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Chironomid Remains in Recent Sediments of Lake Washington

Abstract

The vertical distribution of chironomid remains in the sediment of Lake Washington was determined in each centimeter of a core 35 cm long taken from a depth of 63 m in 1975. The time covered is nearly 100 years, and thus includes the period of eutrophication and recovery. More than 900 individuals representing 51 taxa were found, most of them of littoral and sublittoral origin. *Protanypus* sp. and *Heterotrissocladius* sp. were more frequent in older sediments, whereas *Phaenopsectra* sp. was more frequent in younger sediments. The differences were small, and the results show that the bottom fauna did not respond to eutrophication with major changes in species composition.

Introduction

A sedimentary record of the eutrophication of Lake Washington and the lake's recovery after diversion of sewage has been demonstrated to exist as vertical variations in the composition of diatom remains (Stockner and Benson, 1967), pigments of bluegreen algae (Griffiths and Edmondson, 1975), and chemical properties of the sediments (Shapiro *et al.*, 1971; Edmondson, 1974). The preserved larval head capsules of midges of the family Chironomidae are very useful indicators of past changes in the condition of a lake (Deevey, 1942; Frey, 1964; Hofmann, 1971; Warwick, 1974). Although knowledge of the present chironomid fauna of Lake Washington is far from complete, a survey of the chironomid remains in the recent sediments was judged as worthwhile in view of the well documented changes in the lake during the last 60 years.

Lake Washington experienced two periods of eutrophication, the second with treated sewage effluent in the period 1941-1968 (Edmondson, 1972). Concentrations of oxygen in the hypolimnion in late summer remained above 3 mg/l most of the time, and anaerobic conditions did not develop for prolonged periods in a large part of the lake. Thus large qualitative changes in the hypolimnetic fauna based on oxygen requirements would not be expected, although species with specialized food requirements might be expected to change since the character of the phytoplankton varied greatly.

Methods

The core (Laboratory No. 61C) was taken on 5 February 1975 with an automatic piston corer, 35 mm in diameter, at 63 m depth in the central part of Lake Washington, near the western shore (point MP in Shapiro *et al.*, 1971). The sediment was cut in slices 1 cm thick and treated according to methods slightly modified from Hofmann (1971) After boiling with 10 percent KOH in a water bath for 10-20 minutes, the sample was diluted with water and allowed to settle. The water was decanted and 10 percent HCL added. After a few minutes, the sample was sifted through a 0.22 mm net. The sieved remains were carefully washed with water and transferred to a petri dish and sorted under a binocular at 25 times magnification or more. All remains of chironomid larvae were passed through absolute ethanol and Cedar wood oil and mounted as permanent slides in Canada balsam.

Some fairly complete head capsules were found, but most of the material was heavily fragmented and the identification had to be made from the structure of the mentum only. For this reason, and because of the lack of comparative recent larval material from the littoral part of the lake, some of the genera within the Tanytarsini, Orthocladiinae, and Tanypodinae could not be positively identified.

Results and Discussion

Altogether 950 individuals were recovered from the uppermost 35 cm of the core. The material was surprisingly diverse with 51 different taxa (Table 1). From the large number of taxa found in this limited material, a comparatively large total number of chironomid species in Lake Washington may be postulated.

The great diversity as well as the specific composition of the fauna makes it clear that most of the chironomids found originate from much more shallow areas than the actual sampling site. Of the fifty-one taxa encountered only five, namely *Chironomus*, *Procladius*, *Phaenopsectra*, *Heterotrissocladius*, and *Protanypus*, belong to the fauna of the deep profundal (Thut, 1969; and Wiederholm, unpub. data). About 20 percent of the chironomids found in the core belong to these genera. Since most of them occur also in shallow areas, considerably more than 80 percent of the material may be expected to be the result of redeposition of material from littoral, sublittoral, and more shallow profundal areas. The three dominating genera, *Stempellina*, *Tanytarsus*, and *Cladotanytarsus,* are mostly littoral in their occurrence. Also, the somewhat less frequent *Polypedilum, Dicrotendipes*, *Cladopelma*, and *Paratanytarsus* are most numerous on littoral and sublittoral bottoms.

A remarkable fact is that no specimens of *Stictochironomus*, a regular member of the profundal communities in the eastern part of the lake (Thut, 1969), have been found in the present material. This further underlines the littoral character of the subfossil chironomid fauna.

The abundance of chironomids varies greatly with depth (Fig. 1). Except for the maximum between 12 and 13 cm, which is more than twice the number found at the second highest level, the total number of head capsules seems to be generally higher in the lowest part of the core. The numbers in the upper 9 cm and especially the uppermost 5 cm are remarkably low. No head capsules at all were found in the first and third cm of sediment.

A comparison of the different genera shows that the various peaks reflected in the total number of chironomids are consistent for nearly all taxa. Consistently higher numbers were found at 9-10, 12-13, and 18-20 cm depth. Many taxa show peaks also at 29-30 and 32-34 cm depth. This covariation among a great number of species proves that the head capsules are not randomly distributed along the vertical profile. Instead the variations in numbers must reflect specific events in the lake. These events may be of local character or include the whole lake.

In view of the strongly littoral character of the material as a whole, factors affecting the shallow areas of the lake should be considered first. Among these are currents, waves, and seiches, which may exert an eroding effect on the littoral and sublittoral bottoms resulting in transport and redeposition of sediments into deeper areas. One of the main

TABLE 1. Numbers of chironomids in the upper 35 cm of a core taken from Lake Washington in February, 1975.

	Numbers found	% of total
Stempellina	94	10
Tanytarsus	85	9
Cladotanytarsus	76	8
Procladius	71	8
Polypedilum	62	7
Chironomus	60	6
Dicrotendipes	57	6
Cladopelma	37	4
Paratanytarsus	35	4
Tanytarsini, unidentif.	33	4
Pentaneurini part.	27	3
Heterotrissocladius	26	3
Glyptotendipes	20	2
Protanypus	18	2
Orthocladiinae, unidentif.	14	1
Limnophyes	14	1
Tanypodinae, unidentif.	13	1
cf. **Cricotopus**	13	1
Psectrocladius	12	1
Micropsectra	12	1
Paraphaenocladius	11	1
Nilodorum	11	1
Paratendipes	11	1
Phaenopsectra sp. A	10	1
Phaenopsectra sp. B	10	1
Pseudochironomus	10	1
Endochironomus	9	< 1
cf. **Orthocladius**	8	< 1
Microtendipes	8	< 1
Parachironomus	8	< 1
cf. **Chaetocladius**	7	< 1
Chironomini, unidentif.	7	< 1
Labrundinia	6	< 1
Pseudosmittia	5	< 1
Zavrelia	5	< 1
Parakiefferiella sp. B	4	< 1
Phaenopsectra sp. D	4	< 1
Parakiefferiella sp. A	3	< 1
Orthocladiinae sp. H	3	< 1
Cryptochironomus	3	< 1
Phaenopsectra sp. C	3	< 1
Constempellina	3	< 1
cf. **Corynoneura**	2	< 1
Eukiefferiella	2	< 1
Monodiamesa	1	< 1
Unknown genus near **Paracricotopus**	1	< 1
? **Bryophaenocladius**	1	< 1
Cricotopus (Isocladius)	1	< 1
Orthocladiinae sp. G	1	< 1
Cryptotendipes	1	< 1
? **Fleuria**	1	< 1
Pagastiella	1	< 1
Stenochironomus	1	< 1
Unknown gen. Chironomini	1	< 1
Tanypodinae	117	12
Diamesinae	19	2
Orthocladiinae	128	14
Chironominae, Chironomini	336	35
Chironominae, Tanytarsini	343	36
Unidentified	7	< 1
	950	100

events in the recent history of Lake Washington was the lowering of the level in 1916 by 3.3 m. X-radiographs taken of the present core before slicing show that this date is reflected as a strong lamination extending from 24.5 to 27.5 cm in the core.

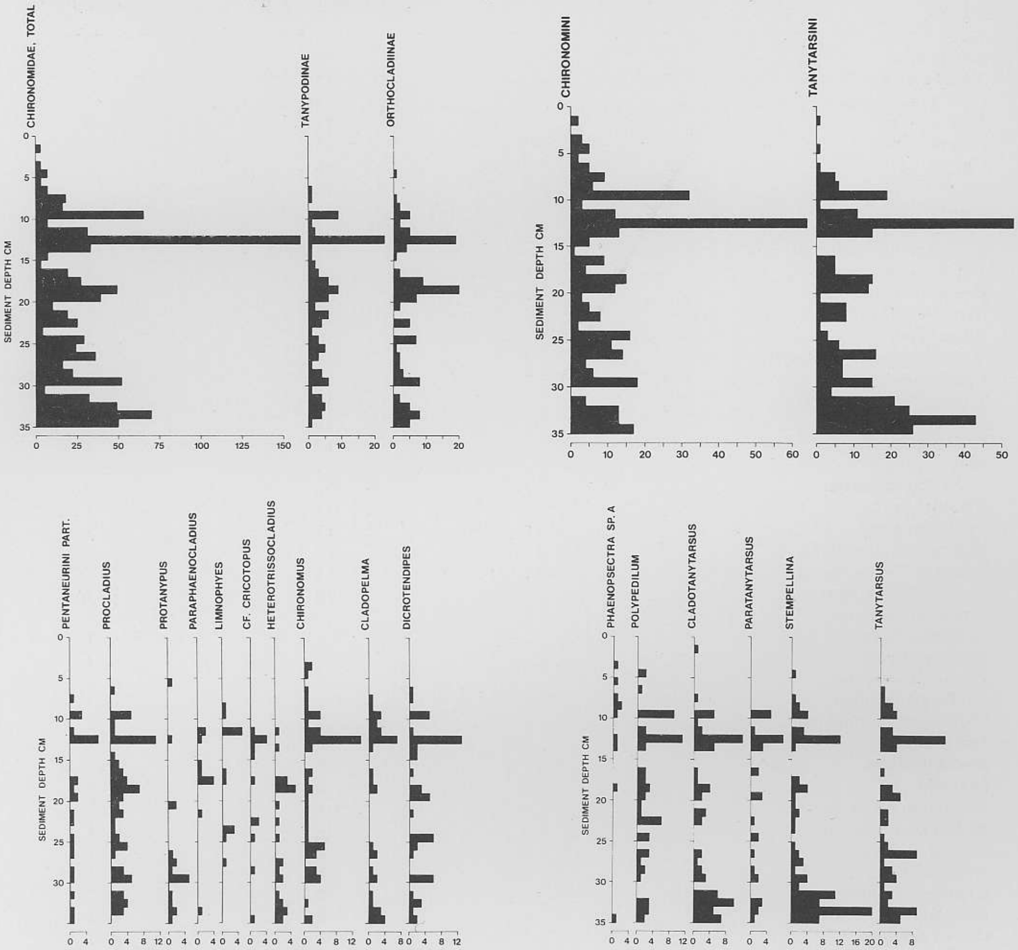

Figure 1. Vertical distribution of chironomids within the sediment core mentioned in Table 1; numbers per cm length of core. The levels 5, 6, 11, and 16 cm may not be strictly quantitative as a result of initial difficulties in the sorting.

The effect that might be expected on the number of fossil chironomids from the lowering of the lake is not clear. The increased erosion of the newly exposed littoral areas may increase the deposition of inorganic material on deeper bottoms, but the animal remains previously deposited in these areas should also be transported to the deeper bottoms. The picture is also complicated by the fact that physical changes after lowering of the lake may have changed production of chironomids during the period of stabilization of the new littoral bottoms and their colonization.

Edmondson and Allison (1970) found several prominent laminations in X-radiographs of cores from the same area of Lake Washington. They assumed that many of them resulted from some event or condition that temporarily increased the local input of silt relative to organic matter, but these events could not be identified. Most of the banding in the upper part of the cores results from layers dominated by diatoms alternating with layers dominated by silt and iron hydroxide. Presumably this alternating reflects seasonal changes in deposition, each clear diatom layer representing a spring bloom (Edmondson, 1974; and pers. comm.). Some cores have occasional X-ray absorptive layers that contain silt, possibly as a result of unusual events of redeposition of littoral material. In the present core, the X-radiograph shows layers from 9.5-10.0 cm, 13.5-14.5 cm, and in a thin layer at 18 cm. These correspond to peaks on the total chironomid curve within 1 cm.

Few clear indications of the periods of eutrophication are shown by the chironomid remains, largely because littoral and sublittoral species comprise the bulk of the material. These species are less useful as indicators of the lake's trophic state than those of the profundal communities. The sedimentary record is also blurred by the effects of the supposedly littoral events discussed above.

Some indication of general changes in the lake compared to earlier periods may, however, be found in the material. Among the specific indicator organisms, the genera *Protanypus* and *Heterotrissocladius* are more frequent in the layers deposited more than 75 years ago, (i.e., below 25 cm depth) than in the more recent material. Members of these genera are primarily restricted to oligotrophic lakes (cf. Sæther, 1975, Table 1). Also, *Phaenopsectra* sp. is more frequent above 15 cm depth of sediment. Species within this genus occur more frequently in more productive lakes than do those of the previous genera. Further, the percentage of *Chironomus* sp. is greater in the upper half of the core than in the lower part. Species of *Chironomus* are associated with mesotrophic-eutrophic conditions when occupying a dominant position in the chironomid fauna. The changes in vertical stratification referred to above are consistent with the known changes in the lake, although the numbers of each taxa are small except for *Chironomus.*

As for the representativeness of the single core studied, it may suffice to cite Griffiths & Edmondson (1975), who, after analysis of pigments in several cores from the actual sampling site, wrote: "The general pattern of the oscillaxanthin profiles are again strikingly similar, which should lend encouragement to investigators who have to interpret data from single cores . . . ." Cores from a more central part of the lake may show a lower proportion of littoral and sublittoral taxa, but major changes in the chironomid fauna, had they occurred, would no doubt show up also in the area studied here.

The scarcity of remains in the top 5 cm must be in part related to the fact that the sediment has not fully compacted, and represents a smaller time of accumulation than a similar thickness of deeper sediment. Cores in this area of the lake have about two-thirds the dry weight content in the top 5 cm as in the next 5 cm. The difference in abundance of remains, however, is not proportional to the time of accumulation. The possibility exists that the production of littoral chironomids has been reduced since the diversion of sewage.

In summary, while the bottom fauna of Lake Washington changed during periods of eutrophication and de-eutrophication, changes in composition of taxa were relatively small. Subtle shifts in species composition may have occurred, but these changes did not reach the level of exclusion of whole genera or a pronounced increase in abundance of others. This condition may be attributed largely to the fact that eutrophication was not permitted to reach the point of generating anaerobic conditions in the hypolimnion, and that enrichment lasted relatively few years.

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