THE TEMPORARY IMPOUNDMENT OF SALT MARSHES FOR THE CONTROL OF COASTAL DEER FLIES

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Adequate control measures for deer flies have not yet been developed. The application of insecticides for the control of adults and larvae over large acreages of semiaquatic habitats, though effective (Hansens, 1956; Jamnback and Wall, 1957, 1959; Williams and Crewe, 1967), may produce adverse side effects on fish and wildlife. Filling of larval sites for industrial and other purposes is effective for local areas, but it is often of no practical value for vast areas of swampy land. Filling also has the disadvantage of permanently destroying the marsh. The use of traps, such as the Manitoba fly trap (Thorsteinson *et al.*, 1965), may be of potential use in certain areas for control purposes, but this method has not yet been perfected. The intent of this paper is to further substantiate the report of Kneen (1968) that deer flies can be controlled by temporarily impounding larval and pupal sites.

Deer flies are semiaquatic organisms in the larval stage. Seldom have they been reported to have been collected in wholly aquatic environments, though Gjullin and Mote (1945) and Roth and Lindquist (1948) report finding large numbers of larvae of *C. discalis* in the bottom mud of shallow alkaline lakes in Oregon. These studies with *C. discalis* coupled with the observation of Philip (1931) with *C. aestuans* demonstrate that some species of *Chrysops*, at least, can survive prolonged periods of submersion in water. Studies of the local distribution of *Chrysops* pupae, however, have shown that this stage of the insect is always found in situations that are not covered with water continuously (Oldroyd, 1964).

Reports previous to our studies suggesting that sudden changes of water levels could be destructive to *Chrysops* are those given by Schwardt (1936) and Oldroyd (1964). Schwardt reported the following observation: "During the spring of 1932, cages were placed along the shore of a pond for the purpose of determining just where in the peripheral mud most of the emergence of *C. callidus* occurred. It was found that pupation and emergence took place at approximately 5 feet from the water line and that as the water receded the larvae followed. After receding about 15 feet over a period of 5 weeks, the water was suddenly returned to its former level by heavy rains. No further emergence occurred and the pond remained uninfested during the following two years." Oldroyd (1964) stated ". . . terrestrial pupae are very easily drowned, and one of the methods of controlling *Chrysops* when it breeds in isolated ponds is artificially to raise the level and so drown the pupae in the soil at the margins." We decided, therefore, to detemine if populations of *C. fuliginosus* Wied. in a coastal salt marsh could be decimated by inundating the larval and pupal sites during the intervals of the larval-pupal and pupal-imaginal molts.

Description of Test Area. The test area is known as the Cat Island Marsh (Fig. 1) and is located within a region of Milford, Connecticut, known locally as the Nells Island Complex. The area is an 80-acre perimeter marshland subject to surface drainage from all surrounding upland. Most of the marsh area is 2.9 feet above mean sea level and is subject to twice daily flooding by normal tides.

Ground cover consists of *Typha latifolia*, *Phragmites communis* and *Spartina* sp. Mosquito ditches in poor condition traverse a large segment of the marsh.

Cat Island is a 2.58 acre gravel deposit having land elevations from mean sea level to 30 feet above mean sea level and is located in the southwestern part of the marsh (Fig. 1). The island partially divides the marsh into two sections. The location of this island presented the opportunity of impounding one portion of the marsh and leaving another area unflooded. The marsh area to the north and northeast of the island was left unflooded and much of that to the south and east of the island (Fig. 1) was impounded to a depth of 1–3 feet by the construction of dikes of marsh soil, running from the eastern and southern tips of the island to the mainland.

SAMPLING METHODS. Surveys for larval *Chrysops* were done in a manner similar to that described by Horsfall (1963) for eggs of floodwater mosquitoes. Soil samples were 6 square inches in size and were obtained by cutting the marsh soil with a bog saw. Samples were placed in plastic bags, taken to the laboratory and washed through a series of graded screens adjusted to capture late instar larvae and pupae. Most of the larvae were preserved in 70 percent ethanol for identification purposes.

Larval sampling was confined to the margin of mosquito ditches. A single mosquito ditch was selected in each area and samples were taken at 9-foot intervals along the ditch. Sampling began at the elevation of the high tidal mark as larvae are usually found only in areas swept daily by tides (MacCreary, 1940). Initially only 3 to 5 samples were taken, but this number proved to be inadequate. Subsequently, larger numbers were obtained.

RESULTS AND DISCUSSION. During the winter of 1967–1968, a larval site for *Chrysops fuliginosus* was located in the salt marsh adjacent to Cat Island which presented the opportunity of impounding only a portion of the marsh and leaving another unflooded to serve as a check area. Assessment of the effect of flooding was made by taking soil samples before and during impoundment in both the inundated and check areas.

On 12 April, two days before impoundment, large numbers of larvae were found in both areas (Table 1). After flooding, a substantial reduction of larvae was noted in the flooded area in comparison to the check. This difference continued until the final collection was made on 2 July. On 5 June, 8 samples were taken along the

TABLE 1.—Larvae and pupae of *Chrysops fuliginosus* collected in the Cat Island salt marsh near the mouth of the Housatonic River, Milford, Connecticut, 1968. Impoundment was effected on April 14, 1968.

		Number of larvae and pupae collected			
		Impounded area		Check area	
Date of collection	Number of samples taken in each area	Total	Average per sample	Total	Average per sample
12 April	4	16	4.00	11	2.75
12 May	3	1	0.33	18	6.00
20 May	3	2	0.66	4	1.33
21 May	3	2	0.66	4	1.33
22 May	3	1	0.33	8	2.67
23 May	5	0	0	3	0.60
28 May	12	1	0.08	10+(3)[1]	1.08
5 June	12	0	0	4+(1)	0.42
13 June	12	1	0.08	15	1.25
2 July	12	0	0	10	0.83

[1] Numbers of pupae given in parentheses.

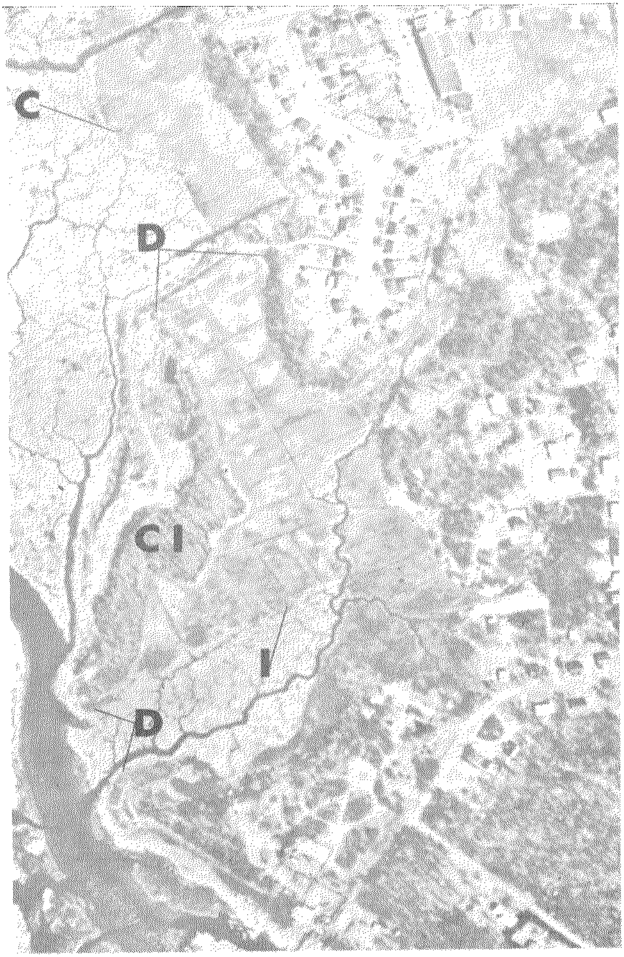

FIG. 1.—Aerial photograph of Cat Island marsh. The marsh area to the south and east of the island was impounded by constructing dikes running from the island to the mainland as shown in the photograph. The marsh area to the north of the island was left unflooded. Key: CI, Cat Island; D, dike; C, sampling site in the control area; I, sampling site in the impounded area.

perimeter of the impoundment between two mosquito ditches to determine if larvae had migrated to the shore. None was found. It had been our intent to maintain the impounded area until the end of July, but a storm accompanied by unusually high tides washed out a large segment of one of the dikes on 1 July. The dike could not be repaired and the experiment was terminated.

At the end of this experiment on 2 July, larvae were still being collected in the unflooded area. Emergence of *C. fuliginosus* from this area had begun prior to 5 June, the date on which the first biting adult was collected. On 2 July large numbers of adults were biting. Thus, even though emergence was not completed by the first week in July, substantial numbers of adults had emerged by that time. The data shown in Table 1 indicate that the flooded area had been impounded long enough to have had an adverse effect on the juvenile population.

A factor that has to be considered is the possibility that larvae in the impounded area migrated away from the sampling sites. Little is known about migration of larval *Chrysops*. *C. discalis* is known to float and to be carried long distances by wind currents (Gjullin and Mote, 1945; Roth and Lindquist, 1948), but this is the only species to have been reported to do so. *Chrysops fuliginosus* does not float. Extensive migrations of larval *Chrysops* by crawling over or beneath the soil surface have not been reported. If larvae had migrated above the soil surface, they would have been subject to predation by killifish. No larvae were collected along the shore of the impoundment, suggesting that larvae were unsuccessful in migrating to a semidry environment to undergo pupation.

Our data suggest that by the proper manipulation of surface water during the period of the larval-pupal and pupal-imaginal molts, populations of deer flies can be controlled. Deer flies would be killed by flooding by either one or a combination of the following: (1) larvae and/or pupae would drown; (2) larvae would be forced from beneath the surface of the soil and into the water where they would be subject to predation; (3) larvae would be unable to find a suitable place to pupate and perhaps ecdysis would be difficult or impossible; and (4) adult flies would be unable to emerge successfully from the pupal exuviae when submerged under one or more feet of water.

SUMMARY. For several years, deer flies have been a nuisance to many residents in Milford, Connecticut. One of the primary pest species is *Chrysops fuliginosus*. Data are presented suggesting that temporary impoundment of salt marshes with perigee tidal waters decimates juvenile populations of *C. fuliginosus*. Impoundment of larval and pupal sites was timed to correspond to the period of the year when *C. fuliginosus* undergoes its larval-pupal and pupal-imaginal molts.

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RETARDATION OF LARVAL DEVELOPMENT OF *AEDES AEGYPTI* (L.) BY THE VITAL DYE, NILE BLUE SULFATE (A) [1]

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INTRODUCTION

In a recent paper, Peters and Chevone (1968) reported the successful internal marking of *Culex pipiens* L. larvae with vital dyes. The work had been undertaken to tag mosquito larvae for ecological investigations based on mark, release and recapture studies, a sampling technique essential for determining absolute population sizes. Of the three vital dyes found suitable as marking agents, Nile Blue Sulfate gave the best results; concentrations of 10.0 p.p.m. yielded 100 percent staining in 27 hours with a mortality only 10.0 percent greater than normal laboratory mortality.

During these studies we noted that larval development was retarded if the larvae remained in Nile Blue Sulfate solutions for extended periods. Kolyer (1966) reported larvae of *Colias* spp. (Lep.) matured into stunted adults when fed plant materials containing Nile Blue Sulfate or Neutral Red.

The following work was initiated to determine the effects of Nile Blue Sulfate on larval development of *Aedes aegypti* (L.), and thereby evaluate the potential use of this dye as a marking agent. A significant change in behavior or physiology of marked larvae by the dye would alter distribution patterns of the larvae. The mark, release, and recapture technique is based on the assumption of normal redistribution of marked individuals. Therefore, if the dye significantly altered the physiology of the larvae, it would introduce errors into population estimates. The investigations undertaken included (1) histological determination of the tissues and organs concentrating the dye in IV instar larvae, (2) effect of low dye concentrations on length of development to pupation, and (3) comparison of oxygen consumption rates of stained and unstained IV instar larvae.

MATERIALS AND METHODS

CULTURE REARING TECHNIQUES. The source of experimental animals was a laboratory culture of *A. aegypti* obtained

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