# TIME-SEGREGATED MOSQUITO COLLECTIONS WITH A CDC MINIATURE LIGHT TRAP[1]

LEE MITCHELL

Toledo Area Sanitary District, 5015 Stickney Avenue, Toledo, OH 43612

ABSTRACT. A modified CDC miniature light trap capable of segregating the mosquito collection according to interval is described. This trap has been used with a controlled $CO_2$ release system to measure the crepuscular and nocturnal activity of pest mosquitoes during the period May through September, 1980, in Lucas County, Ohio. Five *Aedes* species were found to be abundant and active during either the early evening hours or at sunset in a rural wooded habitat. Collections made at a stratification tower located in an urban wooded area indicated that *Aedes vexans* were more readily captured at ground level than at a high elevation; the converse was noted for *Culex pipiens*. The flight activity of *Cx. pipiens* was found to be greatest after midnight at both trap elevations.

## INTRODUCTION

A large number of attractant and non-attractant traps are available for sampling adults of haematophagous insects (Service 1976). New Jersey light traps and CDC miniature light traps baited with $CO_2$ are routinely utilized by entomologists, mosquito abatement districts and public health agencies for the surveillance of adult mosquito populations. These traps may be operated by a variety of power sources and are typically utilized to measure population densities for a duration of one evening. Such collections are useful in a general sense, but they are of limited value in ecological studies because some species are not attracted to the traps and specific information regarding the flight activity of species caught is obscured in an overnight collection.

Traps capable of segregating the insect collection according to time interval have been reported previously (Bast 1960, Horsfall 1962, Standfast 1965, Koch et al. 1977). The insect trap described in this paper can be built easily by most "handy men" and is unique in that it combines the attractive features of a CDC miniature light trap with an interval collection device.

The application of insecticides at a time when pest or vector mosquitoes are most active is an important consideration in control programs from an economic as well as an environmental perspective. The use of a CDC segregative light trap and a controlled release of $CO_2$ provides the opportunity to monitor the collection of mosquitoes over a 12-hr period. The purpose of this study was to field-test the new insect trap and to determine the peak activity periods of mosquitoes in two woodland habitats.

## MATERIALS AND METHODS

The top portion of the trap was a modification of the CDC miniature light trap described by Sudia and Chamberlain (1962). A 4 in. diam × 0.5 in. acrylic (Lexan®) "collar" was cemented over the midpoint of a 3.5 in. diam × 6 in. section of acrylic tubing utilized for the motor and fan housing. This allowed the top portion of the trap to fit into a 4 in. diam × 4.5 in. section of acrylic tubing attached to the main plate. This section of tubing contains a plastic screen funnel which guides the insects into a killing tube. The top portion of the trap is removable and allows an easy access to the motor and fan.[2] A 12 in. pizza pan was inverted over the top portion of the trap in order to

[1] Presented at the San Antonio AMCA Meeting, March 1981.

[2] Concession Supply Co., 1016 Summit St., Toledo, OH.

protect the light, fan motor and collected specimens from inclement weather.

The main plate (11.5 × 16.5 in.) was constructed from 0.25 in. acrylic and holds the rotating tube carrier and control box. The acrylic tube carrier (10 in. diam × 0.25 in.) was notched around the circumference and drilled with 12 holes (1.25 in. diam), which served as receptacles for 3 in. sections of acrylic tubing. The killing tubes (1.25 in. diam × 5 in.) collect the trapped specimens and are attached to the rotating carrier with 1 in. diam × 2 in. sections of Tygon® plastic tubing. Air circulation holes (1/32 in.) were drilled in the bottom and along the lower sides of each killing tube. A strip (0.25 × 0.5 × 2.5 in.) of resin impregnated with dichlorvos [Vapona® (Shell No-Pest Strip)] was the insecticide utilized in each killing tube. An application of dry graphite film lubricant facilitated movement between the main plate and the tube carrier.

The electronically controlled tube carrier is of the turntable type; a 1 lb weight and pulley system provides the force needed to rotate the carrier once each hour following activation by the timer (Fig. 1). The plastic shaft and base were attached to the tube carrier with 3 metal screws. Two metal screws were also used to hold the plastic pulley (2 in. diam) to the shaft. The tube carrier is allowed to advance by an escapement mechanism (Standfast 1965) fashioned from 0.25 in. diam acrylic and cemented to the main plate (Fig. 2). The escapement mechanism is activated by a 6 v solenoid[2] with a throw of 0.25 inch.

The timer consists of a wind-up alarm clock movement with a bronze arm and magnet soldered to the minute hand (Fig. 3). The hour hand was removed from the clock movement. The magnet activates a mercury switch[3] once each hour, which in turn activates the solenoid and the escapement mechanism. The timer and mercury switch are enclosed in a 6 × 6 × 3 in. hinged acrylic "control" box. A 6 volt, 30 amp motorcycle battery[4] provides power for the fan motor, light (Chicago Miniature Lamp No. 1490) and solenoid. Two phone plugs and inline jacks allow the control box to be disconnected from the turntable unit.

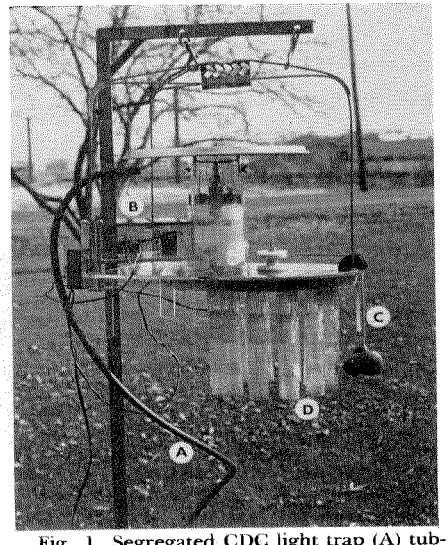

Fig. 1. Segregated CDC light trap (A) tubing from $CO_2$ cylinder, (B) timer, (C) weight and pulley, (D) collection tubes.

The CDC segregative light trap, without the battery, weighs approximately 10 pounds. A hanger with a vertical height of 7 ft was constructed from angle iron and served to support the trap at ground level. A smaller hanger (2 ft) was clamped to a stratification tower and held the trap at an elevation of 30 ft.

A study with the CDC segregative light trap was conducted at two woodland areas in Lucas County, Ohio. Adult mosquitoes were collected at ground level (5 ft) in a rural area (Oak Openings Preserve) during the period 19 May through 21 September 1980. Twelve-hour collections were made at this location from

[3] Warren Radio Co., 1002 Adams St., Toledo, OH.

[4] Hausherr's Machine Works, Old Freehold Rd., Toms River, NJ.

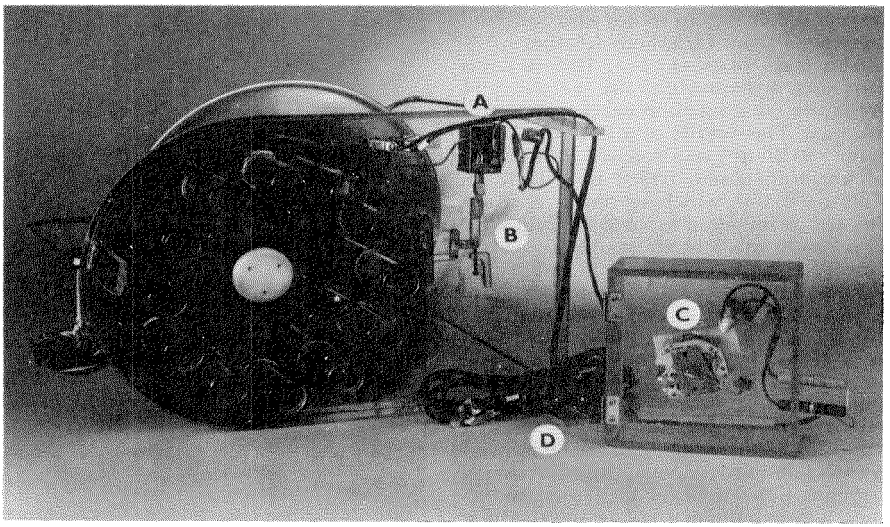


Fig. 2. Segregated CDC light trap (A) solenoid, (B) escapement mechanism, (C) timer, (D) battery lead wires.

either 6 p.m.–6 a.m. (16 nights) or 7 p.m.–7 a.m. (5 nights). A 34 ft tower was constructed from 8 sections of scaffolding (4.25 ft gradations) at an urban site (Donovan). Collections were made once a week at 5 ft and 30 ft levels. If the collections were made at 5 ft (night 1), followed by 30 ft (night 2), the order was reversed for the next week and so on. Meteorological conditions (temperature, precipitation and wind velocity) were either analogous for nights 1 and 2 or the results were not included with the cumulative data. Twelve-hour collections were made at the two tower elevations from either 7 p.m.–7 a.m. (12 nights) or 8 p.m.–8 a.m. (9 nights) during the period 26 June through 18 September.

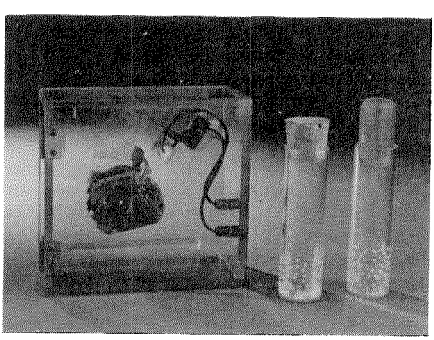

Fig. 3. Segregated CDC light trap timer with mercury switch and mosquito collection tubes.

A controlled release of $CO_2$ at a rate of 1.2 $ft^3$/hr (569 ml/min) was utilized as an attractant with the trap. A $CO_2$ cylinder (ca. 20 lb), regulator and flow meter apparatus was used for this purpose. Tygon® plastic tubing (⅜ in. diam) delivered the $CO_2$ to the level of the trap hood at both collection elevations.

## RESULTS

The collection of adult mosquitoes at the Oak Openings Preserve corresponded to the peak hatch of early season

*Aedes* species in May and June (4 and 8 collections/month, respectively). Collections in July (4), August (3) and September (2) were made less often since the mosquitoes active during the summer months were not the focus of this study. Due to their proclivity to feed on humans and to their relative abundance (in parentheses), the following species were of particular interest: *Aedes vexans* (Meigen) (1116), *Ae. trivittatus* (Coquillett) (718), *Ae. sticticus* (Meigen) (640), *Ae. canadensis* (Theobald) (609) and *Ae. stimulans* (Walker) (169). It may be noted from Table 1 that although these 5 species were active throughout the night, the periods of peak flight activity generally seemed to be either early in the evening (*Ae. stimulans, Ae. canadensis* and *Ae. sticticus)* or at sunset (*Ae. vexans* and *Ae. trivittatus). Aedes vexans* were also attracted to the trap in high numbers during several early morning intervals.

Adult mosquito collections at the Donovan tower site coincided with the peak *Culex* population levels which usually occur in July (9), August (9) and September (4). The predominant mosquitoes collected at the tower site were *Ae. vexans* and *Culex pipiens* Linn. A greater variety and total number of mosquitoes were collected at ground level than at the high elevation in the stratification study. Thirteen species were collected at ground level, compared to 7 species at the high elevation. The mean collection values at ground level and the high elevation were 118.4 and 69.7, respectively. It may be seen from Table 2 that *Aedes* mosquitoes comprised a greater percentage of the total number of specimens collected at ground level (84%) than at the high elevation (20%), whereas the opposite trend was noted for *Culex* at ground level (15%) and at the high elevation (80%).

The hourly samples of *Cx. pipens* collected at 2 tower elevations indicated that the greatest degree of flight activity occurred after midnight. Seventy-six specimens of *Cx. pipiens* were collected during the periods 1–2:00 a.m. and 3–4:00 a.m. at the high elevation. Although fewer *Cx. pipiens* were collected at ground level, the activity trend was similar to that of the higher elevation (Table 3). Thirty-six *Cx. pipiens* were collected

Table 1. Hourly samples of important pest mosquitoes collected at a rural woodland area (1980).*

| Time | Mosquito Species | | | | | Total Hour |
|---|---|---|---|---|---|---|
| | *Ae. canadensis* | *Ae. stimulans* | *Ae. sticticus* | *Ae. vexans* | *Ae. trivittatus* | |
| 6–7:00 p.m. | 89 | 34 | 88 | 16 | 12 | 239 |
| 7–8:00 | 116 | 24 | 120 | 5 | 88 | 353 |
| 8–9:00 | 113 | 16 | 75 | 15 | 119 | 338 |
| 9–10:00 | 75 | 23 | 46 | 116 | 183 | 443 |
| 10–11:00 | 19 | 3 | 8 | 108 | 63 | 201 |
| 11–12:00 | 16 | 8 | 11 | 77 | 45 | 157 |
| 12–1:00 | 14 | 0 | 8 | 80 | 33 | 135 |
| 1–2:00 | 6 | 7 | 4 | 78 | 22 | 117 |
| 2–3:00 | 7 | 4 | 4 | 91 | 26 | 132 |
| 3–4:00 | 2 | 4 | 5 | 80 | 15 | 106 |
| 4–5:00 | 0 | 0 | 5 | 155 | 21 | 181 |
| 5–6:00 | 3 | 1 | 5 | 138 | 23 | 170 |
| 6–7:00 a.m. | 0 | 0 | 0 | 81 | 26 | 107 |
| Totals | 460 | 124 | 379 | 1040 | 676 | 2679 |

* 21 Trapping nights (5/21 through 9/21) for each hourly interval except 6–7 p.m. (16 nights) and 6–7 a.m. (5 nights).

Table 2. *Aedes* and *Culex* mosquitoes collected from two elevations at an urban woodland area.[1]

| Mosquitoes | Number of adults | | Percentage of total | |
|---|---|---|---|---|
| | 5 ft | 30 ft | 5 ft | 30 ft |
| All *Aedes* species[2] | 1295 | 139 | 84 | 20 |
| All *Culex* species[3] | 223 | 558 | 15 | 80 |
| Species in other genera | 21 | 0 | 1 | 0 |

[1] 23 Trapping nights (6/26 thru 9/18).
[2] 7 species, mostly *Ae. vexans*.
[3] 4 species, mostly *Cx. pipiens*.

during the period 12–1:00 a.m. at ground level.

## DISCUSSION

The results indicate that adults of 3 *Aedes* species *(Ae. canadensis, Ae. stimulans* and *Ae. sticticus)* may require early evening control in the Oak Openings area when populations exceed a threshold level. Specifically, an insecticide application with adulticiding equipment could be initiated at 6:00 p.m. and continued until 10–11:00 p.m. A number of important pest and/or vector species are not readily attracted to $CO_2$-baited light traps, such as *Ae. aegypti* (Linn.) and *Ae. triseriatus* (Say). *Aedes stimulans* may be added to this group, as previous larval surveys (unpublished data) in the Oak Openings have indicated that this species and *Ae. canadensis* are about equal in abundance. The number of *Ae. stimulans* collected in this study (Table 1) did not reflect accurately their relative abundance and this observation seems to be valid for several other woodland species as well.

Table 3. Hourly samples of *Culex pipiens* collected from two elevations at an urban woodland area (1980).*

| Time | Elevation | |
|---|---|---|
| | 5 ft | 30 ft |
| 7–8:00 p.m. | 2 | 0 |
| 8–9:00 | 0 | 20 |
| 9–10:00 | 5 | 7 |
| 10–11:00 | 15 | 34 |
| 11–12:00 | 23 | 50 |
| 12–1:00 | 36 | 70 |
| 1–2:00 a.m. | 27 | 76 |
| 2–3:00 | 15 | 68 |
| 3–4:00 | 17 | 76 |
| 4–5:00 | 20 | 47 |
| 5–6:00 | 17 | 43 |
| 6–7:00 | 7 | 39 |
| 7–8:00 | 1 | 3 |
| Totals | 185 | 533 |
| Mean value/Night | 8.8 | 25.4 |

* 21 Trapping nights (6/26 through 9/16) for each hourly interval except 7–8 p.m. (12 nights) and 7–8 a.m. (9 nights).

Acuff (1976) found that *Ae. vexans* and *Ae. trivittatus* were readily attracted to $CO_2$-baited light traps and the results of this study are in agreement. These 2 species would have been captured in even greater numbers if the collections had been made on a more uniform basis throughout the summer. Timing of insecticide application for *Ae. vexans* and *Ae. trivittatus* would more closely correspond to the peak activity period of 8–10:00 p.m., depending on the hour of sunset during the summer months. In northwestern Ohio, the period of sunset (EDST) varies according to "short" and "long" days (Ex. 7:50 p.m. on 19 May, 8:15 p.m. on 1 July, and 6:40 p.m. on 21 September). Horsfall et al. (1973) reported that a segregative light trap operated in Illinois collected 59–69% of the *Ae. vexans* specimens between 10–12:00 p.m. during the months of June, July and August. He also found that during September 80% of the *Ae. vexans* specimens were trapped before midnight.

The preference of *Cx. pipiens* for high elevations in a woodland urban habitat closely agrees with the results of a previous study (Mitchell and Rockett 1979) conducted in a rural sylvan area with standard CDC miniature light traps baited with $CO_2$. *Culex pipiens* adults were most active after midnight, and this indicates that a late night application of insecticide might have potential for controlling this species. Studies with mobile interceptor

traps in Illinois indicated that ovipositing *Cx. pipiens* females were most active shortly after sunset, and ULV adulticiding was initiated at this time (Strickman 1979). Although oviposition was reduced by ca. 50% during the night of treatment, it may be judicious to reevaluate the application time and conditions which are most suitable for effective control of this species with ULV.

The feeding patterns of the *Cx. pipiens* complex have been studied extensively, but results are often conflicting and frequently confuse host utilization with host preference. Several authors (Tempelis 1975, Magnarelli 1977) have reported on the ornithophilic nature of *Cx. pipiens,* although the frequency of feeding on humans is still in question. The collection of many *Cx. pipiens* (84% of the total) in this study at the 30 ft elevation may correspond to the presence of avian hosts in the canopy. The nocturnal activity of *Cx. pipiens* may also be influenced by the decreased movement of birds at their nesting sites. Novak et al. (1981) utilized suction traps in an Indiana forest and found that *Cx. pipiens* and *Cx. restuans* Theobald females were collected in greatest numbers at the canopy elevation. The results of studies conducted in New Jersey (Bast 1961, Bast and Rehn 1963) suggest that the vertical stratification preferences and flight periodicity of *Culex* species may vary in different geographical areas.

Caution must be exercised in the interpretation of flight periodicity data due to the possible bias introduced by environmental factors or the use of attractants (Bidlingmayer 1967). It has been reported that light traps supplemented with $CO_2$ increased the diversity and numbers of species collected (Newhouse et al. 1966) but depressed the overall parous rate by attracting a disproportionate number of nulliparous mosquitoes (Magnarelli 1975, Feldlaufer and Crans 1979). Service (1977) noted that although biting activity in certain African species of *Mansonia* and *Coquillettidia* was restricted to specific periods of the night, they were caught in light traps throughout the night. Host preference studies with human volunteers in the United States have generally focused on the diurnal and crepuscular time intervals; such a regime in northwestern Ohio would suffice for *Aedes* species but would be unsatisfactory for studying *Cx. pipiens.* A study on the feeding preferences of *Cx. pipiens* in a woodland canopy with a human volunteer during late night hours would entail obvious difficulties.

The utilization of a CDC segregative light trap with a controlled release of $CO_2$ is a useful, albeit artificial, system for monitoring the population levels and flight periodicity of some pest and/or vector mosquitoes. The data obtained from such traps should be considered prior to the application of insecticides for adult mosquito control. The accuracy of such a system can be improved with a knowledge of mosquito bionomics and the influence of environmental factors on mosquito behavior.

## ACKNOWLEDGMENTS

The author wishes to thank J. R. Halstead for his major contributions to the design and construction of the trap. Technical assistance was also received from Gary Bennett and Wilfred Sharp. Lester Gilford and Jim Weyer provided photographic expertise. The manuscript benefited from the critical review and valuable comments offered by Woodbridge A. Foster and Robert C. Graves.

### *References Cited*

Acuff, V. R. 1976. Trap biases influencing mosquito collecting. Mosq. News 36:173–176.

Bast, T. F. 1960. An automatic interval collector for the New Jersey light trap. Proc. N.J. Mosq. Exterm. Assoc. 47:95–104.

Bast, T. F. 1961. A note on flight periodicity of mosquitoes. Proc. N.J. Mosq. Exterm. Assoc. 48:203–211.

Bast, T. F. and J. W. H. Rehn. 1963. Vertical distribution of mosquitoes as indicated by light trap collecting in two environments.

Proc. N.J. Mosq. Exterm. Assoc. 50:219–229.

Bidlingmayer, W. L. 1967. A comparison of trapping methods for adult mosquitoes: Species response and environmental influence. J. Med. Entomol. 4:200–220.

Feldlaufer, M. F. and W. J. Crans. 1979. The relative attractiveness of carbon dioxide to parous and nulliparous mosquitoes. J. Med. Entomol. 15:140–142.

Horsfall, W. R. 1962. Trap for separating collections of insects by interval. J. Econ. Ent. 55:808–811.

Horsfall, W. R., H. W. Fowler, Jr., L. J. Moretti and J. R. Larsen. 1973. Bionomics and embryology of the inland floodwater mosquito *Aedes vexans*. Univ. Ill. Press, Urbana. 211 pp.

Koch, H. G., R. C. Axtell and G. R. Baughman. 1977. A suction trap for hourly sampling of coastal biting flies. Mosq. News 37:674–680.

Magnarelli, L. A. 1975. Relative abundance and parity of mosquitoes collected in dry-ice baited and unbaited CDC miniature light traps. Mosq. News 35:350–353.

Magnarelli, L. A. 1977. Host feeding patterns of Connecticut mosquitoes (Diptera: Culicidae). Am. J. Trop. Med. Hyg. 26:547–552.

Mitchell, L. and C. L. Rockett. 1979. Vertical stratification preferences of adult female mosquitoes in a sylvan habitat (Diptera: Culicidae). Great Lakes Entomol. 12:219–223.

Newhouse, V. F., R. W. Chamberlain, J. G. Johnston, Jr. and W. D. Sudia. 1966. Use of dry ice to increase mosquito catches of the CDC miniature light trap. Mosq. News 26:30–35.

Novak, R. J., J. Peloquin and W. Rohrer. 1981. Vertical distribution of adult mosquitoes (Diptera: Culicidae) in a northern deciduous forest in Indiana. J. Med. Entomol. 18:116–122.

Service, M. W. 1976. Mosquito ecology: Field sampling methods. Applied Science Publishers, London. 583 pp.

Service, M. W. 1977. A critical review of procedures for sampling populations of adult mosquitoes. Bull. Entomol. Res. 67:343–382.

Standfast, H. A. 1965. A miniature light trap which automatically segregates the catch into hourly samples. Mosq. News 25:48–53.

Strickman, D. 1979. Malathion as ground-applied ULV evaluated against natural populations of *Culex pipiens* and *Culex restuans*. Mosq. News 39:64–67.

Sudia, W. D. and R. W. Chamberlain. 1962. Battery-operated light trap, an improved model. Mosq. News 22:126–129.

Tempelis, C. H. 1975. Host-feeding patterns of mosquitoes, with a review of advances in analysis of blood meals by serology. J. Med. Entomol. 11:635–653.