. landing rate	0	0.20	0.65	0.15
CO_2-CDC light trap vs. landing rate	0.92	0.58	0.65	0.66

methods. The data represent collections made only on nights when all 3 trap types were employed. During June, the light trap and the landing rate had an overlap of zero, demonstrating total dissimilarity in the populations sampled by each method. The dry ice baited trap and the landing rate had a similarity index of 0.92, however, illustrating the success of the trap in reflecting mosquito nuisance levels in the area. In July, the dry ice baited trap continued to be a far better indicator of mosquito biting problems than the standard light trap. During August, the standard light trap and dry ice supplemented traps were identical to each other in similarity to the landing rate collections. The tabulation for the entire season, however, demonstrates that the dry ice trap was much more similar to landing rates than the light trap.

Since light traps are generally operated every night, the similarity index was applied to all of the light trap data. Despite collecting more mosquitoes, the light trap remained a poor indicator of mosquito nuisance levels. The results, shown in Table 5, demonstrate that the dry ice supplemented CDC trap more accurately reflects bite counts than the standard light trap. In fact, August light trap figures were less similar to landing rates when the light trap was operated nightly because many mosquitoes captured were not found in the biting collections.

The best method for assessing mosquito population levels has been sought for over 80 years. Many scientists, wary of biased results, feel that almost any trap that actively attracts mosquitoes cannot accurately represent the true mosquito fauna in a particular region (Huffaker and Black, 1943, Bidlingmayer 1974). Service (1976) acknowledges this shortcoming but points out that human baited collections provide an estimate of true mosquito pest potential, which is of great importance to control workers.

Table 5. A comparison of the species similarity of mosquitoes collected by 3 sampling techniques. Light trap collections made nightly.

Sampling method	Species overlap (0–1.0)			
	June	July	August	Entire study
N. J. light trap vs. landing rate	0.66	0.31	0.46	0.31
CO_2-CDC light trap vs. landing rate	0.92	0.58	0.65	0.66

Since landing/bite counts vary greatly depending upon the individual collector and the time at which samples are taken, many mosquito abatement districts rely on the standard New Jersey light trap for gathering mosquito population data. Mosquitoes that are not positively phototactic, however, are poorly represented in light trap collections (Huffaker and Black 1943, Service 1976). Studies have indicated that the presence of dry ice not only increases trap collections (Newhouse et al. 1966), but helps provide a truer picture of mosquito pest problems (Parsons et al. 1974).

The current study demonstrated that a dry ice supplement combined with a portable CDC light trap provided an accurate picture of nuisance mosquitoes in a given area. The standard New Jersey light trap was a poor indicator of pest mosquito density, and abatement agencies that depend too heavily on this trap are probably receiving a poor overview of mosquito annoyance. Our data suggest that the addition of dry ice to light traps on a regular basis will provide the consistency of mechanical collection devices, and reflect true mosquito biting problems without the inherent errors of landing/bite counts.

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FIELD TESTS OF THE MOSQUITO FUNGUS *CULICINOMYCES CLAVISPORUS* AGAINST THE AUSTRALIAN ENCEPHALITIS VECTOR *CULEX ANNULIROSTRIS*.

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ABSTRACT. Aqueous suspensions of *Culicinomyces clavisporus* conidia were applied to 5 different breeding habitats of *Culex annulirostris*. This species was controlled in 3 unpolluted sites at dose rates of 10^{10} and 5×10^9 conidia/m² with 95–100% reductions of late-instar larvae occurring during the first week after application. Approximately 80% mortality of larvae was achieved in a pond polluted with sewage effluent treated with 10^{10} conidia/m² but the fungus was ineffective when this rate was applied to an anaerobic pond polluted with decaying plant debris. Examination of larvae removed from the latter site revealed that the conidia failed to germinate and penetrate the host cuticle under these conditions. Larvae which hatched in one of the unpolluted sites 5 days after treatment were controlled by the fungus but there was no evidence that it persisted or recycled to provide significant larval control beyond this period in any of the other treated sites.

INTRODUCTION

Field tests of an Australian strain of the fungus *Culicinomyces clavisporus* Couch, Romney, and Rao are being carried out to evaluate this organism for the biological control of mosquito larvae. The first field experiment, conducted in 1974, showed that it was lethal to *Aedes rupestris* Dobrotworsky larvae breeding in rock pools near Sydney (Sweeney and Panter 1977) and a later test, in 1979, yielded promising results against larvae of *Culex australicus* Dobrotworsky and Drummond in a 300 m² pond at Camden, New South Wales (Sweeney 1981a). These 2 tests were made with conidia produced in the laboratory. Recent tests with a North American strain of this fungus produced good activity against *Ae. taeniorhynchus* (Wiedemann) larvae breeding in brackish coastal pools in North Carolina (Merriam and Axtell 1982).

An important characteristic of *Culicinomyces* is that, unlike most other insect pathogenic fungi, it produces true conidia in submerged culture which offers the possibility for mass production in industrial fermenters. Following the successful production of the first semi-industrial scale batches of the fungus in the penicillin facility of Commonwealth Serum Laboratories, Melbourne, it was decided to make further tests on a larger scale using inoculum from this source. The trials reported herein were made during March 1981 at Mildura, Victoria, against the Australian encephalitis vector, *Culex annulirostris* Skuse.