QUATERNARY RESEARCH 28, 427–430 (1987)

LETTERS TO THE EDITOR

Aquatic Invertebrates as Paleoclimatic Indicators?

Representatives from almost every group of freshwater invertebrates leave fossil remains in Quaternary lacustrine and peat deposits. In recent years, mollusks, beetles, ostracodes, Cladocera, and chironomids have received the most attention in Quaternary ecology. Problems emerge, however, when assessing their utility as paleoclimatic indicators.

The paper by Walker and Mathewes (1987) on fossil chironomids from coastal British Columbia underscores some problems with inferring paleoclimates from freshwater invertebrates. In view of Walker and Mathewes' statement that their study "should be of broad interest to Quaternary scientists" (p. 90), we feel it is equally important to point out the limitations of using chironomids, and freshwater invertebrates in general, as paleoclimatic indicators. Unfortunately, freshwater invertebrates continue to be used in paleoclimatology despite the cautionary concerns expressed by others working with other groups of freshwater invertebrates (e.g., Crisman, 1978; Ouellet, 1983; Hann and Warner, 1987). It is not our intention to reinterpret the paleoecology of Marion Lake, but we wish to focus on three main issues raised by their paper: (a) wide geographical distributions and the value of selected taxa as climatic indicators, (b) developmental changes in catchments and their influence on the limnological environment and invertebrate community structure, and (c) the sensitivity of freshwater invertebrates to regional climatic changes.

In view of the similarity between the late-glacial *Heterotrissocladius* fauna and one of more northern affinities today, Walker and Mathewes interpret "this similarity as being paleoclimatically induced" (p. 90), and they find it "compelling, therefore, to invoke climate as the principal factor regulating occurrence of the *Heterotrissocladius* community" (p. 98), and "we believe climatic variations are necessary to account for the early chironomid succession" (p. 99). In at least two other studies of late-glacial chironomids from temperate lakes in North America, *Heterotrissocladius* is not reported (Sreenivasa, 1973; Stark, 1976). One is led to ask if the *Heterotrissocladius* fauna was as widely distributed during late-glacial time as Walker and Mathewes contend, and if a decline in a late-glacial *Heterotrissocladius* fauna really represents a simultaneous environmental response across North America. It is probably premature to speculate on the ecological and, indeed, on the paleoclimatological significance of a *Heterotrissocladius* fauna with so few detailed studies (from about six sites) of late-glacial chironomid faunas in North America.

Ecological inferences based on identification to generic level only must of necessity be of a general nature. As a consequence of the overwhelming taxonomic difficulties with the Chironomidae (Crisman, 1978), it is often impossible to distinguish among an ecologically diverse group of species within a genus, therefore complicating paleolimnological, and certainly paleoclimatological, reconstructions. We echo Delorme's (1969, p. 1471) statement: "the amount of paleoecological information obtained by such interpretations is proportional to the amount of ecological data available on the particular organism or faunal assemblage." It is this dearth of precise, species-specific ecological data that

0033-5894/87 $3.00

https://doi.org/10.1016/0033-5894(87)90009-3 Published online by Cambridge University Press

so severely constrains the utility of freshwater invertebrates in paleoecological interpretations. Similarly, this brings into question the significance of interpretations based on faunal changes through time in the percentage diagram drawn almost exclusively using genera and species groups (Walker and Mathewes, 1987, Fig. 5, p. 96).

The wide geographical distribution of the "cold-stenothermous" taxa (including *Heterotrissocladius*), which occur at shallow depths at higher latitudes and presumably altitudes and at profundal depths at lower latitudes, suggests that regional climates play little role in regulating their distribution. Only if it can be shown that individual taxa have narrow temperature tolerances will they attain paleoclimatological indicator value.

We prefer to regard this similarity between late-glacial and modern high-latitude littoral faunas as a function of similar lake trophic status, turbidity, and substrate characteristics, especially organic content. Several workers have demonstrated that *Heterotrissocladius* spp. occur in ultraoligotrophic and oligotrophic conditions (Sæther, 1975; Warwick, 1975, 1980). In his detailed investigation of the sedimentary record in the Bay of Quinte, Lake Ontario, Warwick (1975, 1980) showed that some *Heterotrissocladius* spp. can readily tolerate turbid conditions that might occur in pioneering situations with predominantly mineral sediments (Warwick, 1980, p. 1218). It seems that a *Heterotrissocladius* fauna reflects oligotrophy and unstable conditions occasioned in pioneering environments (i.e., high sedimentation, turbidity, low nutrients, and low autochthonous and allochthonous organic input), regardless of climatic regime. Hofmann (1971) and Brodin (1986) similarly associate a *Heterotrissocladius*-dominated fauna with nutrient-poor sediments, unstable environments, and rapid sediment accumulation. Lawrenz (1975, *in* Frey, 1976; Crisman, 1978) ascribed a late-glacial transition from a *Heterotrissocladius/Tanytarsus*-dominated fauna to *Phaenosectra* as due to a trophic change from oligotrophy to mesotrophy as organic content of the profundal sediments increased and lake levels dropped.

Walker and Mathewes list several studies in which the late-glacial chironomid community was dominated by *Heterotrissocladius,* after which the taxon virtually disappears during the postglacial period. In contrast, in their study of Marion Lake, *Heterotrissocladius* constitutes approximately 10% or more of the fauna throughout Holocene time to the present. A more parsimonious explanation for the occurrence of the *Heterotrissocladius*-dominated community during the late-glacial period is its ability to thrive in unstable substrates with low organic content, and in waters with moderate turbidity. Although this suite of conditions may commonly occur during late-glacial periods, and may be associated with cooler climates, it is not necessarily correlated only with cooler climates (as shown by Walker and Mathewes' own study and especially by Warwick (1980)).

Walker and Mathewes' introductory comments on chironomids as lake trophic indicators should not be underestimated. However, the system of lake typology characterized by chironomids was developed for profundal faunas, and the fauna reflects the ecological conditions of the profundal, and not the trophic state of the whole lake (Brinkhurst, 1974). Walker and Mathewes do not differentiate profundal and littoral forms, perhaps a major oversight in view of the purported importance of water temperatures and chironomid distributions; water temperatures can vary dramatically between the littoral and profundal parts of the lake. Perhaps, as in Hofmann's (1979) paper, they do not include a separate discussion on the paleoecology of littoral species because so little is known about their ecology and taxonomy.

Walker and Mathewes have demonstrated that chironomids show responses to environmental changes during postglacial time on the Pacific Northwest coast, but we are not convinced that correlations with pollen transfer functions support conclusively that climate is the explanation, or that chironomids can be regarded as a particularly useful group of freshwater invertebrates for deciphering past climatic changes. We would prefer to interpret the faunal change, coincident with the pollen change at about 10,000 yr B.P., as probably reflecting a major change in allochthonous organic matter and nutrient input to the lake as a consequence of vegetation change within the watershed that may have been climatically directed. Therefore, the chironomid community responded directly to the limnological changes in their immediate environment, the Marion Lake basin, and indirectly to changes in the catchment. Freshwater invertebrate communities are several steps removed from direct climatic influences; the aquatic environment acts as a strong buffer, greatly ameliorating the impact of climatic change.

Like most freshwater organisms used in Quaternary ecology, much more information is needed on the taxonomy, and on both the neo- and paleoecology, of specific taxa before they can be applied to problems of paleoclimatology. There is a need to establish a relationship between water temperature and lake trophic status, and water temperature and species occurrence (presence/absence and relative biomass), as has been attempted by George and Harris (1985) using modern limnological data. Another example is shown by recent progress with ostracodes. Forester (1983) and Delorme (1987) have established that freshwater ostracodes in North America are associated closely with salinity. The next phase is to establish the links between water salinity and climate before ostracodes can be used as paleoclimatic indicators. Work with most of the other groups of freshwater invertebrates in North America has not progressed beyond this point. Any paleoclimatic inference from freshwater invertebrates, albeit even qualitative estimates, may be premature, resulting in misleading and sometimes erroneous reconstructions.

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