ing 3 mosquito larvae were parasitized with a total of 3 female and 1 male nematodes and so failed to pupate.

EXPERIMENT 2. A total of 80 adult mosquitoes developed successfully from 100 larvae exposed (Table 1). Slightly higher parasitism was observed in the 24 hr-exposure group (22.2%) than in the 48 hr-exposure group (14.2%). Sixteen nematodes were recovered from 13 female and 2 male mosquitoes which were parasitized. These comprised 8 female, 4 male and 4 unclassified nematodes. All the parasites emerged 6–9 days after metamorphosis of the mosquitoes on days 9–13. There appeared to be no particular relation between the sexes of the host and parasite, i.e., nematodes of both sexes occurred in both male and female mosquitoes. Only one out of 13 parasitized female mosquitoes developed gravid ovaries like unparasitized females. Yolk deposition was not visible in the ovaries of the other 12 female mosquitoes.

EXPERIMENT 3. A total of 18 female mosquitoes but no males developed successfully from 20 fourth-instar larvae exposed to preparasites (Table 1). Three nematodes escaped naturally from 2 mosquitoes, and 5 nematodes of undetermined sex were removed from 2 mosquitoes which had died by day 8 (i.e. 5 days after emergence). Later, on days 9 to 12, 6 female and 6 male postparasitic nematodes escaped into the water from 7 adult mosquitoes. Thus, 61% of 18 adult mosquitoes were parasitized. Ovarian development was suppressed in all the parasitized females. In the 2nd-instar larvae, exposed together in the same container, 95% became parasitized, and the nematodes emerged before pupation.

All of the nematodes recovered from adult mosquitoes in experiment 2 and 3 were pooled in distilled water. On day 15, molting of some nematodes was observed, and the 1st eggs were found on day 22. Female nematodes were then placed individually in watch glasses with water, and oviposition was noted from five out of 14 females. The number of eggs laid per day by the 5 worms was recorded for 3 days. The range was 38–128 eggs per day and the mean number was 87.7 (S.D. 27.7). The eggs were left in water and the 1st preparasitic larvae hatched 10 and 11 days after oviposition. The number of infective stage nematodes hatched was 120 out of 373 eggs during the observed period of 5 days. These 120 nematodes were placed in 60 ml water containing 30 second-instar mosquito larvae and later 31 female and 33 male postparasitics were recovered.

These observations suggest that preparasitic *R. culicivorax* can infect fully grown mosquito larvae in water. Development of the mosquito larvae to the pupal and adult stages occurs only when the nematodes invade 4th-instar larvae 4 days after molting. Thus, dispersal of the nematodes to other breeding sites may occur via parasitized adult mosquitoes. Worms dispersed to new sites may then copulate and reproduce. It would be interesting to learn whether parasitism of adult mosquitoes does occur in wild populations.

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OPEN MARSH WATER MANAGEMENT IN CONTROL OF *AEDES SOLLICITANS* IN BARRINGTON, R.I.

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The salt marsh mosquito, *Aedes sollicitans* is an important pest in a community surrounded by salt marsh. The females are persistent biters throughout the day (Carpenter & LaCasse 1974). Barrington, R.I. has approximately 454 acres of salt marsh in a total acreage of 5,210, hence *Ae. sollicitans* is an important species to control.

In 1975, a control project was started to deal with this species. Residents felt that adulticiding alone was inefficient and undesirable. The Barrington Mosquito Control Project was formed to identify breeding areas, larvicide, and to institute a program of Open Marsh Water Management (OMWM) (Ferrigno 1975).

The first major problem was that of receiv-

ing State and Federal approval in 1976 for applying OMWM to 2 large areas of salt marsh called One Hundred Acre Cove and North Palmer River. It took approximately one year of collecting data and presenting it to the Army Corps of Engineers, The Dept. of Interior, Fish and Wildlife, and known experts from Cape Cod and New Jersey in order to receive approval of the project. Final approval was issued with the following conditions:

1. All work will be done with hand tools with special attention to be paid to the deposition of spoils, normally raked as level as possible.
2. Ditch work will be as selective as possible.
3. Efforts will be made where possible to maintain water on the marsh surface, using radial ditches off salt ponds, internal ditches, and creating small ponds.
4. Baseline data will be collected, as well as continued surveillance before and after completion of work in each salt marsh section.

Adult populations of *Ae. sollicitans* were monitored by New Jersey light traps, Model #1:w, equipped with a 40 watt bult and a 24 hour timer. The traps were operated from 8:00 pm to 12:00 pm, 7 days a week. The mosquitoes were collected once a week on Mondays, sorted and identified. Initially the mosquitoes were identified by the Massachusett Health Dept. Encephalitis field station, then, by our own personnel. The traps were located in 7 areas of the town, 2 in Hampden Meadows (the area of greatest OMWM), plus 5 other traps in other sections of Town.

OMWM uses 3 variations of ditches: tidal, internal, and ponds with radials. The ditches were dug by hand, using brushcutters, hay knives, edgers, shovels, and rakes. The procedure for digging a selective canal into a salt marsh, was to brush-cut the grass on the surface of the salt marsh, the length and width of the ditch, then, hay knife the upper portion of the salt marsh the length and width of the ditch. Following this, the edge blocks of salt marsh peat were pulled out with rakes. These blocks were broken up and raked as level as possible, or used to fill breeding depressions near the ditch. The ditch dimensions were approximately 3 ft deep and 20 in. to 24 in. wide. The spoils were placed along the side of the ditch alternating every 50 ft from side to side and raked as level as possible to a depth of 1 to 3 in.

All breeding areas where OMWM had not been applied, were treated with the larvicide Flit MLO, until such time as water management could be achieved.

Initial trapping indicated that as much as 70% of the mosquito population came from the salt marshes, particularly in the Hampden Meadows section. *Ae. sollicitans* were so abundant that persistent biting occurred day or night. Historically, this was the area of the greatest number of complaints.

Table 1 shows the total populations of *Ae. sollicitans* collected from all traps in Town from 1976 to 1980, coincident to the ditching completed in the same years. As OMWM increased, the populations of *Ae. sollicitans* decreased. The results indicated that what used to be a 70% figure caught in the light traps decreased to a 2% figure in 1980. By 1980, 18,000 feet of OMWM had been completed including tidal, internal, and radial pond ditches.

The significant decline of *Ae. sollicitans* in Barrington can be attributed to the Barrington Conservation Commission's inception of the Mosquito Control Project. Instead of just adulticiding, the Town decided upon integrated control measures including source reduction, larviciding and OMWM. As a result of this project, a significant reduction of *Ae. sollicitans* was achieved and should continue in the future with maintenance of OMWM. OMWM is a control measure that the Town needed, it was accomplished by 4 men full time. Although time-consuming, almost 18,000 feet of salt marsh ditching was accomplished by hand in 4 years. Summer digging crews supplemented our permanent crew in the large salt marshes. The ditching was as selective as possible for all areas. Some existing ditches needed cleaning out, and in other areas, new ditches off ponds, and artifical ponds. The internal ditches are closed system ditches which hold water and fish in many of our salt marshes, and tie in breeding depressions to one another. Some of our internal ditches that were dug in 1976 are still clean and deep today.

OMWM can be very effective in controlling

Table 1. Populations of *A. sollicitans* Compared to Footage of Ditching in Salt Marsh.

Year	Total numbers of female mosquitoes trapped	Ditching (ft.)
1976	563	1325
1977	820	6200
1978	196	11,525
1979	148	16,480
1980	70	18,000

all salt marsh mosquitoes including *Ae. cantator*, and *Ae. taeniorhynchus* although for the purposes of this report, only *Ae. sollicitans* was considered.

It is interesting to note that we located a salt marsh across the Palmer River in Warren, R.I. about ½ to 1 mile away, which breeds heavily and did not appear to significantly affect mosquitoes populations in traps 1 and 4 in Hampden Meadows, suggesting that infestation by *Ae. sollicitans* may be more localized in effect than originally thought.

Over 18,000 feet of ditching have been dug under the supervision of the Army Corps of Engineers, Department of Interior; Fish and Wildlife Service, the Rhode Island State Coastal Resources Management Council, the Rhode Island Fish and Wildlife Service, the local Conservation Commission, and the Town Council. The results of our work have been scrutinized by these agencies and also by the newly formed Rhode Island Mosquito Abatement Board. The reduction of the salt marsh mosquitoes plus the reduction of insecticides used on the salt marsh are considered beneficial by all concerned.

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A BIOASSAY APPARATUS FOR EVALUATING LARVICIDES AGAINST BLACK FLIES[1]

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Apparatuses for bioassaying candidate microbial or chemical control agents against black fly larvae must provide movement, oxygenation and cleanliness of water and an attachment substrate that is as uniform as possible within and between containers. A means of providing accurately timed exposures is necessary, and the apparatus itself should not be hazardous to the larvae. Troughs of flowing water such as described by Jamnback and Frempong—Boadu (1966) are inappropriate for our laboratory because of space limitations. Preliminary tests with devices that use a stream of air bubbles to provide water movement and oxygenation, such as the apparatus described by Lacey and Mulla (1976), tend to provide an inhomogeneous test environment as reflected by the fact that the black fly larvae congregate as nearly as possible to the air bubbles. Colbo and Thompson (1978) described an apparatus for rearing black fly larvae that was suitable also for bioassay work. Movement of water in their apparatus was provided by a magnetic

[1] The opinions or assertions contained herein are the private views of the authors and are not to be construed as official or as reflecting the views of the Department of the Army or the Department of Defense. Use of proprietary names herein does not constitute indorsement.