OBSERVATIONS ON THE SALINITY ON NATURAL AND IMPOUNDED SALT-MARSH AREAS IN NEW JERSEY IN RELATION TO VEGETATION, MOSQUITOES AND PREDATORS

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The mosquito-breeding potential of existing and proposed impoundments and adjacent unimpounded salt-marsh areas in New Jersey was studied in cooperation with the State Division of Fish and Game and Agricultural Experiment Station from 1953 through 1955.[1] Descriptions of the areas, the techniques used, and the results of the study were given by Chapman and Ferrigno (1956). This paper covers observations made on salinity in relation to vegetation, mosquitoes, and their predators not heretofore reported.

Horsfall (1955) presented a general compilation of the reported salinity tolerances of many mosquito species but the paucity of the data is quite evident. Darsie and Springer (1957), reporting on a companion study of some Delaware impoundments and salt-marsh areas, mentioned some of the misconceptions that have accrued with respect to the salinity tolerance and breeding habits of *Culex salinarius* Coq. Many of them exist because insufficient observations have been made in different habitats. Even Carpenter and La Casse (1955) make no mention of this species breeding in saline waters.

Salinity data were taken monthly from one station in each vegetative or ecological type in six fresh-water impoundments in 1954 and 1955 and from four unimpounded salt-marsh areas in 1953 through 1955 (Table 1). Simultaneous observations were made on the presence and identity of mosquito larvae (Table 2) and potential predators (Table 3). Salinities were based on the total chloride as determined by the reaction of the water sample with silver nitrate and a color indicator and are expressed as the percent of the mean salinity of the Atlantic Ocean, which is 32,210 p.p.m. The "number of readings" column in the tables indicates the number of times that a plant, mosquito, or predator occurred in the sampling program. The presence of *Anopheles*, *Culex*, and especially *Aedes* larvae, in the vicinity of a plant in water of a known salinity does not necessarily indicate a site of oviposition, but only denotes the collection of the larvae in that locality. The concentration of receding waters containing mosquito larvae into potholes and depressions is a phenomenon well understood but often overlooked.

As shown in Table 1, the highest mean salinities in the impounded areas were tolerated by common three-square, soft stem bulrush; bare areas, Olney's three-square, and common reed; the lowest mean salinities occurred in stations along the wood line and adjacent to it which contained sedge. The highest single reading was 44.6, noted in Olney's three-square. In the unimpounded areas the highest mean readings were observed in salt-marsh cord grass, black grass, and salt-meadow cord grass, and the lowest in saltgrass and switch-grass along the upland margins. The highest readings were 137.0 and 115.5 in salt-marsh cord grass and 101.8 in black grass.

The previous report (Chapman and Ferrigno) showed that in the impoundments cattail, common reed, and soft-stem bulrush in that order always produced the

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TABLE 1.—Range of salinity in the immediate vicinity of plant species or ecological types in the New Jersey impounded and unimpounded salt-marsh areas, 1953–55, expressed as percent of mean ocean salinity

Plant or ecological type	Impounded areas			Unimpounded areas		
	Number of readings	Range	Mean	Number of readings	Range	Mean
Bare	6	0.9–18.5	9.3	—	—	—
Carex sp. (sedge)	7	.3– 1.5	0.7	—	—	—
Distichlis spicata (L.) (saltgrass)	—	—	—	15	7.4– 45.6	25.5
Ditches	9	.3–13.7	2.6	12	11.0– 83.6	47.9
Eleocharis olivacea Torr. (spike rush)	7	1.5– 5.1	2.6	—	—	—
Juncus gerhardi Loisel (black grass)	—	—	—	30	5.9–101.8	50.9
effusus L. (soft rush)	33	.3–35.3	3.5	—	—	—
Panicum virgatum L. (switch grass)	18	.6–39.2	6.1	32	1.5– 76.9	20.5
Phragmites communis Trin. (common reed)	19	.8–35.2	8.6	—	—	—
Scirpus americanus Pers. (common three-square)	11	.9–36.5	11.5	—	—	—
olneyi Gray (Olney's three-square)	39	.3–44.6	8.7	56	4.0– 83.0	35.5
validus Vahl. (soft-stem bulrush)	7	1.7–30.8	10.8	—	—	—
Typha angustifolia L. and *latifolia* L. (cattail)	34	.5–43.2	7.5	—	—	—
Spartina alterniflora (Loisel) (salt-marsh cord grass)	—	—	—	61	8.8–137.0	52.3
patens (Ait.) (salt-meadow cord grass)	—	—	—	56	1.8– 97.3	40.9
alterniflora and *patens* mixture	—	—	—	17	12.1– 55.8	27.9
Wood line	7	.3– .5	.4	—	—	—

largest numbers of *Culex salinarius*. All these plant species were found in areas with high mean salinities. Also it was shown that bare areas and those with soft-stem bulrush, both with high mean salinities, gave the highest counts of *Anopheles bradleyi* King in the impoundments.

As shown in Table 2, *Aedes sollicitans*, *Aedes cantator*, *Anopheles bradleyi*, and *Culex salinarius*, generally known as salt-marsh mosquitoes (Headlee 1945), tolerated both the highest maximum and mean salinities in both the impounded and unimpounded areas. *Aedes canadensis*, *Mansonia perturbans*, and *Anopheles crucians* appeared to be the least tolerant of all species to high salinities. *M. perturbans* was generally found abundant only in impoundments that remained flooded and these flooded impoundments were always the least saline. Drawing down impoundments usually prevented their breeding (Chapman and Ferrigno).

In data not shown, an impoundment in 1953 with salinities up to 12.0 percent produced fair numbers of *Anopheles quadrimaculatus*, but none were found the next 2 years, when much higher salinities were recorded.

The maximum salinities in which the various species were found breeding were as follows: *Aedes sollicitans* 137.0, *Aedes cantator* 109.4 and 98.2, *Culex salinarius* 83.6, and *Anopheles bradleyi* 55.8. Since the data show that within the impoundments *Culex salinarius* was consistently dipped from water with a high mean salinity, and that this was the most abundant species in cattail, common reed, and soft-stem bulrush, all of which were in areas with high mean salinities, it is obvious that it prefers saline conditions to fresh water in this general area.

The most tolerant predators in the impoundments appeared to be a giant water bug (*Belostomatidae*), predacious diving

TABLE 2.—Range of salinity in New Jersey impounded and unimpounded salt-marsh areas in which various mosquito larvae were dipped, 1953–55, expressed as percent of mean ocean salinity

Mosquito species	Impounded areas			Unimpounded areas		
	Number of readings	Range	Mean	Number of readings	Range	Mean
Aedes canadensis (Theob.)	13	0.3– 4.8	1.2	1	—	15.1
cantator (Coq.)	45	.3–44.6	7.4	49	1.5–109.4	40.0
sollicitans (Wlkr.)	35	.9–44.6	11.0	58	11.0–137.0	49.5
vexans (Meig.)	24	.3–33.3	5.5	4	1.5– 27.5	9.4
Anopheles bradleyi King	18	.5–44.6	10.0	50	4.6– 55.8	28.0
crucians Wied.	18	.3–16.7	4.3	—	—	—
Culex restuans Theob.	5	.9–17.5	6.0	—	—	—
salinarius Coq.	61	.5–43.2	8.9	25	11.0– 83.6	27.4
territans Wlkr.	33	.3–33.3	4.6	—	—	—
Culiseta inornata (Will.)	—	—	—	1	—	24.5
Mansonia perturbans (Wlkr.)	7	.5– 2.4	1.6	—	—	—

TABLE 3.—Range of salinity in New Jersey impounded and unimpounded salt-marsh areas in which various predators of mosquito larvae and pupae were observed, 1953–55, expressed as percent of mean ocean salinity

Predator	Impounded areas			Unimpounded areas		
	Number of readings	Range	Mean	Number of readings	Range	Mean
Coleoptera						
Dytiscidae (predacious diving beetles)	70	0.3–44.6	7.6	30	1.5– 67.0	24.6
Hydrophilidae (water scavenger beetles)	2	.5– 1.4	1.0	4	18.5– 72.7	39.9
Heteroptera						
Belostomatidae						
Belostoma lutarium (Stol.)	13	.8–43.8	9.6	9	6.8– 32.5	16.2
Naucoridae						
Pelocoris femoratus (P. de B.)	7	.8–26.1	6.7	—	—	—
Notonectidae						
Notonecta spp.	8	.8– 5.9	3.4	—	—	—
Odonata						
Damselfly naiads	18	.4–14.2	3.4	3	6.2– 12.1	8.5
Dragonfly naiads	12	.3–14.2	4.5	22	4.1– 92.8	33.1
Minnows	19	.3–35.3	6.2	130	6.8–109.4	39.4

beetles, a creeping water bug (*Naucoridae*), and minnows. Water scavenger beetles, minnows (principally *Cyprinodon variegatus* Lace. and *Fundulus* spp.), and dragonfly naiads were the most tolerant species in the unimpounded areas. High salinities were no barrier to some of these predators, since minnows and dragonfly naiads were noted in waters containing salinities of 109.4 and 92.8 percent, respectively.

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