

EFFECTS OF ULTRAVIOLET RADIATION ON ADULTS OF *Aedes aegypti* (L.) (DIPTERA:CULICIDAE)¹

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INTRODUCTION. An earlier paper (Riordan, 1966) described the effects of a high-intensity light flash on *Aedes aegypti* (L.), part of a program undertaken to discover alternatives to gamma-radiation and chemicals for applying the "sterile-male" technique of insect control. It was suspected that the ultraviolet portion of the flash spectrum might be responsible for the sterilizing effects noted and that, therefore, it would be worthwhile investigating the effects of more prolonged UV irradiation.

Although the effects of ultraviolet radiation on bacteria and on various cell cultures have been studied, little has been done to determine the effects of UV radiation on insects. The only work on mosquitoes appears to be that of MacGregor (1933) who noted paralysis and death when larvae and pupae were exposed.

This paper reports changes in fecundity and mating of *A. aegypti* adults following exposure to measured amounts of UV radiation.

METHODS. The irradiation apparatus (Fig. 1) was designed to be as simple as possible. The UV tube (A) is a Model LS-7, 6 inches in overall length and rated at 4 watts. The suppliers (Raytech Equipment Co., Somers, Conn., U.S.A.) state that over 90 percent of the radiation from this tube is at 2,537 angstrom units. The plastic cylinder (B) has an inside diameter of 1¼ inches leaving a space around the tube of 5/16 inch in depth in which up to 100 mosquitoes at a time were treated. At 5/16 inch the radiation intensity from the LS-7 tube is 2400

$\mu\text{w}/\text{cm}^2$, measured with a "Black-ray UV intensity meter," (Ultra-violet Products Inc., San Gabriel, California, U.S.A.). Screened ports (C) and (D) are provided for forced ventilation; treatments were conducted at 45° F. to obviate any effects from high ambient temperatures caused by the tube.

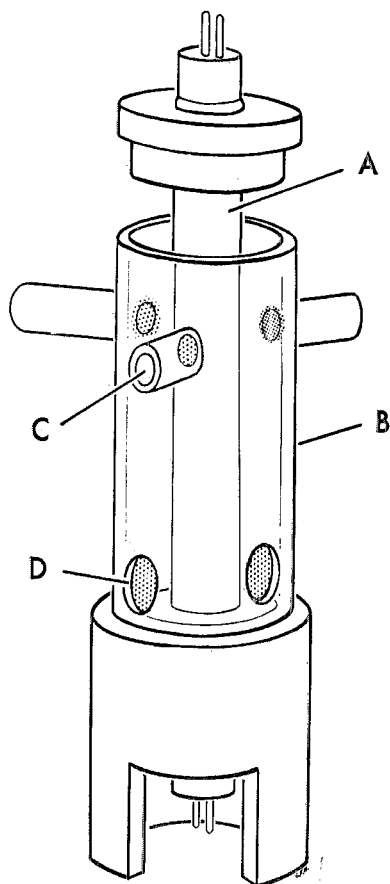


FIG. 1.—Apparatus used for ultraviolet irradiation of mosquitoes.

¹A preliminary report of this work was presented at the joint 23rd Annual Meeting of the American Mosquito Control Association Inc. and the 35th Annual Conference of the California Mosquito Control Association Inc.

The method of obtaining unmated adult mosquitoes has been previously described (Riordan, 1965); unless otherwise stated, treatments were given immediately following removal from 55° F. After treatment the mosquitoes were held in cages 10 x 10 x 16 inches high at room temperature (70-72° F.) for 24 hours before assessing mortality and carrying out subsequent procedures. Females oviposited on sheets of filter paper, being confined in inverted plastic tumblers (Riordan, 1966). Controls of untreated mosquitoes were set up with each replicate in all experiments.

The fertility of treated males was tested in two ways: firstly, by pairing up to 25 survivors individually with blood-fed virgin females in the tumblers, and secondly, by holding up to 200 survivors en masse in a cage and introducing virgin females 3 to 4 days old, in a ratio of 1:1, 24 hours after treatment. In the latter case females were blood-fed and removed for oviposition after 48 to 72 hours' confinement with the males. Because of the numbers involved and the extra work of dissecting and examining the spermathecae of samples of these females, each dose was administered as a separate experiment (replicated three or more times) with its own control.

Possible variation of effects due to the same total dose of UV radiation being delivered at different intensities was tested by confining the mosquitoes in a small plastic trough covered with a piece of Saran Wrap. The distance between the tube and the mosquitoes could thus be

varied and the treatment time adjusted accordingly.

Possible variation of effects due to ages of the mosquitoes differing at the time of irradiation was tested by removing a sufficient number from the 55° F. emergence room, holding them in the laboratory at 70 to 72° F., and treating samples of 100 on successive days.

The competitiveness of treated males was investigated by caging 24-hour survivors with 75 to 150 untreated males of the same age and from the same hatch, together with virgin females in ratios of 1:1:1, 5:1:1, and 10:1:1, respectively. Controls were untreated males caged with virgin females at a ratio of 1:1. After 3 to 4 days the females were given a blood meal and 50 from each of two replicates placed in the oviposition tumblers. Mating was determined by examining spermathecae for the presence of sperm.

The effects of UV irradiation on virgin females was also investigated, a blood meal being offered after treatment and previously unmated males being confined with the blood-fed females in the oviposition tumblers.

RESULTS

MORTALITY AND STERILITY OF TREATED MALES. The results of treating males and pairing them either individually or en masse with virgin females are shown in Tables 1 and 2 respectively.

The longevity tests showed that mean longevity after treatment was unaffected

TABLE 1.—Results of irradiating males of *A. aegypti* and pairing survivors individually with blood-fed virgin females.

| Minutes UV irradiation | No. dead at 24 hrs. (3 repli- cates n=130) | No. of ♀♀ ovipositing (from 2 repli- cates n=50) | Progeny/ ♂ ♀ pairs (3 replicates) | Reduction in nos. of progeny, % |
|---------------------------|--|---|---|---------------------------------------|
| 0 (control) | 1 | 48 | 2126/75 | .. |
| ½ | 3 | 46 | 1233/75 | 43 |
| 1 | 5 | 49 | 236/75 | 90 |
| 2 | 6 | 43 | 86/75 | 96 |
| 4 | 7 | 46 | 4/75 | >99 |
| 8 | 59 | no record | 0/64 | 100 |

TABLE 2.—RESULTS of irradiating males of *A. aegypti* and confining survivors "en masse" with equal numbers of virgin females.

| | Minutes of UV irradiation | | | | | | | |
|----------------------------------|---------------------------|-----------|---------|-----------|---------|-----------|---------|-----------|
| | 1 | (Control) | 2 | (Control) | 3 | (Control) | 4 | (Control) |
| ♀ containing sperm/no. dissected | 49/54 | 95/105 | 80/118 | 67/70 | 58/107 | 62/76 | 12/18 | 10/11 |
| % Reduction | 0 | .. | 29 | .. | 38 | .. | 26 | .. |
| ♀ ovipositing/no. propagated | 251/300 | 131/150 | 188/300 | 111/145 | 385/500 | 220/250 | 179/250 | 103/125 |
| % Reduction # | 3 | .. | 18 | .. | 12 | .. | 12 | .. |
| Nos. of progeny | 8665 | 6333 | 2426 | 3069 | 1917 | 1373 | 4415 | 4196 |
| Av. per propagated ♀ | 25 | 32 | 8 | 21 | 13 | 27 | 18 | 34 |
| % Reduction in nos. of progeny | 22 | .. | 62 | .. | 52 | .. | 47 | .. |

* Abbott's correction applied (Healy, 1952).

at $\frac{1}{2}$ and 1 minutes, reduced 28 percent at 2 and 4 minutes and reduced 50 percent at 8 minutes.

In one of the 4-minute treatment replicates the eggs laid by the 49 treated females that oviposited were counted and hatched separately: 52 percent of the eggs from females confined with treated males hatched as compared to 72 percent from 33 females in the control. There was no instance of complete failure to hatch of the eggs from one female and the average number of eggs laid was 70 per oviposition in each case.

Results of experiments designed to detect variation in effects due to intensity of dose-rate were erratic. However, it appeared that there was little if any variation when UV radiation was administered for 12 minutes at $900 \mu\text{W}/\text{cm}^2$, for 36 minutes at $300 \mu\text{W}/\text{cm}^2$, or for 108 minutes at $100 \mu\text{W}/\text{cm}^2$.

No variations in degree of effect (compared to controls) due to differences in age at time of treatment were detected. In the competitiveness experiments the greatest reductions in progeny achieved were 37 percent for 2 minutes treatment, 10:1:1 ratio and 13 percent for 3 minutes treatment, 10:1:1 ratio: mating was 104 percent and 107 percent respectively compared to the controls. In the 5:1:1 and the 1:1:1 tests mating frequency was also equal to or greater than that of the controls and so were the numbers of progeny.

MORTALITY AND STERILITY OF TREATED FEMALES. Negligible mortality at 24 hours

was caused to females by the UV treatments. Other results are shown in Table 3.

Mating of treated females, determined by dissection of samples from several of the tests, was reduced little, if at all.

DISCUSSION. It is evident from the data from the various experiments in which male adult *Aedes aegypti* were subjected to UV irradiation that the factor contributing most strongly to the subsequent reduction in progeny was the failure of some of the males to mate. It is not known if this was due to a general debilitation or if damage was caused to specific areas (e.g., nerve centres, flight muscles, genitalia, etc.). No physical damage was detected by visual examination. Subjective observations during the experiments indicated that treated males became progressively less active with increasing dose. Apparently there was a threshold, so that when treated males were confined individually with virgin females varying proportions of the latter would remain uniseminated, whereas in the "en masse" experiments unaffected males were able to achieve several matings.

Samples of treated males were frequently dissected during the various tests and almost invariably contained large quantities of active sperm.

That there was some effect on quantity or viability of sperm is indicated by (1) data from the 2-minute treatment, 10:1:1 ratio competitiveness test, (2) the "en

TABLE 3.—Results of irradiating virgin females of *A. aegypti*.

| UV irradiation | ♀ ♀ Blood-feeding (4 replicates) | | Blood-fed ♀ ♀ ovipositing (from 3 replicates) | | Progeny (4 replicates) | |
|----------------|-------------------------------------|--------------------------|---|--------------------------|---------------------------|-----------------------|
| | No. | % reduction [*] | No. | % reduction [*] | No. | Av. per ovipositing ♀ |
| 0 (control) | 172/191 | .. | 96/116 | .. | 3360 | 35 |
| $\frac{1}{2}$ | 145/190 | 16 | 97/111 | <0 | 3143 | 32 |
| 1 | 155/196 | 12 | 94/109 | <0 | 1875 | 20 |
| 2 | 84/191 | 51 | 48/78 | 25 | 1565 | 33 |
| 4 | 48/191 | 72 | 28/48 | 30 | 955 | 34 |
| 8 | 13/173 | 80 | 5/9 | 34 | 68 | 14 |

^{*} Abbott's correction applied.

masse" experiments, where the reduction in numbers of progeny exceeded the reduction in matings, particularly for the 2-minute treatment when any general debilitating effect would be less than for the 3- and 4-minute treatments, and (3), the test in which eggs from females confined with males treated for 4 minutes subsequently achieved 20 percent less hatching than the relevant control.

The general debilitation effect of the UV radiation is further evident in the results of the experiments with females where the major factor contributing to the final result of reduced numbers of progeny was the failure of many females to take blood. Oviposition was also reduced.

Much further work would have been required to determine the actual nature of the damage to the mosquitoes caused by the UV radiation. This was not undertaken because the results here reported offer no evidence that 2537A UV irradiation would be effective for the "sterile-male" method of insect control.

SUMMARY. Male and female adults of *Aedes aegypti* were irradiated with 2537A ultraviolet. Mortality and reduced num-

bers of progeny, varying with dose, resulted. The major factor contributing to the reduction of progeny when males were irradiated was failure to mate. Transfer to females of reduced quantities of sperm or of non-viable sperm was a secondary factor. In the females, failure to take blood was the chief cause of subsequent reduction in numbers of progeny. Reduced oviposition was a secondary factor. 2537A ultraviolet irradiation is not, therefore, a practical alternative to gamma-irradiation or chemicals for application of the 'sterile-male' technique of insect control.

References

- HEALY, M. J. R. 1952. A table of Abbott's correction for natural mortality. *Ann. Appl. Biol.* 39:211-212.
- MACGREGOR, MALCOLM E. 1933. Certain pathological effects of ultra-violet radiation on mosquito larvae and pupae. *Roy. Soc. London Proc. Ser. B.* 112:27-38.
- RIORDAN, D. F. 1965. Method for obtaining large numbers of unmated *Aedes aegypti* (L.). *Mosq. News* 25:28-29.
- RIORDAN, D. F. 1966. Effects of high-intensity light-flashes on mortality and reproduction of *Aedes aegypti* (L.) (Diptera: Culicidae). *Canad. J. Zool.* 44:895-902.

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