POPULATION DENSITIES OF KNOWN INVERTEBRATE PREDATORS OF MOSQUITO LARVAE IN UTAH MARSHLANDS

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Mosquito control agencies have continually searched for new and alternative methods of effective control. In 1902, Lutz described both Odonata and Notonectidae nymphs as invertebrate predators of mosquito larvae and Davenport (1902) suggested stocking ponds with fish "or other larvicidal aquatic organisms." Since that time, many lists of potential predators of mosquito larvae have been compiled, but only various species of fish, especially *Gambusia affinis,* have been used extensively.

Of the invertebrates that are considered predators, larval and adult Dytiscidae and Hydrophilidae (Coleoptera) and all stages of Notonectidae (Hemiptera) have received the most attention as potential biocontrol agents. Other invertebrate predators include various Odonata, other families of Hemiptera and Coleoptera, predacious Diptera (especially other Culicidae), and a few Crustacea (Jenkins 1964).

The South Salt Lake County Mosquito Abatement District, in conjunction with the University of Utah, initiated studies in 1969 to determine the aquatic macroinvertebrates of Utah marshlands and the effects of pesticides on them, as a basis for studies regarding the feasibility of using invertebrate predators for mosquito larval control. The area chosen as the most suitable for the study was the Ogden Bay Waterfowl Management Area (Weber Co., Utah) within the control area of the Weber County Mosquito Abatement District. The area of study was a known mosquito producer and control methods presently used include water management, insecticides and the planting of *G. affinis,* although the latter have not established themselves on the refuge (Benge and Fronk 1970).

MATERIALS AND METHODS. Nine collection sites were established on the refuge and weekly collections were made from the end of April through September 1969, for a total of 186 separate collections. A cubic foot sampler constructed of wire mesh on five sides and a solid metal bottom slide was used to make the collections. The sampler was placed in the water and mud, and the bottom slide inserted so that a portion of the mud and all vegetation, debris and organisms were retained as the water drained out. The entire contents were returned to the laboratory in containers. The samples were then sorted, counted and identified to the lowest taxon possible. All macroinvertebrates were preserved in alcohol.

The study was not directed to determining the mosquito population of the area. The sites were selected for their permanence or semi-permanence and the sampler was not usable in dense vegetation or near the shore line. However, knowing whether mosquito larvae were present in collection area was felt to be important; therefore, one day was spent utilizing a pint dipper to determine if mosquito larvae were present at the sites selected. Although no records were kept, larvae were frequently found, close to the shore line or in the vegetation, and often in abundance.

RESULTS. Table 1 lists, by family, the invertebrate predators found and their monthly totals. The major genera of Dytiscidae collected were *Hygrotus, Laccophilus* and *Rhantus; Berosus* and *Enochrus* were the two genera of Hydrophilidae most often taken, although *Tropisternus* and *Helophorus* were also collected. The majority of the Notonectidae collected were immatures of the genus *Notonecta* and the adults were generally *N. unifasciata.* The three most common genera of Odonata were *Ischnura, Enallagma* and *Aeschna.*

TABLE 1.—Monthly totals of potential invertebrate predators collected on Ogden Bay Waterfowl Management Area, Utah, in 1969.

Group	April	May	June	July	August	Sept.	Total
Odonata							
Coenagrionidae	36	36	39	18	53	206	388
Aeschnidae	..	1	..	1	9	27	38
Others	7	7	..	1	2	3	20
Hemiptera							
Notonectidae							
Nymphs	..	7	18	62	34	37	158
Adults	1	..	..	3	19	13	36
Others	..	12	2	4	15	12	45
Coleoptera							
Hydrophilidae							
Larvae	4	62	86	61	51	18	282
Adults	2	16	44	13	6	6	87
Dytiscidae							
Larvae	5	65	35	6	9	15	135
Adults	7	14	45	76	8	7	157
Others	..	..	1	1	1	..	3

DISCUSSION. Corbet (1962) reported that although Odonata are effective predators, they would probably not decrease a population of any particular species unless they occupied an environment where only one or two choices were available for food as they are facultative feeders. Laird (1947) mentioned that the Zygoptera would probably be more important than the Anisoptera since the latter are primarily bottom feeders, whereas the former range throughout the water depths and would more likely encounter mosquito larvae. On the Ogden Bay refuge, Odonata probably provide little control as they are most abundant late in the mosquito season.

Notonectidae have frequently been reported as predators of mosquito larvae. Hinman (1934) felt that *N. undulata* was the most voracious of all Hemiptera. However, Ellis and Borden (1970) concluded from laboratory studies that, although *N. undulata* preferred mosquito larvae, they would probably be an ineffective control measure in natural situations because their predation rate decreased as the larval density increased and would therefore be unable to suppress a rapid increase or large population of mosquito larvae. Ten *N. unifasciata,* the most abundant species found in the present study, were reported by Bay (1967) as giving nearly 100 percent control in 100 gallon field tubs.

Although Corixidae were found in abundance in the study area, they are not considered as predators here, as they are probably only accidentally predacious on mosquito larvae (Sailer and Lienk 1954).

Of the Coleoptera, Dytiscidae are considered to have the most potential as a control measure (Twinn 1931, Baldwin, James and Welch 1955, James 1965). But, as early as 1917 Chidester reported that dytiscids may be important in killing mosquito larvae only if they are concentrated into small pools, not if the larvae are widely distributed. Larval hydrophilids have been reported as predators of mosquito larvae but the two most numerous genera collected in the present study, *Enochrus* and *Berosus,* have been reported by James (1965) not to be predators of mosquito larvae. Nielsen and Nielsen (1953) stated that *T. lateralis,* also collected here, could be effective in small, roadside pools as both predator and prey would be concentrated.

The majority of reports of invertebrate predators have been either chance observations or laboratory studies. Few, if any, attempts have been made to apply these results to control work in the field. A long list of potential predators can be drawn up

but its significance is doubtful because there is little or no knowledge of "the quantitative relationship between mosquito larvae and their predators" (Bates 1949).

Invertebrate predators do not confine their attacks to mosquito larvae (Twinn 1931) but they can serve as a check on the number emerging (Sailer and Lienk 1954). As Curtis (1953) indicated, the predators must pursue the larvae into the mosquito's natural habitat and in a small, isolated pond, this would probably occur. However, when the water and the mosquito's habitat extend over large areas, the same conclusion cannot be reached. Nielsen (1955) and Mulla (1961) both observed that predators do not reduce the number of larvae present to any considerable degree. Mulla (1961) also mentioned that there is a time lag between the buildup of mosquitoes and their invertebrate predators.

At the densities in which invertebrate predators of mosquito larvae naturally exist, they do not appear to be capable of reducing the numbers of larvae sufficiently to allow them to be the only means of control used. Bay (1967) mentioned the possibility of mass rearing and release of invertebrate predators but stated that since techniques have not been sufficiently developed for laboratory rearing of them, there is little hope for their use beyond what naturally occurs. However, Washino (1968) stated that since many of the invertebrate predators reach their peak abundance in the early summer, perhaps control methods, such as insecticide applications, could be modified to take advantage of any natural control the predators may offer.

SUMMARY. In 1969, a study was conducted on the Ogden Bay Waterfowl Management Area to determine the invertebrate predators of mosquito larvae and other aquatic macroinvertebrates present in the area. Potential predators collected included larval Odonata, Notonectidae nymphs and adults, and adult and larval Dytiscidae and Hydrophilidae.

CONCLUSION. A large number of invertebrate predators of mosquito larvae exist naturally in some mosquito-producing waters of Utah but do not appear to serve as an effective control. Further studies are needed to determine the best method for taking advantage of the natural control they offer, and also techniques should be developed for the mass rearing and dispersal of these predators to augment the control programs of mosquito abatement districts.

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A.M.C.A.'S RESPONSE TO THE CURRENT ECOLOGICAL ERA

A PANEL DISCUSSION

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(Summaries prepared by authors)

SOUTH ATLANTIC REGION

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My comments are supposed to represent the situation in the South Atlantic region but will actually be more representative of the situation in Florida than the other states in the area. Alabama has little organized mosquito control. South Carolina, I am told, has had little impact thus far from the Eco-era. Georgia has one very active district, which is patterned after the best of the Florida programs and I will comment on its problems and responses as we go along.

Generally, the policy in Florida is to do as much mosquito control as possible with as little harmful effect on the environment as necessary, an easy thing to say.

This policy was first stated by the Florida State Board of Health (*Florida Health Notes*—Vol. 40—No. 5 written by Dr. Maurice W. Provost), in their definition of strategy in mosquito control operation—"killing mosquitoes at such times and places and in such ways that people get maximum relief for every dollar spent and lose nothing of value in the obtaining of this relief."

In those early days it was very difficult, however, to practice such strategy because too little was known of the relation between mosquito and estuarine biology to say nothing about the lack of mosquito control knowledge in general. Even so, the same issue of *Florida Health Notes* contains this strong warning issued in 1948, not 1971—"DDT is a poison to many more forms of life than just mosquitoes. So, for that matter, are many other accepted and widely used insecticides. Certain formulations of DDT are highly toxic to aquatic animals such as fish, crayfish, crabs and others. Beyond certain dosages, it can be very toxic to birds and mammals and, finally no matter how used, it is certain to kill many non-mosquito forms of life. And yet, in spite of all this potential for serious damage, if used properly in mosquito control, DDT can be as safe as any insecticide used against corn-borers,