Discrimination Of Frasnian (Late Devonian) Palmatolepis Species Using Multivariate Analysis Of Platform Elements

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Abstract

Species of Palmatolepis are a primary means for recognizing and correlating the subdivisions of the Late Devonian. Attempts to further refine the Frasnian conodont zonation utilizing smaller scaled species have led to the increasingly finer subdivision of morphologic features of the P1 elements, especially platform outline and lobe development. However, subtle differences and variation in shapes of the P1 elements make reliable discrimination of these species problematic and identification of Frasnian zones difficult.

This study employs discriminant function analyses for the differentiation of key Frasnian Palmatolepis species (P. bogartensis, P. bogardi, P. gigas, P. hassi, P. muelleri, P. rhenana, and P. winchelli) based on 84 specimens previously analyzed by Klapper & Foster (1986,1993), who used the method of equal arc segmentation. Using scanned images on the ArcGIS Desktop, primary landmarks were placed at the central node, ventral tip and dorsal tip. Primary reference points were placed half the distance from the central node to ventral tip and half the distance from the central node to dorsal tip, and then halfway between these points. Landmarks points were positioned along the conodont perimeter at right angles from each primary reference point. A program of functions executed by Matlab software calculated interdistance distances based on the Cartesian coordinates. Discriminate function analysis of the standardized measurements shows reliable statistically significant differences between the species examined. The analysis yields clearly defined morphologic characters and establishes shape-diagnostic criteria for ease in identification.

Introduction

Efforts to further refine the Late Devonian conodont zonation has led to increasingly finer subdivision of morphologic features of the P1 elements of Palmatolepis, especially platform outline and lobe development, in order to create shorter ranged species. Ziegler & Sandberg (1990, 2000) developed a “Standard Late Devonian Conodont Zonation”, using species based on gradual morphological changes in the P1 elements through time as determined through visual examination of individuals in the population. In contrast, Klapper & Foster (1986, 1993) employed morphometric analysis to show that the multilevel species could be also distinguished by subtle differences in outlines of the P1 elements, and proposed that additional quantitative shape analysis of P1 elements would yield valuable information for species-level taxonomy and biostratigraphy. The quantitative approach was strongly criticized by Ziegler & Sandberg (2000) because intraspecific variation was not fully evaluated in the analysis. Klapper and Foster’s Palmatolepis species do not correspond to species recognized by Ziegler & Sandberg and a controversy exists over two recognized by Ziegler & Sandberg and a controversy exists over two.

This study employs Geographic Information Systems (GIS) integrated with Matlab software to quantitatively analyze shapes and outlines of P1 elements of Frasnian species of Palmatolepis. Discriminate function analysis of the standardized measurements shows reliable statistically significant differences among the species examined. This study does not assume that either Klapper or Foster’s or Ziegler and Sandberg’s taxonomy is correct, but this method yields a relatively unbiased resolution of the controversy over the characterization of Frasnian Palmatolepis species.

Methods

- 94 specimens photographed by G. Klapper (Fig.1.2)
- Loaded jeggs into ArcMap (GIS software)
- Determined P1 morphotype (surface features) based on designated primary and secondary landmarks (central node as basal landmark)
- Create new feature per feature class layer with thin tracing landmarks (Figs.2-3)
- Create secondary landmarks using the central node as the basal landmark (Figs.2-4)
- Connect landmarks (Figs.5-6)
- Distance set 1 P1 outline morphology based on geometry using only the central node as the main landmark
- Create primary reference points (Figs.5-6)
- Connect branch (Figs.7-8)
- Discriminate function analysis, including Manova and Mahalanobis distances, performed by Matlab software at 1000 bootstrap iterations (Figs.8-16). Cluster analysis based on Mahalanobis distances. Classify function for placement of P1 jeggs

Results

- Analyses of P1 surface features (Distance set 1) and P1 outline morphology (Distance set 2) separately each yields statistically significant differences among the species of the Palmatolepis winchelli group.
- The best discrimination of species, though, is produced by the combination of outline morphology and surface feature morphology (Distance set 1 and Distance set 3 combined).
- No single, or small number of characters, allows for reliable species discrimination.
- All three analyses confirm the species taxonomy of Klapper and Foster.
- The histotype of Palmatolepis gigas is a large example of P1 winchelli.

Conclusions

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