

determined if *Culiseta* congregate both in talus and on cliffs facing north-west, north, etc., around to south, just by observing their daily activity patterns at those different exposures.

Further observation of this talus habitat from break-up to freeze-up may determine if this is the overwintering site of these two species of *Culiseta*, or the summer resting site,—and should also show when the seasonal swarming peak occurs. If this talus is an overwintering site and if the habitat of the immatures is far away as mentioned earlier, perhaps the adults follow local fly-ways, resembling on a small scale the long-distance routes of migratory birds, with return of the females to the breeding area in spring for egg-laying. Prevailing breezes during the suggested migratory periods may provide

much of the required energy, in both directions. Or the mosquitoes may be carried here by the breeze and blocked by the mountain, thus having no control over their long-range flight routes, if such do indeed exist.

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## REVERSION OF DIELDRIN-RESISTANCE IN *ANOPHELES ALBIMANUS* WIEDEMANN

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Dieldrin-resistance in insects is decisive (Brown, 1961) and when fully developed in mosquito larvae it is in the order of several thousand-fold (Davison and Mason, 1963; Klassen and Brown, in press). Although it has been suggested that dieldrin-resistance may arise as a post-adaptation of insects exposed to sublethal dosages of a cyclodiene (Garin, 1953), compelling evidence for this viewpoint has not been published. On the other hand it has been shown that dieldrin-resistance arises as a result of Darwinian selection for preadaptations, and that it segregates as a partially dominant allele in mosquitoes (Davidson and Mason, 1963; Khan and Brown, 1961) and in other insects (Brown, 1961). Nevertheless it is evident from the data of

Klassen and Brown (in press) that this allele does not attain full expression until modifiers have been accumulated by intensive selection.

The frequency of this allele was evidently as high as 6 percent in some field populations of *Anopheles gambiae* before cyclodienes had been directed against them in the malaria eradication program (Armstrong *et al.*, 1956). Of course the possibility has not been ruled out that such high frequencies of the allele in mosquito populations have arisen through their inadvertent selection with cyclodienes used against agricultural insects.

Reversion of dieldrin-resistance to complete susceptibility within 25 generations was reported by Shanahan (1960) in a

highly resistant laboratory colony of *Phaenicia cuprina*. In a laboratory colony of *Anopheles gambiae* dieldrin-resistance remained stable over a period of years (Davidson and Mason, 1963), while in other mosquito colonies dieldrin-resistance is known to be unstable (Klassen and Brown, unpublished data). Recently, Georghiou and Metcalf (1963) reported the reversion of dieldrin-resistance in a laboratory colony of *Anopheles albimanus* which had been selected with a carbamate insecticide, m-isopropylphenyl methylcarbamate. These workers suggested that the reversion of the resistance might have been induced in some way by selection by the carbamate. The purpose of this communication is to report the spontaneous reversion of dieldrin-resistance in a heterogeneous strain of *A. albimanus*.

Our colony of *A. albimanus*, the only colony in our laboratory, was derived in 1962 as a subcolony of the dieldrin-resistant colony maintained at Johns Hopkins University. That colony had been derived

from dieldrin-resistant field populations in El Salvador.

Larvae were reared at a density of 75-100 in white enamel pans 10 x 12 inches with shallow water and fed daily on a coarsely ground mixture of equal parts of Kellogg's Concentrate, wheat germ and live yeast. During their second stadium the larvae were transferred to clean pans with fresh water and food. This method of rearing provided vigorous larvae of uniform size. The adults were maintained at all times as a strong colony in a nylon covered cage 12 x 9 x 9 inches in an insectary maintained at 80° F. and 65 percent relative humidity. As a source of blood, a guinea pig with a shaven back was taped to a pan and offered at least every second day. A wet sponge placed on the nylon cage-top provided water while a honey-saturated ball of cotton-wool provided energy. Oviposition was accomplished in a water-filled petri dish-bottom lined with a strip of filter paper.

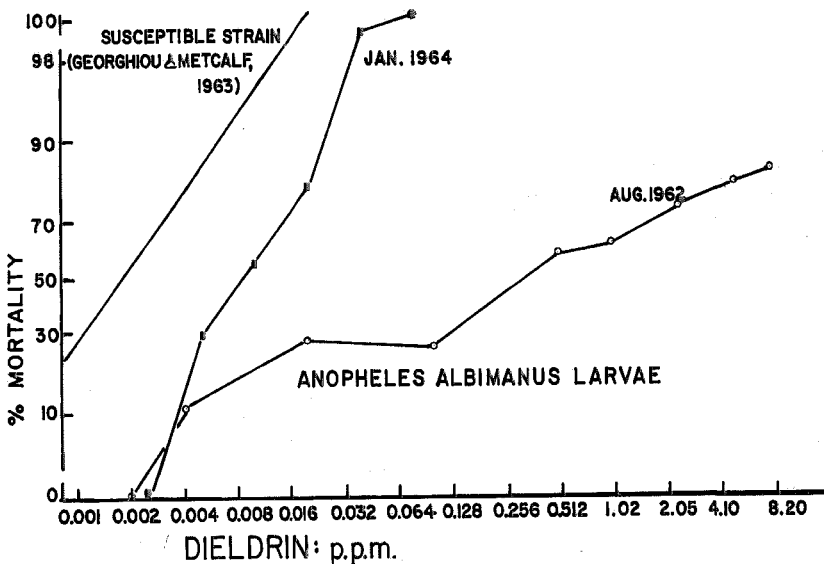


FIG. 1.—Dosage mortality relationships to dieldrin for a laboratory colony of *Anopheles albimanus* in August 1962 and January 1964. For comparison the dosage-mortality regression line of a susceptible strain was plotted from the data of Georghiou and Metcalf (1963).

The dosage-mortality relationships for the larvae were determined in August, 1962, by the WHO standard method (World Health Organization, 1960) and indicated that this population was heterogeneous with regard to dieldrin-resistance (Fig. 1). Moreover, by means of time-to-death methodology, French and Kitzmiller (1963) found this same population to consist of 50 percent homozygous susceptibles, 36 percent heterozygotes and 14 percent of the individuals being homozygous for the allele for dieldrin-resistance. Sixteen months subsequent to these determinations an attempt was made to select for dieldrin-resistance using the techniques of French and Kitzmiller, whereby the susceptibles may be screened off from the heterozygotes and homozygotes by exposing larvae for 4 hours to 8 p.p.m. dieldrin. None of the 2000 larvae exposed survived. A similar group of larvae was then exposed to 0.08 p.p.m. dieldrin for 24 hours—a dosage known to screen off only susceptibles in the case of *Aedes aegypti* (Khan and Brown, 1961). Again there were no survivors. In neither case was there any mortality within the controls. Subsequently (January, 1964) the dosage mortality relationships for the population were determined (Fig. 1); they also indicate that the dieldrin-resistance of this strain of *A. albimanus* had reverted to susceptibility within about 16 generations in the absence of contact with insecticides. For the purpose of comparison the dosage-mortality line determined by Georghiou and Metcalf (1963) for a fully susceptible strain is also plotted in Figure 1, and it is evident from both the similarity of the slope of this line and its proximity to that plotted for the reverted colony that these populations differ only in the degree of tolerance.

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