Joannea Geol. Paläont. 9: 25-30 (2007)

Taxonomic Diversity of Middle Miocene Ostracod Assemblages – A Useful Tool for Palaeoenvironmental Characterization of the Hainburg Area (Vienna Basin)

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Diversity of a given organismic assemblage can be expressed through the integration of taxonomic richness at various hierarchical levels (cf. WHATLEY 1990). It can be called taxonomic diversity. For comparative purposes of animal assemblages CLARKE & WARWICK (1998) proposed a diversity index which takes the length of the path connecting two species, traced through a Linnean hierarchical classification of the full set of species in the assemblage into consideration. The index was named Average Taxonomic Distinctness (AvTD or Delta+) and measures the average length of the taxonomic path between any two randomly chosen species (*i,j*):

$$(\mathrm{AvTD}) = \mathrm{Delta}+ = [(\Sigma\Sigma_{i<j}\,\omega_{ij}/(s(s-1)/2)]$$

s = number of species present, ω_{ij} = taxonomic distance or distinctness weight

The AvTD can be seen as a generalisation of Simpson's diversity index (CLARKE & WARWICK 2001). This diversity index has already been used for fossil ostracods by GALOUKAS & DANIELOPOL (2004). It proved useful as an additional tool for further characterisation of ostracod assemblages characterising a stressful environment in the Late Cenozoic of Cyprus Island.

We apply here the AvTD index to data obtained during a project dealing with the description of Middle Miocene ostracod assemblages from the Vienna Basin (Hainburg, Lower Austria). Within this project, lead by one of us (W.E.P.), ostracods were studied by GROSS (2002, 2006) under various aspects, respectively systematics, biostratigraphy and palaeoecology. Ostracod assemblages have already been recognized by GROSS (2002), which differ depending on the palaeoecological situation. In the Hainburg area the influx of freshwater seems to have modulated the composition of the ostracod assemblages.

The present contribution intends to demonstrate the application of the AvTD index in order to extract additional palaeoecological information, respectively to differentiate between two areas, a predeltaic and an eumarine one.

Ostracods from 10, up to 100 m long sediment-cores were studied (in total 66 samples; 59 from Badenian, 7 from Sarmatian deposits) originating mainly from an area located close to Bad Deutsch Altenburg (Fig. 1).

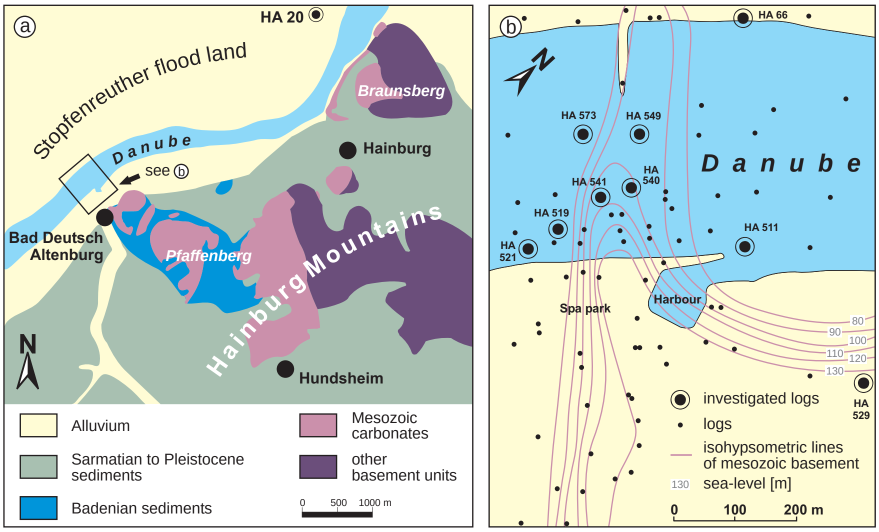

Fig. 1: Geologic map of the Hainburg area with the location of the sampling sites. a) General situation. b) Detailed map of the investigated wells.

For the present purpose the ostracods (all belong to the order Podocopida) were classified into five taxonomic units: suborder, superfamily, family, genus and species. Gross (2002, 2006) recognized 63 species belonging to: 2 suborders (Podocopa and Platycopa), 4 superfamilies (Cytheroidea, Bairdioidea, Cypridoidea, Cytherelloidea), 15 families (11 Cytheroidea, 2 Cypridoidea, 1 Bairdioidea, 1 Cytherelloidea families) and 37 genera (31 Cytheroidea, 3 Cypridoidea, 2 Bairdioidea genera and 1 Cytherelloidea genus). Note that two suborders converge in the order Podocopida.

We will discuss here only the Badenian ostracods from 16 samples belonging to seven cores containing several ostracod species as palaeoecological markers and at least four species (the lowest limit for computation of the AvTD). Respectively, we used the non-marine species belonging to the genera *Ilyocypris* (Ilyocyprididae), *Fabaeformiscandona* (Candonidae) and *Pseudolimnocythere* (Loxoconchidae), which occur in samples from boreholes labelled in Gross (2006) HA 519, HA 521, HA 540, HA 541 and HA 573 (cf. Fig. 1). A species of the genus *Fabaeformiscandona* occurs in the sample HA521/5. As the species richness of this sample is too low (cf. two species) we did not use it for computation. It should also be noted that the genus *Pseudolimnocythere* is represented by a unique species, *P. hainburgensis*, which belongs to a predominantly stygobitic group (Danielopol et al. 1991).

This species occurred only in two samples, HA 519/1 and 541/7 (Gross 2002, 2006). We did not use the latter sample in our computation because of the low number of taxa *in situ*, respectively two *Callistocythere* species.

We hypothesize that the area, called A in table 1, forms a predeltaic zone with fluctuating and lowered salinity. We use for characterisation of eumarine conditions the ostracod species belonging to the genus *Cytherella* (Cytherellidae). Representatives of cytherelloids live generally under eumarine salinity conditions (Hartmann 1989). The investigated samples (cf. Tab. 1) originate from the cores HA 20, HA 66 and HA 511. For our taxonomic diversity characterisation we eliminated the obviously drifted non-marine species belonging to the genera mentioned above from the species lists. Therefore the average taxonomic diversity was calculated using 45 species belonging to 34 genera included in 13 families, which belong to four superfamilies and two suborders (Tab. 1).

Area	Borehole Sample No.	Sub-Order	Super-Family	Family	Genus	Species	AvTD( )
A	HA 519/5	1	1	3	3	5	48.0
A	HA 519/7	1	1	4	4	4	53.33
A	HA 540/1	1	1	6	11	14	53.63
A	HA 540/3	1	1	4	5	6	57.33
A	HA 541/4	1	1	5	6	11	52.73
A	HA 541/5	1	1	4	4	5	56.0
A	HA 541/7	1	1	3	3	4	53.33
A	HA 573/19	1	2	8	16	23	54.47
B	HA 511/4	2	3	9	12	21	67.05
B	HA 511/7	2	3	8	9	15	65.71
B	HA 511/8	2	3	8	12	22	62.86
B	HA 511/9	2	3	7	11	15	65.90
B	HA 511/11	2	3	8	12	21	66.19
B	HA 66/21	2	4	9	11	14	72.97
B	HA 20/8	2	3	11	18	25	63.60
B	HA 20/9	2	3	9	19	23	63.0
	total taxa	**2**	**4**	**13**	**34**	**45**	**61.13**

Tab. 1: Taxonomic diversity of 16 ostracod assemblages from the Hainburg area (data from Gross 2006).

The results were represented graphically using the AvTD algorithm described in Clarke & Warwick (2001) and implemented in the computer programme-package PRIMER v.6 (Clarke & Gorley 2006).

The examination of the AvTD index for the eight samples of domain A showed a range of values between 48 and 57.33 (Fig. 2 and Tab. 1). One sample (HA573/19) displays a value, which lies outside the lower 95 % of the delta value simulated by randomisation of subsamples from the total species list (cf. Fig. 2 and for details of the procedure Clarke & Warwick 2001). All eight values of the A domain are located below the total AvTD value (Fig. 2). The median value for the species is 7.5, for the genera and families 4.5. Most of the species belong to one superfamily, the Cytheroidea.

The samples from the wells HA 20, HA 66, and HA 511 containing cytherelloids belong to domain B. The AvTD values vary between 62.86 and 72.97.

The sample HA66/21 lies outside the upper 95 % of the delta value simulated by randomisation of subsamples from the total species list (Fig. 2). The median value for species is 21.5, for genera 12, for families 8.5. In most cases there are three superfamilies and two suborders.

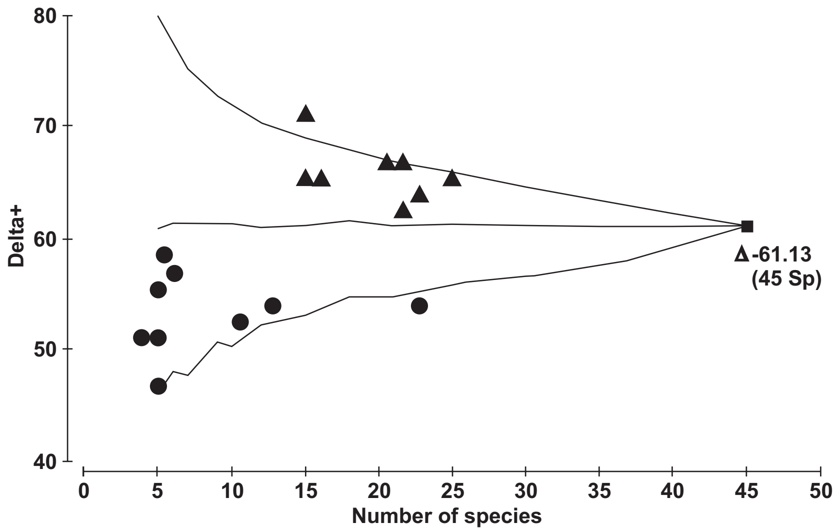

Fig. 2: Taxonomic diversity (AvTD values) of 16 ostracod assemblages from Hainburg area (dots = values for samples from domain A, triangle = samples from domain B, square = AvTD value for the total species list (cf. Tab. 1), thin line = 95 % probability funnel for the expected range of the AvTD (= delta) values.

The data presented here supplement those presented in Gross (2002), respectively that we are dealing with two palaeoenvironmental domains – a predeltaic one and an eumarine one.

Looking at the position of the wells (cf. Fig. 1) we will note that the predeltaic zone is located on the left side and those where eumarine conditions seems to have prevailed on the right side. The taxonomic diversity of the samples from zone A is much lower than those of zone B, suggesting that the influx of freshwater into the marine system produced stressful biological conditions to the ostracods. Zone B, with a higher taxonomic diversity, suggests more stable and favourable ecological conditions as experienced by the ostracod species.

We conclude that the examination of the AvTD index represents a useful palaeoecological descriptor when combined with additional information like palaeoecological data for the selected ostracod taxa used here.

Acknowledgements
The work of D.L.D. is supported by the Austrian Science Fund (FWF project No. P-17738-BO3). D.L.D. acknowledges discussions related to the statistics of the taxonomic diversity that he had during the years with Prof. F. Österreicher (Salzburg) and Dr. K.R. Clarke (Plymouth). The Austrian Science Fund (FWF project No. 12229-GEO) sponsored the work of M.G., which was also supported by the Austrian Academy of Sciences. K. Minati (Mondsee) read a first draft of the manuscript.

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