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SURVEY OF 13 POLK COUNTY, FLORIDA LAKES FOR MOSQUITO (DIPTERA:CULICIDAE) AND MIDGE (DIPTERA:CHIRONOMIDAE) PRODUCTION

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ABSTRACT

A survey was conducted at 30 sites in 13 lakes in Polk County, Florida to: (1) determine the extent of mosquito and midge production in the lake sites, (2) define more precisely some of the environmental factors that influence mosquito and midge densities, and (3) determine if the physical appearance of a site would enable accurate estimates of the mosquito and midge production potential. Although the emphasis of this survey was on *Coquillettidia perturbans* (Walker), data were collected on the mosquitoes *Anopheles*, *Culex*, *Mansonia*, and *Uranotaenia* and the chironomid midge *Glyptotendipes paripes* Edwards. Results of previous studies in marshes indicate that higher numbers of *Coquillettidia* larvae are found in sites with (1) dense stands of emergent vegetation, (2) substrates characterized by a thick layer of detritus, (3) water depths less than 1 m, and (4) dense stands of shoreline vegetation. Production in sites with these characteristics was found to be greater than previously realized. Estimates of *Coquillettidia* production made at the beginning of the study were found to be correct in 20 of the 30 instances. Production potentials that were over- or under-estimated were due primarily to changes in trap locations (due to fluctuating water levels) in which dramatic changes in habitat conditions occurred. It appears that, with only cursory observation, an accurate estimate of a site's potential for mosquito and midge production can be made.

RESUMEN

Se condujo un reconocimiento de 30 lugares en 13 lagos en el Condado de Polk, Florida para: (1) determinar el grado de producción de mosquitos y de moscas de agua en localidades en el lago, (2) definir con más precisión algunos de los factores ambientales que influyen la densidad de los mosquitos y de las moscas de agua, y (3) determinar si la apariencia física de un lugar pudiera facilitar estimadas del potencial de producción de mosquitos y de moscas de agua. Aunque el énfasis de este reconocimiento se le dió a *Coquillettidia perturbans* (Walker), se colectaron datos de los mosquitos *Anopheles*, *Culex*, *Mansonia*, y *Uranotaenia* y la quirinómida mosca de agua *Glytotendipes paripes* Edwards. Resultados de previos estudios en pantanos indicaron que se encontraron altos números de larvas de *Coquilletidia* en lugares con (1) densa emergente vegetación, (2) substratos caracterizados por un capa densa de detritus, (3) profundidad de agua menos de 1 m, y (4) densa vegetación en la orilla. La producción en lugares con estas características fué mayor de lo que previamente se creía. Se encontró que estimados de producción de *Coquillettidia* hechos al principio de este estudio eran correctos en 20 de cada 30 veces. Los potenciales de producción que se sobre-estimaron o bajo-estimaron, fueron debidos principalmente a combios de lugar de las trampas (debido a los combios del nivel del agua) en los cuales ocurrieron cambios dramáticos en las con-

diciones de habitación. Aparentemente, con solo observaciones superficiales se puede hacer un estimado del potencial de producción de mosquitos y de moscas de agua de un lugar.

The marshy conditions in the littoral zones of many central Florida lakes appear conducive to the production of large numbers of mosquitoes and midges (Beck & Beck 1969, Ali 1980, Morris et al. 1985, Callahan & Morris 1987). The nutrient rich waters, thick layers of non-compacted organic matter, and dense stands of aquatic plants with roots loosely penetrating the detrital layers are conditions that many mosquitoes and chironomid midges find attractive (McNeel 1932, Bidlingmayer 1968, Beck & Beck 1969, Guille 1976). Judging from the complaints from residents living adjacent to these lakes, large numbers of pestiferous mosquitoes are periodically produced in these bodies of water. While mosquito production in the lakes may not have as great a potential as that of natural marshes or phosphate mined areas, the 37,665 ha covered by the 550 freshwater lakes in Polk County provide numerous habitats for mosquito larvae. This survey was conducted in an urban area to (1) estimate mosquito and midge production in selected lake sites, (2) define more precisely some of the environmental factors that influence their densities, and (3) determine if the characterization of the physical appearance of a site would enable accurate estimates of the mosquito and midge production potential.

METHODS AND MATERIALS

Thirty sampling sites, ranging in size from 0.1 to 1.4 ha, were selected in 13 lakes with surface areas from 10 to 298 ha. Larval mosquitoes were collected with the wand and pump system (Morris et al. 1985) approximately once every 4 weeks from April 23 to August 23, 1985. Adult mosquitoes and midges were collected with emergence traps (Slaff et al. 1984) from April 9 to November 4, 1985. Trap tops were collected once every 2 weeks. Emergence traps in several lakes were moved farther from shore than originally planned when lack of rainfall caused lake levels to decline.

Results of previous studies in marshes indicated that the better sites for *Coquillettidia perturbans* (Walker) larvae are those that have: (1) water depths less than 1 m, (2) dense stands of shoreline vegetation (Morris & Callahan, unpublished), (3) dense stands of emergent vegetation, and (4) substrates characterized by thick layers of detritus (McNeel 1932, Bidlingmayer 1968, Batzer & Sjogren 1986). At each site, observations were made on the density and height of shoreline vegetation, species and density of the aquatic vegetation, water depth, and bottom type. These observations were made without prolonged or complicated procedures or highly sophisticated sampling devices in an attempt to mimic the methods that are or could be used by typical mosquito inspectors.

Sites with shorelines dominated by shrubs or trees less than 3 m high with little or no understory, pastures, highways, or other exposed areas were classified as "open". Sites with shorelines dominated by woods with trees taller than 3 m and dense understories of herbs, shrubs, and vines were classed as "wooded".

Sampling sites were confined to monocultures or co-dominant stands of aquatic plants (Table 1). Most of the sites contained only cattails (*Typha* spp.). Several sites had cattails mixed with pickerelweed (*Pontederia cordata* Linn.), maidencane (*Panicum hemitomon* Schult.), or water hyacinth (*Eichhornia crassipes* (Mart.) Solms.). The remaining sites contained monocultures of maidencane or sedge (*Carex* spp.) or were a mixture of water hyacinth and sedge. Density of the aquatic plants was recorded as "sparse" when the airboat easily moved through the site and "dense" when the plants tended to impede the boat's progress.

TABLE 1. PHYSICAL ATTRIBUTES AND PREDICTED *COQUILLETTIDIA PERTURBANS* PRODUCTION OF 30 SITES ON 13 POLK COUNTY, FLORIDA LAKES IN APRIL/MAY 1985. (ALL WATER DEPTHS WERE LESS THAN 1 M).

Lake-Site	Site size (ha)	Shore veg.	Site veg.[a] /density	Bottom type	Expected production of *Coq.*
Lk Alfred-NE	0.1	Wooded	CT/Sparse	Sand	Fair
Lk Alfred-SW	0.4	Wooded	CT-PW/Dense	Detritus	Good
Lk Cannon-NW	0.8	Wooded	CT-MC/Dense	Sand/Det	Fair
Lk Hartridge-NE	0.8	Wooded	CT/Dense	Detritus	Good
Lk Hartridge-NW	1.4	Wooded	CT/Sparse	Sand/Det	Fair
Lk Hartridge-S	1.2	Open	CT/Dense	Sand/Det	Fair
Lk Howard-SW	0.8	Wooded	CT/Dense	Det/Muck	Fair
Lk Idylwild-N	0.1	Wooded	CT/Dense	Detritus	Good
Lk Idylwild-SE	0.2	Wooded	CT/Dense	Detritus	Good
Lk Idylwild-SW	0.2	Wooded	CT/Dense	Detritus	Good
Lk Jessie-N	0.6	Wooded	CT/Dense	Muck	Fair
Lk Jessie-SE	0.8	Wooded	MC/Dense	Sand	Fair
Lk Lulu-NW	0.4	Wooded	CT/Sparse	Detritus	Fair
Lk Lulu-SE	0.3	Wooded	CT/Sparse	Muck	Fair
Lk Lulu-SW	0.1	Open	CT/Dense	Muck	Fair
Lk Mariam-ECT	0.3	Wooded	CT/Dense	Detritus	Good
Lk Mariam-EMX	0.3	Wooded	WH-CX/Dense	Detritus	Good
Lk Mariam-N	0.3	Wooded	CX/Dense	Muck	Fair
Lk Mariam-NE	0.3	Wooded	WH-CT/Dense	Detritus	Good
Lk Mariam-SW	0.3	Wooded	CT/Dense	Detritus	Good
Lk Mariam-W	0.3	Open	WH-CX/Dense	Muck/Det	Fair
Lk Marianna-N	1.1	Open	CT/Sparse	Sand/Muck	Fair
Lk Marianna-SE	1.0	Wooded	CT/Sparse	Sand/Det	Fair
Lk Marianna-W	0.2	Wooded	MC/Sparse	Muck	Fair
Lk Mirror-N	0.3	Wooded	CT/Dense	Detritus	Good
Lk Rochelle-NE	0.3	Wooded	CT/Sparse	Sand	Fair
Lk Shipp-S	0.7	Wooded	CT/Dense	Sand	Fair
Lk Spring-E	0.1	Open	CT/Dense	Detritus	Fair
Lk Spring-N	0.1	Wooded	MC-CT/Sparse	Detritus	Fair
Lk Spring-NW	0.1	Wooded	CT/Sparse	Detritus	Fair

[a]CT = cattail, CX = sedge, MC = maidencane, PW = pickerelweed, WH = water hyacinth

Bottom type was determined by using a pole to probe the substrate. Hard, barely impenetrable substrates were labeled "sand", while soft, easily probed deposits were classified as "muck" or "detritus", depending on grab or core samples (APHA 1981) and/or visual observation.

Using the criteria listed above, 1 to 6 sampling sites were selected on each lake in areas judged to have the greatest potential of producing *Coquillettidia*. All sites had water depths less than 1 m. The other 3 habitat characteristics associated with high numbers of *Coquillettidia* larvae (tall, dense shoreline vegetation; dense stands of aquatic vegetation; thick layers of detritus) were used to classify the 30 sites as "expected good" or "expected fair" for potential *Coquillettidia* production (Table 1). Sites with all 3 characteristics were labeled "expected good"; all other sites were classified as "expected fair". Even though a site may have been selected as the best or one of the best available on a particular lake, it still may have received only an "expected fair" rating in terms of *Coquillettidia* production. Since trap locations were changed due to fluctuations in the water levels, site characteristics were re-evaluated at the conclusion of the survey; expected production potentials were not revised.

Although the emphasis in this study was on *Coquillettidia*, data were also collected on the mosquitoes *Anopheles crucians* Wiedemann, *An. quadrimaculatus* Say, *Culex erraticus* (Dyar and Knab), *Cx. pilosus* (Dyar and Knab), *Cx.nigripalpus* Theobald, *Cx. salinarius* Coquillett, *Mansonia titillans* (Walker), *Uranotaenia lowii* Theobald, and *Ur. sapphirina* (Osten Saken) and the chironomid midge *Glyptotendipes paripes* Edwards.

A fungus problem on the emergence trap tops prevented identification to species in many cases. As a result, analyses were performed using mosquito genera instead of individual species. Adult mosquito and midge production is presented as the mean number collected per day per hectare. Data were analyzed on an IBM PC XT using the SPSS/PC+ statistical program (Norusis 1986). The *F*-test was used to determine homogeneity of variance. The Mann-Whitney *U* test and the Kruskal-Wallis one-way analysis of variance were used to determine significant differences in habitat characteristics and in mosquito and midge numbers between the sites. The Pearson product-moment correlation was used to determine relationships between mosquito and midge numbers at the sites (Steele & Torrie 1980, Norusis 1986).

RESULTS AND DISCUSSION

ADULT MOSQUITOES

Over 46% of the adults collected on the emergence trap tops were *Culex* (Table 2). *Uranotaenia* were the next most frequently collected mosquitoes (24.6%); *Anopheles* and *Coquillettidia* were collected in approximately equal numbers (14.2% and 12.9%, respectively), while *Mansonia* were rarely collected (2.1%).

As shown in Table 3, Lake Alfred-SW consistently ranked high for all genera of mosquitoes. Lake Howard-SW was a prime site for *Culex* and all genera except *Coquillettidia*. Lake Mariam-NE and Lake Mariam-SW ranked high for *Coquillettidia* and all genera except *Culex*. The top ranked sites for *Coquillettidia* (Lake Alfred-SW, Lake Mariam-NE, Lake Mariam-SW, and Lake Hartridge-NW) also had high rankings for total mosquitoes (ranks 1, 3, 6, and 4, respectively).

Although *Anopheles*, *Culex*, *Mansonia*, and *Uranotaenia* were found in higher numbers in the wooded sites, their numbers were not much higher than those found in sites adjacent to open shorelines. *Coquillettidia* were the only mosquitoes found in significantly greater numbers in sites adjacent to wooded shorelines. Mosquitoes in general were found in higher numbers in those sites with detritus and/or in those with dense stands of emergent aquatic vegetation.

Only 3 of the 10 sites expected to produce large numbers of *Coquillettidia* actually had a high level of production (Table 3). Of the 7 that were found to be "fair" production sites for *Coquillettidia*, the changes in emergence trap locations appear to have affected production results. At the conclusion of the study, traps in 5 of these 7 sites (Lake Hartridge-NE, Lake Idylwild-N, Lake Idylwild-SE, Lake Idylwild-W, and Lake Mirror-N) had been moved to sand bottom locations. The other 2 traps in Lake Mariam-ECT and Lake Mariam-EMX had been relocated to sparse stands of emergent vegetation.

Seventeen of the 20 sites originally labeled "expected fair" had moderate or poor production of *Coquillettidia* (Table 3). The 3 exceptions were Lake Alfred-NE, Lake Hartridge-NW, and Lake Mariam-N. The emergence trap at the Lake Mariam-N location was moved from a muck bottom to a detrital bottom during the survey. Those at Lake Alfred-NE and Lake Hartridge-NW were moved to locations with more dense emergent vegetation or thicker layers of detritus. These changes appeared to have made these sites more conducive to *Coquillettidia* than originally estimated.

The presence or absence of a thick layer of detritus was found to be a very important factor when considering the production potential of a site for *Coquillettidia*. This impor-

TABLE 2. MEAN NUMBER OF ADULT MOSQUITOES AND MIDGES PRODUCED/DAY/HA BASED ON EMERGENCE TRAP COLLECTIONS AT THE 30 SITES IN 13 POLK COUNTY, FLORIDA LAKES FROM APRIL 9 THROUGH NOVEMBER 4, 1985. SITES ARE GROUPED ACCORDING TO THEIR EXPECTED *COQUILLETTIDIA* PRODUTION POTENTIAL.

	Mosquitoes							
Lake-Site	*Anoph.*	*Culex*	*Mans.*	*Coq.*	*Uran.*	Total	Midges	n
"Expected good" sites								
Lk Alfred-SW	936	2934	437	3246	3371	10925	97232	14
Lk Hartridge-NE	365	61	0	61	0	487	135229	14
Lk Idylwild-N	0	0	0	0	0	0	108904	14
Lk Idylwild-SE	0	118	0	0	0	118	170379	14
Lk Idylwild-SW	317	380	0	0	634	1332	121687	13
Lk Mariam-ECT	365	243	0	61	183	852	83911	14
Lk Mariam-EMX	183	487	0	122	304	1095	38274	14
Lk Mariam-NE	669	183	183	487	669	2191	99185	14
Lk Mariam-SW	1156	122	61	426	365	2130	114397	14
Lk Mirror-N	0	65	0	0	0	65	117049	13
Mean	399	459	68	440	553	1920	108625	14
"Expected fair" sites								
Lk Alfred-NE	0	0	0	163	0	163	83993	11
Lk Cannon-NW	0	0	0	0	0	0	327207	13
Lk Hartridge-NW	426	304	0	243	61	1034	96056	14
Lk Hartridge-S	210	2031	0	0	0	2242	114036	12
Lk Howard-SW	272	10687	0	0	3608	14567	89955	13
Lk Jessie-N	0	348	116	0	348	811	56302	14
Lk Jessie-SE	0	174	0	116	58	348	143536	14
Lk Lulu-NW	127	127	0	0	127	382	153120	14
Lk Lulu-SE	149	0	0	0	74	223	178269	12
Lk Lulu-SW	316	519	0	0	104	935	111030	9
Lk Mariam-N	524	262	0	327	131	1244	78575	14
Lk Mariam-W	327	131	65	65	196	786	89314	14
Lk Marianna-N	122	122	0	61	0	306	106237	14
Lk Marianna-SE	159	317	0	0	79	555	113395	11
Lk Marianna-W	0	0	0	0	0	0	96652	14
Lk Rochelle-NE	121	182	0	61	242	605	153761	14
Lk Shipp-S	0	0	69	0	69	138	160712	13
Lk Spring-E	0	484	0	0	0	484	235939	13
Lk Spring-N	0	0	0	0	0	0	388676	12
Lk Spring-NW	0	0	0	0	0	0	223484	13
Mean	138	784	13	52	255	1241	150012	13

tance has been reported in previous studies by McNeel (1932), Bidlingmayer (1968), Guille (1976), and Batzer & Sjogren (1986) and should have a more dominant role than the aquatic plant species when sites are delineated for study.

LARVAL MOSQUITOES

Only 126 mosquito larvae were collected in the 965 larval samples. Since the numbers were so low, statistical analyses were not performed on this data.

Although the wand and pump system was developed for collecting *Coquillettidia* and *Mansonia* larvae (Morris et al. 1985), over 60% of the larvae (76 larvae) collected

TABLE 3. RANKS DETERMINED BY KRUSKAL-WALLIS ONE-WAY ANALYSIS OF VARIANCE.

	Mosquitoes						
Lake-Site	*Anoph.*	*Culex*	*Mans.*	*Coq.*	*Uran.*	Total	Midges
Lk Alfred-NE	18	20	6	5	18	21	25
Lk Alfred-SW	3	2	1	1	1	1	15
Lk Cannon-NW	18	20	6	11	18	26	2
Lk Hartridge-NE	10	19	6	10	18	16	6
Lk Hartridge-NW	6	4	6	4	17	4	19
Lk Hartridge-S	13	6	6	11	18	12	18
Lk Howard-SW	5	1	6	11	4	2	27
Lk Idylwild-N	18	20	6	11	18	26	12
Lk Idylwild-SE	18	16	6	11	18	22	7
Lk Idylwild-SW	4	5	6	11	12	8	13
Lk Jessie-N	18	7	4	11	7	13	29
Lk Jessie-SE	18	15	6	7	17	18	11
Lk Lulu-NW	17	16	6	11	16	17	10
Lk Lulu-SE	16	20	6	11	13	23	3
Lk Lulu-SW	9	3	6	11	10	7	21
Lk Mariam-ECT	11	10	6	10	9	11	23
Lk Mariam-EMX	14	8	6	9	2	5	30
Lk Mariam-N	7	13	6	6	8	10	26
Lk Mariam-NE	1	11	2	2	5	3	20
Lk Mariam-SW	2	16	5	3	3	6	14
Lk Mariam-W	8	14	3	8	6	9	24
Lk Marianna-N	15	16	6	10	18	19	16
Lk Marianna-SE	12	12	6	11	11	15	22
Lk Marianna-W	18	20	6	11	18	26	28
Lk Mirror-N	18	18	6	11	18	25	17
Lk Rochelle-NE	15	17	6	10	14	14	9
Lk Shipp-S	18	20	3	11	15	24	8
Lk Spring-E	18	9	6	11	18	20	5
Lk Spring-N	18	20	6	11	18	26	1
Lk Spring-NW	18	20	6	11	18	26	4

in this study were *Culex*. Approximately 25% (31) were *Coquillettidia*, 6% (8) were *Anopheles*, 6% (8) were *Mansonia*, and 2% (3) were *Uranotaenia*.

In general, greater numbers of larvae were found at those sites associated with high numbers of adult mosquitoes. Almost one-half of the *Coquillettidia* larvae (14) were collected at Lake Alfred-SW. The Lake Mariam-SW site accounted for 15 of the 31 *Coquillettidia* collected. Most of the *Culex*(51 of the 78 larvae) were collected at Lake Mariam-SW.

Adult Midges

All midges were identified as *Glyptotendipes paripes* Edwards, the predominant nuisance species of chironomid midge in Florida (Beck & Beck 1969, Ali 1980).

At the conclusion of the study, midge numbers were only slightly higher in those sites with open shorelines than in those with wooded shorelines. Patterson (1964, 1965) noted that chironomid midge larvae are found predominantly in the peripheral sandy bottom areas of Florida lakes, many having a larval density of 500 or more per square foot. In this study, midge numbers were also found to be much higher in sites with sand bottoms. Midge numbers were only slightly higher at those sites with sparse stands of emergent vegetation.

The mean number of midges collected from those sites labeled "expected fair" for *Coquillettidia* production was typically much greater than the numbers collected from the "expected good" *Coquillettidia* production sites (Tables 2 and 3). The most productive midge sites, Lake Spring-N and Lake Cannon-NW, were 2 of the 5 sites where no adult mosquitoes of any species were collected, even though the production of *Coquillettidia* in these sites was expected to be moderate.

Those sites with open shorelines, sparse stands of emergent vegetation, and sand bottoms usually had lower mosquito and higher midge production ($r = -0.1005$, $p < 0.01$) (Table 3). Conversely, sites with higher rankings for *Coquillettidia* and total mosquitoes usually had lower numbers of midges. There were only 2 sites (Lake Alfred-NE and Lake Marianna-W) in which both midge and total mosquito production were extremely low.

Conclusion

Results of this survey indicate that lakes are capable of producing large numbers of both man-biting mosquitoes and midges. In inhabited areas where lakes are a dominant part of the topography, this production can significantly increase the extent of the mosquito and midge problems.

Of the 2 sampling methods used in this survey, the emergence trap was more efficient and produced a better estimate of the production in a lake. This is not surprising since the emergence trap samples are continuous while the wand and pump samples are temporal. Emergence traps are inexpensive to construct and operate and provide reliable results over a lengthy period of time. With both mosquitoes and midges, frequent collection of the trap tops provides an accurate picture of the species compositions and densities.

Results of this lake study corroborate those of previous marsh studies (McNeel 1932, Bidlingmayer 1968, Morris & Callahan, unpublished) in which the highest numbers of *Coquillettidia perturbans* were found to be produced at sites (1) less than 1 m deep, (2) where the lake bottom is covered by a thick layer of detritus, (3) with dense stands of emergent aquatic vegetation, and (4) that are adjacent to shorelines dominated by tall, dense vegetation. These conditions are also conducive to the production of larger numbers of other man-biting mosquitoes. This high level of production along the lakeshores probably creates more of the mosquito problem in these areas than previously realized.

Chironomid midges appear to have a wider tolerance to environmental conditions than mosquitoes (Ali 1980), but in this study the numbers were found to be generally higher in sites (1) with predominantly sand bottoms, (2) with sparse stands of aquatic vegetation, and (3) that are adjacent to sparsely vegetated shorelines.

Littoral zones are extremely diverse and it is usually not possible to classify an entire lake as being a "good" or "fair" environment for mosquitoes or midges. However, in the majority of cases, using simple methods to classify aquatic and shoreline vegetation, water depth, and bottom type, it is possible to easily and quickly examine clearly defined sections along lake edges and produce accurate estimates of the mosquito and midge production potential for control purposes.

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SCAPTERISCUS DIDACTYLUS (ORTHOPTERA: GRYLLOTALPIDAE) IN THE DOMINICAN REPUBLIC

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ABSTRACT

Scapteriscus didactylus (Latreille) is reported for the first time from the Dominican Republic, where it is widespread in coastal localities and one inland locality sampled. Materials identified from guts of adults and nymphs from the inland and 4 coastal