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Ostracoda from inland waterbodies with saline influence in Central Germany: Implications for palaeoenvironmental reconstruction

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ABSTRACT

As a necessary precursor to reconstructing the palaeoenvironmental conditions likely to be temporarily influenced by salt bearing ground waters, modern sites of Central Germany, known from the literature to be continental salt water localities, were investigated for their ostracod faunas. Analysing their associations enables the test of several methods in palaeoenvironmental analysis based on ostracods. In total, 54 ostracod taxa are documented. One species, *Microdarwinula zimmeri*, is new for the area. Interesting is the historical occurrence of *Cyprideis torosa* and *Cytheromorpha fuscata*, typically regarded as indicators of brackish water. The draining of wetlands has led to the disappearance of many former inland salt sites so that only a few of the sampled water bodies still show slightly elevated salinity (oligohaline range). The most important factors for the distribution of ostracod associations are groundwater influence, turbidity and ecological stability, whereas the type of dominating ions is of lesser importance because of time-averaging using taphocoenoses from surface sediments in our study. The relative proportion of ecological groups of ostracods appears to be the best tool for reconstructing past habitat types. The newly established Ostracod Permanence Index and Ostracod Turbulence Index allow the recognition of the influx of ground and surface waters, perennial habitats and flowing waters. A test of the Mutual Ostracod Temperature Range (MOTR) method demonstrates its capability to reconstruct, with a precision of +/−2 °C, the mean July and January air temperatures for the time interval 2002–2012. Additionally, the study contributes to the poorly known Recent distribution of ostracods in Central Germany.

1. Introduction

Ostracoda, small bivalved crustaceans, are one of the microfossil groups best suited for reconstructing past continental environments. For such purposes, ecological and distribution data are needed. However, studies on Recent ostracods in the German federal states of Thuringia and Saxony-Anhalt are very rare, despite numerous investigations on Pleistocene Ostracoda by Pietrzeniuk, Diebel and Fuhrmann (e.g. Diebel and Pietrzeniuk, 1969, 1977, 1978a, 1978b, 1984; Fuhrmann, 2008, 2013). The aim of the present study is 1) to test ostracods as indicators of habitat types and 2) to establish baseline distributional data for the modern ostracod fauna from Central German localities previously reported to have salt water influence. Our analysis includes the test of 3) the Mutual Ostracod Temperature Range (MOTR) method for palaeoclimate reconstruction. The study prepares palaeoenvironmental reconstructions based on Holocene ostracod associations in Central Germany.

2. Study area

In Central Germany, alternating sequences of Triassic sandstone and limestone reflect the oscillation between shallow sea and terrestrial fluvial sedimentation in the Thuringian Basin during the Permian and Triassic. Jurassic and Cretaceous as well as Tertiary strata are rarely preserved today. The larger central part of the Thuringian Basin is covered by Triassic rocks whereas sediments of the Permian, including Zechstein evaporites, are only exposed at its margin. Numerous sinkholes formed due to the dissolution of Permian and Triassic evaporites (Seidel, 2003; Wirth, 2008). After the silting up or artificial draining of the lakes covering the depressions in historical times, large reed flats with small relict water bodies developed. Although most of these water bodies contain salinities less than 2 psu today, halophytic plants still grow on the salt bearing soil in many places (Westhus et al., 1997). The 23 sites

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investigated in this study are situated in the Thuringian Basin and its surroundings (Fig. 1).

The modern climate in Germany is generally humid, however, large parts of Central Germany are characterised by relatively dry conditions resulting from the rain shadow caused by the Harz Mountains. The annual precipitation is 450–500 mm/year (Fabig, 2007). Annual air temperature fluctuations are characterised by strong seasonality in the temperate climate zone. Mean values of −0.5 °C for January and 17.5 °C for July are published for the period 2002–2012 in Jena, south-eastern Thuringian Basin (weather station of the Max Planck Institute for Biogeochemistry, Jena).

3. Material and methods

We carried out a sampling campaign in the Thuringian Basin and adjacent areas (see Supplementary data) from summer 2006 to late spring 2007 complemented by samples from the former Süsser See and Bindersee taken in 2004. Additionally, more detailed collections were carried out around Bilzingsleben and in the area of Bad Kösen–Groß Heringen in summer 2010 as well as the Pennickental at Jena in summer 2011. Data from Altenburg (Fuhrmann, 2010) and the Plothener fish ponds sampled in spring 2012 by Gemeinhardt and Frenzel (2014) as well as older material from Erfurt and Bad Kösen probably taken in 1966/68, from Siebleben taken in 1969 and from Bilzingsleben taken in 1978/79 (material from the Diebel & Pietrzeniuk ostracod collection in the Museum für Naturkunde Berlin) complete our data set. Those older collections are stored dried in micropalaeontological slides. The valves were identified and counted by us for adding the data to our modern training set. During our sampling campaign in 2006 and 2007, conductivity, pH and temperature of the water were measured using a multiprobe WTW 340i and the habitats were characterised. The sampling was carried out exclusively in shallow waters (<1 m water depth) reflecting the small size of the majority of water bodies. Many of the 23 sites were sampled at multiple stations covering different habitat types and almost all stations were sampled only one time resulting in 77 modern samples in total (compare Fig. 1 and Supplementary data).

Water quality analyses included ion chromatography (Dionex DX-120) for anions and ICP-OES (Varian 725 ES) for cations. After transformation of ionic masses into equivalent masses, the percentages of the main ions were calculated and used for chemical classification of water bodies.

Ostracods were sampled with a hand net (ca. 0.1 mm) by scraping the uppermost 1–2 cm of the surface sediment. The 100–200 ml sample was washed through a 200 μm sieve. Ostracod carapaces and valves were picked from the dry residues using a wetted fine-tipped brush. Ostracods were counted and identified relying on Meisch (2000) and Fuhrmann (2013). Valves recognisable as reworked through abrasion or corrosion marks were excluded from analysis. For most samples, it was not possible to identify individuals that were still living during sampling due to the use of material from various collections. Therefore, we decided to use total associations instead.

The software package PAST (Hammer and Harper, 2005) served for statistical analyses. A PCA on samples containing at least 50 valves each was carried out in order to identify associations and groups of samples bound to habitat types and environmental factors respectively. This PCA is based on 62 of the 77 samples and untransformed relative abundances of 36 ostracod species after excluding species present in less than three samples or never exceeding 5% of the association of each sample. Before analysis, the matrix was tested on highly correlated ($>|\pm 0.9|$) variables using Spearmen's Rank Correlation as recommended by Backhaus et al. (2010). The MOTR method uses calibrated temperature ranges determined from a combination of species distributions and an interpolated climate model in a Geographical Information System (Horne, 2007; Horne and Mezquita, 2008). The calibrated

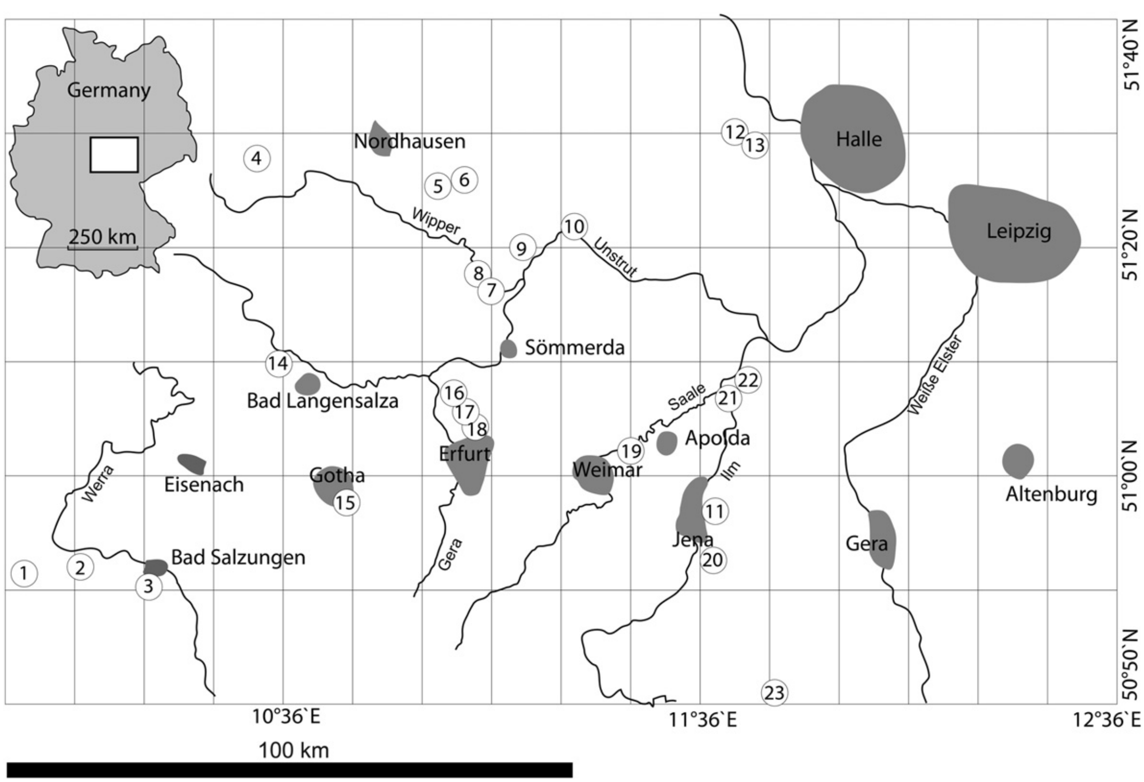

Fig. 1. Map of the investigated sites in Central Germany. The numbers indicate the studied modern localities; number of sampled stations are bracketed: 1 — Unterbreizbach (1); 2 — Merkers (1); 3 — Etmarshausen (1); 4 — Kraja (1); 5 — Numburger Quellen (1); 6 — Stausee Kelbra (1); 7 — Kindelbrück (4); 8 — Bilzingsleben (13); 9 — Esperstedt (2); 10 — Solequelle Artern (1); 11 — Fürstenquelle Jena (2); 12 — Süsser See (2); 13 — Bindersee (3); 14 — Grossengottern (2); 15 — Siebleben (2); 16 — Hasslebensee (2); 17 — Alperstedter See (1); 18 — Stotternheimer See (1); 19 — Oßmannstedt; 20 — Pennickental (7); 21 — Groß Heringen (3); 22 — Bad Kösen (9); and 23 — Plothener fish ponds (2).