Spatio-temporal distribution of ostracod species in saline inland lakes (Mansfeld lake area; Central Germany)

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as well as the sampling time, is crucial. Biodiversity of ostracods is biased by sampling time, the variability of the ostracod assemblages between sampling month and that the relationship between abundance of valves and living ostracods is not straightforward. Therefore, without precise knowledge of the ecological requirements of a species at a local scale, uncertainties may for the palaeoecological indication of a species.

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1. Introduction

Global climate change and predictions of its consequences for future distribution and diversity of the Earth´s biota is distinctly biased to the terrestrial megafauna and megaflora (Baillie *et al.*, 2008). Despite their high diversity, vast array of ecosystem services, and their importance for the human wellbeing, invertebrates are often neglected in biodiversity conservation policies due to the unawareness of the general public to invertebrates. Moreover, basic science on invertebrates is scarce and underfunded which contributes to that most species remain undescribed and the spatial and temporal distribution of species as well as their ecological preferences is mostly unknown (Cardoso *et al.*, 2011).

Ostracods (bivalved microcrustaceans), are one of the most diverse groups of living benthic invertebrates (Horne et al. ~~, Meisch & Martens~~, 2019), inhabit almost all types of aquatic environments: marine, freshwater and even some semi-terrestrial (Horne et al. ~~, Cohen & Martens~~, 2002). In particular, freshwater ostracods are of great interest in a variety of ecological and evolutionary studies because they are partially found *en masse* in aquatic environments and their calcified valves are common and well preserved in lake sediments (Martens *et al.*, 2008). Although ostracods have generally very broad ecological tolerances, distribution is mainly determined by a variety of physico-chemical (a biotic) factors (temperature, pH, salinity, oxygen content, substrate type and depth) (Mezquita *et al.*, 2005), as well as abiotic factors (competition, predation, commensalism) (Guisan et al. ~~, Thuiller & Zimmermann~~, 2010) and each species has specific tolerances and preferences to these factors (Kiss, 2007). The short life-cycles (sometimes <1 year) and high population rates allow ostracod assemblages to respond quickly to local environmental changes (De Bie *et al.*, 2012).

Abstract

Ostracods are a diverse group of microcrustaceans with a ubiquitous distribution in a wide array of aquatic habitats and are common constituents of lake sediments. Inferences on temporal-spatial distribution of ostracod species is the prerequisite for reconstructions of palaeoenvironmental conditions. This requires a precise knowledge not only about ecological preferences and specific life histories, but also the understanding how (local) ecological parameters affect ostracod species assemblages (abundance and composition). Generally, these studies are rare and often characterized by an insufficient differentiation of living specimens from the total amount of valves of the modern population leading to uncertainties in species occurrences and diversity data.

Modern ostracod populations were sampled from 12 water bodies within a relatively small study area (Mansfeld lake area, Central Germany). Physico-chemical parameters (temperature, oxygen content, salinity, pH) were measured *in situ* and the uppermost 2 cm of sediment were collected in different seasons (April, June, September). Relative abundances of ostracods (soft parts and valves), differentiated for adults and juveniles were used for statistical analyses (Spearman`s rank correlation, Canonical correspondence analysis, Cluster analyses, Fisher´s α), to investigate relationships between species distribution and environmental factors as well as to identify habitat similarities and ostracod species assemblages.

In total, 27 ostracod species (20 living species) were identified. Majority of them are considered as very common (cosmopolitan) freshwater species. Only two species are usually known from brackish water. The relative abundances of ostracods show strong fluctuations during the study period and differences in composition of the ostracod species assemblages between and within the water bodies. There are also strong differences between bio- and taphocoenoses.

The measured physico-chemical parameters which are usually considered as most important drivers on ostracod species distribution do not contribute to explain the observed temporal-spatial distribution of the ostracod species. Differences in taphocoenoses show, that taphonomic processes can be very local and the sampling site, as well as the sampling time, is crucial.

Biodiversity of ostracods is biased by sampling time, the variability of the ostracod assemblages between sampling month and that the relationship between abundance of valves and living ostracods is not straightforward. Therefore, without precise knowledge of the ecological requirements of a species at a local scale, uncertainties may for the palaeoecological indication of a species.

Given this backdrop, ostracods have established as proxies for manifold palaeoenvironmental studies in recent decades (Boomer et al. ~~Horne & Slipper~~, 2003). Precise autecological inferences based on fossil material depends on extensive knowledge about the ecological requirements and life-cycle information of the different species, as well as additionally (local) influences on these. Nonetheless, comprehensive studies on these are still rare (Viehberg, 2005; Külköylüoğlu, et al. ~~Yılmaz & Yavuzatmaca~~, 2017). However, life cycle (or seasonal distribution), ecology, and transfer into the geologic record (taphonomic processes) have rarely been considered together. This, in turn, is problematic, as sometimes incorrect diversity estimates are obtained and, most importantly, imprecise assumptions are made about ecological preferences or (subtle) responses to environmental changes are overlooked, which leads to a discrepancy between Recent and fossil data. Also problematic is the, often, insufficient differentiation between living ostracods (biocoenoses) and valves (taphocoenoses). Diversity and ecology of species are usually evaluated on the basis of Recent material (but usually only valves). Species or entire assemblages may be ~~are~~, thus, assigned to incorrect environmental conditions. In addition, studies are mostly based on large-scale trends, which are transferred to local scales (e.g., Pint *et al.*, 2017). The Mansfeld lake area offers several water bodies all differing slightly with respect to hydrochemistry, hydro(geo)logy or degree of pollution settled within a relatively small geographical area. These water bodies offer as 'natural laboratories' ideal conditions to study the effects of regional and local environmental parameters and their seasonal fluctuations on the distribution of individual ostracod species, but also on the entire community. The region is located 25 km west of Halle (Saale), a city of Saxony-Anhalt, in the centre of the central German dry region. It is characterized by low precipitation (428 mm/a), a negative water balance, as well as short and pronounced extreme rainfall events (Wennrich, 2005). Another peculiarity of the

region is the natural salinity of the water bodies, which is caused by saline inflows of salt deposits of Permian age from the underground (Wennrich et al. ~~Meng & Schmiedl~~, 2007). Temperature and salinity are thought to be major controlling factors for distribution of freshwater ostracod species (Ruiz *et al.*, 2013). Accordingly, spatial ostracod species distribution, abundance, and diversity in the Mansfeld lake area should reflect differences in salinity levels. By repeated sampling, we also wanted to investigate if there is a seasonal effect on the distribution and abundance of the ostracod species related to the specific life-cycle of the species.

Chapter „Study area" is missing

2. Materials and methods

Three sampling campaigns were carried out in 2019 (April 16, June 7 and September 12) in the Mansfeld lake area. During each sampling campaign, 10-12 water bodies (ponds, small lakes, ditch) were investigated. An overview about the sampling localities is provided in Table 1. Generally, we tried to visit the same sampling site at each water body during each campaign as far as possible. Exceptions were made at the lakes TE and ST due to limited access due to dense vegetation of the first sampling site. The sampling localities differed ~80 m north and 120 m east, respectively, from the first site.

Most of the investigated water bodies (KS, BS, TE, TE2, QW and MG) (1) lie within the area of the former lake 'Salziger See'. 'Süßer See' is located north of the former 'Salziger See', outside the lake basin, but is directly connected by ditches with KS, BS and MG. Both ('Süßer See' and former 'Salziger See') are located in the deepest part of a large depression (Teutschenthal Anticline) (Wennrich *et al.*, 2007). The remaining water bodies (OT, OT2, WL, TA, ST) (1) are located outside this area, topographically higher and with a maximum distance of 3 km, but

(1) Give a reference for the full names or exact locations of these stations.

mostly located at the marginal area of the former `Salziger See´ (Fig 1). Although the water bodies presumably all have the same catchment, they have different sub-catchments, and the water bodies outside the anticline have different hydrological conditions (e.g., saline inflows). Physico-chemical variables (water temperature, electrical conductivity, pH and oxygen content) were measured *in situ* using probes of the company WTW. Sediment samples were collected from the uppermost few (approx.1-2) centimetres of sediment in the littoral zone using a hand net. 1

The samples were fixed with 70% Ethanol to preserve living specimens. The sediment samples were washed with tap water through standard sieves sizes (1000 µm, 500 µm, 250 µm and 125 µm). The sieve residues from mesh sizes 500 µm and 250 µm were transferred to sample bags using 70% ethanol. Ostracods were separated from sediment and species were sorted under a binocular microscope. Ostracods with soft parts were preserved in ethanol for further investigations, empty carapaces and valves were dried at room temperature and stored in micro cells. Empty carapaces and valves were sorted by juveniles and adults. Different juvenile stages were not distinguished.

Species identification was based in most cases on valve morphology according to Meisch (2000), Fuhrmann (2012), and Wennrich (2005). For some unidentified species soft part analysis was performed. All ostracod valves were counted (carapace = two valves) and relative abundances were calculated.

Data analyses

Spearman`s rank correlation test was applied to identify relation among abundances of living assemblages ~~species~~ and physico-chemical parameters.

1 Sampled area? (approx.)

Canonical correspondence analysis (CCA) was used to investigate the relationships between the distribution of living ostracod assemblages ~~species~~ and physical and chemical environmental parameters. Relative abundances of species were used for CCA analyses. Four environmental variables including water temperature, electrical conductivity, oxygen content and pH, were selected for the CCA.

To calculate Fisher´s α diversity and richness of the water bodies, the absolute numbers of taphocoenoses of all three months were summed for each species. Additionally, to reveal ostracod assemblages and determine habitat similarities a cluster analysis was carried out. Cluster analyses were performed based on relative abundances of the species, separately for biocoenoses and taphocoenoses in two ways (for water bodies and species). As clustering algorithm, Ward´s method to a Euclidian distance matrix was used. In all analyses, samples (water bodies) containing less than 100 individuals were excluded. Furthermore, all species with overall abundances ≤5% and occurring only in one site were also excluded from the analyses. All statistical analyses were conducted using PAST version 3.25 (2019). add reference

3. Results

Physico-chemical variables and habitat characteristics

Water temperature shows the strongest seasonal fluctuations ranging between 8.6 in April and 26.5°C in June (Fig 2 A). Temperature ranges and fluctuations are similar for all water bodies. Generally, higher water temperatures were measured in smaller water bodies (e.g., WL). The lowest temperatures are provided by a spring (QW). This locality provided the strongest difference of the water temperature compared to other water bodies in June.

Conductivity values range between 1.3 mS/cm (OT2) and 26.7 mS/cm (Fig 2 B).

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The water bodies within the area of the former lake 'Salziger See' (KS, BS, TE, TE2 and QW) have highest conductivity values in April and lowest in September. They provide generally higher values than localities outside this area. The spring QW exhibits the strongest seasonal fluctuations from 14.5 to 26.7 MS/cm. The other localities display relatively constant values during the sampling period.

Dissolved oxygen (DO) concentrations vary between 2.77 mg/l (OT2) and 19.4 mg/l (BS) and ~~is~~ are in April in most localities higher than in the following months (Fig 2 C). Although temperatures were markedly lower in September, the oxygen content of the water bodies is similar to the values measured in June. In contrast to temperature ranges, ~~is~~ the oxygen content is more specifically for the localities. For instance, contrary to the general trend, displays OT highest oxygen value in June.

In all sites, pH values were ≥ 7 at each sampling site and reach a maximum of 8.9 in BS (Fig 2 D). The lowest value 7 was measured in the spring QW in September. Mean pH values are higher in April (8.3), than those in June (8.0) and September (7.7). Generally, values in June and September are relatively similar, except OT where the June value reflects the April value.

Substrate texture is dominated by sandy (e.g., BS and KS) and muddy substrate (e.g., TE, TA). Some localities are characterised by algae (SS), detritus (e.g., BS) or aquatic macrophytes (OT). Detailed information is summarised in Table 1.

Ostracod communities

General observations

Ostracods were found in all localities (and all samples). Living ostracods were found in ~~8~~ eight out of ~~10~~ ten water bodies in April, ~~10~~ ten out of ~~11~~ eleven in June, and ~~9~~ nine out of ~~10~~ ten in September. The abundance of valves and living ostracods var~~y~~ies extremely between the localities, within the habitats, and between the months. Compared to the previous months, number of valves and living ostracods were significantly lower in September. An extreme case was documented in a small pond (WS) where number of living ostracods decreased from several hundred (April 794, June 989) to only one specimen in September (Fig 3). Other localities provide a lower variation in living ostracod numbers (e.g., KS). (1)

Species list

In total, 27 podocopid ostracod species were identified based on valve morphology according to Meisch (2000) and Fuhrmann (2012). Twenty species of them were also found living. In some cases, soft parts were analysed, too, in order to identify individuals on species level, e.g., *F. fabaeformis*, *F. holzkampfi*, *H. incongruens* and *I. gibba*. ?

The following ostracod species were found: systematic based on?

Superfamily: Darwinuloidea Brady & Norman, 1889
  Family: Darwinulidae Brady & Norman, 1889
    Genus: *Darwinula* Brady & Robertson, 1885
      Darwinula stevensoni (Brady & Robertson, 1870)

Superfamily: Cypridoidea Baird, 1845
  Family: Candonidae Kaufmann, 1900
    Subfamily: Candoninae Kaufmann, 1900
      Genus: *Candona* Baird, 1845
        Candona candida (O.F. Müller, 1776)
        Candona neglecta Sars, 1887
      Genus: *Fabaeformiscandona* Krstić, 1972
        Fabaeformiscandona fabaeformis (Fischer, 1851)
        Fabaeformiscandona holzkampfi (Hartwig, 1900)
      Genus: *Pseudocandona* Kaufmann, 1900
        Pseudocandona compressa (Koch, 1838)
        Pseudocandona marchica (Hartwig, 1899

(1) What is the reference volume or area for these numbers?

Genus: *Candonopsis* Vavra, 1891
Candonopsis kingsleii (Brady & Robertson, 1870)
Subfamily: Cyclocypridinae Kaufmann, 1900
Genus: *Physocypria* Vavra, 1897
Physocypria kraepelini G.W. Müller, 1903
Family: Ilyocyprididae Kaufmann, 1900
Subfamily: Ilyocypridinae Kaufmann, 1900
Genus: *Ilyocypris* Brady & Norman, 1889
Ilyocypris bradyi Sars, 1890
Ilyocypris gibba (Ramdohr, 1808)
Ilyocypris monstrifica (Norman, 1862)
Family: Notodromatidae Kaufmann, 1900
Subfamily: Notodromatinae Kaufmann, 1900
Genus: *Notodromas* Lilljeborg, 1853
Notodromas monacha (O.F. Müller, 1776)
Family: Cyprididae Baird, 1845
Subfamily: Eucypridinae Bronstein, 1947
Genus: *Eucypris* Vavra, 1891
Eucypris virens (Jurine, 1820)
Eucypris sp? not italics
Genus: *Prionocypris* Brady & Norman, 1896
Prionocypris zenkeri (Chyzer & Toth, 1858)
Subfamily: Herpetocypridinae Kaufmann, 1900
Genus: *Herpetocypris* Brady & Norman, 1889
Herpetocypris chevreuxi (Sars, 1896)
Subfamily: Cyprinotinae Bronstein, 1947
Genus: *Heterocypris* Claus, 1892
Heterocypris incongruens (Ramdohr, 1808)
Heterocypris salina (Brady, 1868)
Subfamily: Cypridopsinae Kaufmann, 1900
Genus: *Cypridopsis* Brady, 1867
Cypridopsis vidua (O.F. Müller, 1776)
Genus: *Plesiocypridopsis* Rome, 1965
Plesiocypridopsis newtoni (Brady & Robertson, 1870)
Genus: *Sarscypridopsis* McKenzie, 1977
Sarscypridopsis aculeata (Costa, 1847)
Genus: *Potamocypris* Brady, 1870
Potamocypris arcuata (Sars, 1903)
Potamocypris smaragdina (Vavra, 1891)
Superfamily: Cytheroidea Baird, 1850
Family: Limnocytheridae Klie, 1938
Subfamily: Limnocytherinae Klie, 1938
Genus: *Limnocythere* Brady, 1867

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Limnocythere inopinata (Baird, 1843)
Family: Cytherididae Sars, 1925
Genus: *Cyprideis* Jones, 1857
Cyprideis torosa (Jones, 1850)
Family: Loxoconchidae Sars, 1925
Genus: *Cytheromorpha* Hirschmann, 1909
Cytheromorpha fuscata (Brady, 1869)

Spatial and seasonal distribution

General remarks

Seasonal distribution of the ostracod species of the Mansfeld lake area is displayed at Fig 3. The species list is sorted by maximum salinity tolerance values according to Frenzel et al. (2010). This results in 5 five groups, each for the ranges of ≤5 PSU, ≤10 PSU, ≤15 PSU, ≤20 PSU, and ≤25 PSU, whereby group I refers to the lowest salinity values and group V to the highest. Within this groups, species are also sorted by increasing salinity tolerance. Water bodies were also classified in ascending order according to salinity values. Category a includes water bodies outside the former 'Salziger See' area. These water bodies have lower salinity values (0.7 to 4 PSU) and are comparatively small. Category b consist of the water bodies within the former 'Salziger See' with higher salinity values (4.4 to 20.7 PSU), and are larger than the water bodies in category a (except QW). Category c comprises SS, the largest lake in the study area, and MG, a section of a ditch that encircles the former 'Salziger See'. Both water bodies have low salinity values (0.9 to 1.3 PSU). All of the species are freshwater species (except *C. torosa* and *C. fuscata*), most of them are found in group I (lowest salinity tolerance) and the lowest number of species is found in groups with higher salinity tolerances (Group IV and V).

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1 Would be a help for the reader to have a table summarizing the characteristics of salinity groups I–V as well as water bodies a–c, because it is referred to through the following text.

In water bodies of category a are on average significantly smaller number of species than in water bodies of category b.

The water bodies display significant differences in terms of their species composition in bio- and taphocoenoses between the sampling months.

April

Even if the number of species that belong to group I is highest, in April almost all species of this group occur only very sporadically and in very low abundances (mostly ≤5%). This is particularly clear in biocoenoses and slightly less pronounced in taphocoenoses (Fig 3).

In group II there is a distinct increase in species number and abundances. Especially in section II a, more species in higher numbers occur, notably for three species (*C. candida, C. vidua, L. inopinata*) with a lower salinity tolerance in this group. In category b the increase can also be observed, but less significant. Here, species are more common, but abundances are still rather low (mostly ≤5%), especially in taphocoenoses, and also but much less pronounced, in biocoenoses. This development is mainly due to higher appearances of *H. salina*.

Although group III (≤15 PSU) includes only half as many species as group II, the species are equally common and abundant. Here, as well, abundances in bio- and taphocoenoses are significantly higher in III a than in III b, where abundances especially in taphocoenoses are rather low (≤5%). In biocoenoses, species richness is the same than in group II b, but the abundances are slightly higher.

Higher abundances in group II and III in category a are mainly explained by three species (*C. vidua, L. inopinata* and *P. kraepelini*), which often and plentiful occur in both, bio- and

taphocoenoses. Species belongs to group IV were not found living in April, although *S. aculeata* is the most abundant species in TE and TE2 in taphocoenoses.

In group V category a, occurrences and abundances are very low, but approximately highest in category b, which is cause by *C. torosa*.

In general, in category a) the most common and abundant species in taphocoenoses are the same as in biocoenoses. For instance, *C. vidua* and, *P. kraepelini* are common and abundant, *L. inopinata* occurs locally but with high abundances, and *C. candida* is common but with low abundances and never found alive). In category b, *C. torosa* is the only common and abundant species in bio- and taphocoenoses. Generally, most of the common species are not very abundant (e.g., *C. candida, L. inopinata, H. salina*). Abundant species in taphocoenoses are not abundant in biocoenoses (*H. salina, I. gibba, S. aculeate*) and common and abundant species in biocoenoses are not in taphocoenoses (e.g., *H. salina, C. neglecta, D. stevensoni*).

June

In June the distribution of the species is much more inconsistent compared to April. In Group I (i.e., low salinity tolerant-species) comparatively few species (e.g., in comparison to group II) can be found again. Nevertheless, there are significantly more species than in April. Species with lowest salinity tolerances (uppermost species of group I) are particularly widespread. This applies to all three categories. Overall, in this group species are not only more common, there is also an increase in abundances, both in bio- and taphocoenoses. In group II, in all water bodies species are more common, and abundance of some species increase significantly.

In category a, the species distribution mainly relies on the species with comparatively low salinity tolerances (uppermost). The water bodies are nearly similar in their species composition.

In category b, on the other hand, the differences between the water bodies are larger. Almost all species occur in KS and BS, while species are basically not apparent in the other water bodies. ? An exception represents *H. salina*, which is common and abundant in all water bodies of category b. Abundances also increase slightly in category c, but a comparison is difficult as this category only includes one water body.

In group III are only two of the four species of category a (*D. stevensoni* and *P. kraepelini*). But these are very common and abundant in bio- and taphocoenoses. In category b the occurrence is more dispersed and species in bio- and taphocoenoses are not very abundant. In category c also two species occur (same like in category a). Abundances in taphocoenosis of *D. stevensoni* are low but in biocoenoses it is relatively high (≤40%). In group IV a, species are very rare (one species ≤4%). 1 In category b two species occur with low abundances. In category c no species was found. Group V is dominated by *C. torosa*, in category a in very low numbers, but in category b and c it is the most common and abundant species in bio- and taphocoenoses.

In general, in all of the three categories abundant species in biocoenoses are also abundant in taphocoenoses (with few exceptions e.g., *C. vidua* in ST and *H. salina* in TE2).

September

In September, species from group I were found sporadically in the water bodies and only in very low abundances. Except *P. marchica*, which occurs in category a alive and is also very abundant in taphocoenoses.

In category b and c species are slightly more common and more often alive. Also in group II a, the species occur only very sporadically, but the abundances in biocoenoses increase slightly (due to *C. vidua*). In taphocoenoses the abundance also increases due to the mass occurrence of

1 How abundance or low diversity? If only one species relative abundance would be 100%?

C. vidua and *L. inopinata*. In category b, species are more common in both bio- and taphocoenoses with a slight increase in abundances in taphocoenoses, even if most of the species occur in low relative abundances (≤5%). In particular, living species are common but occur with low abundances in this group and category. In category c, just a few species occur and with low abundances, except of *C. vidua* which is the most common and abundant species. Group III a is the category with highest abundances for these water bodies, although absolute numbers of specimens are generally very low. relative? Taphocoenoses are characterized by *P. kraepelini*, which is very common and abundant. In taphocoenoses of category b, all species occur in KS but are nearly absent in the other water bodies and abundances are very low (all ≤5%). In biocoenoses the relative abundances increase (two species between 40-70%). In bio- and taphocoenoses of category c abundances are low (≤4 in biocoenoses and ≤5% in taphocoenoses) and species are not very common. In group IV and V, category a just two species (*S. aculeate* a and *C. torosa*) occur in one water body (OT2). They are not very common and relative abundance is low (≤5%) except for adult *S. aculeate* a (≤40%) In category b and c, the same two species occur. *S. aculeata*, however, is more abundant and was also found alive. *C. torosa* on the other hand is the most abundant species in bio- and taphocoenoses and was ~~nearly~~ not found in nearly all water bodies.

Samples from September are characterized by lowest number of species, as *P. zenkeri*, *C. kingsleii*, *E. virens*, *F. fabaeformis*, *H. incongruens* and *P. newtoni* did not occur~~red~~.

It should also be noted, that in September a relatively large number of species (in comparison to the previous month), not occurring in taphocoenoses are found in biocoenoses (e.g., *C. vidua*, *D. stevensoni*, *C. neglecta*). However, occurrences in the water bodies are similar to previous samplings.

In general, in all categories most of the species that are abundant in taphocoenoses are also abundant in biocoenoses. But there are more exceptions in September than in the previous month. is C. *vidua* for example is the second most species in OT2, but is not present in taphocoenoses, *L. inopinata* is the most abundant species in taphocoenoses in WL, but living specimens ~~not~~ did not occur ~~red~~, instead *D. stevensoni* is dominant (but just with one living specimen) in biocoenoses, but is not present in taphocoenoses. ?

In category b most of the species that are abundant in biocoenoses are less abundant in taphocoenoses (≤4%), except *C. torosa* which is abundant in both.

In category c abundances of bio- and taphocoenoses correspond most closely. relative?

In summary

Comparing the ostracod species of categories a and b (i.e., low vs higher salinities), two patterns stand out. First, two species (*P. marchica and N. monacha*) occur exclusively in (bio- and taphocoenoses) category a (low salinity), and two species (*P. compressa, I. gibba*) appear only in category b (higher salinity). But these species are recorded with low specimen numbers only. The second point relates to the abundances of species. Some species occur in both water body categories, but are common and abundant only in one category, while they occur sporadically and with low numbers (and mostly only in taphocoenoses) in the other category. Although there are fluctuations in the abundances of the water bodies between the months (especially in the absolute values), it is noticeable that two species of the biocoenoses (*C. vidua* and *P. kraepelini*) are common and mostly dominant in the water bodies with lower salinities in all months. The same applies for the water bodies with higher salinity, the species here are *H. salina* and *C. torosa*. The same pattern can be observed in taphocoenoses.

Despite the lower salinity values the ostracod assemblages of category c differ from category a. Peculiarly, the ostracod assemblages of category c represent a combination of category a and b, due to the occurrence of the most abundant species *C. vidua* and *C. torosa*.

There is another aspect, differentiating the water bodies from each other. First, there ~~are~~ is a lower number of species in smaller water bodies, dominated by one species while other species provide only small numbers (e.g., in OT2, *P. kraepelini* exaggerates with 85% the other two species *F. holzkampfi*; 9% and *C. vidua*; 6% by far). This becomes particularly obvious in biocoenoses and is very stable during all months.

Contrary, in larger water bodies, there are significantly more living specimens while no species is clearly dominant. Rather, species distribution is much more balanced and varies during the months. The ambiguous distribution of species can be also seen in the Cluster analyses of water bodies and species (Fig 4). The Cluster analysis of the biocoenoses reveals that the similarity of the water bodies depends on the seasonal distribution of the species. Each sampling (i.e., month) provides slightly different species composition contributing to distinct species assemblages.

Thus, taken all together there are neither distinct types of water bodies (and related environmental conditions) nor specific living ostracod species assemblages. ! ?

The picture is somewhat clearer in taphocoenoses of the five water body groups. More or less the three samplings of a water body form a group, mostly together with spatially close (or connected) water bodies (ex. KS, BS, MG, SS are one group). Only WL and TA form separate groups, but are also more spatially distant from the other water bodies, and thus are more isolated. Cluster analysis of the species revealed only two groups that can be associated with an environmental parameter. These are *P. kraepelini* and *C. vidua* occurring in lower saline water bodies as well as *I. gibba* and *H. salina* occurring in water bodies with higher salinities.

However, again, most species (the remaining 16) are in one group showing no species-specific preferences.

Seasonal population structure

There is no generalized pattern in taphocoenoses distribution of adult and juvenile valves (Fig 5). Very different ratios were found between water bodies and between the sampling month s. Some localities show relatively constant ratios through the sampling period (e.g., KS, WL), while others vary greatly (e.g., BS, TE2). Some water bodies, provided significantly more adults than juveniles (e.g., KS, WL) while juveniles exaggerate adults in other water bodies (e.g., QW, TA). The same applies to biocoenoses which are also characterized by very variable adult/juvenile ratios.

However, there is a generally upwards trend of juvenile ostracod from April to September.

Species Diversity

For the Fisher´s α diversity and richness data, taphocoenoses for all three months were considered together (Fig 6). Diversity and richness show the same trend, whereby the richness shows partially lower values. Richness and Fisher´s α diversity also do not show a clear trend or pattern in relation to salinity. Up to 4 PSU, species richness and diversity decrease with increasing salinity, following the pattern from Frenzel (2009). From 4 PSU, however, richness increase, and has its maximum at 6 PSU. After that, the richness and diversity of species decrease again.

Inferences on species life cycle

Although only three samplings were made, covering only half a year, the species show clear shown by differences in their abundance patterns. The strongest fluctuations of the biocoenoses are L. *inopinata* with a clear maximum in June. *D. stevensoni* and *H. salina* also have a maximum in summer, although the differences between the months are much smaller, and the number of individuals is generally significantly lower than that of *L. inopinata*. While *C. vidua* has its minimum in summer but occurs in very low numbers in both April and September and shows no clear maximum, *C. torosa* has its maximum in September. *P. kraepelini* shows a clear maximum in April. This trend can be seen in the relative as well as in the absolute numbers. Almost all species show the same pattern between adults and juveniles in the biocoenoses. For example, adult *D. stevensoni* are most abundant in summer, juveniles as well. In addition, there are always significantly more adult individuals of a species than juveniles. ? Sampling effect (>250µm)

Which? Abundance? Rel. abundance? A/J?

The values of the taphocoenoses are (partly) significantly higher than those of the biocoenoses (except for *D. stevensoni*, here the biocoenoses is significantly higher). Again, significant differences can be seen between the samplings. *H. salina* shows the same pattern as in the biocoenoses (max. in June), in all other species the trends are not synchronous. For *P. kraepelini*,

synchronous?

for example, the maximum of the taphocoenoses is above the minimum of the biocoenoses and thus temporally shifted from the maximum of the biocoenoses in April, while for *L. inopinata* the maximum of the taphocoenoses is in April. In contrast, in *C. torosa* and *C. vidua*, a

in taphocoenoses

continuous decrease in the number of valves is observed over the months.

Species distribution and environmental conditions

Living ostracods occur in the Mansfeld lakes at salinity range between 0.7 and 11.5 PSU (Fig 8). Most species are associated with values between 1 to 6 PSU. Only three species (*H. incongruens*, *H. salina* and *I. gibba*) occur at values up to 11.5 PSU. *H. salina* shows the highest tolerance to salinity (1.4-11.5 PSU).

Living Ostracods were found in a temperature range between 9.4 up to 26.5°C. On average, most species were found between temperatures from 10 to 24 °C. Five species (*C. candida, F. fabaeformis, I. monstrifica, L. inopinata, N. monacha* and *S. aculeata*) occur in warmer water bodies (>18°C). The dissolved oxygen values, at which living ostracods were found, range between 4.3 mg/l and 19.4 mg/l. Majority of species occur between 5 and 16 mg/l. Although the range of most species is high there are more species associated with lower dissolved oxygen values. Just three species (*C. neglecta, C. torosa* and *H. salina*) were found living at values over 19 mg/l.

The pH range which corresponds to the occurrence of living ostracods is between 7.2 and 8.9. Most species are present between 7.5 and 8.6. Three species (*C. neglecta, C. torosa* and *H. salina*) occur in the entire pH range. Only *C. candida* were found in water bodies with higher pH values (8.2 to 8.6). ? But C. neglecta, C. torosa and H. salina as well?

The Canonical correspondence analysis plot (Fig 9) shows the relationships between physico-chemical parameters, ostracod species and localities. The first axis explains with 60% most of the variation and can be correlated with the parameters pH, temperature and dissolved oxygen. The second axis explains 22.5% of the variation and can be correlated with conductivity. However, only a few species show a significant correlation with the measured parameters (S1). *D. stevensoni* correlates with pH (r=0.56, p=0.02) and dissolved oxygen (r=0.57, p=0.02), *L. inopinata* with temperature (r=0.53, p=0.03) and *P. marchica* (r=0.54, p=0.02) with dissolved oxygen. Two species correlate with salinity, *H. salina* (r=0.51, p=0.03) and *S. aculeata* (r=0.57, p=0.02). Nevertheless, no (habitat specific) groups can be distinguished in the CCA.

Really? No ostracods are plotted.

4. Discussion

General aspects on ostracod species distribution

All ostracod species found are reported as cosmopolitan, euryoecious freshwater species, and are typical for central Germany (Meisch, 2000; Fuhrmann, 2012), and in particular for the region Mansfeld (Wennrich, 2005; Pint *et al.*, 2015). Due to the natural salinity of the lakes the occurrence of the two brackish water species *C. fuscata* and *C. torosa* ~~are~~ is not uncommon and already previously documented (Pint et al., 2012; Wennrich, 2005). So far, no findings of living *C. torosa* from (saline) inland occurrences in Germany are known, although valves of *C. torosa* have been found in higher saline water bodies in central Germany (Pint *et al.*, 2012; Scharf et al. ~~Herzog & Pint~~, 2017). The disappearance of *C. torosa* in Mansfeld area was explained by the draining of the 'Salziger See' in 1892 (Fuhrmann, 2012; Scharf *et al.*, 2017) and also Pint et al. (2012; 2015) were not able to find living *C. torosa* in the region. Therefore, the high numbers of living individuals of *C. torosa* found, especially in lower saline water bodies, are ~~somewhat~~ surprising. ? C. fuscata was also found living?

With 27 species found in the Mansfeld area, with a maximum of 17 species in one site (and maximum of 9 living), the number of species is relatively high with regard to the size of the study area and the small size of the water bodies. Size of the region (and number of water bodies) is decisive for the number of species found (Altınsaçlı, 2001; Rossetti et al. ~~Bartoli & Martens~~, 2004; Külköylüoğlu et al. ~~Sari & Akdemir~~, 2012). The number of species found within a water body depends, among other things, on size of the water body (Rossetti *et al.*, 2006; Valls *et al.*, 2016; Marchegiano *et al.*, 2017), type of habitat and related environmental conditions (Külköylüoğlu & Vinyard, 2000; Altınsaçlı, 2001; Külköylüoglu *et al.*, 2018).

+ connectivity/transport
Taphonomic processes influence taphocoenoses in addition.

In particular, the species richness and diversity of a water body results from an interplay of different factors, such as substrate type, vegetation, food availability, season and water depth (Smith & Delorme, 2010). The more ecological niches a water body has, the more species can be found (Iglikowska & Namiotko, 2012). High species richness usually indicates undisturbed habitats and stable environmental conditions (Carbonel *et al.*, 1988; Valls *et al.*, 2016). In literature, diversity changes in relation to salinity show a species minimum between 5-6 PSU, which is explained by the low tolerance of freshwater species to salinity (Remane, 1934; Frenzel, 2009). In contrast, the investigated water bodies show a maximum around 6 PSU. This supports the high tolerance of the species present with respect to salinity. Variability of salinity?

For an evaluation, by however, species composition must also be considered. As previously mentioned, ~~are~~ by most of the species occurring in the Mansfeld lake area are considered as widespread generalists with regard to their ecological preferences (in particular the common and abundant species). Actually, it is stated that cosmopolitan species often occur in disturbed and destroyed recolonized? habitats (Külköylüoğlu, 2013; Ghaouaci *et al.*, 2017). Külköylüoğlu (2013) describes this case as short explanation would be fine so-called `pseudo-richness´. Our data confirm this hypothesis, especially at the `Süßer See´, and at the residual lakes of the former `Salziger See´. Due to mining activities in the region during the last 800 years, soil and waters are exposed to high levels of pollutants from geological sources, but also anthropogenic pollutants from mine tailings and smelting products of copper shale mining (Frühauf, 1999; Becker *et al.*, 2001). In particular, `Süßer See´ is considered as a sink for heavy metals (Becker *et al.*, 2001). In addition, there are also considerable nitrogen and phosphate inputs from intensively agricultural use of the region (Lewandowski et al. ~~Schauser &~~ by ~~Hupfer~~, 2003; Schmidt et al. ~~Frühauf & Dammann~~, 2010).

Spatial distribution of ostracod species

Although the occurring ostracod species are reported to have wide and rather unspecific ecological preferences, each water body is characterised by specific ostracod species assemblages. Despite some water bodies are more similar (e.g., water bodies of former `Salziger See´) in their assemblages than others (e.g., water bodies without former `Salziger See´), each water body shows specific species composition (and species richness) and abundances during the sampling period. These differences can be explained by different biotic and abiotic conditions (Smith & Delorme, 2010) and cluster analysis of the taphocoenoses revealed that similarities could originate from the hydrological connection of some water bodies (SS,KS,BS and MG).

The differentiation between living ostracods and valves shows that species abundance and richness is much higher in valves which is reported by other studies, too (e.g. Akita et al., 2016; Valls et al., 2016). This might be due to the different temporal scales integrated by these two associations. Biocoenoses represent short-term population dynamics and associated environmental conditions at the time the sample was taken and are therefore strongly influenced by the seasonality or life-cycle, respectively, of the species (Winegardner *et al.*, 2015).

Taphocoenoses, on the other hand, integrate, through accumulation and time average ing, several generations over seasons and years and, thus, a larger range of environmental fluctuations (Poquet *et al.*, 2007). In addition, some species, which are present in taphocoenoses, are rare or absent in biocoenoses, due to the fact that variations between seasons and years are captured (Levi *et al.*, 2014). Also, substrate type and sedimentation rate are important to be considered for the number of specimens and species composition. According to Hellmund et al., by (2011) and Wennrich (2005) a sedimentation rate of approx. 1cm/y can be assumed for the `Süßer See´ and former `Salziger See´. The sediment volume available at site depends on the underground

③ I agree. But would add that D. stevensoni is also very slender and could easily pass the mesh of the sieve (250µm) as isolated valves.

volumes? sample depth? ①

surface. On gravel considerably lower amounts of samples could be taken than on muddy substrate. Thus, the sampled sediment is estimated to represent about 1-2 years. Taphocoenoses not only contain ostracods through time, but also valves relocated from other areas within a lake or other water bodies (e.g. transported by waterfowls) and may be included to the sample (spatial factor) (Mezquita *et al.*, 2005; Winegardner *et al.*, 2015). This can lead to a distortion of the results (Dieffenbacher-Krall, 2013). An indication of valve transportation is the extremely high ② number of adult valves compared to juvenile valves in most water bodies. Another indication for taphonomic processes is the occurrence of some living species that were not found in the taphocoenoses of the respective water bodies (e.g., *C. vidua* and *D. stevensoni*). This is especially true for *D. stevensoni*, because here, in sum, significantly more living than valves were found. These may have been relocated or destroyed. The latter aspect is favoured by the fact, that valves of *D. stevensoni* are very thin and fragile (Meisch, 2000). The preservability of the valves therefore also plays a role in which valves (and in which abundances) are found. ③

The strong differences of species abundances demonstrate that the location of sampling within a water body is crucial. Sampling positions only a few meters away from each other can provide significantly different live and dead species assemblages which might be caused by differences in microhabitat conditions (Decrouy, 2009) or very local currents. This could be a reason why no living *C. torosa* has been found in the past few decades. The occurrence of single ostracod species or populations in a water body can be, therefore, very local (Smith & Delorme, 2010; Marchegiano *et al.*, 2017) and is not mandatorily related to changes in water chemistry (i.e., salinity) as it is often assumed as in the case of *C. torosa*. In order to obtain a comprehensive picture of the ostracod fauna, multiple sampling should therefore ideally be carried out. If only one

② Can be used in a relative way only because of the longsieve size used.

① A sedimentation rate of 1cm/year for fine grained sediment. Gravel implies no sedimentation / or erosion / a taphocoenosis from gravel or coarse sand could cover several years or more.

sampling can take place at a site, this site should be carefully selected in order to better classify the results.

add living/dead ratio as taphonomic proxy

Seasonal distribution of ostracod species

The differences in abundances and occurrences of species in the samples show, that not only sampling site but also the time (i.e., specific month) of sampling have an important influence on the distribution and abundance of living species due to their specific life-cycles (Decrouy, 2009; Altınsaçlı, et al. ~~Perçin-Paçal & Altınsaçlı~~, 2015) and also contributes to significant differences in taphocoenoses. Although the taphocoenoses usually integrate~~s~~ over several years and should therefore not show any inter-annual variations, sometimes strong differences occur in the number of species (Poquet *et al.*, 2007), the number of valves and the ratio of adult and juvenile valves of a species (Decrouy, 2009). Some species are represented by valves only (and with very low abundances) during the sampling period, which raises the question where these valves originate from. One explanation could be also very local distribution patterns of the species within a water body (Poquet & Mesquita-Joanes, 2011). The species could live elsewhere in the water body and the valves have been relocated (Mezquita *et al.*, 2005). Another explanation could be the ① occasional entry of single specimens through passive dispersal by water fowls or mammals (Dieffenbacher-Krall, 2013). The Mansfeld lake area is not only a bird sanctuary with numerous water fowl species, it is also a staging and wintering site. Migratory birds pass this area in spring and late autumn (Al Hussein *et al.*, 2000). Some ostracod species could be transported from other regions in this way, but cannot prevail due to unfavorable ecological conditions and/or competition, food supply, etc. This is supported by the fact that some species occur only in April (*C. kingsleii*) and June (*P. newtony, P. zenkeri*) but completely disappeared in September. An

① But this explains a very few individuals only.

air-born colonization by migratory birds is also assumed for the foraminifer genus *Ammonia* and the ostracod species *C. fuscata* (Wennrich *et al.*, 2007). Birds will not only play an important role in the dispersal of species from other regions, but also in the distribution of species between and within the water bodies in this area.

Furthermore, it is possible that a species may no longer occur in a water body because one or more environmental conditions have changed (Poquet *et al.*, 2007). Thus, the temporary occurrence of some species cannot be explained by the life-cycle alone. All these aspects (e.g., single/few valves from a species in one month only, higher adult: juvenile ratio in valves) rather indicate strongly dynamic conditions in the sampling sites (i.e., littoral) of the water bodies due to high seasonal variations. These variations include daily, seasonal as well as inter-annual fluctuation, like temperature or water level fluctuation (flooding increase habitat availability, drawdown decrease habitat availability (observed in WL and SS for example)) (Gasith & Gafny, 1990) and higher wave motion (Peters & Lodge, 2009). In addition, the littoral is most affected by terrestrial run-off (detritus, sediment and nutrient input from terrestrial sources) and transient species from the surrounding ecosystem (Peters & Lodge, 2009). Due to the location in the central German dry region, the water bodies are highly affected by long dry periods (with low water levels) and short extreme precipitation events (and high run-offs with high nutrient inputs) (Schmidt *et al.*, 2010). These factors indicate a disturbed habitat and could be stressors for the species (Padisák, 1993).

add comparison of seasonal occurance with literature data (eg. Meisch 2000)

Ecological inferences

According to Fuhrmann (2012) and Meisch (2000), most of the species found prefer warm stagnant or cool stagnant water bodies. However, this is not applicable in order to explain the spatial

distribution of the species in this study. The area is spatially very limited, deviations of abiotic parameters of the water bodies are relatively small and almost all species are assumed to have large tolerance ranges for (measurable) physico-chemical parameters. Thus, all species occurrences reflect the known range of physico-chemical parameters (Frenzel *et al.*, 2010; Ruiz *et al.*, 2013). Only *I. bradyi* was found living? in higher saline waterbodies (up to 7.9 PSU) than the known range from literature (4.5 PSU). The higher range of *Potamocypris* is probably due to the merging of two species because of the difficulty in distinguishing them from each other.

Due to this the question arises, 1 why not all species were found in all water bodies. As explained above, sampling of the water bodies may not cover the entire ostracod fauna of a water body (Poquet & Mesquita-Joanes, 2011). Hints for this could be provided by the higher number of species in the taphocoenoses and the deviations of species composition and abundances in bio- and taphocoenoses.

Furthermore, the water bodies could provide, e.g. due to different hydro(geo)logical condition, such as residence time, inflow and/or run off, different hydrochemical compositions, like major ion concentrations (Mezquita *et al.*, 2001; Smith & Delorme, 2010) that could have a undetected control on the species distribution. Also, other not-measured (micro)habitat specific factors are possible, like substrate type, presence and coverage of vegetation, food supply and flow energy (Mezquita *et al.*, 2005; Kiss, 2007; Marchegiano *et al.*, 2017).

However, not only habitat conditions, but also metacommunity dynamics, e.g. source-sink effects, dispersal rates, mass and rescue effects, are important drivers in the distribution, abundance and life-cycle of species and can contract the structuring role of environmental parameters, especially in cosmopolitan species (Leibold *et al.*, 2004; Guisan *et al.*, 2010).

Studies revealed that species move, for example, to other microhabitats when the optimal niche

1 But there are more environmental factors than salinity. + transport, migration, taphonomy, variability of the environment

Okay, is discussed below.

is occupied or competing species develop contrary life-cycles to avoid competition (Carbonel *et al.*, 1988).

Nonetheless, this implies that the species might be not controlled by the most commonly considered environmental parameters but it also implies that they are not as euryoecious or generalistic as assumed.

The two species that occur exclusively in low saline (*P. marchica* and *N. monacha*) and higher saline (P. compressa and *I. gibba*) water bodies occur (except for *P. marchica*) in such low abundances (<4%) that their occurrence is not significant enough to distinguish water bodies with respect to salinity. *P. marchica* is more abundant but shows no (negative) correlation with salinity in CCA. Two species, *C. vidua* and P. *kraepelini*, occur in higher abundances in lower salinity water bodies (category a) and also form a group in the cluster analysis. However, they also show no correlation with salinity or other parameters in the CCA. In water bodies with higher salinities (category b), *H. salina* and *C. torosa* are particularly abundant, and the CCA also shows a correlation between *H. salina* and salinity. In the cluster analysis, *H. salina* forms a group with *I. gibba*. However, *H. salina* shows higher abundances only in one water body (TE), and *I. gibba* also generally occurs only in two water bodies (TE2 and QW). Moreover, both *C. vidua*, *P. kraepelini*, and *H. salina* also occur in other water bodies and show only slight differences in abundance in some cases, especially in the taphocoenoses. This highlights the differences between bio- and taphocoenoses.

italics

Considering correlations of the species with the measured parameters (CCA), together with the species abundances of the species, it emerges that only few species correlate with certain parameters (e.g., *L. inopinata* with temperature). However, the indifferent pattern of the species in the CCA implies that species composition is water body specific and not directly controlled by

the measured parameters. For instance, a species does not occur in water bodies with the same or better conditions (e.g., slightly higher temperatures). Although the measured physico-chemical parameters salinity, pH, temperature and oxygen content cannot explain the species distribution, the parameters probably influence the population dynamics. Studies show, for example, that the lifespan of *D. stevensoni* can range from <1 to 4 years depending on the temperature (Van Doninck *et al.*, 2003), while *L. inopinata* develops different abundances and overwintering strategies depending on whether they live in freshwater or saline water bodies and these populations never co-occur. Freshwater populations appear in April/May and disappear in October/November, while saline population overwinter (Geiger 1998). Variations in the temporal occurrence of *L. inopinata* in different water bodies (BS & WL) were also observed in the Mansfeld area. Whether these are caused by the different salinities (BS: 6.4 PSU, WL: 2.1 PSU) of the water bodies is uncertain.

missing in references

In the Mansfeld area, not only the occurrence of *C. torosa* is surprising, but also its distribution. Although *C. torosa* is known as a widespread and ecological ly opportunistic species, it is considered as an indicator species for brackish water and is often used as index fossil to reconstruct palaeosalinity and -temperature (Pint *et al.*, 2012; Scharf *et al.*, 2017). In the Mansfeld area, however, *C. torosa* occurs only between 0.9 to 7.9 PSU, having the highest population density at lower saline water bodies (0.9 and 1.3 PSU), and thus cannot be used as a salinity indicator in this area. The position of *C. torosa* in the CCA near coordinate origin indicates that it is not affected by measured physico-chemical parameters and also in the cluster analyses *C. torosa* shows no similarities with other species. This implies other or at least further environmental controls beside salinity and temperature. It is also important to consider possible autecological differences between marine and ~~terrestrial~~ athalassic populations.

1

I disagree. C. torosa indicates brackish water, it may be, however, present through the entire brackish-marine – hypersaline range. Using this species for indicating salinity levels needs association or morphological analyses! C. torosa is most abundand at the German coast in oligohaline settings too.

Wang *et al.* (2021) figure out that populations from different regions are adapt ed to local aquatic environments and therefore develop specific preferences. Thus, the actual preference range of a species may be locally very narrow. The above-mentioned examples show, this assumption is not only restricted to a large spatial scale, but can also be valid on a local scale for spatially close water bodies with different conditions, such as the Mansfeld area. So, each water body provides a specific combination of biotic and abiotic ly conditions ~~providing differing habitat conditions~~ ly for the ostracods. As a result, species seems to develop their specific population dynamics/different life-cycles, depending on the conditions they encounter (Leibold *et al.*, 2004). Thus, no habitat specific species assemblages related to the documented physico-chemical parameters can be distinguished in this study.

5. Conclusion

This actualistic-autecological survey focuses on the spatial and temporal distribution of ostracod assemblages in ~~12~~ twelve saline inland water bodies with special emphasis to differences between bio- and taphocoenoses.

It can be shown that not only the place, but also the time of sampling, can provide very different results with regard to inferences of ostracod species distribution (and the associated conclusions regarding the environment). Furthermore, it is important to consider differences between biocoenoses and taphocoenoses and related mechanisms: the biocoenoses i is always only a snapshot and the sampling season has a large influence, the taphocoenoses i on the other hand integrate s often longer but difficult to estimate temporal scales. Biases due to taphonomic processes can be very local including transport and relocation (e.g., species loss, dispersal). Thus, the relationship between abundance and species composition of living ostracods and

related taphocoenoses is, however, not straightforward. Partially, strong deviations of species numbers and/or occurrences in bio- or taphocoenoses between the months highlighting the relevance of post-mortem processes even on short time scales (i.e., month). This must be taken into account when fossil material is interpreted.

There is no simple pattern in species distribution and abundances although all species are considered as common freshwater species and are known for wide ecological tolerances. The water bodies show differences in ostracod species assemblage composition which cannot explained by measured ecological parameters. Especially, salinity has a comparably small influence on the ostracod species distribution. For species considered as cosmopolitan and/or euryoecious it can be assumed that community dynamics (inter/intraspecific competition, sink-source dynamic, mass effect, dispersal rates) counteracts the structuring role of environmental parameters. ~~However, n~~ N ot all ostracod species are found in all water bodies. This highlights, that current assumptions on autecological inferences on 'common' species are not sufficient to explain distribution of these species. Other factors that have received little attention (e.g., vegetation types, composition or texture of substrate, nutrient input, hydrologic conditions) could provide further clues and thus increase the indicator potential of these generalists. The distribution of species and the waterbody specific life-cycles of species suggest that each species has adapted to its aquatic environment, not only on a large spatial scale, but also on a local scale. In particular, the occurrence of *C. torosa* in slightly saline inland waterbodies questions this species as a proxy for (palaeo-) salinity. (1) This indicates that caution is required when interpreting fossil records in terms of biodiversity, (palaeo-) limnological and (palaeo-) ecological conditions. The Mansfeld lake area represents an example region, as here, in a narrowly defined area with a ly relative homogeneity in the assumed control variables (pH, salinity, temperature, oxygen content), these

(1) Again, I disagree. It works well in Salinity transfer functions.

variables do not contribute to the explanation of the species distribution pattern. Future studies must therefore consider other environmental factors (biotic and abiotic) for the identification of major controls on species occurrence.

replicate; us

Therefore, in order to obtain reliable and conclusive data, ~~several~~ samples should ideally always be carried out and a distinction should be made between living specimens and valves. This provides a better understanding of the spatial and temporal distribution and a better assessment of variability and possible taphonomic processes, as well as precise ecological inferences.

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better to move to V

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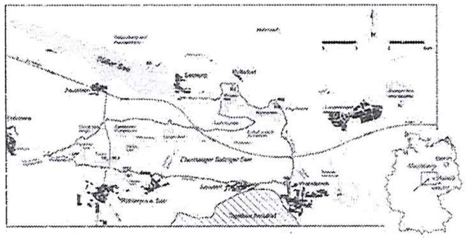
Figure 1

Geographical location in Germany and sampling sites in the Mansfeld lake area (modified after Wennrich 2005).



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supporting land management decisions in the Central German dry region by geoecological research. pp. 111–122. Book? Report? Thesis?

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Figure 3(on next page)

Relative abundance of valves and living ostracod species in April, June, and September.

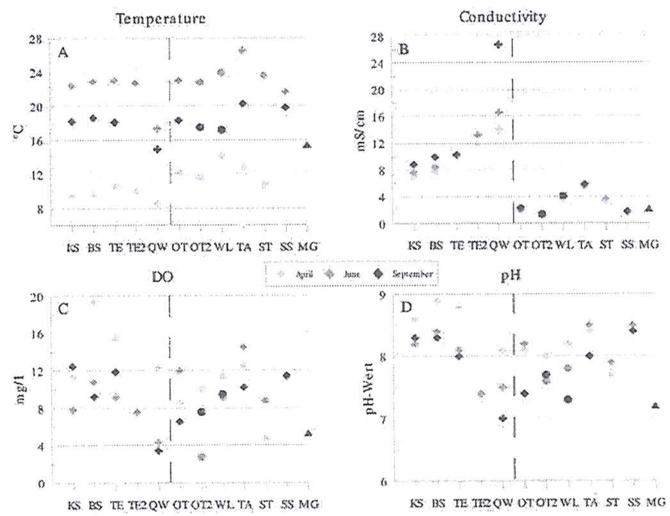
Cc=*Candona candida*, Cn= *Candona neglecta*, Cf= *Cytheromorpha fuscata*. Ck= *Candonopsis kingsleii*, Ct=*Cyprideis torosa*. Cv= *Cypridopsis vidua*, Ds= *Darwinula stevensoni*, E sp?= *Eucypris* sp?, Ev= *Eucypris virens*, Ff= *Fabaeformiscandona fabaeformis*, Fh= *Fabaeformiscandonda holzkampfi*, Hc= *Herpetocypris chevreuxi*, Hi= *Heterocypris incongruens*, Hs= *Heterocypris salina*, Ib= *Ilyocypris bradyi*, Ig= *Ilyocypris gibba*, Im=*Ilyocypris monstrifica*, Li= *Limnocythere inopinata*, Nm= *Notodromas monacha*, Pk= *Physocypria kraepelini*, Pn= *Plesiocypridopsis newtoni*, Pa= *Potamocypris arcuat~~e~~a*, Ps= *Potamocypris smaragdina*, Pz= *Prionocypris zenkeri*, Psc= *Pseudocandona compressa*, Psm= *Pseudocandona marchica*, Sa= *Sarscypridopsis aculeata*.

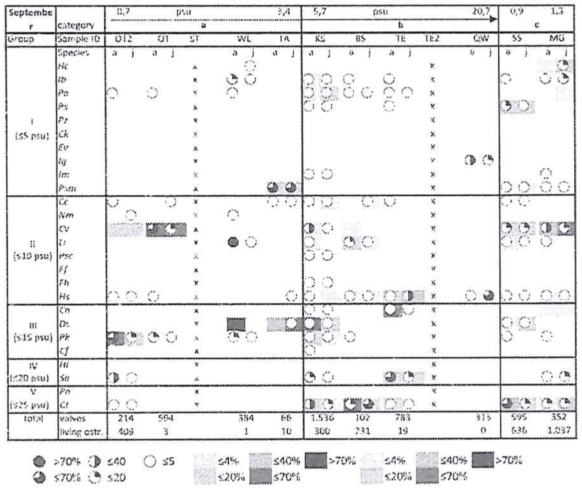
Which symbols are for living ostracods, which for empty valves? What does the lines mean?

Figure 2

Physico-chemical parameters of the investigated water bodies in the Mansfeld lake area in terms of temperature, conductivity, DO (dissolved oxygen) and pH.

Symbols represent: ◆ =lake, + = temporary source fed ditch section, ● =pond, ▲ = ditch.

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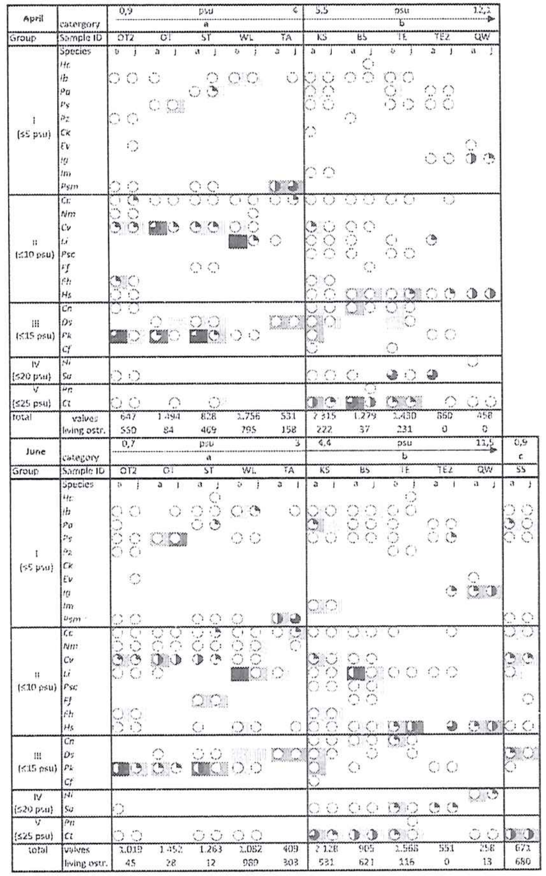
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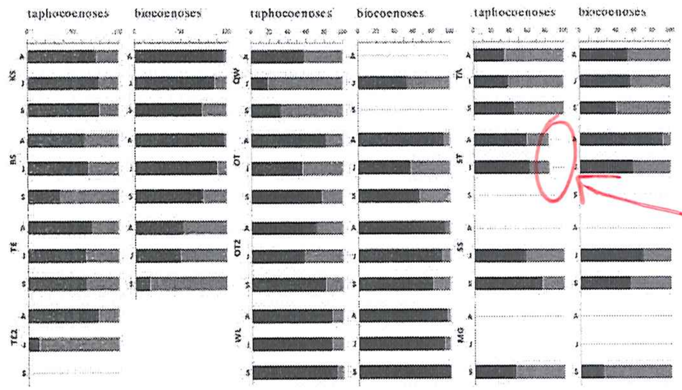
Figure 5

Ratios of adult and juvenile ostracod ~~species~~ values in the water bodies. Left columns refer to taphocoenoses, right columns biocoenoses. Abbreviations of the water bodies as in Table 1.

black = adult ? ?
grey = juvenile ?



Why not 100%?

Figure 4

Cluster analyses of water bodies (left side) and species (right side) for thaphocoenoses (upper side) and biocoenoses (lower side).

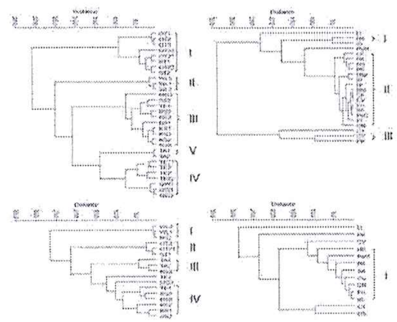
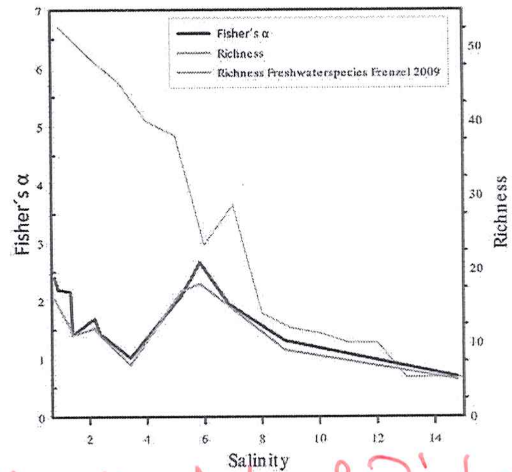


Figure 7

Seasonal distribution of common and abundant species in the study area differentiated for adult and juveniles and distribution of living specimens and valves. Absolute and relative abundances summarized for all water bodies.

Figure 6

Fisher´s α diversity and richness of cumulated taphocoenoses of the water bodies at Mansfeld in comparison with richness of freshwater species in waterbodies in the catchment of the Baltic sea Frenzel (2009).



Adding the data of Pint et al. (2015) would create an enlarged reference of data
The curves by Remane and Frenzel were compiled by summing up ranges of tolerances:

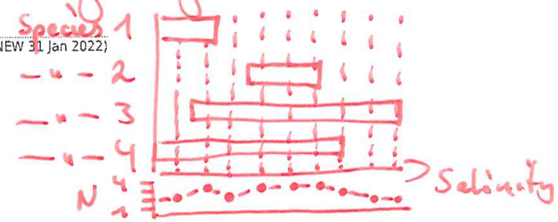
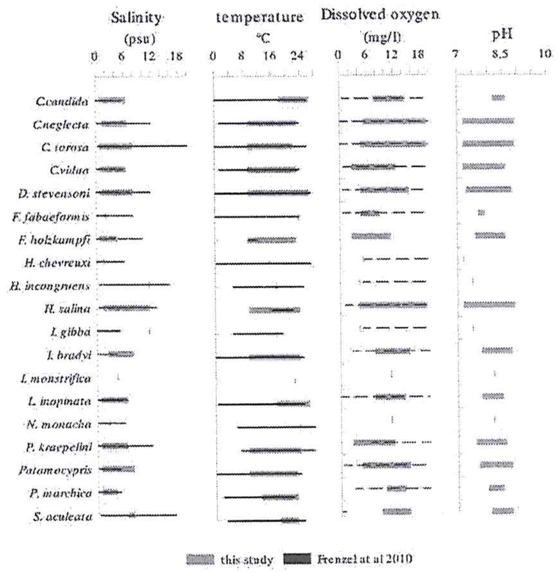
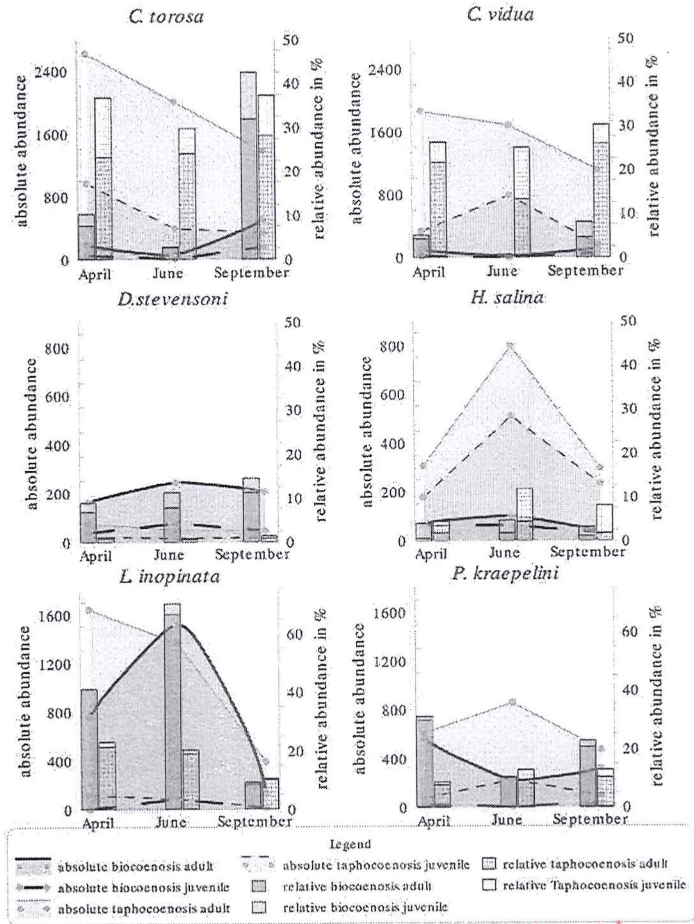


Figure 8

Occurrence of ostracod species in relation to fluctuations in salinity, temperature, dissolved oxygen and pH related to all samplings and localities compared to the study of Frenzel et al 2010.





Probably better splitting each diagram into biocoenosis and taphocoenosis data.

Table 1(on next page)

Overview of sampling sites in terms of name and sample-ID, coordinates, habitat type, substrate, vegetation and sample month.

Information on substrate and macrophytes are classified as following: substrate: 1=sand, 2=mud; vegetation: 0=none, 1=algae, 2=aquatic macrophytes, sample month: A=April, J=June, S=September

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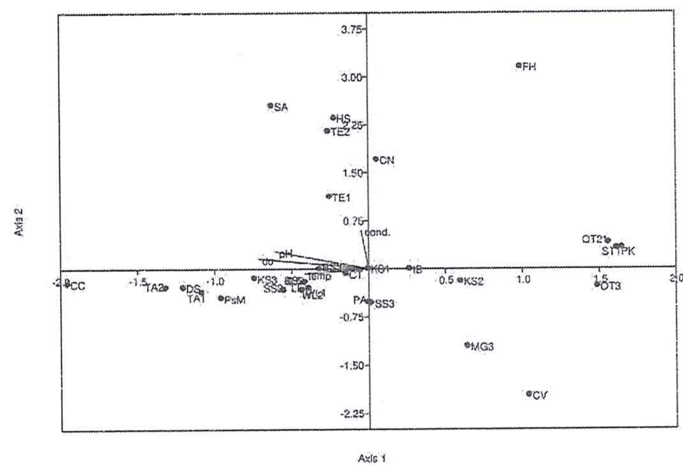
Figure 9

First two axes of Canonical correspondence analysis (CCA) ordination plot of ostracods, environmental variables and water bodies (Sample-ID Table 1 and month with 1=April, 2=June and 3= September).

Species code similar to Fig. 3, cond= conductivity, do=dissolved oxygen, temp= temperature and pH.



Name	Sample-Id	Latitude (N)	Longitude (E)	habitat type	substrate	vegetation	sample month
Kernersee	KS	51.485102	11.740385	lake	1	0	A/J/S
Bindersee	BS	51.489583	11.724183	lake	1	1	A/J/S
Teufe	TE	51.470694	11.675120	lake	2	1	A/J/S
Teufe 2	TE2	51.471072	11.676226	lake	2	1	A/J
Quelle im Wald	QW	51.470166	11.668428	temporary source fed ditch section	2	1	A/J/S
Ottilienteich	OT	51.467471	11.682365	lake	2	2	A/J/S
Ottilienteich 2	OT2	51.468329	11.682151	pond	1	0	A/J/S
Wannsleben	WL	51.465623	11.744928	pond	2	0	A/J/S
Tongrube Alte Schule	TA	51.463703	11.764960	lake	2	1	A/J/S
Salzatal	ST	51.485483	11.790107	lake	1	0	A/J
Süßer See	SS	51.498387	11.676360	lake	1	1	J/S
Mittelgraben	MG	51.485583	11.741115	ditch	1	2	S