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EFFECT OF A SALT WATER INTRUSION ON A FRESHWATER CHIRONOMIDAE COMMUNITY: A PALEOLIMNOLOGICAL STUDY

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Abstract

Examination of two 90 cm sediment cores from Front Lake, a shallow (1 m) eutrophic habitat, revealed a chironomid community consisting of at least 24 species prior to the destruction of the fauna by an intrusion of salt water resulting from the high tides associated with the Saxby Gale of 1869. With the withdrawal of the salt water and a return to freshwater conditions, 23 species recolonized the lake. Of these, 22 were also found in the preintrusion community. The three species not common to both freshwater periods constituted only 2.3% of the head capsules recovered. Consequently, the chironomid community established in Front Lake both before and after the salt water intrusion had essentially identical species compositions, relative abundances of each species, and species diversity indices.

Introduction

Nursall (1952) and Paterson & Fernando (1969a, b; 1970), amongst others, have shown that macro-invertebrate colonization of newly formed aquatic habitats proceeds very rapidly and is essentially complete, with respect to species composition, after one complete growing season. Subsequent changes in the fauna primarily involve modifications in the relative abundances of the various species brought about by time related changes in the trophic structure of the habitat.

An understanding of the rates and processes of colonization and stabilization of aquatic communities is of obvious importance in predicting the recovery of habitats from natural or man-induced perturbations. If it is assumed that the destruction of the original community does not modify the trophic potential of the habitat, then the question is raised as to whether the community that will become established upon removal of the disturbance will be identical to the pre-disturbance community.

In 1868, Lieutenant S. M. Saxby of the Royal Navy, published in the London papers a warning that on October 5, 1869 the position of the sun and moon would be such that unusually high tides would result (Machum, 1965). This tide, accompanied by gale force winds, funneled up the Bay of Fundy between New Brunswick and Nova Scotia and peaked at 17.5 m above extreme low water level. A tide of this height would flood the marshes at the head of the bay, and several of the shallow freshwater lakes located on the landward side of the marshes, with the silt laden waters of the Bay of Fundy.

Front Lake, one such shallow lake, is 5.6 m above mean sea level and would have been flooded by the Saxby gale. This presented an opportunity to examine the effect of a naturally occurring perturbation on a freshwater chironomid community. Head capsules of the Chironomidae frequently have been used to reconstruct past conditions in lakes (Deevey, 1942; Stahl, 1959, 1969; Frey, 1964; Harmsworth, 1968; Alhomen & Haavisto, 1969) but the cores are most commonly

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obtained in relatively deep water where mixing at the mud-water interface is minimal. In a shallow habitat, such as Front Lake, such mixing would be extensive and discrete strata would not be observed. However, we felt it would be possible to compare and contrast the chironomid community inhabiting the lake prior to, and after, the massive salt water intrusion.

Methods

Front Lake is a small (ca 110 ha) eutrophic lake situated 10 km N.E. of Sackville, N. B. It is located on the landward edge of the Tantramar salt marsh at the head of the Bay of Fundy. The lake is shallow (ca 1 m) and supports extensive growth of *Scirpus validus* Vahl, *Potamogeton natans* L., *Acorus calamus* L. and *Nuphar* sp.

Two 90 cm cores were taken in September, 1972 from the midpoint of the widest portion of the lake with a hand-driven 5 cm inside diameter aluminium coring tube. Water depth at the sampling site was 1 m. The two cores were taken 1 m apart. The cores were extruded, wrapped in aluminium foil, frozen and then sawed into 1 cm sections. Each section selected for examination was dried at 60°C for 48 hr. A weighed sample was then ignited in a muffle furnace at 600°C for 2 hrs, cooled to room temperature in a desiccator, and reweighed to determine loss on ignition which is interpreted as a measure of the relative abundance of organic material.

A further weighed sample (0.5 g) was softened in distilled water and gently strained through a 0.105 mm sieve. The material trapped in the sieve was back-

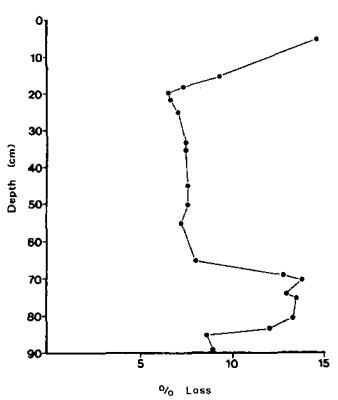

Fig. 1. Loss on ignition (%) measurements for sediment from various depths below the mud-water interface. Each point is an average of the values obtained from the two cores.

washed into a counting chamber and examined with a stereomicroscope. All chironomid head capsule remains were removed and mounted on microscope slides for identification. Only those head capsules which were complete enough to allow for identification were counted. Chironomid nomenclature follows Hamilton *et al.*, (1969).

Species diversity was calculated by the method of Shannon & Weaver (Odum, 1971).

Both cores were examined but as the results obtained were essentially identical, the data have been pooled.

Results

1) *Sediment characteristics*

Visual examination of the cores revealed five zones which could be discriminated on the basis of colour and texture of the sediment. Between 34 and 65 cm the sediment was of uniform texture and, as will be discussed later, was devoid of recognizable remains of freshwater organisms. This zone is interpreted as constituting relatively unadulterated marine silts deposited by the Saxby gale. Between the 65 cm and 75 cm levels the sediment appeared to be a mixture of the marine silts with the underlying freshwater deposits. The change in the nature of the sediments above 65 cm is indicated by the percent loss on ignition (Fig. 1). The situation observed between the 18 cm and 34 cm levels in the cores is more difficult to interpret. The sediment in this region is very similar to the marine silts although the content of organic matter is somewhat lower and chironomid remains are present. The chironomid remains might be partially explained by downward mixing as a result of the shallowness of the habitat but it is also possible that this zone represents a period of rapid sedimentation after the withdrawal of the salt water intrusion. This rapid sedimentation would result from the extensive quantities of marine silt that must have been deposited in the drainage basin of the lake during the gale and then transported into the lake basin by freshwater drainage and surface run-off. Decomposition and leaching could have reduced both the organic and salt content of these sediments prior to their deposition in the lake.

The sediments between the surface and 18 cm appear identical to those below 75 cm.

2) *Chironomid fauna*

The chironomid taxa recovered from the cores are listed

Table 1. Chironomidae head capsules recovered from two 90 cm cores obtained from Front Lake, N. B. Before and after refer to the periods prior to, and after, the flooding of the lake basin by salt water. + = present; — = absent.

Taxa	After	Before
Tanypodinae		
Procladius	+	+
Unident. Tanypod	+	+
Orthocladiinae		
Coryneura	+	+
Cricotopus sp. 1	+	+
Cricotopus sp. 2	+	+
Limnophyes	+	+
Psectrocladius	+	+
Trissocladius	+	+
Unident. Orthoclad. 1	+	+
2	+	+
Chironominae		
Chironomus	+	+
Cryptochironomus	+	+
Dicrotendipes sp. 1	+	+
Dicrotendipes sp. 2	—	+
Einfeldia sp. 1	+	+
Einfeldia sp. 2	+	+
Glyptotendipes	+	—
Harnishia	+	+
Microtendipes	+	+
Phaenopsectra	+	+
Polypedilum sp. 1	+	+
Polypedilum sp. 2	+	+
Stichtochironomus	—	+
Unident. Tanytarsini	+	+
Stempellina	+	+
Total Taxa	23	24

in Table 1. The forms encountered all appear to be common inhabitants of local shallow lakes but identifications based only on head capsules, particularly as these are often damaged, has certainly resulted in the grouping of more than one species into several of the recognized taxa. In spite of this obvious shortcoming, it can be seen that the chironomid faunas inhabiting the lake both before and after the salt water intrusion are very similar. Of the 25 recognized taxa, 24 were found in the sediments below the tidal silt and 23 were recovered from the more recent freshwater sediments. Each of the three species restricted to only one zone was never represented by more than three head capsules. Collectively, these three species accounted for only 2.3% of the 303 head capsules examined. Consequently, the apparent restriction of each of these species to one zone is probably a result of the problems associated with sampling rare species and is not indicative of differences in the composition of the chironomid communities occuring in the lake prior to, and after the intrusion.

The average number of chironomid head capsules recovered per 0.5 g of dry sediment from different depths is shown in Fig. 2. The rapid decline from 47

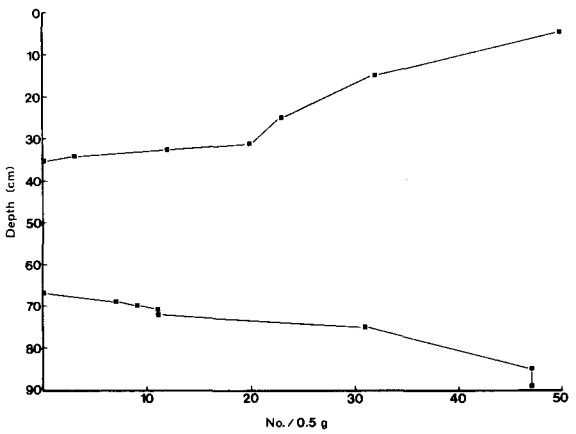

Fig. 2. Variation with depth in the abundance of head capsules of chironomid larvae. Each point is an average of the values obtained from the two cores.

head capsules per 0.5 g at 89 and 85 cm to a complete absence at 67 cm reflects a 'dilution' of the superficial sediments by the tidal silt introduced by the Saxby gale. The apparent increase in head capsule abundance from the 34 cm level to the 5 cm level is again a result of the downward mixing of freshwater sediments into the tidal silt. However, it can be seen that the abundance at the 5 cm level (50/0.5 g) is essentially identical to the abundance in the deepest layers of the cores.

While it has been shown that the species composition and the abundance of head capsules are essentially identical in the freshwater sediments deposited both before and after the salt water intrusion, the question arises as to the possibility of changes in the relative abundance of each species in the two zones. When the abundance of each species is expressed as a percentage of the total number of chironomids recovered from the two regions of the cores (Fig. 3) it is seen that only one species *(Trissocladius)* showed a change in its contribution to both communities that amounted to more than 4%. The similarity in the number of species and the relative abundance of each species found in the two regions of freshwater sediments within the cores re-

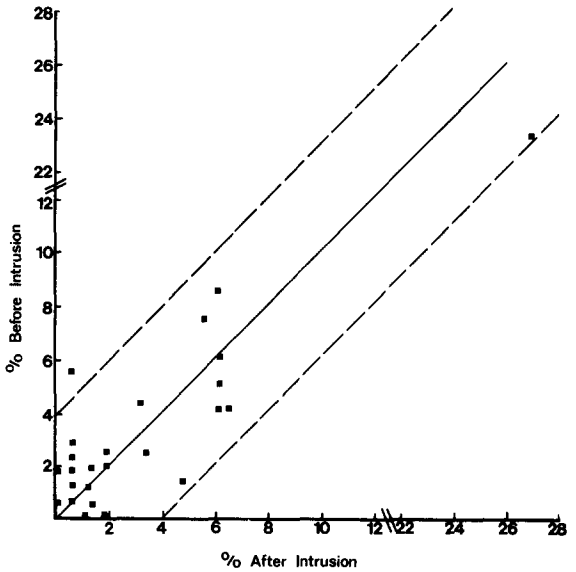

Fig. 3. A comparison of the relative importance of each recognized chironomid species to the chironomid community existing in Front Lake before and after the salt water intrusion. The relative abundance is expressed as the percentage of the total head capsules from each zone contributed by each species. The solid line represents the theoretical situation if the two communities were identical. Dashed lines enclose the region where the contribution of each species to the two communities does not change by more than ± 4%. Note break in scale.

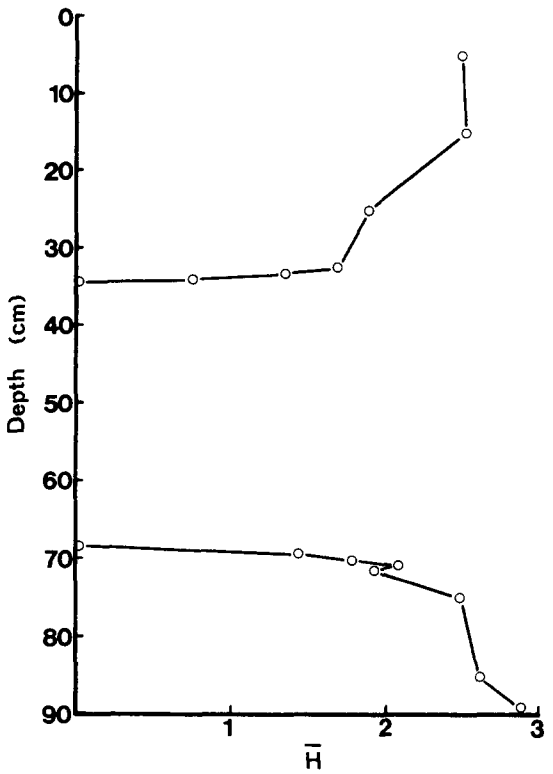

Fig. 4. Shannon and Weaver species diversity ($\bar{H}$) for the chironomid community found at each examined depth in the sediment of Front Lake. The numbers found in the two cores were pooled prior to calculation of $\bar{H}$.
$\bar{H} = -\Sigma$ Pi log e Pi.

sulted in very similar species diversity indices for the two regions (Fig. 4).

Discussion

Larval chironomids are a major component of the macro-invertebrate fauna of a majority of lentic habitats. While it has long been recognized that some general correlations can be established between the types of chironomids found in the profundal zone of lakes and the trophic status of the lake (Deevey, 1941; Weerekoon, 1956), little information appears to be available on the manner in which interactions between morphological, edaphic and climatic factors; or a measure of trophic status, are related to the composition of the chironomid community in shallow water habitats.

In Front Lake, the massive intrusion of salt water caused by the Saxby gale would have eradicated the chironomid community. However, flushing of the salt water from the lake would rapidly re-establish a freshwater habitat which, with the exception of a minor decrease in depth, would have the same morphological, edaphic and climatic characteristics as found prior to the intrusion. As several of the species recovered from the cores are commonly found in association with macrophytic vegetation in this region, the rate of colonization by these species would be dependent on the re-establishment of the vegetation in the lake. However, colonization would not be hampered by an absence or rarity of potential colonizers in the region of the newly established habitat. Within 2 km of Front Lake there are numerous shallow water bodies located above the level reached by the tides of the Saxby gale and adult chironomids emerging from these sites would serve as a pool of potential colonizers. It is interesting to note that these habitats presently contain numerous species not recorded from Front Lake although the habitats appear to be superficially very similar.

While it is not presently known how the various biotic

and abiotic parameters interact to control the structure and composition of shallow water chironomid communities, the analysis of the cores from Front Lake suggests that recolonization of such a habitat after a major environmental perturbation destroyed the fauna and flora, but did not substantially alter the abiotic characteristics, resulted in the establishment of a chironomid community structure essentially identical to the pre-perturbation community.

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