DISTRIBUTION OF FLOODWATER MOSQUITO EGGS IN A PARTIALLY WOODED, CENTRAL MICHIGAN LOWLAND

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ABSTRACT. Three contrasting sites in a partially wooded, temporarily flooded lowland in central Michigan were sampled for eggs of *Aedes* mosquitoes to determine which sites were the most attractive for oviposition. A difference in species composition was observed at the site with a significantly ($P<0.05$) lower mean percent soil moisture in the spring and fall. The greatest density of eggs ($4560/0.56m^2$; primarily *Ae. vexans* (Meigen)) was found on soil that maintained the highest mean percent soil moisture in the spring (52.9%) and fall (52.0%). The soil was a silt loam with a dense stand of canary grass (*Phalaris arundinacea* L.).

INTRODUCTION

Floodwater mosquitoes include those in the genus *Psorophora* and many species in the genus *Aedes*. The term "floodwater" refers to mosquitoes that lay their eggs on moist soil that is temporarily flooded, usually on a seasonal basis (Horsfall 1963). This survey deals with the *Ae.* species which are dominant north of 40° N.L. and for the most part are univoltine. Three environmental factors, viz., soil moisture, soil texture and surface vegetation, that can be easily recognized by mosquito abatement workers were studied. Three areas with distinct differences in surface vegetation were sampled for eggs of *Ae.* spp. in a temporarily flooded central Michigan lowland (43° N.L.).

Several factors made the lowland suitable for a study of this kind: sharply defined zones of vegetation within a relatively small area; annual flooding which produced standing water long enough for complete development of mosquito larvae; and large numbers of *Ae.* mosquitoes produced from the site each spring.

METHODS AND MATERIALS

A 2 ha site adjacent to the city of Mt. Pleasant, MI, was chosen for this study. The site is normally flooded annually from April to early June by melted snow and surface runoff from adjacent open areas, and sporadically during August and September rainfall. Three markedly different habitats were chosen (Fig. 1). Area 1 was a shallow depression with little or no emergent vegetation to shade the soil after the floodwater had receded. Later in the season a thin layer of organic matter, primarily from drift and leaf litter, accumulated on the surface.

Area 2 was dominated by a dense growth of canary grass (*Philaris arundinacea* L.) which reached a height of 1 m or more late in the season and provided a humid, shaded area. The soil was covered with a thick layer of matted canary grass stems which also kept the substrate shaded and moist. Area 3 was a stand of eastern cottonwood (*Populus deltoides* Marsh.) which partially surrounded Area 2. The cottonwoods were 5–8 m high and provided complete shade from early June to mid-October The substrate in Area 3 was composed primarily of loosely compacted, leafy duff.

Within each of the three areas a $2.25m^2$ plot was selected arbitrarily for removal of soil samples during mid-November after oviposition had ceased for the season. Twenty-five 225 cm^2 soil samples (totaling 25% of each plot) 4 cm deep were chosen at random and removed from each of the 3 plots. An egg separation technique was used which in-

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volved 3 steps: sieving (No. 20, 40, 60 and 100 mesh), flotation and pipetting. The reliability of this method is based on the recovery of a single, artificially-introduced egg from a given sample (Horsfall 1956). Better than 85% recovery was consistently achieved in our tests. After extraction the eggs were identified to species using stereoptics at 80X in bright reflected light over a nonreflective black background under water (Horsfall et al. 1975).

Soil texture of areas 1–3 was determined by removing several soil cores 2 cm in diameter by 15 cm deep from each area and analyzing the samples following a soil hydrometer method (Pramer and Schmidt 1965). Soil moisture was measured by removing 3 soil cores 1.5 cm in diameter by 4 cm deep from each sampling area every 5th day from 10 May to 5 June (the beginning of oviposition) and 10 October to 19 November (after oviposition had ceased). The samples were oven dried at 85±C for 48 hr. The mean values for each sampling date were then averaged for the entire sampling period (Table 1).

RESULTS AND DISCUSSION

The eggs of the following 6 *Ae.* spp. were collected (Table 2): *Ae. vexans* (Meigen), *Ae. fitchii* (Felt and Young), *Ae. stimulans* (Walker), *Ae. trivittatus* (Coquillett), *Ae. canadensis* (Theobald), and *Ae. sticticus* (Meigen). The eggs of *Ae. fitchii* and *Ae. stimulans* are very similar morphologically (Kalpage and Brust 1968) and were recorded together as the *fitchii/stimulans* group. The behavior of these two species is similar and adults of both species are known to frequent wooded sites (Irwin 1943).

During the spring and fall Areas 1 and 2 were very similar in soil texture and,

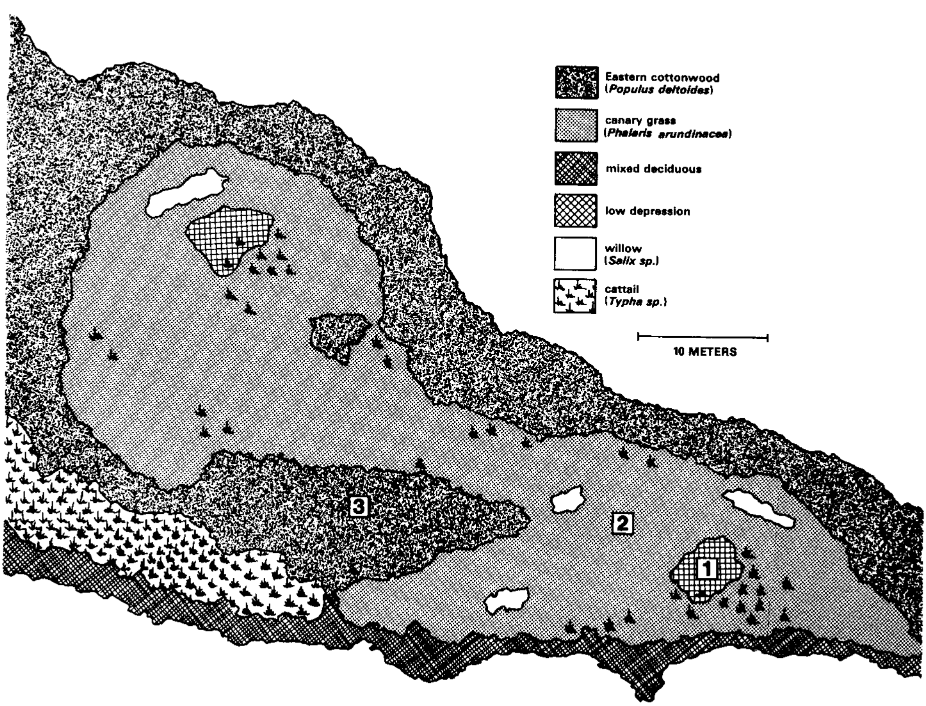

Figure 1. Surface vegetation occurring in a temporarily flooded lowland.

Species	Total No.	Area 1 depression (organic detritus)* Mean No./Sample ± SE	% of Total	Total No.	Area 2 canary grass (Phalaris) Mean No./Sample ± SE	% of Total	Total No.	Area 3 cottonwood (Populus) Mean No./Sample ± SE	% of Total
Aedes vexans	217	8.7 ± 1.6	81	4027	161.0 ± 18.5	88	267	10.7 ± 2.7	66
A. fitchii/stimulans	25	1.0 ± 0.3	9	496	19.8 ± 4.4	11	67	2.7 ± 1.0	16
A. trivittatus	13	0.5 ± 0.2	5	33	1.3 ± 0.4	<1	29	1.2 ± 0.4	7
A. canadensis	12	0.5 ± 0.5	5	4	0.2 ± 0.1	<1	0	...	...
A. sticticus	0	...	...	0	...	...	44	1.8 ± 0.5	11
Total	267			4560			407		

* emergent vegetation sparse

Table 1. Soil texture and moisture content (based on oven dry weight) of Areas 1 to 3.

Area	Soil Texture % Sand	Silt	Clay	Mean % Soil* Moisture (spring)	Mean % Soil** Moisture (fall)
1 depression (organic detritus)	(silt loam) 0	66.6	33.4	46.3a	49.5a
2 canary grass (Phalaris)	(silt loam) 5.7	63.4	30.9	52.9a	52.0a
3 cottonwood (Populus)	(clay) 0	43.2	56.8	29.1b	41.3b

a Numbers in the same column followed by the same letter are not significantly different at the 5% level of probability.

* sampled every fifth day 5/10 - 6/5

** sampled every fifth day 10/10 - 11/19

Table 2. Proportions of floodwater mosquito eggs in Areas 1 to 3.

more importantly, in their ability to retain moisture, but Area 2 maintained a dense stand of canary grass whereas Area 1 lacked significant emergent vegetation. Both areas contained similar percentages of each *Ae.* spp. but the density of eggs in Area 2 (4560/0.56m^2) was over 15 times greater than Area 1 (Table 2).

Area 3, composed of a loosely packed, leafy duff with an underlying layer of clay, did not retain its moisture in the top 4 cm as well as Areas 1 and 2 (Table 1). The species composition in Area 3 included the lowest percentage of *Ae. vexans* eggs and the highest percentage of *Ae. fitchii/stimulans* eggs. Area 3 also produced the only eggs of *Ae. sticticus,* which represented 11% of all eggs in the area. The eggs of *Ae. trivittatus* and *Ae. canadensis* were found in too few numbers to determine preferences of the adults for these oviposition substrates.

The behavior of floodwater mosquitoes in regard to oviposition stimuli is complex and not yet fully understood. The results of this study suggest the importance of soil moisture in conjunction with certain vegetative canopies as factors for determining optimal oviposition sites. These factors, especially the effects of soil moisture, need to be studied over a greater range of the oviposition season and in a variety of geographic locations for a more thorough understanding of this behavior.

Similar studies by Horsfall (1963), Horsfall et al. (1973), and (Horsfall et al. (1975) involving horizontal distribution of floodwater mosquito eggs have dealt primarily with zones associated with maximum and minimum flood levels. The results of this study, although not entirely conclusive, provide additional guidelines for locating concentrations of *Ae.* eggs in areas of the North Central United States where zones of maximum and minimum flooding may be difficult to determine and where similar plant assemblages occur.

ACKNOWLEDGMENTS

The authors thank W.R. Horsfall for the use of the egg separation facilities at the University of Illinois and D. Strickman for his technical assistance. Gratitude is also expressed to E.S. Del Fosse of the Lee County Hyacinth Control District, Ft. Myers, Florida for his critical review of the manuscript.

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