SEASONAL CHANGES OF CHIRONOMID POPULATIONS IN A SHALLOW NATURAL LAKE AND IN A MAN-MADE WATER COOLING RESERVOIR IN CENTRAL FLORIDA[1]

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ABSTRACT. Population changes of chironomids in a natural lake and in a man-made cooling reservoir were studied from November 1978 to February 1981. Biweekly collections were made at 20 stations in the lake and 16 in the reservoir. Water temperature and dissolved oxygen were measured at each station. On one occasion, samples of water and sediment were collected from each habitat.

Glyptotendipes paripes, Chironomus crassicaudatus and *C. decorus* predominated among the collected species. *Glyptotendipes paripes* represented 63% and *C. crassicaudatus* 18% of the total collections made in the lake. The monthly compositions ranged from <1 to 97% for the former and <1 to 87% for the latter species. Their density in the lake varied from <100 to 6000/m² and <10 to 1800/m², respectively. Tanypodinae constituted 15% of the total larvae; their density fluctuated between 20 and 500/m² over the study period. In the reservoir, *G. paripes* formed 80% of the total collections with monthly compositions of 40 to 97%, and density ranging from 300 to 8000/m². *Chironomus decorus* composed 16% of the total larvae. Its density fluctuated from 5 to 2000/m².

The spring and summer increases of *G. paripes* demonstrate significant correlations (r=+0.78 lake and +0.72 reservoir) with changes in water temperature. The consistently higher number of *G. paripes* in the reservoir than in the lake may have been due to a higher (3–5°C) water temperature in the reservoir. Significant spatial variations existed in the nitrogen, phosphorus and carbon concentrations in water and substrates in each habitat.

INTRODUCTION

The central portion of peninsular Florida contains hundreds of lakes of various sizes, some of which support dense populations of chironomid larvae. Massive emergence of adult midges from these lakes frequently occur and pose severe nuisance and economic problems for the people working or residing near the midge sources. The problems created by adult chironomids were discussed by Ali (1980).

In the last decade, the City of Sanford, FL, has suffered increased annoyance and economic loss due to these pestiferous insects emerging from adjacent Lake Monroe. According to an economic study[2], an annual loss of 3–4 million dollars for Sanford results from chironomid-related problems. Lake Monroe and a man-made water cooling reservoir are the 2 main sources of midges in this area. Reported here are the seasonal qualitative and quantitative changes of midge populations in the 2 habitats.

MATERIALS AND METHODS

STUDY AREAS:

Lake Monroe. This natural lake covers 4,000 ha of Seminole and Volusia Counties and is ca. 8.5 km long and 6.0 km wide at the widest point (Fig. 1). The St. Johns River enters from the east and flows through the middle of Lake Monroe but the water movement in the lake is hardly noticeable. The City of Sanford borders the south end of the lake. Water in Lake Monroe is turbid and depths range from <1 m around the perimeter to 3.0 m in the central portions. Sedi-

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[1] Florida Agricultural Experiment Stations Journal Series No. 3078.

[2] Economic Impact Statement, 1977, Blind Mosquito (Midge) Task Force, Sanford Chamber of Commerce, Seminole Co., FL. 4 pp.

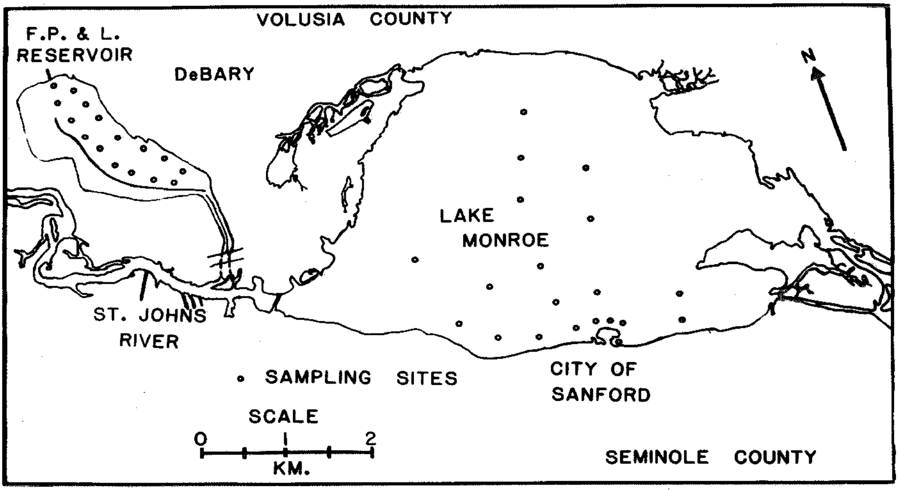

Fig. 1. Location of sampling stations for chironomid larvae in Lake Monroe and Florida Power and Light Company's Reservoir, Seminole and Volusia Counties, FL.

ments consist primarily of mud ooze and fine silt. However, in a few areas, sand is the predominant substrate.

The Reservoir. This water body supplied by the St. Johns River is 450 ha at the surface, 4 km long, 1.25 km wide at the widest point and ca. 3 m deep. It is a closed system with no river water entering or leaving until so desired through lock systems. It receives heated discharge from the Florida Power and Light Company's power plant in the southwest corner of Volusia County and is located about 5–6 km northwest of Sanford (Fig. 1). The narrow end of the reservoir has 2 parallel concrete-lined channels, one receiving the hot water and the other carrying the cooled water to the plant. A narrow concrete road starting at the southeast end extends for 2.5 km into the reservoir and partitions the circling outflow and inflow waters. In the channels and the narrow area of the reservoir, the water currents range up to 0.5 m/sec, but in the wide portion, water movement is very slow. The bottom is covered primarily with decomposing natural vegetation that once inhabited the area and was cut prior to flooding the reservoir. A few patches of sand also exist on the bottom.

SAMPLING. Twenty stations for sampling midge larvae were established in Lake Monroe and 16 in the reservoir (Fig. 1). Each station was marked with a permanent buoy. Biweekly samples of benthic mud were collected from each habitat from November 1978 to February 1981. A minimum of 3 mud samples at each station was collected by using an Ekman dredge (15 × 15 × 30 cm). To separate midge larvae, each sample was processed according to the method of Mulla et al. (1971) and larvae were identified and counted in the laboratory as in Ali et al. (1977). On each sampling date, water temperature and dissolved oxygen were measured at surface and bottom of the water column at each station with a YSI meter (Model 54-A, Yellow Springs Instrument Co., OH).

In August 1979, quantitative water and sediment samples were collected from 16 stations in the lake and 11 in the reservoir for analysis of selected chemical parameters. Three samples of water near the lake bottom were collected at each station with a 2-liter Kemmerer bottle, and 3 samples of substrate were obtained from the 5–6 cm surface layer of sediment by employing a modified Ekman dredge (Mulla et al. 1973). These samples were stored in the freezer until the time of analysis. The water samples were analyzed for pH, electrical conductivity (EC), chemical oxygen demand (COD), ammonium nitrogen (N), organic N, nitrate N, orthophosphorus (P), and total P, by standard procedures (A.P.H.A. 1971). Samples of wet sediments were analyzed for ammonium N, organic N, water soluble P, extractable P and organic carbon (C). The methods used for sediment analyses were the same as adopted and described in Reddy and Graetz (1980).

RESULTS

Midges belonging to the species, *Glyptotendipes paripes* Edwards, *Chironomus crassicaudatus* Malloch, *Chironomus decorus* Johannsen, *Goeldichironomus holoprasinus* (Goeldi), *Cryptochironomus fulvus* Joh., *Polypedilum halterale* (Coq.), *Parachironomus* sp., *Tanytarsus* spp., *Rheotanytarsus* sp., *Coelotanypus concinnus* (Coq.), *Coelotanypus scapularis* (Loew), *Procladius sublettei* Roback and *Cricotopus* spp. were collected. A few other species of minor quantitative importance may also inhabit the study areas.

LAKE MONROE. Larval population trends of *G. paripes* and *C. crassicaudatus* in Lake Monroe from November 1978 to February 1981 are shown in Fig. 2. Population changes of larval tanypodines,

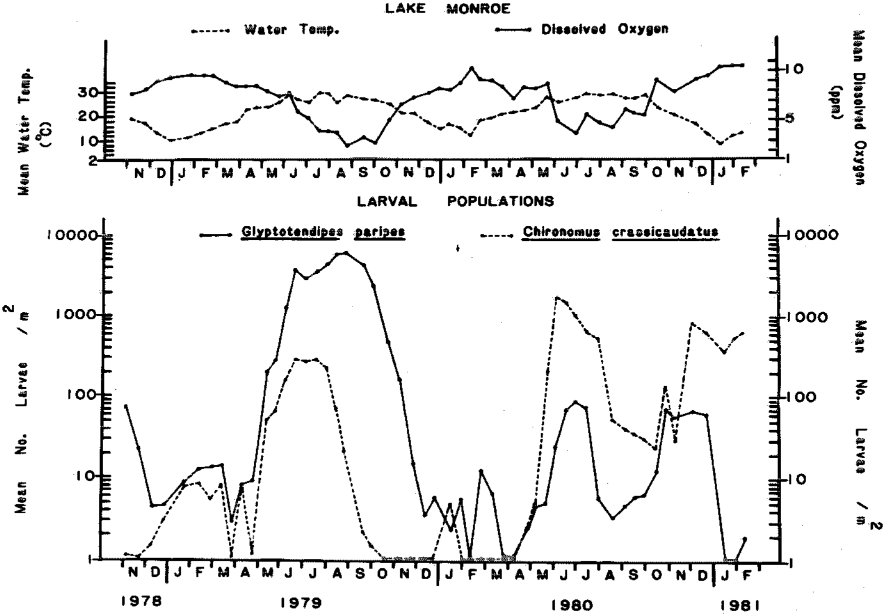

Fig. 2. Larval population trends of *Glyptotendipes paripes* and *Chironomus crassicaudatus* in Lake Monroe, Seminole and Volusia Counties, FL (Nov. 1978–Feb. 1981). The water temperature and dissolved oxygen represent the mean of surface and bottom readings taken at 20 stations and averaged for each sampling date.

other midges and total Chironomidae, during the 28 months of investigation are presented in Fig. 3. The figures also show the temporal changes of dissolved oxygen and water temperature. *Glyptotendipes paripes* and *C. crassicaudatus* were present year-round. The former species formed 63% and the latter 18% of the total collections. *Glyptotendipes paripes* comprised from <1 to 87% of the monthly totals of larvae collected (Fig. 4). Density of *G. paripes* remained $<100/m^2$ from November 1978 to April 1979, but from May to September 1979, it fluctuated between 2000 and $6000/m^2$; however, during the same period of 1980, density of *G. paripes* remained $<100/m^2$. The density of *C. crassicaudatus* was $<10/m^2$ from November 1978 to April 1979, but in May–July 1979, it reached up to $300/m^2$ and declined gradually to negligible numbers during the winter months. In Lake Monroe, *G. paripes* outnumbered *C. crassicaudatus* from November 1978 to April 1980; however, from May 1980 to February 1981, *C. crassicaudatus* predominated (Fig. 2).

Populations of tanypodines (mostly *C. concinnus* and *P. freemani*) in Lake Monroe varied from 20 to $500/m^2$ and constituted 15% of the total midge larvae collected in 28 months. The monthly compositions ranged from 2 to 94% (Fig. 4). The tanypodines predominated usually during the winter period when *G. paripes* and *C. crassicaudatus* declined. The lowest numbers of tanypodines occurred during fall. The density of other Chironomidae (predominantly *C. fulvus* and *P. halterale*) remained $<100/m^2$ through most of the

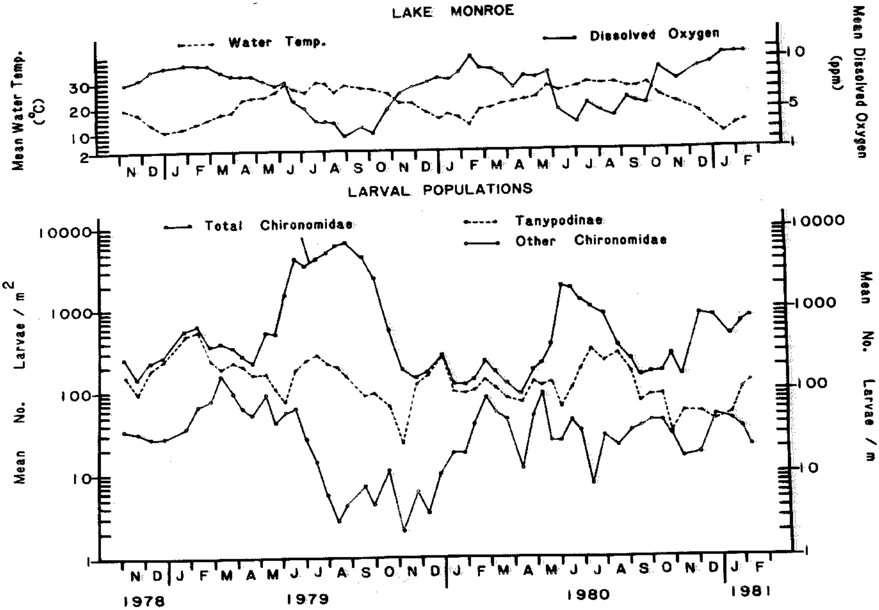

Fig. 3. Larval population trends of Tanypodinae, unidentified Chironomidae, and total Chironomidae in Lake Monroe, Seminole and Volusia Counties, FL (Nov. 1978–Feb. 1981). The water temperature and dissolved oxygen represent the mean of surface and bottom readings taken at 20 stations and averaged for each sampling date.

study period. They constituted 4% of the total midges and <1 to 37% of the monthly totals. Overall, the density of total chironomids remained $>100/m^2$ throughout the observation period and reached up to $7000/m^2$. Highest densities usually prevailed during summer. However, in the winter of 1980–81, large numbers of *C. crassicaudatus* had occupied the lake.

The chemical characteristics of the lake water and sediments shown in Table 1 indicate an appreciable spatial variation of some parameters. The variation of COD of the water ranged from 1.0–118.5 µg/ml among stations. The levels of ortho-P concentration in water were high (range of 0.11–0.38 µg/ml), indicating the eutrophic status of the lake. In the sediment, much wider range of N, P and C concentration was observed among stations. Sediments with high C content rep-

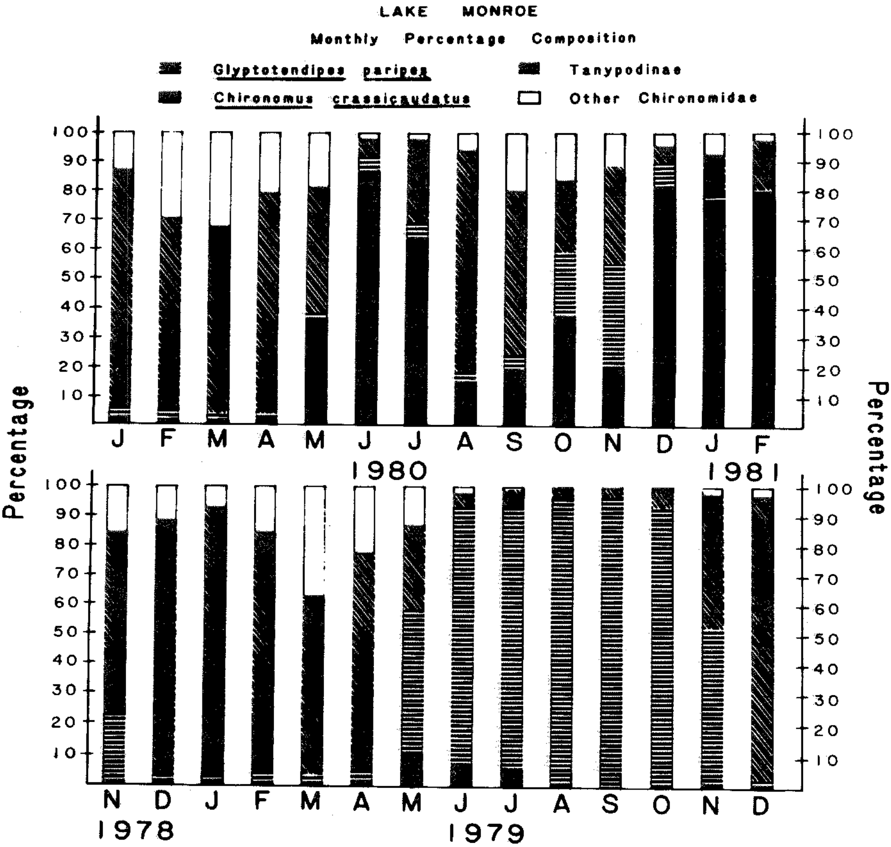

Fig. 4. Monthly percentage composition of chironomid larvae in Lake Monroe, Seminole and Volusia Counties, FL (Nov. 1978–Feb. 1981).

Table 1. Selected chemical parameters of water and sediment in Lake Monroe and Florida Power and Light Company's Cooling Reservoir, Seminole and Volusia Co., FL (August 1979).

	Lake Monroe				Florida Power and Light Co. Reservoir			
	Range	Mean			Range	Mean		
Parameter	μg/ml		n	CV(%)	μg/ml		n	CV(%)
				Water				
Ammonium N	0.06—0.10	0.08	48	13	0.03—0.26	0.12	32	61
Nitrate N	0.17—0.40	0.25	48	22	0.05—0.08	0.06	32	15
Organic N	0.56—2.74	1.09	48	44	0.05—6.51	1.47	30	105
Ortho-P	0.11—0.38	0.16	48	32	0.001—0.020	0.002	32	251
Total P	0.13—0.42	0.19	48	24	0.001—0.090	0.05	32	34
COD	1.00—118.50	19.40	48	123	1.00—37.00	16.19	32	70
pH	6.30—7.30	6.90	48	4	7.20—8.10	7.80	32	3
EC (μmhos/cm)	930.00—1050.00	969.00	48	3	3120.00—3300.00	3220.00	32	2
				Sediment				
Ammonium N (μg/g)	39.00—590.00	250.00	48	66	29.00—615.0	247.00	32	71
Organic N (%)	0.10—2.03	1.01	48	50	0.01—2.83	1.57	31	78
Water soluble P (μg/g)	0.12—3.60	1.09	46	77	0.37—7.50	2.39	32	77
Extractable P (μg/g)	11.00—124.00	66.40	48	46	8.00—51.00	28.60	32	43
Organic C (%)	0.26—17.85	9.96	47	39	0.19—25.80	12.50	32	77

N = Nitrogen; P = Phosphorus; COD = Chemical oxygen demand; pH = Hydrogen ion concentration; EC = Electrical conductivity; C = Carbon.

resent more intense anaerobic conditions compared to the sediments with low carbon.

THE RESERVOIR. Population changes of *G. paripes* and *C. decorus* in the reservoir are shown in Fig. 5 along with the changes of dissolved oxygen and water temperature. The density of tanypodines, other midge species, and overall total Chironomidae is presented in Fig. 6. *Glyptotendipes paripes* was by far the most abundant species collected in the reservoir and formed 80% of the total collections with monthly composition varying from 40 to 97%. *Chironomus decorus* composed 16% of the total midge larvae and fluctuated from <1 to 49% in the monthly collections (Fig. 7). The density of *G. paripes* varied from 300 to 8000/m^2 and that of *C. decorus* from 5 to 2000/m^2. High densities (>1000/m^2) of *G. paripes* were encountered through most of the sampling period. It exceeded 2000/m^2 from June to November but gradually declined during winter. By contrast, *C. decorus* attained maximum densities during winter and spring and declined during summer and autumn. The Tanypodinae and other midge species generally did not exceed 300/m^2. Each of these 2 groups formed only 2% of the total chironomids collected. The monthly composition range of the tanypodines was <1–10% while the same range for other less common species was <1–6%. The density of total chironomids consistently exceeded 1000/m^2 during the study period (except for January–February 1981)

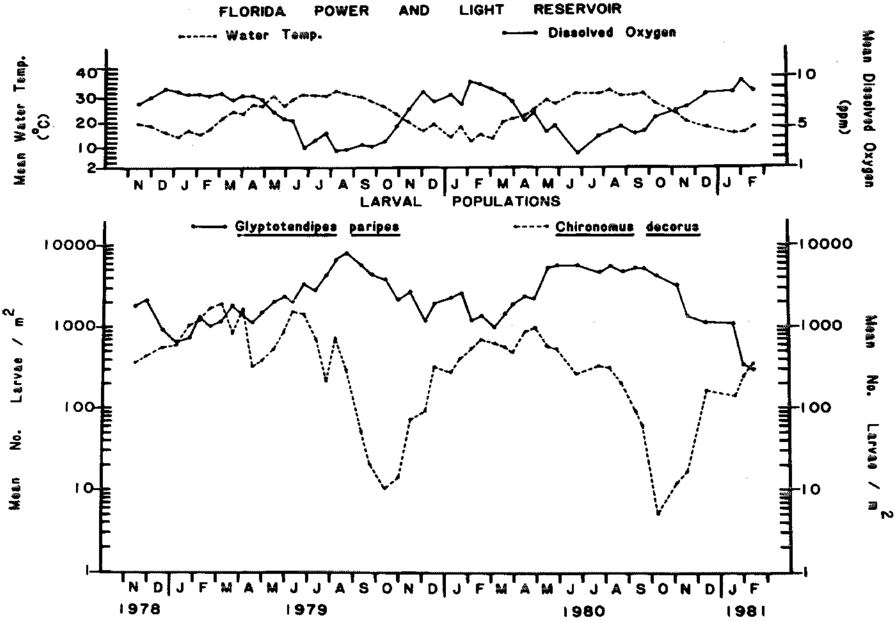

Fig. 5. Larval population trends of *Glyptotendipes paripes* and *Chironomus decorus* in Florida Power and Light Company's Reservoir, DeBary, Volusia County, FL (Nov. 1978–Feb. 1981). The water temperature and dissolved oxygen represent the mean of surface and bottom readings taken at 16 stations and averaged for each sampling date.

with populations prevailing at 4000 to 8000/m² during spring and summer.

The chemical parameters of water showed remarkable variations in N and P concentrations in different parts of the reservoir (Table 1). The ortho-P concentration in water was low and ranged from 0.001–0.02 μg/ml among stations. Spatial variations of sediment N, P and C were similar to Lake Monroe sediments.

DISCUSSION

Glyptotendipes paripes was common in both habitats, but *C. crassicaudatus* was common in the lake and occurred in negligible numbers in the reservoir. A similar difference was noted for *C. decorus* which was abundant in the reservoir but rarely occurred in the lake. *Glyptotendipes paripes, C. crassicaudatus* and *C. decorus* were quantitatively important in the 2 habitats. These species pose pest problems in the Sanford area from April to November each year. Although no qualitative differences were noted between the species composition in the 2 habitats, it is evident that the reservoir supported denser populations of total chironomids than the lake, especially *G. paripes.*

Among the intrinsic and extrinsic factors affecting seasonal changes of aquatic insect populations, temperature is regarded as the most obvious, affecting seasonal cycles and abundance of some aquatic insects including chironomids (Ali et al. 1977, Elliott 1967). The spring and summer increases of *G. paripes* in the lake showed significant correlation (r=+0.78) with the higher water temperatures dur-

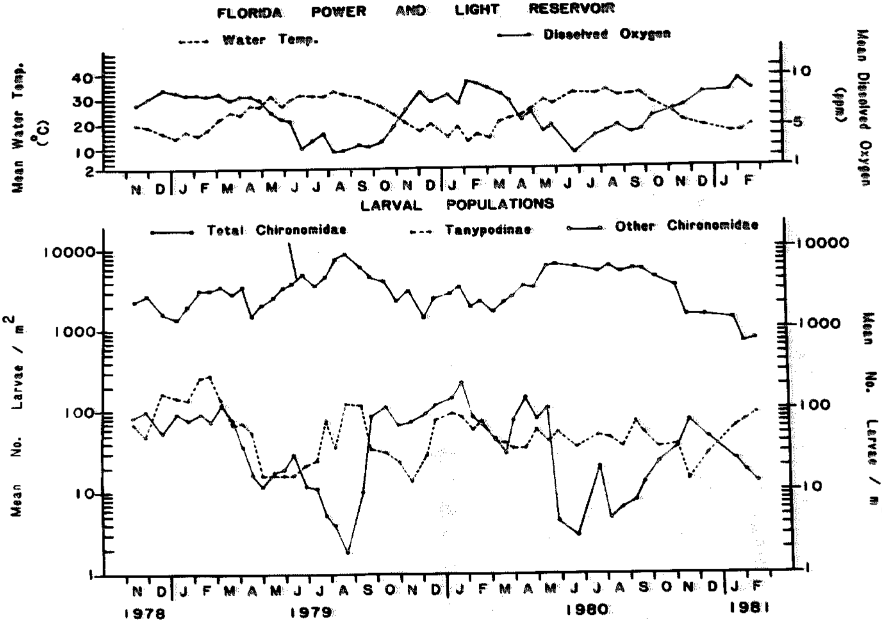

Fig. 6. Larval population trends of Tanypodinae, unidentified Chironomidae, and total Chironomidae in Florida Power and Light Company's Reservoir, DeBary, Volusia County, FL (Nov. 1978–Feb. 1981). The water temperature and dissolved oxygen represent the mean of surface and bottom readings taken at 16 stations and averaged for each sampling date.

ing these seasons. There was a similar positive correlation (r=+0.72) between density of *G. paripes* and water temperature in the reservoir. As expected, the levels of dissolved oxygen in both habitats declined with increasing water temperatures during spring and summer.

The higher densities of midges prevailing in the reservoir could be attributed to the 3–5°C higher monthly water temperatures in the reservoir. The warmer water would be favorable for a more rapid growth of midges and may indicate that the reservoir produces many more generations of a midge species than the lake. A number of other factors, such as the seasonal availability of phytoplankton and zooplankton (midge food), the nature and intensity of local oviposition, presence or absence of natural

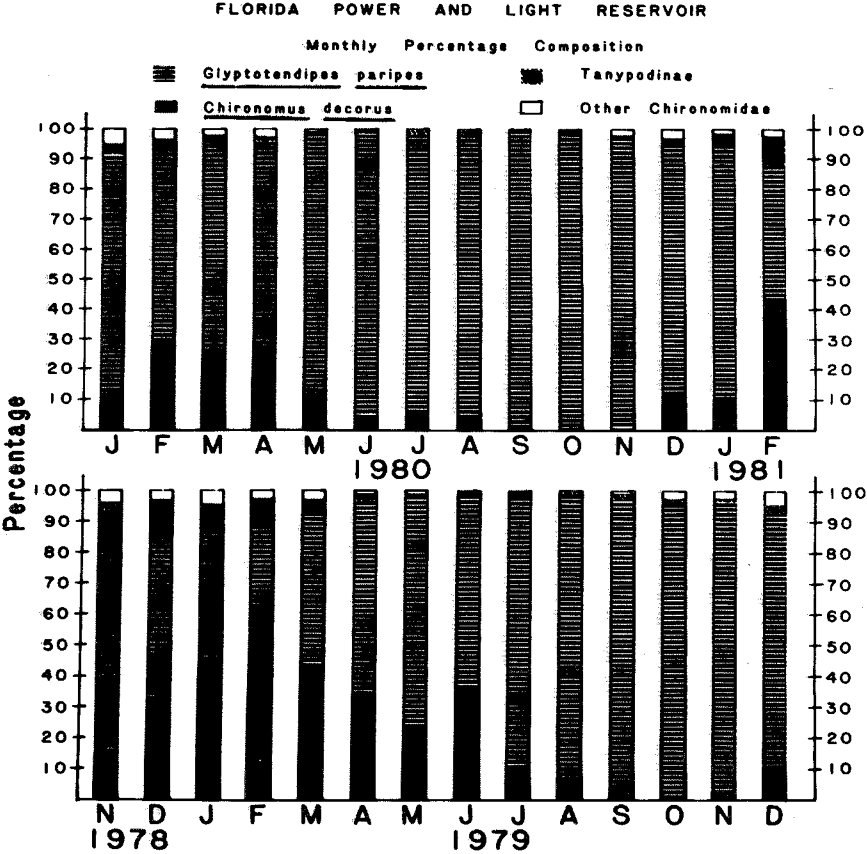

Fig. 7. Monthly percentage composition of chironomid larvae in Florida Power and Light Company's Reservoir, DeBary, Volusia County, FL (Nov. 1978–Feb. 1981).

enemies, abundance and competition for food and space, and the prevailing favorable or unfavorable chemical conditions may also influence the spatial and seasonal quantitative differences of midges in the 2 habitats. These biological and chemical parameters were not studied routinely.

A comparison of selected chemical parameters of the lake water and sediments with that of the reservoir (Table 1) indicates differences of some parameters, such as the levels of total P in water and extractable P in sediments, the EC, and other parameters. However, it is not known at present as to which of these parameters and at what levels are conducive or nonconducive to midge production. A preliminary study by Ali and Reddy (unpublished) in Lake Monroe and the reservoir has indicated an inverse relationship between C content in the sediments and benthic midge density. Sediments rich in C, generally, have high microbial activity, resulting in accumulation of toxic organic acids and increased levels of ammonium N and ortho-P (Ponnamperuma 1972). The high concentrations of these nutrients can possibly inhibit population growth of midge larvae. Elaborate laboratory and field studies on the biological and chemical nutrient relationships with the pest species of midges are presently being conducted to understand this aspect of chironomid ecology for the eventual development of midge control strategies.

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