PROCEEDINGS OF THE TWENTIETH ANNUAL MEETING of the UTAH MOSQUITO ABATEMENT ASSOCIATION

held at

AIR FORCE PLANT 81

Hercules, Inc.

Magna, Utah

edited by

Glen C. Collett

Mary K. Benge

UTAH MOSQUITO ABATEMENT ASSOCIATION

P.O. BOX 307

MIDVALE, UTAH

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TWENTIETH ANNUAL MEETING

Resolutions

Whereas, the program committee and officers have provided us with an excellent program of outstanding speakers and

Whereas, the speakers have gone to considerable effort to bring us helpful and up-to-date information and in many cases, such as those participating from California, have come long distances to contribute to our program, and

Whereas, the members of the Board of Directors and the employees of the Magna Mosquito Abatement District have made adequate arrangements for us, and

Whereas, the members of the various committees have performed their duties well, with this our twentieth meeting, and

Whereas, the United States Air Force has provided us with a place to meet and many conveniences for our meetings, and

Whereas, the management of Hercules, Incorporated has been very considerate in granting us eating privileges at the Company cafeteria, and

Whereas, the Magna Times did provide us with front page publicity, and

Whereas, the officers of the Association have performed their duties well and faithfully throughout the year, and for this meeting,

Therefore, be it resolved that we extend our sincere thanks to everyone who has aided in any way to make this twentieth Annual Meeting of the Utah Mosquito Abatement Association a success (October 2-3, 1967).

Whereas, Dr. George F. Knowlton has been of service to the Utah Mosquito Abatement Association since it was organized, and

Whereas, he has faithfully served the cause of organized mosquito control in an effective manner

Therefore, be it resolved that we extend to him our thanks and appreciation for his participation and cooperation.

Whereas, the late Dr. D Elden Beck served as a long time friend of the Association and worked to promote its purposes and objectives,

Therefore, it is resolved that we obtain a picture of Dr. Beck to appear in this year's Proceedings.

Resolutions Committee

Reed S. Roberts, Chairman

DR. D ELDEN BECK

Dr. D Elden Beck participated for many years in the activities of the Utah Mosquito Abatement Association and served as Vice-President in 1963-64 and as President in 1964-65.

His ability, knowledge and leadership were inspiring to all of the members of the association and his contributions increased the value of all mosquito control programs in the state.

Because of his contribution and the inspiration he gave us, We, the members of the Utah Mosquito Abatement Association, dedicate the Proceedings of our Twentieth Annual Meeting to the memory of Dr. D Elden Beck.

PROCEEDINGS OF THE TWENTIETH ANNUAL MEETING
UTAH MOSQUITO ABATEMENT ASSOCIATION

The opening session of the Twentieth Utah Mosquito Abatement Association convened at Air Force Plant 81 Hercules, Inc., Magna, Utah, and was called to order at 9:30 a.m. by President J. Larry Nielsen, presiding. Welcoming address was given by Dr. Carl Clark, President Board of Trustees, Magna Mosquito Abatement District. Response for the Utah Mosquito Abatement Association was given by J. Larry Nielsen.

THE UTAH COMMUNITY PESTICIDE STUDY

STEPHEN L. WARNICK, *Ph. D., Principal Investigator*
Salt Lake City, Utah

The increased use of pesticides — whether they are insecticides, herbicides, fungicides, or nematocides, or chlorinated hydrocarbons, organic phosphates, carbamates, arsenicals, or botanicals — has excited extreme interest at the scientific, political, and public levels. If pesticides remained where they were applied, or broke down into harmless compounds, perhaps biologists could ignore their extensive use. Unfortunately, pesticides may travel thousands of miles, may be transformed into compounds more deadly, may be concentrated by the food chain, and at least one of them (DDT) is stored in the fat of non-occupationally-exposed humans at a mean level of 12.7 ppm. The value of pesticides in combating insects and disease and in increasing vital food production is recognized, but their complexity, persistence, and high degree of biological activity certainly requires intensive investigation of possible effects on humans.

The Utah State Division of Health was recently awarded a $125,000 grant by the National Communicable Disease Center of the U.S. Public Health Service to do a community study on pesticides. Robert W. Sherwood, M. D., Director of Preventive Medicine, will act as Project Director. Stephen L. Warnick, Ph. D., has been employed as Principal Investigator.

The Utah Study is one of fifteen that have been established nationwide by the Public Health Service to determine if pesticides are causing health problems.

The study will first seek to determine the types and amounts of pesticides to which a community and its individuals are exposed. Then, on a long term basis, the Division will compare clinical and laboratory evidences of possible pesticide-related disease in heavily-exposed people, with a minimally-exposed control group. Also, all known chronic and acute poisonings linked with pesticides will be investigated.

Salt Lake County has been selected as the primary study area. The population will be divided into three groups: 1) urban—minimally-exposed, 2) rural—environmentally-exposed, and 3) occupational — maximally-exposed.

So far, four part-time field representatives have surveyed the nature and degree of pesticide exposure. The data from this survey is found in Table I. The demographic data, morbidity and mortality statistics, areas and amounts of pesticide usage, ecological factors, and industries and distributors concerned with pesticides in Salt Lake County have all been determined.

A Pesticide Laboratory is being established, and sensitive instruments will be provided by the Public Health Service for pesticide analysis. Postmortem tissues from people who are accidentally killed, or who are suicide or murder victims, will be analyzed to establish the pesticide levels in the study groups. Environmental levels, including air, water, soil, food, fish and wildlife, and aquatic plants and animals will be determined with the cooperation of other state and federal agencies.

An intensive long-term physical, neurological, chemical, and medical surveillance will be undertaken with volunteers from the maximally and minimally-exposed groups. They will be given physical examinations, including extensive laboratory evaluations, and periodic check-ups to determine if they have differences in disease incidence or severity, or any noticeable bio-chemical changes in body functions that might be pesticide-related.

In cooperation with physicians, cases of acute and chronic pesticide poisoning will be investigated, and assistance given in diagnosing and treating such cases. Also, in cooperation with appropriate agencies, an educational program will be carried out to inform the general public of the safe use and known dangers of pesticides.

Arrangements have been made with the Zoology Department of the University of Utah to investigate pesticides in water supplies and in the aquatic environment. Also, arrangements are being made with physicians and laboratories to do the clinical and laboratory studies.

A Technical Advisory Committee, composed of representatives of the agencies involved in the study, has already been selected. There will be five full-time and eight part-time employees on the staff. The study is expected to last several years.

TABLE I

PESTICIDES APPLIED — SALT LAKE COUNTY (JULY 1966 - JULY 1967)

Pounds of Active Chemical

Pesticide	Farm	Livestock	Fruit	Commercial Applicators	Domestic	Govt. Agencies	Mosquito Abatement	Total All Users
INSECTICIDES:								
Org. Phosphates								
Diazinon	533	60	......	1,064	......	......	......	1,657
Guthion	1,044	......	3,588	40	......	......	......	4,672
Malathion	1,405	440	1,200	2,406	2,662	......	575	8,688
Parathion	2,775	......	2,391	90	......	......	9,117	14,373
Others	434	492	......	114	1,404	115	280	2,839
						Sub-Total		32,229
Chlorinated Hydrocarbons								
Chlordane	......	......	......	6,962	5,083	......	......	12,045
DDT	1,725	......	5,279	976	2,055	......	110	10,145
Dieldrin	......	......	......	562	220	27	......	809
Methoxychlor	160	1,200	......	......	......	......	......	1,360
Other	......	33	546	88	1,832	......	203	2,702
Carbaryl	1,856	......	......	965	700	810	......	4,331
						Sub-Total		27,061
HERBICIDES:								
Arsenic	......	......	150	......	250,000	......	......	250,150
2,4-D	16,626	......	......	883	5,105	4,720	......	27,334
Dalthal	7,415	......	......	......	500	......	......	7,915
Tillam	3,461	......	......	......	......	......	......	3,461
Other	321	78	......	......	2,680	......	......	3,079
						Sub-Total		291,939
MISCELLANEOUS:								
Fuel Oil	......	......	......	210	......	......	19,250	19,460
Others	436	......	1,167	......	118	......	......	1,721
						Sub-Total		21,181
SUM TOTALS	38,191	2,303	14,321	14,360	272,359	5,672	29,535	376,741

HABITAT MANIPULATION FOR WILDLIFE AND MOSQUITO CONTROL

JOHN E. NAGEL — *Principal biologist — waterfowl*

Utah State Fish and Game Department
Salt Lake City, Utah

Habitat manipulation for wildlife and mosquito control while sounding impressive is more a matter of common sense than an elaborate and/or expensive program involving thousands of dollars. Marshes along the east side of the Great Salt Lake represent every facet, both good and bad, of marsh management. These marshes are from the most intensively managed to areas which are managed in name only. Proper management of these areas for wildlife and mosquito control compliment one another. By the same token, areas which are mismanaged or poorly managed often develop into mosquito problem areas for surrounding communities.

The key to successful management of any marsh area both for wildlife and for mosquito control is maintenance of controlled water levels. Controlling water levels allows the proper development of marsh and water to develop as a permanent ecological fixture of the marsh complex. At the same time a regulated water level reduces habitat types which florish in intermittently flooded conditions which are often heavy mosquito production areas.

The Utah State Division of Fish and Game controls and operates more than 70,000 acres of high quality waterfowl habitat along the east side of the Great Salt Lake. Many of these areas are located in close proximity to densely populated areas up and down the Wasatch front. These areas are among the most productive in the United States in terms of waterfowl production and migration. However, proper management of these waterfowl areas has practically eliminated mosquito problems. Mosquito control for our waterfowl areas has been developed into a program of periodic control with minor dosages of insecticides to control incidental insect production rather than a program of crash application of heavy dosages of chemicals to control rampant outbreaks of noxious insects.

As mentioned above, marsh management practices developed by the Utah State Division of Fish and Game are based on the proper control and distribution of available water supplies. All of our management areas are managed with the underlying premise of reuse of available water supplies.

This reuse of water is accomplished by development of a series of primary and secondary dikes. These dikes are constructed with a series of culverts, headgates and water control structures. Corrugated metal culverts equipped with metal risers are utilized to distribute water and maintain water levels in pond areas above the dikes. Headgates, both concrete and metal, are used to distribute available water to all sections of the marsh complex. Water control structures in the form of by-pass spillways allow marsh managers to by-pass water during spring runoff periods which would damage the physical components of marsh developments. Habitat, and the resultant flooding could result in conditions which would be ideal for the production of mosquitoes and other insect pests.

This series of dikes and water control structures allows marsh managers to utilize existing water supplies to the best advantage of the marsh complex. Primary dikes are used to impound water for use by emergent marsh areas below the dike. In addition these open water areas develop heavy growths of subsequent aquatic vegetation which serve as food supplies for waterfowl produced on the area as well as migrating flocks of waterfowl. Culverts in primary dikes assure a distribution of water to marshes below impounded areas. In times of drought those culverts can be closed to assure maintenance of water levels in the impounded areas.

Secondary dikes are used primarily as water distribution systems. During periods of adequate water these dikes and their respective water control structures are used to distribute water supplies to develop marsh complexes to their full capacity. In addition during drought periods water supplies can be directed into open water areas to insure that these pond areas will be maintained during the drouth. By-passing marsh areas during drouth saves water by eliminating water losses caused by transpiration of water by emergent marsh plants. As mentioned above, secondary dikes and water control structures are used to distribute water during periods of peak water supplies. Distribution of these flood waters assure that the water will be used beneficially to develop intermittent marsh areas which are beneficial to wildlife.

The management practices outlined above result in the development of optimum wildlife habitat. Marshes developed through a series of dikes and related water control structures are extremely productive and attractive to waterfowl because of the interspersion of emergent marsh and open water areas. This type of marsh complex can only be maintained through the stabilization of water levels.

Stabilization of water levels also aids in reducing the problem of mosquito production on these marsh areas. Therefore, it becomes readily apparent that correct management of marsh areas to develop maximum waterfowl habitat also results in a minimum of mosquito production and the two management activities are compatible. The Great Salt Lake marshes are prime examples that waterfowl areas can be developed close to urban areas without serious mosquito problems developing as a by-product of marsh management.

EFFECTS OF A PLANNED AGRICULTURAL LAND IMPROVEMENT PROGRAM ON MOSQUITO PRODUCTION

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In Davis County, Utah, the Wheeler Machinery Company Test Area contains over 900 acres of land bordered by the Farmington Bay Waterfowl Management Area on the south and the Great Salt Lake on the west. The land has been used during the past five years for field testing heavy, reconditioned, earth-moving equipment. A benefit derived incidental to the testing of equipment has been agricultural land improvement accomplished by grading, leveling, draining, and the construction of water management and control facilities.

Before any improvement of this land was attempted, the officers of Wheeler Machinery Company requested the County Soil Conservation Service to prepare a plan for the most productive and beneficial utilization of this sub-marginal land bordering the Great Salt Lake.

After an intensive study, representatives of the Soil Conservation Service recommended that about 525 acres of the best ground be converted into the production of agricultural crops, principally feed crops for livestock. It was recommended that the remainder of the ground be converted into managed waterfowl units.

As both the agricultural aspect and the waterfowl management program entailed the storage, use, and management of water, it was evident that an increase in the production of mosquitoes and other noxious insects could accompany the development program unless proper measures were incorporated into the program to prevent this possibility.

As a result of this situation, the authors of this paper and their colleagues who are engaged in a cooperative research program of water management for multipurpose use on the marshes, were invited to participate in planning the development of the test area and to continue with a study of the results of the development program as it pertained to the production of mosquitoes.

Thus, the Wheeler Machinery Company Test Area became a study site of the cooperative research program in operation in 1963[1] and was included in a similar study which began in 1966.[2]

[1]This study was supported in part by funds provided in Research Grant WP-00027, Department of Health, Education and Welfare, Public Health Service, National Institutes of Health, Research and Training Grants Branch, Division of Water Supply and Pollution Control.

[2]This study was supported in part by funds provided in Research Grant CC-00171, Department of Health, Education and Welfare, Public Health Service, National Communicable Disease Center.

The cooperative planning to eliminate, as much as possible, mosquito production on this property began in 1963. At this time weekly inspections, during the mosquito season, were started on selected mosquito breeding areas and potential mosquito producing situations on the test site. These inspections were continued through 1966. The results of this study are presented in this paper.

In the initial survey of the test area all of the potential mosquito producing situations were located and recorded on a map of the property prepared by the Soil Conservation Service. The extent of each potential mosquito producing site was indicated on the map. This was accompanied by a description of the habitat and the source of the water.

The weekly inspections determined the location and the size of the area in which mosquito larvae were present, the species present, and the number of each species taken per dip. Thus, the approximate numbers produced at each site were ascertained.

Larvae were found in sixteen locations on the 900 acre test site and each location was designated as a sampling station. The stations varied in size from a few feet of surface area to approximately fifteen acres. The vegetation where the larvae were found was predominantly salt grass (*Distichlis stricta* [Torr.] Rybd.)

It was found, as a result of this study, that the following species of mosquitoes were produced on this study area: *Aedes dorsalis* (Meigen), *Culex tarsalis* Coquillett, *Culiseta inornata* (Williston), *Culex erythrothorax* Dyar, *Aedes fitchii* (Felt and Young), and *Culex pipiens* Linn. They are listed in order of relative abundance according to the larval survey.

At the end of 1967 approximately 500 acres of land had been developed for the production of forage crops. Part of this has been planted and crops produced, principally barley, alfalfa and pasture grasses. The land producing crops is irrigated from four large water storage reservoirs constructed for this purpose. The water is pumped from the reservoirs and applied to the land by a moving sprinkling system.

In the construction of the storage reservoirs and irrigation system, mosquito production has been reduced to a minimum by including measures designed to accomplish this objective.

To date, none of the proposed waterfowl units have been constructed. The plans for these units also include measures to prevent mosquito production.

As a result of the incorporation of mosquito control measures into the agricultural development program on the Wheeler Machinery Company Test Area mosquito production has been reduced or eliminated in many localities that were producing when development began, and prevented in places where such production could have occurred.

Of the sixteen stations which were routinely sampled for larvae, three were completely eliminated as the result of filling and leveling during the course of agricultural development. In two impoundments mosquito production occurred around margins in the shallow water where salt grass was present. This was corrected by covering the salt grass with soil pushed in from higher ground. This produced an even, abrupt shore line without salt grass and established the water at a depth of six to twelve inches. This eliminated mosquito production and did not materially reduce the water storage capacity of the impoundments.

Two larvae sampling stations, many years ago, had been salt water evaporation ponds. They had become heavily vegetated with salt grass, *D. stricta*. Each time the area was flooded, large broods of *A. dorsalis* were produced. Frequent insecticidal applications by the local mosquito abatement agency were required for control. In late 1963 a water channel was constructed to provide an inflow of water into these depressions which were formerly ponds. The water level was elevated to a depth exceeding twelve inches. The following year the submerged salt grass was unable to survive. The elimination of the salt grass and the greater water depth converted these previously heavy mosquito breeding sources to areas of little importance from the standpoint of mosquito production. Habitats ecologically similar to these stations prior to modification continued to produce large broods of *A. dorsalis* after each flooding.

Previous to the land development program, a flowing well provided a source for mosquito production. During the first stages of land development, the water from the well was diverted to the north for a period of one week or less and to the south for a similar period of time, thus preventing an accumulation of water for a sufficient period to produce mosquitoes. Eventually the water was diverted into a nearby impoundment with the consequent elimination of mosquitoes from this source.

A small irregular shaped lake was formed by constructing a dike approximately one quarter of a mile in length along one side of a natural depression. The lake was filled to overflowing each spring. The water level gradually receded during the summer because of withdrawal for irrigation. Although 75 to 100 yards of the shore line was sampled weekly, no mosquito production was detected. The gradual drawdown and the abruptness of the shore line were considered to be factors in preventing mosquito development.

Two small mosquito breeding areas were created as the result of water seeping through the dikes of an impoundment. One of these was subsequently eliminated by constructing a small drainage ditch to remove the seepage water.

Several of the reservoirs and more permanent natural ponds were stocked with the mosquito fish, *Gambusia affinis*. The fact that these areas are of little consequence in the production of mosquitoes may be attributed, in part, to the predaceous activities of the fish.

Two areas, unaffected by the agricultural land development, have continued to produce *A. dorsalis* in large numbers each time they are flooded during the mosquito season. These also can be eliminated when the land development encompasses these locations.

SUMMARY

During the process of land development and accompanying water use and management on the Wheeler property, fourteen of the sixteen mosquito producing sites routinely sampled have been eliminated as problem areas by the development program. The remaining two are in unimproved areas and will eventually be eliminated as the land development encompasses these locations.

The great increase in the amount of water stored on and applied to the land for irrigation and the use of livestock has been accomplished by careful planning without creating significant mosquito producing situations. The reduction or elimination and the prevention of mosquito producing situations have been accomplished by the application of the following measures:

1. Filling and land leveling.
2. Shore line modification.
3. Elimination of salt grass.
4. Maintaining constant water levels.
5. Increasing water depth in selected situations.
6. Gradual drawdown of water levels in impoundments.
7. Preventing recurrent and prolonged flooding.
8. Use of Gambusia fish where practical.

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INSPECTION AND CONTROL TECHNIQUES FOR THE PASTURE MOSQUITO, *AEDES NIGROMACULIS*

W. D. MURRAY, MANAGER-ENTOMOLOGIST

Delta Mosquito Abatement District

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I. *Introduction.*

The Public sees the pasture mosquito, *Aedes nigromaculis,* primarily in the open grassy yard, or while hanging clothes, or in school yards, or while playing golf, or while watching an evening ball game. There is little understanding or even thought of the source of this pest. Occasionally a comment will be forthcoming relative to a nearby river or ditch and its possible association with the swarms of adults, although the technical worker recognizes quickly the unlikelihood of such association.

People may fret about the sleep-disturbing house mosquito, *Culex quinquefasciatus,* but they scream when a heavy infestation of pasture mosquitoes descends on them — they pick up the barbecue supplies and go inside, or they grab the golf bag and return to the club house. In many cases they make an urgent call to the local mosquito abatement district, if one is available. In an area where the pasture mosquito is dominant, the mosquito control agency must place a major emphasis on it, sometimes to the neglect of other important species.

What might a mosquito abatement district do to combat this species? First, information on the biology must be obtained. Next, technical aids and procedures must be developed, and, finally, a professionally sound control program must be instituted.

II. *Biology*

Aedes nigromaculis is called the "Pasture Mosquito" or, sometimes, the "Field Mosquito." These common names indicate clearly the major sources of larval production — pastures or fields.

Adults lay eggs primarily on muddy, drying areas in open fields. The eggs, after deposition, require a period of time for development, therefore an immediate flooding on newly laid eggs cannot trigger their hatching. With drying and with time, many or most of the eggs may become ready to hatch at the next irrigation or flooding. The eggs which hatch do so at almost exactly the same time, perhaps within minutes of each other.

The larvae develop very rapidly in the hottest part of the summer, passing from one stage to the next in less than a day's time. The four larval stages plus the pupal stage may be completed and the adults emerge from the water within four days after water first covered the eggs.

Emerging adults must mature for about a day before they can fly effectively and take food. Dispersal flights are one of the most unpleasant phenomena of this species. In the southern San Joaquin Valley, radioactive-marked adults have been collected seven miles from the point of release. There is good evidence that twenty mile flights occur under favorable conditions. Thunderstorms sometimes appear to trigger heavy flights.

The pasture mosquito is a diurnal, sun-loving species. It feeds throughout the day, but is more active in the morning and evening than in the heat of the day. It does not feed in darkness. It is strongly attracted to lights and will feed vigorously if there is sufficient light intensity, regardless of the time of night.

III. *Technical Aids.*

1. Maps.

A most essential step before a professionally sound program can be established in at least most districts is the preparation of good maps. These maps will have many uses, but the most important will be to delineate larval sources.

1) Aerial photographs have been taken of most of the agricultural land in the west. The office of the County Agricultural and Stabilization Committee (ASC) has a complete set in most counties. Frequently the County Supervisors have a set, housed with the County Planning Commission. Some mosquito districts buy a set for their own use. In agricultural areas these maps are scaled at eight inches to a mile, a very convenient scale for use on standard 8½ x 11 inch paper. Most of the land is identified by sections (square miles) and the term "Section Survey" has been given to this mapping concept.

2) Tracings. The aerial photo is not convenient for general field or office use. The Delta Mosquito Abatement District uses it to determine the exact position of fields, fences, lanes, roads, houses, ditches, etc. Such items are traced from the photo onto a good quality tracing paper, using a well-lighted tracing table. A rapid field survey is made to determine the meaning of questionable marks on the aerial photo and to record all important items on the master tracing.

3) Stencils. The Delta MAD uses a Multigraph duplicator for many purposes, including the duplication of maps. Information from the master tracing is copied onto a Multigraph stencil, again using the tracing table. Numerous copies of the maps of each section are then run off on the duplicator. The blank copies of the maps are used for many purposes:

a) Larval sources. Sources are marked as red areas in the appropriate fields as they are found. These records are permanent so long as the fields and the sources persist.

b) Airplane spray orders. At the close of each day the Inspector-Operators outline on a clean map the areas of the fields they wish to have air sprayed. The pilot organizes his flights for the next morning on the basis of these maps.

c) Master records. All larval sources in each section are summarized on the maps at the end of each season. Insecticide usages are kept with the map records. These records are kept for many years.

d) Crop records. Each year all crops are recorded in their appropriate fields. Crop maps have been of much value in planning for zone boundaries, for source reduction contacts, etc.

e) Ownership records. For each important section in the district a map is prepared showing ownership names and boundaries. This map can be brought up to date about once a year, using county records. There have been innumerable times when such records saved much time and embarrassment as compared with the alternative of a trip to the court house each time this type of information was needed.

2. Records.

Various record forms are printed on the back of the maps, or on separate sheets. These include information of exact gallons of spray used; exact acres treated; time required for treatment; estimate of larval population; note on adults present, if any; bees, skittish animals, and hazardous objects such as trees and powerlines (for pilot assistance); etc.

3. Field Condition Chart.

The maps provide information on "where," but they do not indicate "when." The Field Condition Chart is a simple observation and memory device which helps determine when control is needed.

Section	**Field No.**	**Date**	**Condition D-Dry W-Wet S-Sprayed**	**Date To Check**	**Date To Spray**

The blank spaces fill both sides of a sheet of paper, permitting entries for about 160 different fields.

Most Inspector-Operators in the Delta MAD have from 150 up to 300 or more separate sources which may produce the pasture mosquito. These men simply cannot remember the condition of all these fields each day. The Chart provides spaces for listing all the sections in an Inspector-Operator's zone, and all the known fields in each section. The Chart is maintained in a current status by planned inspections and by using a soft pencil and an eraser for recording the condition of each field in the appropriate spaces.

The exact time when irrigation will occur usually is not known to anyone, including the irrigator. The Inspector-Operator knows it cannot happen when the hay is being cut, or when the bales are in the field. Also, he knows it should not happen in less than ten days after a preceding irrigation. Being certain of his dates from the Chart, he may safely ignore the field during such periods. However, as the expected time for irrigation approaches, he must inspect the field almost daily.

IV. *Inspection Procedures.*

1. Larval inspections with the dipper or simply by visual observation of water sources are well known and will not be discussed here other than to note that they are of major importance.

2. Pasture mosquitoes rest on vegetation in the fields. They are attracted to moving objects and will fly towards, swarm around, and land on a person, a horse or cow, a Jeep, a waving cloth, or other objects which invade their territory. The simplest of survey techniques is a brief walk through a field, or over an attractive area such as a grassy school yard, counting all adults which land on the clothing or skin. When adults are numerous, a count of "so many per leg" is made.

3. Light traps. Pasture mosquitoes are attracted towards a strong light but do not move towards a weak light with good consistency. Light traps with a 25 watt bulb are good measuring devices for *Culex* species, and they usually collect *Aedes* species which

are in the vicinity. However, they do not provide a sensitive index of actual numbers of pasture mosquitoes present.

4. Complaints. When a complaint call is received, several questions asked by the Office Secretary usually permit positive identification of the pasture mosquito: "Are they biting outside?" and "Are they biting in the daytime (or under lights)?" If the answer is yes to both questions, the pasture mosquito is strongly suspected. Partly through the District's public education program and partly through compulsion, people call the office when the problem reaches an unacceptable level. The District has found the Public to be a very useful inspection arm, frequently reporting an incipient outbreak in time for the District to eliminate the adults before they have spread over a wide area.

V. *Control Procedures.*

1. Equipment.

1) Airplane. This does over 90% of the spraying in the Delta MAD. The District owns a Pawnee 235 plane, which disperses one gallon of liquid insecticide per acre at a swath width of 66 feet. The pilot usually covers about 150 acres per hour. Total cost is about 29¢ per acre, including the pilot's salary, insurance depreciation costs on the plane, maintenance and supplies.

2) Hand sprayer. Miscellaneous small jobs are done by hand when possible. The Inspector-Operator is not expected to remain in any field for very long — he must inspect many fields each day and cannot afford to devote too much time to just a few fields. He applies two gallons per acre, using a 4 gallon sprayer which has a solid stream nozzle.

3) Power sprayer. There is a power sprayer on every Jeep. However, the Inspector-Operator is not permitted to drive in wet irrigated pastures or alfalfa fields. The spray tank performs an important function in pasture mosquito control as a source of insecticide to fill the hand sprayer.

2. Insecticides.

The pasture mosquito is the only species that has caused a significant problem due to the development of insecticide resistance. It became resistant to DDT in the second year of use, to Toxaphene after two years, to parathion after eight years, to methyl parathion after two years, and to fenthion (Baytex) after five years. Dursban, an unusually effective insecticide against some insects, appears to be little if any better than fenthion against fenthion-resistant pasture mosquitoes.

During 1967 a non-phytotoxic oil (Flit) was tested and gave indications of being useful against fenthion-resistant larvae, but at a much greater expense.

VI. *Source Reduction.*

Efforts of the Source Reduction staff to reduce larval sources of the pasture mosquito have not been particularly successful. Drainage at the low end of a pasture may help, but most pastures in this district are too flat or are too poorly leveled to permit adequate total field drainage through a drain ditch and return flow system.

VII. *Summary.*

The philosophy of the Delta MAD is that control of the pasture mosquito requires a sound, professional effort for maximum success. All staff members and employees must understand the biology and habits of this species, they must understand and use various survey and record-keeping devices, and they must use certain basic control procedures if they expect to achieve effective, efficient control of the pasture mosquito.

EXPERIENCES WITH AERIAL DUSTING IN THE KERN M.A.D. 1967

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A record volume of water from the Kern River watershed in 1967, more than three times normal, resulted in flooding of several thousand acres south and west of Bakersfield for long periods of time. Much of this acreage developed into ideal sources for production of *Culex tarsalis,* the vector of encephalitis in California.

As temperatures increased with the advancing summer season, we experienced ever increasing larval populations of *C. tarsalis.* We found it necessary to apply liquid larvicides by air at weekly to ten day intervals over much of the flooded region. Vegetative canopies consisting of grass, brush, and trees became quite dense, affecting the results of our larviciding applications. These were made as aqueous solutions at ½ gallon per acre or as ULV sprays at 2½ to 8 ounces per acre. Of the two spraying techniques, the ULV applications proved superior to the aqueous. Neither, however, were adequate because of the dense vegetative canopy in many locations.

In June, the *C. tarsalis* larval density had reached a level of 50 per dip under a heavy canopy of mesquite and grass over hundreds of acres. Obviously the aerial spraying was not getting the job accomplished.

These circumstances indicated the necessity of changing our approach if we hoped to attain any degree of control of *C. tarsalis.* Following discussion with pesticide formulators and regulating agencies, we decided to try a parathion dust formulation. This we obtained as a 2% ethyl parathion from Wilbur Ellis Company, Fresno, California. The dust was prepared from a local anhydrous, alkali, aluminum silicate with a pH of 5.4 - 6.5, known as Frianite. It was screened through a 325 mesh screen to provide an average of 44 micron particle size. In preparing the dust, a 98½% technical parathion is sprayed within a ribbon blender to impregnate and coat the particles.

The airplane used in applying the dust was a Call Air A-9, equipped with a standard Swathmaster, Jr. spreader. In application, the dust is gravity released from the hopper to the spreader.

Limited swath pattern evalutions indicated a swath of 220 to 300 feet. The first application made with the dust and equipment described, was over a location where we had previously failed to obtain satisfactory results with our liquid sprays. Flying at 90 miles per hour at heights of 30 to 50 feet necessary to clear the trees and brush, the dust was applied at 2.5 lbs. per acre across swaths of 220 feet with a parathion dosage of .049 per acre.

Results were more than surprising. No live larvae could be found where prior to treatment counts up to 50 per dip were common. In addition to numerous dead larvae, adult *C. Tarsalis* were found floating upon the water surface where vegetative canopy was most dense. In subsequent applications, we continued to obtain results similar to that experienced with the first trial. Highly effective results were later on occasion obtained at a parathion dosage of approximately .033 lbs. per acre at a gross of 1⅔ lbs. per acre.

More than 20 tons of 2% parathion has been used by the District with excellent results. Trials have also been made for control of *Aedes nigromaculis* larvae and adults with equally good results. One such application was made over a 420 acre area containing all aquatic stages plus a heavy infestation of adults. Control was complete on all stages except the pupae.

Trials with 4% malathion, 4% parathion and 2% baytex have been made or are planned. One malathion application of interest can be reported upon at this time. This was made over 20 acres of duck clubs containing a heavy aquatic population of all stages of *C. tarsalis*. Twenty-four (24) hours following the application of .16 lbs. of malathion per acre, only fourth stage larvae and pupae could be found. Obviously this could be interpreted as an insufficient dosage and this we could expect at such a low dosage of malathion.

As with all things, our experiences larviciding and adulticiding with dust have not proven to be a panacea. On a few instances we have had applications turn out to be complete failures. These, however, have occurred only a few times. We do not know why these failed but suspect it is a mechanical problem, one of not getting the dust to the target. We have observed that wind drifts will move the dust completely off the intended swath and suspect that under certain weather conditions, the dust will not settle upon open water. On the contrary, however, we have had successful dusting applications in winds exceeding 10 M.P.H. when allowance is made for an adequate margin of drift. Over wooded areas when allowing for drift, winds actually seemed to improve results.

GENERAL CONSIDERATIONS RELATIVE TO THE USE OF VERY LOW VOLUME LARVICIDING IN MOSQUITO CONTROL

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The impressive talk by Mr. Ingretsen reminded me that probably none of us can name the Russian cosmonauts who have successfully completed orbits around the earth; nor even all of the American astronauts who have had similar experiences. We live in an age of scientific advance so great and so rapid that even the spectacular has become commonplace.

But I'm confident that everyone here knows that Dr. John Kilpatrick of the Communicable Disease Center, U. S. Public Health Service, was in charge of the very low volume airspray project which interrupted the encephalitis epidemic in Dallas in 1965. This was the practical proof of a spectacular advance in our own field, and we applaud Dr. Kilpatrick for it. I predict that before this meeting is over, all here will know William E. Burgoyne, Kenneth G. Whitesell, and Richard F. Frolli — for during the past summer, they showed how the very low volume system can be utilized effectively and economically for larviciding in practical local mosquito control programs where every dollar spent must be well justified.

Here is a very prosaic illustration (see Fig. 1) of spectacular progress in larviciding—progess that has accumulated through a 30-year period and through the efforts of many men—most of whose names have been forgotten, if they were ever known, by most of us. The fact is that today, even with inflation and rising costs, we can and routinely do control spraying at a cost of less than $.50 per acre (parathion applied by aircraft). Mosquito control on the same acre would have cost a minimum of $5.50 in 1935 (50 gallons of oil costing $4.50 and two hours of hand labor costing $1.00). This represents a nine-fold decrease in the unit cost per acre. During the same period, there was at least a three-fold increase in the cost of wages, materials, and most services. Taking this into account, we may say that the cost of routine mosquito larviciding is now only one twenty-seventh as great as in 1935! The very low volume system promises still greater economy. Its use may well decrease the application cost, for the aircraft service, from about $.25 - $.30 per acre to less than $.10 per acre. This method is also particularly well suited for use by helicopters, at reasonable costs.

(Photo comparing insecticide dosage rates 1935-1965)

FIG. 1 PROGRESS IN THE DEVELOPMENT OF LOW VOLUME SPRAYING IN MOSQUITO CONTROL.

The improvements were not made quickly, nor all at once. They came about gradually, small step by small step, through the painstaking work of many people in science and management.

Look again at the illustration. In 1935 the principal insecticides for larviciding were furnace oil, kerosene, diesel oil, and pyrethrum emulsion, all of which had to be applied at a rate of 50 gallons per acre, by the hand sprayers and power equipment then available.

By 1945 a great breakthrough had taken place: the utility of DDT had been demonstrated and methodology for its use had been developed. The trend toward low volume larviciding had begun. Applications of five gallons per acre or less quickly became common. Some applications of less than one quart per acre were successful.

The excitement occasioned by the introduction of DDT as a pesticide of great efficacy tended to cause workers to overlook a corollary development in the dispersal of larvicides which is perhaps as important as DDT itself. I refer to the fact that whereas earlier larviciding had been accomplished in areas which support vegetation by using a volume of insecticide so great that all screening plants were thoroughly wetted and runoff from them would reach the water containing the mosquito larvae, some of the new equipment used with DDT divided the sprayed material into droplets so small that the primary dispersal took place in the air rather than by runoff into the water. Although some droplets were lost by impingement upon the emergent vegetation, a sufficient portion of the insecticide passed between the screening plants to reach the water surface and runoff was no longer necessary for effective larviciding. If the open spaces among the plants in an overgrown pool approximates half of the area of the pool, it appears reasonable to expect that approximately half of the insecticide will get through and into the water — so that for control, it should only be necessary to adjust the concentration of insecticide to allow for the loss of insecticide due to impingement on the plants. If this premise has merit, then a runoff application ceases to be important, and the application rate can be reduced to a very low volume indeed! (This is, of course, an oversimplification. The movement of very small spray droplets suspended in air is a very complex matter, not easily explained).

An instance which appears to support this reasoning was noted in the larviciding of rice fields in Colusa, near the end of the season. Where the rice was growing erect in the field so that there was open water and open air spaces between the stems, the application was fully successful. But in the same fields, where the rice had lodged so as to form an almost impenetrable "thatch" above the water, some live larvae were taken after spraying, indicating that only part of the spray material had reached the water. In flying over these fields, it was impossible to see the water through the lodged rice, although it could be seen easily where the rice was still erect.

As DDT came into general use, about 1945, the economy of the lower volume applications, particularly with aircraft, was immediately apparent. Economy minded technical and management personnel gradually reduced the application rates, generally increasing the concentration of the insecticide to compensate for the lower volumes applied. By 1955, most mosquito control agencies in California had reduced the "standard" aircraft application rate to one gallon per acre, ground spray rates were lowered to two to three gallons per acre and hand spray rates were down to two to five gallons per acre. Efforts to lower the aircraft application rates by using smaller nozzles with lower delivery rates (which also produced smaller droplets) were not successful, and it was then assumed that one gallon per acre was the minimum practical application rate for use in a dry, hot climate. Efforts to obtain lower application rates were suspended until 1964 when we prevailed upon David E. Reed, Manager of the Fresno Westside Mosquito Abatement District, to reduce the application rate to one-half gallon per acre by removing half the nozzles on the spray boom of an aircraft equipped to deliver one gallon per acre. The results were so satisfactory that he adopted the one-half gallon rate for field operations. Gordon E. Smith, Manager of the East Side Mosquito Abatement District, was also requested to try this technique, and he too found it so satisfactory and economical as to warrant its adoption for general use. Since then, most other mosquito control agencies in California have adopted the one-half gallon rate. We believe that reducing the delivery rate by reducing the number of nozzles so that the spray droplet size is not reduced explains the present success with the reduced rate.

During the same 1964 season, a series of tests (Mulhern et al) confirmed the preliminary results obtained in 1962 and 1963, and in subsequent years, the study project to be reported upon by Mr. Burgoyne has refined the method and demonstrated its practicality, at a volume as low as six fluid ounces per acre. The formulations used contained only 1.6 fluid ounces or less insecticide concentrate. Still lower volume applications are possible and have been successfully made but we have emphasized reliability of results under field conditions and have not been too concerned about achieving the absolute minimum application rate.

The primary forces responsible for the dispersal of spray droplets released from an aircraft are gravity, the turbulent air currents induced by the passage of the plane through the air and the natural air currents above the area sprayed. Additional factors which substantially affect the dispersal of the droplets are droplet size, viscosity, specific gravity, rate of fall, evaporation, and downwind drift. The modification of any of these may influence the path of the falling droplets. This subject is under continuous study by Akesson, Yates, et al, at the University of California, Davis, and by others, and has been the subject of many informative reports and papers. It is far too complex a matter for comprehensive discussion here. However, some comments may be in order.

Viscosity

A liquid of relatively high viscosity will pass through a nozzle having a small orifice more slowly than a material of low viscosity. Yet the droplets will usually be larger (and may be more uniform in size) than those produced with the less viscous material. Viscosity of the spray formulation thus affects delivery rate and droplet size. It is also frequently true that the liquids of higher viscosity are less volatile than the lighter materials and viscosity may be related to evaporation. (Example — undiluted malathion concentrate is of relatively high viscosity, low volatility, and high specific gravity.) Compared to light oils such as kerosene and to water, it flows more slowly through fine orifices, forms larger droplets which fall faster while exhibiting almost no evaporation and has a much longer residual life. A much higher percentage of the sprayed material may fall in or near the target area.

Specific Gravity

Specific gravity is much less important than droplet size in determining the rate at which a spray droplet will fall through the air and is normally not considered when applying water-mixed formulations or oil solutions which have a specific gravity only slightly greater or less than water. However, this factor may become more important when using formulations which have a high specific gravity, as malathion = sp. gr. 1.25, or Dibrom 14 = sp. gr. 1.9, particularly when these materials are dispensed in relatively large droplets, i.e., 50-300 microns.

Droplet size, rate of fall, and downwind drift

The velocity which a droplet of liquid falling through air will attain is affected greatly by the size of the droplet. For a liquid having specific gravity 1.0 (water), the theoretical terminal velocities of certain droplet sizes falling through still air have been calculated as follows:

Diameter (microns)	**Terminal velocity (ft./min.)**	**Time to fall 10 ft. (seconds)**
5	0.15	4020.0 (67 min.)
10	1.7	1020.0 (17 min.)
50	14.6	41.0
100	55.0	10.0
200	142.0	6.5
500	420.0	2.1

For liquids which have a greater specific gravity than 1.0 (such as malathion and Dibrom), the droplets will fall faster and will thus not drift so far downwind.

Evaporation

The effect of evaporation upon small droplets of water is well expressed by the following quotation from the "Handbook for Agricultural Pilots" published in Holland:

"Evaporation of water droplets —

"Approximate lifetimes of drops of pure water in air at 15°C (60° F) and 40% relative humidity are:

Initial diameter, microns	*Life in seconds*
50	4
100	16
200	63

"The rate of fall in still air of a 200 micron drop is rather over 2 ft./sec. so that such a drop will evaporate comparatively little in falling 20 feet to the ground. A drop initially 100 microns in diameter will start to fall at rather less than 1 ft./sec. Evaporation during fall will not be important in slowing its fall still further and it could not in fact fall to the ground from 20 feet; it will have evaporated completely by about halfway. The drop initially 50 microns in diameter will only survive about one foot of free fall at this humidity."

It is apparent that there is a great loss of the smaller droplets of water mixed sprays and that evaporation control is essential for very low volume sprays, which must be applied as small droplets to obtain sufficient coverage of the treated area. Much of the pioneer work with very low volume sprays was done with malathion — probably because it naturally has properties which experience with very low volume sprays has shown to be desirable. For other toxicants, to which extenders must be added in order to dilute the toxicant to suit the equipment employed, the extender should have low volatility, and we think it would be highly desirable that the final mixture have physical properties similar to those of undiluted malathion.

One must always bear in mind that in operational spraying, we are not dealing with a "still air" condition. There is almost always some wind which tends to affect the paths of the falling droplets. In addition to its horizontal component, the wind has considerable turbulence, which is so variable as to defy precise calculation. There may be very definite rising or falling components. A crosswind movement of only one or two miles per hour may be sufficient to severely distort the spray swath, resulting in an abnormal deposit pattern. The smaller droplets are affected to a greater degree than the larger ones and may drift far out of the target area before settling down to the earth.

Conclusion

The tests to be reported upon have demonstrated a pattern which yields effective results with reasonable consistency. It should be possible to utilize this information as the basis for developing recommendations for the practical employment of the very-low-volume method of applying larvicides for mosquito control. It is, however, strongly recommended that technical development be continuously carried on to improve and refine this technique to the optimum.

WHAT LOW VOLUME LARVICIDING MEANS TO AN OPERATIONAL MOSQUITO CONTROL AGENCY WHERE ECONOMY IS ESSENTIAL

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ABSTRACT

The Colusa Mosquito Abatement District comprises 160 square miles of land lying wholly within the County of Colusa in the Sacramento Valley of California. The principal mosquito sources are in pastures, duck clubs, and rice fields. The primary mosquito control efforts of the District have in the past been directed toward the control of *Aedes* mosquito species produced in the pastures and duck clubs. The dominant mosquito species which occur in the rice fields are *Anopheles freeborni* and *Culex tarsalis*. The rice field mosquito sources have received little attention because it has not been practicable with the resources available to the District to larvicide the 22,000 acres of rice. There are several reasons why this is so: There are not enough operators on the staff to adequately inspect the rice fields to determine the best time for treatment; the ordinary procedure of dipping to determine larval densities is unsatisfactory, particularly late in the growing season when the vegetation is high and dense; larvicidal applications at standard application rates appear not to penetrate the dense vegetative growth as the rice approaches maturity so that the level of control obtained by spraying is low.

On the basis of past observations and experience, it was thought that the entire rice area should be sprayed periodically with the timing based on seasonal variations in larval populations, rather than upon the results of local larval inspections. However, comprehensive spraying had not been financially feasible with conventional larviciding techniques.

Voluminous data were provided by Dr. Stanley F. Bailey, Department of Entomology, University of California, Davis, showing the seasonal variations in density of both *C. tarsalis* and *A. freeborni*. From these data it was possible to determine the peaks of population and to develop a spraying schedule by which the entire acreage of rice could be sprayed three times (June 1, July 18, and August 28) with reasonable confidence that a substantial reduction in rice field mosquitoes could be obtained. With the lowered application costs inherent in the low volume system of dispensing insecticides by aircraft, it may be both technically and financially practicable to develop a successful program for the control of *Anopheles* and *Culex* mosquitoes in rice fields.

LARGE SCALE FIELD TESTS OF LOW VOLUME SPRAYS (LV) IN CALIFORNIA MOSQUITO CONTROL DURING 1967

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ABSTRACT

Contract 0242, the United States Department of Agriculture and the Department of Agricultural Engineering, University of California — Davis cooperating, was funded in 1965 to investigate the use of low volume sprays (under ½ gallon total spray per acre) for California Mosquito Control. Work in 1965 and 1966 has been reported elsewhere.[1]

The test program in 1967 had the following objectives:

1. To investigate the use of a helicopter with spinner-type spray nozzles flying swaths over 100 feet wide;
2. To study economic means for controlling rice-field mosquitoes;
3. To aid in the development of new mosquitocides suitable for the LV technique.

Four full-scale tests were made with a Piper Pawnee 150 aircraft and a Bell G-5 helicopter to control *Anopheles* and *Culex* in rice and *Aedes* in irrigated pasture. Runs were made July 25 and August 10 with the helicopter over 7410 acres, August 29 with the helicopter over 1310 acres, and September 14 with the Pawnee over 1310 acres. The chemicals used were Dursban (0.0125 to 0.05 pounds per acre) and Fenthion (0.1 pounds per acre). Application rates were 6.0 fl. oz. per acre with the helicopter and 4.0 fl. oz. per acre with the Pawnee.

The effective swath of the helicopter was 250 feet; of the Pawnee, 125 feet.

Thirty additional small plot treatments were made over rice and pasture with the Pawnee at 8.0 fl. oz. per acre. Bee colonies were exposed. Studies of the effects of the sprays on fish and wildlife still continue. Plant samples were taken after each test for residue analysis.

Analysis of the data is not complete at this time (October 1967), but indications are that low volume will take its place as another useful tool for mosquito control in the near future.

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[1] Calif. Vector Views 13(8):1966, and Proc. Calif. Mosq. Control Assoc., 34. 1966.

THE USE OF DURSBAN IN LOW VOLUME SPRAYS IN CALIFORNIA MOSQUITO CONTROL DURING 1967

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ABSTRACT

Dursban was one of two materials used for 1967 LV mosquito control studies in the Colusa, Sutter-Yuba areas of California. Although some of the data has yet to be analyzed, promising control was obtained utilizing the technological advances under development with LV spraying. It was found that against pasture mosquitoes, principally *Aedes* spp., .05 pounds of Dursban was needed to control the late fourth instar larvae. However, against the rice field mosquitoes, principally *Anopheles* and *Culex* spp., .0125 pounds of Dursban was sufficient through July, but because of the increase in vegetation density and cover, .025 appeared necessary in August.

A concurrent but separate ground application study of ponded water, using Dursban at .05 pounds per acre, resulted in residual control of 3-10 or more weeks, where normal practices required retreatment on a 1-2 week basis.

LOW VOLUME TRIALS IN KINGS MOSQUITO ABATEMENT DISTRICT

BY
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Thomas D. Mulhern, California State Health Department, goaded us this year to test a low volume spray aircraft under routine operational conditions. This 1967 season we larvicided 34,888 acres with Baytex and oil at application rates of 6 oz. per acre; the dosage rate was 0.1 lb. of actual fenthion per acre. The trial ran daily for a period of twelve control weeks from mid-July through September.

The LV rig was simple and inexpensive. It consisted of an 8 gallon hopper, an aircraft fuel transfer pump and boom with four 8003 fan tips. The installation was made on a PA-18A Super-cub by the district pilots, George Martinez and Dale Hobson, at a cost of less than $150.00. The plane was worked at an altitude of 20 feet and because it was clean exteriorly of the pump, it attained a working speed of 105 mph. T. D. Mulhern determined the desired 100′ swath width visually, using aluminum foil; bioassays confirmed this swath width. The aircraft capabilities were 190 acres per load.

The results were excellent the first few weeks of spraying. The LV application killed *Culex tarsalis* (Coquillett) in dense corn, river areas and sloughs. It was effective on the same species in open areas such as, flooded grain stubble, native pastures, and reservoirs. It did equally as well on *Aedes nigromaculis* (Ludlow) found in irrigated pastures and alfalfa fields. No damage resulted to crops from the oil, nor to the wildlife from the concentrated toxicant. By the 4th week of August, 830 sources had been treated. These ranged from ¼ acre to 600 acres in size and the accumulated work amounted to 21,000 acres.

The honeymoon was over Labor Day week-end, however. Control operators began reporting misses in pasture areas. The spray pattern was apparently ragged. Fields appeared striped with dead larvae and live larvae. Sometimes all the larvae in the field survived a spraying. It was believed at first that the misses were due to the unsettled weather, the wind and temperature changes at the time. Failures occurred on 85% of those fields treated.

An additional 493 sources or 13,000 acres were treated through September to pursue the faults. During this time oil carriers were changed from kerosene to carrot oil, the pilot was changed and the swath width was checked and rechecked. Standardized tests of the plane appeared satisfactory under controlled conditions, yet failures prevailed on about 10% of the fields treated under operational conditions. Due to the questionable fidelity of operations, the trial was terminated September 30th.

Just why the system failed at the end was never determined, but it was not fully understood why it worked in the first place. When and where it failed is known. The failures occurred at the end of a long hot spell and the prelude to the cyclonic wind season. The failures occurred in irrigated pasture areas infested with *Aedes nigromaculis*. The spray pattern was definitely too ragged when applied in the wind, prevalent during operational spraying.

Perhaps latent resistance to organo-phosphate chemicals or vigor tolerance played a role in the control failures. It shouldn't be difficult to overcome the imperfections as more basic information is known and applied.

The simple spray system developed by Kings Mosquito Abatement District worked extremely well. It can be installed in any light agricultural aircraft with only slight modifications. Next year it will be installed on the district Piper Pawnees at Kings. To overcome spray pattern irregularities, the working swath width will be narrowed to 66 feet and the aircraft will fly on the deck. This will sacrifice efficiency but for greater effectiveness. The perfection, registration and availability of heavier concentrate formulations should enhance the outlook on control.

In 1968, low volume concentrate spraying will become operational in many California mosquito control districts. At first the technique will be employed as back-up systems for the conventional high volume systems and be used for specialized jobs. Eventually, the technique will replace high volume spraying in total.

MOSQUITO CONTROL, PUBLIC RELATIONS AND THE PRESS

JACK MONSON

Deseret News Reporter

Salt Lake City, Utah

Public relations is a two-wheeled vehicle that can be used beneficially or can create disaster depending on the attitude of those associated with the medium.

You people in mosquito abatement work can use the public relations as a good vehicle if you will think of the many benefits it can offer in letting the public know about your work.

In most instances, your office is being paid for from taxes or some other method of levy. The public is interested in just what you are doing with their money. So any experimental work you attempt, whether it succeeds or fails, is of interest to the people.

These various experiments can be used to your benefit by letting the people know what you are planning and then what you expect to learn when completed.

It doesn't hurt to let your public know how the tests are progressing. This can be done through periodic releases or by contacting a reporter friend or calling your local news media. In your public relations program, you should not forget the radio and television stations. Television can help you — picture wise — much more than the newspapers can. They can let the people actually see what you are doing in your work and bring the public closer to what you are striving to achieve. Don't be afraid of releasing information to the press. If you don't have a close relationship with the news media, develop some contacts as soon as possible.

In some instances people have shied away from news coverage because of the bad publicity they might receive. In most cases, however, I believe a newspaper or other news source will try to help you keep the public abreast of your work and what you are doing to abate the mosquito problems.

Here in Salt Lake the managers of both the city and county abatement districts have been very fair in releasing information. They will alert the news media as soon as they find a possible health problem arising from mosquitoes. By telling the public the truth about such matters it oftentimes can help solve the problem. It is when information is kept quiet that public servants get into real trouble, and I know there have been some instances of encephalitis appearing in certain areas.

The Mosquito District managers in Salt Lake have notified the press about dangerous disease increases and we have printed it. It has also been released over other media. Rather than the populace getting panicky, they have taken the report rather calmly and the outbreak was soon under control.

The public is also very interested in what you plan to do about ridding their neighborhoods or areas of mosquitoes and they are greatly appreciative of having such information.

This past spring in Salt Lake County we had an excess of moisture and both Glen Collett and Jay Graham were concerned about not being able to treat the ponds and other swampy areas in time to prevent an over-population of mosquitoes. I was called and told about the problem and asked if I could put a piece in the paper informing the public about the problem and explaining what the abatement districts were planning.

The people, I think, appreciated this information and didn't do much complaining to the districts when they found more mosquitoes in their areas than in previous years. I know Glen appreciated the article and it helped.

There are many projects that you people engage in throughout the years, — such as trying to discover various characteristics about mosquitoes' lives. This might include discovering how far they travel and the best method of control.

The general public doesn't know one mosquito from another. All they know is that when one lights on their arm, hand, face, or any bare spot on their body, they will get a small knot and it will itch.

But oftentimes, you, through the news media, can explain what the various species of mosquitoes do and how the public can protect themselves.

During the past few years I have worked with the two Salt Lake mosquito districts, we have had very good working relations.

Not only is there immediate news value in some of your work but there are feature type stories that can let the public know you are working for their benefit and not for yourselves.

Through the help of Glen and Jay I have written stories on various experiments they have been conducting. These include an employee going out late at night and sitting under a tree, lamp, or in a field just to let the mosquitoes bite him, or, tending a flock of chickens and then testing their blood at the end of the summer to check for diseases, if any, that mosquitoes might transmit.

Glen told me about the Spryte they use in spraying the marshes in the duck clubs north of the city. I was able to get some good pictures and tell people how the machine traveled through the water and inaccessible places to spray.

The public appreciated knowing about the equipment. Possibly many had seen it at work but didn't know about its use or who owned it.

There have been stories about plane spraying. One story was about a plane that had mechanical trouble and landed on a small island northwest of the city. It was an interesting and appealing story. The pilot was able to make his own repairs and then flew the craft off the island as the news media took pictures and spiritually helped boost the plane back into the sky.

I know you gentlemen oftentimes get very involved in your jobs and this is good to have such interest in your work, but also try to remember other people are also interested.

If you don't think you have anything of interest to report, just go home and tell your wife or children about what you did in trying to prevent the mosquito population from increasing. You'll find that in most cases they are very interested. This can be a lead to you that what you are doing might make a good news story.

Like my editor once told me, "If you are interested in something then it will be of interest to others."

You will be surprised at the number of people who are interested in your work and how you are progressing in solving the mosquito control problem.

As an illustration, Jay, in just discussing various phases of mosquito work mentioned about his knowing where a large hatch of mosquito fish were located. He said he had been giving them to people with ornamental ponds and was looking for other people with similar ponds and pools. Because it grabbed my attention I wrote an article and took pictures of one of Glen's men catching some fish. People read it and I believe the mosquito district had calls and found some pools they didn't know about.

So again, what interests you will interest many other people if you put it before the public.

One caution, don't give the information out in a technical manner. Most people can't translate your special terms into something meaningful to them. Describe what you are doing in the most simple terms possible, but if necessary, throw in some technical words to clarify your point. You understand all you say and write, but to a layman such as myself, it's hard to understand what you mean. If I can't understand it then I'm certain others will have the same difficulty.

As mentioned before, you can oftentimes send a press release to the local papers or other news media, but the most effective method of getting your message across to the public is to have a reporter tag along with you on some of your field trips.

Then you can tell and show him exactly what you are doing, how effective it is, and your plans for future expansion.

The reporter can then interpret for himself what you are doing. Since he is trained in interpreting the news he can help less educated people understand your work.

Don't write your news releases like you do your conference papers. You would find few people able to comprehend them and newspaper editor or other media editor would have little use for them unless you had talked with him prior to submitting the release.

USE OF THE SPRYTE FOR DITCHING IN SUB-MARGINAL AREAS

KARL JOSEPHSON,

Box Elder Mosquito Abatement District

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In the fall of 1963 I talked with my son Paul, who worked with Thiokol, Logan division as a designer of off Hi-way snow vehicles. We talked of a tractor that might pull a plow or ditcher in our soft, muddy sub-marginal areas. He told me the Spryte should do the job. We arranged for a demonstration. The date was set and I borrowed a new International ditcher from Brigham Implement. This ditcher didn't have a hydraulic ram on it and was adjusted only by hand crank. We towed the ditcher by Jeep to the field designated and met Paul with the Spryte there. We had some board members present and some of our employees there also. We hitched the ditcher to the Spryte and got set. The field was North of Brigham, part of a large meadow area that is always too wet to farm. We decided to follow an old drain that was all filled up from years of tromping by cattle and other livestock. The ground in this area just oozed water as you walked on it with a fair sod of salt grass, etc. We started out and what a surprise! We made a ditch, a beautiful ditch, 18″ deep and 36″ wide. As we proceeded at about 5 miles per hour, the ditcher went deeper and deeper then stopped the Spryte. We backed the Spryte and ditcher out, readjusted the ditcher and went on. We soon got into standing water then on until it was over a foot deep on top of the ground! We still went on making the ditch to the place we wanted to stop. This was more than half a mile of ditch in less than an hour, and in an area that, as one board member put it, "would mire a saddle blanket." What a thrill, I had put something together that would do so much good in areas that were so neglected.

During 1964 we made a survey of all sub-marginal areas by taking a cross section of property in each area needing this service. We then made maps of these areas and figured approximate lengths and depths of ditches needed to serve the areas and contacted a local contractor to get his price to dig these drains. The least expensive by a backhoe was $20,000.00!

To the property owners under our survey, we sent a letter explaining the object of the survey and on a separate sheet a questionnaire, to be answered and returned in a self-addressed, postage paid envelope. On this we asked, "Would they consider paying all, part, or none of the cost for the drains we suggested, also what kind of equipment to dig the ditch, ditcher or backhoe?" More than half of the returned sheets said they would bear part of the cost and only three said "No drain construction."

This information was presented to the Board during the winter of 1964-65 and after much consideration and discussion I was directed to purchase the equipment to start a "water management program." Meantime I had met with Blaine Rich, head of Thiokol, Logan division. We discussed our problem and he came up with a Spryte they had taken in on a trade for a larger type snow vehicle from Mountain Standard Fuel Supply. This unit had 7 hours use on it. We purchased this unit with a low gear on it for $5,617.00, then a new International ditcher for $398.00, and a trailer to haul the Spryte for $150.00. Now to put this unit together and start it to work. Total cost $6,165.00!

We figured we could make these drains for $10.00 per hour — paying all costs, that is, labor for contacting the water control and for the actual field work and prorating the equipment cost over a ten year period. After the first year this was raised to $15.00 per hour with the property owner paying half the cost and our standing for the other half. In most areas we can average a mile of ditch per hour. Some areas are slower depending on how wet they are and the type of growth. In sod we go fine, either wet or damp, but in tullies and bayonet grass of extremely wet areas it takes longer. We very seldom find the area "too wet" but have done so in a few cases.

We have one man go out and check as the requests come in. Each owner is approached, his area checked and mapped, then the location put in and agreed upon by both. The papers are signed by the owner, one guaranteeing the cost and another to release us from damages resulting from our work. After this, the ditches are actually dug. So far we have been busy just taking care of the calls as they come in. We haven't been out contacting anyone this year. The neighbors adjacent to the areas we have provided this service seem to want it performed for them while we are there.

We mounted a spray boom and sprayer on the rear of the Spryte and powered it with a small Briggs & Stratton Engine. The boom is a foldaway type and we found we can spray up to ½ acre per minute with this equipment. It covers a 50 foot swath and we use this in areas up to 50 acres in size that can't be sprayed by Jeep. We also have a hand nozzle and hose we use for spot spraying.

We feel this project is very successful and it is reflected by the reduction of sources of mosquito breeding areas, as well as better farming methods. We have seen pastures that had too much water on part and none on the other part raise a poor crop of "meadow hay" on part of it. After this was ditched, the "too wet" area and the "too dry" area all raised a good crop of hay by water management. We have seen wet areas dried up so a larger, more permanent, drain could be dug by a backhoe. We have seen areas drain out after a flooding whether caused by rain or over-irrigation.

We are not giving competition to any contractor as none of them have equipment to go into these wet sub-marginal areas and make ditches.

We have had to make some changes on our Spryte during the process of making these ditches — one of these being, stronger belts for the track, another, replacing the 1500 pound rear axle with a new 3,000 pound axle, and some other minor changes. Thiokol worked with us on this all the way through, giving us very fine backing and cooperation. They also made movies of several of our operations using them to help sell their equipment.

CURRENT STATUS OF PARATHION RESISTANCE IN UTAH

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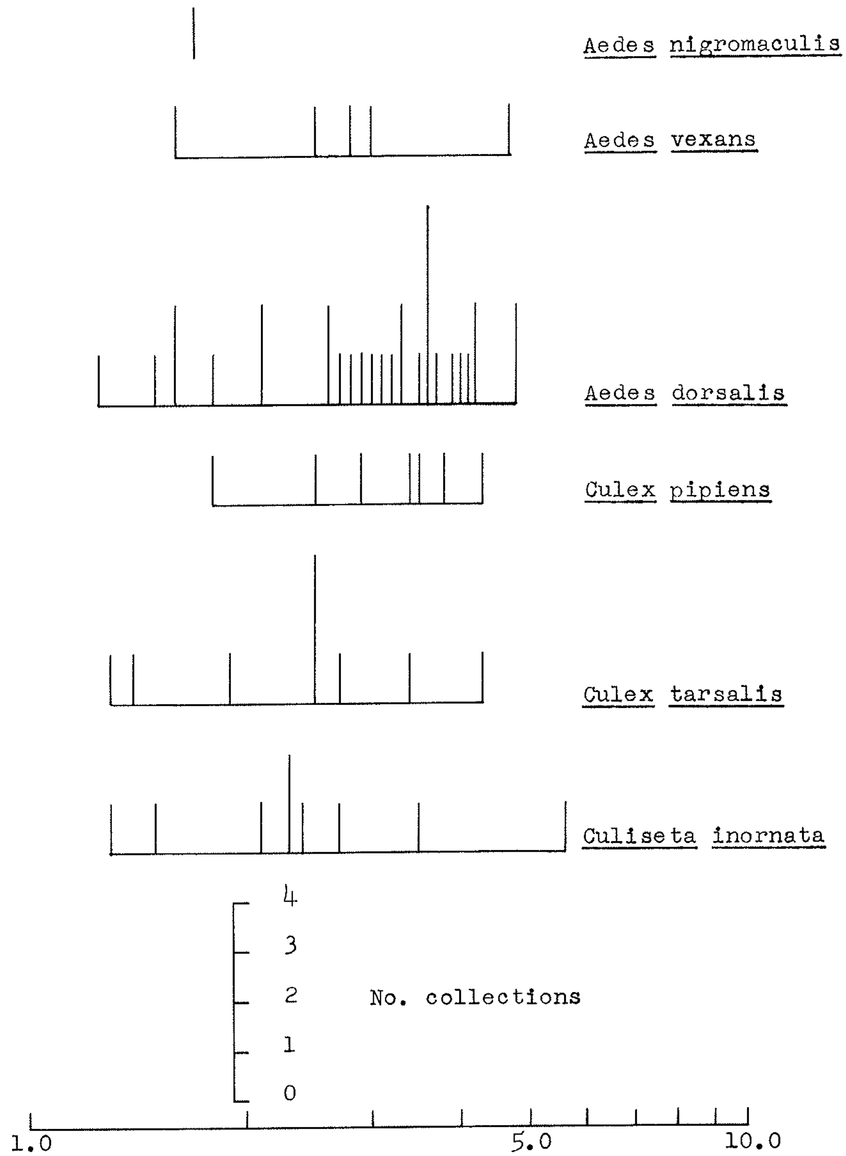
DDT and heptachlor resistance developed in Utah during the past decade in *Aedes dorsalis*, *Culex pipiens*, and *Culex tarsalis* (Graham and Rees, 1958; Reid, 1957; Collett and Reid, 1962). The organophosphorus compounds parathion, malathion, and fenthion have been used since the chlorinated hydrocarbons were discontinued. Tests to determine whether organophosphorus resistance had begun to develop were initiated in 1965 (Womeldorf, *et al*, 1965). At that time, no larval populations were found to be parathion resistant. Limited tests were conducted during 1966 and 1967, mainly in the mosquito abatement districts in Salt Lake County. This report summarizes parathion susceptibility data on Utah mosquito larval populations collected during the past three years.

Materials and methods. Field-collected larvae were collected and tested at the third or fourth instar against acetone solutions of technical insecticides as described by Womeldorf *et al* (ibid) except that control mortality was ignored. This was done because a procedural error was discovered which produced control mortality often greatly in excess of low-dosage mortality. Tests were considered invalid and are not included here if excessive pupation (about 10%) occurred, if many points were obviously poorly fitted to the regression line, or if there was an admixture of species in excess of about 10%.

Results and discussion. Parathion test results obtained during 1965-1967 in Utah are listed in Table 1. The range of LC_{50} values (no more than about 4-fold) within each species is probably the normal variation which would be expected to occur when populations from different areas are tested at various times. Additionally, the ordering of the LC_{50} values does not appear to be related to the slopes as indicated by the LC_{90}/LC_{50} ratio, nor to area, nor to time of testing. Figure 1 shows the relationship of LC_{50} values to each other. The conclusion is that no evidence of parathion resistance has yet been found in Utah.

It is not safe to assume that parathion resistance does not exist, since testing has been limited to only part of the controlled areas of the State and only a few populations of the operationally-important species

Figure 1. PARATHION LC_{50} VALUES, 1965-1967.



have been sampled. An increased surveillance effort will be needed to answer the question of whether parathion resistance is developing in Utah.

Acknowledgements. Personnel of the cooperating mosquito abatement districts assisted in collecting mosquito larvae for the tests. Tsai Yuan-Hwang performed most of the 1965 tests, while Keith Wagstaff has assumed the testing duties since then.

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Table 1.—Parathion susceptibility levels, 1965-7, by ascending LC_{50} values. LC_{50} and LC_{90} values expressed as parts per billion.

Species	*Control agency*	*Location*	*Date*	LC_{50}	LC_{90}	$LC_{90}/_{50}$
Aedes nigromaculis	S. Salt Lake County	2nd E, 1900 W	7-10-67	1.7	2.5	1.5
Aedes vexans	S. Salt Lake Co.	2700 S 950 W	7-23-65	1.6	2.6	1.6
		600 S 10000 W	8-31-67	2.5	4.5	1.8
		5300 S 800 W	7-18-67	2.8	5.2	1.9
		3800 S 750 W	8-18-66	3.0	5.7	1.9
		4894 S 290 W	8-10-65	4.7	7.4	1.6
Aedes dorsalis	S. Salt Lake Co.	Roper Yard	7-13-65	1.2	1.7	1.4
		10050 S 500 W	7-22-65	1.5	2.7	1.8
	Salt Lake City	Harrison Gun Club	7-23-65	1.6	2.6	1.6
		Ambassador Gun Club	8-24-65	1.6	2.5	1.6
		Harrison Gun Club	7-23-65	1.8	2.5	1.4
		Gillmor Meadow	6-29-65	2.1	3.4	1.6
		N. Hardock L.	7-29-66	2.1	2.6	1.2
	Uncontrolled	Tooele Co.	6-23-65	2.6	3.9	1.5
	S. Salt Lake Co.	Hogle Farm	7-11-67	2.6	3.7	1.4
	Salt Lake City	Williams Lake	6-24-65	2.7	4.7	1.7
		Hinckley	6-24-65	2.8	4.0	1.4
	Weber Co.	Roy	6-23-65	2.9	6.1	2.1
	Salt Lake City	Rudy Gun Club	6-23-65	3.0	4.2	1.4
		Hills	9-14-65	3.1	5.4	1.7
	S. Salt Lake Co.	unknown	7-11-67	3.2	5.3	1.7
		6A-17	7-11-67	3.3	5.4	1.6
		No. Sewage Plant	7-20-67	3.3	5.1	1.5
	Weber Co.	W. Weber	9- 1-65	3.5	5.3	1.5
	Magna	Garfield	6-23-65	3.6	6.0	1.7
	Salt Lake City	1700 N 2450 W	8-24-65	3.6	4.9	1.4
		Blackhawk Gun Club	8-25-65	3.6	4.8	1.3
		Brown's dump	8-26-65	3.6	5.8	1.6
	Magna	5000 W	8-27-65	3.7	6.2	1.7
	Davis Co.	Redwood Road	8-24-65	3.9	8.8	2.3
	Salt Lake City	Hinckley	8-30-65	4.0	6.0	1.5
		North Point Canal	6-24-65	4.1	5.6	1.4
		North Point Canal	6-24-65	4.2	6.1	1.5
	Magna	Garfield	8-27-65	4.2	6.2	1.5
	Salt Lake City	Hinckley	6-23-65	4.8	7.7	1.6
	Utah Co.	Lehi	9- 8-65	4.8	7.7	1.6
Culex pipiens	Weber Co.	Riverdale	6-24-65	1.8	2.3	1.3
	S. Salt Lake Co.	2270 S 940 W	8-12-66	2.5	3.6	1.4
		4925 S 1350 E	7-13-67	2.9	4.9	1.7
		4200 S 450 W	8-12-65	3.4	5.0	1.5
		4550 S 1350 W	7-27-65	3.5	5.4	1.5
		3500 S 1000 W	7-20-67	3.8	5.6	1.5
		4500 E Atwood Blvd.	6- 3-67	4.3	5.6	1.5
Culex tarsalis	S. Salt Lake Co.	3700 S 750 W	7-28-66	1.3	1.6	1.2
		4800 S 550 W	7-28-66	1.4	2.0	1.4
		5300 S Vine St.	7-12-65	1.9	3.1	1.6
		5300 S Vine St.	7- 6-65	2.5	4.0	1.6
		13800 S 1200 W	8-25-66	2.5	4.2	1.7
		Farmington	7- 3-67	2.5	4.8	1.9
		4350 S 630 W	8- 9-65	2.7	4.3	1.6
	Weber Co.	Geo. East duck club	9- 1-65	3.4	6.4	1.9
		W. Weber	9- 1-65	4.3	6.8	1.6
Culiseta inornata	S. Salt Lake Co.	10000 S 500 W	7-15-65	1.3	1.8	1.4
	Magna	2400 S 9200 W	9- 2-65	1.5	2.3	1.5
	S. Salt Lake Co.	7100 S 1175 W	9-11-67	2.1	3.6	1.7
		Decker Lake	7-13-67	2.3	4.4	1.9
		Meadowmoor School	9-28-67	2.3	4.5	2.0
	Uncontrolled	Tooele Co.	9- 3-65	2.4	5.9	2.5
	S. Salt Lake Co.	11300 S 1300 W	9-29-67	2.7	4.3	1.6
	Utah Co.		9- 8-65	3.5	6.1	1.7
	Box Elder Co.	Burt's slough	6-23-65	5.6	11.0	2.0

SOME PHYSICAL AND CHEMICAL FACTORS OF TREE ROT HOLES

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Rot holes in trees provide a unique environmental habitat for several species of mosquitoes and other insects. A crustacean, a nematode, rotifers and protozoans are also reported from tree holes (Jenkins and Carpenter, 1946). During the course of study of tree hole inhabiting mosquitoes, we have become interested in various environmental factors associated with tree holes and mosquito production. The only species of mosquitoes found to inhabit rot holes in this study was *Aedes hendersoni* Cockerell. Published records prior to 1960 (Harmston, 1949) refer to the occurrence of *Aedes triseriatus* (Say) in Colorado but it is believed that these records are actually in reference to *A. hendersoni* (Nielsen, Linam, and Rees, 1963; Nielsen, Arnell, and Linam, 1967), as it was not until 1960 that Breland elevated *A. hendersoni* to full species rank. Harmston in a later study of the mosquitoes of Colorado (1962) reports *A. hendersoni* to be present in the state but does not report the presence of *A. triseriatus*.

An area at Lime, Pueblo County, Colorado, approximately four miles south of Pueblo, Colorado, was selected as a study area because of an abundance of rot holes in the trees. In an area 80 x 85 yards there are 100 trees, ten of which contain rot holes. Seven other trees containing rot holes were found within one-half mile of this locality. Lime is an abandoned mining community with the St. Charles River running through its outskirts. Large numbers of cottonwood trees (*Populus sargenti* Dode) grow along the river margins. Beyond the boundaries of the trees is a prairie type habitat with tree cactus, yucca, sage, and grass as the main flora. Yearly precipitation is approximately eleven inches.

All rot holes studied in this area were found in the cottonwood, *P. sargenti,* though rot holes containing mosquito larvae have been found in Siberian Elms (*Ulmus pumila*) at both Lamar and Pueblo, Colorado. The height of rot holes in the cottonwoods varied from ground level to twenty feet above ground level. Most rot holes were located where a branch had fallen and the core had rotted. Another type, considerably less common, had the hole located in the crotch of two branches. The latter type was shallow, two and a half inches maximum depth, and only one hole of this type was found to contain larvae of *A. hendersoni*.

Diameter of rot holes ranged from one-half inch to six inches. The direction the holes faced with respect to true north ranged from 6° to 360°. Height, diameter, and exposure had no apparent significant relationship as to whether the tree hole contained mosquito larvae or not.

In a study of tree holes in *Quercus* and *Umbellularia* in California, the principal insect inhabitant was *Aedes varipalpus* and the water in these tree holes gave an acid reaction (Usinger, 1956). Chapman (1964) reported willow and cottonwood tree hole waters to be basic. In our studies all pH values have been basic; the range extending from a pH of 7.5 to 10.0. The pH remained relatively constant in each tree hole until the water began to dry up in the fall, at which time it became more basic.

The temperature of the water in the tree holes varied from day to day as a group, but the difference between temperatures of individual rot holes on the same day were very slight. The highest temperature recorded for the water in any one tree hole was 19° C and the lowest was 6° C.

Water from tree holes containing larvae and from holes lacking larvae was analyzed by a flame photometer for sodium, potassium, and chlorides. In all cases the concentration of potassium was significantly higher than the concentration of sodium. Table I shows some of these results. Sodium concentrations ranged from 21.5 milli-equivalents per liter to 68 meq/L. Potassium ranged from 60 meq/L to 251 meq/L. Chlorides were present in only trace amounts. It becomes apparent, upon examination of the data, that neither potassium nor sodium are limiting factors for the presence of tree hole inhabiting mosquito larvae. There was no significant difference in sodium and potassium content of water collected from tree holes in the fall of the year as compared to samples collected in the spring. In some water samples obtained in the spring there was a definite decrease in amount of phosphorus as compared to water collected from the same tree hole in the fall.

The occurrence of phosphorus in water in tree holes is somewhat erratic as can be seen in Table II. It is relatively high in some water samples and very low in others. In an attempt to explain this variation, soil samples were taken near the bases of several trees. These samples were analyzed by use of a soil testing kit (Helige-Troug) which gave a measure of relative concentrations of free ions in solution. A correlation was found to exist between water samples exhibiting a high phosphorous content and soil samples showing a high phosphorus content (Table III). It thus seems logical to conclude that phosphorus is dissolved out of the soil and enters the root vascular system. The occurrence of phosphorus in water in tree holes thus seems dependent upon the amount of phosphorus in the soil. It does not seem to be limiting to the development of *A. hendersoni* larvae. Examined superficially, no reasonable explanation is at once evident as to why water collected from a tree hole in September shows a relatively high concentration of phosphorus and water collected from this same tree hole in May of the following year shows a relatively low concentration of phosphorus. It may be that this element is more rapidly absorbed by meristematic tissue during the rapid spring growth than later in the year when leaf and twig growth slows and finally ceases.

More probably, however, phosphorous ions are leached from the plant tissues by water (Kozlowski, 1964) and collect in tree holes. Thus there would be a gradual build-up of this ion as the summer progressed. Tamm (1951) found large amounts of calcium, sodium, potassium, and phosphorus to be leached out of trees by rainwater. This explains, to a large extent, why the concentrations of certain ions are so high under trees. It would seem that these ions may then be dissolved by water and once again enter the vascular system of the tree. Some of these ions may be leached out of the tissues of the tree and collected in the tree holes. If not collected in the tree hole, ions may be leached out of the tree by subsequent rains and once again carried to the soil where the cycle may be repeated again.

The source of the water found in tree holes has long been a subject of speculation. From our observations it seems that in the majority of cases this is metabolic water, absorbed from the soil through the root system of the tree and transported by the vascular system. Evidence to support this contention may be gained by the correlation of ion content of the soil and the ion content of the water in the rot hole. It is also possible to cover the opening of a tree hole and thus exclude any precipitation. Water may still appear in this sealed cavity. It is also evident that the majority of tree rot holes dry up in the fall of the year, generally in late September and October, and remain dry until the following spring. This drying is correlated closely with leaf drop and subsequent reduction in water transport. These results are contrary to those of Chapman (1964) obtained in California. In his study most of the tree holes retained their water.

In some cases there seems no doubt that precipitation provides some, if not all, of water found in rot holes. A favorable exposure to rain seems a prerequisite for this type of situation.

The xylem underlying several rot holes was examined. An increment borer was used to obtain the xylem samples for examination. As one would suspect, the floor of the cavity and the area immediately under it consists of pulpy, decayed xylem tissue. However, the xylem tissue located a few inches below the floor of the cavity is normal in appearance.

Many aspects of the tree hole habitat are still poorly understood. Studies concerning the amount of water necessary to initiate egg hatching and percent of egg hatch at first flooding should prove highly interesting. The role of predators of mosquito larvae in tree holes still needs investigation and there is certainly need for further chemical and physical studies.

TABLE I

FLAME PHOTOMETER ANALYSIS OF WATER FROM SELECTED ROT HOLES FOR SODIUM AND POTASSIUM

Tree Number	Concentration of Sodium Oct. 1966	May 1967	Concentration of Potassium Oct. 1966	May 1967
5	36.0 meq/L	39.5 meq/L	154.0 meq/L	123.0 meq/L
6	15.0 meq/L	15.5 meq/L	133.0 meq/L	125.0 meq/L
17	30.0 meq/L	21.0 meq/L	60.0 meq/L	44.0 meq/L
*14	21.5 meq/L	....	140.0 meq/L	....
*15	68.0 meq/L	....	251.0 meq/L	....
*11	....	....	18.0 meq/L	38.0 meq/L

*Larvae Present

TABLE II

RELATIVE CONCENTRATIONS OF MINERALS IN WATER FROM SELECTED ROT HOLES

Tree No.	Phosphorous	Potassium	Calcium	Magnesium	Nitrates	Ammonia
5	Low	Very High	None	High	Low	High
6	High	Very High	None	Medium	Low	High
14	Very Low	Very High	Very Low	High	Very Low	High
15	Very High	Very High	None	High	Very Low	Medium
17	Very High	Very High	None	Medium	Low	High

TABLE III

RELATIVE CONCENTRATION OF MINERALS FROM SOIL SAMPLES BELOW TREE

Tree No.	Phosphorous	Potassium	Calcium	Magnesium	Nitrates	Ammonia
5	Low	Very High	Very High	High	....	....
17	Medium	Very High	Very High	High	....	....

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NOTES ON THE DISTRIBUTION AND BIOLOGY OF TREE HOLE MOSQUITOES IN UTAH

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Rot cavities of deciduous trees provide a unique and specialized mosquito habitat. They are formed by a fracture in the bark that exposes the sapwood. The tree hole enlarges and deepens by the action of weathering and the attack on the exposed wood by bacteria and fungi. In cases where the tree hole can retain water an aquatic microhabitat develops capable of supporting a variety of organisms including certain mosquito species, most of which are restricted to the tree hole habitat. The water in the tree hole can come either from the vascular system of the tree itself, from an external source such as precipitation, or both. The tree hole water is rich in organic matter and contains the bacteria, yeasts, and photozoans which presumably make up the larval diet.

The tree holes are sampled by means of a rubber syringe attached to a long plastic tube. Water is drawn from the hole and emptied into a porcelain pan or strained through a small screen. Since the water is often extremely dark, this latter method is often necessary to observe the presence of mosquito larvae. Often scrapings are taken from the sides of the tree hole above the water line where the *Aedes* species deposit eggs. The scrapings are flooded with distilled water. If eggs are present, hatching usually occurs and larvae can be reared in the laboratory.

At the present time, ten mosquito species that breed exclusively in tree holes are known from the western United States. These are: *Aedes hendersoni* Cockerell, *Aedes kompi* Vargas and Downs, *Aedes monticola* Belkin and McDonald, *Aedes muelleri* Dyar, *Aedes purpureipes* Aitken, *Aedes sierrensis* (Ludlow), *Aedes varipalpus* (Coq.), *Anopheles barberi* (Coq.), *Orthopodomyia kummi* Edwards, *and Orthopodomyia signifera* (Coq.). *Anopheles barberi, A. kompi, A. manticola, A. muelleri, A. purpureipes,* and *O. Kummi* have not been reported north of central Arizona; *A. hendersoni* occurs in Colorado, Wyoming, and Idaho, but has never been found in Utah. Two collections of *Culex pipiens* L. larvae have been taken from tree holes in northern Utah. This species is more often found in other situations and is not considered to be a true tree hole species. This paper will be concerned only with the remaining three species, *A. sierrensis, A. varipalpus,* and *O. signifera.*

In the spring of 1967, three collections of *O. signifera* were taken in southeastern Utah, one from Salt Creek in Canyonlands National Park, and two near Bluff, San Juan County. Subsequently, several more collections were taken from Salt Creek and other localities in Canyonlands National Park. Little is known of the habits of the Utah *Orthopodomyia.* Fourth instar larvae were collected as early as March 19, and an apparent overwintering generation was collected in late October. All collections were taken from the cottonwood *Populus fremonti* S. Wats.

A. varipalpus appears to be the most restricted in distribution of the *A. varipalpus* complex which includes two other species, *A. monticola* and *A. sierrensis*. *A. monticola* is widely distributed in the southern half of Arizona. The distribution of *A. sierrensis* is discussed below. The only valid records of *A. varipalpus* are from Williams, Arizona, and from southwestern Utah. We have taken collections from Cottonwood Canyon, Kane County; Beaver Dam Wash, Washington County; and from several localities on the Virgin River drainage in or near Zion National Park, Washington and Kane Counties. Larvae of all instars have been taken from Fremont's cottonwood and willow trees as late as December 31, and as early as March 17, indicating that overwintering occurs in the larval stage when the tree holes do not freeze solid. Despite intensive collecting throughout the southern half of the state we have been unable to find *A. varipalpus* except in the above mentioned localities.

A. sierrensis, the Pacific Coast tree hole mosquito, has been found in Utah only in a limited area on the Weber River near Ogden. Larvae have been taken from tree holes in Fremont's cottonwood and narrowleaf cottonwood from localities near the mouth of Weber Canyon to about five miles downstream from the mouth of the canyon. About twelve productive tree holes occur in a grove of cottonwoods covering several acres at Riverdale, immediately southwest of Ogden. These tree holes have been under intensive observation since May, 1965, to determine some of the biology and habits of the species.

This Utah population of *A. sierrensis* is interesting from a distributional standpoint. Until recently, the nearest records of *A. sierrensis* were from central Idaho, on the Salmon River. This species is widely distributed and quite common along the Pacific Coast and eastward to western Montana. The Riverdale, Utah, population is adjacent to the large Ogden railroad yards to which there is considerable freight traffic from the Pacific Northwest. It is possible that the *A. sierrensis* population on the Weber River is an accidental introduction from the Pacific Coast via the railroad.

In August, 1967, several collections of *A. sierrensis* were taken on the Snake River near Blackfoot, Idaho. This record considerably closes the gap between the Utah population and the Salmon River collections. Also, in studies over the past two and one-half years we have found the Utah *A. sierrensis* population to be well adapted to the severe Utah winters, an environmental condition they would not be subjected to in the milder Pacific Coast climate. Active larvae have been found in the Riverdale tree holes as late as the first week of January, under several inches of ice in water with temperatures as low as 30° F. First instar larvae have been found in late February after winter thaws melted the previously solidly frozen tree holes enough to hatch eggs laid the previous year.

It is now our belief that the Riverdale *A. sierrensis* population is a remnant of a much more extensive *A. sierrensis* population which occurred throughout northern Utah and the northwestern states of Idaho, Montana, Washington, and Oregon, during Pleistocene times when the climate in this area was much wetter and milder. During a period about 10,000 years ago Lake Bonneville covered much of northern and western Utah and was probably surrounded by groves of deciduous trees which provided a suitable habitat for *A. sierrensis*. As the climate became drier and Lake Bonneville receded, *A. sierrensis* probably became restricted to some of the remaining groves of deciduous trees in the area. More collecting is necessary in the cottonwood groves of the Wasatch front canyons to see if other isolated populations of *A. sierrensis* exist.

The inland populations of *A. sierrensis* are isolated and far removed geographically from the Pacific Coast *A. sierrensis* populations. The possibility exists that these populations may have differentiated from the coastal *A. sierrensis*. Detailed morphological studies are being conducted at the present time to determine if differences exist which warrant assigning these inland populations to a new specific or subspecific taxonomic category.

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THE EMERGENCE OF *CHRYSOPS DISCALIS* WILLISTON ON THE SHORE OF THE GREAT SALT LAKE, UTAH

(DIPTERA - TABANIDAE)

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A study of the deer flies and horse flies is being conducted in the marshes bordering the southeastern shore of Great Salt Lake, Utah.[1] The marshlands, which constitute the study area, were created largely by the construction of a series of earthen dikes to

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impound the drainage water that flows into the Great Salt Lake. In the development of these marshes, habitats suitable for the production of insect pests such as mosquitoes, gnats, deer flies and horse flies have been greatly extended. These marshes, with their abundance of insect pests and potential vectors of the causative agents of diseases of man and other animals are in the immediate vicinity of the most densely human populated area in Utah. This situation is an incentive for conducting this study.

This report, covering the 1966-67 seasons, is confined to the determination of the emergence of the deer fly *Chrysops discalis* Williston in these marshes. *C. discalis* was selected for this study as it is the most abundant and important tabanid species within the study area.

The purpose of this phase of the study was to determine the sites on the marshes where this deer fly emerges, factors influencing its emergence, and the relative abundance of *C. discalis* on the marshes.

It was determined by Knudsen and Rees (1967) that the gravid female *C. discalis* selects a suitable oviposition site consisting of vegetation or any stationary object located above water. On these objects she lays a cluster of approximately 400 eggs. Following a period of from two to five days the eggs hatch, at which time the larvae drop into the water and immediately burrow into the bottom mud.

The larvae remain in the mud until the following season when, as they mature, they pupate on the surface of moist soil. If the water is removed from the larval habitats before pupation occurs, the last larval instar will pupate in the moist soil of the formerly submerged area. However, if the water remains, the larvae then migrate through the bottom mud to adjacent moist soil above water level where they pupate and the adults emerge.

Pupal skins of the emerged flies are found at the surface of the ground in relatively large numbers where the adults have emerged. In most instances the pupal skins are found adhering to the ground by the posterior end with the anterior end projecting out of the soil about two-thirds of the length of the skin, thus making them conspicuous.

The procedure followed in the determination of deer fly emergence was to periodically count the pupil skins within an established meter square quadrat then remove the skins with a pair of forceps following each count. During 1967 when the water remained on the larval habitats, 199 quadrats were established along 52 transects which began at the margin of the water and continued inland until pupal skins were no longer present. Each quadrat was marked at the corners with red enamel paint and each transect was numbered to insure correct correlations for later pupal skin counts. At three weekly intervals the skins of the emerged adults were counted and removed. As a result, counts were made three times from each quadrat within each of the 52 transects.

During each count other data were obtained, such as air and soil temperatures, distance of pupal skins from the surface water, and potential oviposition sites. Emerging adults which were detected at the time the counts were conducted were observed to determine how emergences take place. At a later date, soil samples were collected to determine the soil composition and the percent of soil moisture within the quadrats.

The texture of the soil along the pond margins was found to range from a silt loam to fine clay. The predominant plants within the study area are: *Distichlis stricta* (Torr.) Rybd. (saltgrass); *Salicornia rubra* A. Nels. (glasswort); *Allenrolfea occidentalis* (Wats.) Kuntze (pickleweed); and *Sarcobatus vermiculatus* (Hook) Torr. (greasewood).

During the 1966 season the water was withdrawn from some impoundments and the larvae pupated in the moist soil of the formerly submerged area. The greatest concentrations of pupal skins were collected in the immediate vicinity of saltgrass stands and usually within eight feet of this vegetation. The maximum distance at which the skins were collected from these stands was 120 feet (see figure 1). Meter square quadrats and transects were used in taking these collections. A total of 564 *Chrysops* skins were counted. The maximum number of pupal skins counted from within a single quadrat was 34 skins.

During the 1967 season water remained in the impoundments during the season at near constant levels. In this situation the larvae migrated from the water impoundments to the moist soil of the adjacent slightly elevated areas. In August and September a total of 4,021 pupal skins were collected in the quadrats along the shore line. The pupal skins were collected within quadrats ranging in distance from zero to 26 feet from shore line. The greatest concentrations of pupal skins were found at distances of between three and 16 feet from the water. In any count, the maximum number within a single quadrat was 109 pupal skins.

In most cases during the 1967 season, the pupal skins were found in distinct soil moisture zones. During the weekly surveys it was noted that as the soil within the quadrats decreased in moisture content, the zones of emerging adults receded nearer to the water margin (see figure 2). In some instances where the soil was elevated in small mounds at the base of plants, such as greasewood, a concentration of pupal skins was observed. In these areas, predation upon pupae lying beneath the surface by Brewer's blackbird, *Euphagus cyanocephalus* (Wagler), and yellow-headed blackbird, *Xanthocephalus xanthocephalus* (Bonaparte), was observed.

The results of the tests to determine soil moisture content show that an apparent correlation exists between pupal skin densities and percent of soil moisture. Data collected late in the season indicates that the greatest pupal skin densities occur in soil containing between 14 and 34 per cent moisture. Gerry (1948) found that the greatest larval densities occurred in areas where the sod had a 70% moisture content,

FIGURE I

1966 SEASON

AVERAGE NUMBER OF CHRYSOPS PUPAL SKINS PER METER SQUARE QUADRAT COMPARED WITH DISTANCE FROM POTENTIAL EGG LAYING SITES.

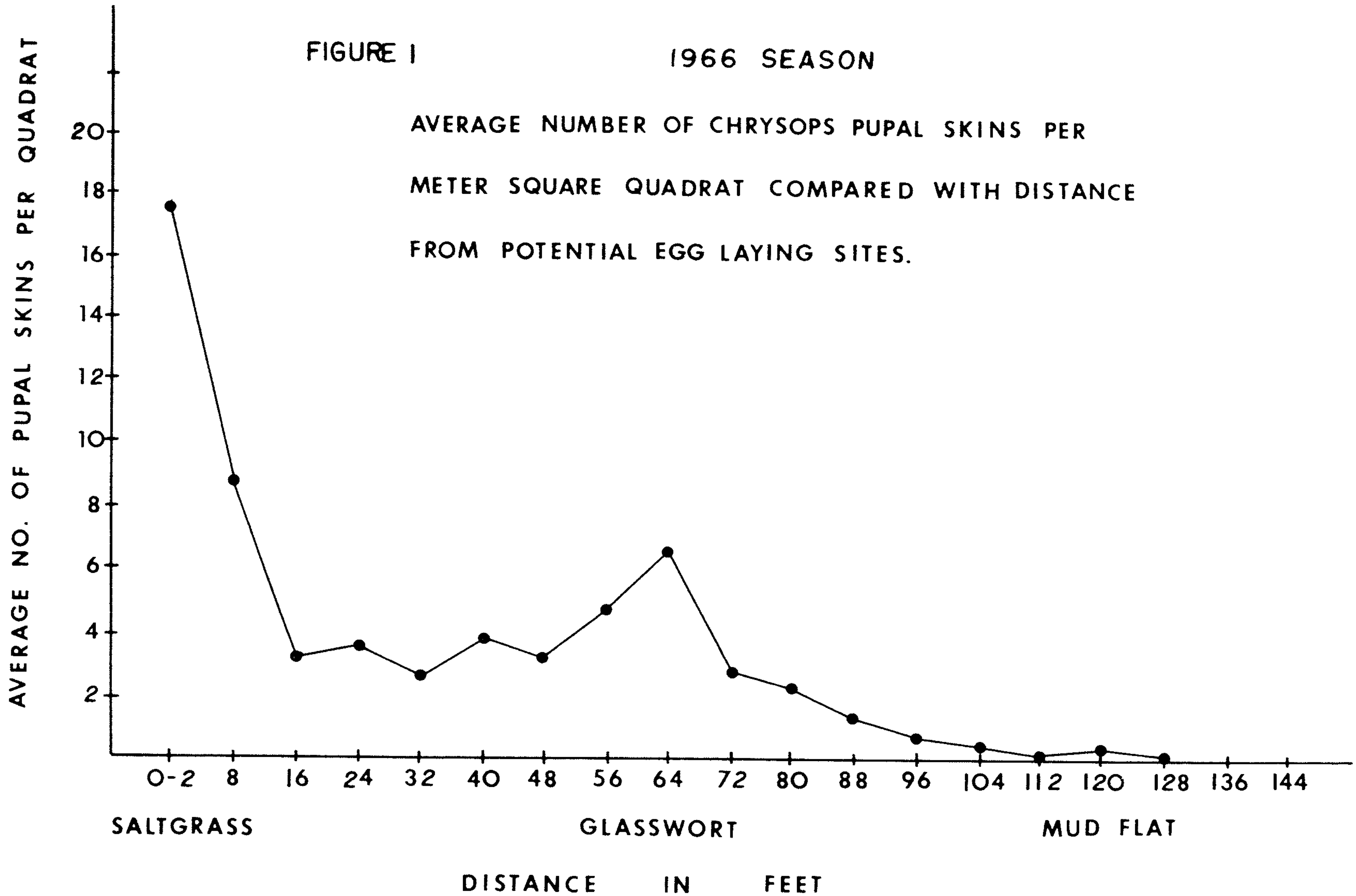
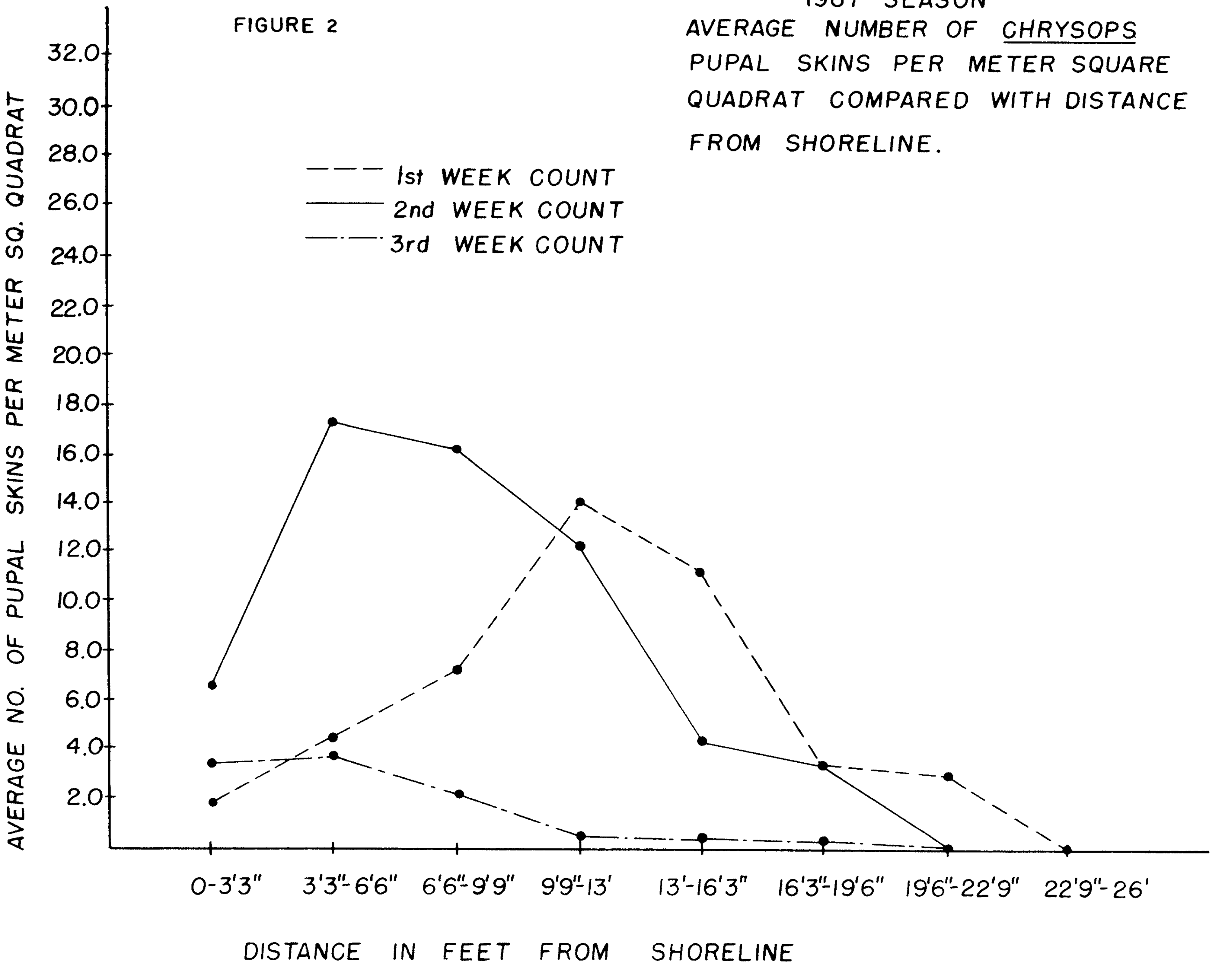


FIGURE 2

1967 SEASON
AVERAGE NUMBER OF *CHRYSOPS* PUPAL SKINS PER METER SQUARE QUADRAT COMPARED WITH DISTANCE FROM SHORELINE.



a 6% chloride content and dense ground cover which tended to eliminate extreme fluctuations of temperatures and rapid drying of the marsh surface.

Conclusions to date:

1. Where water has been withdrawn from impoundments exposing former lake bottoms, pupation and eventual emergence of the adult will occur at the site of the last larval instar.

2. Where water is maintained at near constant levels in impoundments the larvae are forced to migrate to the moist soil of adjacent slightly elevated areas and there pupation and emergence occur.

3. Pupal skins collected during the 1966 season were present in the greatest numbers in the immediate vicinity of vegetation in areas from which the surface water had recently been removed.

4. During the 1966 investigation it was determined that as the distance from oviposition sites increased the number of pupal skins decreased terminating at 120 feet (see figure 1).

5. Pupal skins collected during the 1967 season were found in greatest numbers in moist soil at a distance of from three to 16 feet from the water margin. The maximum distance from the water at which emergence occurred was 26 feet (see figure 2).

6. Data obtained during the 1967 season shows a negative correlation existing between the distance from the oviposition sites and number of pupal skins. This was a result of water level stability which forced the larvae to migrate to the soil where adult emergence occurs. Adult emergence increased in numbers as the distance from oviposition sites increased. This was constant until an optimum distance from the vegetation was attained between 16 and 36 feet. At that distance the number of skins then began to decrease, terminating at a maximum distance of 74 feet.

7. Soil samples taken in 1967 show a positive correlation exists between pupal skin densities and soil moisture content. The greatest densities of skins were collected from soil containing between 14 and 34 per cent moisture.

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THE BRINE FLY PROBLEM ON THE GREAT SALT LAKE BEACHES

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As you will note the word "control" was left out of the title of this paper due to the fact that control has been completely unsuccessful. The brine fly as it is called on the Great Salt Lake is in the genus *Ephyridae*. They are small, mostly gray or blackish flies often present in countless numbers about salt or alkaline water in which the peculiar larvae live. It is believed the larvae live near the bottom of lakes such as the Great Salt Lake, and the pupae attach themselves to rocks, tumbleweeds or other debris. Storms frequently detach immense numbers of the pupae which float and are carried to the shores where they are washed up on the sand in great heaps.

It has been said that indians in the early days collected, dried and, after rubbing off the skins by hand, prepared a food called Koo-chah-bie. They had great feasts with this food. Maybe we could have a great feast out on the beach and have a pupae fry. (It might be one way to reduce the fly population.) However I don't think it would be too successful — I'm a hamburger fan myself.

The adult flies emerge and often swarm in great numbers on the surface of the water and along the shores of lakes. I've received numerous complaints over the past four years from beach owners and even the local newspapers concerning these flies around the Great Salt Lake. During the past summer-which seems to have been the worst yet — from late June until late August great numbers of these flies swarmed around the two beach resorts on the south shore causing a tremendous nuisance to bathers. The shore-line looked as though it was a long black carpet extending for miles in both directions driving many people away and certainly hurting the economy of the area.

Both Sunset and Silver Sands Beaches are located in the Magna Mosquito Abatement District and some fly control was attempted. However, being a low budget district and extremely busy with our mosquito control program we were unable to spend much time or research on the problem.

We did treat the area several times with different methods and materials but little success was accomplished. Both fogging and ground spraying were tried with Malathion, Baytex, DDT and low volume materials. The low volume materials were Baygon and Baytex and were applied by a Mighty Mo hand spray unit. Both water and fuel oil were used as carrying agents in these attempts at control. All treatment was done in the early morning hours when no bathers were present and wind was calm. Little success was realized except for a 24-hour reduction in adult fly populations after treatment. A daily spraying program was also carried out by the beach owners using fuel oil and other materials but no satisfactory results were obtained even though many of the flies were killed.

All shore-line areas on the south and east seemed to be affected by the flies, including the west shore of Antelope Island. All control attempts were aimed at adult fly populations, and until a successful larvae control program is started very little will be accomplished.

Not a great deal is known about the larval, pupal and adult habits of these flies and certainly someone should dig further into this area and find an answer to this tremendous problem.

These flies are spread out over such a wide area and in such great numbers that it is extremely difficult for any type of successful adult control.