QUALITATIVE AND QUANTITATIVE STUDIES ON CHIRONOMIDAE (DIPTERA) AND SELECTED PHYSICO-CHEMICAL PARAMETERS IN TWO TRIBUTARIES OF THE WEKIVA RIVER, CENTRAL FLORIDA

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ABSTRACT

Aquatic midge (Chironomidae: Diptera) larval densities, 24-h adult emergence, and larval and adult dry biomass were estimated monthly for two years in two tributaries of the Wekiva River, central Florida, along with selected physico-chemical water parameters. Twenty-four genera of midges were identified in Blackwater Creek and 26 in Rock Springs Run, with subfamily Chironominae dominating the midge fauna. Larval densities in the former stream ranged from 56 to 757 per m^2, with 24-h periods adult emergence ranging from 0 to 95 per m^2. The latter stream supported 138 to 1277 larvae per m^2 with 0 to 68 emergent adults per m^2 taken during 24-h periods. Mean larval biomass in Rock Springs Run (42 mg per m^2) was significantly ($P<0.05$) higher than in Blackwater Creek (27 mg per m^2), while mean adult biomass in both habitats was essentially identical (1.1 mg per m^2). Annual midge productivity estimates (1.12 g dry wt per m^2) in each stream indicated that both were oligotrophic. Water volume was the overriding abiotic factor noted in both habitats, influencing many of the observed water parameters and altering the midge generic composition, especially in Blackwater Creek.

Key Words: Chironomidae, midges, populations, productivity, seasonal changes, streams, physico-chemical parameters

RESUMEN

Las densidades larvales de moscas de agua (Chironomidae: Diptera), la emergencia de adultos en 24 horas, y la biomasa larval y de adultos, así como parámetros físico-químicos de agua seleccionados, fueron determinados mensualmente durante dos años en dos tributarios del río Wekiva, en Florida Central. Fueron identificados 24 géneros de moscas de agua en el arroyo Blackwater y 26 en Rock Springs Run, con la subfamilia Chironominae dominando la fauna de moscas de agua. Las densidades larvales en la primera corriente estuvieron en el rango de 56-757 por m^2, con adultos emergidos en 24 h en el rango de 0-65 por m^2. La última corriente tuvo 138-1277 larvas por m^2 con 0-68 adultos emergentes por m^2 tomados durante períodos de 24 h. La biomasa media larval en Rock Springs Run (42 mg por m^2) fue significativamente ($P<0.05$) más alta que en el arroyo Blackwater (27 mg por m^2), mientras que la biomasa de adultos en ambos habitats fue esencialmente idéntica (1.1 mg por m^2). Los estimados de producción anual (1.12 g de peso seco por m^2) en cada corriente indicaron que ambas fueron oligotróficas. El volumen de agua fue el factor abiótico más importante encontrado en ambos habitats, inluenciando muchos de los parámetros de agua observados y alterando la composición genérica de las moscas de agua, especialmente en el arroyo Blackwater.

In inland aquatic ecosystems, Chironomidae (Diptera) often are among the dominant macroinvertebrates and one of the most important components of aquatic food chains (Tokeshi 1995a). This is particularly true for Florida, where almost 25% of the state's land is covered with swamps (Ewel 1990), marshes (Kushlan 1990), lakes (Brenner *et al*. 1990) or streams (Nordlie 1990). Although chironomid midges are regarded as important organisms in all of these ecosystems, very little information on their quantitative or qualitative composition is presently available, and this is specifically true for lotic systems.

The present investigation was undertaken in two tributaries of the Wekiva River, central Florida. Qualitative and quantitative samples of midge larvae and emergent adults were collected monthly from each stream for two years to assess the midge larval and adult densities and productivity. Selected physico-chemical parameters in both habitats were also measured to elucidate their influence on the midge populations.

METHODS AND MATERIALS

The study streams were in the Wekiva River basin (a part of the St. Johns River basin) in central Florida (Fig. 1). Blackwater Creek is about 40 km long second order sand bottom stream with both calcareous and swamp-bog stream aspects (Beck 1965). Rock Springs Run is a first order calcareous stream (Beck 1965) about 14.5 km long. Water current in both streams varied from 2-50 cm per sec; local variation in current velocity resulted in substrates which varied from exposed sand to thick deposits of detritus and silt.

For sampling chironomid larvae and adults and for measuring selected physico-chemical parameters, 10 sampling stations were selected in each stream. The exact locations of the sampling stations were determined by coordinates using a Panasonic model LX-G5500 Global Positioning System receiver (Panasonic Company, Secaucus, NJ).

Each stream was sampled (for 2 days) monthly from February 1993 to January 1995. Each sample series was collected between 0830 and 1230 local time. On day 1,

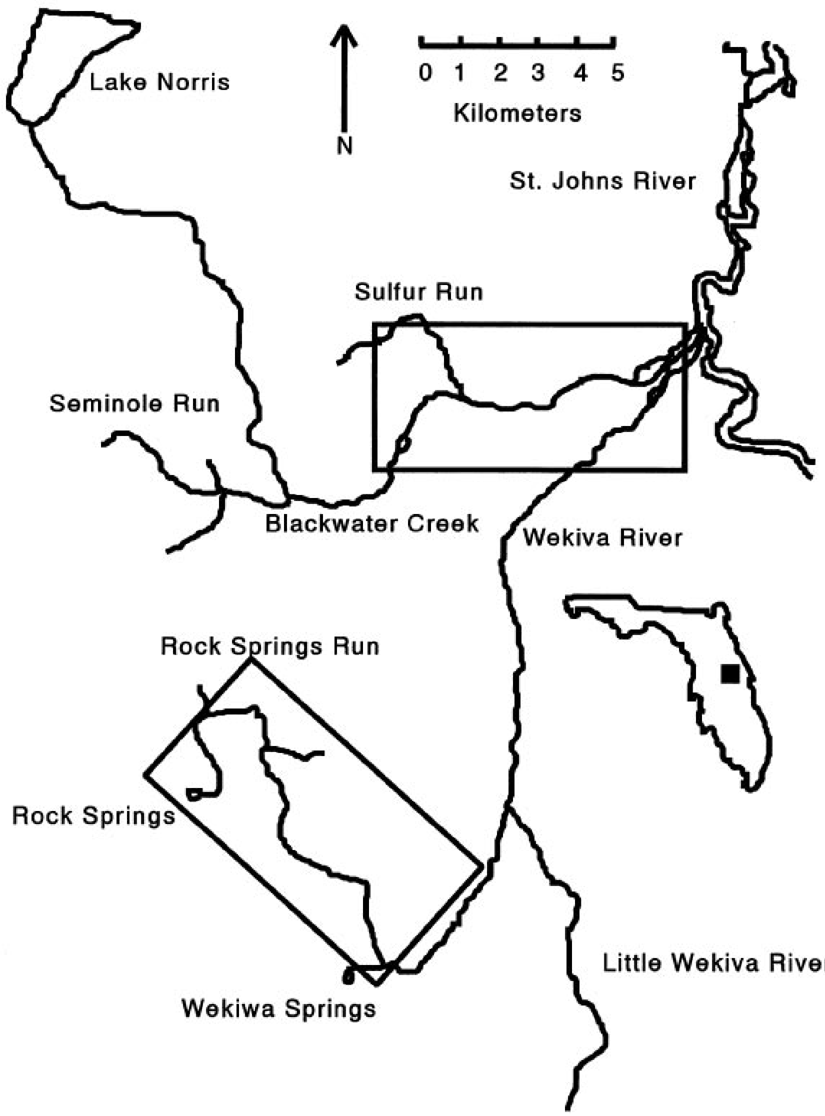

Fig. 1. Map of the Wekiva River Basin, central Florida, with Blackwater Creek and Rock Springs Run study areas marked by boxes. Relative location of area map is shown on outline map of Florida.

a 0.25 m^2 emergence cone trap (Ali 1996) was randomly placed on the stream bottom at each location. Also, selected physical and chemical parameters were measured *in situ* close to the sediment/water interface at or very near each sampling station with portable meters or appropriate field kits. The parameters included: current velocity

(Model 2030R mechanical flowmeter, General Oceanics Company, Miami, FL), pH (Model 107 pH meter, Corning Glass Works, Corning, NY), dissolved oxygen (Model 54A dissolved oxygen meter, Yellow Springs Instrument Company Inc., Yellow Springs, OH), turbidity (Model DRT 1000 nephelometer, HF Instruments, Bolton, Ontario or a Mini 20 portable spectrophotometer fitted with a nephelometer module, Milton Roy Company, Rochester, NY), nitrate-N (Model NCR kit, LaMotte Company, Chestertown, MD), conductivity and water temperature (Model 140 conductivity-temperature-salinity meter, Orion Research Inc., Boston, MA). Secchi disk transparency was measured with a 20 cm Secchi disk connected to a vertical steel rod. For statistical analysis, pH was converted to H^+ concentration.

On day 2 of monthly samplings, chironomid larval and adult samples were collected. One benthic sample was collected from each station at about 1 m or less upstream of the cone sample area with a 15 × 15 × 15 cm Ekman dredge mounted on a 1.5 m steel pole (APHA 1992). Benthic samples were immediately washed through a 350 µm pore screen and stored on ice until returned to the laboratory. Adult samples were collected from the cone traps using the procedure of Mulla *et al.* (1974).

All benthic and adult samples were examined for Chironomidae and analyzed within 48 h using standard methods, (APHA 1992, Ali *et al.* 1977). Midge larvae were identified (under 40-400× magnification) to genus using the keys of Epler (1992), while the adults were examined under 40× magnification to determine their subfamily or tribe using the keys provided by Weiderholm (1989). Time constraints and damage to specimens during drying for biomass determination purposes prevented further identification of adults. Larval as well as adult dry biomasses were determined using the method of Dermott & Paterson (1974).

Rainfall data (30-day cumulative) provided by the Florida Department of Environmental Protection, Division of Recreation and Parks for Wekiwa Springs State Park (1800 Wekiwa Circle, Apopka, FL) were used to estimate water inputs to Rock Springs Run. Water volume for Blackwater Creek was estimated from 30-day mean water elevation data provided by the United States Geologic Survey, Water Resources Division (224 W. Central Parkway, Altamonte Springs, FL) from gauging station 02235200.

Productivity of midges was estimated using the formula of Iwakuma (1986).

Statistical analysis of collected data and their graphical presentation was made by utilizing Instat V. 2.04 (Graphpad Software, Inc., San Diego, CA) and SlideWrite Plus V. 6.0 (Advanced Graphics Software, Inc., Carlsbad, CA).

RESULTS

Larvae of 24 chironomid genera belonging to subfamilies Chironominae (tribes Chironomini and Tanytarsini), Tanypodinae and Orthocladiinae were identified in Blackwater Creek whereas 26 genera occurred in Rock Springs Run (Table 1). Trends of monthly mean midge larval densities, emergent adults and dry biomass for both streams are shown in Fig. 2. Midge larval density in Blackwater Creek ranged from 56 to 757 per m^2 and emergent adults from 0 to 95 per m^2: Rock Springs Run from 138 to 1277 per m^2 (larvae) and from 0 to 68 per m^2 (adults). Midge dry biomass in Blackwater Creek varied from 0.9 to 88.8 mg per m^2 (larvae) and 0.0 to 2.5 mg per m^2 (adults) and in Rock Springs Run from 13.3 to 114.4 mg per m^2 (larvae) and 0.0 to 2.6 mg per m^2 (adults).

Members of the tribe Chironomini were the most abundant midges, comprising 47.0% of total midge larvae (n=1926) during the study period in Blackwater Creek (BC) and 55.8% of the total (n=2473) in Rock Springs Run (RSR). This was followed

TABLE 1. LIST OF CHIRONOMID LARVAL GENERA AND PERCENT COMPOSITION OCCURRING IN BLACKWATER CREEK AND ROCK SPRINGS RUN, CENTRAL FLORIDA (FEBRUARY 1993 TO JANUARY 1995).

Blackwater Creek Taxon	Percent	Rock Springs Run Taxon	Percent
Chironomini	47.0	**Chironomini**	55.8
Chironomus	2.0	*Apedilum*	0.2
Cryptochironomus	1.7	*Chironomus*	0.7
Cryptotendipes	3.8	*Cryptochironomus*	9.1
Demicryptochironomus	0.6	*Cryptotendipes*	0.7
Dicrotendipes	0.6	*Demicryptochironomus*	0.7
Fissimentum	15.1	*Dicrotendipes*	0.5
Paracladopelma	0.9	*Fissimentum*	2.5
Paralauterborniella	2.6	*Microtendipes*	0.2
Phaenopsectra	5.5	*Paracladopelma*	1.6
Polypedilum	11.9	*Paralauterborniella*	3.1
Pseudochironomus	1.2	*Phaenopsectra*	0.5
Stenochironomus	0.6	*Polypedilum*	21.4
Stictochironomus	0.6	*Pseudochironomus*	13.4
Tanytarsini	33.6	*Stelechomyia*	0.2
Cladotanytarsus	2.9	*Stenochironomus*	0.9
Paratanytarsus	0.9	**Tanytarsini**	31.6
Tanytarsus	29.7	*Cladotanytarsus*	16.4
Tanypodinae	15.4	*Paratanytarsus*	1.5
Ablabesmyia	5.2	*Tanytarsus*	13.7
Clinotanypus	5.8	**Tanypodinae**	8.1
Paramerina	2.0	*Ablabesmyia*	2.8
Procladius	1.7	*Clinotanypus*	1.1
Tanypus	0.6	*Paramerina*	1.8
Orthocladiinae	4.0	*Procladius*	2.2
Cricotopus-Orthocladius	2.3	*Tanypus*	0.2
Epoicacladius	1.4	**Orthocladiinae**	4.5
Thienemanniella	0.3	*Cricotopus-Orthocladius*	2.7
		Epoicacladius	1.6
		Thienemanniella	0.2

by Tanytarsini (33.6% BC and 31.6% RSR), Tanypodinae (15.4% BC and 8.1% RSR) and Orthocladiinae (4.0% BC and 4.5% RSR). *Tanytarsus* van der Wulp was the most common genus (29.7% of total larvae) in Blackwater Creek, followed by *Fissimentum* Cranston & Nolte (15%) and *Polypedilum* Kieffer (11.9%). *Fissimentum* was recently described by Cranston & Nolte (1996) from the previously described larval taxon, Chironomini Genus A Roback. In Rock Springs Run, *Polypedilum* was the most common midge (21.4% of total midges), followed by *Cladotanytarsus* Kieffer (16.4%), *Tanytarsus* (13.7%), and *Pseudochironomus* Malloch (13.4%).

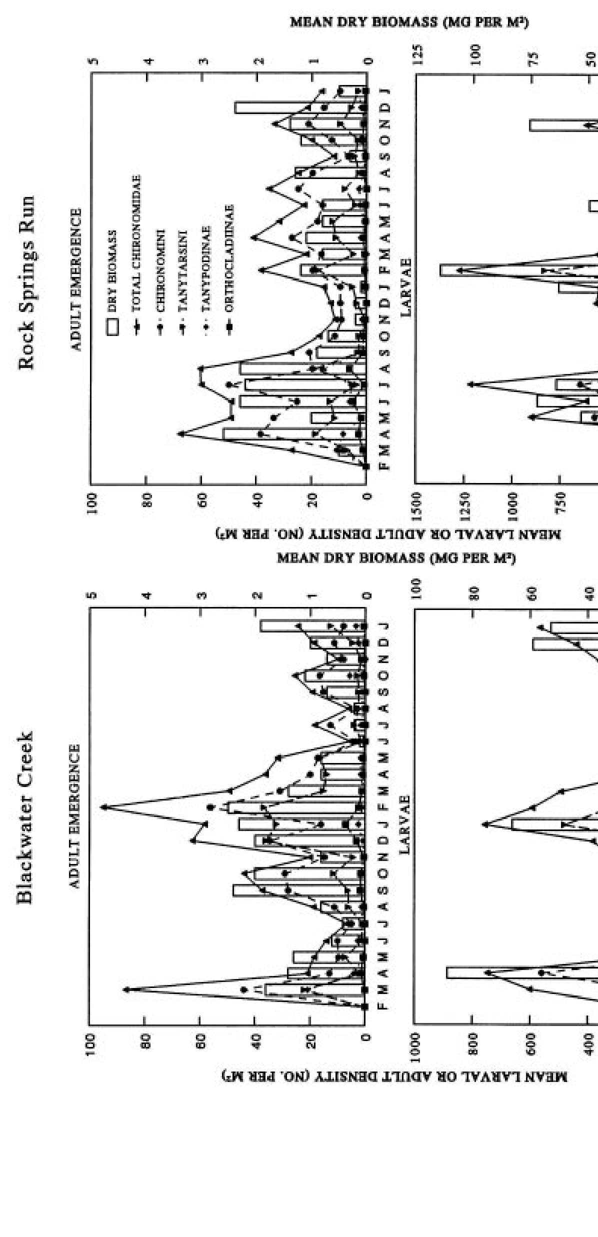

Fig. 2. Mean monthly density and dry biomass trends for larval and adult chironomids in Blackwater Creek and Rock Springs Run, central Florida (February 1993 to January 1995).

ANOVA of chironomid subfamily or tribe abundance with the Friedman nonparametric repeated measures test found significant ($P<0.0001$) differences in Blackwater Creek (Fr=49.19) and Rock Springs Run (Fr=57.96). Based on Dunn's Multiple Comparison as the post test, Chironomini were significantly ($P<0.001$) more numerous than all other higher taxa and Tanytarsini were significantly ($P<0.001$) more numerous than Orthocladiinae in both streams. Rock Springs Run supported a significantly ($P<0.05$) greater mean larval dry biomass (Student's *t*-test, $t=2.13$, $n=21$).

Among emergent adults, Chironomini were the most common, comprising 56.3% and 61.3% of total for Blackwater Creek ($n=1866$) and Rock Springs Run ($n=1812$), respectively. This was followed by Tanytarsini (32.8% BC and 24.2% RSR), Tanypodinae (7.7% BC and 10.3% RSR), and Orthocladiinae (3.2% BC and 4.3% RSR). Significant ($P<0.001$) differences were found in abundance among higher taxa in Blackwater Creek (Fr=56.57) and Rock Springs Run (Fr=53.15) using the Friedman repeated measures test. Post tests revealed densities of Chironomini and Tanytarsini significantly ($P<0.001$) higher than Orthocladiinae in both streams, Tanytarsini higher ($P<0.05$) than Tanypodinae in Rock Springs Run and Tanypodinae higher ($P<0.05$) than Orthocladiinae in Blackwater Creek.

Trends of selected physico-chemical water parameters in both habitats are shown in Fig. 3. Water volume in both streams significantly influenced some parameters, as indicated by inverse correlations (Pearson *r*) with dissolved oxygen, nitrate-N, and pH in both streams. Water elevation was inversely correlated with conductivity and Secchi disk transparency in Blackwater Creek, and rainfall was correlated with turbidity in Rock Springs Run (Table 2).

Mean midge larval density and dry biomass were analyzed by linear correlation (Pearson *r*) against monthly mean physico-chemical parameters. Chironomini in both streams were significantly ($P<0.05$) correlated with current, with pH in Rock Springs Run and inversely correlated with temperature in Blackwater Creek (Table 3). Tanytarsini were inversely correlated with temperature in Blackwater Creek. Tanypodinae were inversely correlated with current in both streams, as well as conductivity and nitrate-N in Blackwater Creek and correlated with water elevation in Blackwater Creek. Orthocladiinae were correlated with pH in both streams and inversely correlated with water elevation in Blackwater Creek. Mean total larval density and larval biomass were inversely correlated with temperature in Blackwater Creek.

For both streams the Iwakuma (1986) formula gave an overall mean chironomid productivity value of 1.1±0.8 g dry wt per m^2 per year. The P/B ratios of midges in Blackwater Creek and Rock Springs Run were 40.7 and 26.2, respectively.

Discussion

Based on the criteria of Tokeshi (1995b), the study streams were considered oligotrophic because of their low (1.1 g per m^2) annual chironomid productivity. The recorded water nitrate-N levels, generally in the oligotrophic-mesotrophic range (Wetzel 1983), and low recorded conductivity values further support this classification. This is in agreement with the findings of Duarte & Canfield (1990) for Rock Springs Run. The high seasonal and geographic variability found in the midge larval and adult data can be attributed to a number of sources. Microhabitat differences, random disturbances, seasonal changes and resource partitioning all contribute to very heterogenous distributions of midge populations (Rae 1985, Schmid 1993, Ruse 1994). Sampling deficiencies, such as possible larval loss due to washing, as well as the limited sample size and number may have contributed to the variability. To date, no definite means are available to accurately estimate benthic chironomid larval density (Tokeshi 1995c).

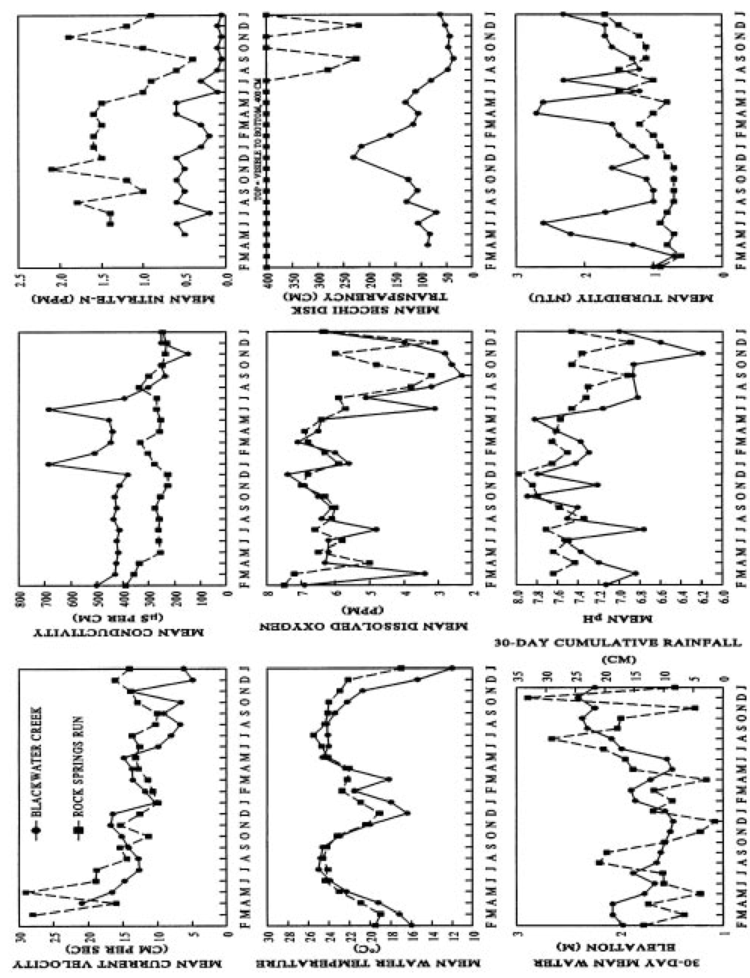

Fig. 3. Trends of selected monthly mean physico-chemical water parameters for Blackwater Creek and Rock Springs Run, central Florida (February 1993 to January 1995).

TABLE 2. MATRIX OF SIGNIFICANT (P<0.05) PEARSON R CORRELATION COEFFICIENTS OF 30-DAY MEAN WATER ELEVATION (FOR BLACKWATER CREEK) AND 30-DAY CUMULATIVE RAINFALL (FOR ROCK SPRINGS RUN) WITH SELECTED PHYSICO-CHEMICAL WATER PARAMETERS FOR BLACKWATER CREEK AND ROCK SPRINGS RUN, CENTRAL FLORIDA (FEBRUARY 1993 TO JANUARY 1995).

Parameter	Water Elevation Blackwater Creek	Cumulative Rainfall Rock Springs Run
Dissolved Oxygen	-0.609	-0.723
Specific Conductivity	-0.706	ns
Nitrate-N	-0.789	-0.559
pH	-0.794	-0.721
Secchi Disk Transparency	-0.773	ns
Turbidity	ns	0.407

ns=Not significant (P>0.05)

Soponis (1980) reported 42 chironomid genera identified from pupal exuviae in Turkey Creek, a first order spring run in north Florida (Gadsden County) and Mattson *et al*. (1995) reported 68 from the Suwannee River basin in north central Florida. The 24-26 midge genera found in the present study are considerably less than the number reported for parts of north Florida, but greater than the 10 genera reported by Cowell & Carew (1976) in a tributary of the Hillsborough River south of the study area in west central Florida. While smaller numbers of genera may be expected in a smaller sample area, the peninsula effect may also influence the faunal diversity of these study streams (Webb 1990). Nevertheless, the generic paucity in the study streams is compatible with the 26 chironomid genera found by Ferrington *et al.* (1993) in a second-order rainforest stream in El Verde, Puerto Rico.

Chironomid populations at middle latitudes show a direct correlation with water temperature (Pinder 1995) as also noted in Rock Springs Run. The inverse relationship of chironomids with water temperature in Blackwater Creek is unusual but not unprecedented. Ferrington *et al*. (1993) reported a similar response with chironomid emergence in Puerto Rico. Beck (1977) reported that species of several chironomid genera (also found in the present study) have winter emergence in the southeastern United States.

Water volume appeared to be the dominant abiotic factor influencing midge populations during the study period, especially in Blackwater Creek. Changes in water volume significantly altered the physico-chemical conditions of the streams (probably by dilution), consequently influencing midge populations.

The abundance of Chironomini in faster currents in both streams was anticipated. Many Chironomini use spun nets to capture food. Faster currents increase the efficiency of the nets, thus allowing better feeding and survival (Walshe 1951). Tanypodinae larvae tend to be free-living, thus more susceptible to drift in faster currents (Pinder 1995), as depicted by inverse correlations of these larvae with current velocity in both habitats.

Many chironomids are sensitive to acidification (Beck 1977). Evidence of this reaction was found for Orthocladiinae in both streams, and Chironomini in Rock Springs Run. Beck (1977) reported many species of genera found in these systems to be alkaliphilous.

TABLE 3. MATRIX OF SIGNIFICANT ($P<0.05$) PEARSON *R* CORRELATION COEFFICIENTS OF CHIRONOMID LARVAL DENSITY AND DRY BIOMASS [TRANSFORMED LOG(N+1)] WITH SELECTED PHYSICO-CHEMICAL PARAMETERS (CURRENT VELOCITY=CURR, SPECIFIC CONDUCTIVITY=K, 30-DAY MEAN WATER ELEVATION=ELEV, NITRATE-N=NIT-N, 30-DAY CUMULATIVE RAINFALL=RAIN, AND WATER TEMPERATURE=TEMP) FOR BLACKWATER CREEK AND ROCK SPRINGS RUN, CENTRAL FLORIDA (FEBRUARY 1993 TO JANUARY 1995).

Blackwater Creek						
Taxon	Curr *n*=22	*k* *n*=24	Elev *n*=24	Nit-N *n*=21	pH *n*=23	Temp *n*=24
Chironomini	0.44	ns	ns	ns	ns	-0.54
Tanytarsini	ns	ns	ns	ns	ns	-0.48
Tanypodinae	-0.57	-0.57	0.60	-0.51	ns	ns
Orthocladiinae	ns	ns	-0.44	ns	0.42	ns
Mean Total Larval Density	ns	ns	ns	ns	ns	-0.64
Mean Total Larval Biomass	ns	ns	ns	ns	ns	-0.58

Rock Springs Run						
Taxon	Curr *n*=23	*k* *n*=24	Rain *n*=24	Nit-N *n*=20	pH *n*=23	Temp *n*=24
Chironomini	0.42	ns	ns	ns	0.50	ns
Tanytarsini	ns	ns	ns	ns	ns	ns
Tanypodinae	-0.43	ns	ns	ns	ns	ns
Orthocladiinae	ns	ns	ns	ns	0.57	ns
Mean Total Larval Density	ns	ns	ns	ns	ns	ns
Mean Total Larval Biomass	ns	ns	ns	ns	ns	ns

ns=Not significant ($P>0.05$).

Chironomids are a critical component of the benthos of these streams. Even at an oligotrophic level, midge productivity for an entire stream becomes very important. Using a hypothetical 5 m width, Rock Springs Run would have an annual midge productivity of 81 kg dry wt and Blackwater Creek 226 kg dry wt. The high P/B ratios noted indicate a rapid overturn of biomass by these organisms. This secondary productivity represents a tremendous potential for nutrient cycling and energy flow. No published data on productivity of chironomids in other streams in Florida are available at present for comparison.

This study provides an initial database on lotic chironomid production in two Florida streams. These streams were relatively unpolluted and of oligotrophic nature, with year-round chironomid activity. This investigation warrants further laboratory and/or field studies to discern the influences of environmental and chemical parameters in regulating spatial and seasonal changes of chironomid populations in the two habitats.

Acknowledgments

Gratitude is expressed to Joe Bishop and Jon Blanchard, Florida Department of Agriculture and Consumer Services, Division of Forestry (Withlacoochee District) and to Parks Small, Barry Birch and Jim Gibson, Florida Department of Environmental Protection, Division of Recreation and Parks (Wekiwa Springs Geopark). We thank King's Landing Canoe Rentals for assistance in sampling Rock Springs Run. This is Florida Agricultural Experiment Station Journal Series R-05045.

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