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WHO/Mal/275 ✓
14 October 1960

ORIGINAL: ENGLISH

RECENT RESEARCH ON INSECTICIDE RESISTANCE IN MOSQUITOS^a

by

G. Davidson and C. Elizabeth Jackson
Ross Institute of Tropical Hygiene,
London School of Hygiene and Tropical
Medicine, London

(Director: Professor G. Macdonald, C.M.G.)

A detailed study of the nature and mode of inheritance of dieldrin-resistance in a strain of Anopheles gambiae from the Western Sokoto region of Northern Nigeria, and of DDT-resistance in a strain of A. sudaicus from Indonesia has already been made and recorded.^{1,2,3} Dieldrin-resistance in A. gambiae was shown to depend on a single genetic factor semi-dominant in its manifestation and imparting cross-resistance to other cyclodiene chlorinated hydrocarbons and to gamma-BHC but not to DDT. DDT-resistance in A. sudaicus also shows a monofactorial type of inheritance, but here the factor is recessive in nature and imparts cross-resistance to DDT-analogues but not to dieldrin or to gamma-BHC.

Two other dieldrin-resistant strains of A. gambiae have now been studied, one from Kano in Northern Nigeria⁴ and one from Bobo Dioulasso in French West Africa, and an identical type of resistance to that found in the strain from Western Sokoto demonstrated. In addition, dieldrin-resistance has been studied in three other species of mosquitos, A. albimanus, A. quadrimaculatus and Culex fatigans, and a single semi-dominant factor has been shown to operate in all of them. The resemblance of the resistance in the two anopheline species to that previously investigated in A. gambiae is enhanced by the fact that the discriminating dosages of dieldrin separating susceptibles from hybrids, and hybrids from resistants, are almost identical in both larvae and adult tests. In the case of C. fatigans

^a This investigation was carried out with the financial assistance of the World Health Organization. Detailed reports on some investigated problems are being prepared for separate publications elsewhere.

the discriminating dosages applicable to the adults are somewhat higher than in the anophelines. In other words, the susceptible and hybrid adults are more tolerant to the insecticide than are the adult anophelines.

Three strains of A. quadrimaculatus, one from Maryland, one from Florida, and one from South Carolina, USA, have been used in these investigations. From the first two, dieldrin-resistant strains have been selected which are susceptible to DDT. Attempts to select DDT resistance from the original mixed populations have failed. The South Carolina strain is susceptible to both insecticides.

The dieldrin-resistant strain of C. fatigans originates from Ceylon. Attempts to select DDT-resistance from it have so far failed. The susceptible strain of this species used for crossing with this resistant strain is one from Malaya. Both strains are much more tolerant to DDT in the adult stage than any susceptible anophelines. In fact they appear to be as tolerant as the DDT-resistant strains of anophelines so far investigated. However, the larvae are more susceptible to DDT than those of susceptible strains of anophelines. It would thus appear that C. fatigans shows a natural high tolerance to DDT in the adult stage and that this is a characteristic of the species and does not stem from any specific factors for resistance.

The dieldrin-resistant strain of A. albimanus was selected from a mixed population of this species from El Salvador. Like the other dieldrin-resistant species it is susceptible to DDT. The susceptible strain of the same species used for inheritance studies originated from Panama. Selection of the original mixed El Salvador population with DDT resulted in the production of what was apparently a true DDT-resistant strain of this species. Testing this selected strain on dieldrin revealed the presence of some dieldrin-resistant individuals, and selection of it with this insecticide produced a strain which would tolerate very high dosages of both DDT and dieldrin on consecutive exposures, i.e., a strain showing double resistance.

From the strain showing DDT-resistance and some dieldrin-resistant individuals there has now been isolated a strain resistant to DDT and completely susceptible to dieldrin.

This isolation of three strains of the same species, one resistant to DDT but susceptible to dieldrin, one resistant to dieldrin but susceptible to DDT, and a third resistant to both insecticides, is in itself a proof that two separate genetic factors are involved. Further confirmation has come from the crossing of the DDT-resistant strain with the susceptible Panama strain and studying the mode of inheritance of DDT-resistance. A pattern of inheritance has been demonstrated almost identical with that shown in A. sundaicus, viz., a monofactorial type of inheritance dependent on a virtually recessive factor. It remains now to cross the DDT-resistant strain with the dieldrin-resistant to show whether the factors occur on the same chromosome (and, if so, how far apart) or on separate chromosomes, and this work is in progress.

Finally, DDT-resistance has also been studied in a third anopheline species, A. stephensi. By comparing a resistant strain from Iraq with a susceptible strain from India and crossing them, DDT-resistance in this species has been shown to impart cross-resistance to DDT-analogues but continued susceptibility to dieldrin and gamma-BHC. The inheritance pattern differs slightly from that shown by A. sundaicus and A. albimanus in that the single factor involved is semi-dominant when 24-hour mortalities from exposures to the insecticide are considered. When, however, immediate knockdown counts after removal from the insecticide are made, the factor appears to be more recessive than dominant.

DDT-resistance in A. stephensi is of a comparatively low order, some 10 to 20 times only and exact discrimination between the genotypes is impossible. The establishment of the monofactorial character of the inheritance of resistance in this species has been confirmed finally by a process of repeatedly backcrossing the heterozygote with the susceptible parent and exposing the offspring to a dosage of DDT which is known to eliminate susceptibles completely. The survivors have then been recrossed with the susceptible strain and the process of selection repeated. The mortality at each stage of selection has remained more or less at the same level. It has not shown the consistent rise expected where more than one genetic factor is involved.

These studies, then, have amply confirmed that resistance in mosquitos is of two independent types, DDT-resistance and dieldrin-resistance. Further they have shown that resistance is dependent on a single genetic factor, semi-dominant in the case of dieldrin-resistance and recessive or nearly so in the case of DDT-resistance, the remarkable feature being that these characteristics apply to different species in widely separated parts of the world. That the two factors can exist together in the same population of the same species is now definitely established and should further stimulate the search for new and efficient insecticides outside the chlorinated hydrocarbon group of organic chemicals.

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