WORLD HEALTH ORGANIZATION

ORGANISATION MONDIALE DE LA SANTE

WHO/Mal/307
10 August 1961

ORIGINAL: ENGLISH

RESISTANCE OF MALARIA VECTORS IN GREECE

THE SITUATION IN 1960

by

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1. INTRODUCTION

The present paper deals with the results of a series of tests carried out in Greece on insecticide resistance to DDT and dieldrin in adults of three malaria vectors. These tests were made during the period 21 June to 8 October 1960.[1] The details of these tests appear in Table I.

Map 1 shows the geographical location of the areas studied. Map 2 is a large-scale sketch of the well-known Skala zone which includes four of the 13 A. sacharovi areas studied in 1960.

Table II records the LC_{50} values obtained by the graphical method. It will be seen that, in several instances, in addition to the standard 60-min. exposure, tests were performed on separate batches of the same mosquito populations for longer periods, i.e. 120, 240, 480 and, in one case, 960 minutes.

Data related to spraying operations and insecticidal pressure in general are too complex to be presented in tabular form only. For this reason Table III records the indoor residual spraying history of the areas studied. Other insecticidal measures, not mentioned in the Table, comprised from 1946 to 1956 air larviciding in the close vicinity of the A. sacharovi areas and, from 1947 to 1959, ground larviciding near Anthili, Chalastra and Haghios Athanassios. Both air and

[1] Previous results have appeared in WHO/Mal/189, 203, 242 and 266 and in two papers by the author (Belios, 1960a, 1960b).

ground larviciding were carried out chiefly with DDT but from 1954 to 1956 with insecticides of the dieldrin group. Household insecticides, quite often containing chlorinated hydrocarbons, were also regularly used, and probably still are, as space-sprays for nuisance abatement by a considerable proportion of the rural population (Belios, 1954).

In addition to these "public health" operations, chlorinated and organo-phosphorus insecticides, usually purchased from the Agricultural Bank of Greece on a loan-credit basis, are used in widely varying amounts for the control of insects which attack all the major and many of the minor crops, especially in irrigated land. Thus larvae of Chironomidae in rice-fields are combatted with one or two, usually heavy, BHC or aldrin applications shortly after flooding. Cotton pests are controlled with O-P insecticides as well as with a DDT/BHC powder which, besides contaminating irrigation water, may, when carried by the wind, reach other neighbouring anopheline breeding places. Vegetable and fruit plants (beans, salads, melons etc.) are also often treated with miscellaneous insecticides, and so are some fruit trees.

Specific examples of this "multi-sided" selective pressure will be cited in due course.

For an objective approach to the overall resistance situation, it should also be borne in mind that many of the areas studied were chosen, several years ago, from those in which resistance and/or selective pressure were known or expected to be the strongest.

2. RESULTS OF TESTS ON A. SACHAROVI, AND DISCUSSION

2.1 Results with DDT (Table II)

On basis of the practical criteria set forth in WHO/Mal/266 (per cent. mortality at 4% DDT after a 60-min. exposure and 24-hour observation) and after some further elaboration for which the dosage-mortality regression lines and longer exposures have also been taken into account, the A. sacharovi populations tested in 1960 in 12 areas may be classified as:

- susceptible in: (1) Dystos; and (2) Katohi (respectively 100 and 96% mortality after a 60-min. exposure);

- intermediate "A" (slightly to moderately tolerant) in: (1) Aloros; (2) Anthili; (3) Drakospilia; (4) Haghios Athanassios; (5) Kalamaki; and (6) Nisseloudi (mortality from 70 to 86.6% after a 60-min. exposure and, where tested, from 82.5 to 100% after a 120-min. exposure);

- intermediate "B" (more tolerant than in the previous sub-group) in: (1) Chalastra; and (2) Souli (respectively 52.4 and 62.5% mortality after a 60-min. exposure or, in the case of Chalastra, from 71.4 to 88% after a 120-min. exposure);

- "borderline": in Koutson (50% mortality after a 60-min. exposure, but a small sample tested);

- resistant: in Leimonas (with mortalities of 38, 74.6, 89.5 and 99.3% after respectively 60-, 120-, 240- and 480-min. exposures).

The two tests in Skala proper, termed "Special" in Table II, have been performed on artificially selected A. sacharovi F_1 generations, i.e. on specimens reared in the Skala Malaria Experimental Station from eggs deposited by field-collected females which had survived a 60-min. exposure to 4% DDT. The detailed results of these tests appear in Table IV together with those deriving from the 60-min. tests in Leimonas which is only 3 km distant and where other conditions are quite comparable. The respective dosage-mortality regression lines are shown in Graph 1.

These data may help discussion of the nature of the loss of susceptibility of A. sacharovi to DDT. This has variously been attributed to true resistance or, in order to account for its low levels, to an interplay between true resistance and irritability (de Zulueta, 1959) or possibly to vigour tolerance (Davidson, 1958a, 1958b). The latter interpretation would be corroborated by the concomitant specific dieldrin resistance (Davidson, 1958a).

Table IV and Graph 1 indicate that resistance in the local A. sacharovi may possibly be somewhat increased by further selection. This would not be expected in a case of vigour tolerance (Davidson, 1958b).

As the samples tested in Skala proper were rather small, an attempt was made to find out whether a careful appraisal of other dosage-mortality regression lines, along the principles enunciated by Hoskins & Gordon (1956) would not also point to true resistance in this species. Graph 2 shows the dosage-mortality lines for the 60-min. exposures to DDT in three areas (Katohi, Nisseloudi and Leimonas, classified respectively in the susceptible, intermediate and resistant groups) in which the samples tested were the largest of the 60-min. series (respectively 275, 437 and 499 specimens including controls). A flattening of the Nisseloudi dosage-mortality regression line is to be observed when it is compared to the outer two. Although no "plateau"-type response was found either in Nisseloudi or in the other "intermediate" areas (except Koutson, where only 80 specimens were tested), Graph 2 may be interpreted as also pointing to true resistance rather than induced vigour tolerance. On the other hand, the steepness of the outer dosage-mortality lines in Graph 2 is rather moderate and this too may be indicative of true, monofactorially inherited resistance (Brown, 1959).

Graph 3, relating to A. sacharovi in Leimonas, is reproduced as it is a good example of dosage-mortality regression lines for progressively increasing exposures (from 1 to 8 hours), all of which gave mortalities below 100%. The numbers of specimens tested were quite adequate (respectively 499, 647, 644 and 640 including controls).

The 1960 tests with DDT have shown, as previously (Belios, 1960a, 1960b), that the range in the levels of resistance in this species, although much narrower than the range found with dieldrin (see next paragraph), is still surprisingly wide. Even more unexpected is, at first sight, the fact that local A. sacharovi populations should still be fully susceptible in areas such as Katohi. These points will be discussed more fully in paragraph 2.3.

2.2 Results with dieldrin (Table II)

On a similar basis (per cent. mortality at the highest dose tested, i.e. 1.6% dieldrin, and log-probit lines) the A. sacharovi populations tested in 10 areas may be classified as follows:

- susceptible in Dystos (100% mortality after a 60-min. exposure);
- intermediate "A" in Katohi (85% increasing to 98% after a 120-min. exposure);
- intermediate "B" in: (1) Chalastra (52.4%[1]); and (2) Kalamaki (86% after 240-min.);
- moderately resistant in: (1) Aloros; and (2) Anthili (>50% after a 120-min. exposure or >80% after a 240-min. exposure);
- strongly resistant in: (1) Nisseloudi; (2) Drakospilia; and (3) Haghios Athanassios (>35% after a 120-min. exposure or >60% after a 240-min. exposure);
- extremely resistant in Asterion (no mortality after 60-min. and 120-min. exposures and only 1.3% and 6.3% after 240- and 480-min. exposures respectively).

The dosage-mortality regression lines for identical exposure times, arranged in the order cited, show a practically continuous succession of forms, from the moderately steep and straight line of the susceptible A. sacharovi population of Dystos to flatter and flatter lines with plateau-responses through the intermediate to the resistant sub-groups. No late steepening is to be seen even with the longest exposures tried. This might have shown up if higher concentrations had been used, unless (as seems probable, at least in Asterion) some notable fraction of the mosquito population had grown completely immune to this insecticide. What is certain is that, as found previously, we are here dealing with true, specific resistance reaching in one area a very high level.

2.3 Resistance levels in relation with the quantum and mode of selective pressure

As noted, amongst the most distinctive features of the 1960 (and previous) tests on A. sacharovi, was the very wide range in the levels of resistance (especially to dieldrin) as illustrated in paragraphs 2.1 and 2.2. Another feature of importance is the practical impossibility of correlating, in several areas, the level of resistance found with the quantum of selective pressure if residual spraying history alone (Table III) is taken into account. Typical examples are the following:

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[1] In the second series of the Chalastra tests the 1.6% dieldrin mortalities after 120-, 240-, 480- and 980-min. exposures were respectively 66.7, 72, 80 and 96%.

Resistance levels to DDT as well as to dieldrin were highest at Asterion, Leimonas and Skala proper of the Skala zone. Yet these have been residually sprayed only once with dieldrin in the last five years (in 1957), and once again with O-P insecticides, by the I.T. Team, WHO (in 1959).

At the other extreme we find Katohi, which has been residually treated for 15 consecutive years including, in these last five years, five rounds with DDT and four with BHC or dieldrin. Yet the status of the local A. sacharovi is practically susceptible to DDT and merely intermediate "A" to dieldrin (Table III, and paragraphs 2.1 and 2.2).

Between these "extremes" several intermediate situations are to be found, as well as "normal" ones where the level of resistance could be considered as more or less in line with insecticidal pressure from indoor residual applications.

In an attempt to clarify the situation, the author has sought, and obtained, information from the Ministry of Agriculture as to the types and amounts of insecticides used for agricultural purposes in the areas studied for resistance in A. sacharovi. From the information thus collected a reasonable gross correlation between the amounts of agricultural insecticides reported and the resistance levels does emerge in several instances. Detailed data have to be omitted but it may be mentioned that in the Skala zone agricultural insecticides (DDT, BHC, endrin, aldrin, O-P) were "extensively used". In Katohi, on the contrary, a "very limited use" of such insecticides (DDT, O-P) was reported. Other areas where the scale of use of agricultural insecticides is not incompatible with the resistance level included Nisseloudi and Aloros (DDT, BHC, O-P) and Kalamaki (DDT, O-P). There still remain a few areas where the situation is not clear. In Drakospilia and Koutson, with rather high resistance levels, the only agricultural insecticides reported were of the O-P group. Unless one is to suppose that some data concerning the use of privately purchased agricultural insecticides are missing, or that perhaps (as has been observed for other arthropods) O-P insecticides, alone or in association with chlorinated hydrocarbons, may select for resistance to the latter, an alternative selective agent might be sought in household insecticides (see Introduction) which the author had already incriminated several years ago (Belios, 1954).

From the above discussion it may be concluded that the situation, under field conditions, is a very complex one and that, under these circumstances, no clear-cut deductions are permitted.[1] But on the whole it does seem that selection in the larval stage is an important, perhaps the most important, mechanism operating on this species. This has already been suspected in the case of air larviciding (Belios, 1960a). Present evidence would show that agricultural insecticides may be at least as effective.

2.4 Comparison of the DDT and dieldrin resistance levels of 1959 and 1960

In a previous paper (Belios, 1960a), the author compared all available LC_{50} values for DDT in seven A. sacharovi areas studied for two or three years. The present Table V comprises only the 1959 and 1960 results in this species. In addition to containing data for DDT as well as for dieldrin, results in Table V are more uniform since they have all been obtained with the same technique (the more recent WHO testing technique).

It will be seen that, with the exception of Chalastra (for DDT) and Haghios Athanassios (for dieldrin), all other changes, either way, were minor. Since field A. sacharovi populations are expected to be genetically mixed and selective pressure from agricultural insecticides to vary from year to year, even the major LC_{50} fluctuations are not a matter for surprise.

The author's recent impression (1960a) that a slight recession in DDT resistance was probably occurring in the years subsequent to the discontinuation of air spraying, is not verified by the 1960 results. The general impression remains that, on the whole, the resistance spectrum and magnitude have not undergone any gross changes in the last three or four years, or perhaps still longer if field data are to be given full credit.

2.5 Correlation between DDT and dieldrin resistance

This may be best explored through the per cent. mortalities at the highest concentrations tested in 1960.

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[1] It is hoped that some more light may be shed from further selection tests, in adults as well as in larvae, planned for 1961. But again, due to the impossibility of colonizing A. sacharovi, no results can be expected beyond the F_1 generation.

The A. sacharovi populations in Dystos and in Chalastra respectively, fall into the same susceptibility (or resistance) group for each insecticide.

In the other seven areas where tests were made on both insecticides, a positive correlation is also apparent, although the relative levels of tolerance or resistance to dieldrin are generally higher than to DDT. The same applies to Leimonas (studied for DDT) and Asterion (studied for dieldrin) which are only 4-1/2 km distant (Skala zone). In this respect the picture is similar to that of A. albimanus in Central America.

3. RESULTS OF TESTS ON A. MACULIPENNIS AND A. SUPERPICTUS, AND DISCUSSION

A. maculipennis

Tests were made in 1960 in three areas. In two of these (Nissi and Poros) where A. maculipennis maculipennis is the prevailing form, the LC_{50} values as well as the 60-min. exposure mortalities at the highest concentration used (100% in both DDT and dieldrin tests) should be considered normal. It may be noted that in 1958, in another area, an LC_{50} of 2% for DDT (WHO/Mal/242, Belios, 1960b) was recorded in this form, indicating some tolerance.

In Photini, where A. maculipennis subalpinus prevails, there seems also to exist some tolerance to DDT (LC_{50} = 1.7% and 80% mortality after a 60-min. exposure, reaching 100% only after a 120-min. exposure). Although the sample tested was a small one, the LC_{50} found for this variety in 1958 in Stymphalia (N. Peloponnese) was quite comparable, i.e. 1.6% (see WHO/Mal/242).

Comparison of the 1959 and 1960 results in Nissi, Poros and Photini shows slight to moderate fluctuations either way for one or other insecticide, as shown in Table VI.

A. superpictus

Four areas were studied in 1960. The results for both DDT and dieldrin showed normal susceptibility, except perhaps in the Agra area where the 60-min. exposure to 1.6% dieldrin failed to kill all the specimens (98.1%). Older field results (Belios, 1954) had pointed to the same conclusion.

Comparable data between 1959 and 1960 in three of the above areas show an increase in susceptibility in two of these for both insecticides and a decrease in the third (Table VI).

4. SUMMARY

Results of WHO tests for insecticide resistance to DDT and dieldrin, made in 1960 in a group of "unfavourable" areas, are presented in tabular and graphical forms and analysed and discussed in the text.

On basis of the practical criteria proposed in WHO/Mal/266, A. sacharovi populations tested for DDT resistance in 12 areas were found either susceptible (two areas) or "intermediate" (eight areas) or resistant (one area); results in one area were inconclusive (borderline?). In still another area tests were made on artificially selected F_1 generations. Several considerations indicate that true DDT resistance rather than vigour tolerance is present in this species.

On basis of the same criteria A. sacharovi was found to be susceptible to dieldrin in one area, intermediate in another three and moderately to highly resistant in the remaining six areas. In one of these a 480-min. exposure to 1.6% dieldrin failed to kill more than 6.3% of the specimens tested. True dieldrin resistance is thus once more confirmed.

There is a definite correlation between DDT and dieldrin resistance in A. sacharovi but a clear double resistance was so far found only in the Skala zone. The resistance levels to the two insecticides in several areas and the geographical extent of resistance itself seem to have undergone little change for some years now. Selective pressure on the larval stage of A. sacharovi through accidental contamination of breeding places with agricultural insecticides is probably more important than pressure from indoor residual spraying.

Both varieties of A. maculipennis and A. superpictus, in the present as in previous tests, were found as a rule fully susceptible to either DDT or dieldrin and only exceptionally slightly tolerant to DDT (A. maculipennis) or to dieldrin (A. superpictus).

ACKNOWLEDGEMENTS

The author is much indebted to the Division of Malaria Eradication, World Health Organization, for supplying him with the necessary test kits.

He also expresses his grateful thanks to the Ministry of Social Welfare, Greece, for the material assistance which made possible the implementation of the present programme of tests.

He similarly wishes to thank the Ministry of Agriculture, Greece, for their information on the use of insecticides in agriculture.

He finally expresses his appreciation to his assistants in the field, Messrs S. Anghelakos, N. Zissopoulos, S. Georgiadis and J. Zographos of the Skala, Lamia and Provatas Malaria Experimental Stations and of the Department of Malariology and Tropical Medicine of the Athens School of Hygiene.

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Results of resistance tests in various countries, including Greece, have appeared in:

WHO/Mal/189/WHO/Insecticides/63 of 2 June 1957

WHO/Mal/203/WHO/Insecticides/77 of 24 April 1958

WHO/Mal/242/WHO/Insecticides/100 of 15 September 1959

WHO/Mal/266 of 8 July 1960

TABLE I. SUMMARY OF WHO TESTS FOR INSECTICIDE RESISTANCE IN GREEK ANOPHELINE VECTORS, 1960

Species	Number of areas studied	Number of tests			Number of mosquitos tested
		DDT	DLD	Total	
A. sacharovi	13	52	46	98	12 904
A. maculipennis	3	9	8	17	2 026
A. superpictus	4	12	12	24	2 319
TOTAL	20	73	66	139	17 249

TABLE II. RESULTS OF WHO TESTS FOR INSECTICIDE RESISTANCE IN ADULT ANOPHELINES
GREECE, JUNE - OCTOBER 1960

(In brackets: number of tests)

	Population (1951)	Date of tests	Species	LC50 for DDT after exposure of: 60 min.	120 min.	240 min.	480 min.	LC50 for dieldrin after exposure of: 60 min.	120 min.	240 min.	480 min.	960 min.	Remarks
1	104	7-10 Sept.	A. sacharovi	(1) 2.8	(3) 1.4	-	-	(1) 0.8	(1) 0.6	(1) 0.4?	(2) 0.37	-	-
2	1 540	29 July - 1 Aug.	"	(1) 2.8	(2) 1.6	-	-	(1) > 1.6	(1) > 1.6	(2) 0.45	-	-	-
3	"	25-28 August	"	(3) 1.7	-	-	-	(1) > 1.6	(1) 1.0	(2) 0.32	-	-	-
4	96	15-21 July	"	-	-	-	-	(2) α	(2) α	(2) ≫ 1.6	(2) ≫ 1.6	-	-
5	4 547	28-29 June	"	(1) 3.6	(1) 2.2	-	-	(1) 1.4	(1) 1.3	-	-	-	-
6	"	12-16 July	"	-	(1) 1.3	(1) 1.2	-	-	(1) 0.5	(1) 0.54	(1) 0.23	(1) 0.11	-
7	274	28-30 June	"	(1) 3.3	(2) 2.6	-	-	(1) > 1.6	(1) > 1.6	-	-	-	-
8	476	28-30 June	"	(2) 0.45	-	-	-	(2) 0.19	-	-	-	-	-
9	3 046	21-24 June	"	(4) 2.5	-	-	-	(1) > 1.6	(1) > 1.6	(1) > 1.6	-	-	-
10	550	6-9 July	"	-	(3) 1.7	-	-	-	-	(2) 0.35	-	-	-
11	2 246	18-20 August	"	(2) 1.0	-	-	-	(1) 0.22	(2) 0.05	-	-	-	-
12	587	5 August	"	(1) ≥ 4	-	-	-	-	-	-	-	-	-
13	472	6-14 July	"	(2) > 4	(3) 2.8	(3) 1.9	(3) 1.6	-	-	-	-	-	-
14	180	2-9 September	"	(4) 2.4	(2) 0.9	-	-	(4) ≫ 1.6	(1) > 1.6	(2) 0.5	-	-	-
15	1 938	8-10 August	"	(2) > 4	-	-	-	-	-	-	-	-	Special test
16	"	7-8 October	"	(2) > 4	-	-	-	-	-	-	-	-	" "
17	83	6-7 October	"	(2) 2.7	-	-	-	-	-	-	-	-	-
18	533	23-25 July	A. maculip. type	(2) < 0.5	-	-	-	(2) 0.08	-	-	-	-	-
19	184	12-15 July	" subalpinus	(1) 1.7	(2) < 0.5	-	-	(2) < 0.1	-	-	-	-	-
20	412	21-27 July	" type	(4) 0.67	-	-	-	(4) 0.12	-	-	-	-	-
21	237	20-22 September	A. superpictus	(3) 0.46	-	-	-	(3) 0.26	-	-	-	-	-
22	23	4-5 August	"	(2) 0.25	-	-	-	(2) ≪ 0.1	-	-	-	-	-
23	537	23-24 July	"	(2) 0.2	-	-	-	(2) ≪ 0.1	-	-	-	-	-
24	118	10-13 August	"	(4) 0.22	-	-	-	(4) < 0.1	-	-	-	-	-

TABLE III. RESIDUAL SPRAYING HISTORY, IN GREECE, 1946-1960

No.	Area	District	1946	1947	1948	1949	1950	1951	1952	1953	1954	1955	1956	1957	1958	1959	1960
1	Aloros	Emathia	DDT	DDT	DDT	DDT	-	-	-	-	LIN,CHL	DLD,BHC,CHL	-	DDT,DLD	DDT,BHC,CHL	DDT,DDT,DDT	DDT
2	Anthili	Phthiotis	DDT	DDT	DDT	DDT	DDT	DDT	DDT	-	CHL	DLD	-	BHC,DDT	-	-	DDT+DLD
3	Asterion	Lakonia	DDT	DDT	DDT	DDT	DDT	DDT	DDT	DDT	DDT	-	-	DLD	-	-	-
4	Chalastra	Saloniki	DDT	DDT	DDT	DDT	DDT	DDT	DDT	DDT	CHL	DLD,CHL	-	BHC,DDT	DDT	DDT,DDT	DDT,DDT
5	Drakospilia	Phthiotis	DDT	-	-	DDT	DDT	DDT	DDT	-	LIN	CHL	-	-	-	-	-
6	Dystos	Euboea	DDT	DDT	DDT	DDT	DDT	DDT	DDT	-	CHL	CHL	-	BHC,DDT	-	-	DDT
7	Hagh. Athanassios	Drama	-	DDT	DDT	DDT	DDT	-	-	-	CHL	DLD	BHC	BHC,DDT	BHC,DDT	DDT	DDT,DDT
8	Kalamaki	Larissa	DDT	DDT	-	-	DDT	DDT	DDT	-	DDT,CHL	DLD	BHC	BHC	DDT	DDT	DDT
9	Katohi	Etol/nia	DDT	DDT	DDT	DDT	DDT	DDT	DDT	DDT	DLD,CHL	DLD,CHL	BHC,DLD	BHC,DDT	DDT	DDT,BHC	DDT,DDT
10	Koutson	Xanthi	DDT	DDT	DDT	DDT	DDT	DDT	-	DDT	DLD,DDT	DLD	CHL	BHC,DDT	-	DDT	DDT
11	Leimonas	Lakonia	DDT	DDT	DDT	DDT	DDT	-	DDT	-	CHL	CHL	-	DLD	-	-	-
12	Nisselondi	Emathia	DDT	DDT	DDT	DDT	DDT	DDT	-	DDT	DDT,CHL	DDT,DLD,CHL	BHC	DDT	DDT	DDT,BHC	-
13	Skala	Lakonia	DDT	DDT	DDT	DDT	DDT	-	DDT	-	CHL	CHL	-	DLD	-	-	-
14	Souli	Lakonia	DDT	DDT	DDT	DDT	DDT	-	-	-	CHL	CHL	-	-	-	-	-
15	Nissi	Pella	-	-	-	-	DDT	-	DDT	DDT	LIN	DDT,CHL	BHC	-	DDT	DDT,DDT	DDT,DDT
16	Photini	Kastoria	DDT	DDT	-	-	DDT	DDT	-	-	CHL	-	-	-	-	-	-
17	Poros	Erros	DDT	DDT	DDT	DDT	DDT	DDT	DDT	-	DDT	DLD,CHL	CHL	BHC,DDT	-	-	-
18	Agra	Rhodopi	-	-	-	DDT	DDT	-	-	-	-	DLD	CHL	DLD,DDT	-	-	-
19	Karavas	Lakonia	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20	Paliouri-Kastri	Phthiotis	DDT	DDT	DDT	DDT	DDT	DDT	-	-	-	-	-	-	-	-	-
21	Skiada	Rhodopi	-	-	-	-	DDT	-	-	-	-	DLD	CHL	DLD,DDT	-	-	-

TABLE IV. A. sacharovi ADULT MORTALITIES, 60-MIN. EXPOSURES; SKALA ZONE, GREECE, 1960

Area	Date of tests	Percentage concentration of DDT				Control
		0.5	0.1	2.0	4.0	
Leimonas	6-7 July	1 (100)	3 (100)	11 (100)	38 (100)	0 (99)
Skala proper*	8-10 July	0 (30)	0 (30)	3.3 (30)	20 (30)	0 (30)
" " *	7-8 October	0 (20)	0 (20)	5 (20)	30 (20)	0 (20)

(In brackets: number of specimens tested)

* Special tests (F_1)

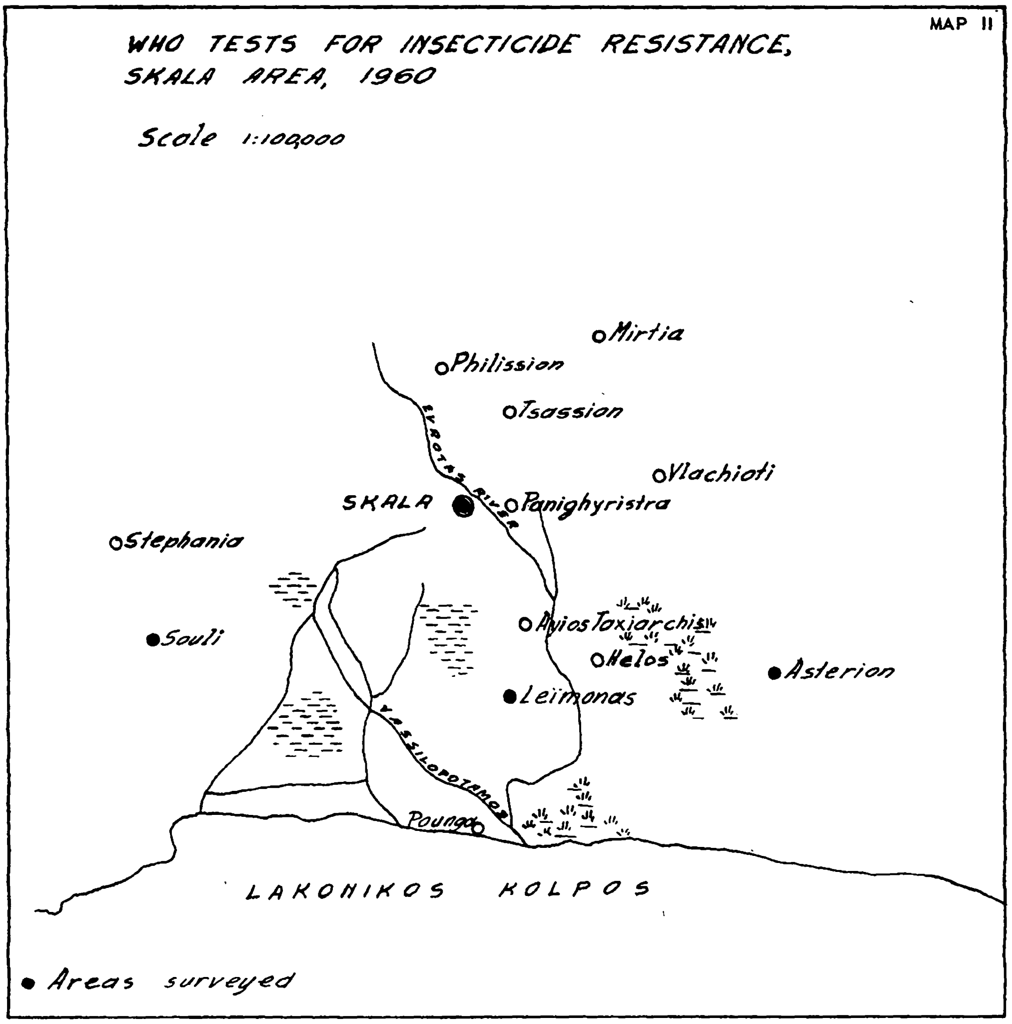
TABLE V. COMPARISON OF THE LC_{50} VALUES OBTAINED IN 1959 AND 1960 IN A. sacharovi ADULTS

No.	Areas	LC_{50} for DDT		LC_{50} for DLD	
		1959	1960	1959	1960
1	Aloros	2.3	2.8	1.0	0.8
2	Chalastra	1.0	3.6	-	-
3	Drakospilia	2.4	3.3	-	-
4	Dystos	1.6	0.45	0.25	0.19
5	Hagh. Athanassios	1.4	2.5	0.4	> 1.6
6	Katohi	1.0	1.0	0.16	0.22
7	Koutson	3.4	≥ 4.0	-	-

TABLE VI. COMPARISON OF THE LC_{50} VALUES OBTAINED IN 1959 AND 1960 IN *A. maculipennis* AND *A. superpictus* ADULTS

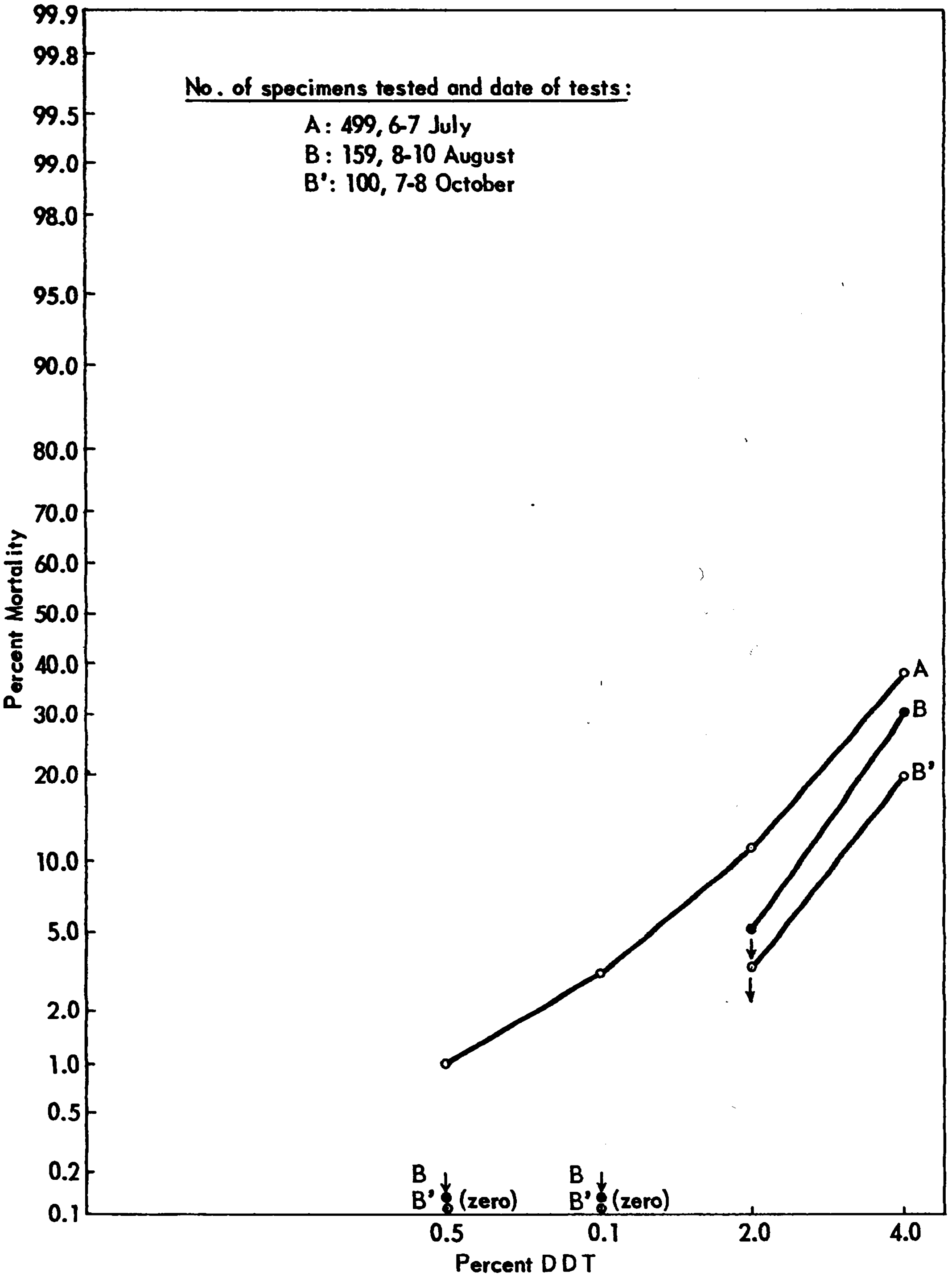
No.	Areas	LC_{50} for DDT		LC_{50} for DLD		Species
		1959	1960	1959	1960	
1	Nissi	1.1	< 0.5	0.19	0.08	*A. maculipennis maculipennis*
2	Poros	0.7	0.67	0.08	0.12	" " "
3	Photini	1.1	1.7	0.28	< 0.1	" " *subalpinus*
4	Agra	0.3	0.46	0.15	0.26	*A. superpictus*
5	Karavas	0.9	0.25	0.19	0.01	" "
6	Skiada	0.46	0.22	0.16	0.06	" "

Mosquitos tested
● A. sacharovi
○ A. maculipennis (typicus or subalpinus)
▲ A. superpictus


MAP II
WHO TESTS FOR INSECTICIDE RESISTANCE,
SKALA AREA, 1960
Scale 1:100,000
Mirtia
Philission
Tsassion
EVROTAS RIVER
Vlachioti
SKALA
Panighyristra
Stephania
Ayios Taxiarchis
Souli
Helos
Asterion
Leimonas
VASSILOPOTAMOS
Pounda
LAKONIKOS KOLPOS
Areas surveyed

Graph. 1. *A.sacharovi* ADULT MORTALITIES,60-MIN. EXPOSURES,SKALA ZONE, 1960

Comparison of log-probit regression lines of field-collected specimens (line A,Leimonas) and laboratory selected F_1 generations (lines B and B',Skala- proper)



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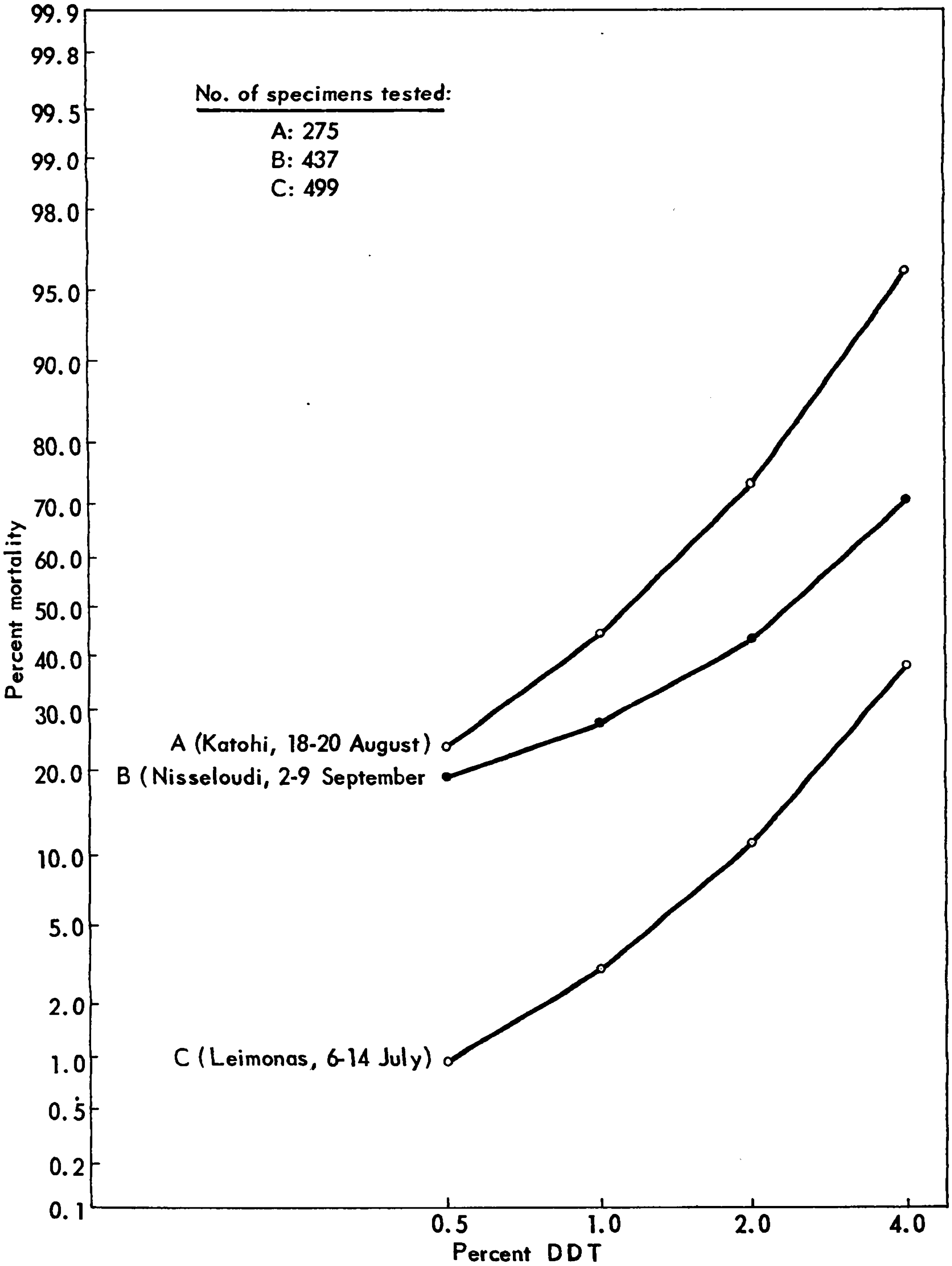
Graph. 2. *A. sacharovi* ADULT MORTALITIES, 60-MIN. EXPOSURES, GREECE 1960

Comparison of log-probit lines in areas with susceptible (A), «intermediate» (B) and resistant (C) local populations.



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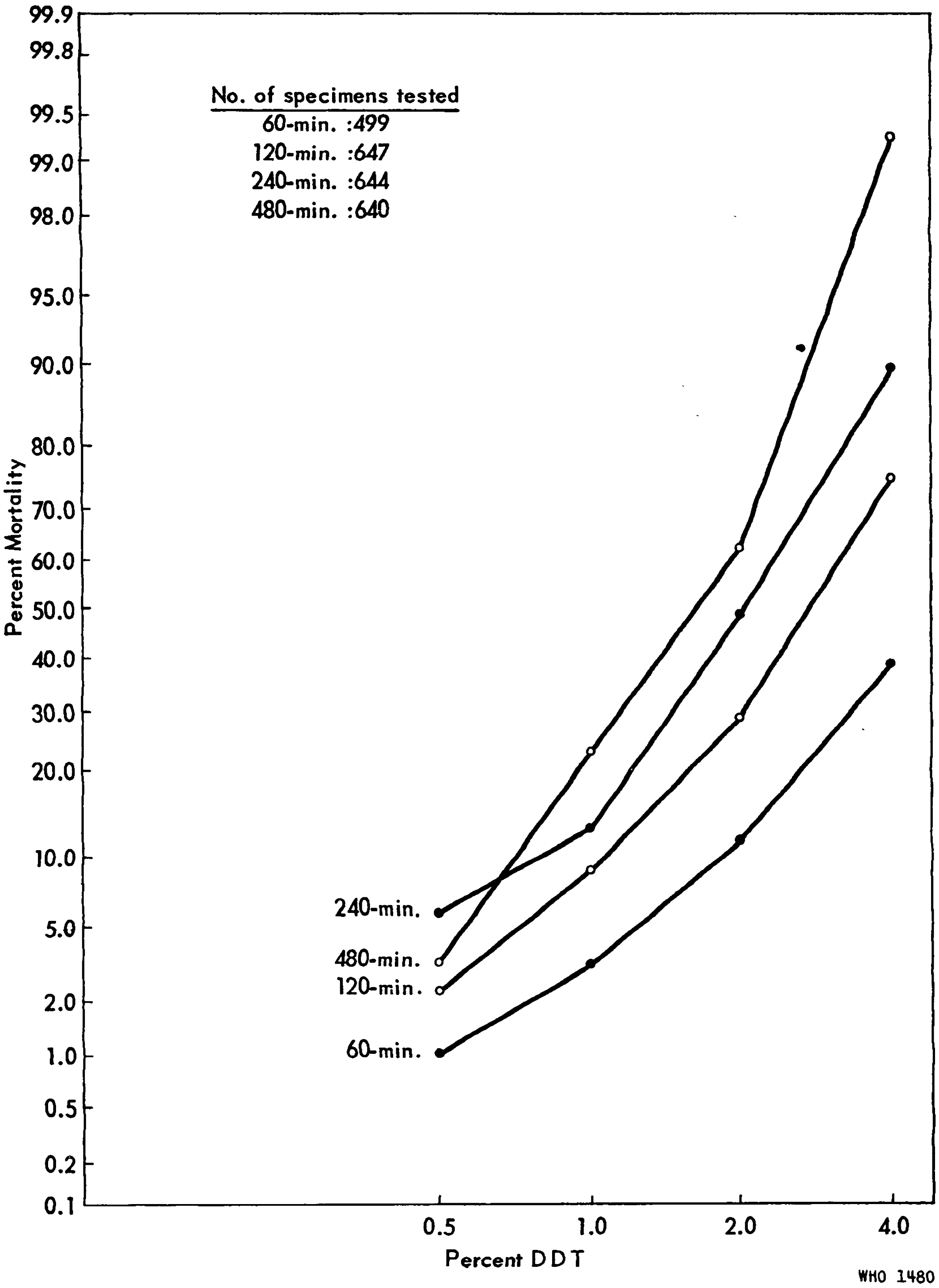
Graph. 3. *A.sacharovi* ADULT MORTALITIES, LEIMONAS, SKALA ZONE, 6-14 July 1960

Comparison of log-probit lines for increasing exposure times



WHO 1480

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