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CLADOCERAN FAUNA FROM THE ARCHEOLOGICAL SITE VLADAŘ IN CZECH REPUBLIC

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Abstract

The study described in this paper is a part of a multi-proxy project, which deals with sediments originating from a former artificial water reservoir situated at the large fortified hilltop site of Vladař. The oldest sediments were deposited around 350 BC and sedimentation continues till recent times. Number of palaeoecological analyses have been applied (pollen, macroremains, charcoal, wood, *Cyanobacteria*, algae, fungi, Cladocera, chemical elements, radiocarbon dating, archaeological artefact).

The present contribution deals with analysis of chitinous fragments of Cladocera found within the trench. The results of this study clearly suggest a connection between the influence of human activity on the hilltop and the trophic status of the water in the cistern. Some phases of increased water eutrophication were distinguished on the basis of Cladocera species preferring nutrient rich water (*Chydorus sphaericus*, *Bosmina longirostris*).

Key words: palaeoecology, Cladocera analysis, artificial reservoir, environmental archaeology

INTRODUCTION

The main purpose of this paper is to show the first results of Cladoceran analysis from an artificial water reservoir (45 x 30 m), which is situated at the large fortified hilltop Vladař (western Bohemia, CZ 50°05´N, 13°13´E). This locality was being studied intensively during recent years in the aspect of environmental archaeology. The sedimentation started around 350 BC (Pokorný & Kaplan 2004, Pokorný *et al.* 2005).

Cladocera analysis is only a part of a multi-proxy project which incorporates a wide variety of palaeoecological methods, such as analyses of pollen, green algae and other microfossils, plant macroremains (seeds, charcoal, wood), and chemical analyses. This investigation is feasible due to the existence of a continuous sedimentary record-infilling of a reservoir (an underground reservoir for rainwater). This is the first time Cladocera analysis has been employed in such a case in the Czech Republic.

METHODS

Cladocera analysis was carried out by the standard method according to Frey (1986); including heating in 10% KOH on a hot plate stirrer and screening through a 50 µm sieve. The calculation of chydorid fragments follows Frey (1986). The identification and taxonomy of the chydorids follow Frey (1958, 1959) and Flössner (1972). Only statistically significant samples were evaluated by means of Cladocera analysis. Samples were taken from the trench situated in the centre of reservoir. Thickness of deposited sediments was 275 cm. Subsamples for Cladocera analyses were taken every 10 cm and in some stages every 5 cm throughout whole trench. Stratigraphy has been based on pollen and archaeological data. Absolute dating is based on radiocarbon chronology and is complemented by archaeological finds in some instances (Pokorný *et al.* 2005).

RESULTS

Cladocera remains preserved in the sediments of the reservoir were studied to reconstruct the history of the water ecosystem in the context of the vegetation history and land-use as reconstructed by the pollen stratigraphy. During the oldest documented period, the hill-fort has been settled by a considerable number of permanent inhabitants. It has been almost completely deforested and was a place for diverse agricultural practices. The site has been partly abandoned by the end of the 3rd century BC. Final abandonment is dated around 0 BC/AD. Natural succession started at that time, leading to the development of natural forest communities. (Pokorný *et al.* 2005).

The 22 samples examined represent a period of nearly 2000 years. 19 Cladocera species belonging to 3 families were found there – all quite well preserved. The frequency distribution of the species divides the core into five faunal

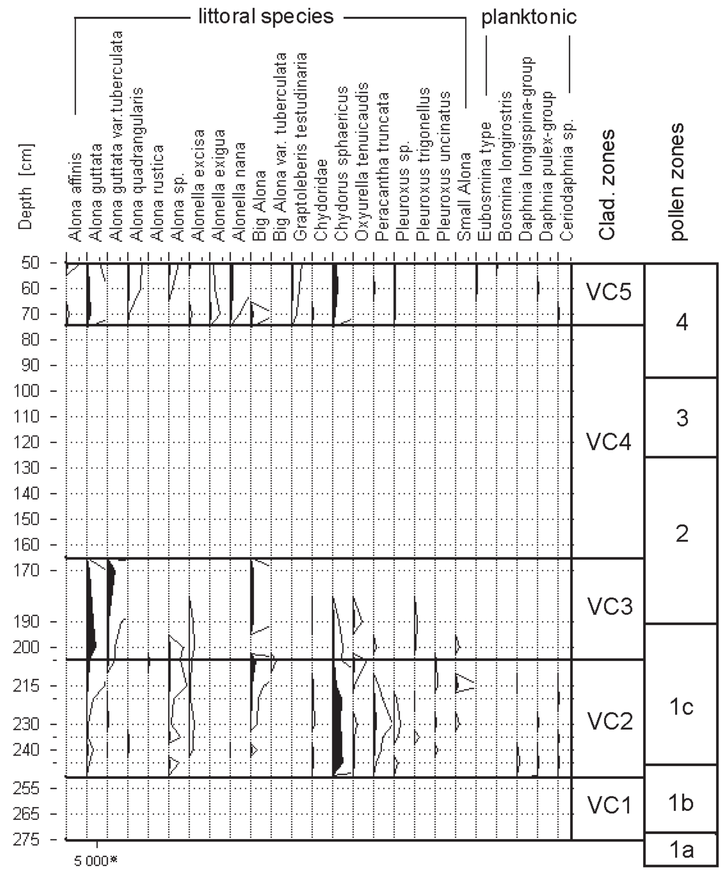

Fig. 1. Concentration diagram of Cladocera from archaeological site Vladař. Values given are the total number of specimens in 1 cm^3 of fresh sediment.

zones (Fig. 1), which roughly correspond to pollen assemblage zones (Pokorný *et al.* 2005).

The cladoceran assemblages throughout the sequence are dominated by chydorids. This littoral component is most frequently represented by taxa such as *Chydorus sphaericus*, *Alona guttata*, *Oxyurella tenuicaudis*, *Peracantha truncata*. The characteristic pelagic species are also present (*Bosmina longirostris*, *Eubosmina* T., *Daphnia longispina*-group, *Daphnia pulex*-group), but only sporadically (probably due to small size of water body, no real pelagic biotope was developed).

CLADOCERAN STRATIGRAPHY

VC1 (275–245 cm) around 350 BC (La Tene Period)

This phase is characterised by the absence of cladoceran remains. According to palynological and macroremains analyses, this phase is characterised by the presence of water plants (*Potamogeton* sp., *Alisma plantago - aquatica*, *Batracium* sp., *Lemna trisulca*) and number of ruderals (*Chenopodiaceae*, *Artemisia*, *Urtica* sp.) and other anthropogenic plant species. The water quality and environment was probably unsuitable for Cladocera, because very sporadic remains were found.

VC2 (245–215 cm) *ca.* 300 to 200 BC

This phase is characterised by domination of: *Chydorus sphaericus* - *Alona* sp. - *Peracantha truncata*. Among littoral forms, apart from *Chydorus sphaericus*, the genera *Alona* (*A. quadrangularis*, *A. guttata*, *A. guttata* var. *tuberculata*, *A. rustica*), *Alonella* (*A. excisa*, *A. nana*), *Pleuroxus trigonellus*, *Peracantha truncata*, *Oxyurella tenuicaudis* and *Ceriodaphnia* sp. were found. Most of the littoral Cladocera at this stage are commonly associated with macrophytes (Whiteside *et al.* 1978, Whiteside & Swindol 1988). The results of plankton analyses in contemporary waters have shown, that *Chydorus sphaericus* has a tendency to occure in pelagic zone, particularly during *Cyanobacteria* blooms. *Chydorus sphaericus* is a species considered by many researchers to be an index of high trophy and good anthropogenic index (Alhonen 1986, Korhola 1990). Pelagic species are also present – *Daphnia longispina* - group, *Daphnia pulex* - group.

VC3 (215–180 cm) *ca.* 200 BC – 0 BC/AD

In this phase the dominants are: *Alona guttata* - *A. guttata* var. *tuberculata* - *A. affinis* -*Chydorus sphaericus*. An abrupt increase of *Alona guttata* is apparent. *Alonella excisa*, *Alona rustica*, and especially *Alona guttata* var. *tuberculata*, seems to be related to low pH (*e.g.* Nilssen & Sandoy 1990).

Sarmaja-Korjonen & Alhonen (1999) have found a huge numbers of *A. guttata* var. *tuberculata* within aquatic-moss layers. *A. guttata* and especially *A. rustica* are most common at pH<5 (Walseng 1994). Studies from Ireland have shown that *A. rustica* occured with highest frequency on *Sphagnum* peat substrates and that it had a differential distribution among distinct substrate types (Duigan 1992).

Oxyurella tenuicaudis has achieved its maximum. This species is a typical element of various amphibian biotopes (Flössner 1972). The absence of pelagic species contributes to the hypothesis about the overgrowth of the water body (Szeroczynska & Gąsiorowski 2002).

VC4 (180–70 cm) 1 – 1000 AD

The transition to the zone VC4 is indicated by a sharp change from high abundance to very low frequencies of Cladocera remains. This is the second period with scarcely cladoceran remains. According to pollen analysis, the site was suddenly abandoned and succession towards the forest started. The reservoir was overgrown with mosses and sedges.

VC5 (70–45 cm) 1500 AD – present

This phase is characterised by domination of: *Chydorus sphaericus - Alona guttata - Alonella nana - Eubosmina* T. The composition of Cladocera species is very similar to phase VC2. Three new species have appeared – *Graptoleberis testudinaria*, *Eubosmina* T. and *Bosmina longirostris*.

The species preferring higher trophy are more common in this period (*Bosmina longirostris*). A slight increase of trophic state is also perceptible from the increase of *A. exigua*, which is considered as β-mesotrophic species (Flössner 1972). According to studies on Irish lakes (Duigan 1992), *Graptoleberis testudinaria* together with *Chydorus sphaericus* were recorded in lakes with vegetation dominated by *Sphagnum*. Similarly Sarmaja-Korjonen & Alhonen (1999) found out a massive development of *Graptoleberis testudinaria* in moss-layers. Also Schmidt *et al.* (2000) and Szeroczyńska & Gąsiorowski (2002) noticed these species in shallower lakes with macrophytes.

CONCLUSION

The study showed that there was a diverse fauna of littoral Cladocera in the reservoir. Some of the littoral Cladocera taxa appear to react to higher trophy. Cladocera analysis may thus provide a valuable additional method for identifying eutrophication phases caused by man (Mikulski 1978, Sarmaja-Korjonen & Alhonen 1999, Szeroczyńska 1991, 1998a, 2002, Goslar *et al.* 1999, Schmidt *et al.* 2000, Bałaga *et al.* 2002).

Concerning bio-stratigraphies, cladoceran zonation is almost identical to pollen assemblage zones.

Some phases of increased water eutrophication were distinguished on the basis of Cladocera species preferring nutrient rich water (phases VC2, VC5). It was observed by Szeroczyńska (2002), that the intensity of the expressed abundance of species in sediments is dependent on the size (area and depth) of the water body. The smaller the water body is, the greater is the change in the species composition of zooplankton. Smaller water bodies react faster to an excessive supply of nutrients, and therefore the change is more clearly evident in the sediment record.

The simplest indicator of water level, which can be used in tracing lake-peatbog transitions, is the presence or absence of Cladocera and the character of its disappearance (Szeroczyńska & Gąsiorowski 2002). The ratio of planktonic to littoral Cladocera species is a widely used tool in palaeoecological reconstructions of lake-level changes. Many scientists have studied this issue of water level changes (Ralska-Jasiewiczowa, Starkel 1988, Korhola *et al.* 2000, Alhonen 1970, Whiteside 1970, Szeroczyńska 1998, Sarmaja-Korjonen & Alhonen 1999, Sarmaja-Korjonen & Hyvärinen 1999). According to these studies, most of the declined lakes transformed into peat bogs. Such transitions are caused by natural (*e.g.* climatic) and anthropogenic factors, which can be traced on the basis of chemical and biological analysis of lake sediments – the best archive of nature. Remains of Cladocera are one of the languages, in which this archiv is written (Frey 1986).

Concerning the cause of absence of Cladocera remains in phase VC1 can be only speculated – unfavourable conditions arising from very strong human impact (nitrophytes, roundworm's eggs *etc.*) or very low water level or also there is a possibility, that their chitinous shells were destroyed or diluted by some mechanical or chemical factor. Similar situation was described by Sarmaja-Korjonen & Hyvärinen (1999). The cause of the second absence is probably different. According to visual stratigraphy, there is a noticeable horizon of trunks and branches. When the settlement was abandoned, the acropolis was overgrown with dense forest, consequently the hydrological regime changed. Reforestation is followed by the decrease of the water level in the former reservoir. Originally open water turned into a peat bog with sedges, and promptly with willow and birch (Pokorný *et al*. 2005).

The results of this study clearly suggest a connection between the influence of human activity on the hilltop and the trophic and water level changes in the reservoir.

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REFERENCES

Alhonen P. 1970. On the significance of the planktonic/littoral ratio in the cladoceran stratigraphy. *Commentationes Biologicae* 35, 1–9.

Alhonen P. 1986. Holocene lacustrine microfossils and environmental changes. *Bulletin of the Geological Society Finland* 58, 57–69.

Bałaga K., Szeroczyńska K., Taras H., Magierski J. 2002. Natural and anthropogenic conditioning of the development of Lake Perespilno (Lublin Polesie) in the Holocene. *Limnological Review* 2, 15–27.

Duigan C.A. 1992. The ecology and distribution of the littoral fresh-water Chydoridae (Branchiopoda, Anomopoda) of Ireland, with taxonomic comments on some species. *Hydrobiologia* 241, 1–70.

Flössner D. 1972. Branchiopoda, Branchiura. Die Tierwelt Deutschlands 60, 1–501.

Frey D.G. 1958. The late-glacial cladoceran fauna of a small lake. *Archiv für Hydrobiologie* 54, 209–275.

Frey D.G. 1959. The taxonomic and phylogenetic significance of head pores of the Chydoridae (Cladocera). *Internationale Revue der gesamten Hydrobiologie* 44, 27–50.

Frey D.G. 1986. Cladocera analysis. In Berglund B.E. (ed) *Handbook of Holocene Palaeocology and Palaeohydrology*, 667–692, J. Wiley and Sons, Chichester.

Goslar T., Ralska-Jasiewiczowa, M., van Geel B., Łącka B., Szeroczyńska K., Chróst L., Walanus A. 1999. Anthropogenic changes in the sediment composition of Lake Gosciaz (central Poland), during the last 330 yrs. *Journal of Paleolimnology* 22, 171–185.

Korhola A. 1990. Palaeolimnology and hydroseral development of the Kotasuo Bog, Southern Finland, with special reference to the Cladocera. *Annales Academiae Scientiarum Fennicae* 155, 5–40.

Korhola A., Rautio M., 2000. Cladocera and other small branchiopods. In Smol J.P., Birks H.J.B., Last W.M. (eds) *Tracking Environmental change Using Lake Sediments: Zoological Indicators*, 4, 5–41, Kluwer, Dordrecht.

Mikulski J.S. 1978. Man impact upon Gopło Lake as reflected in Cladocera community remains in sediments. *Polskie Archiwum Hydrobiologii* 25, 291–295.

Nilssen J.P., Sandoy S. 1990. Recent lake acidification and cladoceran dynamics: surface sediment and core analyses from lakes in Norway, Scotland and Sweden. In Battarbee R.W., Mason J., Renberg I., Talling J.P. (eds) *Palaeolimnology and lake acidification*, 73–83, The Royal Society, London.

Pokorný P., Kaplan M. 2004. Die paläoekologische Untersuchung des befestigen Arrals auf dem Berg Vladař. Ziklsetzung, metodische Voraussetzungen und erste Ergebnisse. *Archäologische Arbeitsgkmeinschaft Ostbayern/West – und Südböhmen*, 106–125. Verlag Marie Leidorf, Rahden/Westfalen.

Pokorný P., Sádlo J., Mikolášová K., Veselý J. 2005. Palaeoenvironmental investigations at the hillfort Vladař. *Archeologické rozhledy*, Praha, in press.

Ralska-Jasiewiczowa M., Starkel L. 1988. Record of the hydrological changes during the Holocene in the lake, mire and fluvial deposits of Poland. *Folia Quaternaria* 57, 91–127.

Schmidt R., Müller J., Drescher-Schneider R., Krisai R., Szeroczyńska K., Baric A. 2000. Changes in lake level and trophy at Lake Vrana, a large karstic lake on the Island of Cres (Croatia), with respect to palaeoclimate and anthropogenic impacts during the last approx. 16,000 years. *Journal of Limnology* 59, 113–130.

Sarmaja-Korjonen K., Alhonen P. 1999. Cladoceran and diatom evidence of lake-level fluctuations from a Finnish lake and the effect of aquatic-moss layers on microfossil assemblages. *Journal of Palaeolimnology* 22, 277–290.

Sarmaja-Korjonen K., Hyvärinen H. 1999. Cladoceran and diatom stratigraphy of calcareous lake sediments from Kuusamo, NE Finland. Indications of Holocene lake-level changes. *Fennia* 177, 55–70.

Szeroczyńska K. 1991. Impact of prehistoric settlements on the Cladocera in the sediments of Lake Suszek, Bledowo and Skrzetuszewskie. *Hydrobiologia* 225, 105–114.

Szeroczyńska K. 1998. Anthropogenic transformation of nine lakes in Central Poland from Mesolithic to modern times in the light of Cladocera analysis. *Studia Geologica Polonica* 112, 123–165.

Szeroczyńska K. 2002. Human impact on lakes recorded in the remains of Cladocera (Crustacea). *Quaternary International* 95–96, 165–174.

Szeroczyńska K., Gąsiorowski M. 2002. Palaeohydrological aspect of transformation of lakes into peat bogs during Middle Holocene on the basis of Cladocera analysis in the northern Poland. *Studia Quaternaria* 19, 55–60.

Walseng B. 1994. Alona spp. in Norway: Distribution and Ecology. *Verhandlungen, Internationale Vereinigung für Limnologie* 25, 2358–2359.

Whiteside M.C. 1970. Danish Chydorid Cladocera: modern ecology and core studies. *Ecological Monographs* 40, 79–118.

Whiteside M.C., Williams J.B., White C.P. 1978. Seasonal abundance and pattern of chydorid Cladocera in mud and vegetative habitats. *Ecology* 59, 1177–1188.

Whiteside M.C., Swindol M.R. 1988. Guidelines and limitations to cladoceran palaeoecological interpretations. *Palaeogeography, Palaeoclimatology, Palaeoecology* 62, 405–412.