entific and Specialized Personnel an official advisory committee, finally known as the National Committee on Physicists and Mathematicians, with the primary function of advising local boards and appeal boards on the merits of scientific grounds put forward in support of requests for individual deferments. Our own contacts with this committee were notably short-lived, since our representatives began their services as members of the committee just in time to witness its dissolution as a result of bureau politics at their worst. The disappearance of this committee was a bitter disappointment, since it gave real promise of providing an intelligent, democratic and practical solution to our deferment problems. However, enough had been accomplished during the first half of 1943—even if at times the accomplishment was like that of a stubborn rear-guard—to secure our essential professional activities until the early months of 1944, when the sharp alteration of policy by the Selective Service System introduced a state of affairs with which most of those present are better acquainted than I am. The prevailing principles of Selective Service leave us very little room for present helpful activities, though there are few of us who fail to realize that those principles, if long maintained in operation, threaten the destruction of our supply of young scientists and technicians. It may therefore be anticipated that the current inactivity of the War Policy Committee in respect to draft problems will presently give way to renewed concern and renewed activity.

A problem which is, so far as the scientific professions are concerned, inseparable from the whole fundamental concept of Selective Service is that of the assignment of selectees to duty within the Armed Services after induction. It is certainly of the utmost importance for the national security that the training of the scientist should not be lost by virtue of his induction and subsequent assignment. In the case of doctors and medical scientists, the organization of both Army and Navy eliminates their diversion to other than medical service and thus insures against the waste of their professional preparation. In the case of other scientists, equally essential to the proper functioning of a modern military organization, this is not the case. Indeed, examples of vital needs for scientific personnel which remained unfilled while qualified scientists were occupied in the non-scientific non-technical duties of some earlier assignment are all too common. It is quite clear that the military services need to develop a flexible and accurate mechanism for segregating scientific personnel and reserving it for the technical requirements of the organization. I have no doubt that the Army and the Navy, on the basis of the lessons of this war, will find their own solutions for this problem. However, it remains a fact that during this war the problem has not been satisfactorily solved so far as scientific or other rare skills are concerned. I mention this matter in emphatic terms because it explains in part the resolution and firmness with which we have insisted in all our dealings with the Washington authorities that the mathematician employed in essential teaching or in essential war research, and also the student of mathematics preparing himself for such essential employment, should be given the greatest consideration for individual deferment under appropriate directives.

At the present time the War Policy Committee is working largely toward the future. It is plain that we shall meet many new and altogether different problems, some of which we can already recognize while others can still hardly be guessed.

To-night, however, my theme has been historical and I do not propose to venture into the realm of the future. At the historical level it has not been possible for me to give more than a rapid sketch of events, as I have seen them. You will all realize, I am sure, that a completely adequate account of these matters is not possible at the present stage. I hope you will agree with me that a thorough and painstaking history of this war period of American mathematics can and must be written when the time is ripe. With this thought in mind, I have taken the preliminary steps towards setting up a committee of the society to undertake this important task. We shall all await the fruits of its labors with the deepest interest—and also, of course, with patience.

MALARIA AND THE WAR[1]

By Lieutenant Colonel O. R. McCOY, M.C.,

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NEVER before have millions of men engaged in tropical warfare. Disease prevention, always a major factor in military operations, now must include protection from all maladies that thrive in warm climates. Of these, malaria is by far the most important.

The military prowess of malaria has been demonstrated in other wars, but never before has this great disease predator had such an unsurpassed opportunity to exert its influence on the armies of many

[1] Presented at the symposium on "Parasitology in Relation to the War," held at the meeting of the American Association for the Advancement of Science in Cleveland, Ohio, September 12, 1944.

[2] On leave from the School of Medicine and Dentistry, University of Rochester, Rochester, N. Y.

nations. In some sectors malarial parasites have caused far more casualties than enemy bombs and bullets. To-day large numbers of Japanese soldiers are "withering on the vine" weakened by malnutrition and rendered non-effective by malaria and other tropical scourges.

The Army first felt the impact of malaria during the defense of Bataan. On-the-spot observers estimate that more than half of the men were weakened by malaria at the time of the surrender. Malaria casualties made costly the early attempts to regain the Solomons and New Guinea. At one time several allied divisions were out of action because of repeated malaria relapses, and patients with the disease occupied 40 per cent. of the hospital beds. Lessons learned from these experiences have had beneficial effect on later campaigns. Great strides have been made in the prevention of malaria in military forces. These accomplishments will stand us in good stead, for highly malarious regions stand between our present positions and the Japanese homeland.

At war's beginning malaria upheld an unsavory reputation as the world's greatest disease scourge; this in spite of the fact that effective methods of prevention had been known for four decades. In some places, our own southern states, for example, malaria was on the decline, but in the great tropical belt little progress in control had been achieved.

Will the war alter the world picture of malaria? Will the movement of armies, the disturbance of civilian populations and the intercontinental flight of hordes of airplanes spread the disease and increase its ravages? Or will scientific discoveries made under pressure of war provide better weapons for world-wide control? Observations of the war to date tempt one to speculate on the answers to these questions, particularly in relation to the malaria situation in our own country.

DRUGS FOR THE PREVENTION AND TREATMENT OF MALARIA

Cinchona bark with its alkaloid, quinine, has been renowned as a specific for malaria for several centuries. Researches started in Germany during the last world war culminated fifteen years later in the invention of atabrine, a drug soon proved equal to quinine. Although employed in this country as early as 1932, atabrine at the start of the war was not well known to the American public or even among physicians. Quinine remained the commonly used remedy. The loss of the principal sources of cinchona bark to the Japanese with the fall of Java in March, 1942, abruptly altered the situation. Quinine supplies were limited to accumulated stockpiles, and atabrine had to be used to meet the urgent military demand for anti-malarial drugs. This enforced shift has not in any way been a military handicap. Army experience, backed by civilian studies, has shown that atabrine is in many ways preferable to quinine and just as free from undesirable effects. If unlimited supplies of quinine were now available, atabrine would remain the drug of choice for most military uses.

Neither quinine nor atabrine is an ideal anti-malarial, although either one employed in proper dosage promptly controls symptoms. Neither drug is a true causal prophylactic—that is, will destroy sporozoites and prevent mosquito-borne infection. Treatment with quinine or atabrine does not completely cure malaria caused by *Plasmodium vivax*. Relapses may occur regardless of dosage employed.

The search for a better anti-malarial than quinine or atabrine has been the subject of intensive effort beginning more than a year before the attack on Pearl Harbor. The Subcommittee on Tropical Diseases, formed by the National Research Council at the request of the Surgeon General, initiated a program which has included the synthesis of new drugs and the systematic testing of more than 8,000 compounds. These investigations have been conducted in civilian laboratories under projects approved by the Council of Medical Research and financed by the Office of Scientific Research and Development. Hundreds of scientists have contributed to this enterprise and many hundred thousands of dollars have been spent. Anti-malarial activity of some degree has been found in many groups of chemical substances heretofore not known to possess such properties. The ideal anti-malarial has not yet been found, but promising leads toward better drugs have been uncovered.

As a result of the intensive studies under the National Research Council program, better understanding of the action and effective use of the drugs now available for chemotherapy of malaria has been achieved. Through the work of Shannon and his associates it has been learned that atabrine must be given in relatively large initial doses in order to attain plasma concentrations sufficient to produce prompt clinical response. When administered in this manner atabrine equals the quick action of quinine when the drugs are given by mouth. Atabrine injected intramuscularly produces a high plasma concentration within a few minutes. Sufficient evidence, however, is not available to decide the relative effectiveness of atabrine administered intramuscularly as compared with quinine given intravenously for the treatment of cerebral malaria.

Allied armies have gained tremendous experience in the use of atabrine in the suppressive treatment of malaria. Thousands of men have been given small doses of atabrine regularly for many months to hold in check malarial infection which otherwise would incapacitate them. Much has been learned regarding the most effective methods of administration for this purpose. Dosages totaling 0.7 gram per week, almost twice the amount recommended before the war, are now commonly employed. No evidence has been obtained that long-continued usage in such doses causes any ill effect. The observation that suppressive (so-called chemoprophylactic) treatment will not prevent mosquito-borne infection with vivax malaria has been abundantly confirmed. Attacks of vivax malaria experienced after suppressive medication is discontinued have constituted the major portion of the Army's malaria problem.

On the other hand, the demonstration of the effectiveness of atabrine in preventing development of falciparum malaria has been an important finding in the experience gained since the start of the war. When atabrine is administered in proper dosage before, during and after exposure to falciparum infection, later appearance of symptoms is consistently prevented. Falciparum malaria, better known as malignant tertian or tropical malaria, has caused far less trouble than was anticipated. High standards of Army medical care have kept the death rate from this virulent form of malaria at an amazingly low figure.

The discussion of drugs can not be concluded without mentioning the important work of Drs. Woodward and Doering in accomplishing the synthesis of quinine. So far, only minute amounts of the drug have been produced, but the possibility of eventual large-scale synthetic production is opened up. Although new substances related to quinine may be discovered which possess greater anti-malarial activity, the synthesis of quinine by itself is not an answer to the Army's malaria problem. Atabrine is already available and is generally preferable. What is most urgently needed is a new drug which will prevent or effect a permanent cure of vivax malaria. The primary goal of the present research program is to discover such an agent.

MEASURES FOR CONTROL OF MALARIA

Control of malaria depends fundamentally on the prevention of bites by infected anopheline mosquitoes. A variety of means may be employed to attain this end. Draining, filling or larviciding of mosquito breeding places, screening of buildings and spraying of insecticides are among the procedures most widely used. The success of the Army in preventing malaria at base installations has been achieved chiefly by thorough and widespread application of these proven measures.

At the beginning of mobilization it was feared that rapid expansion of the Army might cause increase in malaria among troops in this country, since the majority were to undergo training in southern states where malaria was still endemic. The Army strengthened mosquito control at military installations and made arrangement for the U. S. Public Health Service to conduct control measures in a mile-wide zone surrounding the reservations. This huge program has continued for three years, and about 10 million dollars have been spent. Malaria rates have not only remained less than those for peacetime years, but in 1943 decreased to the record low of only 0.2 per 1,000 for troops stationed in the continental United States. Thus, mosquito control has effectively prevented malaria from becoming a threat to the Army in this country.

Prevention of malaria among troops in the field is much more difficult. Time, effort and adequate supplies are required to achieve mosquito control in newly occupied territory. Malaria survey and control units, commanded by specially trained parasitologists, entomologists and sanitary engineers, have accomplished remarkable feats in eliminating mosquito hazards at base staging areas overseas and in many places have extended their work into battle zones. Troops in combat, however, must rely chiefly on personal protective measures to prevent infection. The use of atabrine to suppress symptoms has already been discussed. Protective clothing, use of nets, repellents and insecticidal sprays are measures that the individual soldier must himself apply to prevent bites by infected mosquitoes. Education of all ranks and branches of the Army in the importance of malaria has been carried out by special training programs, lectures, moving picture films, posters and booklets. Unit discipline in the enforcement of individual preventive measures has proved to be the most important factor influencing malaria rates in front-line troops.

Before the war began a coordinated research program under the auspices of the National Research Council, financed by the Office of Scientific Research and Development, through the Committee for Medical Research, was undertaken at the request of the Surgeon General to develop better insecticides and repellents. The bulk of this investigation has been carried on by the Bureau of Entomology and Plant Quarantine of the U. S. Department of Agriculture working in cooperation with various other agencies. New insect repellents have been developed which, applied to the skin, retain their effect for several hours and are far better than any available to the Army before the war. They are efficient not only against mosquitoes, but also against mites, sandflies and other insect disease vectors. Another important wartime advance has been the development of the aerosol insecticide dispenser, more familiarly known as the "mosquito bomb." This handy one-pound device contains enough pyrethrum insecticide to kill mosquitoes in 150,000 cubic feet of space. Pressure from the inert gas freon discharges the insecticide in very small particles in the form of an aerosol which remains in the air for several hours. It is thus much more efficient than previously used flit-guns and is a weapon against insects that can easily be transported into forward areas.

The most outstanding advance in insect control during this war has been the discovery of the remarkable insecticidal properties of DDT—an abbreviation for the chemical compound, dichloro-diphenyl-trichloroethane. This substance, first used by the Army as a louse powder in typhus control, is also highly valuable as a mosquito larvicide and as an insecticide to kill adult mosquitoes. In recent months production of DDT has increased sufficiently so that large quantities are now available to the armed forces for mosquito control. DDT must not be regarded as a miraculous agent which will suddenly do away with the malaria problem, as some extravagant press reports have suggested. It does, however, offer promise of revolutionary methods of control which ought eventually to improve the malaria situation even in hyperendemic and poverty-stricken regions.

Full knowledge of the applications of DDT in malaria control is not yet attained. DDT is more toxic to mosquito larvae than any substance heretofore known. Consequently, it can be used in small amounts with resultant saving of time and effort in larviciding operations. The application for malaria control which is most promising, however, is its use in spraying the habitations of native carriers. When DDT in kerosene solution is sprayed on interior surfaces a residue is left which will kill insects lighting on the treated areas for several months. Since the destruction of infected adult mosquitoes constitutes the most effective break in the chain of transmission of malaria, this usage, with its long lasting effect, offers great promise for control of the disease in many tropical regions where it has been a principal cause of poor health and poverty. The world-wide postwar picture of malaria will be greatly changed by the advent of DDT.

Influence of the War on the Spread of Malaria

Disturbed conditions of war tend to favor the spread of infectious diseases. A double opportunity exists for increased dissemination of malaria. Many men infected overseas will harbor latent infections when they return to their homes, thus making possible the introduction of the disease into regions now malaria-free. A more important hazard, however, is the possible spread of dangerous mosquito vectors, such as *Anopheles gambiae,* into new areas.

The disastrous results which followed the introduction of *Anopheles gambiae* from Africa into Brazil a decade ago are well known. A vigorous campaign conducted by the Brazilian Government aided by the Rockefeller Foundation eliminated this menace to the health of the western hemisphere in 1940, but three years of effort and the expenditure of some millions of dollars were required before success was achieved. Strict enforcement of regulations regarding insecticidal spraying of aircraft have thus far prevented reintroduction of *gambiae* from Africa, although the volume of travel has increased a thousand fold.

Recent reports, however, indicate a threatening spread of *Anopheles gambiae* on the continent of Africa. While formerly confined to the upper Nile, this species in the last few years has extended its range down river into middle Egypt. The role of increased war travel in this spread is not clear, but it appears to be a contributing factor. Alarming epidemics of malaria have already occurred in this new *gambiae* territory, and potential calamity threatens the populous region of the lower Nile delta. The Rockefeller Foundation is again lending its resources and experience in a renewed battle against spread of this dangerous malaria vector.

Wartime activities change the malaria picture in parts of the Pacific. For example, clearing of jungle undergrowth at base areas in New Guinea has favored the propagation of *Anopheles punctulatus,* which prefers sunlight in its breeding places. Shell holes, bomb craters and road ruts create other new breeding places. Most of these man-made influences on the malaria situation will, of course, gradually disappear as the armies move on. A hazard of greater importance is the possible introduction of anophelines into Pacific islands now free from malaria. Hawaii, Samoa, Fiji and other island groups in the central Pacific have never suffered from malaria because anopheline mosquitoes to transmit the disease are not indigenous. Introduction of a potent vector in these places would be a disaster. Unceasing vigilance is necessary everywhere to prevent spread of insect disease vectors by aircraft. A commission composed of representatives of the Army, Navy and the U. S. Public Health Service has been investigating the new hazards of disease introduction resulting from modern advances in transportation. Quarantine regulations will be strengthened where indicated.

The possible spread of malaria in this country by returned soldiers has caused public concern. However, the possible introduction of anopheline species which are efficient carriers of malaria is potentially more dangerous. The efficiency and abundance of mosquito vectors have greater influence on the prevalence of malaria than changes in the status of the human reservoir. The hazard of the establishment of foci of malaria in places now free from the disease is real and can not be overlooked. Chief efforts of public health authorities should be directed toward the elimination of anopheline mosquitoes. Attempts to regulate the location and movement of possible carriers of malaria meet many practical difficulties and offer slight hope of producing fruitful results.

Members of the armed forces who have had malaria overseas will receive adequate treatment before discharge. It is true that many may still harbor latent infection and may suffer a relapse at a later date. At present no drug is known which will completely eliminate the parasite and no means are available to detect those who may continue to harbor a latent infection. Many individuals suffer only a single attack of malaria, and among those who relapse the chance of subsequent attacks continually decreases. It appears safe to estimate that probably 80 per cent. of men in the services who have had malaria will be entirely free from the disease at the time they are discharged. To attempt follow-up of servicemen merely on the basis of a history of having had malaria would result in much wasted effort.

A concerted campaign against *Anopheles quadrimaculatus,* the only important malaria vector in the United States, is the most feasible and effective effort that can be made in this country. Such a program is already planned by the U. S. Public Health Service. Cooperative mosquito control projects by state and local agencies will contribute greatly to reduction of our malaria problem. Not only will chance of the establishment of new foci be lessened but, more important, the control of the disease will be strengthened in areas where it is now endemic. Improved diagnosis and reporting of malaria, especially in states where it does not now exist, will enable prompt recognition of outbreaks and immediate institution of mosquito control measures. If proper measures are employed, extension of malaria in this country should not occur as a result of the war. During the past few years malaria has decreased to the lowest level ever recorded, both in the military and civilian populations. With properly directed efforts in mosquito control this decline should be maintained, and it is reasonable to hope that malaria may some day be completely eradicated from the United States.

The war has given tremendous impetus to the study of malaria, to the search for new drugs and to the development of improved methods of control. The gains from wartime advances in knowledge of malaria and its prevention appear to far outweigh the adverse effects of the war in spreading the disease and its vectors. Our armies are demonstrating that white men can invade the tropics and conquer malaria. The world can look optimistically toward more effective malaria control in the postwar years.

OBITUARY

MAURICE COLE TANQUARY

MAURICE COLE TANQUARY, professor of entomology (apiculture) in the Department of Agriculture of the University of Minnesota, St. Paul, died in the University Hospital on October 25, after an illness of over a month.

Professor Tanquary was born on November 26, 1881, and was reared on a farm near Lawrenceville, Ill. As a young man he taught in public schools and began his college work at Vincennes University. Transferring to the University of Illinois, he received the A.B. degree in 1907. He continued as a graduate student and as assistant in zoology and entomology at the University of Illinois, receiving his M.A. in 1908 and his Ph.D. in 1912.

On completion of his doctorate he was appointed instructor in entomology in the Kansas State College of Agriculture but in 1913 was given leave of absence to join the Crocker Land Expedition as zoologist. Returning from the Arctic in 1916 he was advanced to an assistant professorship at Kansas State College and to associate rank in 1919.

Later in 1919 Professor Tanquary was made state entomologist of Texas and chief of the division of entomology in the College of Agriculture and Mechanic Arts, holding these positions until 1924. In 1928 he was appointed professor of entomology at the University of Minnesota.

In early life he became much interested in the habits of insects. His first published paper reported experiments on the adoption of *Lasius, Formica* and *Polyergus* queens by colonies of alien species. His doctorate thesis, published in 1913 in the *Bulletin* of the Illinois State Laboratory of Natural History, was entitled "Biological and Embryological Studies on Formicidae." It was natural that as he advanced in economic entomology, he devoted more and more attention to the problems of beekeeping and of honey production.

The result was a determination to devote himself to this field. He resigned his position in Texas in 1924 and established in North Dakota a large commercial apiary, where he continued his studies on the habits of bees and bee management unhampered by other