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OBSERVATIONS ON THE DENSITY OF PHLEBOTOMUS POPULATIONS FOLLOWING DDT CAMPAIGNS *

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The success of the antimalaria campaign in Greece, which has been in progress since 1945, is well known.^{6, 9, 10} This project has been carried out by the Greek Government Malaria Service with the financial and technical aid, first of UNRRA, and later of the Interim Commission of the World Health Organization and the American Mission for Aid to Greece. Houses and outbuildings were treated with residual DDT in 1946, 1947, and 1948 throughout practically the whole of the malarious areas of continental Greece and its islands. Most of the spraying has been done in villages, but military installations and numerous public and private buildings in urban areas have also been treated. It has been known for several years^{3, 4, 5} that house-spraying with DDT, now the most widely used method of malaria control, is also the most effective single measure for the control of sandflies of the genus *Phlebotomus*, the vectors of sandfly fever and leishmaniasis. However, the results of a widespread, long-term, house-spraying programme had never been measured in terms of phlebotomus control, particularly in the temperate zone where so many of the acute problems connected with sandflies and disease occur. Fragmentary published and personal reports from Greece indicated that sandflies were greatly reduced or had even "disappeared". The situation therefore offered a favourable opportunity to determine just what had happened to phlebotomus in the barrage of DDT laid down during the campaign.

Arrangements for this survey were made through the New York office of the Interim Commission of the World Health Organization and the WHO Mission in Greece. The writer was in Greece from 6 June to 24 October 1948. Laboratory facilities were most generously furnished by the School of Hygiene, Athens, and by the Hygiene Centre, Canea, Crete.

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The general plan was to make as many observations as possible on the mainland and to devote special attention to the Nomos^a of Canea in Crete, where there are several classical foci of leishmaniasis. The sandflies of Greece have been studied by a number of investigators, with identified collections totalling thousands of specimens. There were available, therefore, adequate data concerning the normal abundance and distribution of species in the areas which we surveyed. The dominant species in Greece, as in most parts of the Mediterranean region, is *Phlebotomus papatasi*, the principal or sole vector of sandfly fever, and the species responsible for most of the annoyance from sandfly bites. There are also present *P. major* and *P. sergenti*, the probable vectors in Greece of kala-azar and oriental sore respectively, together with eight other species. While there were no exact sandfly observations immediately preceding the application of DDT, it was possible to make a rough reconstruction of the situation on the basis of the reports of local residents. It has been the general experience in various countries that, where sandflies are abundant, most of the people recognize phlebotomi with considerable accuracy and distinguish them from mosquitos, the insects with which they are most likely to be confused. In the sprayed areas, where, it may be stated at the outset, sandflies are now extremely scarce, we received repeated and consistent reports, accompanied by corroborating circumstantial evidence, that sandflies had formerly been constantly present in annoying abundance, but that they had "disappeared" with the first spraying of the individuals' premises and had not returned.

As an index of normal sandfly abundance during the season of 1948 we made an effort to locate villages or groups of houses where DDT had never been used or at least not recently. We found such areas in certain non-malarious villages near Athens and in some of its suburbs. The very numerous sandflies, in some cases hundreds in a single house, we considered evidence that 1948 was not an off year for phlebotomus.

Summary of Observations

Our observations and the details of catches of identified phlebotomus are being published elsewhere² and are only briefly summarized here.

Athens

The city had never been sprayed *in toto* but there were nevertheless a great many treated public and private buildings scattered throughout the city and its suburbs. The peripheral effect of such sprayed centres has never been studied. Furthermore, the use of household sprays containing

^a A nomos is an administrative district of which there are four in Crete.—Ed.

DDT is now fairly common. Whatever the combined effect of these factors, sandflies were at a rather low level in the city. A survey with random sampling of houses was made in three districts of Athens. In two districts in the north-east portion 63 unsprayed houses averaged about four sandflies per house, with about half the houses completely negative and most of the sandflies concentrated in a few places. In the third district in the western part of the city the incidence was greater, with eight houses averaging about 17 sandflies.

Athens suburbs

Nea Smyrni. Sandflies were formerly abundant in this large suburb between Athens and the sea. During the summer of 1946 it was sprayed from the air with DDT. The people reported an immediate cessation of sandfly annoyance which lasted for the rest of the season and that, indeed, sandflies have been scarce ever since. Very few sandflies were found in the centre of this suburb, though we did find them in moderate abundance in a dairy at its periphery. The effect of airspray on phlebotomus has never been studied, but the reported results in this one instance, as well as other considerations, point to the desirability of exploring the method as a rapid and economical means of securing at least temporary sandfly control.

Elliniko. This suburb along the sea beyond the airport has long been notorious for its sandflies. Some residual DDT had been applied in 1945 in quarters occupied by the British, but there had been no organized spraying recently. Moderate numbers of sandflies were found in several houses, with 200-300 in one case which were soon reduced to negligible numbers by the regular use of a household spray.

The only species in our collections in Athens and its suburbs, where a total of 497 sandflies was found, was *P. papatasi*.

There had been many cases of sandfly fever in 1945 among the personnel of UNRRA and the British forces in the Athens area. Spraying of living quarters gave immediate and complete control.

Villages in Attica

Most of these villages had been sprayed for three consecutive seasons. In about a dozen sprayed villages within a radius of 40-50 kilometres of Athens, sandflies were extremely scarce. Treated houses were uniformly negative. Those few sandflies caught in sprayed villages were almost entirely in houses which, for one reason or another, had missed the spraying or had not yet received the 1948 treatment. The people gave consistent reports of former sandfly abundance which had ceased with the first treatment.

Several non-malarious villages near Athens, consisting largely of scattered summer residences, had not been sprayed. Sandflies were frequently abundant. In one in particular, Kinetta, about 55 kilometres west of Athens, sandflies were extremely abundant, with several houses harbouring hundreds. Our identified collections in this village totalled 1,284 sandflies belonging to seven species.

In Melissa, a large village 12 kilometres north-east of Athens, the 1948 treatment (carried out in June) was interrupted when nearly finished and at our request was not resumed, so that comparative observations could be made throughout the season in the treated and untreated portions. Houses which had a few sandflies just before the spraying were negative afterwards, although a few sandflies could be found outdoors at night, particularly around one farmhouse which had not been sprayed in previous years. An evening search in the sections which had been sprayed for three consecutive years showed sandflies to be extremely scarce. Only one or two sandflies were seen out of doors and the people reported that, whereas sandflies were formerly very abundant, they were no longer bitten outdoors at night. In the unsprayed group of houses sandflies were very numerous, 100-300 being found in each of several houses, but the numbers declined during the rest of the summer, due in part to the use of household sprays and perhaps in part to the peripheral effect of sprayed houses 100-200 metres distant. Evening observations, particularly at one house in the unsprayed group, showed that the sandflies continued to be abroad out of doors and yielded data on several species other than *P. papatasi* (particularly *P. alexandri* which was fairly abundant and gave way late in the season to a preponderance of *P. major*).

Canea, Crete

This place was of particular interest because of the separate foci of kala-azar and oriental sore within the limits of the city. A careful study of both sandflies and leishmaniasis had been made in the mid-thirties, particularly by Adler, Theodor & Witenberg.¹ Kala-azar was found chiefly in the section known as Agios Ioannis, comprising about twenty city blocks in the south-east corner of the city, while the old Turkish quarter, Splanzia, surrounding the harbour, was an intense focus of oriental sore. Adler *et al.*¹ had found *P. papatasi* to be abundant in both, but that, of the other species, *P. major* predominated in Agios Ioannis and other kala-azar foci, while it was very scarce in Splanzia, where its place was taken by *P. sergenti*. On these and experimental grounds, *P. major* and *P. sergenti* were considered the respective vectors of kala-azar and oriental sore.

In Crete, unlike Attica, we were unable to find any areas "uncontaminated" by the application of DDT. Canea had not been sprayed as a

whole, but, as in Athens, there were many treated buildings. The accessible villages had all been sprayed. In both Canea and the villages sandflies were at an extremely low level. As on the mainland, we received numerous reports that sandflies had been abundant but that they had decreased or disappeared with the first treatment of the particular premises or at the time DDT was being applied in the vicinity. In several houses in Agios Ioannis, lying between groups of houses which had been treated with residual DDT in 1946, we were able to find small numbers of sandflies, never more than a dozen or so at a time (mostly *P. papatasi*). Repeated evening searches in Agios Ioannis, where Adler *et al.*¹ had been able to capture 50-120 *P. major* in an evening at the same time in the season, yielded only a scattering of sandflies (the total for nine evenings was 15 sandflies, including 8 *P. major*). On some evenings not a single sandfly was seen. Sandflies were similarly scarce in several other sections, including Splanzia. Night searches in three villages were equally unproductive of sandflies (the total capture was 4 sandflies).

Leishmaniasis. Kala-azar in the Nomos of Canea, which comprises the western quarter of Crete, has greatly declined, from about 50 cases annually in the mid-thirties to an average of about five during the last five years. The one clear feature of this decrease is that DDT had had nothing to do with bringing it about. It was associated with the destruction of stray dogs on account of rabies, the destruction of dogs found infected with kala-azar, and the great decrease of the whole dog population on account of the food shortage during the war. Most of the kala-azar cases of the whole nomos formerly came from Agios Ioannis. Only two cases have been known from that section in the last five years. Whatever may have brought about the decline, it is difficult to estimate the role played by the present scarcity of sandflies in keeping kala-azar down. The dog population has about returned to normal. Information is lacking about reservoirs other than dogs or man and about normal kala-azar cycles.

With regard to oriental sore, most of the medical men we met in Crete agreed that a sharp drop in its incidence occurred in 1946, which they attributed to the introduction of DDT. Our observations confirm the scarcity of cases which have developed in the past two years. The records of the dermatological section of the Hygiene Centre, Canea, were destroyed during the war and only the period since April 1946 is now covered. The physician in charge estimated that the clinic was treating about 1,200 cases per year before 1946, a figure borne out by his records from April to July 1946, with a monthly average of about 120 cases. Thereafter they never exceeded about 40 in any month and averaged 27 in 1947, and 17 in the first eight months of 1948. Various villages in the Nomos of Rethimnon, which are known to be oriental-sore foci, were visited. As in Canea, recent cases have been rather scarce. In both this nomos and that of Iraklion there had been a near-epidemic of oriental sore about 1938-1939,

which declined following a mass-treatment campaign. A further drop, however, was associated by some medical men with the DDT campaign. Cycles in the incidence of oriental sore, with crests at about twenty-year intervals, have been noted for both Crete^{7, 8} and the endemic area in the Peloponnesus,⁷ which, however, seem to have been less marked in Canea. The data certainly suggest a connexion between the DDT, the present scarcity of phlebotomus, and the reduced incidence of oriental sore, but definite conclusions, as in the case of kala-azar, must await a longer period of observation.

Italy and Sardinia

A brief visit was made to Italy and Sardinia in the latter half of August 1948.

Through the kindness of Dr A. Corradetti, of the Istituto Superiore di Sanità, Rome, it was possible to observe an extensive experimental project for the control of oriental sore which he has in progress in the Abruzzi. Within a heavily infected area of about 200 square kilometres, practically every building was treated with residual DDT during the summer of 1948. The experimental area is surrounded on three sides by an untreated region with an equally intense infection-rate. We made observations in both treated and untreated areas. In the latter *P. perfilliewi*, the dominant sandfly and supposed vector, was extremely abundant. In the sprayed area sandflies were in general very scarce. As was the case in Greece, no sandflies could be found in sprayed houses in daytime searches. However, in one place we encountered a heavy evening flight which was apparently the progeny of a generation which had laid eggs before the spraying 73 days previously. By good fortune we were able to witness the actual destruction of great numbers of sandflies of this flight as they encountered the residual DDT. In a dining-room a shower of sandflies fell on the table and floor, all showing the typical signs of DDT poisoning—agitation and lack of co-ordination. At one time there were 400-500 sandflies on the ceiling above a cluster of lights, all in a state of agitation. Over 100 specimens were picked off the table and it was estimated that well over a thousand sandflies had entered the room. The phenomenon of the sandfly shower on the table had been observed following the spraying but not for some time before our visit. It continued with reduced intensity for several days after our experience. On a visit two weeks later Dr Corradetti could find only an occasional sandfly out of doors and none in the room, while extreme abundance still prevailed in the unsprayed area.

Professor Missiroli informed us that in the Pontine marshes sandflies had caused severe annoyance before the DDT-malaria campaign started in 1944. They have ceased to be a cause of complaint.

In connexion with the anopheline-eradication project carried out in Sardinia by the Ente Regionale per la Lotta Anti Anofelica in Sardegna (ERLAAS), every man-made structure in the island was sprayed with residual DDT during the winter of 1947-1948. We are indebted to Dr J. A. Logan, Superintendent, ERLAAS, and Dr T. G. H. Aitken, Entomologist, ERLAAS, for the opportunity of visiting certain areas in the southern part of the island. By popular report the sandfly annoyance of former years had been absent in 1948. Houses in several villages were negative eight or nine months after the spraying. In several villages Dr Aitken's staff had collected sandflies on four or five occasions during August and September 1947. The catch from one village consisted of about 80 sandflies, all the males and an identified sample of the females being *P. papatasi*. An evening visit to this village yielded no sandflies at all. The only live sandflies we saw in Sardinia were ten specimens in an unsprayed cave.

Summary and Conclusions

With regard to the effect on phlebotomus of residual DDT applied during the campaigns in Greece and Italy, the results form part of a consistent pattern observed previously in other countries. The following general conclusions seem warranted:

1. The treatment of interiors with residual DDT gives immediate and virtually complete protection from sandflies indoors.
2. House spraying alone, with an annual treatment, preferably before the sandfly season, eventually reduces the phlebotomus population within the sprayed areas nearly to vanishing point. This effect can be expected to be most marked in closely built, compact communities.

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