

malathion continuously as an adulticide for 17 years without control failures. Surprisingly, the *Cx. pipiens* complex population in Memphis, Tennessee, was reported to be resistant to malathion after only 8 seasons of use (Moseley et al. 1977). Susceptibility monitoring continues as an integral part of the control programs of both Texas counties.

We hope that this correlated laboratory-field approach to testing mosquito populations will serve as a practical resistance evaluation model for other control programs too, and that pronouncements concerning the presence of insecticidal resistance will be based on data which documents actual control failures.

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## STUDIES OF MALE OFFSPRING FROM OVERWINTERING *CULEX PIPIENS* COMPLEX MOSQUITOES

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**ABSTRACT.** Female overwintering *Culex pipiens* complex mosquitoes were collected in February and March, 1979, in Memphis, Tennessee. Following shipment to Fort Collins, Colorado, and acclimation to laboratory conditions, the DV/D ratio of male progeny of these mosquitoes were determined. Based on

the interpretation of DV/D ratios, approximately 50% were intermediate forms, 40% *p. pipiens*, and 10% *p. quinquefasciatus*. The data indicate that in the Memphis area, a small proportion of the overwintering population will be *quinquefasciatus*-like, even though *quinquefasciatus* has not been shown to hibernate.

#### INTRODUCTION

Recent renewed interest in the *Culex pipiens* complex has led to the listing of *Cx. pipiens* Linnaeus and *Cx. quinquefasciatus* Say as distinct species (Knight 1978). This revision was based on studies of the complex in Southeast Asia (Sirivanakarn 1976), Australia (Miles 1976), and South Africa (Jupp 1978). Within the U.S.A.,

the status of the complex remains perplexing, and the only known reliable method of distinguishing *pipiens pipiens* and *pipiens quinquefasciatus* adults is by the DV/D ratio of the male genitalia (Sundaraman 1949). An intergradation zone was outlined where both *pipiens* and *quinquefasciatus* occur and where intermediates and various mixtures of the three are likely to be found (Barr 1957).

Considerable gene flow between members of the complex was found (Jakob et al. 1979) in Memphis, Tennessee, which is located on the southern edge of the inter-gradation zone.

In further studies on the complex in Memphis, overwintering females were shipped to the Vector-Borne Diseases Division, Center for Disease Control, Fort Collins, Colorado, acclimated to laboratory conditions, blood-fed, and allowed to oviposit. We determined the DV/D ratios of male offspring produced by these overwintering females and the results are herein reported.

#### MATERIALS AND METHODS

Overwintering females were collected from natural resting sites, principally culverts, on February 13 and 14 and on March 1 and 8, 1979. More than 200 females were collected each time. They were shipped in insulated containers, with moist towelling, and were held in cages at 25°C, 75–80% R.H., for 5 days before being offered an avian host for an overnight period. Four days later, an oviposition dish was placed in the cage, and egg rafts were collected over a 3-day period. Rearing of larvae followed standard procedures of this laboratory. A sample of the male offspring from each collection date was examined for DV/D ratios. Measurements were made on terminalia in clove oil rather than by preparing permanent mounts (Jakob et al. op. cit.).

Ambient temperatures in the area for the 2-week period preceding each collection are summarized below:

Date	Range (°C) of average daily temp.	Temp. range (°C)		Average daily (°C) departure from normal
		Min.	Max.	
Feb. 13–14	–9 to 5.5	–12.8	12.2	–4.7
March 1	2 to 17.7	–6.6	20.6	–0.94
March 8	2.5 to 18	–2.2	21.2	+0.47

The records show that mean daily temperatures were well below the level at

which activity for most mosquito species ceases. In addition, the average temperature for the month of January, 1979 was –0.5°C (a departure from normal of –4.5°C). Although no specimens were examined for the presence of fat bodies indicative of hibernation, the climatological data agree well with the finding (Tate and Vincent 1936) that the preferred temperature for hibernating *pipiens* females was approximately 8°C. Unfortunately, no temperature records are available for the microhabitats in which the collections were made; thus, the exact physiological status of the overwintering mosquitoes is unknown.

#### RESULTS AND DISCUSSION

More than 160 male offspring from each collection were examined. The distribution of DV/D ratios obtained are shown in Fig. 1. The data show that, based on our interpretation of DV/D ratios, approximately 90% of the male offspring from each collection were the *pipiens* form and intermediates. Within the *pipiens* group, a large majority of the DV/D ratios fell in the upper extreme of the range for the group. These values correspond well with ratios obtained for males from natural resting stations during the breeding season in Memphis (Jakob et al. op. cit.) and are not totally unexpected in view of the northern cline shown for the species (Barr op. cit.). Similarly, the preponderance of ratios in the lower half of the intermediate range agrees with results obtained in crossing experiments (Knight 1953, Barr and Kartman 1951). Backcrossing to parent

type resulted in reversion to parent type faster with *pipiens* than with *quinquefas-*

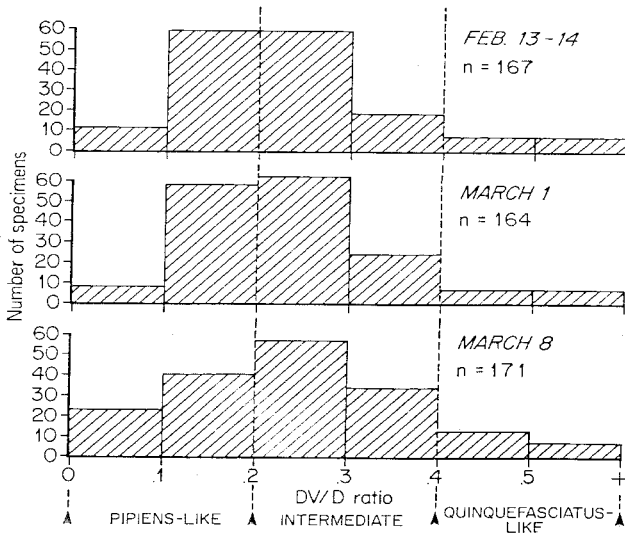


Fig. 1 Distribution of DV/D ratios of  $\delta\delta$  offspring of overwintering *pipiens* complex  $\text{♀♀}$  collected on specified dates, Memphis, Tenn., 1979.

*ciatus*. Whether this effect would also result from crosses of intermediates is not known.

The distributions of *pipiens* and *quinquefasciatus* suggest that temperature is a prime limiting factor. Although *pipiens* is well adapted to temperate climates, *quinquefasciatus* is apparently unable to cope with low temperatures. McMillan (1958) suggested that only individuals similar to *pipiens* could overwinter successfully near the northern edge of the intergradation zone. In our study, approximately 10% of the male offspring from overwintering females are considered to be *quinquefasciatus*. No marked reduction in proportion of *quinquefasciatus* offspring was obtained between the February 13-14 and March 8 collections. Thus, it is reasonable to suggest that in the Memphis area a small percentage of the overwintering population will be *quinquefasciatus*-like. This fact would also help explain the relative abundance of this form in early sea-

son resting site collections (Jakob et al., op. cit.). The authors are not aware of any previous data suggesting hibernation in *quinquefasciatus*.

Tests for presence of virus in 17 pools (385 specimens) of surviving females were negative.

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## MALATHION RESISTANCE IN *ANOPHELES STEPHENSI* LISTON IN LAHORE, PAKISTAN

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**ABSTRACT.** The Lahore area of Pakistan has been under malathion spraying pressure since 1976 at the rate of two treatments per year, 1 gm/m<sup>2</sup> per round. Susceptibility tests on *An. stephensi* from Lahore with 5% malathion (1 hour exposure) showed an average survival of 68.95% indicating the presence of resistant in-

dividuals. Malathion resistance in *An. stephensi* from Pakistan is being herein reported for the first time. The gene(s) for malathion resistance was present in high frequencies in populations near Lahore. Selection for malathion resistance in the laboratory resulted in a 20 times increase after only three selected generations.

### INTRODUCTION

*Anopheles stephensi* and *An. culicifacies* are major vectors of malaria in Pakistan and neighbouring countries. In Pakistan, DDT was used for mosquito control from 1961 to 1975 (2 cycles/year, 1-2gm/m<sup>2</sup>). In the early 1960's DDT showed good control of malaria vector, but by the early 1970's it failed to control these species (WHO, 1976). Therefore, in 1975 DDT was partially replaced by BHC, but resistance to BHC also appeared subsequently.

Recently Rathor and Toqir (1980) reported that *An. culicifacies* in the Lahore area has become nearly homozygous for DDT resistance, and the frequency of the DDT susceptible gene was so low that an attempt to select for DDT susceptibility in the laboratory did not succeed. In 1976 malathion was introduced in Pakistan for mosquito control, and it is still being used (2 cycles/year, 1 gm/m<sup>2</sup>). Sumithion (Fenitrothion) has also been used in selected areas of Punjab Province.