EVALUATION OF HAND APPLIED NALED THERMAL FOG FOR *WYEOMYIA* CONTROL

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ABSTRACT. Tests on the effect of hand applied naled thermal fog, both as a single treatment on one day/week and a single treatment on 3 successive days, did not control *Wyeomyia vanduzeei* and *Wy. mitchellii.* Five-min landing/biting counts in a native oak/palm woodland demonstrated that single applications produced an average landing rate decrease of 13%. Treatments 3 days in succession did not suppress the landing rate.

INTRODUCTION

Two bromeliads, *Tillandsia utriculata* Linn. and *Billbergia pyramidalis* (Sims) Lindley, are productive *Wyeomyia* habitats in urban areas. *Tillandsia utriculata,* a native arboreal epiphyte, frequently attaches to rough-barked trees such as oak (Frank and Curtis 1981), while *B. pyramidalis,* an exotic, is terrestrial. Rainfall or domestic irrigation contained in the leaf bracts of these bromeliads commonly enables these southern Florida plant species to produce *Wyeomyia vanduzeei* Dyar and Knab and *Wy. mitchellii* (Theobald). Because these 2 bromeliads serve as decorative landscaping plants, *Wyeomyia* mosquitoes are in direct association with humans.

Control of both *Wyeomyia* larvae and adults has eluded the technology of operational mosquito control. Larviciding in *Tillandsia* is difficult because of their abundance and inaccessibility in trees. *Billbergia pyramidalis* are difficult for larviciding because their dense overlapping leaves exclude chemical penetration to the central water-filled cup.

Adults of these 2 mosquitoes are particularly pestiferous in southern Florida in shaded areas where bromeliads are numerous. They exhibit an erratic/wary biting behavior similar to *Aedes aegypti* (Linn). Adults of both *Wy. vanduzeei* and *Wy. mitchellii* are daylight active; therefore, normal crepuscular ultra low volume (ULV) adulticiding is ineffective.

During May-July 1983, the Indian River Mosquito Control District conducted a series of experiments to evaluate the efficiency of thermal fogging for controlling *Wy. vanduzeei* and *Wy. mitchellii* adults. The objective of our study was to develop a functional adulticiding program that could be used by mosquito control agencies or homeowners, by achieving 80–90% reduction of adult *Wyeomyia* with a limited number of chemical applications.

METHODS AND MATERIALS

Study site: Three discrete oak/palm woodlands, separated by about 300 m (900 ft), were selected in Vero Beach, Florida. Each of the sites was approximately 0.3 acres (0.1 ha) in area. Vegetation at each site was dominated by native oak (*Quercus virginiana* P. Mill.) and palm (*Sabal palmetto* (Walt.) Todd) with a dense shrub understory. These 3 sites were selected because their isolation from other possible *Wyeomyia* preadult habitats eliminated the possibility of immigration. *Wyeomyia vanduzeei* has a restricted flight range with the adults dispersing short distances from their emergence site (Frank and Curtis 1977).

Landing rates: All population monitoring was performed by the same 2 individuals taking landing rates at one of several designated locations within each site. For 5 min, the total number of mosquitoes that landed and attempted blood engorgement was counted. This method was selected because trapping techniques using light or bait are not successful for collecting adult *Wy. vanduzeei* and *Wy. mitchellii* (Frank and Curtis 1977). However, they are anthropophilic. Each sampling event included measurement of temperature, wind speed and relative humidity.

For 30 days prior to commencement of the adulticiding tests, daily (Monday-Friday) landing rates were taken at each of the 3 sites between 0800–0900 h. The sequence for sampling was rotated randomly among the 3 sites. This was to establish a baseline estimation of changes in mosquito numbers at each of the selected locations. One site was selected as an untreated control and compared with the 2 insecticide test areas.

Statistical analysis: For statistical purposes, the landing rates of the 2 collectors were averaged. The data were smoothed with a 2-day moving average (Box and Jenkins 1976).

Fogging: In each of the experiments, one or more sites was treated by thermal fogging with Dibrom 14 (naled) diluted with diesel fuel (1:99). The insecticide was applied with a London Turbo Hand Fogger (London Fog Co., Crystal Bay, MN). Treatment was at a rate of 5–6 gal (19–23 liters)/h. The fogger was hand carried at approximately 2 miles/h (55 m/min). This procedure is similar to that used by Linley et al.

(1987) for insecticidal testing against *Culicoides furens* (Poey). Evaluation was on the effect of either the single treatment on one day or a treatment on 3 consecutive days. Landing/biting counts were taken before the treatment. Posttreatment landing rates were taken 24 h following the application. If the experiment was for 3 successive daily treatments, the mean of the 3 pretreatment and 3 posttreatment landing rates were computed. This produced a single smoothed value for comparison.

RESULTS

Figure 1 shows the results of the preliminary adult sampling used to establish baseline population levels. Graphically, Fig. 1 illustrates the percent change from one daily sampling event to the next. This summary of the pretreatment data illustrates the dissimilarity among the landing rates at the 3 sites. Clearly, on consecutive days the individual percent changes differed at each site. To evaluate site stability in relation to mosquito population fluctuation, we employed the methodology of Bidlingmayer (1985). This involves the conversion of the data to standard normal deviates (Sokal and Rohlf 1981). Comparability was tested by Pearson product-moment correlation. The probability matrix generated by this test demonstrated there was no association among all 3 sites (n = 18, $P < 0.25$). Although Site 1 and Site 2 exhibited some statistical similarity (n = 18, $P <$ 0.08), a change in one was not necessarily indicative of a change in the other. This made it impossible to use the original experimental design, which had anticipated a traditional "control" vs. "treated" comparison. Instead we used moving average smoothing technique, which is discussed later.

Sites 1 and 3 were selected for treatment because they had the highest landing rates. Eleven insecticidal treatments were applied between these 2 sites. Figure 2 shows pretreatment and posttreatment landing rates. Statistically, the percent change between the pretreatment and the posttreatment landing rates ranged between a decrease of 48% and an increase of 66% with a mean decrease of 13% (Fig. 3).

Six tests were conducted with naled applied 3 days in succession. Figure 4 shows the results of both pretreatment and posttreatment landing

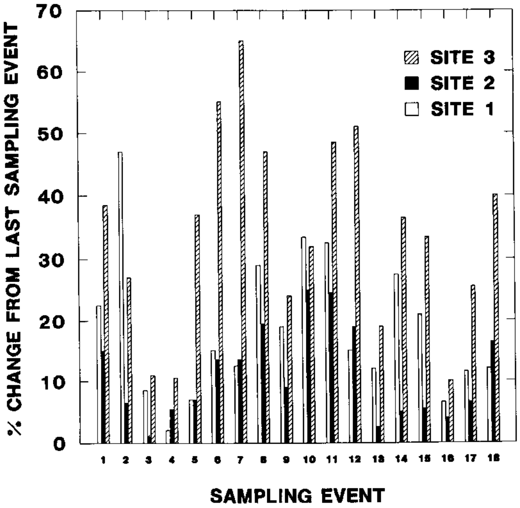

Fig. 1. Preliminary *Wyeomyia* landing rates (mean of 2 samples). Percent change from last daily sampling event.

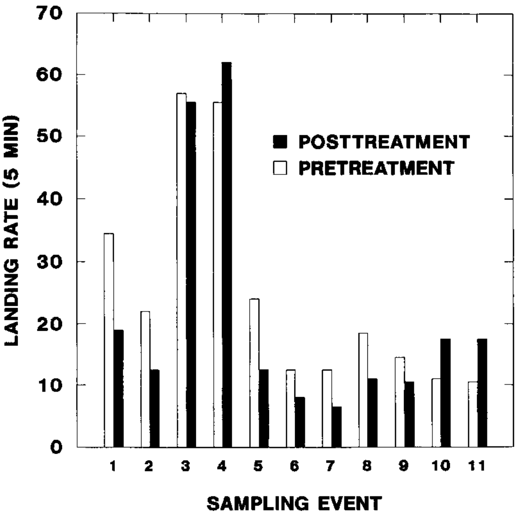

Fig. 2. Efficiency of thermal naled fog in a single application. Pretreatment and posttreatment landing rates are 2 day averages.

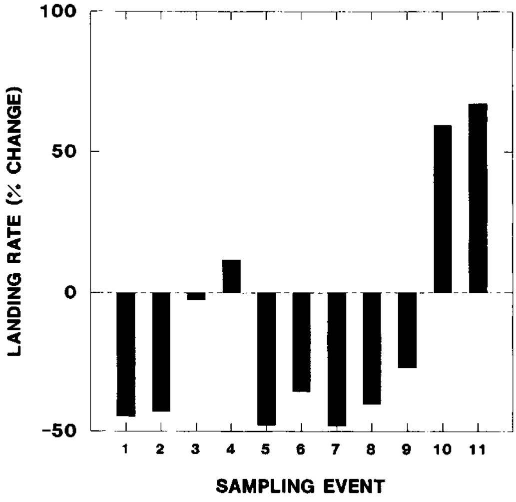

Fig. 3. Percent change in *Wyeomyia* landing rates following a single treatment with thermal naled fog.

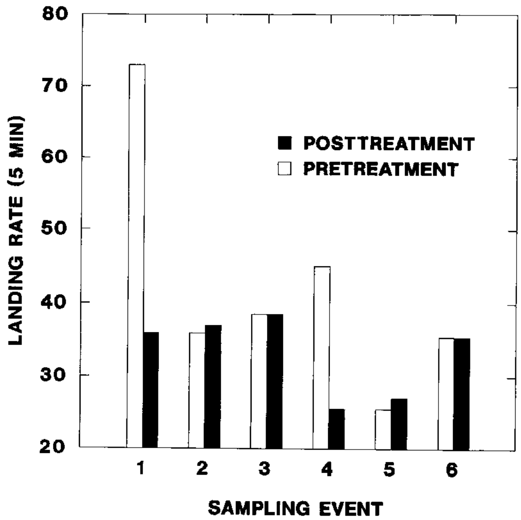

Fig. 4. Efficiency of thermal naled fog in 3 successive daily treatments. Pretreatment and posttreatment landing rates are 2 day averages.

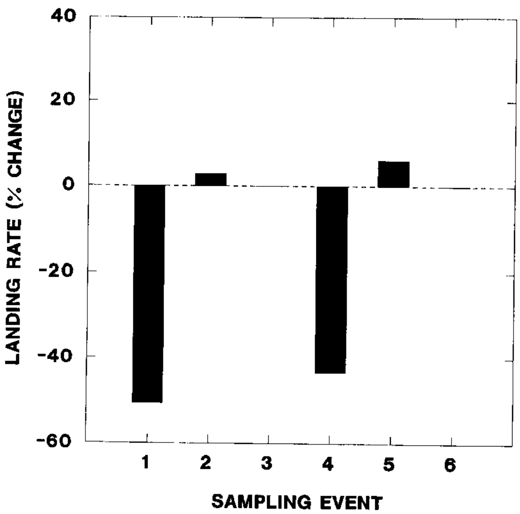

Fig. 5. Percent change in *Wyeomyia* landing rates following 3 successive daily treatments with thermal naled fog.

rates for this series of tests. Percent changes of *Wyeomyia* landing rates ranged from a decrease of 50.7% to an increase of 5.9% with a mean decrease of 14.3% (Fig. 5).

DISCUSSION

The idea of selecting several sites for the study with the intent of one serving as a control was educational. It demonstrated a concern all researchers on this subject should consider. In many adulticiding studies, an isolated control site is selected that presumably will mimic the same population fluctuations as the test site. It is often assumed that even if there is a numerical disparity between sites, the same environmental and biological factors are driving the sites and the percent changes in mosquito abundance will be comparable. If true, this allows statistically valid comparisons to be made between treatment and control sites.

However, in this study a comparison of the standard normal deviates of the pretreatment samples demonstrated that there was insufficient consistency among *Wyeomyia* populations to allow any of the 3 sites to serve as a control. For statistical purposes, we turned instead to a 2-day moving average of landing rates. This commonly used data processing method minimized the normal landing rate variation while retaining the natural trend in the data, and presented the smoothest numeric data ensemble for analysis. Additionally, we were most interested in whether there was a real reduction in mosquito numbers resulting from insecticide treatment.

The single treatment experiments with thermal naled resulted in an average 13% reduction, which was well below the 80–90% target. Figure 3 demonstrates that in 7 of the 11 tests, there was a > 36% reduction in *Wyeomyia* landing rates. The 4 other tests showed a small reduction or an increase from the 2-day mean pretreatment *Wyeomyia* landing rate.

Thermal naled treatments on 3 successive days also proved ineffective in providing adequate control (Fig. 5). The largest observed reduction in *Wyeomyia* numbers in any of the tests (50.7%) occurred in this series of experiments. However, in 4 of the 6 three successive day treatments, there was either no change or a slight increase in mosquito abundance.

Reasons for the failure of hand fogging with naled to control adult *Wyeomyia* are unclear. *Wyeomyia* adults normally exhibit extensive vertical flight distribution along tree trunks (Frank and Curtis 1977). Therefore, the majority of the adults may be avoiding the low-lying fog by being above it, although with each test, we observed the fog dispersing up into the canopy. Also, bromeliads positioned in the tree canopy as well as the canopy itself, may provide harborage for resting mosquitoes. We have no reason to question the susceptibility of *Wyeomyia* to thermal naled. In a series of preliminary trials conducted immediately prior to this study using caged *Wyeomyia*, we achieved > 90% control.

Biologically, the nonsynchronous emergence of *Wyeomyia* supplies a steady daily recruitment that may mask any benefits of hand fogging for adults. Initially, it was hoped we would find that a single fogging treatment would provide effective localized *Wyeomyia* control. However, even with the pressure of 3 successive daily treatments, there was not adequate *Wyeomyia* control to justify using naled thermal fogging for even specialized applications. We believe from these results that physical (e.g., removal of plants) and perhaps biological (e.g., introduction of predators or competitors for resources), rather than chemical, will prove to be the superior control strategies for *Wyeomyia* mosquitoes.

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