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# Measurements from drawings or photographs – developing an integrated approach for conchostracan classification

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The method of conchostracan classification developed by Goretzki (2003) and improved by Scholze and Schneider (2015) is based on a set of quantitative and semi-quantitative criteria derived from morphometric measurements of conchostracan carapaces. This method involves drawings made using a stereomicroscope with mirror tube (camera lucida) attached. This method is labour-intensive and time-consuming. This study was aimed to test the possibility of deriving the same parameters from digital photographs.

Conchostracans from two localities formed the study material. The Monastery Ravine section is located on the right bank of the Volga River near the town of Tetyushi (East European Platform). The section exposes sediments of the Urzhumian and Severodvinian regional stages (Middle–Late Permian). The Babiy Kamen' section is located on the right bank of the Tom' river (Kuznetsk basin, West Siberia) and comprises deposits of Late Permian and Early Triassic.

For statistical analysis of four arrays of data, the official licensed program STATISTICA v12 has been used. Data arrays were the collections of biometric parameters of conchostracan carapaces, which included quantitative and semi-quantitative characters. The quantitative parameters are (Fig. 1): length (L), height (H), length of the dorsal margin (l), height of the larval valve (h), valve shape (H/L), length of the dorsal margin (l/L), and size of the larval valve (h/H). Semiquantitative parameters comprise the coefficients of the maximal curvature at the dorsal margin (e/l), at the anterior margin (a/b) and at the posterior margin (c/d) (Scholze, Schneider, 2015).

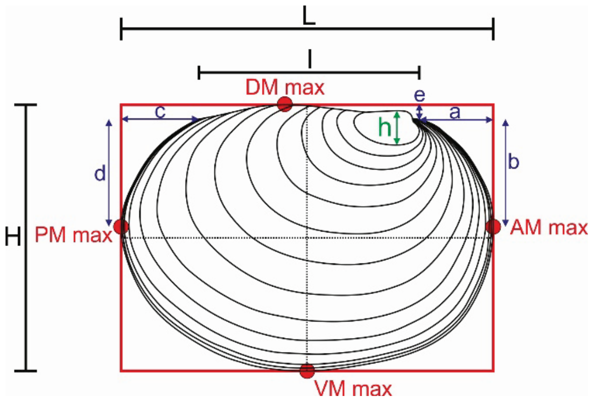


Fig.1. Measurements parameters for a conchostracan valve in lateral view (Scholze, Schneider, 2015)

To detect correlation among arrays of data, normality tests need to be conducted for each parameter. If the distribution deviates from normal, the nonparametric Spearman's rank correlation coefficient ($r_s$) is applied; for normal distribution, the Pearson's linear correlation coefficient ($r_p$) was used. Normal distribution was tested with Shapiro-Wilk and Kolmogorov-Smirnov tests (Grzybowski et al., 2017).

The Gaussian curve of normal distribution has the characteristic bell shape, which allows to detect the characteristic valve shape for each species. *Pseudestheria novacastrensis* (Mitchell, 1927) is characterized by an ovoid valve shape with a long dorsal margin, while the valve of *Pseudestheria exigua* (Eichwald, 1860) is roundish with a long dorsal margin.

Valve parameters taken from drawing and photograph measurements have a moderate or high correlation. A high correlation of H, L, l, h, d and H/L occurs in both species. In *Pseudestheria exigua* (Eichwald, 1860), a high correlation of h/H is noted. The parameters H, L, l and h are stationary. Their detection and measurement is nearly always unchanged and does not depend on the accuracy of the drawing or the quality of the photograph.

Most taxonomically relevant parameters for classification and species determination are the H/L and l/L coefficients (Scholze & Schneider, 2015). The H/L parameters shows a strong correlation although it is somewhat lowered due to error. The l/L parameter shows moderate correlation, although l and L exhibit high correlation. This may perhaps be explained by the fact that when l/L is determined by division of the highly correlative l through L the measurement error increases, leading to a decrease in correlation.

The h/H parameter of *Pseudestheria exigua* (Eichwald, 1860) shows a high correlation due to the high correlation coefficients of the h and H parameters.

The valve curvature parameters a, b, c, d, e and their derivatives, the semi-quantitative parameters a/b, c/d, e/l exhibit moderate correlation, with the exception of the parameter d. The measurement of these parameters depends on the frame construction. Minimal translations of the frame position lead to considerable changes of these parameters (Scholze, Schneider, 2015). The value of the e parameter is often very low. Therefore, even small measurement errors (1–2 mm) cause large inaccuracies when converted to scale units.

The measurement accuracy of the main valve parameters H, L, l and h from photographs is high, but the potential of this approach is somewhat limited. This method can be applied to well-preserved material. Using a microscope with camera lucida, lost parts of a conchostracan valve can be reconstructed rather reliably, but this is more difficult when working with photographs, which leads to inaccurate measurements. Problems also occur when determining the edges of the dorsal margin from low-quality photographs. Thus, the measurement error increases.

The main advantage of a photograph-based approach is the rapidity of measurements. In summary, the best procedure is measuring selected specimens from a collection using a microscope with camera lucida, and photograph-based measuring of the remaining material.

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