

## Multivariate Techniques in Analysing the Morphological Variations of the Genus *Monochoria*

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Multivariate analysis techniques are used to arrange biological data for interpreting and detecting variations among variable groups. The main objectives of this study were i) to analyse morphological variation in the genus *Monochoria* C.Presl (Pontederiaceae) in order to identify how raw data would be more useful for clear visualisation of characters, ii) to use multivariate techniques in analysing the morphological variations of the genus *Monochoria* and iii) to perform a statistical shape analysis to gain support for the groups identified in the analysis on the basis of leaf morphological variation observed in the field and thereby to re-assess the species boundaries of the genus.

The pie charts of qualitative characters had two categories with about 92% and 8% for the two pie divisions. The maximum cophenetic correlation value was obtained for the Un-weighted Pair Group Method with Arithmetic Mean (UPGMA) clustering algorithm. Therefore, classification was performed using a UPGMA clustering algorithm and the sample species visualised the first primary groupings, *M. hastata* (Group A) and *M. vaginalis*. The three sub-groupings of the species type *M. vaginalis* were named as Group B1, Group B2 and Group B3.

The non-parametric MANOVA test and the pair-wise non-parametric MANOVA test justified the significance of the difference among the four groups obtained and the significance of the pair-wise difference among each group at 5% significance level. The Principle Coordinate Analysis states that the sample specimens MV53, MV54 and MV56 are outliers of the Group B3, due to extreme outliers for individual characters measured for these 3 specimens. Similarity Percentage Analysis (SIMPER) revealed that the maximum separations of the groups correspond to Groups A and B1. The plant height up to leaf base and petiole length were the variables that contributed most for dissimilarity among Groups B1, B2, B3 and A.

The Elliptical Fourier shape analysis verified the dissimilarity of the shape of the leaves of all four groups, an observation made in the field for members of *M. vaginalis*. The shape patterns obtained by the Elliptical Fourier analysis confirmed the changes of the leaf shapes very clearly.

The analysis supported the morphological variations observed, especially the leaf shapes, which resulted in three primary groupings (Group B1, B2 and B3). Use of mixed data is recommended as it was more useful i) to obtain a clear idea regarding the distribution of each variable separately, ii) to identify groups with similar morphological characters and iii) as detailed analysis could be performed on the data sets.