MOSQUITO DISTRIBUTION AND ABUNDANCE IN AN INLAND SALT MARSH, SALTVILLE, VIRGINIA

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ABSTRACT. At an inland salt marsh, the most abundant mosquitoes collected were *Aedes sollicitans* and *Ae. vexans*. Their widespread occurrence was attributed to chloride tolerance ranges of 1,000–30,000 and 500–11,500 ppm, respectively. *Anopheles punctipennis* was also collected in pools containing chloride concentrations between 0.0 and 3,000 ppm. The chloride concentration range of this species contributed to its association with *Ae. sollicitans*. Approximately 90–95% of the breeding sites of *Ae. sollicitans* and *Ae. vexans* were not located in areas where natural and historical landmarks occurred, therefore mosquito control procedures could be compatible with the preservation of this disjunct salt marsh.

INTRODUCTION

The presence of salt marsh mosquitoes at inland salt marsh sites has been reviewed by Fellton (1944). The infestation of salt marsh mosquitoes in man-made salt-water habitats, such as roadside ditches, has recently caused concern among mosquito control workers (Berlin 1977). These man-made habitats have been infested not only by salt marsh mosquitoes, but also fresh-water mosquitoes (Kardatzke 1980). In Saltville, Virginia (81°52′N, 36°52′E) there exists a disjunct salt marsh (32 ha), 560 km from the eastern shore of Virginia. Several fresh-water and salt-water ponds and pools are present and range in salinity from 9–33,000 ppm. This salt marsh has been partially filled, drained and mined for salt several times in the past (Ogle 1981), but there have always been numerous mosquito breeding sites present in the area.

Aedes sollicitans (Walker) is the most frequently encountered salt marsh mosquito at inland salt-water habitats (Fellton 1944, Berlin 1977). Preliminary investigations indicate that it is also present in large numbers in Saltville. This mosquito is a major nuisance wherever it occurs, and in Saltville its biting habits caused an environmental conflict.

Not only is the area a favorite habitat of mosquitoes, but there are several attributes of natural and historical value which are considered worth preserving by several local groups. Five halophytic plants are present; *Atriplex patula* Linn. (orach), *Eleocharis parvula* (R and S) Link (spikerush), *Juncus gerardi* Loiseleus (black grass), *Salicornia europaea*

Linn. (glasswort) and *Scirpus robustus* Pursh. (bulrush) (Ogle 1981). Three salt-loving insects are known to occur. They are: a carabid, *Bembidion constrictum* Leconte; a biting midge, *Culicoides variipennis* (Coq.) and a brine fly, *Ephydra packardi* (Wirth). The salt marsh is also the location of many Pleistocene mammal fossils (Ray et al. 1967), Indian artifacts (C. Totten, personal communication) and is frequently visited by several species of birds which normally fly up the coastal flyway (Decker, unpublished manuscript).

The purpose of this study was to locate mosquito breeding sites, determine species associations and estimate landing rates; also, to determine if mosquito control could be achieved with minimal damage to this unique habitat.

MATERIALS AND METHODS

In 1979, the salt marshes and surrounding fields were partitioned into 8 quadrants and surveyed for mosquito breeding sites (Fig. 1). Collections were divided into five 2-week periods from April 25–September 5, 1979. Quadrants were surveyed twice within each period. Larval abundance was measured using a standard white enameled dipper (0.47 liter). Ten samples from each site were taken and the average number of larvae per dip was calculated. Landing counts were determined by aspirating mosquitoes from a human located at the center of the study area, once weekly, from 1800–1830 hr. Larval habitats were classified (see Table 2) and chloride concentrations were taken using a Yellow

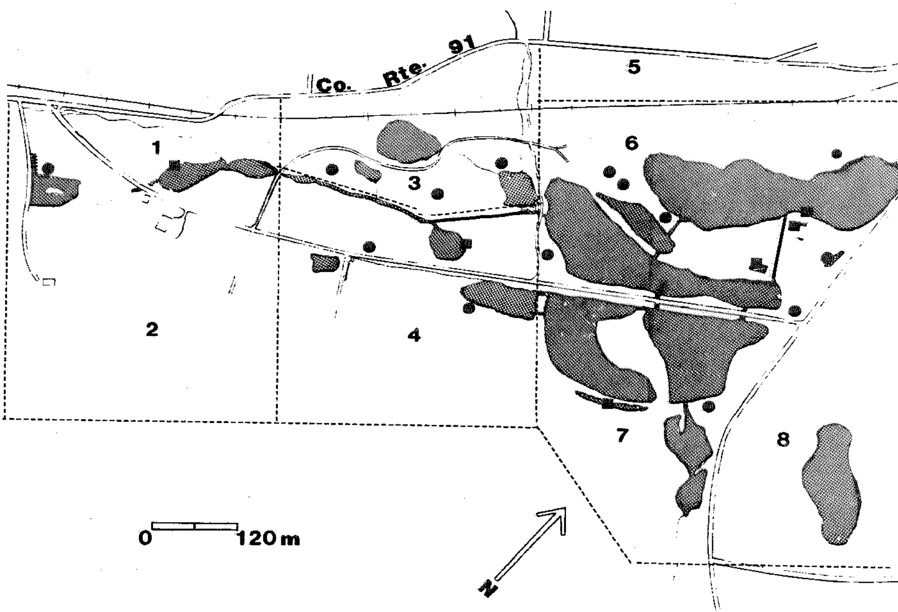

Fig. 1. Salt marsh and surrounding fields showing 8 quadrants surveyed and positive breeding sites for *Ae. sollicitans* and/or *Ae. vexans*. Sites to be drained (●), sites to be filled (■).

Springs Instrument model 33 salinometer. Mosquito associations were determined.

RESULTS AND DISCUSSION

Seven mosquito species were collected in this survey (Table 1). The most abundant species was *Ae. sollicitans*. This species was present in 5 of the 8 habitats examined (Table 2) and was associated with all species except *Culiseta inornata* (Will.) and *Culex territans* (Walker) (Table 3). In other studies (Horsfall 1955), *Ae. sollicitans* was infrequently associated with these 2 species. It appears also to be the first time *Ae. sollicitans* larvae have been reported in association with *Anopheles punctipennis* (Say).

Species associations were related to chloride tolerance ranges. *Aedes sollicitans* had the widest chloride tolerance range (1,000–30,000 ppm) (Table 2). This contributed to its widespread occurrence and association with typically freshwater species. *Aexes vexans* (Meigen) was frequently associated with *Ae. sollicitans*. This association was most likely due to the wide chloride tolerance range of the latter as well as that of *Ae. vexans* (500–11,500 ppm). The presence of *An. punctipennis* at a chloride concentration of 3,000 ppm is unusual, though Chidester (1920) collected them from brackish water (specific gravity 1.0048, 27°C). Rapp (1960) also found *An. punctipennis* at inland sites with salt concentrations as high as 2,499 ppm. *Anopheles punctipennis* may have devel-

Table 1. Seasonal abundance of mosquito larvae collected in Saltville, VA, 1979.*

Species	25 Apr.–5 May	30 May–7 Jun.	5 Jul.–19 Jul.	25 Jul.–9 Aug.	30 Aug.–5 Sep.
Ae. sollicitans	>5	>5	1–5	>5	<1
Ae. vexans	1–5	>5	1–5	<1	
An. punctipennis	1–5	<1	<1	1–5	<1
Cx. pipiens		<1		>5	<1
Cx. restuans	<1	>5	1–5	<1	
Cx. territans	<1	<1	<1	<1	
Cs. inornata	<1				

* Number per dip.

Table 2. Chloride concentration and habitat type of mosquito larvae collected in Saltville, VA, 1979.

Species	Chloride conc. (ppm)	Habitat Type* A	B	C	D	E	F	G	H
Ae. sollicitans	1,000–30,000	+	+	+				+	+
Ae. vexans	500–11,500		+	+				+	
An. punctipennis	0.0–3,000		+	+	+		+		+
Cx. pipiens	0.0–1,000		+	+		+	+	+	+
Cx. restuans	0.0–1,000		+	+		+	+	+	+
Cx. territans	0.0–1,000			+		+	+		
Cs. inornata	0.0–1,000								+

* A—Salt pond edges.
B—Old brine well heads.
C—Temporary marshes.
D—Stream edges.
E—Old tires.
F—Fresh-water ditches.
G—Tire tracks.
H—Sinkholes.

Table 3. Association of mosquito larvae in Saltville, VA, 1979.

Species	*Ae. sollicitans*	*Ae. vexans*	*An. punctipennis*	*Cx. pipiens*	*Cx. restuans*	*Cx. territans*	*Cs. inornata*
Ae. sollicitans	—	+	+	+	+	−	−
Ae. vexans	+	—	+	+	+	+	−
An. punctipennis	+	+	—	+	+	+	+
Cx. pipiens	+	+	+	—	+	+	−
Cx. restuans	+	+	+	+	—	+	−
Cx. territans	−	+	+	+	+	—	−
Cs. inornata	−	−	+	−	−	−	—

oped a larval tolerance to chlorides similar to that suggested for other fresh-water species (Kardatzke 1980).

The brine fields are underlain by a salt deposit (Ray et al. 1967), and whenever tire tracks or hoofprints are made in the soil, we observed that the first mosquitoes to colonize the depressions were *Culex pipiens* Linn., *Cx. restuans* Theobald and *Ae. vexans*. Then, 2–4 weeks later when the chloride concentrations increased to 1,000 ppm, *Ae. sollicitans* became the predominant, and eventually the only species collected from these depressions.

Landing counts showed that *Ae. sollicitans* was the most annoying mosquito present in the area (90% of total catch) and *Ae. vexans* the second most annoying mosquito (9% of total catch). Landing counts in mid-July were as high as 12 per min. for *Ae. sollicitans*.

Fifty-seven breeding sites were located in the study area and 20 were positive for *Ae. sollicitans* and/or *Ae. vexans* (Fig. 1). Of these 20 sites, only 6 were located where fill rather than drainage was recommended as a control measure. Drainage of these 6 sites could not be done because the sites were frequently inundated by water from the ponds or from underground salt-water seepage. Only 2 halophytes were located at these sites *(S. europaea* and *J. gerardi)*. Both species were abundant along the shoreline of the salt ponds and ditches. Visual estimates indicated that less than 5% of the habitats of these 2 halophytes were at the 6 sites that were to be filled. Drainage of the other 14 sites would have little effect on the halophytic plants, because besides the above 2 halophytes, only *A. patula* was present. The 3 halophytes occurred in areas where there was no standing water and would most likely still be present at the 14 sites after drainage.

By determining that *Ae. sollicitans* and *Ae. vexans* were the most annoying mosquitoes, locating their breeding sites and associating breeding sites with halophytic plants, we were able to recommend a minimal amount of habitat alteration. The distinct flora and fauna were thus preserved and most of the brine fields were left undisturbed for future archeological investigations.

ACKNOWLEDGMENTS

The technical help of J. Bohart and C. B. Totten is greatly appreciated. Financial support from the town of Saltville, and the time spent by W. Allison at the study site were also appreciated.

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