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EFFECT OF PASTURE BURNING ON SURVIVAL OF *AEDES* MOSQUITO EGGS

W. H. WILDER AND R. M. TAKAHASHI

University of California Mosquito Control Research, 5544 Air Terminal Drive, Fresno, California 93727

ABSTRACT. Burning dry dormant pasture grass was tested as a means of controlling the mosquitoes *Aedes nigromaculis* (Ludlow) and *Aedes melanimon* Dyar by destroying their eggs. Test plots containing bermuda grass (*Cynodon dactylon*) were ignited and allowed to burn. The method, however, did not significantly reduce mosquito larval production. Temperature measurements with heat sensitive, lacquered probes showed that lethal temperatures are often not attained near ground level where most eggs are deposited.

INTRODUCTION

The multivoltine *Aedes nigromaculis* (Ludlow) and *Ae. melanimon* Dyar are 2 major species of pest mosquitoes in the central valley of California. Both are found in irrigated pastures and other similar floodwater habitats. Their eggs, which are deposited at the base of vegetation during summer and early autumn, are quiescent during winter.

During the winter, most of the above ground vegetation containing the eggs is killed by frost, creating a flammable material after the moisture content drops in late winter. If the overwintering eggs could be destroyed (i.e. by fire) before irrigations begin the following growing season then initial mosquito control measures could be postponed until reinfestation by immigrating females occurs. In California, the use of fire to destroy mosquito eggs has not been reported. However it could be an inexpensive practical control technique in limited situations, i.e. bermuda grass (*Cynodon dactylon*) pastures where vegetative regrowth occurs in the spring despite winter burning.

In the Don delta, U.S.S.R., Shumkov (1969) conducted tests to ascertain reductions in mosquitoes coincidental with control burning of marshy vegetation during autumn. He concluded that there was a high mortality (99.3–99.5%) of *Aedes* eggs due to the burning. Larvae of the 2 species, *Ae. c. caspius* and *Ae. vexans*, were absent in the burnt areas during the following 2 floodings but became reestablished after that.

Conversely, in an early report (Miller 1930), J. L. Clarke described the burning of a marsh resulting in an "intense heat"; after which he removed a sample of sod containing eggs of *Ae. vexans*. These were kept flooded indoors all winter with subsequent hatching in March of the following year.

In the present study, a group of field test plots, or minipastures, was used to evaluate winter burning as a method for temporarily controlling *Ae. nigromaculis* and *Ae. melanimon*.

MATERIALS AND METHODS

The test area was located in the southern San Joaquin Valley about 22 miles WNW of Bakersfield, CA. and consisted of a series of 6 × 30 × 0.3m plots with 50 cm sloped borders. The plots can be independently flooded by either well or canal water. Vegetation was predominantly bermuda grass but also included a variety of weeds. These plots have existed since 1974 during which time they have been repeatedly flooded during the growing season to produce a mixture of both species of mosquito larvae for testing candidate larvicides.

Burning took place in early February, 1977, after an abnormally dry winter, and killing frosts had left the vegetation very dry, so that once started, the 30 cm high grass continued burning until the plot was consumed. Thirteen plots were burned and 12 alternating plots were left unburned as controls. We estimated that 90% of the total area of the burned plots was consumed, and 10% missed. Air temperature and RH, as extrapolated from nearby Wasco and Bakersfield weather service records were estimated to be 22°C and 30% at the time of burning.

After burning, the plots were not used until early June when the new overgrowth in all plots was mowed. Since the plots were not irrigated prior to the planned flooding, no additional oviposition would have occurred after the burn, and therefore any eggs present at the time would have been deposited prior to burning. The plots were flood irrigated in groups of 7 to 10 on 3 separate days during June 1977; each irrigation included both burned and unburned plots. Sampling took place on the 3rd and 4th day after flooding, when the larvae were 3rd and 4th stage and consisted of taking 10 to 30 dips (with 400 ml dippers) along the plot edges in grassy areas, i.e., in areas of probable habitat. The larval samples were transported to the laboratory for counting and identification.

At the time of the original burning in 1977, no attempt was made to measure the temperatures generated by the fire. However, under similar conditions, on 2 separate days (1/24 and 3/2 or Jan. 24 and March 2) in winter 1979, 3 plots were again burned in order to discover the temperatures to which the eggs would be exposed. Accordingly, a series of 10 temperature-indicating lacquers (Tempilaq™ with heat-sensitive ranges from 38°C to 288°C in 27.8°C (50°F) increments were obtained; a given lacquer will show evidence of melting when it is exposed to a temperature which meets or exceeds its rated value. These lacquers were separately painted onto individual 1 ml disposable glass pipettes to make several sets of "temperature probes," each set having 1 each of the 10 different lacquered probes.

For use in the field, the probes were emplaced vertically among the vegetation with their tips extending 4 cm beneath the soil surface; the individual probes of a set were placed ca. 8 cm apart. Four sets were used among 1 plot on 1/24 and 7 sets were used among 2 plots on 3/2, for a total of 110 probes used.

Just prior to burning, measurements were taken of air temperature, RH, and soil temperature 1 cm below the surface under dense vegetation. These were respectively 9.4°C, 42%, and 11.1°C on 1/

24/79, and 14.4°C, 37%, and 11.1°C on 3/2/79. On 1/24 several grab samples of vegetation were taken prior to burning; these were pooled, weighed, oven-dried and reweighed to determine moisture content, which was 32% (wet wt.).

Upon ignition the vegetation readily burned, and as before in 1977, an apparent intense heat evolved, with flames reaching 1 m high at times. Afterwards a measurement was taken of the position along each probe above which the lacquer melting occurred.

In addition to the field experiments, a laboratory test was conducted to detect mortality when quiescent eggs are exposed to various temperatures. Eggs were harvested from gravid field-collected adults during August 1977 and stored at 15–17°C and 80% RH until their use in December when the nonviable (collapsed) eggs were discarded. For testing, groups of 90 eggs were spread out into 5 cm diam. aluminum weighing trays and placed in a preheated drying oven for 2 minutes. This was approximately the minimum time for the trays to reach the prescribed temperatures as revealed by temperature-indicating lacquer marks on separate trays placed in the same location. After exposure, the eggs were transferred to moist filter papers and stored in a room maintained at 27°C and 75% RH with 14 hr light/10 hr dark cycle for 6 days in order to condition them before hatch. The eggs were then flooded with 250 ml of 27°C tap water with 10 ml of 1% bakers' yeast suspension for a period of 24 hr after which the hatched larvae were counted.

RESULTS AND DISCUSSION

The average number of larvae per dip and the species ratio in samples are shown in Table 1. An analysis of variance comparing average numbers of larvae from burned vs unburned plots, and between flooding dates, showed that differences were not significant at the 5% level. Also the difference in the species ratios between burned and unburned plots was not significant indicating that the 2 species were about equally affected. The fact that the unburned plots produced about twice as many larvae per dip sample as did the burned plots may indicate an actual decrease in egg numbers due to the treatment. However this difference was not statistically valid due to a high error-mean-square in the analysis (high variability within samples), which is common in field collections such as these. The use of additional test plots and more dip samples may have eventually shown statistical significance, but for practical control purposes there was no worthwhile reduction in the population. Our original hypothesis was that the apparent high heat involved would have readily destroyed all eggs in the path of the flames, sparing only those in the small unburned areas. In fact, the unburned areas were generally those which were only sparsely covered with vegetation and would not have been expected to contain many eggs, since *Ae. nigromaculis* usually oviposits in dense grassy areas (Miura and Takahashi 1973). Consequently, almost complete reduction of the mosquito egg population might have been anticipated.

The results of the laboratory oven-exposure tests show that no eggs hatched in any of the groups exposed to temperatures at or above 66°C.

Examination of the temperature probes showed that generally there was a gradient of melt between the lowest temperature value probe (38°C) and the highest (288°C). The lower value probes showed lacquer melt along all except the lower end near the soil, whereas the higher value probes showed melt only at the upper ends. The average distance from the ground to the first appearance of lacquer melt on the 38°C probes was 1.4 cm (range: 0–5.5 cm); 3.1 cm (range: 0–12 cm) on the 66°C probes and 2.6 cm (range: 0–7 cm) on the 93°C probes. The distance on all other probes (121–288°C) measured 3.5 to 8 cm. This is significant because ca. 98% of all *Ae. nigromaculis* eggs in grass clumps are lower than 3 cm above the ground (Miura and Takahashi

Table 1. Average numbers of larvae per 400 ml dip sample after flooding 25 test plots and the ratios of *Ae. nigromaculis* to *Ae. melanimon.*

	Burned				Unburned			
Date Flooded	No. Plots	No. Dip Samples	$\bar{x}$ An:Am[1]	$\bar{x}$ Larvae Per Sample	No. Plots	No. Dip Samples	$\bar{x}$ An:Am	$\bar{x}$ Larvae Per Sample
6/13	4	105	1:1.2	10.6	3	70	1:3	22.7
6/21	5	125	1:1.6	3.4	5	125	1:1.6	8
6/27	4	80	1.2:1	5.5	4	80	1:1.4	8.7

[1] An is *Ae. nigromaculis.* Am is *Ae. melanimon.*

1973) and therefore are located in a zone below the fire which often did not produce the 66°C and higher temperatures which would kill the eggs. It appears then, that many of these eggs, because of their proximity to ground level, escaped the lethal high temperatures found higher in the flames, and thereby remained viable through subsequent flood irrigation and hatching. We have therefore concluded from these studies that the winter burning of dormant pastures as described is not likely to achieve satisfactory control of these 2 mosquitoes.

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CONSOLIDATION OF LARVAE AFTER SEPARATION OF PUPAE IN THE MASS PRODUCTION OF *ANOPHELES ALBIMANUS* WIEDEMANN

JOYCE E. F. FOWLER AND DONALD L. BAILEY

Insects Affecting Man and Animals Research Laboratory, USDA, AR, SEA, Gainesville, Florida 32604

ABSTRACT. Experiments showed that consolidation of larvae remaining in rearing trays after the 2nd harvest of pupae was feasible and beneficial in mass rearing *Anopheles albimanus* Wiedemann. Consolidation after the 1st harvest is not recommended, because the size of the resulting pupae and the production from survivors in rearing trays are reduced.

INTRODUCTION

A major consideration in the mass rearing of insects is conservation of space, especially when several days are required from the time eggs are set in rearing containers until the desired life stage has been harvested. Also, with some insects, several days may be required for harvesting because of differential developmental time of the immature stages. When this is the case, after some of the insects have been removed from the rearing containers, consolidation of the remaining younger life stages into fewer containers reduces the space required for