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The status of anopheline mosquitos with regard  
to resistance to insecticides

Introduction

The table which follows this introduction represents a summary of information reported to WHO Geneva up to 15 April 1960.<sup>1</sup> It supersedes information published in the Weekly Epidemiological Reports.

The resistance here recorded is confined to those groups of chlorinated hydrocarbons normally used in recent years in campaigns of malaria control and malaria eradication. Resistance to gamma BHC (lindane) is not shown separately, as it is believed that this is nearly always linked to resistance to dieldrin, regardless of which of these insecticides has been used in the area concerned. As no species of *Anopheles* has ever been found to possess actually a high degree of tolerance to any of these hydrocarbon insecticides, it is presumed that every case of resistance detected in the field is due to selection pressure from one or other of these insecticides. In many areas the pressure is undoubtedly produced by the presence on the walls of houses of residual insecticide applied for the purpose of controlling the malaria vector. In certain countries, however, resistance has appeared before any such applications were made, and must be attributed to the spraying of crops against agricultural pests. Notable instances of this are El Salvador (resistance in *A. albimanus*) and Egypt (resistance in *A. pharoensis*).

The table is based on a study of the record forms used by investigators in the field. Information reported to WHO in summary form only has not been included, neither has information based on those tests which fail to meet the WHO criteria of reliability.

<sup>1</sup> Previous summaries were contained in WHO/Mal/189, WHO/Insecticides/63 of 2 June 1957; WHO/Mal/199, WHO/Insecticides/74 of 18 February 1958; WHO/Mal/203, WHO/Insecticides/77 of 23 April 1958; WHO/Mal/224, WHO/Insecticides/95 of 1 May 1959 and WHO/Mal/242, WHO/Insecticides/100 of 15 September 1959.

In the first column of the table the species of *Anopheles* exhibiting resistance are listed alphabetically. An asterisk indicates those species which are believed to be non-vectors, or whose role as vectors is unconfirmed (and probably a minor one) in the area concerned.

Column 3 gives the region, or other major political division, in which resistance has been demonstrated. For some countries the districts or subsidiary divisions concerned are also given and are inset from the left-hand margin of the column. The aim has been to give only territorial units which can be traced by reference to the Codepid Epidemiological Cable Code Map Supplement (WHO 1954).

Only where it was not possible to identify these has another name (the one given by the investigator on his record form) been inserted.

In the operative columns 4 and 5 of the table, three abbreviations are used:

- Res = Resistance
- Susc = Susceptibility
- Int = Intermediate condition

The criteria for designating a mosquito population as resistant is necessarily somewhat arbitrary. In this summary it means that at least half the mosquitos survived one hour's contact with 4% DDT, or with 1.6% dieldrin, under the conditions of the WHO standard adult susceptibility test. It should be clear that this is not in itself a proof that DDT or dieldrin, applied to the walls in the dosages normally used, will fail to control the vector mosquito to the extent necessary to interrupt malaria transmission. It is, however, a strong indication that the use of a particular insecticide may become uneconomic, or may fail altogether in the specified area. Furthermore, the recording of this resistance shows the necessity of taking all due precautions to prevent the importation of the resistant vector species into other malarious areas.

The "Intermediate condition" is likewise an arbitrary category, used here merely for convenience. It means that the mosquito populations so designated have not so far exhibited resistance as defined above, but have nevertheless shown a degree of tolerance to the insecticide substantially greater than that of normally susceptible mosquitos of the same species. Even this condition proves an unsuitable one (particularly in the case of dieldrin) which will lead to a condition of resistance if the same insecticide continues to be used in the area.

It has been found necessary to provide two columns for dates as it is now some years since resistance was first detected in a number of countries and recent tests have often been performed to check the status of the mosquitos after an interval without insecticidal pressure. In at least one case (Indonesia: A. sundaicus) a vector mosquito formerly resistant to DDT is shown to have reverted to susceptibility. It is likely also that certain populations of A. sacharovi in Greece, now reported in an intermediate condition with regard to DDT, were formerly among those which exhibited resistance to this insecticide.

Species	Country	Region and District	Reaction to DDT	Reaction to dieldrin	Date of evidence	Most recent confirmation
<u>A. aconitum</u>	INDONESIA	JAVA	Susc	Res	III.60	
		Jogja Subah	Susc	Res	X.60	
<u>A. albimanus</u>	BRITISH HONDURAS	BELIZE	Susc	Res	II.59	
		CORDOBA	Susc	Int	XI.59	
	COLOMBIA	ORIENTE	Susc	Res	VI-VII.59	
		Bayamo	Susc	Res	VI-VII.59	
		Holguin	Susc	Res	VI-VII.59	
	CUBA	Manzanillo	Susc	Res	VI-VII.59	
	DOMINICAN REPUBLIC	SAMANA	Susc	Res	IX-X.59	
		Julia Molina	Susc	Res	VIII.59	
		SANTIAGO	Susc	Res	II.60	
ECUADOR	TRUJILLO	Susc	Res	VI.59		
	EL-ORO	Susc	Res	VII.59	II.60	
	GUAYAS	Susc	Res	III.60		
	LOS RIOS	Susc	Res	XI.58		
EL SALVADOR	CABANAS	-	Res	XI.59		
	LA LIBERTAD	Res	Res	VI.59	III.60	
				VII.59		
	LA UNION	Res	Res	I.59		
	SAN MIGUEL	Res	Res	VII.58	I.60	
	SAN SALVADOR	Res	Res	IX.59		

Species	Country	Region and District	Reaction to DDT	Reaction to dieldrin	Date of evidence	Most recent confirmation
<i>A. albimanus</i> (continued)	EL SALVADOR (continued)	SAN VICENTE	Res	Res	VI.59 IX.59	XI.59
		SONSONATE	Int	Res	VII.58	
		USulutAN	Res	-	VIII.59	X.59
	FEDERATION OF BRITISH WEST INDIES	JAMAICA St. Catherine	Susc	Int	XI.58	
		CHIQUIMULA	Susc	Res	IV.59	
		EL-PROGRESO	Res	Res	IX.59	III.60
	GUATEMALA	ESCUINTLA	Res	Res	IX.58	III.60
		GUATEMALA	Susc	Res	VII.59	
		RETALHULEU	Res		III.60	
		SUCHI TEPEQUEZ	Susc	Res	VII.59	
		ZACAPA	Susc	Res	XI.58	
		QUANAMINTH	Susc	Res	II.60	
	HONDURAS	CHOLUTECA	Susc	Res	XI.59	
		COMAYAGUA	Res	Res	XI.58	II.59
	MEXICO	FRANCISCO MORAZAN	Susc	Res	XI.58	II.59
MI CHOACAN Apatzingan		-	Res	IV.59		

Species	Country	Region and District	Reaction to DDT	Reaction to dieldrin	Date of evidence	Most recent confirmation
<u>A. albimanus</u> (continued)	NICARAGUA	CARAZO	Res	Res	XI.59	XI.59
		CHINENDEGA	Res	Res	VI.59 X.58	XI.59 IX.59
		ESTELI	Res	Res	II.60	
		GRANADA	Int	Res	X.59	
		LEON	Res	Res	VII-IX.59	XII.59
		MANAGUA	Res	Res	X.58	XII.59
		MASAYA	Int	-	VII.59	
		NUEVA SEGOVIA	Susc	Res	X.58	
		RIVAS	Susc	Res	X.59	
		META	Susc	Res	IX-X.59	XII.59
<u>A. albicansis</u> *	COLOMBIA	COJEDES	Susc	Res	X.59	
		PORTUGUESA	Susc	Res	XI.59	XII.59
		BOMBAY Panchmahal	Res	-	I.60	II.60
		RAJASTHAN Udaipur	Int	-	XII.58	I.59
<u>A. annularis</u> *	INDONESIA	JAVA Bodjonegoro	Susc	Res	II.58	
		PARA Belem	Int	Res	V.59	
<u>A. aquasalis</u>	BRAZIL					

Species	Country	Region and District	Reaction to DDT	Reaction to dieldrin	Date of evidence	Most recent confirmation
<u>A. aquasalis</u> (continued)	FEDERATION OF BRITISH WEST INDIES	TRINIDAD Moruga	Susc	Res	VIII.58	
<u>A. barbirostris</u> *	VENEZUELA	SUCRE	Susc	Res	VIII.59	
<u>A. constani</u> *	INDONESIA	JAVA Surabaya	Susc	Res	III.58	
<u>tenebrosus</u>	SAUDI ARABIA	HASA Dhahran	Susc	Res	1957	V.58
<u>A. culicifacies</u>	INDIA	BOMBAY Baroda Panchmahal Thana	Int Int -	- Susc Res	IX.59 IX.59 1958	III.60 I.60
<u>A. filipinae</u> *	PHILIPPINES	RAJASTHAN Udaipur	-	Int	III.59	
<u>A. fluviatilis</u> *	SAUDI ARABIA	NORTHERN LUZON Claveria	Susc	Res	IX.59	
<u>A. gambiae</u>	SAUDI ARABIA	HASA Dhahran	Susc	Res	II.59	
	CAMEROON (NORTH)	DIAMARE	Susc	Res	VII.59	
	DAHOMEY	COTONOU	-	Int	II.59	
	HAUTE VOLTA	BOBO-DIOULASSO	Susc	Res	VII.57	II.58
	IVORY COAST	ABIDJAN	Susc	Res	V.58	
		GRAND-BASSAM	Susc	Res	VII.57	II.58

Species	Country	Region and District	Reaction to DDT	Reaction to dieldrin	Date of evidence	Most recent confirmation
<u>A. gambiae</u> (continued)	LIBERIA	CENTRAL PROVINCE Gbarnga	Susc	Res	X.57	VII.59
	NIGERIA	NORTHERN REGION Kano Sokoto	Susc Susc	Res Res	1956 XI.55	
	TOGO	TSEVIE LOME	Susc	Res	VIII.59	
<u>A. hyrcanus</u> <u>sinensis</u>	TAIWAN		Res	-	1957	
<u>A. maculipennis</u> <u>labranchiae</u>	MOROCCO	RABAT	Susc	Res*	VI-IX.59	
<u>A. minimus</u> <u>flavirostris</u>	PHILIPPINES	MINDANAO	Susc	Res	VII.59	
<u>A. pharoensis</u>	EGYPT	REHEIRA	Int	Res	IX.59	
		CAIRO	Int	Res	VIII.59	
		FAIYUM	Int	Res	VIII.59	
		FOULDIYA	Int	Res	IX-X.59	
		CHARBIYA	Int	Res	IX.59	
		GIZA	Int	Res	IX.59	
		ISMAILIA	Int	Res	IX.59	
		MINUFYA	Int	Res	IX.59	
		QALYUBIYA	Int	Res	IX.59	
		SHARQIYA	Int	Res	IX.59	

\* Possibly a seasonal tolerance: subject to confirmation.

Species	Country	Region and District	Reaction to DDT	Reaction to dieldrin	Date of evidence	Most recent confirmation
<u>A. pharoensis</u> (continued)	SUDAN	BLUE NILE Sennar	Int	Res	XII.59	
<u>A. pseudopuncti-</u> <u>pennis</u>	MEXICO	MICHUACAN MORELOS	Susc Susc	Res Res	IX.58 IX.58	IV.59 VIII.59
<u>A. pulcherrimus</u> *	NICARAGUA	LEON	Susc	Int	V.59	
<u>A. punctimacula</u>	SAUDI ARABIA	HASA Dhahran	Susc	Res	1956	II.58
<u>A. quadrimacu-</u> <u>latus</u>	COLOMBIA	CHOCO	Int	-	II.59	
<u>A. sacharovi</u>	MEXICO	TAMAULIPAS San ernando	-	Res	VII.59	
	USA	MISSISSIPPI Bolivar	Susc Res	Res Res	VI-VII.59 IX.59	VII.59 VIII.59
	GREECE	GEORGIA Clarke CENTRAL Euboea Phthiotis MACEDONIA Pieria	Int Int Int	- Res -	- - (VII.57)	
		PELOPONNESUS Laconia	Res	Res	(VIII.56)	VII.58
		THESSALY Larissa	Int	Res	-	VIII.59
		THRACE Xanthi	Res	-	-	VIII.59

Species	Country	Region and District	Reaction to DDT	Reaction to dieldrin	Date of evidence	Most recent confirmation
<u>A. sacharovi</u> (continued)	TURKEY	ICELE	Res	-	VI.58	
		Tarsus	Res	Susc	VIII-XI.59	
		MARAS	Res	Susc	VI.58	
<u>A. sergenti</u>	JORDAN	SEYHAN	Res	Susc	VI.58	
		Adana	Susc	Res	XI.58	I.59
<u>A. splendidus*</u>	INDIA	DEAD SEA	Susc	Res		
		BIHAR	Susc	Res	1957-58	
<u>A. stephensi</u>	INDIA	Singhbhum	Susc	Susc		
		MADRAS	Res	Susc	1958	
IRAN	IRAN	Salem	Res	Susc	X.57	IV.58
		OSTAN 6 (CHECHOM)	Res	Susc	X.57	IV.58
		OSTAN 7 (HAFIOM)	Res	Susc	X.57	IX.59
IRAQ	IRAQ	OSTAN 8 (HASHIOM)	Res	Res		
		BASRA	Res	Susc	X.57	
<u>A. stephensi</u> <u>mysorensis</u>	SAUDI ARABIA	MUNTAFIQ	Res	Susc	X.57	
		HUSA	Res	Susc	XI-XII.55	V.58
<u>A. strodei*</u>	VENEZUELA	Dahran	Res	Susc		
		SUCRE	Susc	Res	VI.59	
<u>A. subpictus</u> <u>malayensis</u>	INDONESIA	JAVA	Susc	Res	XI.57	V.58
		Surabaja	Susc	Res		

Species	Country	Region and District	Reaction to DDT	Reaction to dieldrin	Date of evidence	Most recent confirmation
<u>A. subpictus subpictus*</u>	INDIA	BOMBAY STATE: Poona	Res	Res	1958	VIII.59
		DELHI	Res	Susc	1955/1956	X.59
		HYDERABAD: Bhir	Int	Res	1958	
		MADHYA PRADESH: Nagpur	Int	Res	1958	
		RAJASTHAN: Udaipur	Int	-		VIII.58
	INDONESIA	WEST BENGAL: 24 Parganas	Int	Res	1958	
		JAVA: Semarang	Int	Res	1957	
		Surabaya	Susc	Res	XI.57	V.58
	NEPAL	Tjirebon	Susc	Res	XI.57	
		AMLEKHGANJ	Res	-	X-XI.58	
WEST PAKISTAN	PUNJAB: Sheikhupura	Res	-	VIII.58		
	ARAKAN: Akiab	Res	-	V.57		
BURMA	Arakan	Res	-	V.57		
	INDONESIA	JAVA: Banjumas	Res	Susc	55/56	
Djakarta		Res	-	1954		
Jogjakarta		Susc	Res	III.60	VI.56	
<u>A. sundaicus</u>						

Species	Country	Region and District	Reaction to DDT	Reaction to dieldrin	Date of evidence	Most recent confirmation
<u>A. sundaiicus</u> (continued)	INDONESIA (continued)	JAVA: (continued) Kedu Semarang Surabaya Tjirebon	Res * (Res) Res Res	Susc - - -	55/56 1954 1954 1954	III.60 VI.56 VI.56
<u>A. triannulatus</u> *	VENEZUELA	PORTUGUESA	Susc	Res	XI.59	XII.59
<u>A. vagus</u> *	INDONESIA	JAVA: Surabaya	Susc	Res	XI.57	V.58
<u>A. vagus</u> <u>limosus</u> *	PHILIPPINES	MINDANAO	Susc	Res	VII.59	

\* Tests in III.60 indicated reversion to susceptibility.

