MALARIA VECTOR RESISTANCE TO INSECTICIDES:

(1) with particular reference to Greece;
(2) correlation of vector resistance with larviciding.

by

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Ever since the first attempts to control insects by chemical substances, particularly in the field of agriculture, it has been noted that some species of insects were susceptible to certain chemical substances, while others remained entirely unaffected by the same substances (natural resistance).

At the same time, it was observed that some species of insects, which at the initial phase of the application of a given chemical substance were susceptible to it, after an extensive exposure to the same substance, acquired the ability of resisting its action (induced resistance).

However, it is only in recent years, notably since their occurrence was observed also in the case of residual insecticides, that special attention has been drawn to the above phenomena. It is also interesting to note that the first observations on induced resistance to DDT were made on the house-fly; just when it was thought that the final victory against this insect, as well as against other insects of medical and agricultural importance, was about to be realized.

During the extended antimalaria campaigns with DDT, undertaken immediately after the second world war in certain countries (Italy, Greece, Venezuela), it was observed from the beginning that flies and other domestic insects (fleas, cockroaches, bed-bugs, etc.) disappeared from the DDT-sprayed quarters, together with the malaria vectors.
This fact, naturally, caused a deep impression on the benefited population, and this collateral action of modern malaria control methods was one of the main causes of their whole-hearted reception everywhere.

It was natural therefore that there should be an unfavourable reaction created by the reappearance of house-flies in high density within DDT-sprayed quarters, after the first or second year of a malaria control campaign, and that is what happened in both Greece and Italy in the spring of 1947.

Following the above observations, strains of house-flies resistant to DDT were reported successively in many other countries, as well as strains of house-fly resistant to the other chlorinated insecticides (Italy, Greece, Switzerland, Denmark, United States, Mexico, South America, Israel, Egypt, Australia, etc.). At the same time, laboratory investigations on the phenomenon of resistance in the house-fly were quickly undertaken in many countries. In the same period (1947-1951), it was found that resistance to DDT and other chlorinated insecticides was developed in various other insects, such as Culex molestus (C. autogenicus) in Italy and Greece, Aedes sollicitans, Aedes taeniochynchus and Aedes nigromaculatus in the United States, fleas in Greece, United States and South America, bed-bugs in Greece, United States and Belgian Congo, the German cockroach in the United States, body lice in Egypt, Korea and Japan etc.

On the contrary, up to 1951 from nowhere had a case been reported of anopheline resistance to insecticides. This fact was considered by many malariologists as a good omen, while the question was raised by others whether anopheline mosquitoes possess the necessary qualities for resistance to develop or whether resistance takes a longer time to occur in anopheline than in culicine mosquitoes.

The observations that followed immediately thereafter revealed that for some anopheline species at least the second hypothesis was apparently correct. Thus, in the summer of 1951, during the epidemiological investigation conducted in Peloponnese (Greece) under the special programme we had worked out for that
region, it was observed that DDT house sprays applied suppressively did not, in some instances, have the same effectiveness as in the past, i.e. that only a few days after spraying, *Anopheles sacharovi* adults appeared within the sprayed quarters in unusual density, and that most of them were found resting on sprayed surfaces without showing signs of reaction as a result of their contact with these surfaces. Moreover, it was noted that mosquitoes caught in those buildings and placed in cages were able to survive and the females to lay fertile eggs.

The preliminary communication on the above observations made to the Malaria Section of the World Health Organization was the first warning on the probable manifestation of resistance to DDT by adults of an anopheline species in the field. This hypothesis was confirmed by the investigations which we carried out a few months later in the Skala-Peloponnese (Greece) area. These proved experimentally that *A. sacharovi* adults of the above area showed physiological resistance, not only to DDT but also to Gamexane, and in one case to Chlordane as well, in spite of the fact that the area had never been sprayed with the two latter insecticides.

In order that the course of the anopheline resistance phenomenon in Greece as well as of its influence on the malaria situation may be followed the amendments made from time to time during the last few years to the malaria control programme of Greece will be mentioned here.

In 1952, following the satisfactory results obtained from the programme implemented in Crete and Peloponnese in the previous year (see note on p. 3), it was decided to extend the same programme to the rest of the country also.

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*According to this programme, as well as to that for Crete, the preventive house sprayings with DDT, which had been applied from 1946 uninterruptedly, once a year, in all rural areas of these districts, were discontinued, and the respective areas were placed under a system of periodic epidemiological surveillance. The programme provided also for the application of "suppressive" house sprayings with DDT, whenever indicated (increased anopheline density, detection of positive malaria cases, etc.), and for the prompt treatment of any sources of infection discovered.*
Thus, the total area of house spray with DDT was still further reduced during the years 1952-1953 (Table I). It should be noted however that the use of DDT, during these years, in the antilarval programmes of urban areas as well as in the aerial spray programme of rice fields and major swamps was continued with no substantial change. It should also be noted that residual insecticides were used to some extent for the control of domestic pests by various private sources.

In 1952, two other cases of anopheline resistance in the field were reported. The one was observed in an area of the United States (Tennessee Valley), in which anopheline control was applied concurrently in the larval and adult stages and involved *A. quadrimaculatus*. The other case was observed in Panama and concerns *A. albimanus*. In the latter instance however it was a case of behavioural resistance.

On the other hand, the investigations carried out in Greece in 1953 by the Malaria Department of the School of Hygiene revealed that the resistance of *A. sacharovi* to DDT and the other chlorinated insecticides (chlorodane, Qammexane), which was proved experimentally in Skala during the previous year was not a local phenomenon. It was, in fact, observed that in other districts of Greece also (Aetoloakarnania, Chalkidiki, Drama, Cavalla, etc.), a few days after the application of house spray with these insecticides, the density of *A. sacharovi* in sprayed quarters rose again and tended to reach its pre-spray level within 15-30 days. There was also observed a reduction of the efficacy of indoor DDT applications on the two vectors, *A. superpictus* and *A. maculipennis*.

Moreover, from the data collected by the service of surveillance during 1953, it appeared that the number of positive malaria cases had risen in comparison with the previous year (Tables III and IV).

It was also observed that many of the positive malaria cases detected were from areas where DDT house spray was applied in the same year.

From all this it was becoming clear that the occurrence of the resistance of local vectors and the consequent decline in the efficacy of DDT meant that the prerequisites on which the new antimalaria tactics (see footnote at page 3) in Greece had been based, no longer existed.
The writer, in his capacity of Technical Adviser to the Ministry of Hygiene, presented his views on these new problems and on the indicated measures to avoid undesirable surprises, at the meetings of the Special Malaria Committee held in the autumn of 1953. Particular reference was made by him to the action recommended for the immediate strengthening and reorganization of the malaria control service, to enable it to meet the requirements of the newly created conditions. These measures consisted primarily of a systematic and intensive detection and disposal of the sources of infection, still widely dispersed, before their spread and increase in number made their effective control difficult, if not impossible. 27, 28

In the meantime, the Malaria Control Service of the Ministry of Hygiene, 29 in the face of the new developments, reverted to the suspended general preventive house spray programme with the following basic modifications:

1. The replacement, in large proportion, of DDT by other chlorinated insecticides (chlordane, Gammaxane, Lindane, dieldrin).

2. The application, in place of the traditional single annual spray, of more sprays, with alternate use of the insecticides whenever the relevant observations provided evidence of failure of the first or subsequent sprayings.

3. The preventive spray programme would not be applied as widely as in 1946-1950, but would be restricted to potentially malarious areas.

The above programme, put into effect in 1954, * was continued in 1955 ** throughout the country, except for the Island of Crete, where special conditions prevailed.

In 1954, two new cases were reported of anopheline resistance in the field. The one was observed in two villages of Lebanon and concerns the same species - A. sacharovi 30 - the other in two areas of Java and involves A. sundaicus. 31, 32 In 1955 another case of resistance of A. sundaicus was found in Java (Semarang). 32

* The proportion of insecticides used in 1954 is as follows: DDT 39%, Lindane and Gammaxane 29%, Chlordane 26%, Dieldrin 4%.

** The proportion of insecticides used in 1955 is: Dieldrin 77.2%, Chlordane 19.8%, DDT 2.2%, Gammaxane 0.1%.
Meanwhile, investigations were continued in Greece by the Malaria Department of the School of Hygiene for a further follow-up of the course of anopheline resistance in the country as well as for the assessment of the efficiency of the newly resumed intensive spray programme by alternately used insecticides.

At first, in order to assess numerically the degree of susceptibility of malaria vectors to DDT, three areas were chosen and topical applications of microdoses of DDT on adult mosquitoes as well as the Busvine and Nash technique were used. 33

The number of specimens tested during the above investigations are 21,723 A. sacharovi and 1,448 A. maculipennis. The interpretation of the results of the above tests is hampered by the lack of data in regard to the original levels of susceptibility of Greek malaria vectors to DDT. In spite of this, on the basis of these findings certain conclusions of some interest may be drawn, which are summarized as follows:

1. A significant increase of resistance of A. sacharovi to DDT from year to year in the same area was observed. Thus, in the village of Elos the LD50 of DDT per mosquito rose from 0.080 µg in 1953 to 0.322 µg in 1954 (table V).

2. A considerable difference was observed in the susceptibility of A. sacharovi from place to place in the same year. In Agoulinita (W. Peloponnese), where the concurrently conducted epidemiological investigation had revealed a development of resistance by A. sacharovi not only to DDT but also to chlor dane and Gammexane, the LD50 of DDT for A. sacharovi in 1954 was 0.115 µg per mosquito and the median lethal concentration of DDT 1.39%. From these values it appears that the resistance of A. sacharovi to DDT in Agoulinita was considerably lower than that observed in Elos and Asterion (Skala) during the same year (table V). These observations suggest also that A. sacharovi in Greece was initially more susceptible to DDT than indicated by the above values.

3. The susceptibility to DDT of A. maculipennis, found in Georgiopolis (Crete) in 1954 was higher than that of A. sacharovi in all investigated areas during the same year (table V).
The comparison of the findings of the above tests with those obtained from tests with other anophelines and culicines is also of interest. Thus, the susceptibility of *A. sacharovi* to DDT found in Skala (Greece) is considerably lower than that of all species of mosquitoes tested by Wharton except for *Culex fatigans*, as well as the susceptibility found in susceptible strains of *A. sundaicus* and *A. stephensi*.

Further, the results of the entomological investigations undertaken in most areas of Greece by the Malaria Department of the School of Hygiene in 1954, 1955 in order to assess the efficiency of the various insecticides, can be summarized as follows:

1. DDT, in ordinary doses, ceased almost entirely to have any effect on *A. sacharovi*, while its action on the other two vectors was very low.

2. Chlordane and Gammaxane also showed a greatly reduced efficacy on malaria vectors in Greece.

3. Of all chlorinated insecticides, dieldrin has the highest efficacy on Greek vectors, but the residual action of this insecticide also does not seem to extend, for the time being beyond 3-5 weeks.

On the other hand, from the applications made with various doses of diazinon alone or in combination with dieldrin in the Skala area in 1954, it was found that the action on resistant strains of *A. sacharovi* was initially strong, particularly from the standpoint of immediate killing effect (100% during the first five days). A few days later, however, the action of these insecticides rapidly declined. Of late, it has been brought to our notice that the diazinon samples used in the above tests were seriously deteriorated. It is therefore necessary to repeat the above tests, in order to ascertain how far it is possible to rely on the organophosphoric esters in case of emergency in Greece (malaria epidemics).

In 1955, Busvine conducted susceptibility tests on *A. sacharovi* in Lebanon (Arida) and in Greece (Skala). The median lethal concentration of DDT found by this author in Lebanon was 1.7% and in Greece 3%. From these observations it appears that *A. sacharovi* in Lebanon shows a certain degree of resistance to DDT
while in Greece the resistance developed by this species is well marked and has a
tendency to increase from year to year (table V). Busvine found that A. sacharovi
in Greece (Skala) shows also a high resistance to dieldrin. 36

In 1955, another case of anopheline resistance to DDT was reported. This
was observed in Saudi Arabia (Al-Hasa) and concerns A. stephensi. The median
lethal concentration of DDT found in this case was 5%, while the median lethal
concentration of DDT found among susceptible local strains and among a colony of
the same species was 0.5% and 1.4% respectively. 37 Moreover, in 1955 a series of
susceptibility tests was conducted in Java on A. sundaicus. 32 The median lethal
concentration of DDT found in an area of the North Coast (Semarang) was 9%, while
in an area on the South Coast of Java the median lethal concentration of DDT
found among susceptible strains of the same species was 0.5%.

Latest reports from the Balkan countries state that the vectors of those
countries have not developed any resistance to residual insecticides. 38

However, according to the same sources, in some areas of Yugoslavia (Kosovo,
Macedonia) there was observed in the last three years a rise in the spleen rate
and at the same time an increase in the number of malaria cases. This fact was
attributed to reductions in the spraying programme. 38

Reference should also be made to the observation reported from Bulgaria that
the duration of the residual action of DDT dropped from five months in 1950 to one or
two months in 1955. 38

*    *    *

It is particularly interesting to follow the course of the malaria situation
in rural areas of Greece from the appearance of the phenomenon of resistance by
the vectors to residual insecticides up to the present day.

Inasmuch as there are no morbidity figures, and the mortality figures concern
but towns with a population over 5000, the only data available for the above purpose
are as follows:
1. Parasite rates of infants and schoolchildren taken annually.

2. The findings of the epidemiological surveillance conducted by the Malaria Service from 1951 on.

3. Information on malaria morbidity furnished by private physicians and local authorities during the surveys conducted by members of the Malaria Department of the School of Hygiene.

It is noteworthy that the routine parasite rates of infants and schoolchildren collected during the period under review (table VI) do not indicate any change in the Greek malaria situation.

On the contrary, the data of the epidemiological surveillance (tables III and IV) show that in the last three years a rise in malaria incidence occurred, which, by the way, is not evenly distributed throughout the country. From the same data there appear an absolute prevalence of *P. vivax* and the downward course of *P. falciparum*.

The above findings were also confirmed, in general lines, by information collected during the surveys undertaken in the same period, to which reference is made elsewhere. According to this information, in the last three years small sporadic epidemic outbreaks, as a rule of benign tertian, occurred in some areas which sometimes corresponded to those detected by the epidemiological surveillance, and sometimes did not.\textsuperscript{26,34}

Thus, on the basis of existing data, the present malaria situation in the different districts of the country can be defined as follows:

In the prefectures of SE Peloponnese and eastern Continental Greece, where the malaria problem in the pre-DDT period was very acute,\textsuperscript{39} malaria incidence over the last five years has been insignificant. During this period, the positive malaria cases detected in those prefectures were very few, if any. On the other hand, from all existing indications, breeding of vectors in those prefectures during the same period, and resistance to the insecticides showed no substantial differences, in comparison with other areas of the country.\textsuperscript{26,34} It is also worthy of special mention that among the above prefectures is that of Laconia,
where, as already stated, the development of resistance by *A. sacharovi* was first ascertained and still remains very high. Moreover, it should be added that the said prefectures adjoin areas in which there is actual transmission of malaria.

On the other hand, the number of positive malaria cases detected during the last five years on the Island of Crete, where in the pre-DDT period there were areas with high malaria incidence, is also insignificant (Table II).

Finally, in other prefectures during the last years there was observed an increase, in a varying degree, in the number of positive malaria cases, as well as a progressive extension of areas with positive malaria cases (Table III and IV). But even in this case, there can be no comparison whatever with the malaria incidence of the pre-DDT days in Greece.

Indeed, if it is assumed that the actual number of malaria cases in the country is ten times higher than that discovered by the system of surveillance carried out, the figures derived for the last three years are still very low in comparison with those of the pre-DDT period (15-25 thousand cases annually, as against 1-2 million cases annually).

From all the above evidence one is led to conclude that the present malaria status in Greece is not, on the whole, as unfavourable as might be expected. In fact, it is clear that the nearly complete discontinuance of the residual spray programme in Crete for a whole five-year period and in the other regions for two or three years, together with the concurrent partial or total ineffectiveness of the insecticides owing to the resistance developed to them by the vectors, were not able to reverse the benefits derived from the previous intensive antimalaria campaign of the period 1946-1950. It is also noted that so far no definite relationship was found between the appearance of insecticide resistance in the vector and the distribution of malaria incidence.

At any rate, it seems that the great scarcity or the almost total elimination of sources of infection and, particularly, of *P. falciparum*, that followed the campaign of 1946-1950 played a primary role for the maintenance of the present balance.
Other probable factors that contributed to this effect are the meteorological conditions which, particularly in 1955, were decidedly unfavourable for malaria transmission, as well as perhaps a certain effect, direct or indirect, of the insecticides used at different intervals and in various forms. It is also possible that the detection and treatment of positive cases, although these were practised in a way not at all ideal, as well as other unknown factors, have also contributed to some extent.

It is, of course, impossible to go into further detail and to attempt an interpretation of the problems arising from these general remarks, as this would involve a special study of each particular case.

In final analysis, from all the above, the impression is gained that the revival of the cycle of Plasmodium, when it is broken to a great depth and extent, is not so rapid and easy as is usually believed. From the same observations it also appears that under the above conditions the sensitiveness of malaria indices ordinarily used for the evaluation of the malaria situation is considerably reduced. In fact, if the control of the malaria programme in Greece had been confined to the routine taking of malaria indices, perhaps the change in the malaria situation of recent years would still have remained unnoticed (table VI). Moreover, the above observations lead to the hypothesis that if the measure of suspending the regular spraying programme in Greece had been taken earlier, notably between the years 1948-1949, when from all available data and other indications it had been found that malaria transmission in the country had already reached its end point probably two years before and from the practical point of view the malaria problem as a whole could be considered as eliminated, the appearance of the phenomenon of resistance by the local vectors might in all probability have been prevented. In which case, the clearing of small foci of transmission that might have escaped or been created subsequently through the introduction of Plasmodium from outside, would merely be a matter of application of localized suppressive measures, insomuch as the efficacy of residual insecticides would remain intact. And in this way, the country would not perhaps find itself confronted with the present serious problems.
No one can, of course, be blamed for this hypothetical failure, particularly as it was the general belief at that time among malariologists that sprayings should be continued uninterruptedly and that a suspension thereof might involve serious dangers.

Regardless, however, of the specific problems which have been disclosed relating particularly to Greece, the great lesson of general interest, in our opinion, to be derived from the experience gained in this country is that the discontinuance at the proper time of regular spray programmes is an action of highest necessity and prudence.

Another lesson of general interest also seems, to the author of this paper, to be that in taking the decision of discontinuing large-scale residual spray programmes on country or regional levels, in conformity with the new malaria control strategy, the dangers from probable escapes of scattered foci or small pockets of transmission should not be over-estimated, and that there is no need to await the elimination of the last parasites. Indeed, the decision to discontinue these programmes would be safe when, from all indications, it is made clear that malaria transmission has in each particular case reached as a whole its end point. In this case, the dangers from an eventual appearance of such disturbing factors as the above stated, do not seem to be immediate and can be easily removed, when the efficacy of the insecticides remains high and has not been risked or weakened from their previous extended and unnecessary use on vectors that are liable to develop resistance.

From laboratory investigations on the house-fly it was found that the concurrent action of the insecticides on the adult and larval stage accelerates the development of resistance to the insecticides. It was also observed that the first appearance of strong resistance by culicine mosquitoes in the United States was registered in areas where larvicides and adulticides were concurrently applied.
The same was observed in the case of *A. quadrimaculatus* in the United States and of *A. sundaicus* in Java, whereas, on the contrary, the resistance of *A. sacharovi* found in two villages of Lebanon and of *A. stephensi* in Saudi Arabia seems rather to be associated with the exclusive use of adulticides.

In the case of Greece, it should be pointed out that this country is a unique example of concurrent application on a very large scale of adulticiding and larviciding measures in malaria control.

In line with the generalized house spray programme with DDT in rural areas and the antilarval programmes with DDT in urban areas, there was applied on a large scale from the very beginning in this country the aerial spray of rice fields and major swamps with the same insecticide. It is therefore usually the case in Greece to have rural areas placed under the two methods at the same time.

The psychological effect exercised on the population by the spectacular method of aerial spray, introduced, as it was, under abnormal conditions, was so extended and strong that all subsequent efforts made to remove it proved of no avail, although it had been made clear that this method, as applied, constituted an unnecessary expenditure, and there was also a likelihood that it was perhaps harmful as contributing to the strengthening of the resistance phenomenon.

No specific observations were made on the role played in Greece by the aerial spray in the development of resistance by the malaria vectors, but taking into account the general observations made on this subject, it is reasonable to suggest that the aerial spray contributed to the early and extended development of resistance by malaria vectors in Greece.

**SUMMARY**

After a brief enumeration of the insects that developed resistance to residual insecticides, during the last few years, reference is made to the cases, reported so far, of the development of resistance by malaria vectors in various countries. Special mention is made of the different phases of resistance developed by the malaria vectors in Greece, where this phenomenon appears intense and widespread, as well as of the influence exercised by the said resistance on the course of the malaria situation in the country.
### TABLE I. DATA OF HOUSE SPRAY PROGRAMME APPLIED IN GREECE (1946-1955)

<table>
<thead>
<tr>
<th>Years</th>
<th>Preventive house spray</th>
<th>Suppressive house spray</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>number of villages sprayed</td>
<td>population of villages sprayed</td>
<td>number of villages sprayed</td>
</tr>
<tr>
<td></td>
<td>5 067</td>
<td>3 420 738</td>
<td>-</td>
</tr>
<tr>
<td>1946-50 average</td>
<td>1 930</td>
<td>1 291 100</td>
<td>31</td>
</tr>
<tr>
<td>1951</td>
<td>356</td>
<td>253 749</td>
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<tr>
<td>1952</td>
<td>485</td>
<td>348 032</td>
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</tr>
<tr>
<td>1953</td>
<td>1 938</td>
<td>1 298 235</td>
<td>50</td>
</tr>
<tr>
<td>1954</td>
<td>1 982</td>
<td>1 300 039</td>
<td>35</td>
</tr>
<tr>
<td>1955</td>
<td></td>
<td></td>
<td></td>
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### TABLE II. DATA OF THE EPIDEMIOLOGICAL SURVEILLANCE CONDUCTED IN CRETE (1951-1955)

<table>
<thead>
<tr>
<th>Years</th>
<th>Number of villages found with malaria positive cases</th>
<th>Number of malaria positive cases detected</th>
<th>Parasite species</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>P.v.</td>
</tr>
<tr>
<td>1951</td>
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<td>0</td>
<td>-</td>
</tr>
<tr>
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<td>2</td>
<td>2</td>
<td>2</td>
</tr>
<tr>
<td>1953</td>
<td>2</td>
<td>2</td>
<td>2 100%</td>
</tr>
<tr>
<td>1954</td>
<td>5</td>
<td>6</td>
<td>6 100%</td>
</tr>
<tr>
<td>1955</td>
<td>3</td>
<td>6</td>
<td>4 66.7%</td>
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</table>
### TABLE III. DATA OF THE EPIDEMIOLOGICAL SURVEILLANCE CONDUCTED IN PELOPONNESE (1951-1955)

<table>
<thead>
<tr>
<th>Years</th>
<th>Number of villages found with malaria positive cases</th>
<th>Number of malaria positive cases detected</th>
<th>Parasite species</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td>P.v.</td>
</tr>
<tr>
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<td>27</td>
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<td>37</td>
</tr>
<tr>
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<td>41</td>
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<td>1953</td>
<td>61</td>
<td>206</td>
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<td>138</td>
<td>531</td>
<td>524</td>
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<td>1955</td>
<td>118</td>
<td>443</td>
<td>441</td>
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### TABLE IV. DATA OF THE EPIDEMIOLOGICAL SURVEILLANCE CONDUCTED IN DISTRICTS OF GREECE OTHER THAN CRETE AND PELOPONNESE (1952-1955)

<table>
<thead>
<tr>
<th>Years</th>
<th>Number of villages found with malaria positive cases</th>
<th>Number of malaria positive cases detected</th>
<th>Parasite species</th>
</tr>
</thead>
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<tr>
<td></td>
<td></td>
<td></td>
<td>P.v.</td>
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<td>471</td>
<td>1813</td>
<td>1741</td>
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<td>1955</td>
<td>444</td>
<td>1193</td>
<td>1169</td>
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TABLE V. DATA OF SUSCEPTIBILITY TESTS OF MALARIA VECTORS IN GREECE DURING THE PERIOD 1953-1955

<table>
<thead>
<tr>
<th>Place</th>
<th>Period</th>
<th>Malaria</th>
<th>Type of DDT application</th>
<th>LD$_{50}$</th>
<th>Authors</th>
</tr>
</thead>
<tbody>
<tr>
<td>Elos$^2$ (Skala)</td>
<td>Aug. 1953</td>
<td>A. sacharovi</td>
<td>topical application</td>
<td>0.080</td>
<td>Livadas and Thymakis</td>
</tr>
<tr>
<td>Elos$^2$ (Skala)</td>
<td>Aug. 1954</td>
<td>&quot;</td>
<td>&quot;</td>
<td>0.322</td>
<td>&quot;</td>
</tr>
<tr>
<td>Asterion$^2$ (Skala)</td>
<td>June 1954</td>
<td>&quot;</td>
<td>&quot;</td>
<td>0.302</td>
<td>&quot;</td>
</tr>
<tr>
<td>Asterion$^2$ (Skala)</td>
<td>Aug. 1954</td>
<td>&quot;</td>
<td>&quot;</td>
<td>0.258</td>
<td>&quot;</td>
</tr>
<tr>
<td>Agoulinitza (W. Peloponnese)</td>
<td>July 1954</td>
<td>&quot;</td>
<td>&quot;</td>
<td>0.115</td>
<td>&quot;</td>
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<tr>
<td>Georgiopolis Crete</td>
<td>Sept. 1954</td>
<td>A. maculipennis</td>
<td>&quot;</td>
<td>0.081</td>
<td>&quot;</td>
</tr>
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<td>Agoulinitza (W. Peloponnese)</td>
<td>July 1954</td>
<td>A. sacharovi</td>
<td>Busvine and Nash technique</td>
<td>1.39</td>
<td>&quot;</td>
</tr>
<tr>
<td>Asterion$^2$ (Skala)</td>
<td>Aug. 1954</td>
<td>&quot;</td>
<td>&quot;</td>
<td>2.71</td>
<td>&quot;</td>
</tr>
<tr>
<td>Elos$^2$ (Skala)</td>
<td>Sept. 1955</td>
<td>&quot;</td>
<td>&quot;</td>
<td>3.0</td>
<td>Busvine</td>
</tr>
</tbody>
</table>

1 Unit for topical application: microgram per mosquito; for Busvine and Nash technique percentage concentration of DDT solution

2 Malaria conditions in these villages about two kilometres apart are practically the same
### TABLE VI. INFANTS AND SCHOOLCHILDREN PARASITE RATES IN GREECE FOR THE PERIOD 1946-1955 AND AVERAGES FOR THE PERIOD 1933-1939

<table>
<thead>
<tr>
<th>Years</th>
<th>No. of infants examined</th>
<th>No. of villages surveyed</th>
<th>Infant parasite rates %</th>
<th>No. of school-children examined</th>
<th>No. of villages surveyed</th>
<th>Parasite rates of school-children %</th>
</tr>
</thead>
<tbody>
<tr>
<td>1933-1945 average</td>
<td>2 030</td>
<td>-</td>
<td>10.0</td>
<td>7 535</td>
<td>190</td>
<td>17.2</td>
</tr>
<tr>
<td>1946</td>
<td>558</td>
<td>57</td>
<td>0.18</td>
<td>12 530</td>
<td>183</td>
<td>1.79</td>
</tr>
<tr>
<td>1947</td>
<td>823</td>
<td>70</td>
<td>0</td>
<td>12 952</td>
<td>236</td>
<td>0.21</td>
</tr>
<tr>
<td>1948</td>
<td>1 125</td>
<td>136</td>
<td>0</td>
<td>19 914</td>
<td>241</td>
<td>0.15</td>
</tr>
<tr>
<td>1949</td>
<td>1 045</td>
<td>121</td>
<td>0.38</td>
<td>17 412</td>
<td>250</td>
<td>0.15</td>
</tr>
<tr>
<td>1950</td>
<td>708</td>
<td>71</td>
<td>0.42</td>
<td>20 375</td>
<td>256</td>
<td>0.16</td>
</tr>
<tr>
<td>1951</td>
<td>2 825</td>
<td>271</td>
<td>0.04</td>
<td>12 765</td>
<td>181</td>
<td>0.03</td>
</tr>
<tr>
<td>1952</td>
<td>4 071</td>
<td>-</td>
<td>0.05</td>
<td>23 242</td>
<td>366</td>
<td>0.03</td>
</tr>
<tr>
<td>1953</td>
<td>1 003</td>
<td>-</td>
<td>0.10</td>
<td>12 274</td>
<td>184</td>
<td>0.04</td>
</tr>
<tr>
<td>1954</td>
<td>887</td>
<td>-</td>
<td>0.11</td>
<td>11 596</td>
<td>189</td>
<td>0.09</td>
</tr>
<tr>
<td>1955(^2)</td>
<td>600</td>
<td>-</td>
<td>0.33</td>
<td>6 094</td>
<td>-</td>
<td>0.16</td>
</tr>
</tbody>
</table>

\(^1\) The data of this table up to 1949 were secured from the records of the School of Hygiene within which the Malaria Control Service operated until that period. The data covering later periods were furnished by the appropriate service of the Ministry of Hygiene.

\(^2\) These figures are provisional
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