RECENT MOSQUITO ERADICATION CAMPAIGNS

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UNFORTUNATELY, it is exceedingly difficult to exterminate insect pests over a large area (not to mention the whole world), because of their enormous numbers, small size, and powers of proliferation. Therefore, we have come to be satisfied with 'control' as an objective; and so far as mosquitoes are concerned, control measures are considered satisfactory if they reduce the mosquito population below the 'critical density' necessary for the propagation of disease.

In recent years, however, the feasibility of eradication of mosquitoes from large areas has been demonstrated by the remarkable work directed by Drs. F. L. Soper and D. Bruce Wilson in Brazil. Their two original campaigns seem to have been entirely successful in achieving their objectives; by a few years of intensive work it has been possible to replace widespread and continuous control measures by a relatively small and inexpensive 'quarantine' service.

It will be recalled that the two insects attacked were *Aëdes ægypti*, the yellow fever mosquito, and *Anopheles gambiæ*, the dangerous African malaria vector. Both these mosquitoes are comparatively restricted in their choice of breeding sites to places in, or close to, the haunts of man. Furthermore, *An. gambiæ* was not indigenous in South America (though it appeared to thrive in Brazil). For these reasons the problems were simpler than they might have been. This should not be taken to belittle the many difficulties of organisation, which were overcome so successfully as to provide a model for subsequent eradication schemes.

General Organisation of an Eradication Campaign

The first essential is a survey of the territory by an entomologist with experience of anti-malarial work. This survey is particularly important when the object of eradication is a mosquito not normally present, and where the area invaded must be defined. On the basis of the preliminary survey, and with the aid of large-scale maps, estimates must be made of the staff, equipment and supplies necessary.

The main attack is made against the larval stage of the mosquito. Every suitable breeding site in the entire eradication area must be treated periodically, to prevent breeding for a sufficient period to ensure extermination of the species concerned. Success depends upon the continued thoroughness of a large number of workmen recruited locally (and, possibly, of doubtful reliability). These men can seldom be directly supervised for more than a small fraction of their working time, owing to the vast scale of the operations. The only workable solution is to make each larviciding team (possibly consisting of only one man) responsible for a defined zone, and to have an independent checking service to assess the progress of the work in each zone. The zones are grouped together in sections, and these again into divisions in the charge of a small hierarchy of officers. The lower grades can be recruited locally and trained, whereas the higher ones should be experienced malariologists or at least biologists, medical men, or engineers. All officers must be able to speak the local language.

A highly important part of the organisation (which absorbs about 25–30 per cent of the expenses) is the checking staff, whose duties consist in continually searching for larvæ or adult mosquitoes. Those 'scouts' seeking larvæ systematically check the work of the larviciders; the scouts seeking adults visit suitable 'catching stations' such as human or animal houses likely to be frequented by mosquitoes. The reports of the searching staff provide a means of independently checking the efficiency of the larviciders and assessing the progress of the campaign; negative reports are, of course, as important as positive ones, but require more careful verification. Arrangements are made for specimens of larvæ or adult mosquitoes to be preserved and sent to an entomological laboratory at headquarters for identification.

In order to systematize methods and records, a considerable series of printed instructions and recording forms is necessary. Regional chiefs are required to know exactly what all their subordinates should be doing on any day, so that their activities can be checked by random visits from headquarters. The headquarters staff inevitably become largely occupied with ordering and distribution of equipment and supplies, the engagement and promotion of staff and the solving of difficulties which arise in the work. Once the methods have been decided upon, eradication becomes an exercise in administration rather than an exclusively scientific or technical occupation.

It may now be of interest briefly to describe and compare three recent eradication undertakings, which display some evolution towards more ambitious objectives. I was privileged to witness the latest one (in Sardinia) in its comparatively early stages.

Anopheles gambiae in Upper Egypt

In 1942 there was a severe epidemic of malaria in upper Egypt, followed by another in 1943. Conservative estimates place the number of cases at 200,000, with a death-rate around 10 per cent. The vector was found to be *An. gambiæ*, which does not normally occur in this region, though it is found in the Sudan. There is a possibility that the northern range of this mosquito fluctuates from time to time, and it may thus penetrate into Egypt. The invasion prior to the 1942 outbreak was very considerable, for the mosquito was found to be breeding along a strip of the upper Nile 850 km. (530 miles) long, and varying from 1 to 30 km. (20 miles) wide. The mosquito had some difficulty in maintaining itself in this area; the winter (December to March) is too cold, and the summer (April to August) is too dry. However, the autumn is warm and moist, and there is great proliferation during September to November. *An. gambiæ* certainly survived from 1942 until 1945 in upper Egypt.

To combat the mosquito, the Gambiæ Eradication Service was formed with funds supplied by the Egyptian Government, administered by Dr. S. Madwah, the eradication programme being directed by Dr. J. A. Kerr, of the Rockefeller Foundation. In addition, there were at various times thirty to fifty medical men or engineers supervising the work, the senior ones in charge of the ten main divisions. Smaller areas were under the control of inspectors (senior sanitary inspectors) and foremen. The earlier treatments with oil were changed to Paris Greening, which was cheaper and simpler in the circumstances. Some 300–1,000 labourers applied the insecticide, each man having a definite zone to cover, in which all breeding sites were treated weekly. The area of the

zones varied from 0·2 to 9·2 sq. km. The eradication campaign depended basically on the anti-larval attack, but, in addition, there was some house-spraying with pyrethrum against adults in malarious areas, and also spraying of vehicles to prevent insect transport. The progress of the work was watched from the reports of an army of 'larval scouts' and 'adult searchers'.

The Paris Green treatments began in August 1944, and reached a peak in October; the last specimen of *An. gambiæ* was found in February 1945. Treatments were continued for six more months, and then stopped in the most favourable mosquito season. A careful search was continued for three months, but no more *An. gambiæ* were discovered. It is important to note that whereas the invading *gambiæ* was eradicated, other mosquitoes native to the region gradually reappeared. They are evidently more difficult to exterminate.

Anopheline Eradication in Cyprus

The mosquito eradication campaign in Cyprus, organised by Mr. Mehmed Azis, is novel in two respects: it aims at extermination of all *indigenous* mosquitoes from the island, and it was begun without the impetus of a disastrous malaria epidemic. The programme was undertaken as a measure of permanent improvement of the state of the colony; since, in spite of its arid appearance in summer, Cyprus is highly malarial. The chief vectors are *An. superpictus*, which breeds in very small shallow pools, often difficult to find; *An. sacharovi*, a marsh breeder; and *An. bifurcatus*, which breeds in wells. The last-mentioned species presents a special problem, for the local people often resent the application of larvicide to their only source of water.

The eradication programme in Cyprus was different from the other operations discussed in that it was planned to cover the island in three sections, one in each year, with an overlapping protection fringe to prevent reinfestation of the zone under treatment. As a consequence, a smaller staff was required. The eradication was based on anti-larval measures, and *D.D.T.* solution was used for the first time in an eradication project. Treatments were applied weekly in the plains and fortnightly to sites above 2,000 ft. The areas covered by each larvicider were 25–80 sq. km. (10–30 sq. miles); these were divided into sections for treatment on the various days of the week. Only one or two litres of spray were required for each day's work, and the small amounts required were applied by hand atomizers. In addition to the larvicidal work, a limited amount of drainage work was done to eliminate marsh-breeding forms. There was an attempt to prevent transport of mosquitoes in vehicles by spraying them regularly at certain points on the main roads. The progress of the work was assessed, as usual, by an independent checking staff. In the first year (1946) the work was confined to the long narrow Karpas peninsula, which constitutes a seventh of the total area of the island. This relatively easy task was chosen for the first year to accustom the workers to their task. The Karpas peninsular was apparently cleared of mosquitoes in the first season and, at the time of writing, about half the remainder of the island has been dealt with in the second season.

Mosquito Eradication in Sardinia

Moderately serious malaria is endemic in Sardinia, about 10 per cent of the population suffering annually; this is worse than anywhere in Sicily or Italy. The only important vector is *An. labranchiæ*, which is found at greater altitudes than on the mainland. In 1946 it was decided to use certain funds acquired from the United Nations Relief and Rehabilitation Administration, and controlled by a commission of the Italian Government, to create a mosquito eradication organisation. This project was directed by Dr. J. A. Kerr* of the Rockefeller Foundation, International Health Division, with a British, American, and Italian headquarters staff. The island was surveyed in 1946 and eradication work begun in 1947. As before, the chief reliance was placed on anti-larval work which, as in Cyprus, is being done with 5 per cent *D.D.T.* solution applied from hand atomizers. The average-sized zone for treatment by one man is 10 sq. km., and this is divided into six sections, to be visited on successive weekdays. In contrast to earlier campaigns, an extensive *D.D.T.* house-spraying programme has been employed. About 90 per cent of all dwellings on the island have been spray-painted with a *D.D.T.* emulsion to give a residual insecticidal film. This will be repeated again in the early spring of 1948 and, possibly, in 1949.

The anti-larval work of the first year was confined to an area in the south-west, comprising about a fifth of the area of the island. This is for the training of operators and to test the organisation. In the following year it is proposed to cover the entire island and treat all breeding sites weekly throughout a thirty-six-week breeding season. The progress of the work will be judged from the reports of the usual checking staff, and in the third year of the planned programme, after the cessation of the anti-larval spraying, they will continue to search for mosquitoes to verify the eradication.

Discussion

The success of the earlier campaigns and the experience gained in them has led to the more ambitious objectives of the two latest projects. These involve three new difficulties: (1) the mosquitoes attacked are indigenous; (2) the mosquitoes attacked breed in sites remote from human habitations, and are quite ready to feed on mammals other than man; (3) in both areas there are considerable tracts of rough country, far from roads, to be treated.

To balance these formidable difficulties, there is the introduction of the powerful new synthetic insecticides and the fact that both areas are islands. The value of *D.D.T.* in the larviciding work is very great, for it substantially reduces the amount of equipment which may have to be carried all day over difficult country. The only insecticidal impedimenta required for a day's work is a hand atomizing gun and a litre or so of 5 per cent *D.D.T.* solution. *D.D.T.* has also been used for residual treatment of houses throughout the experimental area; but it appears to me to be of somewhat doubtful value in eradication when the vectors can be found breeding in large numbers in sites remote from houses. The disadvantage consists in the fact that all treated buildings are lost as catching stations; and, in eradication, the whereabouts of the last surviving mosquitoes is important. House treatment with *D.D.T.* is, admittedly, clearly of value in malaria control and it also has the advantage of killing other insect pests; the latter fact sometimes ensures the co-operation of the inhabitants.

* I understand that Dr. Kerr has retired for reasons of health and that Dr. J. A. Logan has taken his place.

APPROXIMATE OVERALL STATISTICS CONCERNING ANOPHELINE ERADICATION PROJECTS

Zone	Anopheline species	Area involved	No. of men employed	Total time	Cost £1,000's*
Brazil	*gambiæ*	?	2000	3½ yr.	530
Upper Egypt	*gambiæ*	4,100 sq. km. 1,500 sq. miles	4000	2 ,,	800
Cyprus	*superpictus, sacharovi,* etc.	9,300 sq. km. 3,600 sq. miles	100	3 ,,	15 (7 months)
Sardinia	*labranchiæ*	23,000 sq. km. 9,000 sq. miles	6000†	3† ,,	more than 500† a year

* On the basis £1 = 4 dollars = 2,000 lira.
† Estimates.

Some overall statistics of the anopheline eradication campaigns are given in the accompanying table. It should, however, be pointed out that such operations are very difficult to compare by the use of such overall figures, or by examining small-scale maps. For example, the area which can be covered by a single larvicider will depend not only on the number of breeding sites present and the ease of travelling, but also on accessibility from sleeping quarters. Some labourers may be unwilling to leave their homes and enter a temporary unusual occupation, especially if they have relatively lucrative local employment. For such reasons as these, there may be manifold differences in the difficulties encountered in such operations in different areas ; nevertheless, it cannot fail to be noticed that the Cyprus venture appears to be very much less expensive than the other ones.

It is too early to give an estimate of the chances of ultimate success of the campaigns now in progress. My visit to Sardinia strongly impressed me with the difficulties of adequately supervising work over such a large and inaccessible area. These latest eradication schemes demand all the faith and energy, as well as the technical and administrative skill, which are being devoted to them.

SCIENTIFIC RESEARCH IN THE BRITISH ZONE OF GERMANY

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FOR the second time within a period of thirty years, science in Germany is struggling for its existence ; but the problems of to-day are different from those of 1918, and so are the ways and means by which a solution is being attempted.

When, after the First World War, Germany had collapsed, the greatest menace to the maintenance of its scientific standing was, besides the financial weakness of the country, the severing of all international relations. German men of science had done more than their colleagues in other countries to help their Government, and especially the systematic study of the possibilities of poison gas as a method of warfare was deeply resented by the Allies. It took a long time before Germans were permitted to participate again in international meetings, the delay being largely dependent on the share taken in war-work ; German astronomers were admitted years before German chemists. In these circumstances, only a national effort could save the position of German science ; but the complete exhaustion of all the usual financial resources seemed to present an insurmountable obstacle. It was mainly the foresight, energy and organising genius of one man, Fritz Haber, to which the preservation of the high level of German science was due : while traditionally only the 'Länder' were the supporters of university activities, he convinced the authorities of the 'Reich' that in this emergency they had to provide ample funds for scientific work of every kind. Under his influence the Notgemeinschaft der Deutschen Wissenschaft came into being, and science in Germany continued to flourish.

To-day the material position of the scientific institutions in Germany is infinitely worse than it was after the First World War ; but, on the credit side, it can be stated that there is little sign of any moral discrimination between men of science inside and outside Germany. This is no doubt due to the fact that this time support of the Governments was certainly more whole-hearted in the Allied field, right up to the perfection of the most powerful weapon of aggression. Immediately after the armistice, contacts were made between the scientific workers of the Allied countries and their German colleagues. The first object was to obtain all possible information for the benefit of the Allies ; but these discussions could not fail to result in the awakening of the old spirit of international solidarity so sadly interrupted during the War, and to-day it is very pleasant to see the efforts made by the occupying Powers to reactivate scientific life and research in Germany. There are differences between the four zones of occupation, and in some regions the endeavour went mainly in the direction of uprooting and transplanting scientific installations and workers, instead of giving them a fresh opportunity in Germany. Moreover, it seems that even members of the universities who had been dismissed as a consequence of the unfavourable verdict of a denazification tribunal were often tempted by offers of employment in other countries, previous enthusiastic support of the Nazi war machine now being no obstacle. Much more evident, however, at least in the British Zone, is the understanding help given by the Allies to all attempts at reviving the scientific activities inside Germany.

As a consequence of the country's unconditional surrender it was entirely for the Allies to decide how much scientific research should be permitted in Germany. The rules were laid down in the Allied Control Council Law No. 25, the object of which is "to prohibit for military purposes scientific research and its practical application, to control them in other fields in which they may create a war potential and to direct them along peaceful lines". A number of subjects are specifically mentioned as prohibited : for example, applied nuclear physics ; applied aerodynamics ; ship construction ; the detection of objects by electromagnetic radiation. Work on other problems requires prior permission, as, for example, research on broadcasting and television, electronic valves, ball bearings, and radioactivity other than for medical purposes. Detailed regulations have been issued for the procedure according to which applications for permission, and periodical reports on the work done, have to be submitted to the Control Council.

It is clear that the effect of Law 25 on German science will depend on the spirit in which it is inter-