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SIXTH SUMMARY OF CASES OF INSECTICIDE
RESISTANCE IN ANOPHELINE MOSQUITOS

The present document is a revised version of the document WHO/Mal/266 of 8 July 1960 ("The status of anopheline mosquitos with regard to resistance to insecticides") and has been prepared to replace it. This action was necessary since it has become clear from additional information received at WHO Headquarters that important corrections of the previous document WHO/Mal/266 must be made.

The present document continues the series of summaries, the last of which was contained in WHO/Mal/242 - WHO/Insecticides/100 of 15 September 1959. The slight change of the title is due to the fact that the detailed records of susceptibility tests have now been omitted.



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Introduction

The table which follows represents a summary of the cases of resistance detected in the field up to 15 April 1960 and reported to WHO, Geneva. It supersedes information contained in earlier summaries.¹

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 naturally a high degree of tolerance to any of these hydrocarbon insecticides (with the exception of seasonal tolerance connected with hibernation in a few species), 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).

¹ 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.

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.

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 used here for designating a mosquito population as resistant are simplified as far as possible and are therefore somewhat arbitrary. In this summary it means that at least half the mosquitos survived for 24 hours 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 indicated above, but have nevertheless shown a degree of tolerance to the insecticide (particularly by an increase in the LC_{100}) substantially greater than that of normally susceptible mosquitos of the same species. Often this condition proves an unstable 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. In other cases however (particularly with DDT) a parallel increase in the LC_{50} and the LC_{100} denotes vigour tolerance, which may likewise be developed by a population of mosquitos under insecticidal pressure. In this paper, both types of response are covered by the term "intermediate condition".¹

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 with or 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.²

¹ The scientific interpretation of test results is explained in Annex 1 to the Tenth Report of the Expert Committee on Insecticides (Wld Hlth Org. techn. Rep. Ser., 1960, 191). On page 22 will be found a graph exemplifying curves of susceptibility, vigour tolerance and incipient resistance to DDT. A curve of the second or the third type would cause the mosquitos to be classed as "Intermediate condition" in the present document.

² Since WHO/Mal/266 appeared an instance of partial reversion from dieldrin resistance to susceptibility has been reported in A. culicifacies in Thana district (Maharashtra, India). This is noted in the last column of the table.

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

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	II-XI.59	
		SONSONATE	Int	Res	VII.58	X.59
	FEDERATION OF BRITISH WEST INDIES	USULUTAN	Res	-	VIII.59	
		JAMAICA				
		St Catherine	Susc	Int	XI.58	
		Clarendon	Susc	Int	I.59	
	GUATEMALA	St Mary's	-	Int	I.59	
		CHIQUIMULA	Susc	Int	IV-VI.59	
		EL-PROGRESO	Res	Res	IX.59	III.60
		ESCUINTLA				
	HAITI	La Democracia	Res	Res	IX.58	III.60
		San José	Int	Int	IV-VI.59	
	HONDURAS	GUATEMALA	Int	Int	VII.59	
		RETALHULEU	Res	Res	III.60	
	MEXICO	SUCHITEPEQUEZ	Int	Int	VII.59	
		ZACAPA	Susc	Res	XI.58	
		QUANAMINTH	Susc	Res	II.60	
		CORTES	Susc	Int	I.59	
	FRANCISCO MORAZAN	COMAYAGUA	Res	Res	XI.58	II.59
			Susc	Res	XI.58	I-IV.59
MICHOCAN		-	-			
	Apatzingan			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	
		CHINENDEGA				
		Chichigalpa	Int	Res	VI-X.59	IX.59
		Morazan	Int	Res	X.58	
		ESTELI	Res	Res	II.60	
		GRANADA	Int	Int	X.59	
		LEON	Res	Res	VI-IX.59	XII.59
		MANAGUA	Res	Res	X.58	XII.59
		MASAYA	Int	Int	VII.59	
		NUEVA SEGOVIA	Susc	Res	X.58	
		RIVAS	Susc	Int	X.59	
		<u>A. albitarsis</u> [*]	BRAZIL	CEARA	Int	-
META	Susc			Int	IX-X.59	XII.59
GUARICO	-			Int	XI.59	
<u>A. annularis</u> [*]	INDIA	PORTUGUESA	Susc	Res	XI.59	XII.59
		BOMBAY	Res	-	I.60	II.60
<u>A. aquasalis</u>	INDONESIA	Panchmahal	Res	-		
		RAJASTHAN	Int	-	XII.58	I.59
		Udaipur	Susc	Res	II.58	
<u>A. aquasalis</u>	BRAZIL	JAVA	Int	Int	V.59	
		Bodjonegoro	Int	Susc	VII.59	
		PARA	Int	Susc		
		Belém	Int	Int		
		Rio Grande do N.	Int	Susc		

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	III-VII.59
	VENEZUELA	SUCRE Irapa S. J. Galdonas Yaguaraparo	Int Susc Susc	Res Int Int	VIII.59 IX.59 VIII.59	
<u>A. barbirostris</u> *	INDONESIA	JAVA Surabaya	Susc	Res	III.58	
	SAUDI ARABIA	HASA Dhahran	Susc	Res	1957	V.58
<u>A. coustani</u> *	INDIA	GUJERAT Baroda	Int ¹	-	IX.59	III.60
		Panchmahal	Int	Susc	IX.59	
<u>A. culicifacies</u>	INDIA	MAHARASHTRA Thana	-	Res	X.58	Int X.59-I.60
		RAJASTHAN Udaipur	-	Int	III.59	
<u>A. filipinae</u> *	PHILIPPINES	NORTHERN LUZON Claveria	-	Res	IX.59	
		SAUDI ARABIA	Susc	Res	II.59	
<u>A. fluviatilis</u> *	CAMEROUN (NORTH)	DIAMARE	Susc	Res	VII.59	
		DAHOMEX	-	Int	II.59	
<u>A. gambiae</u>	IVORY COAST	BOBO-DIOULASSO	Susc	Res	VII.57	II.58
		ABIDJAN	Susc	Res	V.58	
		GRAND-BASSAM	Susc	Res	VII.57	II.58

¹ Tests in one district of Baroda in VI-IX.60 showed resistance to DDT, i.e. LC₅₀^S well in excess of 4%. Editor.

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	Susc	Res	1956	
		Sokoto	Susc	Res	XI.55	
	TOGO	TSEVIE LOME	Susc	Res	VIII.59	
<u>A. hyrcanus</u> <u>sinensis</u>	TAIWAN	Susc ¹	-	1959/60		
<u>A. maculipennis</u> <u>labranchiae</u>	MOROCCO	RABAT	Susc	Int ²	VI-IX.59	
<u>A. minimus</u> <u>flavirostris</u>	PHILIPPINES	MINDANAO	Susc	Res	VII.59	
<u>A. pharoensis</u>	EGYPT	BEHEIRA	Int	Res	IX.59	
		CAIRO	Int	Res	VIII.59	
	FAIYUM	Int	Res	VIII.59		
	FOUADIYA	Int	Res	IX-X.59		
	GHARBIYA	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		

¹ Earlier reported DDT-resistant on basis of tests with locally-impregnated papers which have been proved sub-standard.

² 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	Susc	Res	XIII.59	
<u>A. pseudopuncti-</u> <u>pennis</u>	GUATEMALA	CHIQUIMULA	Susc	Int	IV.59	
	MEXICO	COLIMA	-	Int	IV-VII.59	
		JALISCO	-	Int	VII.59	
		MEXICO	-	Res	VIII.59	
		MICHOACAN	Int	Int	IX.58	IX.59
		MORELOS	Susc	Res	IX.58	VIII.59
	NICARAGUA	LEON	Int	Int	V.59	
<u>A. pulcherrimus</u> *	SAUDI ARABIA	HASA Dhahran	Susc	Res	1956	II.58
<u>A. punctimacula</u>	COLOMBIA	CHOCO	Int	-	II.59	
<u>A. quadrimacu-</u> <u>latus</u>	MEXICO	TAMULIPAS San Fernando	Int) Res)	Res) Int)	VII-VIII.59	
	USA	MISSISSIPPI Bolivar	Susc	Res	VI-VII.59	
		GEORGIA Clarke	Res	Res	IX.59	
<u>A. sacharovi</u>	GREECE	CENTRAL Euboea Phthiotis	Int Int	- Res	- -	VII.59 VIII.59
		MACEDONIA Pieria	Int	-	(VII.57)	VI.59
		PELOPONNESUS Laconia	Res	Res	(VIII.56)	VII.58

Species	Country	Region and District	Reaction to DDT	Reaction to dieldrin	Date of evidence	Most recent confirmation
<u>A. sacharovi</u> (continued)	GREECE (continued)	THESSALY Larissa	Int	Res	-	VIII.59
		THRACE Xanthe	Res	-	-	VIII.59
TURKEY		ICELE Tarsus	Res	-	VI.58	
		MARAS	Res	Susc	VIII-XI.59	1960
		SEYHAN Adana	Res	Susc	VI.58	
		DEAD SEA	Susc	Res	XI.58	I-III.59
<u>A. sergenti</u>	JORDAN		Susc			
<u>A. splendidus</u> *	INDIA	BIHAR Singhbhum	Susc	Res	1957-58	
		MADRAS Salem	Res	Susc	1958	
<u>A. stephensi</u>	INDIA	OSTAN 6 (CHECHOM)	Res	Susc	X.57	IV.58
		OSTAN 7 (HAFTOM)	Res	Susc	X.57	IV.58
		OSTAN 8 (HASHTOM)	Res	Res	X.57	IX.59
IRAQ		BASRA	Res	Susc	X.57	
		MUNTAFIQ	Res	Susc	X.57	
SAUDI ARABIA		HASA Dhahran	Res	Susc	XI-XII.55	V.58
		SUCRE	Susc	Int	VIII.59	
<u>A. strodei</u> *	VENEZUELA					
<u>A. subpictus</u> <u>malayensis</u> *	INDONESIA	JAVA	Susc	Res	XI.57	V.58
		Surabaja				

Species	Country	Region and District	Reaction to DDT	Reaction to dieldrin	Date of evidence	Most recent confirmation
<u>A. subpictus</u> <u>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	
		WEST BENGAL 24 Parganas	Int	Res	1958	
		JAVA	Int	Res	1957	
		Semarang	Susc	Res	XI.57	V.58
		Surabaya	Susc	Res	XI.57	
		Tjirebon	Res	-	X-XI.58	
NEPAL	WEST PAKISTAN	AMLEKHGANJ	Res	-		
		PUNJAB Sheikhupura	Res	-	VIII.58	
BURMA	INDONESIA	ARAKAN	Int	Susc	VIII.57	
		JAVA Djakarta	Res	-	1954	VI.56
<u>A. sundaicus</u>	INDONESIA	Jogjakarta	Susc ¹	Res	III.60	III.60
		Semarang	(Res) ¹	-	VI.55	VI.56
		Surabaya	Res	-	VI.56	VI.56
		Tjirebon	Res	-	1954	VI.56

¹ Tests in III.60 indicated reversion to susceptibility.

Species	Country	Region and District	Reaction to DDT	Reaction to dieldrin	Date of evidence	Most recent confirmation
<u>A. triannulatus</u> *	VENEZUELA	PORTUGUESA	Susc	Res	XI.59	XII.59
<u>A. vagus</u> *	INDONESIA	JAVA Surabaja	Susc	Res	XI.57	V.58
<u>A. vagus</u> * <u>limosus</u>	PHILIPPINES	MINDANAO	Susc	Res	VII.59	

