MOSQUITO CONTROL PROBLEMS IN JAPAN *

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People who have lived from infancy in areas of heavy mosquito infestation become inured to insect attack and more or less indifferent to their presence. This is particularly true where the presence of large numbers of mosquitoes is connected with the production of the basic food supply. In Japan, as in many oriental countries, rice is the staple food, and the rice fields produce tremendous numbers of mosquitoes each summer.

While rice growing is responsible for the greatest production of mosquitoes, the Japanese provide plenty of breeding places for mosquitoes in their cities and towns, with the result that both rural and urban areas are infested. As the Japanese houses are not screened, mosquitoes are a commonplace condition, indoors or outdoors in the evening and at night. Prior to the American occupation, little or nothing was done to control them. A considerable period of education will be necessary before the Japanese people will develop any strong desire to eliminate these pests and disease transmitters.

Basically, the mosquito control problem in Japan can be divided into three main sections:

1. The rice field problem
2. The container problem
3. The foul water problem

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† Mr. Gray (who is also Lecturer in Public Health in the University of California) was sent to Japan during the summer of 1946 by the Surgeon General of the United States Army as Consultant to the Secretary of War, to work with the Commission on Virus and Rickettsial Diseases, Army Epidemiological Board, on problems of mosquito control affecting our military forces and the Japanese civilian population. The members of the Commission present in Japan at the same time were Albert B. Sabin, M.D. (University of Cincinnati), Field Director, and R. Walter Schlesinger, M.D. (University of Pittsburgh), virologist.

In the first section, the two principal species are *Anopheles hyranus sinensis* and *Culex tritaeniorhynchus*. The first is the malaria vector in Japan, and the second is the presumed and probable vector of Japanese B encephalitis.

In the second section, the principal species are *Aedes albopictus*, the dengue vector, and *Aedes togoi*. A very few *Aedes aegypti* have been found on one small island off the coast of Kyushu Island.

In the third section the principal species are *Culex pipiens pallens* and *Armigeres obturans*. On Kyushu Island *Culex quinquefasciatus* is also fairly numerous.

It is only necessary to fly over the Japanese islands to appreciate at once the magnitude of the rice field mosquito control problem. Except in the mountains, the rice fields are everywhere, and rice growing is obviously the dominant agricultural pursuit. Even in mountainous areas, rice is grown on terraces in the steep, narrow valleys. In view of the tremendous extent of the rice fields, several factors concerning mosquito control therein are at once apparent.

1. As rice is the basic staple food of the islands, the methods of mosquito control adopted must not curtail or damage the rice crop.
2. In a country where poverty among the rural people is normal, and where as a result of war the entire nation is impoverished, any mosquito control methods must be very low in cost.

Other factors which become apparent on further study of the problem are:

3. The Japanese have practically no governmental employees who are reasonably well trained in sanitation, and particularly in mosquito control, especially at the local and provincial levels. Therefore mos-

quito control measures must be reasonably simple in principle and in method of application, and be capable of being applied by rice-farmers and local government officials who have little technical training.

4. The comparative scarcity of mechanical or power equipment precludes the possibility of using some methods which are very effective under American conditions (airplanes, power sprayers and excavators).
5. The cost of application of larvicides would be very high in relation to the net income of the agricultural population.

The only immediately apparent possible control measures appear to be a cyclic intermittent flooding and draining of the rice fields during the growing season, and possibly the introduction of larvicidal fish, such as *Gambusia affinis*. Both methods have been recommended for preliminary trial in circumscribed areas, on an experimental basis. The idea of intermittent drying is not new to the Japanese, but intermittent drying in predetermined cycles for the control of mosquito breeding apparently has not occurred to them. The government can establish such cycles and enforce them. Neither is the idea of fish in the rice fields new in Japan, but the fish at present are food types, and they are of little effect in controlling mosquito breeding.

It is not probable that either of these methods, alone or in combination, will completely control mosquito breeding in the rice fields, but they should reduce the output very greatly, probably to a point where the mosquitoes would not be an appreciable factor in disease transmission. In limited areas where either malaria or encephalitis is a problem, supplemental larviciding, plus DDT residual spraying of houses and animal quarters, may be necessary and may be a justifiable expense.

The endemic malaria areas are rather limited in extent and occur principally in central Honshu. It is probable that malaria cases will increase appreciably during the next few years, due to infected military personnel repatriated from tropical regions. Encephalitis has been at a low ebb since 1942, but even in years of greatest prevalence it was limited in its highest incidence to the prefectures along the Inland Sea.

A reasonable reduction in numbers of the two rice field species would certainly make a worth while contribution to human comfort and efficiency in the rural areas of Japan, as well as helping greatly to reduce disease prevalence.

The container breeding group of mosquitoes in Japan is more important than had heretofore been anticipated. Prior to the war, dengue fever had not occurred in the main islands, but in 1942 it appeared as a small epidemic at Nagasaki, and in 1943 and 1944 spread greatly, eventually reaching as far north as a little beyond Tokyo. It appears probable that there were about half a million cases of dengue in Osaka in 1943. Nothing is known or can be surmised as to its prevalence in 1945, owing to the destruction of the Japanese cities, the loss of medical records, and the displacement of the population. It was practically absent in 1946.

The dengue vector in Japan is *Aedes albopictus,* which is quite numerous on Honshu Island as far north as a little north of Tokyo, and on Kyushu and Shikoku Islands, and on the Ryukius. It is typically a breeder in clean water in all kinds of containers, especially under shade or part shade. Its close relative, *Aedes togoi,* which is one of the most numerous mosquitoes in the islands, breeds under similar conditions but appears to stand more sunlight.

Probably both *albopictus* and *togoi* were far more numerous than normal in Japanese cities during the war, for the reason that a large number of houses had concrete tanks (about 3′ x 2′ x 2′) for holding water for fire protection. Judging by the results, these tanks were of little help to the Japanese, but were a tremendous help to the mosquitoes. One of the first steps in the occupation was a requirement that these water tanks be turned upside down, or broken, or filled with earth, and this directive was fairly well complied with, so that the prevalence of *albopictus* and *togoi* in 1946 was apparently much less than normal.

Further prolific breeding sources of *albopictus* and *togoi* are the numerous cemeteries. Some of these, for example at Kobe, are tremendous. Each monument has several depressions and holes in the stone, which contain water practically throughout the year, and in addition, narrow conical flower holders are stuck in the ground in front of the monument. Each bit of water may contain only a few larvae, but the aggregate output of mosquitoes is apparently enormous. This condition has been fairly well corrected by requiring the cemetery caretakers to fill all these holes with coarse sand or fine gravel.

The Japanese are not peculiar in using cemeteries as mosquito nurseries. Most so-called civilized people do so. It is a strange commentary on human intelligence that the graves of the dead are permitted to bring death, disease and discomfort to the living.

The foul-water group of mosquitoes has breeding habits which vary from our own domestic *Culex pipiens*, in that these species seem to tolerate more sunlight than does *Culex pipiens (molestus?)*. The liquid manure tanks in the rice fields and other agricultural areas are usually uncovered or partly covered and *Armigeres obturans* seems to breed readily there in nearly full sunlight, though it apparently prefers shade. *Culex pipiens pallens* definitely prefers shade or darkness, and is seldom found except in shaded polluted water. With the large numbers of benjos and liquid manure tanks in Japan, plus many other places in which foul water collects, the numbers of these two species is generally great, both in urban and rural districts.

Until the Japanese abandon the use of human excrement for fertilizer or change greatly their present methods of using it, there will be considerable difficulty in controlling these two species in the rural areas and in the unsewered portions of their cities. Several changes in methods have been proposed, including mosquito-proof digestion tanks, and the use of dry composting processes.

Observations on the breeding and feeding habits of the principal species of Japanese mosquitoes indicate that reasonable reductions in numbers, which can be obtained at very moderate expense, should result in an appreciable reduction in mosquito transmitted disease in Japan. For example, *Anopheles hyrcanus sinensis*, the dominant anopheline, has a marked preference for large animals as compared to man. Only its tremendous numbers under uncontrolled breeding makes it an effective malaria vector. Intermittent cyclic drying of the rice fields should result in a reduction of at least 80 per cent in this species, and a rapid drop in the malaria case rate in the endemic malaria areas. The use of DDT residual spraying in animal barns should result in a very obvious further reduction in their prevalence, as these quarters are the favorite day-time roosting places for this species.

Intermittent cyclic drying of rice fields should also effect a great reduction in the numbers of *Culex tritaeniorhynchus*, the presumed and probable vector of Japanese B encephalitis. This mosquito, according to observations made in 1946 at Okayama by Dr. Manabu Sasa, an entomologist employed by the Commission on Virus and Rickettsial Diseases, Army Epidemiological Board, has a definite preference for direct sunlight on breeding water, a fact which explains the appreciable reduction in numbers of this species toward the latter part of the season when the rice has grown sufficiently high to exclude sunlight from the water surface in the rice fields. Cyclic intermittent drying as a control measure would therefore be most important during the early part of the rice growing season.

Dr. Sasa's observations indicate that *Culex tritaeniorhynchus* feeds principally on man, horses, cows and goats, which suggests again the possibility of this species as an encephalitis vector.

Japanese B encephalitis, while it was present in epidemic form in 1924 and 1935, has apparently been almost absent in Japan in the past several years, and was certainly almost non-existent in 1946. Not a single case occurred in the American forces in Japan, though a few cases did appear among unvaccinated military personnel in Korea. Only one serologically proven case in a Japanese occurred in Japan, and immunological tests on several groups of children indicated that no infection occurred in such groups in 1946. It appears probable that this disease requires very large numbers of vector mosquitoes for effective transmission, and therefore a moderately high percentage reduction in the numbers of *Culex tritaeniorhynchus* may be effective in preventing infection. However, there are too many unknown factors in the epidemiology of Japanese B encephalitis to warrant any positive statements as to its control. A great deal of further research is needed in regard to this rather baffling disease.

It appears very doubtful to the writer that *Culex pipiens pallens* can be an effective vector of encephalitis or any other disease, as it is a very hesitant biter of humans, and appears to be attracted principally to birds, especially chickens. Certainly there is no comparison between it and our fairly aggressive *Culex pipiens (molestus?)* in the United States.

Both *Aedes albopictus* and *Aedes togoi* are fairly aggressive biters, and *albopictus* would not have to be especially numerous to be an effective vector of dengue. It appears probable that the measures now being taken by the Japanese local governments, under the supervision of the American military government teams, should so greatly reduce the prevalence of *albopictus,* and incidentally of *togoi* also, that large epidemics of dengue may be unlikely in the future.

The mosquito control problem in Japan is one of considerable magnitude, but capable of solution in time. A fairly good start has been made on the control of the container breeding species. It should be possible, by the use of intermittent cyclic drying, possibly supplemented by the introduction of larvicidal fish, to very greatly reduce the tremendous numbers of the two disease vector species in the rice fields, within a period of perhaps ten years.

Two principal difficulties present themselves, aside from the inability of the Japanese people to defray the cost of mosquito control by American methods. One is the ignorance of, and indifference to, mosquitoes by most of the Japanese people. This can be overcome by popular education, and the Ministry of Welfare is undertaking a program of education which should be helpful.

The other difficulty is the scarcity in local governments of technically trained sanitation personnel, who can put into effect actual mosquito control programs. It will take many years to train such personnel and get them into the health departments of the local governments. Some small attempts at training Japanese personnel in mosquito and rodent control have been made by the Public Health and Welfare Section under the Supreme Commander of the Allied Powers, particularly a training school conducted at Kyoto in April, 1946, but the surface of this problem barely has been scratched.

Each local government unit is required to have an insect and rodent control team. These teams are supervised in their work by the American military government teams. In some areas good results are being obtained, but in many little or nothing is accomplished.

In summary, Japan has a definite mosquito transmitted disease problem, but owing to impoverishment of the people the means to combat this situation are very limited. Simple and relatively inexpensive measures can be put into effect which should greatly reduce both the health hazards and the discomfort caused by mosquitoes. Time will be required to educate the Japanese people as to the benefits of mosquito control, and especially to change some of their basic habits in general sanitation. Under American occupation a start is being made toward more healthful and comfortable living in both urban and rural regions.

THE NONSPREADING OF LARVICIDAL OILS ON FLORIDA WATERS

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During the summer of 1943 intensive small-scale field tests were conducted in central Florida to determine the effectiveness of various DDT formulations on the control of anopheline larvae (1). These tests showed that a promising treatment consisted of spot applications of solutions containing 5 per cent of DDT in fuel oil or used crankcase oil. In September, shortly after the summer rainy season, it was found that the oils were not spreading on many of the roadside ditches, borrow pits, and small ponds in which anopheline breeding was still continuing at a high level.

A preliminary survey indicated that oil would not spread in one out of every four ponds. No particular condition, plant association, or other characteristic could be observed which seemed to be associated with this phenomenon. The oils spread freely in ditches on one side of the road and not on the other side, and on some parts of a pond and not on others. Frequently spreading would occur in the center of an open pond, but as the wind drifted the oil film into the vegetation and flotage where breeding was taking place the oil collected into ropelike masses. In one place, where oil from a drip can was slowly collecting on the water surface, many large larvae were found in the grass only 18 inches from the point where the oil was released.

A more extensive survey was made in early December to determine how widespread and how prevalent such areas were, and to investigate the possibility of overcoming this condition by the addition of spreading agents to the solutions. Four rivers, including the famous Suwannee, 2 cypress swamps, 4 roadside ditch margins of 2 springs, and 10 ponds or small lakes, were treated with kerosene, fuel oil, and used crankcase oil. The spreading properties of these oils were determined by measuring the area covered by a single uniform drop of oil. The results are shown in Table 1.

Kerosene did not spread well on any of the areas, and fuel oil gave a fair spread (13 to 24 inches) on only two of them. Although spreading was fair on 14 of the locations treated with used crankcase oil, on only 5 did this material spread as freely as it had during the summer. The spreading ability of all the oils was greatly improved by disturbing the water surface. This would indicate that some type of inhibiting biological film had formed since the cessation of the almost daily rains.

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