ARTICLES

PROGRESS REPORT ON MOSQUITO ECOLOGICAL STUDIES IN CALIFORNIA *

Compiled by

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The California Mosquito Control Association has taken positive action in developing and promoting an effective program of biological investigations of mosquitoes in California since 1950. This action was taken through the "Operational Investigations Committee," which was made up of the following members: G. Edwin Washburn, Turlock Mosquito Abatement District, Chairman; Gordon F. Smith, Kern Mosquito Abatement District; C. Donald Grant, Pulgas-Three Cities Mosquito Abatement District; W. Donald Murray, Delta Mosquito Abatement District; E. Chester Robinson, East Side Mosquito Abatement District; Embree G. Mezger, Solano County Mosquito Abatement District; Herbert P. Herms, Sutter-Yuba Mosquito Abatement District; John N. Belkin, Assistant Professor of Entomology, University of California at Los Angeles.

Through cooperative agreements between the Bureau of Vector Control and the several Mosquito Abatement Districts, $25,000.00 has been set aside to conduct these investigations in subvented mosquito abatement districts each year. These funds were granted to the following units for studies in 1951:

1. The Central Valley Mosquito Ecology Study on Irrigated Pastures; working out of the State of California Vector Control Field Station at Fresno, California; with the Fresno Mosquito Abatement District as the administrative entity.

(a) As a sub-project to the above: an *Aedes* Flight Range Study was carried on in Kern County, California, with the Kern Mosquito Abatement District cooperating.

(b) A continuation of the *Aedes nigromaculis* (Ludlow) embryological studies were carried out at the College of the Pacific in Stockton, California.

2. The Insecticide and Toxicological Studies with the Kern Mosquito Abatement District as the administrative entity.

3. The Rice Field Mosquito Investigations with the Sutter-Yuba Mosquito Abatement District as the administrative entity.

Excerpts and notes from the individual reports which came from these studies follow.

1. A COOPERATIVE ECOLOGICAL STUDY OF IRRIGATED PASTURES, by R. C. Husbands.

When the project in mosquito ecology was first established the problems were well defined. The problems are: The great increase in the amount of land being irrigated as a result of the development of the Central Valley Project, the increasing problems of maintaining the standards of mosquito control in California, the new public health aspects of present control practices, and a complete lack of knowledge about the natural history of pasture mosquitoes.

* Although this is a "Proceedings Paper," it was not received in form for publication until too late to be included with the other AMCA Proceedings papers in the first two numbers of MOSQUITO NEWS following the AMCA meetings in Salt Lake City in March, 1952. Therefore, and since the individual papers of the compilation have already been published in full in the Proceedings of the 20th Annual Conference of the California Mosquito Control Association, the present paper will only call attention to the individual contributions, with notes and excerpts to show their contents.—Editor's Note.

With these problems in mind the project set up specific objectives. Fundamentals were to come first, followed by the more complex aspects of mosquito ecology such as the interaction of various factors, the investigations of mosquito behavior, and the studies of mosquito ova. Objectives selected in the original program were outlined as follows:

1. The significance of *Aedes nigromaculis* (Ludlow) and *Aedes dorsalis* (Meig.) in regard to encephalitis.
2. The seasonal comparisons of the life cycles of species of pasture mosquitoes.
3. The influence of pasture fauna, soil, flora, and irrigation practices upon mosquito populations.
4. The influence of other environmental and biological factors upon the natural history of mosquitoes produced in pastures.
5. The evaluation of all biological material to assist in present and future mosquito control.

Maps and photographs were used to measure and record the amount and distribution of water on the fields. Selected stations were located, marked, and visited regularly to give a continuous record of pasture activities. Laboratory studies guided and confirmed the field data. Details on these and other studies are contained in the California Association Proceedings above cited.

2. EMBRYOLOGICAL INVESTIGATIONS OF *Aedes* MOSQUITOES, by John R. Arnold and Gilbert F. Jones.

The objectives of this study were to determine the exact conditions, chemical, biological, and physical, governing the development of the egg of *A. nigromaculis* and to investigate certain factors causing the arrest of continued development of this mosquito from the time of fertilization to the time of hatching.

The development of the ovum of *Aedes nigromaculis* was studied and described in detail. A series of preserved eggs that had developed to the different egg stages under known conditions was collected but a more effective series is to be made when the techniques for sectioning have been perfected.

An important phase of the embryological study on mosquito eggs has been its direct application to problems in field ecology. In determining the length of time that it takes for a complete cycle of development to take place, from egg to egg, the rate of embryonic development must be considered. If there are indications of dormancy in eggs the embryological approach will help us to understand the action and to analyze the methods of using this factor to set up possible control procedures.

3. FLIGHT STUDY ON *Aedes nigromaculis*, by Gordon F. Smith.

The primary objectives of the *Aedes* flight studies in 1951 were an attempt to prove the basic pattern, developed during 1950, through the use of tagged adults; and to further develop and investigate the ramifications of this pattern.

Since the Central Valley Mosquito Ecology Study Unit (C.V.M.E.S.) located in Fresno, California was experienced in the use of tagging agents and flight range is considered to be a basic ecological problem in mosquito control, this unit participated with the Kern Mosquito Abatement District in the study. In their study at Turlock in 1950 they had been able to demonstrate an *Aedes* flight range of only 1½ miles which is extremely short in view of general field experience. The flight studies conducted during 1950 at Turlock were within the Turlock Mosquito Abatement District boundaries and were, therefore, subject to certain limiting factors. The studies of 1951 were conducted in Kern County outside the boundaries of the Kern Mosquito Abatement District and hence were not subject to the limitations of 1950. It was felt that this latter area which was on a larger scale, with the field information on hand in this area, might give more satisfactory results.

Two methods of tagging were proposed. One, the use of radioactive phosphorus and the other the use of Rhodamine "B" dye. It was decided that, all factors considered, radioactive phosphorus tagging should be the primary method used.

An examination of the data shows sev-

eral interesting features. It is apparent that *A. nigromaculis* and *A. dorsalis* do not move or are not moved great distances (unless special conditions are present to initiate this process). Similar work on other species of migratory mosquitoes suggests that recoveries should have been expected with tagged specimens if actual migration had taken place. Further work along this line should be examined carefully before proceeding to general conclusions.

4. INSECTICIDE AND TOXICOLOGICAL INVESTIGATIONS, by Lewis W. Isaak.

This report is a summation of the toxicological project which was carried out under the direct supervision of the Kern Mosquito Abatement District. Most of the work completed was done on *Culex* larvae rather than *Aedes*. The reasons for this preference are: (1) C. M. Gjullin of the Bureau of Entomology and Plant Quarantine concentrated on *Aedes* in his resistance studies in the San Joaquin Valley during the summer of 1951. (2) The seemingly sudden increase of extreme resistance encountered with *Culex* larvae at the several duck clubs in the Kern Mosquito Abatement District. This resistance to the chlorinates has reached proportions far beyond all previous estimates.

Twelve larvicides have now been screened using *Culex quinquefasciatus*, Say. Of these tested, EPN was the most effective, followed by parathion, aldrin, colloidal aldrin, heptachlor, dieldrin, DDD, DDT, Q–137, chlordane, lindane, and toxaphene, in that order.

Field testing of colloidal compounds has proved them to be superior to the emulsions as a residual larvicide in permanent ponds. One fresh water pond, treated at .075 lb. per acre of colloidal aldrin was kept free of larvae for 73 days during the warmest summer months of June to September. In highly polluted water, however, these compounds appear to be of little value as a residual larvicide.

Screening completed at the Fresno Field Station consisted mostly of obtaining basic information on *Aedes nigromaculis* larvae from an unsprayed area. Insecticides screened were DDT, toxaphene, Q–137, lindane, aldrin and heptachlor. In addition to the unsprayed area, larvae were collected from one field inside the Consolidated District. It was of interest to note that while neither Q–137 nor lindane had ever been sprayed on that field, the larvae were as relatively resistant to these compounds as to the DDT and toxaphene, the two larvicides which had been used in that area frequently.

Preliminary screening was completed with larvae collected from various duck clubs in the Kern area which had previously proved to be resistant to the chlorinates as applied by regular field applications. This extreme resistance as determined by laboratory analysis and field observations, might be explained by the fact that excessive amounts of various chlorinates were applied to an already resistant strain of larvae, thus killing off all the moderately resistant and non-resistant individuals leaving a residue of highly resistant mosquitoes. It was this remaining group which was brought back to the laboratory for screening; running the degree of resistance into staggering proportions. When it was evident that applications of the chlorinates was of no avail, spraying of these resistant ponds was discontinued.

While EPN has proven to be the most effective insecticide so far used and tested, it should not be used in any manner without close cooperation of the manufacturer and regulatory officials.

5. RICE FIELD MOSQUITO STUDIES, by Robert H. Soroker.

Due to a rather rapid change in personnel this project suffered from a lack of continued guidance by one plan or policy. However, in spite of its many handicaps important advances have been made in the ecological studies of *Anopheles freeborni* Aitken and *Culex tarsalis* Coq. Most of the studies have been concentrated on the ecology and biology of *A. freeborni*. Particular attention has been given to the behavior of the adults and their microclimate. Careful observations have shown

that there is a heavy concentration of adult *A. freeborni* at the margins of the rice checks and banks of ditches, as contrasted to the interior of the checks and ditches. This finding may have real significance in a control program.

Efforts to control *A. freeborni* breeding in the rice growing areas of California by an intensive early spring larviciding program have not been outstanding. In fact, it can safely be stated that this plan cannot be relied upon to give a satisfactory control.

CONCLUSION

It is not expected that all of the biological principles learned through these studies will have immediate field application. Many will only lead to further research. All persons engaged in long range mosquito control activities have come to realize that biological investigations have a prominent place in the mosquito control program, and it is with a look toward the future of mosquito control in California that these cooperative studies are being continued.

RECENT DEVELOPMENTS IN THE CONTROL OF RICE FIELD MOSQUITOES IN CALIFORNIA

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The rice field mosquito problem in California is actually a combination of three separate problems, all of them expensive and complex for mosquito abatement districts. Control involves three of the principal genera of mosquitoes—*Aedes, Anopheles* and *Culex*—an all-year problem intensified during the warm months of the year when rice fields are under water.

Two of the mosquito species are disease vectors: *Anopheles freeborni* of malaria, and *Culex tarsalis* of encephalitis. But actually we are concerned with more than a vector problem, serious as this is. Mosquito abatement districts in the rice growing sections of California must not only keep the mosquito population below the disease level, but they must reduce mosquitoes to a point that will satisfy the demands of the tax-paying public.

Rice acreage in California amounts to about 300,000 acres, most of it in the warm, dry northern part of the Sacramento Valley. Of this, more than 100,000 acres are outside of mosquito abatement districts. An increase in the mosquito problem has accompanied the increase in rice acreage.

Most rice is sowed by plane on land that is already flooded. Fields are flooded just before sowing, and the first major control problem occurs when they are first flooded. This initial flooding hatches eggs of *Aedes dorsalis* and *A. nigromaculis* which have been laid a year or more before. In late May and early June, *Culex tarsalis* larvae appear in quantity around the outside borders of fields and even within some fields. *Culex* adults are numerous by the middle and end of June and continue into the fall. The anophelines reach the adult peak in August and September with all aquatic stages of *Anopheles freeborni* in rice fields at this time. From late June until they are drained rice fields become generally infested by larvae of *Culex* and *Anopheles*.

Fortunately, the *Aedes* problem has been a matter of controlling only the one generation early in the spring. Although only one *Aedes* generation appears in any one field, the problem is complicated because *Aedes* larvae may appear in hundreds of acres of rice flooding at the same time and