HABITAT CHARACTERISTICS OF *COQUILLETTIDIA PERTURBANS* IN CENTRAL FLORIDA

J. L. CALLAHAN AND C. D. MORRIS

Polk County Environmental Services, P.O. Box 39, Bartow, FL 33830

ABSTRACT. Habitat characteristics were examined in two marshes and the littoral zones of two lakes in central Florida to determine their effect on the density and distribution of *Coquillettidia perturbans*. Larval and water samples were collected and habitat characteristics were recorded at monthly intervals for one year. Several significantly different physicochemical parameters were found between the marshes and lakeshores. Sites with dissolved oxygen less than 1.5 mg/liter (from October through May), pH less than 5.2, total alkalinity less than 6.0 mg $CaCO_3$/liter, and orthophosphate less than 0.25 mg/liter were associated with significantly higher concentrations of *Cq. perturbans*. Arrow-arum, caric sedge, and maidencane were also associated with higher numbers of *Coquillettidia*.

INTRODUCTION

Coquillettidia perturbans (Walker) is an extremely pestiferous mosquito and has been implicated as a vector for both eastern and western equine encephalomyelitis (Lounibos and Escher 1983). Although common throughout the North American continent, this species probably reaches its greatest abundance in central Florida (McNeel 1932). Here a large number of freshwater marshes, lakes with marshy borders, and unreclaimed phosphate mines, combined with a favorable climate, provide ideal breeding conditions for this species (McNeel 1932, Lounibos and Escher 1983). The immature stages of *Cq. perturbans* belong to a unique group of mosquitoes that does not breathe at the water surface. Instead, they have a modified siphon which is used to pierce the stems and roots of aquatic plants to obtain oxygen, resting sites, and protection from predators (McNeel 1932, Hagmann 1952). Collection of the larvae is difficult since they quickly detach when disturbed and bury themselves in the detritus.

Inorganic ions are a major component of the oviposition medium; the water is almost certainly analyzed with a complex integrated sensory system by the female mosquito prior to oviposition (Bates 1949, Vrtiska and Pappas 1984). Since a body of water has an important effect on the density and distribution of the organisms that live in or near it (Wetzel 1975, Krebs 1978), physicochemical parameters have been used in numerous studies to characterize aquatic habitats and their impact on densities of *Coquillettidia*. However, these research studies have produced conflicting results. In several studies, relationships between water chemistry parameters and the number of mosquitoes appear nonexistent. Bidlingmayer (1968) found no relationship between the color, turbidity, or pH of the water and the density of *Coquillettidia* in marshes in central Florida. He also determined that, while the roots of most marsh plants were satisfactory for larval attachment, if the plants were deeply rooted in firm substrate with little or no detritus then the *Coquillettidia* larvae were either absent or in limited numbers. Guille (1976) determined that the pH, alkalinity and water temperature had no apparent effect on the presence of *Cq. richiardii* (Ficalbi) in marshes in France. Dissolved oxygen levels in the water of breeding sites for *Cq. perturbans* have been found to be significantly different from those in nonbreeding sites (Batzer and Sjogren 1986). The present study was conducted to further clarify the relationship between the aquatic habitat and *Coquillettidia perturbans* larvae.

MATERIALS AND METHODS

Environmental characteristics were examined in two freshwater marshes and in the marshy borders of two freshwater lakes in Polk County, Florida. The Lake Alfred study area is part of an extensive marsh system that covers approximately 10,000 ha (Fig. 1). The vegetation in this marsh system is predominantly pickerelweed (*Pontederia cordata* Linn.), but the approximately 4.5 ha study area at the southeastern tip of the marsh is dominated by maidencane (*Panicum hemitomon* Schult.) and bladderwort (*Utricularia gibba* Linn. and *U. inflata* Walt.). Extensive stands of false maidencane (*Sacciolepis striata* (Linn.) Nash), arrow-arum (*Peltandra virginica* (Linn.) Kunth), and caric sedge (*Carex* spp.) are also found in this study area.

The 19 ha study area near Haines City is part of the same large marsh system as the Lake Alfred marsh. This area is dominated by maidencane, but also contains numerous floating mats of pickerelweed and caric sedge.

Lake Hamilton is an 861 ha lake with a maximum depth of 4.2 m. Marshy areas are found on the southwest shore, on a large island in the middle of the lake, and on a peninsula extending from the north shore. Approximately 143 ha containing para grass (*Panicum purpurascens* Raddi.), water pennywort (*Hydrocotyle umbellata* Linn.), smartweed (*Polygonum coccineum* Muhl. *ex.* Willd. and *P. hydropiperoides* Michx.), cattail (*Typha* spp.), giant bulrush (*Scirpus cal-*

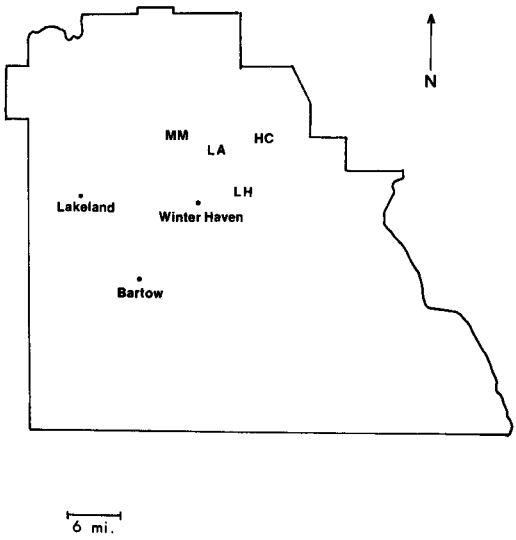

Fig. 1 Location of the four study areas in Polk County, Florida (HC = Haines City marsh, LA = Lake Alfred marsh, LH = Lake Hamilton, MM = Lake Mattie).

ifornicus (C. A. Meyer) Steud.) and maidencane were included in this study area.

Lake Mattie is a 436 ha lake with a maximum depth of 3.9 m. Approximately 85 ha of marsh that are located along the northern edge of the lake were included in the study area. This area includes mainly para grass, torpedograss (*Panicum repens* Linn.), maidencane and cattail.

Sampling stations were randomly selected each month from a grid map of each sampling area. Twelve water and 12 larval samples from each of the four study areas were to have been collected at monthly intervals between June 1984 and May 1985. However, drought conditions that developed midway through the study prevented access to the Haines City marsh and samples there were collected only from June 1984 through December 1984.

Larval samples were collected from an airboat using the pump and wand system developed by Morris et al. (1985). Approximately 24 liters of habitat water was pumped through a nylon mesh sieve; the sieve contents were then rinsed into a sample jar. In the lab, the samples were placed in separation cylinders for approximately 20 hr. Larvae that had surfaced in the cylinders were collected, counted, and identified.

One water sample was collected for each larval sample. Due to the shallow depth of the water column (less than 60 cm), the water samples were collected approximately 15–20 cm below the water surface directly in polyethylene bottles instead of in a standard water sampler. The water samples were cooled overnight at 4°C when analyses could not be completed in one day. Water temperature and dissolved oxygen (Yellow Springs Instrument model 57 oxygen meter), water depth (meter stick) and the dominant emergent vegetation were recorded at each site.

The pH was recorded with a Fisher Accumet model 320 expanded scale research pH meter. Total alkalinity was determined with the American Public Health Association (1981) procedures. The level of inorganic carbon was calculated using the values for alkalinity and pH with the equation developed by Saunders et al. (1962). Color, orthophosphate, ammonia nitrogen, nitrite nitrogen, and total chlorine concentrations were determined on a Bausch and Lomb Spectronic 20 using methods described by APHA (1981) that were modified for use with prepackaged chemical reagents (Hach Company, P.O. Box 389, Loveland, CO 80539). Turbidity was measured spectrophotometrically (Environmental Protection Agency 1971). The phytoplankton biomass was estimated by extracting the chlorophyll *a* (APHA 1981) and calculating its concentration from the optical density using the Richards and Thompson (1952) equation. The soluble protein concentration was determined with the procedure outlined by Van Handel (1986).

The data were analyzed on an IBM PC XT using the analytical procedures of the SPSS/PC+ statistical program (Norusis 1986) to determine which, if any, of the parameters would be of importance in identifying *Cq. perturbans* breeding sites. Mosquito numbers were transformed to $\log_{10}(n + 1)$ prior to analysis. The data gathered from the 328 samples collected from June through December 1984 were used in most of the analyses. The data were subjected to the Bartlett's test for homogeneity of variance (Steele and Torrie 1980) prior to submission to the analysis of variance. The Duncan's Multiple Range Test (DMRT) was used to determine significant differences in larval numbers in relation to physicochemical parameters and vegetation types. The least significant difference (LSD) test was used to establish regions of nonoverlap in habitat parameters and the analysis of covariance was performed to overcome possible inter-habitat variability in mosquito densities in relation to vegetation types (Steele and Torrie 1980, Norusis 1986).

RESULTS AND DISCUSSION

Distinct differences in the dissolved oxygen, pH, total alkalinity, and orthophosphate levels were found between the two habitat types (the Lake Alfred and Haines City marshes and the marshy lake edges of Lake Hamilton and Lake Mattie) (Table 1). Means of the other parameters either showed no significant difference

Table 1. Comparisons of physicochemical parameters and numbers of *Coquillettidia perturbans* in the four study areas from June through December 1984 as determined with the Duncan's Multiple Range Test. Within a parameter, means followed by the same letter are not significantly different at the 0.05 level.

Parameter	Marshes		Lake edges	
	Lake Alfred (n = 81) $\bar{x}$ (SE)	Haines City (n = 81) $\bar{x}$ (SE)	Lake Mattie (n = 78) $\bar{x}$ (SE)	Lake Hamilton (n = 80) $\bar{x}$ (SE)
pH	4.7a (0.1)	4.9a (0.1)	5.8b (0.1)	6.1c (0.1)
Total alkalinity (mg $CaCO_3$/liter)	3.6a (0.8)	3.6a (0.7)	11.1b (1.5)	18.6c (2.8)
Inorganic carbon (mg/liter)	38.5b (6.9)	25.9a (4.6)	15.3a (1.5)	13.7a (2.7)
Color (Pt-Co Units)	420d (16.2)	189b (10.2)	229c (4.5)	121a (11.6)
Chlorophyll *a* (mg/m^3)	100.2a (15.2)	90.9a (12.2)	52.5a (15.6)	57.9a (19.3)
Turbidity (FTU)	1.8a (1.2)	0.5a (0.3)	1.0a (0.7)	7.2a (3.3)
Orthophosphate (mg/liter)	0.04a (0.02)	0.04a (0.03)	0.81c (0.02)	0.55b (0.07)
Ammonia nitrogen (mg/liter)	3.60b (0.09)	1.68a (0.10)	2.08a (0.31)	1.50a (0.20)
Nitrite nitrogen (mg/liter)	0.00a (0.00)	0.00a (0.00)	0.00a (0.00)	0.00a (0.00)
Total chlorine (mg/liter)	0.05a (0.01)	0.05a (0.01)	0.08a (0.02)	0.07a (0.02)
Protein (mg/liter)	5.43b (0.21)	2.90a (0.12)	4.26b (0.37)	1.78a (0.33)
Water temperature (°C)	22.0a (1.9)	23.7a (2.0)	24.2a (1.9)	23.7a (1.6)
Water depth (cm)	46a (2.4)	68b (3.8)	73b (3.6)	43a (3.1)
Dissolved oxygen (mg/liter)	0.8a (0.1)	0.9a (0.1)	1.7ab (0.4)	2.0b (0.4)
Cq. perturbans ($\log_{10}(n + 1)$)	0.53b (0.09)	0.50b (0.10)	0.18a (0.11)	0.04a (0.02)

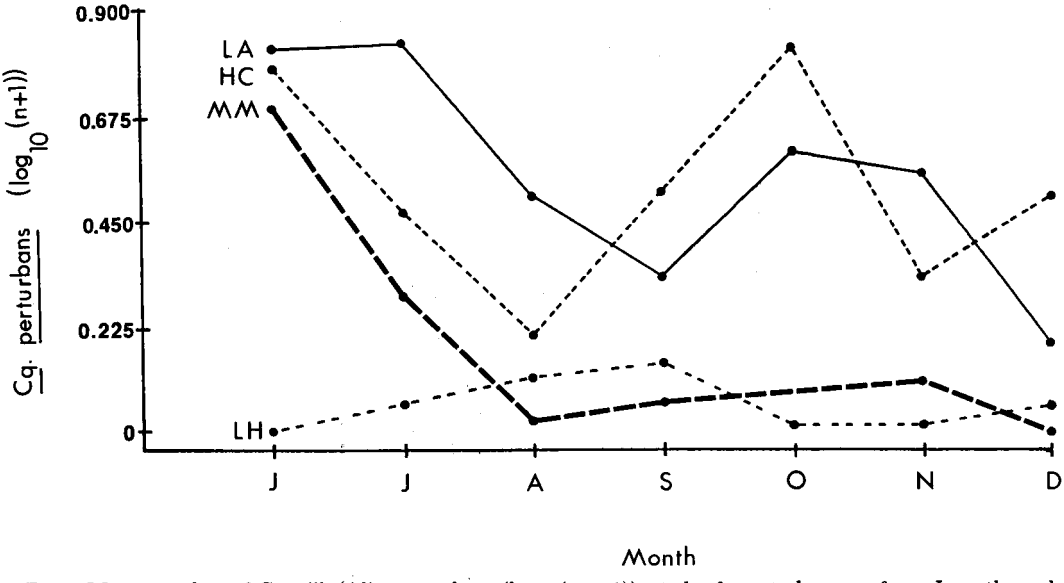

Fig. 2 Mean number of *Coquillettidia perturbans* ($\log_{10}$ (n + 1)) at the four study areas from June through December 1984 (HC = Haines City marsh, LA = Lake Alfred marsh, LH = Lake Hamilton, MM = Lake Mattie).

among all four areas (e.g., chlorophyll *a*, turbidity, nitrite nitrogen, total chlorine and water temperature) or showed a significant difference among the areas but without distinct groupings of the marshes and lake edges (e.g., inorganic carbon, color, ammonia nitrogen, protein and water depth).

Comparisons of the number of *Cq. perturbans* collected in the four areas during the seven months revealed that the Lake Alfred and Haines City marshes had significantly higher numbers of larvae than the marshy shores of Lake Hamilton and Lake Mattie (Table 1). The differences in the numbers of *Coquillettidia* produced in the four areas are shown in Fig. 2.

Based on the results of the least significant difference test, intermediate values were used to distinguish the more productive marsh areas in terms of *Coquillettidia perturbans*. Areas with levels of dissolved oxygen less than 1.5 mg/liter

(from October through May), pH less than 5.2, total alkalinity less than 6.0 mg $CaCO_3$/liter, and orthophosphate less than 0.25 mg/liter were found to have significantly higher numbers of *Coquillettidia* larvae.

The numbers of *Coquillettidia* collected in the different species of aquatic vegetation were also compared. The DMRT indicated that significantly higher numbers of larvae were collected from arrow-arum, maidencane and caric sedge than from any of the other species of aquatic plant examined (Table 2). Pickerelweed, torpedograss, bladderwort, false maidencane, water pennywort and para grass were found to produce moderate numbers of larvae, while cattails were associated with low numbers of larvae. No larvae were ever collected from giant bulrush or smartweed during this study. After adjusting for possible interhabitat variability in dissolved oxygen, pH, alkalinity, and orthophosphate, the analysis of covariance indicated that, regardless of location, arrow-arum and maidencane still contained greater numbers of *Coquillettidia*. The other plant species continued to be associated with low to moderate numbers of *Coquillettidia*.

Table 2. Mean number of *Coquillettidia perturbans* larvae (calculated as $\log_{10}(n + 1)$) collected from different types of aquatic vegetation in the four study areas from June through December 1984. Based on DMRT, groups with the same letter are not significantly different at the 0.05 level.

Plant species	$\bar{x}$ (SE)	n	Group
Smartweed (*Polygonum coccineum, P. hydropiperoides*)	0.0 (0.0)	15	a
Giant bulrush (*Scirpus californicus*)	0.0 (0.0)	2	a
Cattail (*Typha* spp.)	0.03 (0.03)	9	a
Para grass (*Panicum purpurascens*)	0.11 (0.04)	44	a
Water pennywort (*Hydrocotyle umbellata*)	0.12 (0.12)	4	a
False maidencane (*Sacciolepis striata*)	0.19 (0.10)	19	a
Bladderwort (*Utricularia gibba, U. inflata*)	0.22 (0.06)	10	a
Torpedograss (*Panicum repens*)	0.22 (0.08)	20	a
Pickerelweed (*Pontederia cordata*)	0.22 (0.09)	20	a
Caric sedge (*Carex* spp.)	0.51 (0.10)	27	b
Maidencane (*Panicum hemitomon*)	0.52 (0.06)	108	b
Arrow-arum (*Peltandra virginica*)	0.66 (0.10)	7	b

CONCLUSION

Previous studies have indicated that the highest larval densities are associated with marshy areas with 15–30 cm of detritus (non-compacted organic matter) on either a sand or peat substrate (Hagmann 1952, Bidlingmayer 1968, Guille 1976). Tall dense vegetation on shore adjacent to the marsh, dense stands of emergent vegetation and water depths less than 1 m have also been found to have a significant positive influence on *Cq. perturbans* production (Morris and Callahan, unpublished data).

Results of this study indicate that certain physicochemical parameters may be useful indicators of *Cq. perturbans* larval habitats. Marsh areas with levels of dissolved oxygen less than 1.5 mg/liter (from October through May), pH less than 5.2, total alkalinity less than 6.0 mg $CaCO_3$/liter, and orthophosphate less than 0.25 mg/liter were associated with significantly higher concentrations of *Cq. perturbans*. Arrow-arum, caric sedge and maidencane were also associated with the highest densities of *Cq. perturbans*. The natural marsh areas were found to have vastly different water chemistry parameters than the areas found along the lake edges, even though the physical appearance of the four locations was strikingly similar. Together with the characteristics outlined in previous studies, the values for dissolved oxygen, pH, total alkalinity and orthophosphate may be useful indicators of potential breeding sites for *Cq. perturbans*.

ACKNOWLEDGMENTS

The authors wish to thank Eric Wentworth, Hampton Lewis, Ellen Wheeler, Lottie Jordan, and David Dills for their assistance with this project.

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