Nonmarine Ostracoda as Proxies in Geoarchaeology

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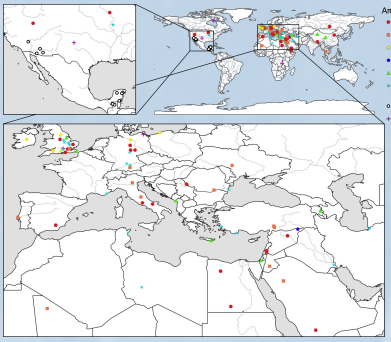
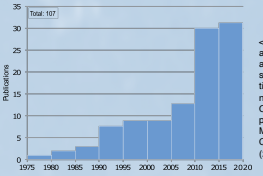
FIGURE 1: SEM picture of *Candona candida* (Müller, 1776), internal view of a right valve, from lake Tangra Yumco on the Tibetan Plateau. Modified from Quante et al. (2022)

INTRODUCTION



^ Archaeological case studies, using nonmarine Ostracoda as proxies (Quante et al., 2022).



< Number of archaeological case studies over time using nonmarine Ostracoda as proxies. Modified from Quante et al. (2022).

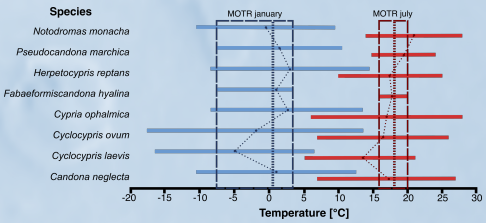
Ostracods are small crustaceans that live in almost all types of aquatic habitats, both natural and man-made. They have a high potential for analyses of aquatic sediments in archaeological investigations, a potential not fully exploited so far. To promote their application for archaeological research questions we present here a review on how nonmarine ostracods can be used to answer (geo-) archaeological research questions, based on a paper published by us recently (Quante et al., 2022).

EXAMPLES OF STUDIES

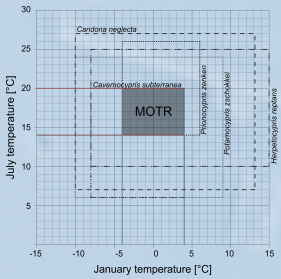
Palaeoenvironmental reconstructions

Most archaeological studies use nonmarine ostracods for analysis of the palaeoenvironment. Examples for applications include:

- Identifying **humid periods** and evaluating human migrations or adaptations based on climatic or environmental reconstructions (e.g. Kalbe et al., 2015; Rosenberg et al., 2011)
- Reconstructing **climatic changes** and changes in human living strategies (e.g. Laschke et al., 2015; Hill et al., 2017)
- Analysing **environmental histories** of areas with human occupation and the **environmental suitability** of areas for human settlements (e.g. Daniel & Frenzel, 2010; Holmes et al., 2010)



^ Reconstruction of winter and summer temperatures at the Middle Pleistocene site Bilzingsleben, Germany, using the Mutual Ostracod Temperature Range (MOTR). Redrawn from Daniel & Frenzel (2010), modified from Quante et al. (2022).

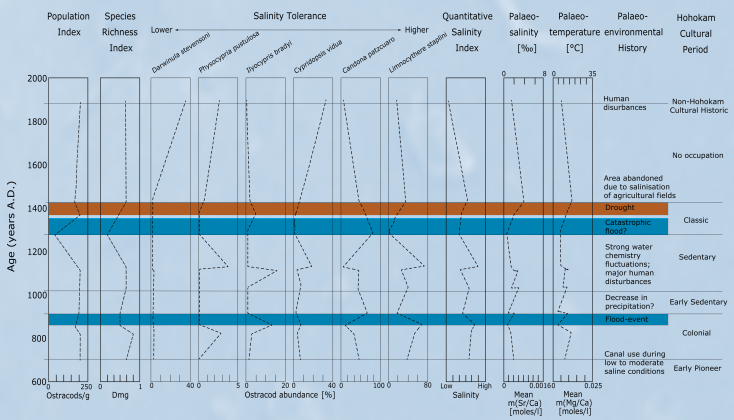


^ A different way to display the MOTR-method and show reconstructed winter and summer temperatures for the Middle Pleistocene Boxgrove hominin site, UK. Redrawn from Holmes et al. (2010), modified from Quante et al. (2022).

Anthropogenic activities

Examples for ostracod-based interpretations of human impacts on the environment through land- and water use are:

- Tracing and evaluating land use, which may through ostracods be detected through **eutrophication events**, and indirectly through, for example, **deforestation** and connected higher erosion rates and thus discharge fluctuations in streams (e.g. Fleury et al., 2015; Mazzini et al., 2016)
- Detecting water works like **canals and dams**, and reconstruct such structures' usage, potentially even with a seasonal chronological resolution (e.g. Palacios-Fest, 1994, 1997)



^ Different ostracod proxies, including shell chemistry proxies, showing the palaeoenvironmental- and human impact-history at the Mayan irrigation systems. Modified from Palacios-Fest (1994, 1997) and Quante et al. (2022).

OSTRACODS AS PROXIES

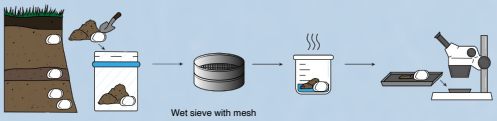
The typical applications are palaeoenvironmental reconstructions and palaeoecological analyses of associations based on ecological information and species-specific preferences and tolerances. Other methods include their taphonomy, morphometric variability, and stable isotope and trace element chemistry of their valves:

Proxies	Methods	
Salinity	Morphological variation	Valve ornamentation
		Sieve pore analysis in Cyprideis torosa
	Relative abundance	Indicator species, ecological groups, transfer functions
	Mutual Ostracod Salinity Range (MOSR)	Indicator species (based on present day ecological ranges; Pint et al. 2017b)
	Stable isotope analysis	$\delta^{18}O$
	Trace elements	Mg/Ca (Sr/Ca)
Water chemistry / pH	Relative abundance	Indicator species
Temperature	Relative abundance	Indicator species, ecological groups, transfer functions
	Mutual Climate Range (MCR)	Delorme Method (analogue MCR; based only on components of a fossil assemblage that co-exist today)
		Mutual Temperature Range (non-analogue MCR; based on all species in a fossil assemblage, e.g., MOTR)
	Trace elements	Mg/Ca, Sr/Ca, Ba/Ca, Li/Ca
	Stable isotope analysis	$\delta^{18}O$, potentially clumped isotopes
Productivity / nutrients	Abundance	Indicator species, total ostracod abundance, relative abundances of ecological groups
	Stable isotope analysis	$\delta^{13}C$
	Trace elements	Trace metals (Cd, Ba, Zn, ...)
Oxygenation	Abundance	Indicator species, relative abundances of ecological groups
	Trace elements	U/Ca
Water depth	Relative abundance	Transfer functions
	Taphonomy	Adult/juvenile ratio, valve/carapace ratio
Water source	Trace elements	$^{87}Sr/^{86}Sr$, $^{143}Nd/^{144}Nd$
Environmental stress	Abundance	Valve/carapace ratio, ecological groups, diversity
Energy regime / post-mortem transport	Abundance	Adult/juvenile ratio
Habitat structure	Abundance	Indicator species, relative abundances of ecological groups

^ Overview of proxies and methods in ostracodology. Only few of these have been used in geoarchaeological studies so far (Quante et al., 2022).

SAMPLING

Sampling and processing is easy and cost efficient. Due to their small size, mostly 0.5–2 mm in length, only small volumes of sediment are needed for analyses. We recommend ~50 g sediment for an ostracod analysis. More recommendations can also be found in Griffiths et al. (1993).



Note lithological and geographical information. Sample in plastic bags.

Wet sieve with mesh sizes 125 μm or 200 μm. For persistent lithologies wash with 5–10% H_2O_2.

Heat at 60°C until dry.

Place on picking tray for study under stereo-microscope.

^ Sampling of ostracods (Quante et al., 2022).

PERSPECTIVES

The many different methods make non-marine ostracods a broad and useful tool in geoarchaeological studies, not only for environmental archaeology, but also for reconstructing anthropogenic impacts like land-use and water works.
Our review, however, also displays the sparsity of detailed nonmarine ostracod studies at archaeological sites, which, regarding the state of research and development of new and better ostracod proxies, may further increase in the coming years.
To sum up, the most typical applications for nonmarine ostracod studies at archaeological sites are:

- **Palaeoenvironments** (e.g. palaeoclimate, habitat type and structure, salinity, temperature, oxygenation)
- **Anthropogenic activities** (e.g. land use, irrigation systems)
- **Provenance of materials**

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REFERENCES

Daniel, T., & Frenzel, P. (2010). Ostrakoden aus der mittelpleistozänen Hominiden-Fundstelle Bilzingsleben. Hugo Obermaier-Gesellschaft, 52. Jahrestagung in Leipzig, 73–78.
Fleury, S., Malaizé, B., Giraudeau, J., Galop, D., Bout-Roumazeilles, V., Martinez, P., Charlier, K., Carbonel, P., & Arnauld, M. C. (2015). Reprint of: Impacts of Mayan land use on Laguna Tuspán watershed (Petén, Guatemala) as seen through clay and ostracode analysis. *Journal of Archaeological Science, 54*, 410–420.
Griffiths, H. I., Rouse, A., & Evans, J. G. (1993). Processing freshwater ostracods from archaeological deposits, with a key to the valves of the major British Genera. *Circaea, 10*, 53–62.
Hill, T., Whittaker, J., Brunning, R., Law, M., Bell, M., Bronk Ramsey, C., Dunbar, E., & Marshall, P. (2017). Palaeoenvironmental investigations of a Mesolithic-Neolithic sedimentary sequence from Queen's Sedgemoor, Somerset. In M. Williams, T. Hill, I. Boomer, & I. P. Wilkinson (Eds.), *The archaeological and forensic applications of microfossils: A deeper understanding of Human history* (pp. 79–102). The Geological Society.
Holmes, J. A., Atkinson, T., Darbyshire, D. F., Horne, D. J., Joordens, J., Roberts, M. B., Sinka, K. J., & Whittaker, J. E. (2010) Middle Pleistocene climate and hydrological environment at the Boxgrove hominin site (West Sussex, UK) from ostracod records. *Quaternary Science Reviews, 29*, 1515–1527.
Kalbe, J., Mischke, S., Dulski, P., & Sharon, G. (2015). The Middle Palaeolithic Nahal Mahanayeem Outlet site, Israel: Reconstructing the environment of Late Pleistocene wetlands in the eastern Mediterranean from ostracods. *Journal of Archaeological Science, 54*, 385–395.
Laschke, S., Frenzel, P., Kloo, S., Nebelung, K., Kabaciński, J., & Terberger, T. (2015). Micropalaeontological investigations of the Final Mesolithic to Early Neolithic site of Dąbki. In J. Kabaciński, S. Hartz, D. C. M. Raemaekers, & T. Terberger (Eds.), *The Dąbki Site in Pomerania and the Neolithisation of the North European Lowlands (c. 5000–3000 cal BC)* (pp. 51–63). Verlag Marie Leidorf.
Mazzini, I., Gliozzi, E., Galaty, M., Bejko, L., Sadori, L., Soulié-Märsche, I., Koçi, R., Van Welden, A., & Bushati, S. (2016). Holocene evolution of Lake Shkodra: Multidisciplinary evidence for diachronic landscape change in northern Albania. *Quaternary Science Reviews, 136*, 85–98.
Palacios-Fest, M. R. (1994). Nonmarine ostracode shell chemistry from ancient Hohokam irrigation canals in Central Arizona: A paleohydrochemical tool for the interpretation of prehistoric human occupation in the North American Southwest. *Geoarchaeology, 9*, 1–29.
Palacios-Fest, M. R. (1997). Paleoenvironmental reconstruction of human activity in Central Arizona using shell chemistry of Hohokam canal ostracodes. *Geoarchaeology: An International Journal, 12*, 211–226.
Quante, E., Pint, A., & Frenzel, P. (2022). Nonmarine Ostracoda as proxies in (geo-) archaeology—A review. *Geoarchaeology, 37*, 711–732.
Rosenberg, T. M., Preusser, F., Fleitmann, D., Schwalb, A., Penkman, K., Schmid, T. W., Al-Shanti, M. A., Kadi, K., & Matter, A. (2011). Humid periods in southern Arabia: Windows of opportunity for modern human dispersal. *Geology, 39*, 1115–1118.

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