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SHORT COMMUNICATION

Effect of Salt Marsh Drainage on the Distribution of *Tabanus nigrovittatus* (Diptera: Tabanidae)

MICHAEL J. MCMAHON AND RANDY GAUGLER

Department of Entomology, Rutgers University,
New Brunswick, NJ 08903

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ABSTRACT Immature stages of *Tabanus nigrovittatus* Macquart inhabit salt marsh sod. A study of the distribution of larvae in relation to the presence or absence of surface water showed that larval densities were higher in salt marsh areas that appeared well drained. Late instars remained above the sod surface more frequently in laboratory conditions mimicking high water-table levels. The development of anaerobic conditions in sod at high water levels probably deterred larvae from burrowing into the sod. Therefore, mosquito control ditches, constructed to augment interstitial drainage inadvertently may have created optimal tabanid larval habitat.

KEY WORDS Tabanidae, salt marsh, larval distribution

THE FLY *Tabanus nigrovittatus* Macquart is a persistent biter of man and animals in coastal areas of the eastern United States. The larval stage inhabits salt marsh sod, where they prey on a variety of invertebrates (Meany et al. 1976). Jamnback & Wall (1959), Freeman & Hansens (1972), and Dukes et al. (1974a) found that *T. nigrovittatus* larvae were most common in areas of marsh dominated by *Spartina alterniflora* Loisel short-form.

The rate of water drainage most likely structures the salt marsh plant community (Dacey & Howes 1984) and, thus, faunal distributions. Ditches have been constructed on salt marshes to accelerate interstitial drainage of the marsh surface and eliminate habitat for mosquito larvae. Dukes et al. (1974b) found no pattern of tabanid larval distribution, but he suggested that this was the result of conducting the study on a salt marsh frequently inundated by the tide. An infrequently inundated tidal marsh may show a tabanid distribution pattern related to the rate of drainage (Lefor et al. 1987). Rockel & Hansens (1970a) found a correlation between marsh elevation above mean high water level (MHW) and the larval tabanid distribution. Therefore, we tested the hypothesis that MHW influences the distribution and behavior of larval *T. nigrovittatus* in tidal salt marshes.

Materials and Methods

Larval Distribution in Nature. Sod samples were collected from a ditched salt marsh dominated by *S. alterniflora* short-form at Leeds Point, NJ, near the upland ecotone on the Forsythe National Wildlife Refuge. This area seldom is inundated by the tide except during high spring tide periods. Areas were chosen for sampling during low tides under two categories: 1) wet (water on the surface of the sod); and 2) dry (no water on the surface of the sod). Otherwise, these areas were chosen randomly, with 26 samples taken in dry and 24 in wet areas. Of these 50 samples, 30 were taken during June 1990, 1 mo before the onset of adult emergence, and 20 were taken during August 1990, 1 mo after the onset of adult emergence. For each sample, 9 cores (0.1 by 0.1 by 0.1 m) were taken in a regularly spaced grid within a 1-m^2 area, combined as one sample, and placed in a Tullgren funnel with a 100-W incandescent lamp fixed above that drove fauna down into jars of 95% ethanol. The heat source was maintained for 5–7 d, depending on ambient temperature and humidity. Larvae were stored in 75% ethanol, and late instars were identified to species using Freeman (1987). The number of *T. nigrovittatus* in each sample was transformed by square root and tested using analysis of variance (ANOVA) (Snedecor & Cochran 1967). Values were back transformed to present actual means characteristic of this species' distribution.

Behavioral Experiment. Sod cores 20 cm in diameter and 10 cm deep were collected from an area of salt marsh covered by *S. alterniflora* short-form. The cores were dried in the Tullgren funnel apparatus described above to kill all fauna and placed in 12 PVC cylinders (20 cm high; 20 cm interior diameter). Tap water was added to realute each core, and the sod was left overnight to allow water reabsorption. To mimic drained and undrained sod conditions, we raised the water level in six cylinders to the sod surface, and left the water level 18 cm below the surface in the remaining six cylinders. A single *T. nigrovittatus* late instar (≈19–25 mm long) was placed in each cylinder and left overnight to acclimate. The presence or absence of larvae on the sod surface was recorded once every 30 min over a 5-h period, totaling 10 observations. This was repeated for 5 consecutive d during light and dark phases in a laboratory with a photoperiod of 12:12 (L:D) h; dark phase observations were made with a hand-held lamp covered with red plexiglas. Larvae found floating in the basin along the side were returned to their respective cylinders immediately and counted as above the surface. The 10 observations during each 5-h period were converted into a percentage subsurface activity value for each period (i.e., 8 times below surface = subsurface activity of 0.80). Data were analyzed using a repeated measures model ANOVA, by comparing the arcsin squareroot of percentage subsurface activity to water level and photophase condition for each larva for 5 consecutive d.

Results and Discussion

Larval Distribution. We found no significant difference in the number of larvae per sample of *T. nigrovittatus* between the different months sampled (June: 1.31 ± 2.51 larvae per sample; August: 1.26 ± 1.80 larvae per sample) ($F = 0.09$; df = 1, 46; $P > 0.76$). However, there were significantly more larvae in dry (2.08 larvae per sample) than wet (0.75 larvae per sample) areas ($F = 13.10$; df = 1, 46; $P < 0.0007$; $R^2 = 0.29$). There was no interaction effect ($F = 2.37$; df = 1, 46; $P > 0.13$). Teal et al. (1986) stated that salt marsh muds saturated by water became anaerobic, which resulted in the build-up of sulfides. We propose that areas of poorly drained salt marsh, being anaerobic, present suboptimal habitat for late instars of *T. nigrovittatus*. Poorly drained salt marsh also may present adverse conditions to the pupae. If not, then marsh surface areas that have minimal drainage might suppress the densities of potential prey species, thereby increasing *T. nigrovittatus* distribution.

The R^2 value from our larval *T. nigrovittatus* distribution study indicated that we explained ≈30% of the variation in larval distribution. We attribute this partial explanation of larval distribution to the low resolution we used in measuring drainage and not the validity of using drainage to track larval distribution. Even though vegetation was trampled in all sample areas, only in 10 of the 24 poorly drained plots did vegetation not recover. These 10 plots still appeared as small undrained salt marsh pools 1 yr after sampling. Combining this with our observations that surface water occurred even during extended periods of tidal levels below MHW indicated that these areas do not drain. We would expect a more complete explanation of larval distribution by using a more exacting method of measuring marsh drainage that accounts for porosity, water chelation, and water-table level.

Behavioral Experiment. Larval behavior did not vary significantly with photophase ($F = 2.36$; df = 1, 29; $P > 0.15$), but larvae showed significantly more subsurface activity in the cylinders with high water levels ($F = 13.17$; df = 1, 29; $P < 0.0046$). Larvae in low water levels were below the surface 98.7% of the time, but larvae in high water levels were below the surface 89.7% of the time. There was no interaction effect with photophase ($F = 1.41$; df = 1, 29; $P > 0.26$). We hypothesized that these larvae were forced to the surface under high water conditions by decreased oxygen and increased sulfide from anaerobic respiration (Bradley & Dunn 1989). In three of the six high-water cylinders, the larvae crawled up and out of the cylinder; one of these larvae died on the fourth day. This implied that conditions in high water levels triggered dispersal behavior in *T. nigrovittatus* larvae, away from suboptimal conditions. However, we expect that the initial and major factor structuring larval distribution is how the females select oviposition sites. But no one has identified where females oviposit, and therefore conditions of the sod females select when choosing larval habitat.

The distribution of emerging adult *T. nigrovittatus* decreased with increased distance from mosquito ditches (Rockel & Hansens 1970b), indicating that the distribution of the late instar population decreased with increased distance from the ditches. Given that mosquito ditches were constructed to accelerate drainage, our results would indicate that mosquito ditches may have generated optimal habitat for late instars. We propose that extensive ditching of salt marshes may inadvertently promote *T. nigrovittatus* populations, thereby exchanging a mosquito control problem for a biting fly problem.

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References Cited

Bradley, P. M. & E. L. Dunn. 1989. Effects of sulfide on the growth of three salt marsh halophytes of the southeastern United States. Bot. Soc. Am. 76: 1707–1713.

Dacey, J.W.H. & B. L. Howes. 1984. Water uptake by roots controls water table movement and sediment oxidation in short *Spartina* marsh. Science 224: 487–489.

Dukes, J. C., T. D. Edwards & R. C. Axtell. 1974a. Distribution of larval Tabanidae (Diptera) in a *Spartina alterniflora* salt marsh. J. Med. Entomol. 11: 79–83.

1974b. Associations of Tabanidae (Diptera) larvae with plant species in salt marshes, Carteret County, North Carolina. Environ. Entomol. 3: 280–286.

Freeman, J. V. 1987. Immature stages of *Tabanus conterminus* and keys to larvae and pupae of common Tabanidae from the United States east coast salt marshes. Ann. Entomol. Soc. Am. 80: 613–623.

Freeman, J. V. & E. J. Hansens. 1972. Collecting larvae of the salt marsh greenhead *Tabanus nigrovittatus* and related species in New Jersey: Comparison of Methods. Environ. Entomol. 1: 653–658.

Jamnback, H. & W. Wall. 1959. The common saltmarsh Tabanidae of Long Island, New York. New York State Museum and Science Service Bulletin, No. 375, Albany.

Lefor, M. W., W. C. Kennard & D. L. Civco. 1987. Relationship of salt-marsh plant distribution to tidal levels in Connecticut, USA. Estuaries 11: 61–68.

Meany, R. A., I. Valiela & J. M. Teal. 1976. Growth, abundance and distribution of larval tabanids in experimentally fertilized plots on a Massachusetts salt marsh. J. Appl. Ecol. 13: 323–332.

Rockel, E. G. & E. J. Hansens. 1970a. Distribution of larval horse flies and deer flies (Diptera: Tabanidae) of a New Jersey salt marsh. Ann. Entomol. Soc. Am. 63: 681–684.

1970b. Emergence and flight activity of salt-marsh horse flies and deer flies. Ann. Entomol. Soc. Am. 63: 27–31.

Snedecor, G. W. & W. G. Cochran. 1967. Statistical methods. Iowa University Press, Ames, IA.

Teal, J. M., E. Pendelton, W. Kitchens & M. W. Young. 1986. The ecology of regularly flooded salt marshes of New England: a community profile. U. S. Fish and Wildlife, Biol. Report No. 85, Washington, DC.

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