# CONTROL OF CALIFORNIA MOSQUITOES RESISTANT TO ORGANOPHOSPHORUS INSECTICIDES

L. L. LEWALLEN[1] AND R. F. PETERS[1]

In developing a chemical mosquito larvicide technology under California conditions, consideration has been given to safety of application, persistence, effect on nontarget organisms, efficacy of extremely low dosages, cost of insecticide, and other factors (Lewallen 1963, Mulla 1964).

When an insecticide becomes incorporated into the operational program of a mosquito abatement district, an overriding consideration in the continuance of its use is whether or not physiological resistance by the mosquito develops. Ordinarily, once a district establishes a routine regime involving the use of a given insecticide, and requirements of performance are satisfactorily met, unless another product is developed that is outstandingly superior in some desirable aspect, there is no pressing need to change to another material. Physiological resistance in mosquito strains has changed all this, however.

RESISTANCE IN *Aedes*. In California, the most urgent problem confronting mosquito abatement districts in the interior valleys is the control of multi-resistant strains of the pasture mosquito, *Aedes nigromaculis* (Ludlow). From about 1946 to 1951 this species was controlled in the larval stage by applications of chlorinated hydrocarbons. Even before the problem of unwanted residues appeared, the development of physiological resistance had precluded use of this kind of material in many abatement districts in California (Gjullin and Peters 1952).

In 1958, abatement districts began to experience control failures with larvicidal applications of parathion on *Aedes nigromaculis* (Lewallen and Brawley 1958, Lewallen and Nicholson 1959). Fortunately, however, other organophosphorus materials became available which were used effectively to re-establish control. The usual sequence of substitutions has been methyl parathion following ethyl parathion failures, then fenthion following failure of both ethyl and methyl parathion. As yet there have been no mass or wholesale failures of fenthion, although scattered reports of failures began to appear late in the 1965 mosquito season, suggesting that physiological resistance to fenthion has begun to be manifested (Gillies and Womeldorf 1966). Previous work has indicated that once resistance to ethyl and methyl parathion and also fenthon has developed, then malathion is useless as well (Brown *et al.*, 1963, Gillies 1964). Sumithion® and several other com-

[1] Bureau of Vector Control, California State Department of Public Health.

mercially available O-P compounds have shown no promise of reestablishing control (Lewallen 1963).

The most recent insecticide candidates that have been developed to the point where commercial availability has been established, and which offer promise of use in mosquito abatement programs are Abate®, and Dursban®[2]. Extensive field tests (see Table 1) with these materials have indicated that Dursban® offers the best prospect of re-establishing control of *A. nigromaculis* resistant to ethyl and methyl parathion and also fenthion. The data in Table 1 were obtained by methods previously outlined (Lewallen 1958, 1963). There appears to be some cross-resistance to Abate® in this species.

TABLE 1.—Results of field tests with Abate® and Dursban® emulsion concentrates on OP-resistant *Aedes nigromaculis* larvae by hand application*.

| Compound | Dosage (lb./acre) | 24 hour % mortality |
| --- | --- | --- |
| Dursban | 0.0025 | 75 |
| " | 0.005 | 99 |
| " | 0.01 | 100 |
| Abate | 0.01 | 82 |
| " | 0.05 | 93 |
| " | 0.1 | 98 |
| Parathion (control) | 0.1 | 16 |
| " | 0.2 | 45 |
| " | 0.5 | 93 |
| " | 1.0 | 100 |

* Although 0.01 lb./acre of Dursban® is very effective in hand applications, up to 0.04 lb./acre is required by airplane to obtain the same degree of control.

Although several carbamates have been extensively tested as substitute mosquito larvicides, none has come into general use as yet (Lewallen 1963, Chapman and Lewallen 1963, Mulla, Metcalf, Kats 1964).

Laboratory tests have revealed a degree of resistance to parathion in some strains of *Aedes melanimon,* but widespread control failures in the field have not been evident (Gillies 1964).

Mountain *Aedes* in California have not been tested for resistance to insecticides. These species are primarily univoltine and very likely may require some time to develop high levels of resistance. Since several chemical control programs are becoming established in mountain localities, a survey of susceptibility levels for the more common species would appear to be desirable.

RESISTANCE IN *Culex*. Resistance to chlorinated hydrocarbons in *Culex* species in California has followed a pattern similar to that of *Aedes nigromaculis* in the interior valleys (Gjullin and Peters 1952). There are some areas in California even today, however, particularly along the coast, where this class of compounds can be used effectively under conditions where residue hazards are of no concern.

One of the best known cases of resistance to organophosphorus materials in *Culex tarsalis* Coquillett was first reported from Fresno County, and involved malathion (Gjullin and Isaak 1957). In addition to this area, indications of resistance to malathion have been found in *C. tarsalis* in some districts with a history of malathion use in their control programs. To date, resistance to parathion has not been noted in any *Culex* species studies (Wilder 1966). Parathion is an effective substitute for malathion in cases where resistance problems have developed. Other organophosphorus materials, such as fenthion, Abate®, or Dursban®, would also be effective.

ANOPHELINES AND OTHER SPECIES. The very limited number of tests conducted thus far have not indicated high levels of resistance to insecticides in *Anopheles freeborni,* a particularly bothersome species in rice-growing areas of California. Likewise, no resistance has been apparent in *Culiseta inornata* (Williston) or *Culiseta incidens* (Thomson).

Possible solutions to the intense insecticide resistance problem in California mosquitoes include improved water management, better source reduction techni-

[2] The use of trade names is for the sake of clarity and does not imply endorsement of these products.

ques, chemosterilants, negatively correlated compounds, biological control, genetic methods, hormone-like materials, photochemical substances, detergents, botanicals or synthetic botanicals, and oils. Each of these has factors limiting its general use—incomplete development, adverse effects on nontarget organisms, or extreme cost. Further research in these areas, however, may alter some of these conditions and make some of the above control methods more promising.

### *References Cited*

BROWN, A. W. A., L. L. LEWALLEN, and P. A. GILLIES. 1963. Organophosphorus resistance in *Aedes nigromaculis* in California. Mosquito News 23:341–345.

GILLIES, P. A. 1964. Organophosphorus resistance in California mosquito larvae. C.M.C.A. Proc. & Papers 32:57–62.

GILLIES, P. A. and D. J. WOMELDORF. 1966. In preparation for publication in Mosquito News.

GJULLIN, C. M., and R. F. PETERS. 1952. Recent studies of mosquito resistance to insecticides in California. Mosquito News 12:1–7.

GJULLIN, C. M., and L. W. ISAAK. 1957. Present status of mosquito resistance to insecticides in the San Joaquin Valley in California. Mosquito News 17:67–70.

LEWALLEN, L. L. 1963. Chemical control investigations on economically important mosquitoes in California 1960–1961. Mosquito News 23:141–144.

LEWALLEN, L. L. and J. H. BRAWLEY. 1958. Parathion resistant *Aedes nigromaculis.* Calif. Vector Views 5:56.

LEWALLEN, L. L., and L. M. NICHOLSON. 1959. Parathion resistant *Aedes nigromaculis* in California. Mosquito News 19:12–14.

MULLA, M. S. 1964. Problems in the development of new mosquito larvicides. C.M.C.A. Proc. & Papers 32:45–47.

MULLA, M. S., R. L. METCALF, and G. KATS. 1964. Evaluation of new mosquito larvicides with notes on resistant strains. Mosquito News 24:312–319.

WILDER, W. H. 1966. In preparation.