

**A REVIEW
OF THE
MOSQUITO
CONTROL PROBLEM
IN DELAWARE
JULY 1959**

By
Leslie D. Beadle, Entomologist

U. S. DEPARTMENT OF HEALTH, EDUCATION, AND WELFARE
PUBLIC HEALTH SERVICE • Bureau of State Services
Communicable Disease Center • Atlanta, Georgia • July 1959

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REQUEST FOR ASSISTANCE

Because of an unusual number of salt-marsh mosquitoes (Aedes sollicitans) in the State during July 1959, Governor J. Caleb Boggs called for a conference on Delaware's mosquito problem on July 22, 1959. An invitation for a representative from the Communicable Disease Center to attend this conference was received on July 20 from Dr. Floyd I. Hudson, Executive Secretary, Delaware State Board of Health. The writer visited Delaware on July 22-23. In addition to attending the meeting, the writer reviewed the mosquito problem with representatives of the State Board of Health, the University of Delaware Agricultural Experiment Station (Department of Entomology), the State Highway Department (Mosquito Control Division), and the State Board of Game and Fish Commissioners. On July 23, observations were made on the effectiveness of certain chemicals used in the State for the control of mosquitoes.

MOSQUITO PROBLEM - 1959

The severity of the mosquito problem in 1959 was attributed to a combination of factors including: (1) a "sneak" tide that occurred late in June (salt marshes were inundated during a severe drought); (2) heavy rains which terminated the drought on July 10 and lasted for a week (total of about 6 inches of rainfall during the week); (3) ineffective larvicides (DDT) that resulted in broods escaping from the marshes; and (4) unfavorable weather conditions that hampered the application of insecticides.

Following the heavy rains on July 10, mosquito inspectors of the Mosquito Control Division were in the field and observed that a huge brood was in the making. Plane application of DDT larvicide, at the rate of .2 lb./acre, was promptly instituted, but unfortunately the larvae proved to be quite resistant to the insecticide. Consequently, a large brood escaped. Dr. Dale Bray, Head of the Department of Entomology, University of Delaware, informed the press to prepare the public for an "invasion" of salt-marsh mosquitoes. Concurrently, efforts were made to step up adulticidal operations by means of planes and ground fogging machines. These efforts were partially nullified by the prevailing rainy weather. For example, one of the State-owned fogging machines was sent to Dover on 4 consecutive days, but it was used only on the 4th day.

The salt-marsh mosquito problem was most acute in the 2 lower counties (Sussex and Kent). A light trap in Dover collected 944 female Aedes sollicitans on July 21, and approximately 3,000 females of this species on July 22.

Residents in the affected areas became quite aroused, and the newspapers suggested that a meeting be held in an effort to find better ways of combatting the mosquito nuisance. Governor Boggs agreed that such a conference would be highly desirable.

GOVERNOR'S MEETING ON MOSQUITO CONTROL

This conference, which was held in Governor Bogg's office from 1:15 to 3:45 p.m. on July 22, 1959, was presided over by Lieutenant Governor David P. Buckson. Representatives of the following State and Federal agencies attended the meeting: State Highway Department (Mosquito Control Division); University of Delaware State Agricultural Experiment Station (Department of Entomology); State Board of Game and Fish Commissioners; State Board of Health; State Audit Bureau; University of Delaware Marine Laboratories; U.S. Fish and Wildlife Service; U.S. Air Force Base, Dover; and the U.S. Public Health Service.

Comments made by representatives of the various agencies are included in the following paragraphs:

Dr. Richard F. Darsie, Jr., Department of Entomology, University of Delaware, reviewed the following mosquito research projects at the Delaware Agricultural Experiment Station:

1. Biology and ecology of *Culex salinarius*, an important pest mosquito in Delaware.
2. An evaluation of the State's mosquito control program by daily sampling of mosquito populations.

This involves the operation of mosquito light traps nightly from May 15 - September 15 at the following locations: Deerhurst, Wilmington, Newport, Delaware City, Dover, Lewes, Rehoboth Beach, Oak Orchard, and Bethany Beach.

3. Toxicity of insecticides for use in mosquito abatement in Delaware.

Dr. Darsie said that Delaware is at the threshold of a new era in mosquito control. The use of DDT on Delaware marshes was started

in 1947. DDT-resistance was first detected in Delaware in 1951. Then a switch was made to Gamma BHC (except for 1954 when DDT again was employed). Tests in 1957 and 1958 indicated that BHC was losing its effectiveness; therefore, DDT was re-employed. Dr. Darsie summarized by saying that "evidence is strong that we are out of business with both materials."

Dr. Darsie said that the prospect is to use Paris green in the marshes as a larvicide and malathion in upland areas as an adulticide. He said that testing work with malathion is far enough along so that it can be employed in operations; but that Paris green had not been sufficiently investigated.

4. Effects on muskrats of aerial applications of BHC and malathion.

The Mosquito Control Division is much concerned about the use of insecticides that would be unduly harmful to muskrats.

5. Appraisal of new ditching of the salt marsh as a mosquito control procedure.

Since 1933, the 20"x20" ditch has been used in Delaware. There is no information, however, on how long this type of ditch remains effective in draining the marsh. There is need for study on the use of other types of ditches that are wider and deeper, and which remain functional indefinitely.

6. Impounding of water on tidal marshes as a means of controlling salt-marsh mosquitoes.

A pilot study has demonstrated that if the marshes are kept flooded during the mosquito season, no Aedes sollicitans breeding will

occur on such marshes. At present a marsh south of Little Creek, Delaware, is being diked, and a 650-acre impoundment should be created during 1959-60.

Mr. Charles D. Murphy, Jr., Director, Mosquito Control Division, State Highway Department, Milford, Delaware, and Dr. Darsie discussed mosquito control operations of the State program.

Mr. Murphy said that 2 types of mosquito control were dovetailed, viz, permanent (ditching) and temporary measures. Permanent control is preferable because it is more economical and effective in the long run, but in order to obtain temporary relief from mosquitoes, application of insecticides is necessary. One of the principal problems encountered is that of insecticide resistance.

Dr. Darsie emphasized that 90% control should be achieved for effective results. Recently, tests indicated that only 70% control was achieved in Kent County. Dr. Darsie said that he was "not prone to continue using insecticides giving 70% control or less, because you just compound the resistance problem". He said that the next move for the Mosquito Control Division would be to use malathion -- but not on the marshes. It was mentioned that malathion had already been used on a limited scale in fogging operations.

Dr. Darsie explained that not all areas show the same degree of resistance. For example, mosquitoes in Kent County are more resistant than those in Sussex County.

Mr. Murphy gave additional information concerning mosquito control. DDT has been used in the State since 1947. For the first time in 1953 (Aug. 13), control was extended to the 2 upper counties.

Last year (1958), the Division sprayed 362,000 acres, which was nearly double the acreage sprayed in 1956.

The use of thermal fogging machines has been expanded slightly; recently one was purchased.

Mr. Murphy pointed out that utilization of insecticides is complicated by weather conditions, since application should not be made when the wind exceeds 10 miles per hour, when the temperature exceeds 85°F., or when it rains. This summer, the Division has been able to spray less than half as much as planned.

With respect to permanent control, Mr. Murphy said that primary attention should be given to 50,000 acres of salt marshes in the 2 lower counties. He mentioned some problems in connection with the use of impoundments to control salt-marsh mosquitoes. The cost is about \$100 per acre (ditching program, however, is probably more expensive in the long run because of the maintenance factor). Availability of water to create the impoundment is a limiting factor. Most of the marshes are privately-owned.

In answer to a question from Lt. Governor Buckson regarding a request for an additional \$100,000, Mr. Murphy replied that the greatest need was for personnel to inspect the marsh areas. Also, he "would like to expand the permanent control measures. Impoundments would involve tremendous amounts of money. Fogging operations would be increased."

Lt. Governor Buckson also inquired with respect to "area analysis"-- where and when to spray. Mr. Murphy said that it involved an inspection

program, i.e. inspection for larvae. Spraying was geared to larval findings. If they failed (i.e. the adults emerged), the procedure was to use biting counts.

Dr. Darsie was asked to comment concerning the immediate answer to the problem. He said that obviously an adulticiding program must be followed. This would involve aerial application of malathion and fogging with ground machines.

Lt. Governor Buckson said that he hoped to assure the affected areas that there will be adequate control. Mr. Murphy said that when the infestation comes, it hits all areas at the same time. The Division's aim has been basically to protect the most heavily populated areas.

U.S. Air Force Base, Dover.

Representatives of the Air Force said that quite a bit of ground fogging is done within the cantonment area of the Air Base. The material (DDT), however, has not proved effective.

Mr. Norman G. Wilder, Director, Delaware Board of Game and Fish

Commissioners, made the following comments:

Of primary importance from the Aedes sollicitans breeding standpoint are the irregularly flooded marshes. The impoundment approach looks very promising. This method is probably cheaper in the long run than ditching, when the maintenance cost is considered.

Mr. Wilder's recommendations were:

1. An area-by-area appraisal of wetland areas to determine mosquito control problems and possible control measures by entomologists working together with fish and wildlife biologists.

2. A mosquito abatement program based on the above findings and legally based on water control easements purchased, if necessary, from marsh owners.

3. A monitoring system by the State Water Pollution Commission of insecticides used to control mosquitoes and other insects.

4. A State Highway policy to consider and, where feasible, to impound tidal waters at all newly constructed water crossings.

Mr. Paul Springer, U.S. Fish and Wildlife Service, made the following remarks pertaining to ditching:

He said that taking water off the marshes serves mosquito control but it is detrimental from the wildlife standpoint. Muskrat interests do not want the marshes to go dry. Mr. Springer pointed out that there are other types of ditching besides the open ditches that have merit, and he would like to see research on this. Limited research on a modified type of ditch has already been carried out in Maryland.

Dr. Floyd I. Hudson, Executive Secretary, Delaware State Board of Health.

In reply to a question regarding any public health problems associated with the excessive mosquito production, Dr. Hudson said that there is always a potential hazard.

Mr. Leslie D. Beadle, Entomologist, Communicable Disease Center, U.S. Public Health Service.

The writer stressed the use of a new technique in the control of salt-marsh mosquitoes, viz, Paris green impregnated on vermiculite as a larvicide. He cited the successful work in Florida and Georgia (Chatham

County Mosquito Control Commission). The use of Paris green pellets in mosquito control offers 2 principal advantages over the methods presently being used in Delaware. Paris green may be employed with little danger of mosquitoes developing resistance, and the pellets may be applied by air during virtually any daylight hour. Furthermore, Paris green is generally recognized as a safe* larvicidal material. One of the disadvantages of the method (as revealed by Mr. Donald MacCreary, Department of Entomology, University of Delaware) is that the cost of application would be increased over that for DDT or BHC.

Lieutenant Governor David P. Buckson

Lt. Governor Buckson requested Mr. Murphy to prepare an overall plan for long range mosquito control work in Delaware and that such a plan should have the concurrence of the various agencies concerned. For the present, he requested that the Mosquito Control Division concentrate on the emergency spraying program in order to provide immediate mosquito relief.

*Mr. Paul Springer (U.S. Fish and Wildlife Service) said that old reports indicate that Paris green is a safe material, but the dosage must be considered.

Dr. Franklin C. Daiber (University of Delaware Marine Laboratories) said that the effects of flushing Paris green-treated areas by the tides could be detrimental to the blue crab.

FIELD OBSERVATIONS ON THE EFFECTIVENESS OF INSECTICIDES AGAINST ADULT MOSQUITOES

A field test was conducted near Dover, Delaware, on July 23, 1959, to determine the effectiveness of DDT on adult mosquitoes.

Female salt-marsh mosquitoes (Aedes sollicitans) were collected in the vicinity of Little Creek, Delaware, and placed in 18 stainless-steel screened cages, 24 per cage. The cages were wrapped in damp newspapers and transported to the Dover airport. The 18 cages were mounted on stands at 50-foot intervals, which formed a line 850 feet long on the airstrip.

Three cages, which were completely covered with damp newspapers, served as untreated controls. Newspapers from the other cages were removed a few minutes before application of the insecticide.

The insecticide tested was DDT, applied at the rate of .2 lb. of DDT in 2 quarts of fuel oil per acre. The insecticide was dispensed from a Stearman biplane at 7:25 p.m. Mortality counts 4 hours after treatment are summarized in the following tabulation:

	<u>Percent Dead</u>	<u>Percent Alive</u>
Treated cages (15)	100	0
Untreated cages (3)	<3	>97

The results of the experiment indicated that DDT was very effective in killing adult salt-marsh mosquitoes.

These results, however, are not in accord with observations made in Dover following an aerial application of DDT earlier in the month. At one observation point within the city, Dr. Darsie made a

post-treatment (DDT) biting count of about 75 mosquitoes in 15 minutes. Thus, it was concluded that the treatment was not very effective.

In contrast, the city of Dover received its first aerial application of malathion (rate of .2 lb. in 1/2 gallon of oil solution per acre) during the evening of July 23. Following this treatment, Dr. Darsie, Mr. Warren Wheatley (Mosquito Control Division), and the writer went to the same observation point that had been used in connection with the DDT treatment. Only 3 mosquitoes were observed in a 15-minute period. This observation, along with others made in the city, suggested that excellent kill was obtained under operational conditions with malathion.

DISCUSSION

The recent scourge of salt-marsh mosquitoes in Delaware is an excellent example of how "history repeats itself" in the mosquito abatement business. In spite of the recent advances in mosquito control techniques, there are times when the mosquito problem becomes extremely acute -- even in areas where mosquito control is highly organized. This same problem has arisen in Florida during recent years. In Delaware, as in many other areas, the prime factors that contributed to the problem in 1959 were (1) environmental conditions that were extremely favorable for salt-marsh mosquito production and simultaneously were unfavorable for chemical control operations, and (2) the insecticide-resistance problem.

In the writer's opinion, great advances have been made in Delaware in combatting the mosquito problem since he visited the State in 1956. In the 1956 report, the following suggestions were made for improving

mosquito control in Delaware: (1) expanding the control program to include all 3 counties of Delaware, (2) increasing the annual appropriation from \$125,000 to \$375,000, (3) transferring the headquarters from Lewes to a more central location, (4) putting more emphasis on proper water management (e.g., impoundments), (5) conducting a State-wide larval survey to determine the most important mosquito sources, and (6) working out a better means of coordination between the various agencies concerned with control of the problem.

It is gratifying to note that most of the above suggestions were put into effect. For example, the program now includes all 3 counties (bulk of the work is still in Kent and Sussex Counties because of the extensive salt marshes in these counties); the appropriation for the last biennium was \$471,000 for each of the 2 fiscal years (ended June 30, 1959); headquarters was transferred last winter from Lewes to Milford; at present 2 large impoundments on salt-marsh areas are under construction; and in 1957 there was created a coordinating committee (State Mosquito Control Advisory Committee) comprised of officials from the State Highway Department, the U. S. Air Force, the State Board of Health, the State Board of Game and Fish Commissioners, and the University of Delaware.

With respect to possible improvements in the State's mosquito abatement program in the future, the following comments are made for consideration:

Larvicidal Operations

Because of the insecticide-resistance problem, the use of BHC

and DDT (chlorinated hydrocarbon insecticides) on the Delaware salt marshes should be discontinued. In view of the success in Florida and Georgia in controlling salt-marsh mosquito larvae with Paris green (an inorganic compound) this insecticide would appear to be an excellent substitute for the BHC and DDT.

Adulticidal Operations

Recent tests show that malathion is highly effective against adult salt-marsh mosquitoes in Delaware. Consideration should be given to the use of this insecticide (an organic phosphorus compound) as a "standard" mosquito adulticide in Delaware.

In airplane application of insecticides, the spray for best results should be applied at a rate of a minimum of 1/2 gallon of liquid per acre.

Permanent Control Measures

For the long-range program, emphasis should be given to source reduction techniques. This involves (1) determining the most important breeding areas based on field surveys, and (2) developing control techniques for these areas that are compatible with other interests, such as fish and wildlife. At present one of the most promising methods in Delaware is the use of impoundments on salt marshes to control Aedes sollicitans. Another promising method is the use of large ditches in lieu of the old 20" x 20" ditch.

Research

There appears to be great need for the following research projects:

Paris green as a larvicide -- It would be highly desirable for the University of Delaware Agricultural Experiment Station to initiate studies during 1959 on the effects of Paris green as a larvicide. This would involve both laboratory and field investigations.

Appraisal of new ditching -- In view of the expense of maintenance associated with the 20" x 20" ditch, experiments should be conducted on the use of larger-sized ditches.

Appraisal of salt marshes as breeding areas for mosquitoes -- It is a well known fact that only a small percentage of the total salt-marsh areas actually breeds mosquitoes. Field studies are needed to locate precisely the mosquito breeding areas on the marshes. These should be plotted accurately on large maps.

Bionomics of *Aedes sollicitans* -- For the long-range program, it would seem prudent to emphasize bionomic studies on the most important mosquito in Delaware. Of particular significance would be studies pertaining to oviposition habits and flight range. The average flight of *Aedes sollicitans* is still not known.

Budget for Mosquito Control

In determining the budget, it should be emphasized that switching to the use of newer insecticides (malathion and Paris green) would be costlier than the continued use of DDT and BHC. It would be false economy, however, to continue the use of DDT and BHC just because these insecticides are cheaper.

SUMMARY AND CONCLUSIONS

1. The recent scourge of salt-marsh mosquitoes (Aedes sollicitans) in Delaware was due to a combination of factors including environmental conditions extremely favorable for mosquito production, but unfavorable for chemical control operations, and the insecticide-resistance problem.
2. Since 1956, the following improvements have been made in combatting the State's mosquito problem: expanding the area under control to all 3 counties; increasing the budget from \$125,000 to \$471,000 per annum; transferring the headquarters of the Mosquito Control Division to a more central location in the State; initiating work on 2 impoundments; and establishing a State Mosquito Control Advisory Committee.
3. Suggestions for possible improvements in the State's mosquito abatement program in the future include the following:
 - a. Larvicidal operations -- Because of the insecticide-resistance problem, the use of BHC and DDT on the salt marshes should be discontinued. A suggested substitute mosquito larvicide is Paris green.
 - b. Adulticidal operations -- Since malathion appears to be an excellent adulticide in Delaware, it is suggested that this material be adopted as the "standard" insecticide for adulticidal operations.
 - c. Permanent control measures -- For the long-range program, emphasis should be on source reduction techniques. Promising methods include the use of impoundments and improved (large) ditches on the salt marshes.

- d. Research -- The following are some of the research problems in Delaware that currently require attention: Studies on Paris green as a larvicide; the appraisal of new types of ditching; a State-wide larval survey to determine the most important breeding sources on the marshes; and studies on the bionomics of Aedes sollicitans, particularly with reference to oviposition habits and flight range.
- e. Budget -- An "adequate" budget would be necessary to take care of the increased costs for the use of the newer insecticides -- malathion and Paris green.
- f. Coordination -- The coordinating committee should hold meetings at frequent intervals in order that the various agencies can keep abreast of developments in the over-all mosquito control program.

ACKNOWLEDGMENT

The writer is grateful to Dr. F. I. Hudson, Executive Secretary, State Board of Health, for the invitation to attend the Governor's conference on mosquito control. Special thanks are due Dr. Richard F. Darsie, Jr., of the University of Delaware; and Mr. Charles D. Murphy, Jr., of the State Highway's Mosquito Control Division for valuable assistance while the writer visited the State.