EDITORIAL SECTION

MOSQUITO CONTROL IN RETROSPECT AND PROSPECT*

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Man probably always has been plagued by mosquitoes. Fossil specimens indicate that there were *Culex* species on earth long before the appearance of human beings. Our forebears in their caves probably slapped these irritating insects and used smudges to stupefy them, even as do Australian aborigines today, in their haystack igloos in Arnhem Land of Northern Australia.[1] Very likely the first method of mosquito control was hand-killing and the second, the use of repelling and stupefying smoke.

Mosquito repellents also probably date back many centuries. Certainly, all primitive peoples in the tropics employ materials such as mud, coconut oil, fish oil, and infusions of certain plants to protect their skin from insect bites. These home-made repellents have some value although not much more than any of the 1,001 concoctions which were suggested by scientists prior to World War II. Now, thanks to the studies of the Orlando and other laboratories during and since the war, there are mosquito repellents of practical value.[2]

Perhaps next in man's armamentarium for mosquito control came mosquito nets. Ross[3] tells us that Herodotus, the Greek historian who lived in the fourth century before Christ, was surprised when he first saw bed nets in Egypt. Ross also quotes Horace as having once said, "And among the military standards, oh, shame! the sun sees a mosquito curtain." I am not sure just what Horace meant. The passage quoted could mean that as the sun rose and the standard bearers grouped together to lead the way into battle, some laggard, comfortably sheltered beneath a mosquito net, was oversleeping. Horace may have been heaping shame on late sleeping rather than on the use of bed nets. However, a Roman poet called Propertius, in the first century before Christ, apparently used the word "disgraceful" to describe these mosquito curtains. He and others seemed to think them unmanly. Even today, in and out of the Armed Forces, I have encountered the same phenomenon—a behavior characteristic worthy of study by psychologists. But despite this handicap, mosquito curtains have come to be used in all parts of the world, at least among the well-to-do. They are still beyond the purchasing power of the average tropical peasant.

No date can be named for the time when the use of netting was extended in scope from protecting a sleeping individual to making an entire room or house safe from mosquitoes, but this must have occurred many years ago. Wire screen cloth was manufactured at least as early as 1857.[4] Today there are marketed many different kinds of screen cloth made from threads of cotton, of local fibers such as sinamay and hemp, of plastics, and of metals like steel, copper, bronze, monel and aluminum.

Another ancient mosquito control measure is drainage. It was used in Italy back in the early days, although doubtless at first it was largely employed for agricultural purposes.[5] We have no certain evidence that a relationship was observed in ancient times between drains and mosquito abatement, but the relief from pest mosquitoes after swamp drainage is often so spectacular that it must have been noticed. When Columella, in the first century B.C., wrote that bogs breed insects

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armed with stings, he was very likely referring to mosquitoes.

A more recent mosquito control measure is the use of larvicides. We know that in 1793 oil—possibly whale oil—was used in Philadelphia rain barrels to kill mosquito larvae. Howard tells us that as a boy in 1867 he used kerosene to kill mosquito larvae in a water trough in Ithaca and in 1892 he conducted careful experiments on a mosquito breeding pond.[6]

Petroleum was an ancient discovery. Herodotus described oil pits near Babylon and Pliny mentioned the use of oil for illumination in Sicily. In the 13th century, Marco Polo referred to the oil springs of Baku. Petroleum was described in America in the 17th century. It would be surprising if no one prior to 1793 had noticed that petroleum will kill mosquito larvae. However, the active growth of the petroleum industry did not begin until about 1860 and the extensive use of oil larvicides dates from the days of Gorgas and LePrince in the Panama Canal Zone, after 1904. Since then, tremendous quantities of oil have been used in all parts of the world against all types of mosquitoes.

In 1921, Barber and Hayne demonstrated Paris green as an *Anopheles* larvicide and this chemical has had very wide usefulness all over the world.

Many other insecticides have been used against mosquito larvae and adults in modern times. Pyrethrum powder, for instance, was introduced into Europe from Persia early in the 19th century and into this country in 1860.[7] Kerosene extracts of pyrethrum have been popular for decades as household sprays and during the 1930's this insecticide was developed into a very useful community weapon for spray-killing mosquitoes.

Since 1942 we have had DDT, thanks to Swiss scientists, to the Allied Armed Forces, to the Orlando laboratories of the Bureau of Entomology and Plant Quarantine, to the Tennessee Valley Authority, to the U. S. Public Health Service laboratories in Savannah, and to many other investigators and demonstrators.[8] This modern insecticide opens a new era in mosquito control.

As mosquitocides have become more potent, so too, methods of application have improved, and there are now available a wide variety of instruments and technics, ranging from small hand sprayers to modern spray-distributing helicopters. In the year 1947, for example, aircraft in the United States dispersed mosquitocides of one kind or another on a cumulative total of more than a million acres.

So much for weapons, now for landmarks. Until the work of Ross and the Italians in 1898, mosquito control was carried out simply to abate personal or public nuisances. Then came the revelation that mosquitoes can act as vectors of malaria, of yellow fever, and of other diseases. This landmark led to the magnificent anti-mosquito campaigns of Gorgas, LePrince, Carter, and their colleagues in Havana and Panama, of Watson, Hunter, and Scharff, and others in Malaya, and of enterprising health officers from Hong Kong to Rio de Janeiro.

Between 1900 and 1910 when such excellent work was being done in certain tropical lands, relatively little mosquito control was accomplished in the United States, aside from small projects on Staten Island, New York, and in California, and in a few other places. One local achievement, however, was the stamping out of yellow fever in New Orleans in 1905 by means of anti-mosquito measures. But most observers at that time felt that the disease was controlled more by isolating patients from mosquitoes than by destroying the insects. Probably as late as 1910 a majority of scientists in the United States had serious doubts about the practical value of Ross's doctrine of mosquito reduction to control mosquito-borne disease.

In 1913–1916, the U. S. Public Health Service carried out in Roanoke Rapids, N. C., and in Electric Mills, Miss., successful demonstrations of malaria control by anti-mosquito measures. About the same time, this Health Service, in cooperation with the International Health Board of The Rockefeller Foundation,

completed other successful and useful demonstrations in Arkansas.

Then the United States entered World War I. Immediately there revived memories of the disastrous effects of malaria and yellow fever in the Civil and Spanish-American Wars. There was serious concern that a concentration of recruits in southern camps might lead to epidemics of mosquito-borne diseases. This well-founded fear stimulated a large anti-mosquito project carried out within cantonments by the Army and Navy and, in extra-cantonment areas, by the U. S. Public Health Service. During the period of the first World War there were no fewer than 43 anti-mosquito projects in 15 states, protecting one and three-quarter million civilians and over 800,000 constantly changing Army and Navy personnel. While not perfect, the results of this project, a landmark in mosquito control, were impressive and led to progress which has continued to this day.

Another landmark had been the demonstration by Watson [9] in Malaya that Ross's strategy of malaria control by general mosquito reduction could profitably be modified to prophylaxis by *species control.* It is not necessary to fight all mosquitoes but only the particular species which are dangerous or troublesome. Watson thus brought mosquito control into focus. Samuel Taylor Darling in Panama as well as in the United States, Hackett and Missiroli in Italy, and many others in various parts of the world soon proved the practical value of Watson's demonstration.

The organization and practical success of the New Jersey Mosquito Extermination Association, and similar projects in Florida, California and elsewhere, proved the economic value of dealing energetically with pest mosquitoes.

But even as late as 1936, one was forced to conclude that man did not know how to control malaria or mosquitoes in the rural tropics at a price the people could pay on a routine community-budget basis. There were no financially feasible malaria control measures for areas of low economic levels.[10] Costs of control procedures available for such places were 50 cents to $2 or more per capita per year. To be practical the cost in the average rural tropical community must not exceed 10 cents per capita per year. Others agreed with this observation.[11] Then in South Africa was developed the pyrethrum spray-killing of adult *Anopheles.* The method had wide usefulness. Soon, for example, it was demonstrated that malaria could be controlled in an average South India village for as little as 8 cents per capita per year.[12] This is a practical figure in such areas. Now, with the added values of residual DDT, one feels certain that malaria control by an attack on the adults of vector anophelines is today economically feasible for many tropical communities, rural and urban.

The demonstration by Soper and Wilson and the Brazilian Malaria Service, in 1939–1940, showed that a species of *Anopheles* can be completely eradicated from an area.[13] One large factor in the success of this project was the previously successful demonstration of the possibilities of *Aedes aegypti* eradication by a nation-wide anti-*Aedes* organization in Brazil between 1926 and 1940.[14] Both personnel and training from the first project were used in the *Anopheles gambiae* compaign.

The extirpation from Brazil of the African species, *A. gambiae,* was a sanitary triumph and suggested the possibility of eradicating other vector species. Today, for instance, there are active projects in Sardinia and Cyprus which are designed to eliminate entirely the local malaria vectors. Whether this will prove to be economically feasible in an average area remains to be seen, but it is a bold and promising concept.

As in the first, so throughout the second, World War, mosquito control was given a great deal of attention and the Armed Forces were able to deal with pest and vector species under all sorts of conditions in every part of the world. All

the accepted weapons were put to full use, and new ones were developed.

During World War II we learned again that mosquito control is never automatic or simple. It requires law and persuasion, organization and training, money, supplies, and technical application. In civil or in military life, mosquito control requires a professional organization to survey, plan, perform, supervise, and maintain the numerous technical procedures continuously required.[15]

A project called *Malaria Control in War Areas* was organized by the U. S. Public Health Service in March of 1942. In cooperation with several state health departments, this program was successful in controlling anopheline mosquito production in extra-cantonment zones of military and war-connected establishments. No fewer than 2,000 such zones were under control by the end of 1944. The project was enlarged in 1945 into what was called *The Extended Program,* designed not only to continue to protect military cantonments but also to guard against the hazard of malaria outbreaks due to malaria carriers returning from overseas. Having protected soldiers from civilian malaria during the war, the project was extended to protect civilians from military malaria. This objective was fully met and there were no malaria epidemics in the United States in 1945, 1946, or 1947.

In July, 1946, Malaria Control in War Areas and The Extended Program were merged into a new U. S. Public Health Service project called *The Communicable Disease Center.* This undertaking embraces much more than malaria control, yet in the latter field its aim is no less than the eradication of endemic malaria in the continental United States. Under the auspices of C.D.C. and in cooperation with various states and counties, there were over two million house sprayings with DDT in the southeastern United States in 1947. This was a most important and concentrated attack on *Anopheles quadrimaculatus.* Here is another conspicuous landmark in the history of malaria and mosquito control.

But where do we go from here? Obviously, malaria will soon become a rare disease within the continental United States. Moreover, DDT is reducing malaria to modest proportions in Greece, and it bids fair to do the same in Italy, in Venezuela, and in several other traditionally malarious areas throughout the world.

In the future, therefore, we may not always expect to obtain funds for mosquito control on the basis of the need for malaria prophylaxis. So, where malaria appears to be a vanishing disease and monies for mosquito control are still budgeted under items for malaria prophylaxis, it would seem to be a forward step to change the budgetary designation. Where residual DDT is being applied on a malaria control basis, it would be good strategy to widen the concept to one of routine sanitation of premises, stressing the broad insecticidal benefits of DDT rather than simply protection from chills and fever. Otherwise those who control the funds may ask why a malaria budget is required in the absence of malaria. Although it has importance, the argument that we want to prevent reappearance of malaria may not carry sufficient weight with the short-memoried public.

Another point which should be noted is the danger that we may be so impressed with DDT that we will neglect naturalistic methods and such substantial anti-mosquito works as drainage and water regulation. One of the great lessons to emerge from the outstanding Tennessee Valley Authority malaria control experiences has been a demonstration of the value of building malaria control into a project—into the very dams and reservoirs themselves. We must emphasize that DDT does not obviate the need for permanent mosquito control measures in many areas.

Finally, it seems to me that those of us who are interested in mosquito and malaria control must begin to stress the fact that although chills and fever are no longer a major problem in the United States, yet malaria as a disease has very

great importance to this country. There are at least four basic reasons. These are (1) national defense, which contemplates the possibility that our Armed Forces may some day have to deal again with malarious areas; (2) world food requirements—there is a vital need to open up malarious areas to greater food production; (3) needs of American business—it is expanding into malarious countries at an increasing rate; (4) the increased cost to us in dollars and cents of every product we import from a malarious country. It seems to me likely that our imports from malarious countries carry a hidden malaria tax of about 5 per cent. If this be true, then in 1938, for instance, malaria in the 29 malarious countries from which we bought needed products cost us over 175 million dollars.

Just as England was and is willing to spend large sums of money on malaria research although malaria is not a problem at home, so we should take a broad view, reorienting our thinking as regards this mosquito-borne disease which is still one of the most important in the world. The power of DDT and the reduction of malaria in the United States must not be allowed to mislead us into a belief that the mosquito and the malaria stories are ended. Our children will hear a good deal about the seriousness of malaria in tropical Africa and Asia and in certain other areas from which we must obtain vital foodstuffs and other necessities. Moreover, the conquest of pest mosquitoes even in this country is still a problem of great importance. No, we are not at the end of the mosquito control road. We have a long and difficult journey ahead and we shall need the help of basic research and original thinking for many years to come.

We must set our sights high and aim at nothing less than the complete control of pest mosquitoes in the United States, and the subjugation of mosquito-borne disease throughout the world. Such concepts today are not absurd; they are bold but practical. The Expert Malaria Committee of the World Health Organization expects to draft plans for a world-wide attack on malaria. The American Mosquito Control Association might well consider drafting, with the help of local societies, a comprehensive nation-wide plan for dealing with pest mosquitoes at home.

The United States is now the world's paramount nation. As an English economist has said, we hold the keys of life and death, we have unparalleled power to influence the course of civilization in cultural, industrial, and political development. In the specialized field represented here today, let us do what we can to keep the United States in the vanguard of research and development, looking forward to that day when not only our own land but the world itself will be rid of crippling mosquito burdens.

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