THE MANAGEMENT OF WATER FOR MOSQUITO CONTROL IN THE COASTAL MARSHES OF FLORIDA

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Water management in one form or another has been practiced from the very beginning of "preventive" mosquito control measures. It constitutes the basis for all control planning, and any adaptations, whether it be drainage, water level fluctuation of impounded waters, diking and dewatering, diking and flooding, or hydraulic filling, are for the sole purpose of preventing the development and emergence of those lowly insects that plague mankind and hinder the economic development of the country.

Our subject therefore is not a new one; much has been done in the past and much has been learned. In the field of salt-marsh mosquito control, however, relatively little has been done due to the magnitude of the problem, insufficient funds, and also because the salt-marsh mosquitoes are not considered vectors of disease. The magnitude of the problem confronting us can be realized only if we consider the thousands upon thousands of salt-marsh acres along the eastern, southern, and western boundaries where it is now impossible to attempt control measures.

During the 1930's, in some locations, extensive salt-marsh ditching programs were carried out with hand labor under the W.P.A. program. The benefits derived are not questioned, but few, if any, districts today could afford to maintain these ditches with hand labor. Although these drainage programs in years past were generally successful in accomplishing their objective, the question arises as to whether they were as effective as they could have been. Was drainage the most economical method of water management?

Research scientists in the mosquito control field are at present unable to answer many questions vital to controlling the salt-marsh species of mosquitoes. When these facts become known through their diligent studies it will be possible to plan and execute preventive control measures with far greater proficiency than at present. The feasibility of salt-marsh mosquito control is of vital interest to many of you in attendance at this convention, and we would like to present a brief summary of what is being done in Florida to combat salt-marsh breeding through water management.

As many of you know, mosquito control programs in Florida are carried out by districts and counties, all of which are now receiving state aid funds and technical assistance through the State Board of Health. The program thus in some respects becomes a joint endeavor between the districts and the Bureau of Entomology in planning and execution of control measures. There are now 46 counties and districts in Florida with a total current budget of local and state funds amounting to approximately $3,273,000 for arthropod control.

Florida's tidal shoreline distance totals 8,426 miles; about three and one-half times the distance from Washington, D. C., to San Francisco. Over 15 percent of the total acreage in the State is marshland. Of the total 5,900,000 marshland acres, an estimated 700,000 acres are considered capable of producing salt-marsh mosquitoes. Studies have shown that in some areas of the state as many as 113,000,000 salt-marsh mosquito eggs are present per acre. No point in Florida is over 70 airline miles distant from either the Gulf of Mexico or the Atlantic Ocean. Of the 36 coastal counties, 30 have mosquito control programs and are expending approximately two and three quarters million dollars this year for mosquito control. The remaining six

counties not participating have a very small population and are not financially able to undertake the work.

In these thirty coastal counties the equipment for executing preventive measures consists of 37 draglines, 1 crawler-mounted Gradall excavator, 6 bulldozers, 3 backhoes, and 4 10-inch hydraulic dredges, plus pumps, trucks, and other incidental equipment. Our principal salt-marsh mosquitoes are *Aedes taeniorhynchus* and *Aedes sollicitans*. In addition, throughout most of the southern half of Florida, sand flies (*Culicoides sp.*) are frequently as much of a nuisance as mosquitoes.

Suffice it to say that each county and district carries out temporary control measures when necessary and great sums of money are expended in this manner. It has been interesting to observe during the past year or two the increasing resistance to chemicals which has seemingly developed in mosquitoes breeding in certain localities, and the interest in "preventive" control measures that has been aroused in some directors after miserable failures in controlling mosquitoes with insecticides.

The "preventive" control program began in earnest during the latter half of 1953 when the legislature made funds available specifically for this type of work. Emphasis has been placed on controlling arthropod production in the salt-marshes, and in this connection several variations of water management are being employed. These are: (1) ditching, (2) diking and flooding, (3) diking, (4) hydraulic filling, (5) vertical drainage, and (6) deepening and filling.

MACHINE DITCHING. This method is familiar to all of you and there probably is nothing we can say about this type of operation that would be new to you. All ditches are dug to a minimum elevation of at least 1.0′ below mean low water in order to maintain tidal water at all times, are sufficiently wide to maintain an open flowing ditch after final bank settlement, and dead ends are avoided as much as possible. Draglines are normally employed for this work; however, two or three districts employ a small backhoe, mounted on a tractor for small, narrow ditching in marl in conjunction with their dragline operations. Double ditching is avoided where possible, but in some of the abandoned farm areas of southern Florida it is necessary to maintain a system of double ditching.

DIKING AND FLOODING. In opposition to diking and dewatering for *Anopheles quadrimaculatus* control, the control of salt-marsh mosquitoes, and sand flies apparently can best be controlled through diking and flooding. Ditched salt-marsh areas can, on occasion, become heavy producers of sand flies which can become as much of a pest annoyance as the mosquitoes which were prevented from breeding because of the drainage work. Two years ago two areas totaling approximately 80 acres were diked and flooded for the purpose of observation and study. The dikes were constructed on all four sides of the area, sand and mud being excavated directly from the marsh and placed upon the salt-marsh vegetation to form the dike. It was desired to ascertain, among other things, if the dike would hold water without preparing the dike foundation by stripping the vegetation in advance of placing the dike material. This method was successful and resulted in a considerable savings in construction costs. The normal tidal variation in this locality is less than one foot between high and low, so a portable 24″ pump was used to flood the diked marsh to a depth of approximately one foot. This was done in May and no additional pumping was required that year. A high minnow population was naturally maintained within the diked area, and if any oviposition did occur around the unsubmerged margins of small island areas, the mosquito larvae apparently failed to reach maturity.

Based on observations made in these areas, it was concluded that this method of control offered possibilities for rapid control of both mosquitoes and sand flies at a far less cost than by ditching or filling. This would be true if extensive pumping was not required. Advantage could be taken of tides to flood the areas in many

localities, and pumping could be disregarded.

DIKING. On the basis of data and observations obtained from the two diked and flooded areas, plans were made for diking and flooding hundreds of additional acres last year. Work proceeded rapidly according to plan except that some areas were not flooded after completion of the dikes. Personnel were not available to carry out as complete observations as would be needed for drawing definite conclusions as to the benefits, if any, obtained from areas diked but not flooded. A detailed study will be made this year on these and other such projects.

The observations that were made seemed to indicate that very little breeding occurred within these diked but unflooded areas. There are at least three logical reasons why this actually may have occurred. (1) There were numerous permanent bodies of water within the dikes that supported a large minnow population. (2) Spring tides were prevented from intermittently flooding the marsh about every three weeks, and (3) the rainfall was probably a little under normal.

On those areas that were initially flooded after the mosquito breeding season began, it was necessary to apply larvicides to control the first brood of mosquitoes emerging from eggs deposited in the marsh area. This was foreseen and expected. No trouble was experienced subsequent to the first brood, and it is believed this can be avoided in the future when it is possible to take advantage of the high fall tides to flood the area initially.

The observations made last summer in the diked and unflooded areas, although certainly not adequate, have led us to revise the working procedure formerly followed in the construction of diking and flooding projects. Since it is possible that data obtained during this next season may show there is very little additional benefit to be obtained through construction of a dike on the landward side of the marsh, this portion of the work is being deferred pending the obtaining of additional data. Work is continuing on the construction of dikes on the shoreward edge of the marsh as the first phase of this work. The dike is tied into high ground at intervals in order to form cells which may later be of value if flooding is indicated. Evidence to date seems to indicate that the shoreward dike will keep spring tides from intermittently flooding the marsh and that rains will not present a serious problem. If such is proven not to be the case, then the landward side dike will be constructed and the area flooded. During the past fiscal year ending on September 30, 1955, a total of 8,162 acres had been diked at a cost of $6.21 per acre. This is only a fraction of the cost that would have been incurred for ditching, or filling, on an acreage basis.

As has been previously pointed out, there is insufficient data available at present to answer many questions that arise concerning the effectiveness of this type of work. In addition to the observations that will be made in areas previously constructed, observations will be made on a specially selected area of about fifty acres on the west coast. Two areas will be diked and compared with three adjacent control areas. The occurrence of breeding will be correlated with tide and rainfall in the hopes of establishing a definite relationship in the diked areas as compared with the natural marsh control areas.

HYDRAULIC DREDGING. Three adjacent counties on the east coast of Florida have each been operating one 10-inch hydraulic dredge, in addition to other equipment, for filling the salt-marsh breeding areas. An additional dredge was purchased by one of the three counties and delivery made in January of this year.

Hydraulic filling, properly executed, is a permanent method of building out mosquito and sand fly breeding areas. Improperly executed, conditions may be created that nullify any filling work done. The three dredges during the last fiscal year pumped 1¼ million yards of material and eliminated 430 acres of breeding area. The material is placed to maximum elevation only high enough to insure the fill being above normal spring high tides,

and with adequate slope for drainage. This elevation is not sufficiently high for property developmental purposes and the developer would have to add more fill dirt before the property would be suitable for residential property.

VERTICAL DRAINAGE. The southern tip of Florida presents many problems in mosquito control due to the rock formation encountered. The Florida Keys are composed almost entirely of rock and coral, ranging from very hard flintlike rock in the eastern and central portion of the Keys to fairly soft rock on the western end at Key West. Ditching, diking, or filling is not generally feasible due to the absence of earth. Most of the breeding areas are saucer-like in formation and drainage has been satisfactorily accomplished to a limited extent by blasting through an overlying impervious rock stratum and permitting drainage into an underlying pervious stratum. Where the elevation of the breeding area is above the tidal level the areas will drain sufficiently to prevent mosquito breeding. In those areas below the tidal elevation it is noted that fluctuation of the water level occurs with the tides although there may be some time lag. This method holds promise for correcting a great many areas in the Florida Keys and it is expected that vertical drainage will be employed considerably in this area in the future.

DEEPENING AND FILLING. A limited amount of work is being performed with draglines and bulldozers in deepening and filling of small salt-marsh breeding areas. The principle involved is to deepen one portion of the breeding area to a depth sufficient to maintain water at all times, and to utilize the excavated material to build up the remaining area to sufficient elevation to prevent water remaining on the area.

CONCLUSION. Continual research work is being carried out throughout our nation in an effort to obtain more information on the habits of mosquitoes and the best ways of controlling them. Many ways are now employed; some of them good and some not so good. Through research and the ultimate development of means for economically and permanently controlling mosquito breeding sources, the mosquito nuisance can be greatly reduced with a saving of thousands of dollars now expended for repetitive measures.

MOSQUITO CONTROL IN NEBRASKA—PAST, PRESENT, AND FUTURE

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Nebraska claims more miles of streams of running water than any other State in the Union. It also has many lakes and marshes, with more than 2,000 lakes in the Sandhill Region alone. The first irrigation ditch in Nebraska was built in 1866 and the first irrigation district, the Farmers' Irrigation District of Scottsbluff County, was started in 1887. Today we have approximately 750,000 acres under ditch irrigation and untold acres under well irrigation.

Not until 1939, when Dr. H. Douglas Tate joined the staff of the Department of Entomology of the Agricultural Experiment Station, was there serious interest in mosquitoes. Previous to Dr. Tate's arrival, mosquitoes were considered pests