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Application of Cladocera analysis in archaeology

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Summary

The fundamental principles of the analysis of subfossil Cladocera remains are presented, together with a discussion of their application in Quaternary geology and archaeology. The paper concludes with a discussion of the results of employing this analysis on two Polish archaeological sites.

Introduction

Cladocera belong to the class Crustacea. They constitute one of the main elements of freshwater fauna. Their bodies are covered with chitinised carapaces which remain preserved in bottom sediments, either after moulting or after the organism's death. They live both in small (temporary) basins and larger ones. Particular species inhabit different parts of the basin. Some stay near the bottom, whilst others inhabit the pelagic zone, but the majority of Central European species are littoral forms.

Some Cladocera feed on bacteria, algae, and organic detritus which they filter from the water and scrape from submerged surfaces. There are, however also a few predatory species. Cladocera are found over vast areas of the Earth and their remains are recorded in periods as early as the Eemian (Last) Interglacial (Frey 1962).

Features which enable an accurate determination of the species are contained in the following subfossil fragments of the carapace: headshields, antennules, elements of the post-abdomen, post-abdominal claws, and ephippia; they exhibit qualities which allow for a proper species identification (Fig. 14). The determination of the number of remains and their species is fundamental to a reconstruction of Cladocera communities living in a basin during the accumulation of a sediment from which the analyzed sample was collected. Particular species are character-ized by definite ecological requirements (Frey 1960); and, consequently, the reconstruction of the species composition of Cladoceran remains in the sample is of great importance in determining the conditions existing in the basin when the layer accumulated. Changes in the composition of the Cladocera remains, presented according to the geological sequence, enable a reconstruction of the basin's history to be made. On the basis of the evolution of the existing ecological conditions, it is possible to speculate about climatic changes (Hofmann 1987).

Cladocera and human activity

Eutrophication is a process typical for freshwater basins. It is a natural phenomenon defined as an increase in the concentration of biogenic substances in water. Its intensity depends on the degree to which food components flow in from the catchment as well as on the stage of geological development the lake has reached. The changes in trophic level are directly bound to changes in the conditions of the habitat, which, in turn, are followed by changes in the composition of zooplankton. When productivity is intensified, species preferring nutrient-rich water arrive (Crisman and Whitehead 1978). Of all Cladocera species, *Bosmina longirostris* is the main one indicating progress in eutrophication. Fluctuations in the occurrence of representatives of the family Bosminidae are closely connected with the changes in the trophic level of a basin.

Agriculture and stock-raising exert great influence on the process of enriching surface waters in food components and, consequently, accelerate eutrophication. When it is caused by human activity around a lake, this supply of nutrients is called anthropogenic (artificial) eutrophication.

A basin is a sensitive recorder of changes taking place in its catchment area. These changes are particularly evident on the temporal scale when, alongside natural

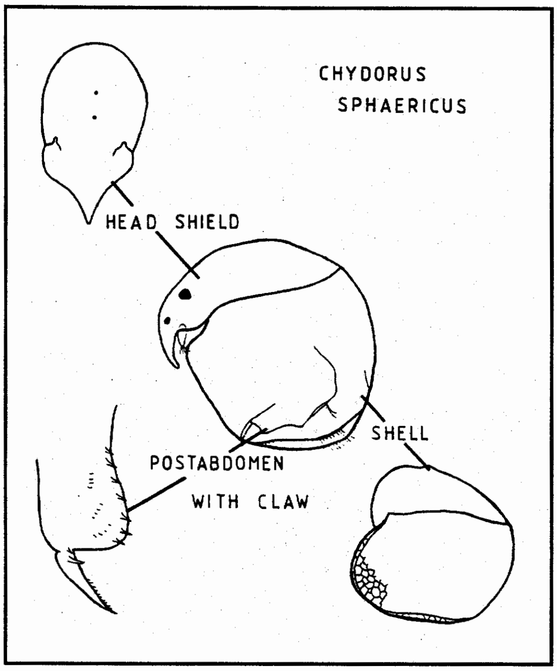


*Figure 14. The relation of the various fossil fragments to the entire living organism (*Chydorus sphaericus*).*

changes in trophic level, changes effected by humans are also recorded. These are connected with successive stages of colonisation around the lake. Human presence, marked by settlements, is not only limited to neolithic and ensuing cultures which have also been reflected in pollen diagrams.

Cladocera analysis also reveals more subtle changes in the environment triggered by the presence of pre-agrarian peoples. Their activity did not have a pronounced effect on flora and thus remains unmarked on pollen diagrams. However, it was not completely neutral to the natural environment. The encampments of pre-agrarian communities and their activities were a significant source of nutrients to the environment. Frequently, these sources were so pronounced that they may have caused an increase in lake trophic level and effected changes in the aquatic environment which were, finally, recorded in bottom sediments. It is possible to perceive and interpret these changes thanks to the reconstruction of Cladocera communities (Szeroczyńska 1991). Likewise, it is possible to trace environmental changes brought about by colonists who, in prehistory, made use of the waters of a lake or its shoreline. These colonists built shoreline and over-water settlements, bridges, dikes, piers, etc.

Another kind of information provided by the analysis of Cladocera concerns changes in water level. This is obtained by calculating the quantitative proportion of pelagic species to littoral ones (Mikulski 1978).

Cladocera analysis is used in complex palaeoecological investigations; it is also sometimes applied in archaeological research (Szeroczyńska 1981). Bog archaeological sites containing sediments of limnic origin are of particular importance here. Complex investigations of material collected directly from archaeological sites help to achieve a more complete reconstruction of living conditions of prehistoric communities.

Such investigations were carried out on a number of archaeological sites in Poland and enabled researchers to find new solutions. This refers particularly to such sites as Giecz (Polcyn and Polcyn 1994) and Mołtajny (Polcyn, in press), which serve to illustrate the investigative potential of Cladocera analysis.

Methods for analysing Cladocera

Material for analysis may be collected from cores of limnic sediment as well as directly from the walls of archaeological trenches. Sampling strategy depends on the information desired. Usually 1 cm^3 of the sediment is analyzed. A laboratory analysis is carried out according to the generally accepted procedure (Frey 1986). A sample is surveyed by means of a microscope (Fig. 15) and all Cladocera remains are counted.

The results of this observation are presented in tables which contain the absolute number of remains found in a 1 cm^3 sample of sediment. This, in turn, forms the basis for further calculations. Diagrams representing the absolute presence of individual species in a sample are a graphic representation of achieved results.

Application of Cladocera analysis on archaeological sites

(i) Giecz

The Early Medieval stronghold in Giecz (Central Wielkopolska) is situated on the rim of the valley of the Moskawa River which, in this place, used to form an overflow-arm in the shape of a long, narrow lake. At that time, the lake provided natural protection for the stronghold. Today, it is a entirely overgrown basin containing 10 metre-thick sediments. In the Early Middle Ages, the stronghold was connected to the settlement located on the opposite shore of the lake. In those days, the settlement was known for its fairs and a Romanesque church, which has survived to the present day. The two places were joined by a dike or a bridge, the remains of which are still visible on the surface as two rows of piles stuck into the ground close to one another.

Archaeological excavations carried out on these dike/bridge relics revealed the structure of the object, which was not subject to unequivocal interpretation. Any final conclusions were to follow the completion of other analyses (i.e. analysis of pollen, plant macrofossils, and Cladocera). The analysis of Cladocera was applied, among others, to two cores, one extracted from inside the wall of an excavation, and the other from inside the object itself, i.e. from between the rows of piles. The results of the study allowed conclusions to be drawn about the conditions existing in the basin before the dike/bridge had been constructed. They also helped to determine finally the function of the object. The first of these conclusions was based on an analysis of species composition of Cladocera remains in particular layers of sediments, whereas the second was based on the curves of total contents of Cladocera in samples. The results gave rise to the following division of layers (Fig. 16).

Open lake The undisturbed lake environment is mirrored in the lowest layers formed under conditions of undisturbed sedimentation. Many Cladocera species, at that time, found very favourable living conditions. The number of remains in 1 cm^3 reached 120,000.

Bridge The curve of the absolute presence of Cladocera in both cores shows significant deviations which reflect disturbances in sedimentation. At the same time, species composition is still characteristic of the fauna of eutrophic lakes, and the number of remains is high. These layers contain rich archaeological material; there is, however, no evidence of any wooden horizontal constructions.

Dike Following the disturbances in the functioning of the bridge, both curves show a drastic fall. The total content of Cladocera in some samples is zero; however, species composition in the other ones remains basically unchanged. It points to different sedimentation conditions which do not necessarily indicate different conditions of lake habitat.

Over the extent of the dike, the course of the curve for both cores is not identical. In the northern core, following a short period of fall, the curve rises again, indicating an aquatic environment. In the southern core, the low values remain throughout, almost to the topmost samples. In the layers discussed, a wealth of archaeological material was discovered. It was here that wooden structural elements were also deposited. The analyzed sediments accumulated during the process of filling in the construction and had as their purpose the creation of a surface extending over the level of the water. After a short period of the structure's functioning along its whole extent, between the rows of piles (a falling curve in both cores), only a part of the structure was used (a rising curve in the northern core and a breakdown in the sedimentation of the northern core). During higher water levels, this part was also inundated, which allowed Cladocera remains to get into the sediment.

Inundation and overgrowth The content of Cladocera in the topmost samples increases, after which it decreases with a simultaneous change in the species composition. Species remained which could withstand very unfavourable habitats. During this period, the dike ceased to exist and the lake gradually turned to land.

(ii) Mołtajny

Cladocera analysis was employed on material originating with a La Tène settlement of the Western Balt Barrow Culture on the island in Lake Arklickie in north-eastern Poland. A core of sediment from the wall of an excavation trench was analyzed (Fig. 17).

Twenty species of Cladocera were identified. These belonged to three families: Bosminidae, Chydoridae and Sididae. The majority of species found in the lowest layers of the sediment sequence are typical of shallow lakes and occur rarely and in small amounts—up to approximately 4,000 remains per cm^3. An increase in the number of remains recorded in the upper layers suggests an enrichment of the

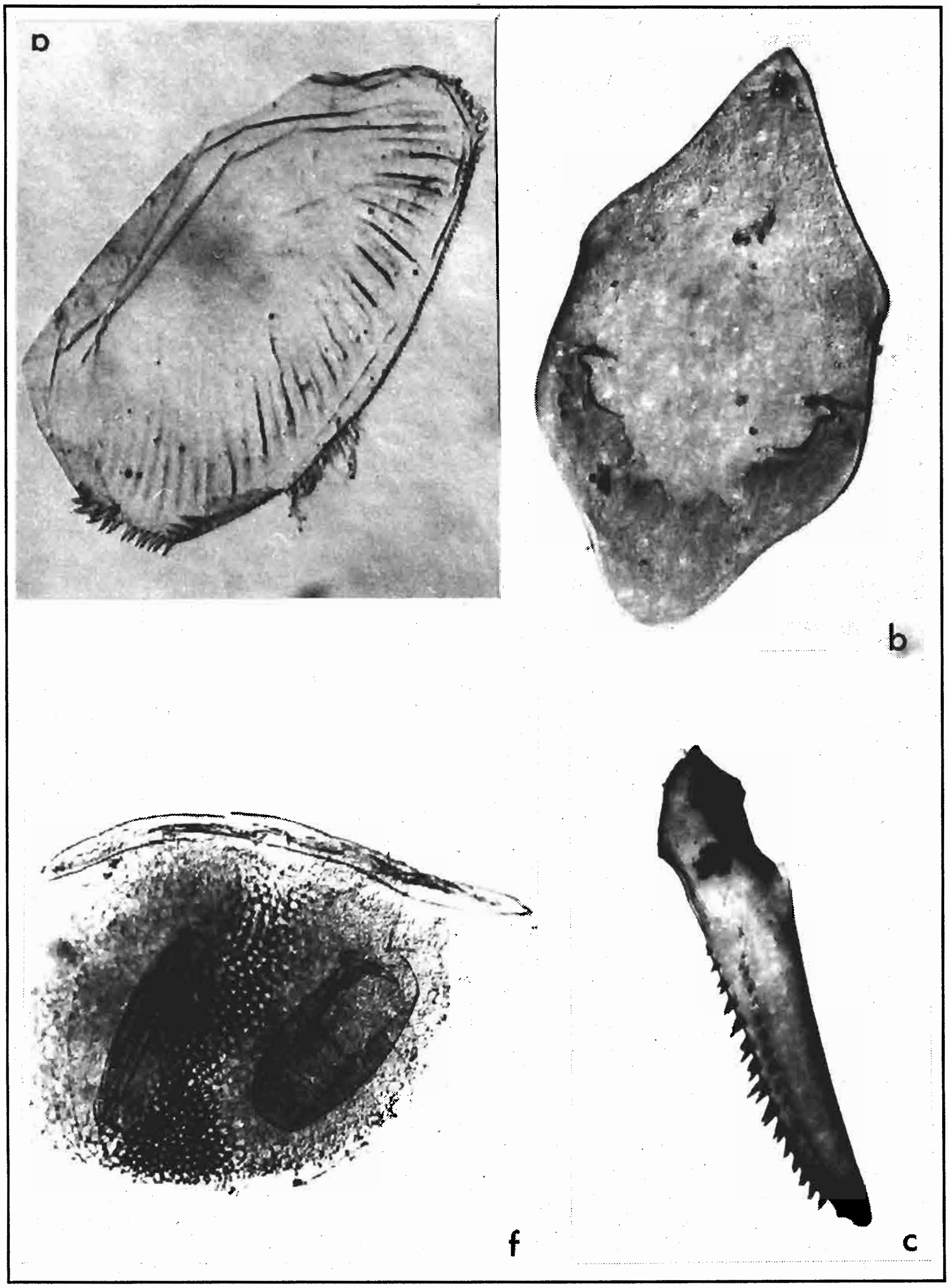
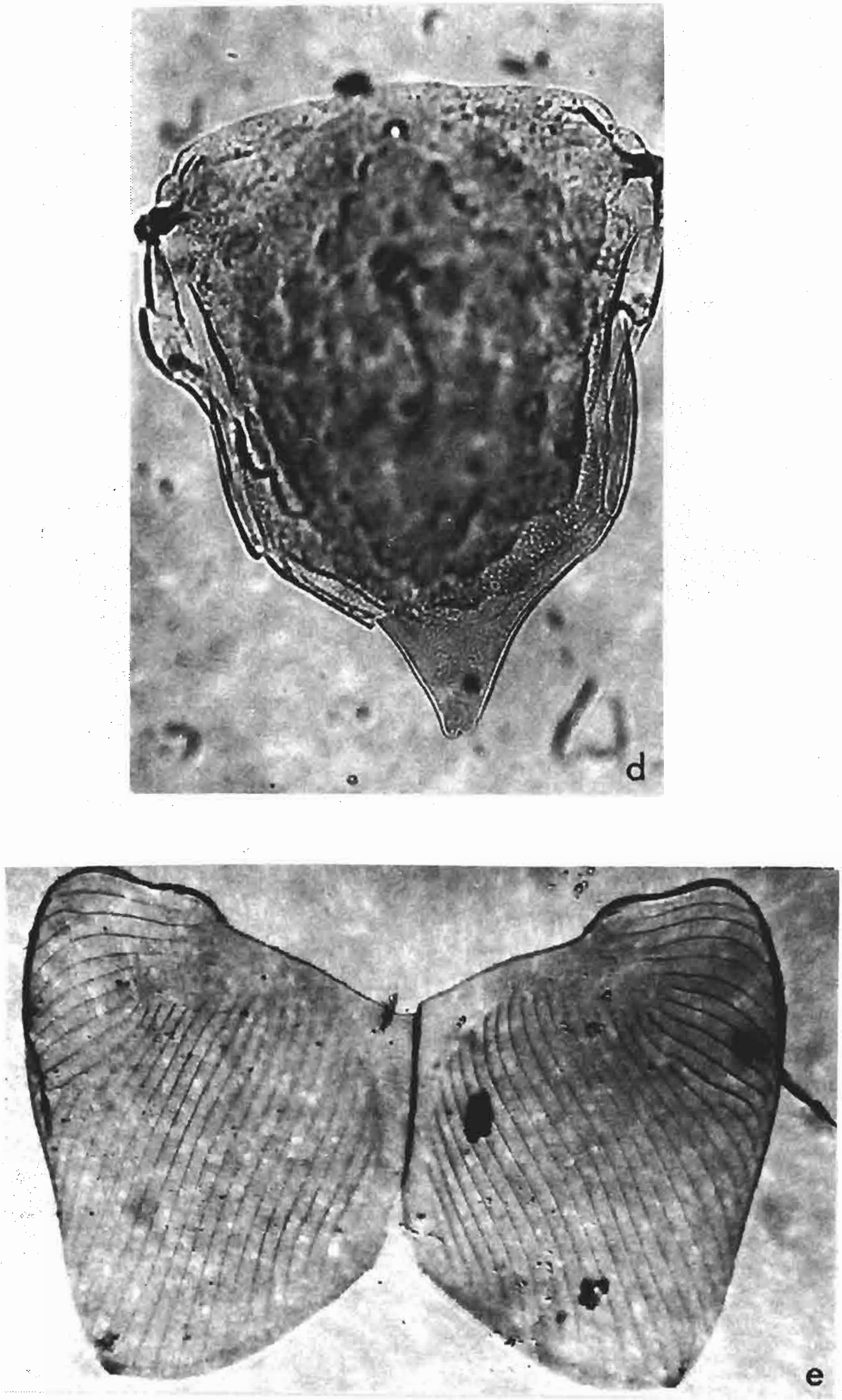


Figure 15 (above and opposite). A microscopic view of the remains of several Cladocera species from Giecz, Poland. a - Peracantha truncata*: shell, x 140; b -* Alona affinis*: head shield, x 140; c -* Camptocercus rectirostris*: postabdomen, x 200; d -* Monospilus dispar*: head shield, x 140; e -* Acroperus harpae*: shell, x 140; f -* Daphnia *sp.: ephippium, x 140.*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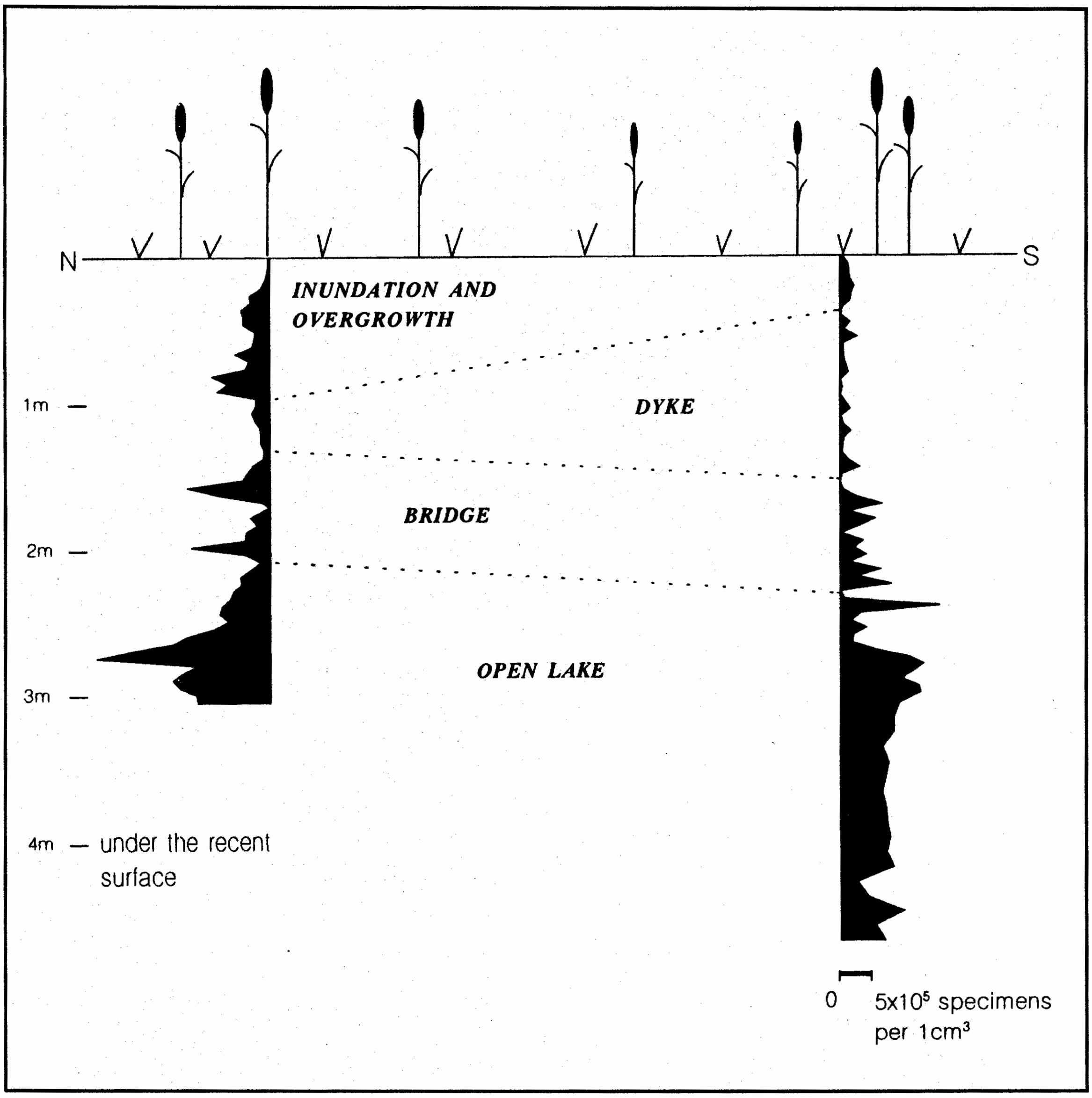

Figure 16. A reconstruction of the Early Medieval lake crossing in Giecz based on Cladocera analysis.

habitat; at the same time, the species composition remains unchanged. These conditions guarantee a maximum development of such littoral and eutrophic species such as *Bosmina longirostris, Chydorus sphaericus, Alona rectangula, A. guttata, Alonella nana.* It is possible to trace a relation between the sudden breakdown in the sedimentation process of Cladocera remains and the appearance of elements of wooden construction which marks the beginning of the culture layer deposition. This indicates that the people of the Western Balt Barrow Culture made use of the shoals to build their settlement. The grid-like structure of the settlement manifests the characteristics of an artificial island. This is confirmed by a culture layer formed above the water's surface (no Cladocera remains were found). The results of the Cladocera analysis preclude the possibility of a pile dwelling settlement, because in such an event, the culture layer would, under aquatic conditions, have accumulated mainly at the bottom of the lake.

Conclusions

1. Cladocera are often the most abundant of the crustaceans preserved in lake sediments. This makes the analysis of subfossil Cladocera remains a prominent method of Quaternary palaeolimnology and geology.

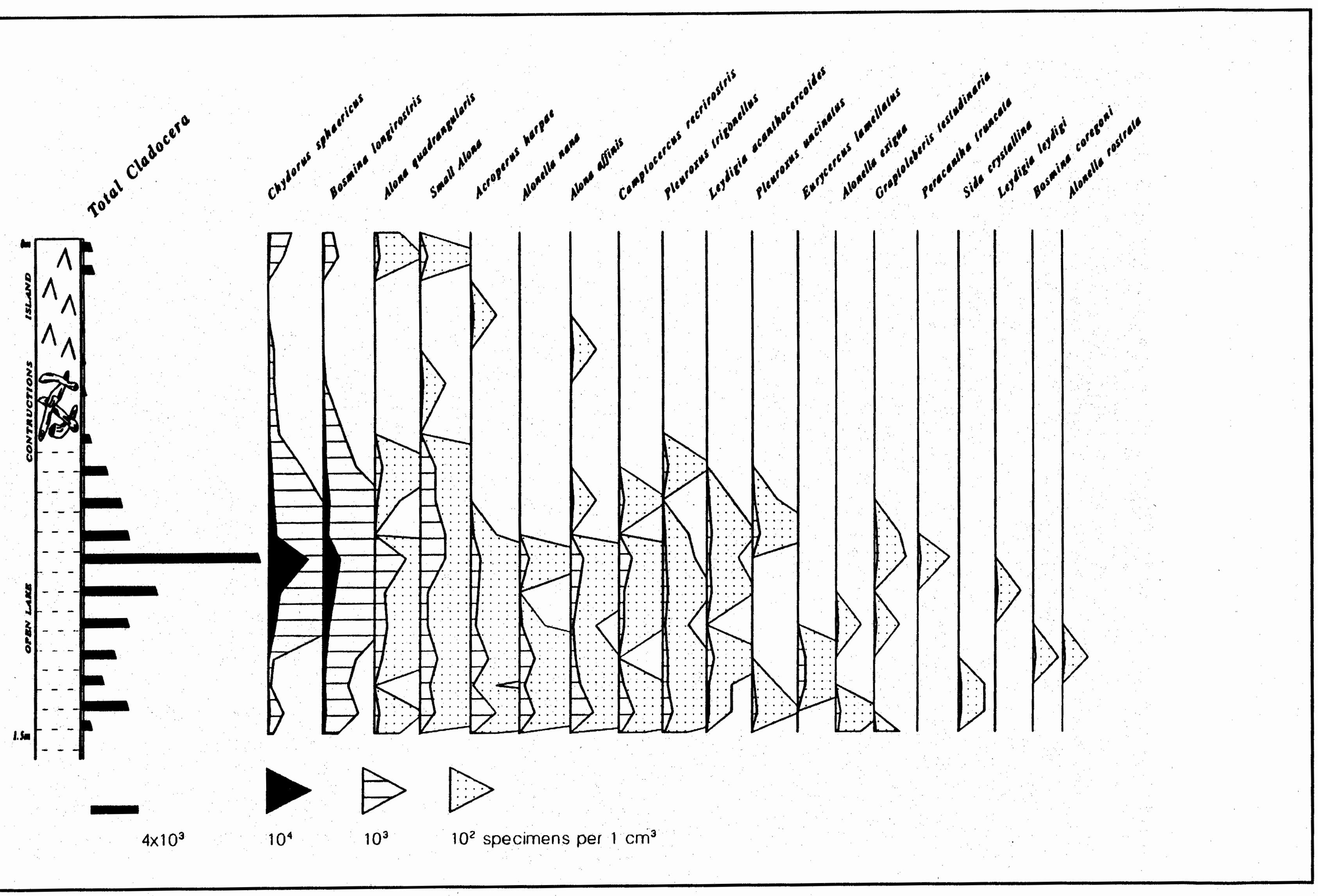

Figure 17. Quantitative and qualitative distribution of Cladocera in the Mołtajny profile.

2. The ecology of modern Cladocera may be used for the interpretation of their subfossil assemblages.

3. Periods of abundance can be associated with climatic or cultural changes in the drainage basin.

4. Changes in the abundance of Cladocera and in species composition may lead to conclusions as to water level changes, water chemistry, changes in lake productivity, and the development of lake flora.

5. Employing Cladocera analysis on two archaeological wetland sites in Poland provided information allowing for much clearer interpretation of the site itself.

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