THE ANTI-MALARIA CAMPAIGN
IN GREECE - 1946
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Greece has been cursed by malaria from classical days; and the disease, until recently, was directly responsible for some 5,000 deaths and, at a conservative estimate, over a million cases a year out of a population of 6 or 7 millions. Malaria cannot, therefore, be excluded from consideration as one causal factor in the situation of the country. It is not unnatural to hope that, with the removal of this factor and the march forward of a people freed from their ancient scourge, better times will come to Greece and a future perceptibly brighter will open before her.

From 1880 in Greece, the idea of prevention and control of malaria has been slowly developing. Drainage of swamps for the settlement of refugees from Turkey was one milestone. The Rockefeller Foundation Mission from 1930 to 1936 was another. The latter left behind a series of well-worked-out experiments, a small corps of trained malariologists and a tradition. They also left behind one of their members, Colonel D. E. Wright, their Chief Sanitary Engineer.

This story begins with the introduction of 4,4′ dichloro-diphenyltrichloroethane (DDT) to Greece late in 1944 and a series of experiments by the Malaria Division of the Athens School of Hygiene, which confirmed, as far as Greece was concerned, the astonishing results which had been observed elsewhere (Livadas et al., June 1945).

Next, Wright returned with UNRRA bearing a wealth of enthusiasm and experience from the United States of America, and a plan was devised to attack anophelines, both adult and larvae, on the widest possible scale throughout the country, using DDT in its various forms as the sole weapon. Wright's influence was of incalculable value in introducing tried and proved techniques, in
supporting the project in its governmental budgetary implications and in gaining the approval of UNRRA for the very heavy supplies programme for the project.

Basically, the School of Hygiene under Professor Livadas handled the organization in the general administrative and malariological aspects, whilst the Malaria Control Section of UNRRA under Wright dealt with the engineering and technical side and the supplies. There was a considerable overlapping of activities, as was to be expected.

The project had certain advantages. There was already a great amount of valuable data and an active malariological department in the Athens School of Hygiene. Geographical and entomological surveys had been carried out for many years: there was no need to repeat them as a preliminary to operative work. Though clinical surveys had declined during the war years it was not hard to establish the wide epidemicity of the disease, aggravated by the failure during the war to maintain such control measures and works as had been in use before 1940.

Next, there were almost limitless resources in supplies. UNRRA backed the scheme and poured in DDT, transport, sprays, in fact everything material that was necessary, including a small fleet of eighteen aeroplanes equipped for air-spraying.

In 1945, preliminary work was begun, more to try out DDT and for training than as a serious attempt at a large operation. The results, however, were so astonishing that the combination of the School of Hygiene and Wright himself persuaded the Government to raise its budgetary figure for malaria control from some £60,000 to £300,000 for 1946.

Four methods of attack were employed. First, in early spring, by hand-spraying to deal with every possible shelter where hibernating mosquitoes might be found in the vicinity of human habitations. Secondly, a larvicidal onslaught at the appropriate time by hand-spraying over a five-kilometre radius. More or less simultaneously, a thorough and systematic spraying of village houses, inside and out. Lastly, a further attack on larvae from the air.

The common vectors in Greece are Anopheles clutus, A. maculipennis and A. superpictus. The two first are found in the lower areas and coastal marshes, the last up to 4,000 feet. A. clutus and A. maculipennis are usually active and reproducing fast by the middle
of April, whilst *A. superpictus* can be safely left for attention until about June.

The organization was worked out during the winter of 1945/46, with headquarters in Athens. The plan called for centralized control with malarialogists and engineers, Greek and UNRRA, scattered through some ten regions, but dependent on Athens for direction and supplies. This plan was found in practice to present great difficulties, and in midsummer it was changed to a system of regionalized control under local-authority committees.

The workers were organized on a whole-time basis, a costly system. The reaction of the population, however, has been such that a strong case has been made for local effort in the actual job and a consequent reduction in national costs, in the future.

The question of transport assumed paramount importance in view of the appalling condition of the Greek roads. At any one time, from 10 to 15 per cent of our trucks would be out of action through mechanical troubles. This had a serious effect on a campaign working to a time schedule based on the unchanging habits of an insect.

The following solutions or emulsions of DDT were used:

(a) Solutions, approximately 5 per cent, in kerosene, for the interiors of houses, about 200 mg. per square foot. Cost, delivered to villages, about 40 cents per gallon (U.S.).

(b) Solution 5 per cent in Diesel oil, for outhouses of all kinds, stables, etc., and other resting-places for mosquitoes. Cost, about 35 cents per gallon.

(c) Water emulsion 5 per cent, from a concentrate containing 26 per cent of DDT. Cost, about 35 cents per gallon.

(d) Solution in Velsicol (Velsicol NR 70-Polymethylnaphthalene) 20 per cent. Used for aeroplane-spraying without dilution (1/2 pint to one acre); and, when diluted one gallon of the 20 per cent solution with 5 gallons Diesel oil, it was used for outbuildings by hand. A 35 per cent concentrate is available, costing proportionately less for portage in the field.

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1. 2.14 g. per square metre.
2. 1 gallon (U.S.) equals 3.78 l.
3. 1 pint equals 0.473 l.
4. 1 acre equals 0.4 ha.
The aeroplanes worked from ten bases. They were piloted by members of the Royal Hellenic Air Force who entered into this dangerous work with enthusiasm. They flew at an altitude of about ten to twenty feet [3-6 m.], releasing a fine oily mist in globules, the size and density of which could be controlled. The machines were small trainer two-seater biplanes with a top flying-speed of about 80 m.p.h. [130 kilometres] and a landing-speed of 40 m.p.h. [65 kilometres]. Failure of the engine whilst over a swamp meant a sudden dive and we were fortunate in having only one fatality out of several accidents. Greek swamps, sparsely timbered and with light vegetation, are particularly suitable for this method of larval control.

Watch was kept by the malariologists and inspectors and it is established that an anopheline swamp needs spraying about once monthly.

Thus the plan. In practice we had every obstacle to surmount; downright anti-campaign propaganda, official inertia, mischievousness, and resistance by groups such as the bee-keeping fraternity and the silkworm breeders. We came to an agreement to avoid the bee-keepers, but were not allowed to remain in the silkworm country. Under ordinary domestic conditions, the DDT crystals in time become free from sprayed walls and are carried by air currents throughout a room. Thus for silkworms it is no protection to be prevented from contact with a treated surface or wall. In one of our experiments mosquitoes hung in a cage in the centre of a sprayed room all died from DDT poisoning, a fact which can have only the explanation given above. DDT and silkworms do not go together, and some other form of control must be used amongst them: here is a field for chemotherapeutical prophylaxis.

However, with this exception we had the full support of the general population. Even where they had, through generations, become resigned to malaria, and almost tolerated it as something inevitable, they were not prepared for the revolution in their lives that followed the eradication of flies, bugs, fleas and other household "symbiotics" which plagued their day's work and destroyed their night's rest. This was something new, and the national clamour for more and more DDT has an appeal no Government can resist.

Before considering the results of the campaign, it was essential to establish whether 1946 was a year of low incidence or not. Livadas has studied this point and his opinion is condensed as follows:
1. Villages which were not protected for various reasons showed a rise in epidemicity and *P. falciparum* was found in all carriers. (This is always an ominous sign.)

2. The climatic conditions in Greece in 1946, if less favourable to an epidemic of malaria than 1938 and 1942, were more favourable to an increase in incidence and spread than the immediately preceding years — 1943, 1944 and 1945.

This being so, the scientifically observed results, which are not yet completed, show a surprising fall in the number of cases and in parasite indices and spleen rates. The very important number of deaths directly attributable to malaria is unfortunately not yet available and in the present state of Greece it is doubtful whether complete figures for 1946 will ever come to hand. A few figures culled at random, however, give a picture which is not unimpressive.

We sprayed some 700,000 houses by hand and, with the planes, about 96,000 acres of malarious swamplands. The Government and the people, without whose co-operation a scheme of this kind must fail, from the beginning have proclaimed "magna cum voce" their approval and desire for a continuation of the project. The mutterings of disgruntled private malaria therapists have not gone unheard and one is sympathetic towards a brother whose main livelihood is snatched from him. For that is what seems to have happened in many districts where no new cases at all have been reported.

The very important if incidental side-issue of fly control holds great promise for the future. To have seen a house-fly in Athens last summer was something to comment upon. The official notifications of dysentery for the whole of Greece for the summer and autumn of 1945 as against 1946 are—July 268 : 151, August 581 : 85, September 510 : 12, October 152 : 6.

*En passant*, so to speak, we sprayed 25,000 acres of olive groves against the *Dacus* fly and were informed of an increased yield of 25 per cent. We wiped out with one air-spraying—a matter of minutes—a plague of caterpillars of the Tene moth which attacks pine and fruit trees. The inhabitants of one suburb of Athens still talk of their freedom from sandflies after an early morning (and definitely unauthorized) spraying from the air by a few of our pilots.

It seems established that DDT is ushering in a period of control over insects to a degree never before imagined. The problem ahead is to learn the most practical and economical method of using DDT.
and it is for the entomologists to supply the answer. Each country presents an individual problem. Is it necessary at all to attack larvae? If every house is a death-trap to the adult insect and all adult insects enter houses and rest on walls—then the expensive larviciding tends to lose its importance in breaking the chain of transmission. The problem is complicated by the habits of Greeks who love to pass the night out of doors in the hot weather and even sleep amongst their crops far from human habitations, where they may well be and in fact are bitten regularly by anophelines from neighbouring marshes. Where such mosquitoes rest during the day is again for the entomologists to discover, and if the mosquitoes insist on finding a house or barn which, if treated by DDT, will mean death for them, then the value of aeroplane spraying is questionable.

The Greek Government has budgeted some £300,000 for the 1947 campaign which is in full swing at the moment over those parts of the land where peaceful pursuits may still be carried on. It is not too much to hope, we think, that in 1948 a modification of our all-out offensive may be considered adequate with consequent saving to the Greek Exchequer and with similar satisfactory results with regard to the reduction, or even eradication, of malaria in Greece.

One is not blind to future prospects. The people of Greece have acquired a certain immunity which, if our plans work out, they will lose. If, then, at some future date, their malaria control should collapse and the country undergo a period of famine and extreme distress so that the inhabitants are ripe for a heavy epidemic, and the epidemic arrives, what then?

This very important query was answered by an eminent malarial biologist who stated in effect that, with the recent advances in malarial prophylaxis and treatment by modern synthetics, a catastrophe of this kind could be quickly controlled and should never reach the appalling incidence and mortality which otherwise might be expected.

Greece lost thousands of its farm animals during the war and occupation. If the *maculipennis* varieties of Greece (*typicus* and *subalpinus*) are not androphilic, but zoophilic, with the present death of cattle due to the war, one wonders whether an increase in incidence of the disease might not have been brought about by a temporary change in diet of *maculipennis*, forced to feed on man.

In actual fact it is doubtful whether during the years following
1942 (an epidemic year) there was any rise in incidence. Curves of graphs show something of a decline, though the evidence on which these graphs were built was scanty.

We took this point into account in spraying stables, both for hibernators and for active insects. There is no hard-and-fast line between the diet of elutus and that of maculipennis. Barber and Rice found maculipennis containing human blood. We were not making a refined scientific experiment to prove or disprove a point in entomology which has already been demonstrated. We were out to kill anophelines wherever we found them—and not only anophelines.

Reliable reports have demonstrated that domestic animals give better performances when freed from the attentions of biting insects. Cows give more milk, horses work better and keep in better condition.

With regard to DDT itself, its properties are well known now. To us the most important feature of this poison is the length of time of its residual action which can be controlled by the amount of DDT applied per unit area. Its deterioration appears in practice to depend on the physical removal of the crystals, rather than on a fall in its inherent killing power. Our own experiments demonstrated, under experimental conditions, good killing power over 300 days after application with 200 mg. per square foot, and the experiments suggest that one application in the spring would suffice for the whole season of transmission. It is not accurately known, however, how long this effect would be obtained in rooms subject to the normal routine of domestic dusting, cleaning, moving of furniture and the vibration of constant occupation.

Another important characteristic of DDT is its absence of toxicity for human beings, in ordinary practice. We are of the opinion that such skin troubles as have been reported are due to the vehicle—i.e., the oil or kerosene rather than to the DDT. One unauthorized experiment was carried out in Crete, where some 2,000 sufferers from scabies were anointed gently with 5 per cent DDT in kerosene. The epidemic cleared up quickly and the only two cases of skin irritation reported were immediately and satisfactorily dealt with by simple bathing with soap and water—removal of the cause. The other cases, mostly children, carried their inunction, without bathing, for from four to seven days and had no complaints.

At present, the price of DDT is probably higher than is reasonable. The demand is so great for agricultural use that it outstrips
the supply, with the inevitable consequences. It also seems that the amount necessary for human protection will be but a fraction of that employed in other fields. One does not like to use the word "exploitation", but it does not seem reasonable that an agent of such tremendous importance as DDT should be subject to no price control and may thereby be withheld from the widest use in increasing agricultural production as well as in preventing disease on a national scale.

It is known that research on new contact insecticides is being carried out in many laboratories. Chemists and entomologists may very well develop new products, giving, for instance, more rapid action. Completely stainless vehicles are required for the emulsions.

The writer, who is a hygienist with no claims to special malarialogical experience other than a year of close association with the DDT campaign of 1946, believes that this insecticide supplies the solution to the ancient malaria problem of Greece. If he is unduly optimistic in this opinion he is at least in good company and encompassed about by a cloud of witnesses.