CHIRONOMIDAE (DIPTERA) OF LOUISIANA
II. THE LIMNOLOGY OF THE UPPER PART OF CANE RIVER LAKE, NATCHITOCHES PARISH, LOUISIANA, WITH PARTICULAR REFERENCE TO THE EMERGENCE OF CHIRONOMIDAE[1]

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Much of what is known about aquatic insect populations has been learned from bottom faunal studies using conventional bottom samplers. Quantitative and qualitative data have been secured in this manner but investigators have experienced difficulty in making positive identifications of the immature forms taken. Consequently, many limnologists have not attempted to make identifications below the family level, or at most to genus. This is particularly true for the Family Chironomidae which comprises one of the major components of the benthos. The problem of generic and specific determination is considerably reduced when tent and funnel traps are used since the adults which are taken in these traps can be more positively identified.

Recent reviews of the literature concerning tent and funnel traps for capturing emerging adults of aquatic insects have been made by Wohlschlag (1950), Jonásson (1954), and Guyer and Hutson (1955). In addition, Sublette and Dendy (1959), and Buscemi (1961) have described modifications of trapping devices.

In view of the difficulty encountered in making positive identification of larval midges, and the scarcity of studies on lakes in southern United States, this research was done to secure quantitative and qualitative data on the benthic organisms, particularly the Chironomidae, through conventional collections made from larval populations and from samples of adults taken by tent and funnel traps.

Appreciation is expressed to Mary Smith Sublette for the preparation of genitalia mounts from pinned specimens and to Judith Jones Buckley for assistance in making the graphs.

History and Physiography of Cane River Lake

At the time of settlement by European immigrants of the lower Red River Valley, the river and surrounding flood plain were in a unique stage of development. For reasons only partially understood, tremendous numbers of logs, much debris, and silt choked the stream. This resulted in the formation of what was locally referred to as the "Great Raft." The damming action of the silt-laden log jams or "raft" caused the river to spill over into the back water swamps which are so characteristic of agrading mature river systems. This produced a series of "braided" channels and connecting shallow lakes (cf. Hutchinson, 1957, page 115). According to John Sibley, 1808, "An account of the Red River and country adjacent", *American Register,* Volume IV, fide Guardia (1927), there were four channels in the vicinity of the town of Natchitoches. These streams were, from east to west: Rigolets du Bon Dieu (now the main channel of Red River). Atoho (now Little River), Cane River (now Cane River Lake, an impoundment) and False River (now Old River). At his writing, Cane River was the boat channel. False River was navigable but had low banks. The Rigolets du Bon Dieu was the smallest of the four, but significantly (as it was later to steal the main channel) it was the swiftest. At the time of Sibley's report the Rigolets was just becoming navigable (Guardia, 1927). Over a period of a few years (the time is contro-

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versial, but probably about 1830-1840) the Rigolets du Bon Dieu channel degraded as a result of successive high water periods and captured the major part of the water flow below Grand Ecore (four miles east of Natchitoches). This left Cane River as a flood water divergence channel navigable by shallow draft boats only during time of high water. During summer months the stream dried up to small stagnant pools. In the spring of 1916 (fide, The Golden Jubilee Issue, *Natchitoches Times,* 1953) two earthen dams were constructed on the channel, one at the upper end northeast of the city of Natchitoches and one located about two and one-half miles northwest of Derry, Louisiana, thus forming Cane River Lake.

The origin of the lake is evidenced by its narrowness and great length, the meandering path it takes through the parish, its regular shoreline and bottom contours, and the many remnants of sandbars. In addition, precipitous slopes forming the shore of much of the lake and the existence of terraces some distance away indicate its stream origin.

Throughout its length the lake is bordered by rich farm land. Consequently, the chief supply of water is run-off from cultivated fields. The main axis of the lake lies northwest-southeast.

The following morphometric features were listed by Geagan and Allen (1961): maximum length, 34.5 miles (55.5 km); mean width, 250 feet (76.2 meters); surface area, 1,044 acres (423.5 hectares); mean depth, 11.5 feet (3.4 meters); maximum depth near the spillway, 25.0 feet (7.6 meters).

Description of the Study Site

Samples taken at irregular intervals and sites during a preliminary survey of Cane River Lake from February 5, 1957, to July 12, 1957, showed the bottom contours and shoreline to be fairly uniform in the upper part of the lake. This survey was made while the junior author was conducting a research program subsidized by a National Institutes of Health research grant, RG-4594. Water samples taken at several sites in the upper end of the lake did not differ markedly from each other in physico-chemical characteristics.

Beginning in June, 1957, a program of seasonal study of the lake was begun at a site approximately one and one-half miles above the "new bridge" (bridge at Church Street crossing) located in downtown Natchitoches, and approximately two and one-fourth miles below the upper dam. In this report only the results obtained during the seasonal study are presented. Since the water quality and bottom features were found to be very similar in the several areas in the upper part of the lake only one transect was used for the seasonal study.

A three-quarter mile stretch of the lake on which the transect site was located lies in a northeast-southwesterly direction. The shoreline is quite regular, the eastern side being less precipitous than the western. The soil on the eastern side is Yahola Sandy Loam and on the western side is Yahola Clay. A few scattered willows, *Salix nigra* Marsh, are located along the shore above and below the sample site. The lake has a well-developed zone of emergent vegetation composed principally of alligator weed, *Alternanthera philoxeroides* (Mart.) Standl., and cutgrass, *Zizaniopsis miliacea* (Michx.) Doll and Asch.

The bottom contours of the seasonal sampling site were very regular, with each lying closely parallel to the shoreline. The one meter contour was located about four meters out from the shore and the two meter contour was about six meters beyond the first. The width of the lake at this point was forty-one meters and the maximum depth 2.8 meters.

Materials and Methods

Collection of adults. Samples of emerging adults were obtained at approximately weekly intervals from June, 1957, to July, 1958, using the traps and techniques described by Sublette and Dendy (1959). Two funnel traps were set on the bottom within each contour zone. Those set within the zero to one meter zone were located in a small cove formed by the outgrowth of alligator weeds. A conical tent trap was suspended over a bed of alligator weeds about fifty feet from the funnel traps. Except for three attempts to evaluate diel periodicity, the traps were lifted at the end of a twenty-four hour period. At the time of trap setting the temperature of each half meter depth of water was taken.

The flasks containing the insects were removed to the laboratory where adult chironomids which had been "wet down" and the exuviae were separated from the other forms and preserved in 70 per cent ethyl alcohol. A slide was later prepared of each adult and exuvia. Dry specimens were pinned on minuten nadeln. Insects other than the Chironomidae were preserved in 70 per cent alcohol and stored.

Collection of larvae. Bottom samples were taken with a six inch Ekman-Birge dredge at approximately monthly intervals. From three to five dredgings were taken at random within each meter contour. All sampling was done during daylight hours. Samples were washed in the field using a screen with 25 meshes per inch, then preserved in 10 per cent formalin. In the laboratory the organisms were removed from the debris, preserved in 70 per cent alcohol, and subsequently separated, counted, and measured volumetrically using Anderson and Hooper's (1956) modification of the technique given by Ball (1948).

Physical and chemical data. Monthly water samples were taken using an APHA sewage sampler. A Whitney electrical resistance thermometer was used to measure water temperature. The pH of the water was determined during a part of the study by a laboratory, line-operated Beckman pH meter. A Taylor block comparator was used in the field for the pH determination during the remaining time. A six inch Secchi's disc was used to estimate light penetration. The turbidity of the water was assayed using a Bausch and Lomb Spectronic 20 colorimeter following the procedure outlined by the Hach Chemical Company, Ames, Iowa.

The Alsterberg modification of the Winkler Method of dissolved oxygen determination was used following the procedure outlined in the 10th edition of *Standard Methods for the Examination of Water, Sewage, and Industrial Wastes* (1955). Phenolphthalein and methyl alkalinities were determined following the procedure given by Welch (1948). Methyl organge alkalinity was obtained by using M-Alka Ver indicator supplied by the Hach Chemical Company, Ames, Iowa.

Physical Features

Bottom sediments. The 0-1.0 meter zone was characterized by sandy silt with much detritus. Plant fragments, especially bits of alligator weed and cutgrass, were concentrated in this zone. Near the end of December, 1957, and throughout much of January, 1958, leaves from sycamore, *Platanus occidentalis* L., located nearby became so abundant upon the bottom that the dredge frequently was prevented from closing properly and had to be reset.

A very distinct shell zone existed in the 1.1-2.0 meter zone. Sublette and Sublette (1958) and Moore (1950, 1952) did not find such a zone in other Louisiana impoundments. Less detritus was present in the second zone and a considerable amount of sand and sandy silt was evident.

The sediment of the 2.1-2.8 meters zone was a soft, brown, flocculent mud with some plant fragments.

Thermal characteristics. In general, the lake showed a strong tendency toward thermal stratification from April to September. However, due to the shallow nature of the lake, the exposure to wind, and the direction of the lake's main axis, thermally stratified waters with an epilimnion, thermocline, and hypolimnion which fit the criteria used by limnologists for other North American lakes were not observed.

On the occasions when a thermocline occurred (July 2, July 16, July 30, September 3, October 14, November 2, December 4, December 16, and April 7) it was present from the surface to a point near the middle or extended from the surface to the bottom (May 17). Isothermal water was frequently observed in January and February. Similar conditions were observed by Moore (1952) on Lake Chicot and Sublette and Sublette (1958) on Chaplain's Lake.

Although only incipient stratification was observed, oxygen depletion in bottom waters persisted throughout the summer months.

Transparency. The maximum Secchi's disc reading was 1.0 meter with a turbidity of 15 ppm, recorded on July 13, and the minimum of 0.3 meter with a turbidity of 58 ppm was obtained December 4. These findings agree well with the result obtained by Geagan and Allen (1961) on lower sections of the lake where a three year average gave 1.99 feet (0.66 meter).

The lake manifested a well-developed phytoplankton but allochthonous sediments were the apparent cause of the much reduced transparency.

Chemical Features

Dissolved oxygen. Although a complete oxygen depletion was recorded only on three occasions (July 13, August 17, and May 17), in direct accordance with the thermal gradients recorded on those dates, there was a general tendency for bottom waters to be depleted of oxygen during the warm seasons. The lowest concentration of oxygen at the surface was 6.2 ppm on August 17, and the highest value of 16.0 ppm was observed on February 22. Geagan and Allen (1961) did not find values as low at the transects where they sampled in the lower (southern) part of the lake.

That a thorough mixing of the water occurred in January is reflected by the homogeneity of water temperatures from surface to bottom and by only a slight difference in surface and bottom oxygen values for the month.

Alkalinity. Normal carbonate was lacking in both surface and bottom waters the entire year. Bicarbonates were the sole source of alkalinity. During most of the study only slight variations were observed between amounts recorded from surface and bottom waters. With two exceptions (September 30, January 4) larger amounts were recorded from bottom water. The highest value obtained from the surface was 172.0 ppm (August 17) with a low of 20.0 ppm (May 17). On May 17, when Cane River Lake showed strong thermal gradients, a value of 234.0 ppm was recorded for bottom water. This is in agreement with Moore's (1950) observations on Lake Providence that higher alkalinity occurred in the lower stratum during periods of thermal stratification.

Hydrogen ion concentration. Surface hydrogen ion concentration varied from pH 6.7 to 8.5 and that of the bottom from pH 6.7 to 7.7. The bottom pH dropped slightly during May, June, July and August which seemed to be in accordance with other changes that occurred.

Results and Discussion

Composition and seasonal changes in the bottom fauna. Conventionally, three major life-zones on the floor of thermally stratified lakes have been recognized: the littoral, sublittoral, and profundal. As these terms have been employed, the littoral extends from the water's edge to the lakeward limits of rooted aquatic vegetation; the profundal occupies all of the lake floor bounded by the hypolimnion; and the sublittoral lies in an intermediate position between the two and represents a zone of transition.

While these have proved useful in previous studies, they do not adequately present the limits of the life-zones found in Cane River Lake. Instead, zonation of the lake floor which approximated meter contours proved more useful and accurate. The littoral zone as evidenced by bottom sediments and associated animal assemblages, encompassed the area between the shoreline and the 1.0 meter contour, although the rooted aquatic plants extended only to about 0.5 meter depth. The 1.1-2.0 meters zone included the sublittoral (=ecotone, cf. Sublette, 1957) or zone of transition from coarse littoral to finer profundal sediments. The profundal zone, with its finely divided, somewhat flocculent yellowish-brown sediments, was located beyond the 2.0 meters contour and made up most of the lake floor.

Table 1.
Mean annual standing crop of bottom fauna, Cane River Lake, Louisiana.

ORGANISMS	0-1.0 M No./M²	0-1.0 M Vol./M²	1.1-2.0 M No./M²	1.1-2.0 M Vol./M²	2.1-3.0 M No./M²	2.1-3.0 M Vol./M²
Oligochaeta	3295	3.9	3922	6.7	754	3.4
Chironomidae	2201	1.9	841	1.95	184	2.8
Chaoborus	–	–	25	0.09	945	1.75
Ceratopogonidae	6	0.01	8	0.01	4	0.01
Ephemeroptera	5	0.04	3	0.34	–	–
Zygoptera	29	0.45	–	–	–	–
Anisoptera	–	–	10	0.33	–	–
Corixidae	14	0.01	–	–	–	–
Gastropoda	538	–	705	–	22	–
Pelecypoda	54	–	–	–	–	–
Hirudinea	26	0.17	–	–	–	–
Turbellaria	14	0.01	–	–	–	–
Mean Total Organisms	6192	6.49	5514	9.42	1909	7.96

Qualitatively and quantitatively, a diversified fauna composed principally of oligochaetes, fewer chironomids, and still smaller numbers of snails and small clams existed in the 0-1.0 meter zone (Table 1). A graphic representation of the total organisms (exclusive of Mollusca) for each zone is presented in Figure 1.

The fauna of the 2.1-3.0 meters zone was made up of relatively large numbers of *Chaoborus* (Culicidae: Diptera), restricted almost entirely to this zone, and oligochaetes, with a very small number of chironomids. A few gastropods occasionally were taken there. These two zones lost their distinctiveness in the transition area and merged together. Oligochaetes, chironomids, and gastropods, in that order, were the major components.

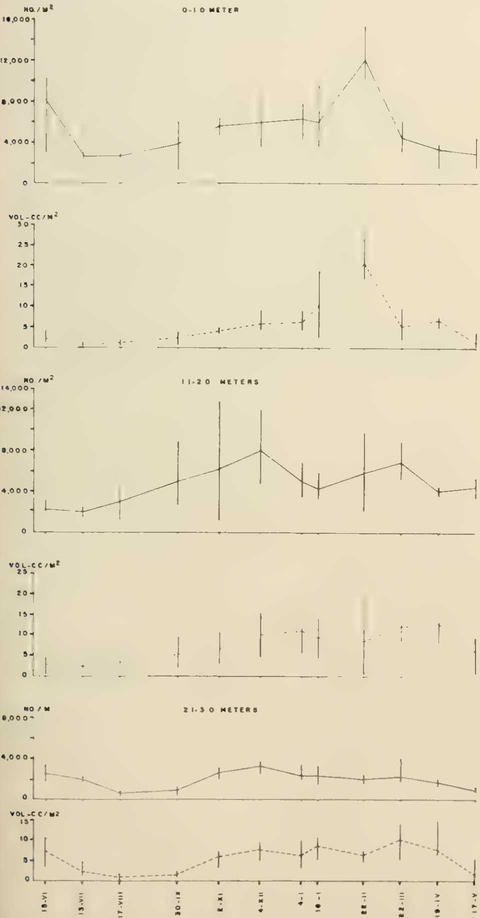

Figure 1. Seasonal abundance of all organisms averaged together. (mean number, solid line; mean volume, dashed line).

The relationship between numbers and volumes of the aquatic earthworms is shown in Table 1. An inverse relationship between numbers and volumes of chironomids was observed in the littoral and profundal zones with the largest number but smallest volume recorded in the 0-1.0 meter zone and the smallest number and largest volume in the 2.1-3.0 meters zone.

The predaceous ceratapogonids were distributed almost uniformly. Immature forms

Figure 2. Seasonal occurrence of Oligochaeta (mean number, solid line; mean volume, dashed line).

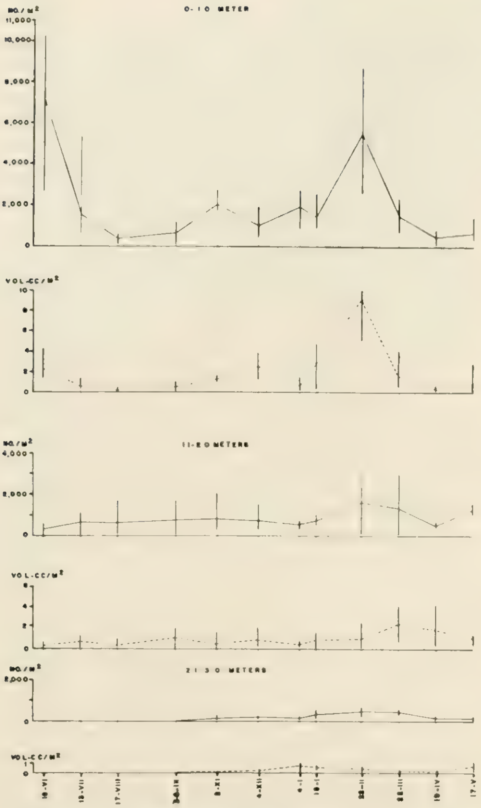

Figure 3. Seasonal abundance of larval Chironomidae, all species averaged together (mean number, solid line; mean volume, dashed line).

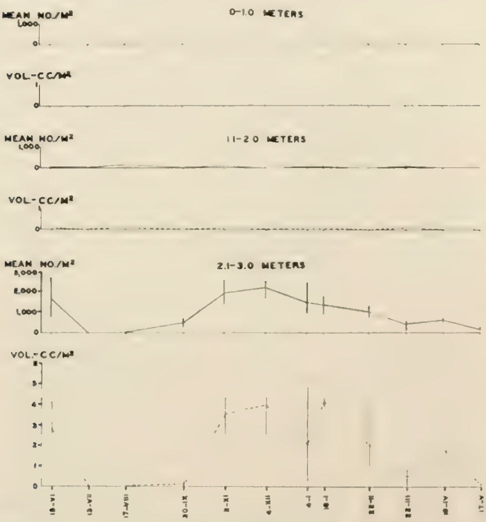

Figure 4. Depth distribution and seasonal abundance of *Chaoborus punctipennis* (Say), (mean number, solid line; mean volume, dashed line).

of the three gastropods, *Campeloma lewisi* (Walker), *Physa integra* (Haldeman), and *Helisoma trivolvis* (Say), were collected frequently in the deeper water as well as the shallow zone. The gastropods were identified by a comparison with specimens identified by Dr. R. Tucker Abbott, The Academy of Natural Sciences of Philadelphia.

Seasonal variations in the benthic assemblages are shown in Fig. 1. Figures 2, 3, and 4 show seasonal trends for each of the three major components: Oligochaeta, Chironomidae, and *Chaoborus*.

Population increases occurred in late winter and again in the spring. Frequently we observed that the volumes increased following a peak in the numbers. This was apparently due to the maturation of the organisms.

The distribution of larval Chironomidae (Fig. 3) during the cold and warm seasons reflected the physical and chemical conditions of the lake during those periods. The virtual absence of chironomids in the deep water during June, July, August, and September is a manifestation of the tendency toward thermal stratification of the lake and the associated poor supply of oxygen. At all other seasons the lack of prolonged thermal and accompanying chemical stratification allowed at least some species to distribute themselves within the profundal zone.

Chaoborus punctipennis (Say) was the most characteristic animal of the profundal bottom during the daylight hours. It was not collected from the 0-1.0 meter zone at any time during the study and was recorded from the 1.1-2.0 meters only on seven occasions (Fig. 4) with the largest number taken August 17, 1957. On that date none were collected from the deeper water. The increase in numbers within the transition zone, presumably resulting from an upward migration to avoid stagnation effects, did not account for all of the profundal zone inhabiting *Chaoborus* that previously occurred there. After the August decline the number gradually increased until a peak was reached about the first of December.

The Emergence of Chironomidae

Forty-six species of Chironomidae were collected during the study. These have been treated taxonomically in Part I of this series. Table 2, which is a checklist of the chironomids found in Cane River Lake, sum-

TABLE 2.
A checklist of the chironomids of Cane River Lake together with the depth distribution based on emergence of adults (x = presence)

Species	Vegetation	0-1.0 Meter	1.1-2.0 Meters	2.1-3.0 Meters
TANYPODINAE				
Tanypus stellatus Coquillett		x		x
Tanypus n. sp. 1		x		
Tanypus n. sp. 2		x	x	
Procladius n. sp. 1			x	
Procladius (Psilotanypus) bellus (Loew)		x	x	x
Pentaneura (Pentaneura) planensis Johannsen	x			
Pentaneura (Pentaneura) pilosella (Loew)	x	x		
Ablabesmyia peleensis (Walley)	x			
Ablabesmyia rhamphe Sublette	x	x		
ORTHOCLADIINAE				
Cricotopus bicinctus (Meigen)	x	x		
Cricotopus remus Sublette	x	x		
Nanocladius alternantherae Dendy and Sublette	x	x	x	
CHIRONOMINAE				
CHIRONOMINI				
Pseudochironomus aix Townes	x	x		
Chironomus (Chironomus) natchitocheae Sublette		x	x	
Chironomus (Chironomus) attenuatus Walker	x	x	x	
Chironomus (Chironomus) fulvipilus Rempel	x			
Chironomus (Dicrotendipes) modestus Say		x		
Chironomus (Dicrotendipes) nervosus Staeger	x	x	x	
Chironomus (Xenochironomus) xenolabis Kieffer	x			
Chironomus (Endochironomus) nigricans Johannsen	x	x		
Chironomus (Cryptochironomus) monochromus v.d. Wulp	x	x		
Chironomus (Cryptochironomus) nigrovittatus Malloch		x	x	
Chironomus (Cryptochironomus) carinatus (Townes)	x	x		
Chironomus (Cryptochironomus) directus (Dendy and Sublette)	x	x		
Chironomus (Cryptochironomus) emorsus (Townes)	x	x	x	
Chironomus (Cryptochironomus) galeator (Townes)		x	x	x
Chironomus (Cryptochironomus) edwardsi (Kruseman)	x	x	x	
Chironomus (Cryptochironomus) ponderosus Sublette		x	x	
Chironomus (Cryptochironomus) fulvus Johannsen	x	x	x	
Glyptotendipes (Phytotendipes) lobiferus (Say)	x	x	x	
Glyptotendipes (Phytotendipes) meridionalis Dendy and Sublette	x	x		
Paralauterborniella elachista (Townes)	x			
Lauterborniella varipennis (Coquillett)	x	x		

TABLE 2. (Continued)
A checklist of the chironomids of Cane River Lake together with the depth distribution based on emergence of adults (x = presence)

Species	Vegetation	0-1.0 Meter	1.1-2.0 Meters	2.1-3.0 Meters
Stenochironomus macateei (Malloch)	x			
Pedionomus beckae Sublette	x	x		
Polypedilum (Polypedilum) trigonum Townes	x			
Polypedilum (Polypedilum) illinoense (Malloch)	x	x		
Polypedilum (Polypedilum) digitifer Townes	x	x	x	x
TANYTARSINI				
Tanytarsus (Cladotanytarsus) viridiventris Malloch		x		
Tanytarsus (Tanytarsus) confusus Malloch		x		
Tanytarsus (Tanytarsus) xanthus Sublette	x	x		
Tanytarsus (Tanytarsus) neoflavellus Malloch	x	x	x	
Tanytarsus (Tanytarsus) dendyi Sublette	x	x	x	
Tanytarsus (Tanytarsus) buckleyi Sublette	x			
Tanytarsus (Tanytarsus) quadratus Sublette	x	x	x	
Tanytarsus (Tanytarsus) recens Sublette	x			

marizes depth distribution, while phenology by months is presented in Table 3. Emergence of adult chironomids in relationship to water temperature is given in Table 4.

Seasonal variation. The very mild winters of this latitude were reflected in the reproductive behavior of the Chironomidae, with some adults emerging, and presumably mating, in every month of the year. However, the emergence from the lake did not occur uniformly. Two distinct periods were discernible in the total emergence for the year. One was from early April to late November (Fig. 5), coinciding with a marked rise in water temperature which occurred beginning about the first of March. The rate of emergence gradually increased throughout the early spring and summer, becoming highest in late September and early October. As water temperatures declined during the fall there was a parallel drop in numbers of midges emerging. The second period of emergence, or rather the lack of it, was from December to April during which time the low water temperatures were associated with a sparse emergence that was irregular in distribution. The two periods were particularly noticeable for those midges trapped over beds of aquatic vegetation (alligator weed).

Adults taken in tent traps over beds of mat vegetation perhaps represent two larval populations; namely, those from the underlying littoral floor and from the vegetation itself. These may be distinguished in the following manner: larvae inhabiting the vegetation beds would be represented by adults in tent traps above the vegetation beds only, whereas adults transforming from larvae on the littoral bottom would be taken not only in traps set over bare bottoms but also by traps set above vegetation.

However, the funnel traps over bare bottoms would take a preponderance of adults of the littoral bottom-inhabiting larvae, since those living on the bottom under the vegetation would tend to migrate laterally (as pupae) to avoid the dark, shadow-producing mass of vegetation above (Scott and Opdyke, 1941). If adults of a species occur in approximately equal numbers in traps from both the littoral floor and from vegetation, the species is assumed to have no substratum preference.

The emergence of chironomids from the

TABLE 3.
Phenology of emergence of adult chironomids by months

Species	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
TANYPODINAE												
Tanypus stellatus Coquillett								x	x	x		
Tanypus n. sp. 1										x		
Tanypus n. sp. 2								x		x		
Procladius (Procladius) n. sp. 1				x								
Procladius (Psilotanypus) bellus (Loew)			x	x	x	x	x	x	x	x	x	
Pentaneura (Pentaneura) planensis Johannsen						x		x				
Pentaneura (Pentaneura) pilosella (Loew)					x	x	x	x	x	x		
Alabesmyia peleensis (Walley)				x	x				x	x	x	
Ablabesmyia rhamphe Sublette					x	x	x	x	x	x		
ORTHOCLADIINAE												
Cricotopus bicinctus (Meigen)				x	x							
Cricotopus remus Sublette				x	x	x						
Nanocladius alternantherae Dendy and Sublette	x		x	x	x	x	x	x	x	x	x	x
CHIRONOMINAE												
CHIRONOMINI												
Pseudochironomus aix Townes				x	x	x	x	x	x	x		
Chironomus (Chironomus) natchitocheae Sublette									x	x		
Chironomus (Chironomus) attenuatus Walker			x	x	x	x	x		x	x	x	
Chironomus (Chironomus) fulvipilus Rempel											x	
Chironomus (Dicrotendipes) modestus Say							x					
Chironomus (Dicrotendipes) nervosus Staeger			x	x	x	x	x	x	x	x		
Chironomus (Xenochironomus) xenolabis Kieffer									x			
Chironomus (Endochironomus) nigricans Johannsen		x		x	x	x	x	x	x	x	x	x
Chironomus (Cryptochironomus) monochromus v.d. Wulp			x	x	x	x	x					
Chironomus (Cryptochironomus) nigrovittatus Malloch						x	x	x	x			
Chironomus (Cryptochironomus) carinatus (Townes)							x	x	x	x		
Chironomus (Cryptochironomus) directus (Dendy and Sublette)				x	x	x	x	x	x	x		
Chironomus (Cryptochironomus) emorsus (Townes)					x	x	x	x	x	x		
Chironomus (Cryptochironomus) galeator (Townes)						x		x	x	x	x	
Chironomus (Cryptochironomus) edwardsi (Kruseman)				x	x	x	x	x	x	x	x	x
Chironomus (Cryptochironomus) ponderosus Sublette					x			x		x		
Chironomus (Cryptochironomus) fulvus Johannsen			x	x	x	x	x	x	x	x		
Glyptotendipes (Phytotendipes) lobiferus (Say)			x	x	x	x	x		x	x		
Glyptotendipes (Phytotendipes) meridionalis Dendy and Sublette			x	x	x	x	x	x	x	x	x	
Paralauterborniella elachista (Townes)							x	x				
Lauterborniella varipennis (Coquillett)							x	x				
Stenochironomus macatecei (Malloch)							x					

TABLE 3. (Continued)
Phenology of emergence of adult chironomids by months

Species	I	II	III	IV	V	VI	VII	VIII	IX	X	XI	XII
Pedionomus beckae Sublette				x			x	x	x	x		
Polypedilum (Polypedilum) trigonum Townes				x					x			
Polypedilum (Polypedilum) illinoense (Malloch)				x	x			x		x	x	
Polypedilum (Polypedilum) digitifer Townes				x	x	x	x	x	x	x	x	
TANYTARSINI												
Tanytarsus (Cladotanytarsus) viridiventris Malloch						x	x				x	
Tanytarsus (Tanytarsus) confusus Malloch								x	x	x		
Tanytarsus (Tanytarsus) xanthus Sublette	x				x	x		x	x	x	x	x
Tanytarsus (Tanytarsus) neoflavellus Malloch	x		x	x	x	x	x		x	x	x	
Tanytarsus (Tanytarsus) dendyi Sublette		x	x		x							
Tanytarsus (Tanytarsus) buckleyi Sublette							x	x	x	x	x	x
Tanytarsus (Tanytarsus) quadratus Sublette		x	x		x			x				
Tanytarsus (Tanytarsus) recens Sublette					x							

littoral benthos (0-1.0 meter) occurred through the warmer months of the year with only slight peaks of abundance observed (Fig. 5). The mean annual emergence of adults per square meter from that area was about half the mean number which emerged per square meter from the vegetation (Table 1 and Fig. 5).

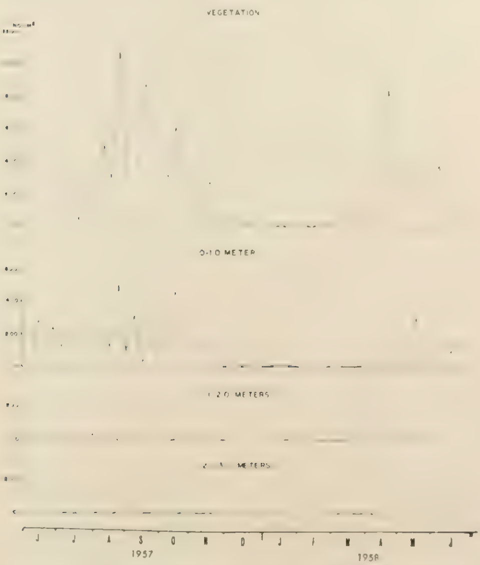

Figure 5. Emergence of adult Chironomidae, all species averaged together.

The number of adults emerging from the littoral zone was much greater than from the profundal (2.1-3.0 meters) and transition zones (1.1-2.0 meters) combined. The emergence of profundal chironomids occurred from July through November, 1957, and in March and April of 1958. The number of individuals arising from that area was small in comparison to the total emergence. In general, emergence decreased with an increase in depth.

Table 5 shows the mean annual emergence per square meter for all insects taken in traps. The caddisflies and mayflies were recorded primarily from the vegetation in April and May, 1958. A few emerged during late August and September, 1957. *Chaoborus* and ceratopogonids made up a very small part of the total organisms trapped during the year.

Species emerging from aquatic vegetation. Thirty-four species of Chironomidae were collected from tent traps set over vegetation. While most of these were also recorded in funnel traps set in shallow water, certain species showed a preference for vegetation habitats. Five species constituted about two-thirds of the total individuals from that location. In order of their abundance they were: *Chironomus (Cryptochironomus) directus* Dendy and Sublette, *Nanocladius*

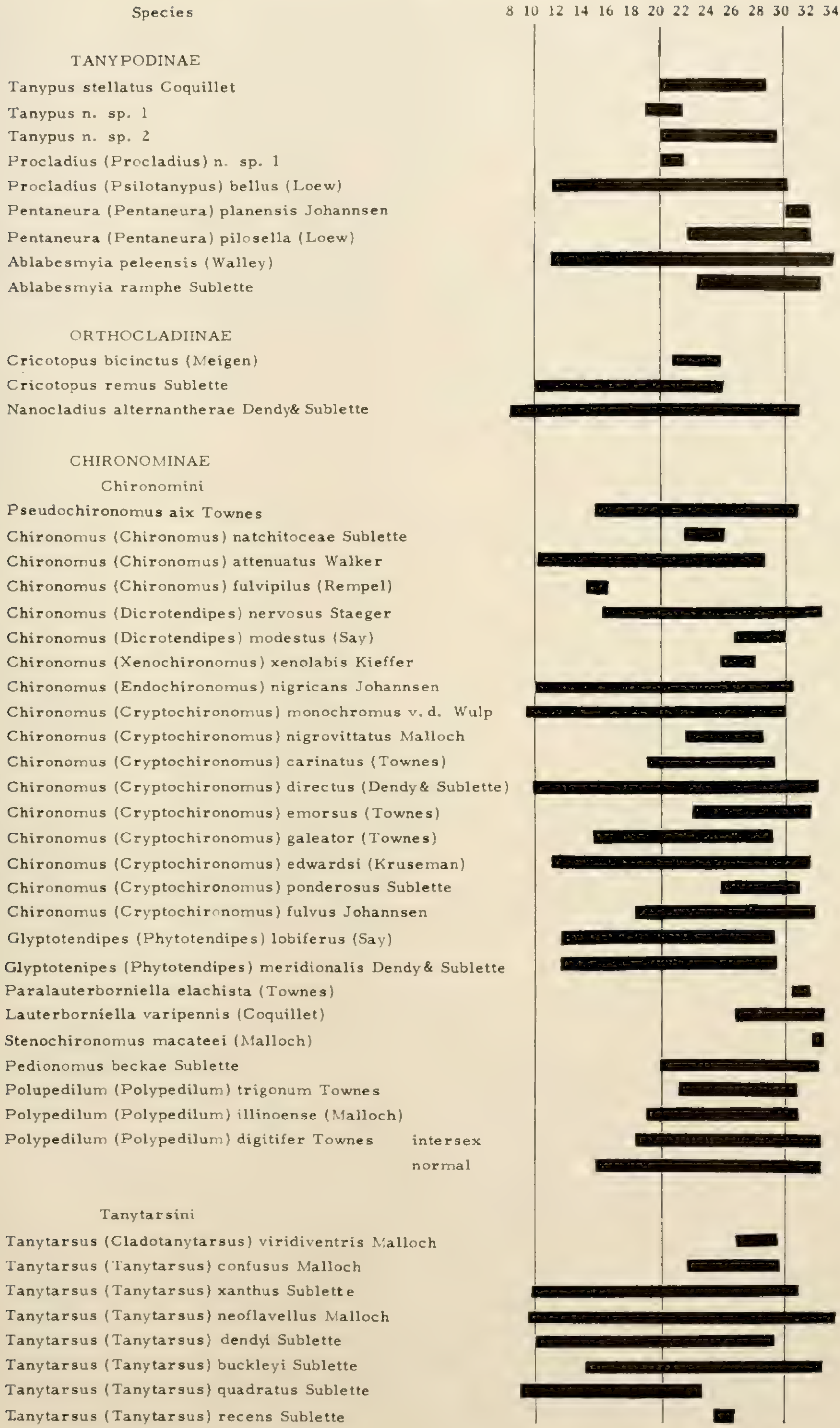

TABLE 4. EMERGENCE OF ADULT CHIRONOMIDS IN RELATIONSHIP TO WATER TEMPERATURE (DEGREES CENTIGRADE)

TABLE 5.
Mean annual emergence of aquatic insects, No./M²

Organism	Vegetation	0-1.0 M	1.1-2.0 M	2.1-3.0 M	Mean Total
Chironomidae	217.9	107.2	21.5	9.6	486.1
Trichoptera	19.4	3.0	0.56	–	22.96
Ephemeroptera	11.0	2.2	0.2	–	13.84
Chaoborus	0.66	0.2	0.19	1.9	2.96
Ceratopogonidae	0.64	0.59	–	–	1.23

alternantherae Dendy and Sublette, *Pseudochironomus aix* Townes, *Chironomus (Dicrotendipes) nervosus* (Staeger) and *Cricotopus remus* Sublette. With one exception, *Chironomus (Cryptochironomus) directus* was taken entirely from the aquatic vegetation (Fig. 6) and comprised one-third

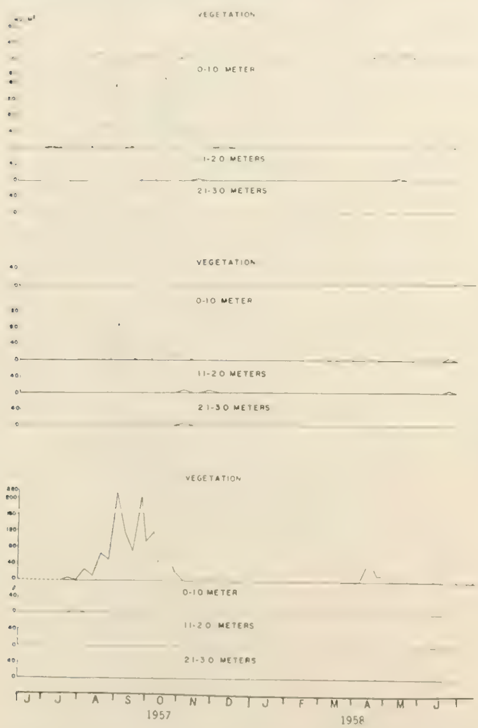

Figure 6. Emergence of adult males of *Chironomus (Cryptochironomus) edwardsi* (above); *Chironomus (Cryptochironomus) galeator* (middle); and *Chironomus (Cryptochironomus) directus* (below).

of the total number of chironomids emerging from vegetation. *Nanocladius alternantherae* and *Pseudochironomus aix* were important littoral forms which occurred primarily in the tent traps, but were occasionally collected in the funnel traps set on the bottom in the shallow water (Figs. 7 and 8). The occurrence of large number of *Pseudochironomus aix* in the spring suggests that the species has one generation each year.

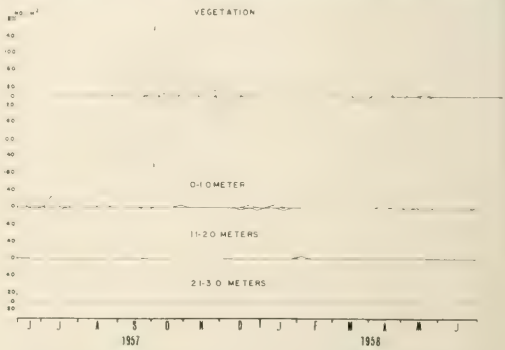

Figure 7. Emergence of adults of *Nanocladius alternantherae* (males, above abscissa; females, below).

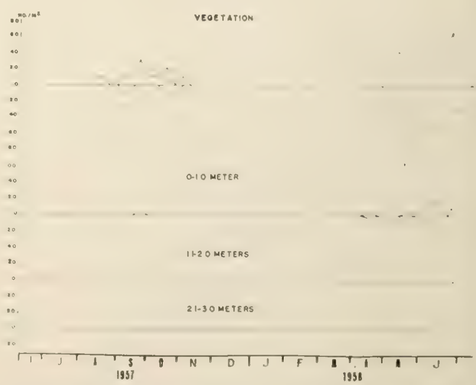

Figure 8. Emergence of adults of *Pseudochironomus aix* (males, above abscissa; females, below).

Cricotopus remus, like *Chironomus (Cryptochironomus) directus,* was limited to the vegetation but was taken in a funnel trap on one occasion. *Chironomus (Dircrotendipes) nervosus* was collected in about equal numbers from the tent and funnel traps.

Of the remaining twenty-nine species, only one or two specimens of *Chirono-*

mus (Xenochironomus) xenolabis (Kieffer), *Stenochironomus macateei* (Malloch) and *Chironomus (Chironomus) fulvipilus* (Rempel) were collected during the study. The other species occurred more frequently but were not numerous (Tables 2, 3, and 4).

Species emerging from the littoral benthos. The predominant species taken by the shallow water funnel traps was *Chironomus (Cryptochironomus) edwardsi* (Kruseman) (Fig. 6) followed closely by *Polypedilum (Tripodura) digitifer* Townes (Fig. 9). The

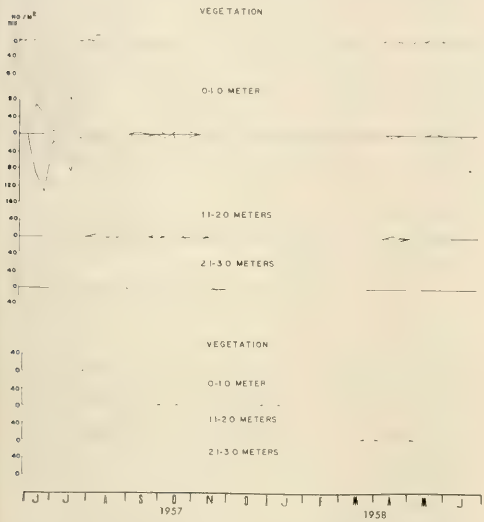

Figure 9. Emergence of adults of *Polypedilum (Polypedilum) digitifer*. Top figure, males (above abscissa) and females (below); bottom figure, intersexes produced by mermethid nematode infections.

relatively small number of *Chironomus edwardsi* taken from vegetation, when compared to the large number which emerged from the littoral bottom, suggests that the species is restricted to the bottom and that the individuals which were taken in the tent traps emerged from the bottom and passed up through the vegetation.

Other species which were frequently trapped were *Glyptotendipes (Phytotendipes) meridionalis* Dendy and Sublette, *Chironomus (Cryptochironomus) galeator* (Townes), *Nanocladius alternantherae* Dendy and Sublette, and *Tanytarsus neoflavellus* Malloch.

Thirty-six species were collected as they emerged from the littoral zone. Other than the species mentioned above, most occurred in small numbers (Tables 2, 3 and 4).

Species emerging from the sublittoral and profundal. The predominant species trapped was *Procladius bellus* (Loew) (Fig. 10) and, in keeping with its predaceous feeding habits, it was found widely distributed. Dur-

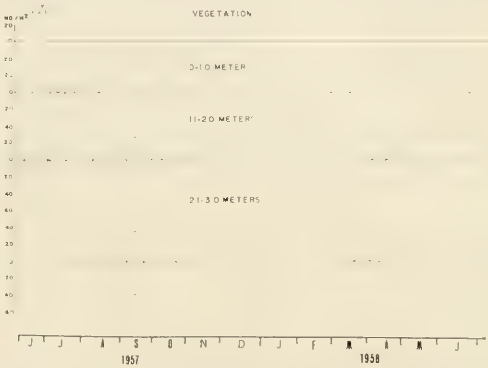

Figure 10. Emergence of adults of *Procladius bellus* (males above abscissa; females, below).

ing the year most of the individuals were taken in water 1 to 2 meters in depth. A few were trapped in the littoral zone during June and July, 1957, and in the spring of 1958.

Only one other species, *Tanypus stellatus* Coquillett, occurred more than once in the profundal zone and it emerged in small numbers. *Chironomus (Cryptochironomus) galeator* (Townes) occurred once in a funnel trap set in the profundal zone (Fig. 6). In general, emergence from depths greater than 1.0 meter was small and sporadic and represented the lower fringes of typical littoral inhabiting populations. A total of nineteen species was taken in small numbers below 1.0 meter depth (Table 2).

Miller (1941) reported *Cricotopus bicinctus* (Meigen) as a typical species found living below the thermocline in Costello Lake, Ontario. Only five individuals were trapped from Cane River Lake and those were taken from the littoral.

Sexual differences. Miller (1941) observed slight differences in the time of emergence and distribution of the sexes. Males showed a tendency to reach their peak of emergence a short time before females, and females were found to be more abundant in deeper water. These differences, he postulated, were in some way correlated with temperature.

Only slight sexual differences were noted for three of the more common species found in Cane River Lake, *Nanocladius alternantherae* Dendy and Sublette, *Polypedilum digitifer* Townes, and *Procladius bellus* (Loew) (Figs. 7, 9, and 10). The ratio of total males to females of *Pseudochironomus aix* Townes for the year was about 1:1 (Fig. 8). However, a difference in the ratio of approximately 3:1 was recorded during the fall and a 1:3 ratio occurred in the spring. *Glyptotendipes meridionalis* Dendy and Sublette also showed an unusual ratio of males to females (Fig. 11). A ratio of three males to one female occurred throughout the year.

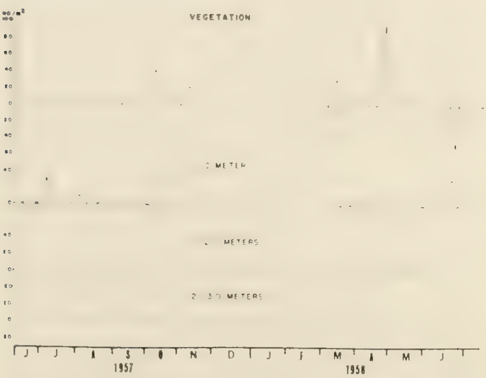

Figure 11. Emergence of adults of *Glyptotendipes (Phytotendipes) meridionalis* (males, above abscissa; females, below).

Intersexuality in a species of Chironomidae. Intersexes of *Polypedilum digitifer* Townes were trapped on several occasions, as has been reported for other chironomids (Wülker, 1961, gives a review of mermithid parasitism in the Chironomidae). The individuals collected showed various degrees of intersexuality and typically bore the characteristic female antennae, and a short, thickened abdomen with much reduced male genitalia. Occasionally, a specimen was taken with an antenna approaching the typical plumose condition of the male.

Diel periodicity. The results of the three attempts to determine daily rhythms of emergence are presented in Figure 12. The greatest emergence of Chironomidae, July 9, 1957, and June 10, 1958, took place between 5 and 9 P.M. A decline in emergence occurred during the next four hours. On June 19, 1958, the traps were lifted at two-hour

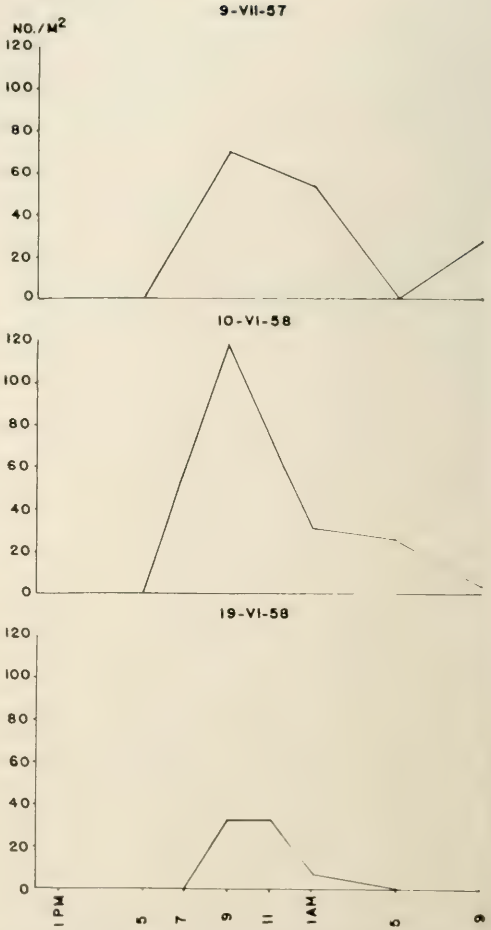

Figure 12. Diel cycle of emergence, all species together, at three selected dates.

intervals from 5 to 1 A.M. in order that more precise periods of emergence might be determined. No adults emerged between 5 and 7 P.M. and equal numbers emerged between 7 and 9 P.M. and 9 and 11 P.M. Emergences declined between 11 P.M. and 1 A.M. No emerging adults were trapped during hours of high light intensity.

SUMMARY

1. This study of the benthic faunal assemblages and the emergence of Chironomidae from Cane River Lake was made from June, 1957, to July, 1958. It is the fourth bottom faunal study which has been made on lakes in Louisiana and the first study in Southern United States in which the emergence of Chironomidae was investigated.

2. The purpose of the study was to secure quantitative and qualitative data on the benthic organisms, particularly the Chironomidae, through collections made from larval populations and from adults taken by tent and funnel trappings. Collections were made using such devices to facilitate positive identifications.

3. Cane River Lake is an impoundment of what was once a channel of Red River. The lake has a length of 34.5 miles, a mean width of 250 feet and an area of 1,044 acres. Run-off is the principal supply of water.

4. The lake has a well developed zone of emergent vegetation. It exhibited a strong tendency toward thermal stratification from April to September but did not stratify stably. Complete oxygen depletion in bottom water occurred on several occasions in accordance with the strong thermal gradients and partial stratification. Bicarbonates were the sole source of alkalinity.

5. Qualitatively and quantitatively, a diversified fauna occurred in the littoral zone. Fewer groups occurred in the profundal. The principal components of the benthos were Oligochaeta, Chironomidae, and *Chaoborus* in that order.

6. The distribution of Chironomidae during the cold and warm seasons reflected the physical and chemical conditions of the lake during those periods. Some chironomids were found distributed in the profundal zone during the cold season but were virtually absent during the warm season.

7. Forty-six species of Chironomidae were collected during the study, including nine Tanypodinae, three Orthocladiinae, twenty-six Chironomini, and eight Tanytarsini.

8. Some adults emerged during every month of the year but two distinct peaks of emergence occurred. One peak was observed during the spring and early summer and the other in the fall.

9. Emergence from the littoral zone was much greater than emergence from the sublittoral and profundal zones combined. A greater number of adults emerged from the aquatic vegetation than from the littoral benthos. Emergence from the littoral bottom occurred from May to November with only slight peaks of numbers observed.

10. In general, the period of greatest emergence of chironomids coincided with a low population of larvae. With an increase in depth the number of larvae recorded and the number of adults emerging decreased.

11. Of the thirty-four species of chironomids taken from the vegetation, five species, *Chironomus (Cryptochironomus) directus, Nanocladius alternantherae, Pseudochironomus aix, Chironomus (Dicrotendipes) nervosus,* and *Cricotopus remus* constituted about two-thirds of the total number of individuals.

12. Thirty-six species of chironomids were trapped from the littoral benthos. The predominant species encountered were *Chironomus (Cryptochironomus) edwardsi* and *Polypedilum digitifer.*

13. Three species were trapped from the profundal with *Procladius bellus* the predominant species.

14. Only slight differences in the emergence of males and females were observed for the three most common species, *Nanocladius alternantherae, Polypedilum digitifer,* and *Procladius bellus.* Differences in the ratio of males to females of *Pseudochironomus aix* and *Glyptotentdipes meridionalis* were recorded.

15. Intersexes of *Polypedilum digitifer* showing various degrees of intersexuality were trapped on several occasions.

16. Limited diel sampling showed that the greatest emergence of chironomids occurred between 5 and 11 P.M.

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ABSTRACT

BUCKLEY, BURTON R. (Northwestern State College, Natchitoches, Louisiana) and JAMES E. SUBLETTE (Eastern New Mexico U., Portales). II. The limnology of the upper part of Cane River Lake, Natchitoches Parish, Louisiana, with particular reference to the emergence of Chironomidae.

Cane River Lake is a shallow impoundment of what was once a channel of Red River. It has a well developed zone of emergent vegetation. While it does not develop stable thermal stratification, it does show occasional oxygen depletion from bottom water during summer months. The principal components of the benthos are Oligochaeta, Chironomidae, and *Chaoborus*, in that order. Forty-six species of chironomids were collected with emergence of some species occurring during every month of the year. Greatest emergence periods coincided with lowest larval population levels. Number of species by site of emergence was thirty-four from vegetation, thirty-six from littoral benthos, and three from the profundal benthos. Intersexuality of *Polypedilum digitifer* Townes is reported. Greatest period of diel emergence was between five and eleven P.M.