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THE PEST MOSQUITO PROBLEM AND ITS RELATION TO PUBLIC HEALTH

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Mosquitoes have always been recognized as pests just as sandspurs, crab grass, English sparrows and starlings. If a starling, for instance, should be found to harbor a virus, or other etiologic agent, of a human disease, the bird is no longer merely in the nuisance class but becomes a health hazard. When some of our so-called pest mosquitoes prove to be capable laboratory vectors of important human diseases, as they have, they, too, become distinct potential hazards to human health.

When our agricultural or other practices multiply mosquito breeding areas so that a hundred mosquitoes grow where one grew before; when these multiplied numbers of insects inflict bites that result in serious allergic, traumatic and infectious manifestations; when the hordes of venomous insects interfere with, or prevent, normal work and recreation, resulting in underdeveloped lands, lowered economic standards and an undernourished populace, then we can safely say that the so-called pest mosquitoes have a health hazard significance overshadowing their nuisance value. This has been recognized by the various State health departments and most of the nearly \$50,000,000 spent annually for mosquito control is for the protection of man. There is now general acceptance of the World Health Organization concept that good health means not

merely freedom from infirmity, but complete physical, mental, and social well-being.

Although there is increasing recognition of the public health importance of mosquitoes as pests, few data are available on this specific subject. A recent survey of the public health importance of irrigation mosquitoes in the Milk River Valley of northern Montana (8) illustrates the serious impact that these pest mosquitoes may impose upon a community. A house-to-house survey of 133 families showed that mosquitoes severely annoyed three-fourths of them and interfered with gardening and other healthful outdoor activities; about half reported that mosquitoes prevented their children from playing out-of-doors during the summer months. Outdoor community activities were essentially nonexistent. Most individuals in all of the families reported varying degrees of irritation from mosquito bites including itching, swelling, and secondary infections. An examination of representative individuals by the interviewing physician revealed that over 50 percent suffered abrasions following mosquito bite, and 40 percent of individuals living in lower class housing showed signs of secondary infection. Over 50 percent of the families used home medication; children were frequently taken to physicians for treatment of mosquito bites,

some even requiring hospitalization due to secondary infections or allergic reactions.

The official attitude of the Public Health Service toward pest mosquitoes was expressed by the Acting Surgeon General in 1950 in a letter to the State and Territorial Health Officers. He stated that pest mosquitoes should receive more attention from health authorities than had been previously accorded them (1, 7, 11). Most State health departments are in agreement with this, and there are increasing requests for the Public Health Service to assist in the solution of pest mosquito problems. These problems fall naturally into two main categories: (1) salt marsh mosquito problems, and (2) fresh water mosquito problems.

SALT MARSH MOSQUITO PROBLEMS

Throughout their known history, the Atlantic, Gulf, and Pacific coastal areas of the United States have been plagued with hordes of salt marsh mosquitoes. These mosquitoes also occur in a number of inland areas usually associated with oil or mining operations and in the vicinity of the Great Salt Lake. Wherever salt marsh mosquito breeding occurs, it is generally characterized by the production of prodigious numbers of the pests, resulting in extreme annoyance to man and animals in the surrounding areas. The intensity of this problem has been responsible for retarding the development and utilization of vast segments of our coastal areas. The magnitude of the annoyance problem is aggravated further by the dispersal habits of certain species.

There are five principal species of salt marsh mosquitoes in the United States. *Aedes sollicitans* occurs along the Atlantic and Gulf Coasts and at some inland points, particularly in the eastern half of the country. *Ae. taeniorhynchus* is found along the Atlantic, Gulf, and southern California coasts, and at some inland points in the southern part of the country. *Ae. cantator* is limited to the Atlantic Coast from Virginia northward. *Ae. squamiger* is found along the Pacific Coast from San

Francisco southward. *Ae. dorsalis* occurs throughout the northern half of the United States from the Atlantic to the Pacific, breeding in both fresh and salt water (5).

Salt marsh mosquitoes have been shown in laboratory tests to be capable of transmitting such diseases as encephalitis, yellow fever, and filariasis. The potentiality of salt marsh mosquitoes serving as natural vectors of diseases must be recognized. However, the principal known public health problems associated with salt marsh mosquitoes are: (1) the extreme annoyance to man and interference with his activities in affected areas, and (2) the severe reactions, including secondary infections, experienced by many individuals bitten by these pests. Salt marsh mosquitoes also are important vectors of heart worms in dogs in southeastern United States.

During recent years, the agricultural, industrial, and recreational development of the coastal areas has proceeded rapidly, with a consequent increase in the human populations exposed to mosquito annoyance. In some instances, the development of coastal areas has aggravated existing salt marsh mosquito problems in an unexpected manner. Greatly increased use of fresh water for agricultural and industrial purposes has resulted in diminished stream flow and subsurface supply, thereby allowing the intrusion of salt water. In a number of localities, the liberation of salt water and other wastes from oil drilling and certain mining activities has resulted in conditions favorable to prolific production of salt marsh mosquitoes (3, 4). On occasions, the magnitude of the nuisance which resulted has forced the industries that created the problem to suspend operations temporarily.

To evaluate the importance of the present salt marsh mosquito problem in the United States, in July 1955 the Communicable Disease Center of the Public Health Service mailed an inquiry to the health officers of 24 states where these insects normally occur. This inquiry requested information regarding the present status of the problem and certain data on control activities. Twenty-two states reported salt

marsh mosquito problems ranging from moderate to severe; the other 2 states considered the problem to be of less magnitude. In some states, the trouble is highly localized; in others, it is extensive. In 6 states, 71 organized mosquito abatement districts are conducting control operations against salt marsh mosquitoes. A much larger number of individual salt marsh mosquito control programs are being conducted in cities and communities, and on military bases in 15 states. (These states include 10 that do not have organized mosquito abatement districts.) The majority of states responding to the inquiry indicated that the health department is either the designated state agency having responsibility for salt marsh mosquito control or is providing technical consultation and guidance to local mosquito control activities.

There is a growing recognition on the part of state and local governments that these pests are a menace to the health and welfare of the populace. Several states have well developed and extensive salt marsh mosquito control programs, and others are taking positive measures to initiate control activities. In some states, the mosquito abatement districts receive financial support, technical consultation, and guidance from the State health department, these activities being considered normal health department functions and responsibilities. In some other states, this help is supplied by the State agricultural, highway, or other departments. In a few instances, well organized and effective local mosquito abatement programs are being carried out with very little State support or participation.

Although the Public Health Service has the authority and is conducting some work on salt marsh mosquitoes, no funds are available specifically for salt marsh mosquito research or control activities, and only limited assistance can be provided to State programs. However, consistent with the man power available, the Communicable Disease Center does, upon request, conduct joint surveys with representatives

of State health departments and makes recommendations to help solve the problem (3, 4).

Present salt marsh mosquito control measures in many instances are applicable only under the specific ecologic conditions of the locality involved. In addition, certain measures require large expenditures of money and are only partially effective. There is certainly need for more knowledge on permanent control measures (drainage, filling, impoundment, salt water extrusion) as to their costs, effectiveness in reducing mosquito production, adaptability to different problem areas, and their influence on other related elements such as wildlife conservation and land values. Basic to all control studies is extensive research on the biology of the various species concerned. These investigations must coincide with the habitat types involved and necessitate in many instances long-term studies. In essence, the solution to salt marsh mosquito problems can be met only through a combined program of laboratory and field research on control methodology and salt marsh mosquito biology. We hope that this need can be met.

FRESH WATER MOSQUITO PROBLEMS

Among the most extensive and severe of the fresh water pest mosquito problems are those associated with the development and utilization of water resources. The proper development and utilization of these resources is a major factor in the future economic progress of the nation, and it is essential that their benefits not be impeded by the creation of public health problems.

State health departments are cognizant of the public health importance of the "man-made" mosquito problems and are making commendable efforts to meet the situation. The Public Health Service is responsible for the incorporation of adequate mosquito prevention and control measures into development programs for the nation's major river basins. In this capacity, it works very closely with the

various State health departments and the various Federal agencies concerned with river basins developments.

The types of water resource development projects with which the more important fresh water mosquito problems are associated are irrigation systems and multi-purpose impoundments.

A tremendous expansion of irrigation is currently under way in the United States, particularly in the West. Over 25 million acres are now under irrigation, representing a capital investment of some two billion dollars, and each year about a million acres more are added. This rapid expansion is being accompanied by proportionate increases in the production of mosquitoes, creating public health problems in most irrigated areas. Among the more important of the mosquito species involved are *Ae. vexans*, *Ae. dorsalis*, *Ae. nigromaculis*, *Psorophora confinnis*, *P. discolor*, and *Culex tarsalis*. The latter species is the principal recognized vector of western equine and St. Louis encephalitis in the western states. Also, it bites man quite readily and is an important pest species aside from its role in disease transmission.

Among the major areas affected by mosquitoes are: (1) the North and South Platte River Valleys of Nebraska, Colorado, and Wyoming; (2) the Milk River Valley in northern Montana; (3) the deep-well irrigated areas of the Southern High Plains of Texas; (4) the Lower Rio Grande Valley; (5) the irrigated basins of the Colorado River and its tributaries; (6) the Great Basin in Utah; (7) the Snake River Valley in Idaho; (8) the Central Valley of California; (9) the Columbia Basin in Washington; and (10) the rice-growing areas of the Mississippi Delta. As an example of the magnitude of these problem areas, the Columbia Basin project alone will eventually bring a million acres under irrigation.

Mosquito production in irrigated areas is primarily associated with faulty irrigation systems, improper land preparation, or inadequate drainage. Solution of these problems is, therefore, of mutual interest to public health and agriculture.

Many types of mosquito problems are associated with impounded water projects. Reservoirs developed for flood control, water storage, hydroelectric power generation, and navigation may produce large populations of mosquitoes if improperly constructed or managed. In impoundments in the southeast, the principal malaria mosquito, *Anopheles quadrimaculatus*, and, to a lesser extent, other anophelines, usually constitute the most abundant species. During the spring flood surcharges or when reservoirs are refilled during periods of heavy summer rains, prolific production of *Ae. vexans* and other pest culicines also may result. For impoundment projects, it is important that mosquito control be "built into" the design and operational plans.

In water fowl refuges or where these are included in impoundments, heavy mosquito production frequently occurs. It has been demonstrated that game management practices can be developed which are mutually beneficial to mosquito control and wildlife. More attention should be given to such potentialities.

Certain species of mosquitoes are domestic in habit. These usually occur as the most persistent problem species in and around the home in urban areas. The yellow fever mosquito, *Ae. aegypti*, is our most domestic species. It is always found closely associated with the home and often becomes a localized pest of some importance. However, the mosquito most commonly found inside dwellings belongs to the *C. quinquefasciatus-piapiens* complex. While this species breeds in artificial containers around dwellings, it also shows a predilection for breeding sites having high organic pollution, such as sewage lagoons, septic tank effluent, or wastes from vegetable or animal processing plants. The use of chemical control measures in these situations is complicated by the fact that most insecticides are inactivated considerably by the high organic content of the breeding medium.

Woodland mosquitoes of the genera *Aedes* and *Psorophora* breed in rain- or

snow-fed pools in or near forests and severely attack native animals and the hapless woodsmen and sportsmen. The ferocity of such attacks occasionally is so great as to drive humans from the woods and to interfere seriously with vocational and recreational activities. Because of the widespread occurrence and inaccessibility of breeding areas, practical control methods for these mosquitoes are unknown except for restricted adulticidal operations (2, 9, 12).

Mansonia mosquitoes are avid biters which readily attack man. Populations of these mosquitoes in localities having large permanent marsh or lake areas thickly covered with vegetation, such as water lettuce, water hyacinth, pickerel weed, and cattail, may become so great as to constitute a real menace to nearby communities (2, 9, 10). Both *Mansonia indubitans* and *M. perturbans* have caused extreme annoyance in central Florida, and *M. perturbans* is considered an important pest in New Jersey also (6). Control measures against *Mansonia* mosquitoes are difficult and expensive, and satisfactory methods are not available.

GENERAL CONCLUSIONS AND PROGRAM POTENTIALITIES

It will be noted that the problems discussed are very diverse and that practical solutions have not been developed. The need for concerted study of these various problems is apparent. The standard of living in this country has ascended to the desirable level at which people are no longer satisfied merely to be free of the scourges of mosquito-borne diseases. Justifiably, they believe that they are entitled to pool their resources and efforts to achieve relief from the voracious attacks of blood-sucking mosquitoes just as they do to control pollution of the water they drink and the air they breathe.

This new awareness and desire to conquer this problem has been demonstrated by the progressive action of several leading public health organizations in the adoption

of resolutions advocating and supporting pest mosquito control activities. Notable among these organizations is the State and Territorial Health Officers Association which adopted the following resolution during its November 1955 meeting: "That a comprehensive program be established in the Public Health Service on salt marsh mosquito control, including laboratory and field research, demonstrations, and technical consultation, to meet the increasing salt marsh mosquito problem in many areas of the United States, including territories and possessions." During November 1955 the American Public Health Association passed an even broader resolution, which includes the mosquito problems associated with water resources development and reads as follows: "Resolved, that the American Public Health Association recommends that a program of research, demonstration and technical consultation in control of mosquito breeding in salt marshes, irrigation systems and other water resources developments, be undertaken by the United States Public Health Service and by State health departments." The Florida Anti-Mosquito Association, in its December 1955 meeting, unanimously passed a resolution calling for support of national movements for a program of research, demonstration, and technical consultation in controlling all mosquitoes which adversely affect the health, comfort, and welfare of the people.

During January and February 1956, several identical bills were introduced in the U. S. Senate and House of Representatives calling for an authorization of a Federal expenditure for work on the mosquito problem.

SUMMARY.—The several problems of the pest mosquitoes of the United States are discussed. These mosquitoes are divided into three principal groups for consideration. They are (1) salt marsh mosquitoes, (2) those fresh water species associated with man's development of water resources, and (3) fresh water species occurring in natural habitats relatively uninfluenced by man's activities. The impact of large pop-

ulations of pest mosquitoes on the public health of a community is described. Also considered are the serious economic losses resulting from the presence of these pests.

Current interest by the public and by mosquito control organizations and health departments in inaugurating measures to alleviate this severe problem is increasing. Much research is necessary to develop the knowledge upon which final successful control operations must be based.

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