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Introduction to the Computer Programme MORPHOMATICA

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MORPHOMATICA is a user-friendly computer programme designed for the morphometric analysis of the shape of ostracods with a more or less smooth outline. The software package (Linhart et al. 2006) with the same name is available at http://palstrat.uni-graz.at.

For the mathematical description of outline shapes MORPHOMATICA uses an original solution, here called "the Linhart algorithm" (cf. details in the next chapter), based on a B-spline method, a popular technique in computer aided geometric design (cf. Hill 1990) which has been applied to morphometric analysis of human skulls by Guéziec (1996).

The MORPHOMATICA project, which started in 2001 at the Limnological Institute, Austrian Academy of Sciences, in Mondsee, and at the Department of Mathematics, University of Salzburg, is a spin-off of a larger project on the morphometrics of non-marine ostracods initiated ten years ago by one of us (A.B.) and from which various publications issued (cf. inter alia Baltanás and Geiger 1998, Baltanás et al. 2002, 2003, Danielopol et al. 2002, Sánchez-González et al. 2004). One should see the computer programme described here as a complement to other computer programmes using alternative approaches, like Eigenshape analysis and/or Fourier analysis (see a review of morphometric methods used by ostracodologists in Danielopol et al. 2002).

MORPHOMATICA and the Linhart's B-spline algorithm have interesting features as compared with other programmes: (1) it uses a reduced number of parameters for the mathematical reconstruction of form; (2) one can identify the segments of the outline described by the B-spline functions; (3) the computation is not excessively long for the solution proposed; (4) it allows to estimate the precision with which the B-spline curve fits the original digitised outline; and (5) it allows to produce virtual "arte–factual" outlines useful

for various topics dealing with theoretical and/or applied morphology. MORPHOMATICA, as other programmes do (cf. those of the Eigenshape analysis method discussed by Rohlf 1996), suffers also from limitations: it performs badly when outlines are much angulated or very heterogeneous. In such cases it seems that Elliptic Fourier analysis -included in programmes like EFA - Eliptic Fourier Analysis (cf. Rohlf 1990) or MAO – Morphometrica Analysis of Outlines, developed by one of us (A.B.), performs better.

The presentation of MORPHOMATICA is here offered in several contributions: the mathematical part presented by W. Neubauer and J. Linhart, the programme description *sensu strictu* written by W. Brauneis, W. Neubauer, A. Stracke, the practical description of creating "tps.dig files" by A. Strake. Finally the presentation of a series of worked examples for morphometric analysis of outlines, prepared by A. Stracke, W. Neubauer, L. Picot and D. Danielopol, are intended to demonstrate the utility of MORPHOMATICA for descriptive work within two research directions: comparative morphology and taxonomy (1st example), morphological variability potentially related to ecological cues (2nd example).

One should note that the information presented with MORPHOMATICA is related to the utilisation of other computer programmes too. MORPHOMATICA uses the digitised information of the valve outlines captured with the programme "Tps.dig" (Rohlf 2001). We used for this programme the version 1.43, which was downloaded from the web site http://life.bio.sunysb.edu/morph/soft-dataacq.html. Additionally the data obtained from the superimposition of outlines allows the computation of the amount of morphological differences (represented by vector dimensions and Euclidean distances). This latter data is further analysed using multivariate statistical methods. In the examples we present it is shown how using non-metric multi dimensional scaling and/or hierarchical cluster analysis one can visualise the data within the framework of morphological spaces. We use since several years the computer package "Primer", with its versions 5 and 6 (Clarke and Gorley 2001, Clarke, K.R. and Gorley, R.N. 2001. Primer v5: User manual/tutorial. Primer-E Ltd., Plymouth 2006) specially designed for multivariate statistical analysis. Note that there are other packages which can be as useful as the one mentioned here. Our preference for "Primer" is due to the user-friendly structure of the programmes, to the excellent manual produced by Clarke and Warwick (2001).

Finally, we recommend to those interested in additional information on geometric morphometrics the various books issued during Morphometric Symposia, like those of Marcus et al. (1996). An excellent introductory text, which has to be consulted, is "Geometric morphometrics for biologists, a primer" (Zelditch et al. 2004).

For the practical use of MORPHOMATICA programme one should consult inter alia also Iepure et al. (2007, 2008), Minati et al. (2008), Danielopol et al. (2008), Gross et al. (2008).

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