MOSQUITO FLIGHT ACTIVITY STUDIES UTILIZING TIMER-EQUIPPED LIGHT TRAPS AND MALAISE TRAPS[1]

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Standfast (1965) stated that in a study of mosquito biology it is essential to know the period of the day or night when the mosquito is active. In addition to providing information relating to the basic biology of mosquitoes, the determination of peak flight activity times has an important control implication. Wright and Knight (1966) pointed out that insecticidal fogs are widely used in adult mosquito control and such treatments are most effective when applied during the time that the species to be controlled is in flight. The study reported here was undertaken with the objective of providing more information on the flight rhythms of Virginia mosquitoes. Two distinctively different types of sampling devices were employed in this study. Timer-equipped light traps served as one method of collecting mosquitoes at desired time intervals and manually operated Malaise traps served as the other method.

Several workers, including Standfast (1965), Harcourt and Cass (1958), Horsfall (1962), Williams (1935), and Hutchins (1940), have used variously modified light traps which partition the catch into pre-set time periods. However, this study represents the first time that Malaise traps have been utitlized for determining diel flight rhythms of mosquitoes.

It is necessary to have an understanding of the elements responsible for initiating

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or suppressing mosquito flight. Wright and Knight (1966) found that light intensity was one of the most critical exogenous factors in controlling flight activity of *Aedes vexans* and *A. trivittatus* when other exogenous factors were not at extremes of their range (e.g., when temperature and humidity values were not extremely low). Clements (1963) pointed out that endogenous circadian rhythms play an important part in the control of mosquito activity and Harker (1961) stated that circadian rhythms are maintained by a physiological clock within the organism that must first be "set" by an external stimulus, such as a change from light to dark, but thereafter maintains the rhythm independent of further stimuli. Bates (1941) in laboratory studies showed that the activity of *Anopheles superpictus* can be independent of the light intensity variation stimulus once the rhythm is established.

It is apparent that the complex interactions of exogenous climatic factors and endogenous circadian rhythms would make difficult the determination of precise activity times of adult mosquitoes. Therefore, we did not delineate precise flight activity times but, rather, attempted to establish trends in activity for the species collected in sufficient numbers.

MATERIALS AND METHODS. Three different locations were used for sampling the mosquito fauna in these investigations. Two of the study sites were established adjacent to embayments of Smith Mountain Reservoir in southwestern Virginia. The third site was a wooded area near an impounded creek that was located about ¼ mile from the Smith Mountain Reservoir system.

Standard New Jersey light traps were modified by fitting them with timing devices as described by Turner and Earp (1968). Four timer-equipped light traps placed in close proximity to one another were operated at a given site on each night of sampling. Individual traps were preset to collect at one of four time intervals during the dark evening hours. The four time intervals represented were dusk (7:52[4] D.S.T.)–11 p.m., 11 p.m.–1 a.m., 1 a.m.–3 a.m., and 3 a.m.–dawn (6:13 D.S.T.). Nights which presented conditions unfavorable for mosquito flight (e.g., rainfall, low temperatures, etc.) were avoided. A total of 30 peak-of-activity study collections were taken by this method during the summer of 1966 and Table 1 presents the data obtained from these experiments.

According to Williams (1935), the numbers of insects taken by light traps are influenced by the factors of activity, density, and phototactic response. Corbet (1961) has shown that swarming, oviposition, and the acquisition of a blood meal affect mosquito response to light. Evidence has also been presented by Standfast (1965) that indicates that host-seeking activity and the acquisition of a blood meal depress the phototactic response.

Therefore, it would appear that a sampling device which offered little or no attracting force to mosquitoes would be devoid of the limitations inherent in light traps and would provide a much more accurate measure of overall mosquito flight activity. Therefore, we conducted a series of peak-of-activity investigations using the Malaise trap as a sampling apparatus. The Malaise trap used in our investigations was a tent-like structure made of fine, weatherproof netting supported by a tubular aluminum frame for an 11′ x 11′ tent. The trap was modeled after the design of Marston (1965). In addition to its freedom from reliance upon the variable phototactic responses of mosquitoes during the night, this trap also permitted the collection of samples with equal efficiency during crepuscular and diurnal periods as well as at night.

The Malaise trap provided a means for 24-hour activity studies. Each 24-hour period of sampling was begun by placing an empty cyanide jar on the trap at 7 p.m. (D.S.T.). The trap catch was removed from the jar at 2-hour intervals at 9 p.m.,

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[4] Average times of sunset and sunrise, respectively, obtained from the 1966 *Nautical Almanac* for the period of the peak-of-activity studies.

11 p.m., 1 a.m., 3 a.m., 5 a.m., and 7 a.m. respectively. After the 7 a.m. collection, the trap was allowed to operate for a continuous 12-hour period throughout the day, and this final sample was removed at 7 p.m. to complete the 24-hour cycle.

Immediately before the killing jar was removed from the trap to collect each 2-hour sample, the interior baffles were inspected for mosquitoes which had not completed their migration to the collecting assembly at the top. The few mosquitoes found in the process of migration to the top were aspirated from the interior of the trap, killed, and placed in with the major sample already present in the cyanide killing jar. The entire process of aspirating the lingering mosquitoes from the interior, collapsing the trap to remove the sample from the killing jar, and re-establishing the trap required less than 5 minutes. Two possible sources of error were the presence of the investigator at the trap during the collecting time and a small, dim head lamp worn by the collector when nocturnal samples were being removed. Table 2 presents the data taken from 7 peak-of-activity study collections by Malaise trap during the summer of 1966 at the impounded creek study site.

Results and Discussion. The data in tables 1 and 2 show that low numbers of most species were taken by both methods. However, certain trends in activity are evident for some species, and a few interesting comparisons of the data taken by both methods can be made.

The two methods of trapping contradicted one another for *Aedes vexans*. Collections of this species by light traps (Table 1) revealed two peaks during the night—one at the dusk–11 p.m. period and a slightly larger one during the 1 a.m. –3 a.m. period. However, *A. vexans* showed no peak of activity in the early morning hours in Malaise traps (Table 2), but flight activity was apparent in the late diurnal and crepuscular periods. Collections of the other three species of *Aedes* were so low that no conclusions can be reached for their flight activity periods.

Both *Anopheles punctipennis* and *Anopheles quadrimaculatus* exhibited similar activity patterns at light traps. Maximum flight activities were initiated in the dusk–11 p.m. period, but subsided to gradually decreasing levels throughout the remainder of the night. The Malaise trap did not provide sufficient numbers of any of the anophelines to permit determinations of their activity patterns by this method.

Table 1 indicates that *Culex salinarius* flight activity was at its peak during the

Table 1.—Composite of 30 peak-of-activity study collections by light trap. Summer, 1966.

	Numbers of specimens captured during stated periods.							
Mosquito Species	dusk–11 p.m.		11 p.m.–1 a.m.		1 a.m.–3 a.m.		3 a.m.–dawn	
	♂	♀	♂	♀	♂	♀	♂	♀
Aedes vexans	1	16	1	7	4	20	0	2
Ae. cinereus	0	4	0	5	0	4	0	3
Ae. canadensis	0	1	0	0	0	0	0	0
Ae. atlanticus	0	1	0	1	0	0	0	0
Anopheles punctipennis	3	48	0	20	0	17	2	4
A. crucians	0	10	0	10	0	5	0	1
A. quadrimaculatus	2	41	0	21	0	7	0	5
Culex salinarius	15	66	1	32	8	30	2	13
C. restuans	1	29	1	24	0	21	0	11
C. territans	1	10	0	2	1	4	1	2
C. erraticus	4	37	0	9	7	17	1	5
Mansonia perturbans	3	56	0	11	1	7	0	4
Psorophora confinnis	3	0	0	6	0	9	0	2
P. ciliata	0	0	0	0	0	2	0	0
P. ferox	0	2	0	0	0	1	0	0
Uranotaenia sapphirina	15	25	5	8	2	12	0	1

TABLE 2.—Composite of 7 peak-of-activity study collections by Malaise trap. Summer, 1966.

Mosquito Species	Numbers of specimens captured during stated periods													
	7–9 p.m.		9–11 p.m.		11 p.m.–1 a.m.		1–3 a.m.		3–5 a.m.		5–7 a.m.		7 a.m.–7 p.m.	
	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀	♂	♀
Aedes vexans	0	30	0	4	0	2	0	1	0	2	0	6	0	1
Ae. cinereus	0	4	0	0	0	0	0	0	0	0	0	1	0	0
Anopheles punctipennis	0	2	0	2	0	2	0	0	0	0	0	0	0	2
A. quadrimaculatus	0	0	0	0	0	0	0	0	0	0	0	2	0	0
Culex salinarius	1	12	0	5	0	13	0	5	0	0	0	13	0	3
C. restuans	0	7	0	7	0	15	0	17	0	5	0	18	0	6
C. territans	3	50	0	8	0	6	0	2	0	0	0	59	1	81
C. erraticus	0	2	0	3	0	0	0	1	0	1	1	1	0	3
Mansonia perturbans	0	4	0	9	0	9	0	6	0	4	0	6	0	0
Psorophora confinnis	0	0	0	0	0	0	0	0	0	0	0	0	1	5
P. ferox	0	3	0	0	0	2	0	0	0	0	0	1	0	10
Uranotaenia sapphirina	0	0	2	1	2	0	1	1	0	0	0	3	0	1

first period of light trap operation from dusk–11 p.m., but subsided to approximately one-half this intensity during the following two sampling periods, and to the lowest level during the final 3 a.m.–dawn period. Malaise trap samples for this species (Table 2) yielded small numbers but did show three apparent peaks: one during the late diurnal and crepuscular period, another at the 11 p.m.–1 a.m. period, and a third during the dawn period.

The light trap study for *C. restuans* indicates that this species' time of flight is remarkably evenly distributed throughout the night. Although Malaise trap collections of *C. restuans* were low in number, these data indicate that this species was active throughout the night and also partially active during the day.

Table 2 offers the apparent solution to the problem of why Gladney and Turner (1968, 1969) experienced extremely low light trap collections of *C. territans* in spite of high larval collections of this species in the same area. Malaise trap data (Table 2) show that *C. territans* exhibited two distinct periods of flight activity. One took place during the dusk crepuscular period from 7 p.m.–9 p.m. while the other was evident during the dawn crepuscular period from 5–7 a.m. Large numbers were also taken in the diurnal sample from 7 a.m.–7 p.m. It is obvious that light traps cannot efficiently attract mosquitoes during such periods of full and partial light; hence, they were evidently functioning during the time of minimum flight activity for this species and, consequently, relatively few adults were collected by this device.

Table 1 indicates that *C. erraticus* was most active from dusk–11 p.m. and declined thereafter to a constant low level. Malaise trap activity studies for this species (Table 2) yielded low numbers and erratic results.

Collections of *Mansonia perturbans* by light trap (Table 1) revealed that this mosquito is most active during the early evening hours from dusk until 11 p.m., after which time flight subsides to generally low levels. At least limited activity prevails during the 7–9 p.m. period as shown in Table 2; however, no flight activity was detected for this species during the full daylight hours.

No activity trend for *Psorophora confinnis* or *P. ferox* could be established because numbers collected by both methods were too low; however, Tables 1 and 2 indicate that there is a diurnal and a nocturnal cycle of activity for both of these species.

The results obtained for *Uranotaenia sapphirina* by both methods (Tables 1 and 2) express an exclusive limitation of activity to the nocturnal hours for this mosquito.

SUMMARY. A comparison of mosquito flight activity data from two distinctively different sampling devices has been presented. Generally, the study revealed a pattern of high level activity for the majority of species during the late crepuscular and early nocturnal periods with activity gradually subsiding as the night progressed. This pattern was evident for *Culex salinarius* and *C. erraticus* but not for *C. territans* and *C. restuans*. In contrast to the generalization of Bates (1949) that time of flight is a group character with related species tending to show similar behavior, *C. territans* exhibited two distinct peaks—one at the dusk crepuscular period and the other at the dawn crepuscular period with flight minima occurring during the nocturnal hours. On the other hand, *C. restuans* was equally active throughout the night.

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BOOK REVIEW

Bloodsucking Flies and Other Nuisance Arthropods of New York State by Hugo Jamnback. 1969. New York State Museum and Science Service Memoir 19: x + 90 pp., illus. $2.00. May be obtained from the New York Museum and Science Service, State Education Building, Albany, New York 12224.

As pointed out by Donald L. Collins in the Preface to this paper, the New York State Museum has a long tradition of interest in arthropods that attack man. A number of papers have resulted from this interest and these will still be used for identification. However, Jamnback's present study will largely replace these as a source of readily available, clearly presented, biological and distributional information.

The publication is divided into three major sections. The first section covers the bloodsucking species and includes Culicidae, Simuliidae, *Culicoides*, Tabanidae, *Symphoromyia*, *Stomoxys*, Ixodidae and Trombiculidae. The second section on non-bloodsucking pest species includes Tricoptera, Ephemeroptera, Chironomidae and Chaoboridae. The third section on control runs the gamut from simple avoidance of pest species (it had never occurred to me that a good way to avoid blackflies was to stay home) through noninsecticidal methods of control to specific recommendations for the use of certain pesticides.

All the bloodsucking groups are supplemented by an annotated list of the species found in New York. The annotations, although brief, carry a lot of information. A slight inconsistency is the exclusion of non-bloodsucking species from some groups and their inclusion in other groups.

"The legal aspects of control in New York" supplemented by an appendix, "Rules and regulations governing the use of chemicals for the control and elimination of aquatic insects," brings together much information on an important and rather delicate subject. Control officers and commercial pesticide applicators will find this portion very valuable. I did not find any reference to "Protected Insects" under the New York Fish and Game Law which apparently makes it illegal for a trout fisherman to slap a blackfly which bites him; perhaps Jamnback feels the less said about this, the better.

Documentation is excellent and the list of references extensive. Typographical errors seem to have been kept to a near minimum. The New York State Museum and Science Service has well supported in this publication a tradition going back to Asa Fitch only two years short of 100 years ago. Jamnback's study with its attractive slick magazine type format, seems to have something for everyone interested in outdoor arthropod pests of people.

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