INTERMITTENT LIGHT AS A MOSQUITO ATTRACTANT IN NEW JERSEY LIGHT TRAPS[1]

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ABSTRACT. Mosquito collections from New Jersey light traps operated with flashing on/off cycles (measured in seconds) of 1/1, 5/5, 10/20, 20/10, 30/30, 45/15 and 59/1, as well as a non-illuminated trap, were compared with continuous light controls in northwestern Bexar County, Texas. No mosquito specimens were collected using the 1/1 cycle and very few specimens were collected with the 5/5 cycle. When compared to continuous controls, the remaining intermittent cycles attracted a number of mosquitoes roughly proportional to the percentage of time during which the light was on over a 1 min period. Use of various flash cycles did not result in any detectable species selectivity within the collections.

INTRODUCTION

Light traps are the most widespread adult mosquito surveillance tools used in the United States. Extensive experimentation has been reported with variations in trap design, placement, light source spectra and luminosity (Robinson 1952, Frost 1953, deJong 1967, Taylor and Brown 1972, Vavra et al. 1974, and Service 1976). Some general conclusions drawn from this reported research are: 1) attraction to light varies with different species, 2) individuals of one species may differ in their response to light depending on age, sex and other physiologic factors, 3) light sources in the near-ultraviolet range are generally most attractive to mosquitoes, and 4) some light sources may repel mosquitoes at close range.

One factor that has not received much attention in mosquito light trap literature is intermittency of an attractant light source. Although flashing light sources have been used in light traps (Vavra et al. 1974, Ross and Service 1979, Service 1979), the intermittent nature of the light source in these studies has generally been incidental to the main objectives of the research. The possibilities that the interaction of light attractancy and repellency might lead to the selective collection of certain mosquito species, the reduction of overall specimen numbers with the preservation of collection diversity, and/or the potential reduction of non-mosquito species in collections led to the development of this study.

METHODS AND MATERIALS

Two standard New Jersey light traps were used in the study with 75 W incandescent black light bulbs as the light sources. The irradiance of the bulbs was mainly in the 320–1100 nm range. An interval timer (Timeco Corp.) was used alternately with the traps to generate intermittent light cycles. One trap was always used as a continuous light control. Fans on the traps ran independently of the light sources and operated continuously on both traps during every collection period. The traps were positioned approximately 10 m from each other and were suspended from a roof overhang on the west side of a residential dwelling in northwestern Bexar County, Texas. Traps were hung so that the light sources were approximately 2 m above ground level. Few, if any, competing light sources were in the area. Trap positions, light bulbs, and the trap used with the timer were alternated nightly to reduce inherent trap and position biases. On/off cycles (measured in seconds) of 1/1, 5/5, 10/20, 20/10, 30/30, 45/15, and 59/1 were tested. When it was found that there was a possible repellency associated with certain short intermittent cycles (see results), a non-illuminated trap was compared to a continuously-lighted control trap to help determine whether mosquitoes were actively avoiding these intermittent light sources or whether there was merely a lack of sufficient attraction during the short "on" cycles. Twelve collections of each cycle were made over various seasons of a 3-year period. Insect specimens were killed in collecting jars containing small pieces of dichlorvos-impregnated plastic. Each morning following a collection night, mosquito specimens were sorted and identified.

RESULTS

The most abundant mosquito species in the collection area were *Culex quinquefasciatus* Say, *Culex tarsalis* Coq., *Psorophora cyanescens* (Coq.), *Aedes vexans* (Meigen) and *Psorophora columbiae* (Dyar and Knab), comprising 29.5%, 17.8%, 15.9%, 9.7% and 7.8%, respectively, of the total collected specimens[2]. For each on/off cycle, the

[1] The opinions and assertions contained herein are those of the author and are not to be construed as views of the Department of the Air Force.

individual collection counts were analyzed using a Wilcoxon's Signed Rank Test (Snedecor and Cochran 1968) to compare the mosquito captures of the intermittent and continuous light traps. The results and total specimen collections are summarized in Table 1. In all cases where the intermittent light was on 50% or less of the time, the count was significantly lower than the corresponding count of the continuous light. The shortest cycle (1/1) collected no mosquito specimens and very few other insects in 12 replications. Light traps using a 5/5 cycle attracted slightly less than 25% of the total number of specimens captured by a simultaneously operated continuous light source (Table 1). Compared to continuously-operated light, intermittent cycles in which the light was on for 10 or more sec at a time attracted a number of mosquitoes roughly proportional to the percentage of time during which the light was operating each minute, except for 59/1 where the intermittent count was nearly double that of the continuous light (Table 1). The non-illuminated trap captured 5 mosquitoes during 12 nights of operation (Table 1). While this is a very small number, it is significant since the 1/1 cycle captured no specimens under apparently similar mosquito population density conditions, i.e., in 12 nights of operation 42 specimens were captured in the control trap for the 1/1 cycle and 38 were captured in the control for the non-illuminated trap. This suggests that light traps with 1/1 and 5/5 cycles initially repelled mosquitoes and other insects. Otherwise, based on the results of the other intermittent cycles, a collection size roughly one-half that of the continuously-operating control would have been expected with the 1/1 and 5/5 cycles since the lights were on one-half of each minute. However, the proportionality between light "on" time in intermittent and the size of the mosquito collections relative to continuously-operated controls did not appear until the light source remained on continuously for at least 10 sec. This suggests that 10 sec or more must elapse before the effects of initial light repellency are no longer reflected in the trap captures.

Table 1. Comparisons of female mosquitoes captured in New Jersey light traps operated with continuous vs. intermittent light.

Flash cycle[1] on/off (sec)	Total number of female mosquitoes captured		Intermittent/ continuous	P[3]
	Intermittent	Continuous		
1/1	0	42	0	<.01
5/5	13	57	0.23	<.025
10/20	21	48	0.44	<.05
30/30	27	61	0.44	<.01
20/10	36	54	0.67	NS
45/15	27	36	0.75	NS
59/1	40	22	1.82	NS
0/60[2]	5	38	0.13	<.01

[1] Twelve replications of each frequency.
[2] Dark (suction) trap compared to continuous light.
[3] Based on Wilcoxon's Signed Rank Test, comparing continuous vs. intermittent light.

Although *Cx. quinquefasciatus* is reported to be only weakly attracted to light traps (Wilton 1981), it was the most frequently captured species and was present throughout all of the study period. The capture rates of *Cx. quinquefasciatus* were compared with that of all other species collectively (Fig. 1). *Culex quinquefasciatus* numbers in Fig. 1 are expressed as a percent of the total capture for both the continuous and intermittent light traps, for each flash cycle tested. When the cycling rates were relatively fast (30 sec or less), the proportions of *Cx. quinquefasciatus* were about the same in the intermittent and continuous light trap collections. However, when the light interval was long, followed by a short dark cycle (45/15, 59/1), the number of *Cx. quinquefasciatus* relative to other species was much higher in intermittent than in continuous light trap collections. Unfortunately, because of low capture frequencies, no other species could be statistically examined this way.

Although not quantified, the numbers of non-mosquito specimens (such as, plant hop-

[2] Other species collected included: *Aedes trivittatus, Ae. sollicitans, Ae. thelcter, Ae. triseriatus, Ae. vexans, Ae. zoosophus, Anopheles pseudopunctipennis, An. punctipennis, Culex erraticus, Cx. nigripalpus, Cx. restuans, Cx. salinarius, Culiseta inornata, Psorophora ciliata, Ps. columbiae, Ps. cyanescens, Ps. discolor* and *Orthopodomyia signifera.*

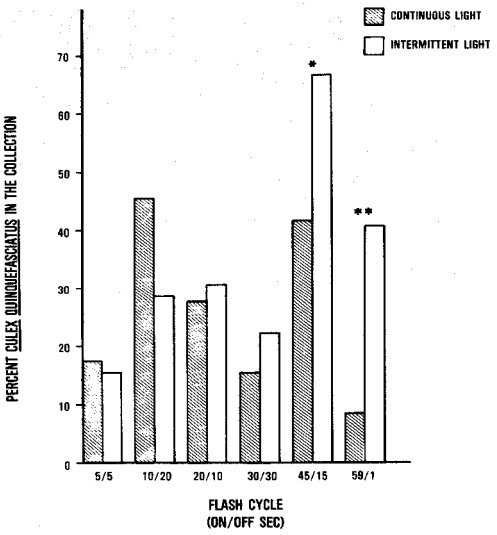

Fig. 1. Comparison of *Culex quinquefasciatus* collections using intermittent or simultaneously-operated continuous light sources in New Jersey light traps. Totals represent 12 replications of each flash frequency.
* $p<.05$ (Chi Square Test)
** $p<.005$ (Chi Square Test)

pers, moths, and beetles) captured using each flash frequency appeared to vary in a similar manner to that shown for mosquitoes.

Mosquito species diversity indices within the collections were compared by Margalef's formula (Southwood 1978). Generally, species diversity was lower in traps with intermittent light (Table 2); however, the 10/20 and the 20/10 cycles were exceptions with higher diversities than controls despite smaller total collection sizes. Collection diversity for the 45/15 cycle was somewhat lower than would be expected from examining the results of the other intermittent cycles. The collection diversity using a 59/1 cycle was essentially identical to that of the continuous control.

DISCUSSION

The absence of mosquitoes (or practically any other insect) in New Jersey light traps operated on the 1/1 cycle contrasts with the findings of Ross and Service (1979) who collected several mosquito species in the Columbian Amazonas using a Monks Wood trap flashing on and off 20–30 times/min. This difference might be attributed to the more definitive on/off nature of an incandescent versus a fluorescent light source as used in the Monks Wood trap which may tend to glow briefly after the power is turned off. Variations in species response may also attribute to the differing results with this flash cycle. In this study, the 1/1 cycle appears to have been repellent since non-illuminated traps captured some mosquitoes in the study area when the overall mosquito population density was essentially the same as indicated by the number of specimens captured in continuously-lighted controls (Table 1).

There may be some advantage to using intermediate frequency on/off cycles in the range of 10/20 or 20/10 as opposed to continuous light since the total number of mosquito specimens is reduced without sacrificing collection diversity. Under operational conditions, this would reduce time needed to sort mosquitoes from other insects and the time needed to identify the mosquitoes. Additionally, mosquito species either repelled by light at close range or ones with eyes quickly desensitizing in the presence and resensitizing in the absence of light (Robinson 1952) may be brought into the trap in proportionately greater numbers. In the case of repellency, species tending to remain at a particular distance from the light source may abruptly change their flight direction when the light goes off much the the same as described by Robinson (1952) for moths flying into an area of shadow near a light source. Such a behavioral change at this "barrier zone" during the brief disappearance of the light could bring these partially repelled species within the influence of the trap's fan.

Based on the results of this and other reported research, one can tentatively conclude that when a point light source suddenly appears in the dark, most mosquito and other insect species are initially repelled. However, after several seconds, some species are attracted (or more appropriately disoriented towards) the light source while other species remain partially repelled at varying distances from the light source. If the light source then goes dark, flight behavioral changes may bring these partially repelled species into the trap prior to or immediately after the next illumination which again initially repels and re-establishes a light "barrier" for certain species. However, despite these possible interactions, intermittent light does not show much promise of significantly increasing mosquito light trap collection selectivity although certain flash cycles may provide as much surveillance information with fewer specimens than continuous light attractants. Species such as *Cx. quinquefasciatus,* while reportedly partially repelled by light at close range and possibly more attracted to certain intermittent light cycles, are still collected with continuous light source attractants.

Table 2. Species diversity indices for cumulative collection data from New Jersey light trap collections.[1]

	Flash cycle [on/off (sec)]							
Light source	1/1	5/5	10/20	30/30	20/10	45/15	59/1	0/60[2]
Continuous	1.90	2.25	1.31	2.22	2.26	2.00	1.62	1.38
Intermittent	0	0.78	1.64	1.52	2.53	0.92	1.64	1.24

[1] As determined by the method of Margalef (1957) in Southwood (1978). Higher indices indicate greater species diversity.
[2] Non-illuminated.

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