WINDOWS VERSION OF RASC COMPUTER PROGRAM FOR RANKING AND SCALING

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Summary

Recently, a new version of RASC has been prepared combining FORTRAN 95 Windows *.EXE files with new Visual Basic code for input preparation (MAKEDAT) as well as graphical presentation of RASC/CASC results. A full description of the RASC method can be found in Agterberg and Gradstein (1999), and a recent large-scale application in Gradstein *et al.* (1999). The main purpose of this paper is to summarize features of the Windows version of the computer program.

Introduction

The RASC method for ranking and scaling of biostratigraphic and other events was developed for mainframe computers about 20 years ago (Gradstein *et al.*, 1985; Agterberg, 1990). The purpose of ranking is to create an optimum sequence of events observed in different wells or sections subject to stratigraphic inconsistencies in the direction of the arrow of time. These inconsistencies, which result in crossovers of lines of correlation between sections, are due to various sampling errors and other sources of uncertainty including reworking and misclassification. They can be resolved by statistical averaging combined with stratigraphic reasoning. The concept of ranking events according to their observed superpositional relationships in order to form an optimum sequence was originally introduced by Hay (1972). Subsequent scaling of the events can be carried out by estimating intervals between successive events along a relative time-scale. This yields the scaled optimum sequence. The CASC (Correlation and standard error calculation) program can be applied to ranking or scaling solutions in order to construct lines of correlation between sections without crossovers.

Twelve years ago a FORTRAN 77 DOS version of RASC was prepared for Personal Computers (Agterberg *et al.*, 1989). This program was extended during the past 5 years to include analysis of variance of deviations from lines fitted in plots of observed events against the (scaled) optimum sequence in individual sections (Gradstein and Agterberg, 1998). The companion program MAKEDAT 'makes' the data. It precedes RASC and CASC applications. Finally, there is a companion program COR for correspondence analysis. In summary, the four programs are designed to: (a) input, organize and store microfossil event data, using MAKEDAT; (b) interactively calculate zonations with variance analysis and normality test, using RASC; (c) interactively calculate well to well correlations with error analysis, using CASC; (d) analyze paleoecologic/geographic trends, using COR.

Purpose of probabilistic biostratigraphy

The nature of the fossil record sampled may favour application of probabilistic stratigraphy. Many industrial and also academic databases may benefit from this approach. Potential benefits include the following:

1. Standardization of the fossil record and stratigraphic methods gives access to all data and results.

2. Data sets and results are easy to communicate and rapidly updated with new information.

3. Integration of all fossil and also physical (e.g. isotope, well-log) events in a single stratigraphic solution, increases resolution and practical use.

4. Methods and results (stratigraphic zonation and correlation) are more objective than hand-made solutions.

5. Analysis of uncertainty in the event record and in the quantitative zonation greatly improves insight into true stratigraphic resolution and reliability of event correlation.

6. Interpolation of most likely (including) missing event positions in sections increases detail in correlations between sections.

7. Unlike subjective stratigraphy, the quantitative methods generally provide more than one possible solution, depending on run parameters thus providing biostratigraphy with multiple working hypotheses.

8. Quantitative stratigraphy methods can handle large and complex data sets, and calculate stratigraphic solutions fast.

A simplified flow chart of a run procedure, using MAKEDAT, RASC and CASC to generate biostratigraphic zonations and geological correlations with uncertainty limits, is given in Fig. 1.

Examples of application

MAKEDAT under Windows is designed to enter, store, organize and reformat biostratigraphic event data for input in RASC, CASC and COR. Fig.2 shows the Fossil Dictionary Editor. Information can be entered fast in the windows on top.

MAXIMIZE BIOSTRATIGRAPHIC RESOLUTION

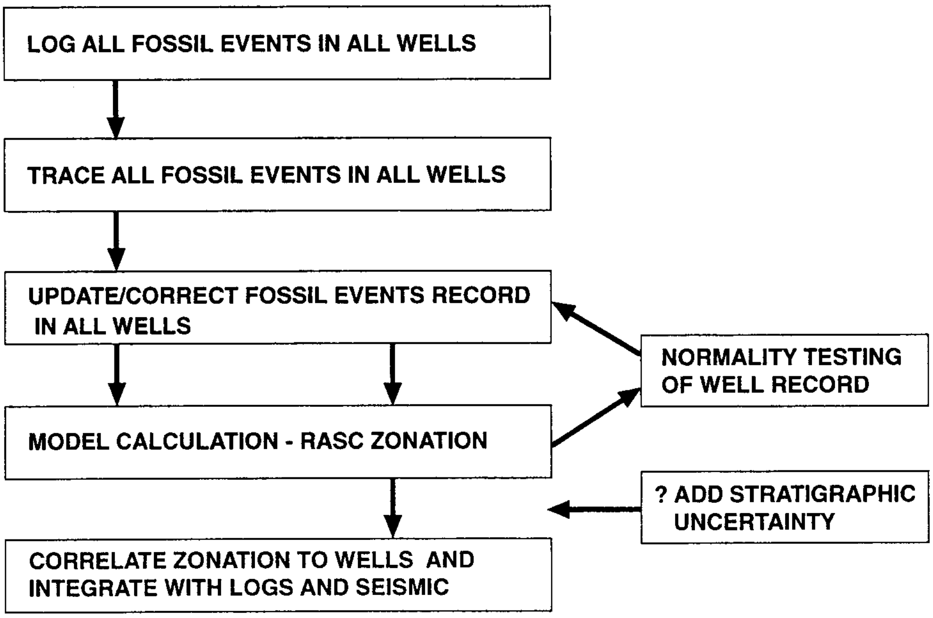

Figure 1. Flow chart of steps in logging, tracing and updating the fossil record, prior to and during zonation, followed by correlation and assignment of stratigraphic uncertainty.

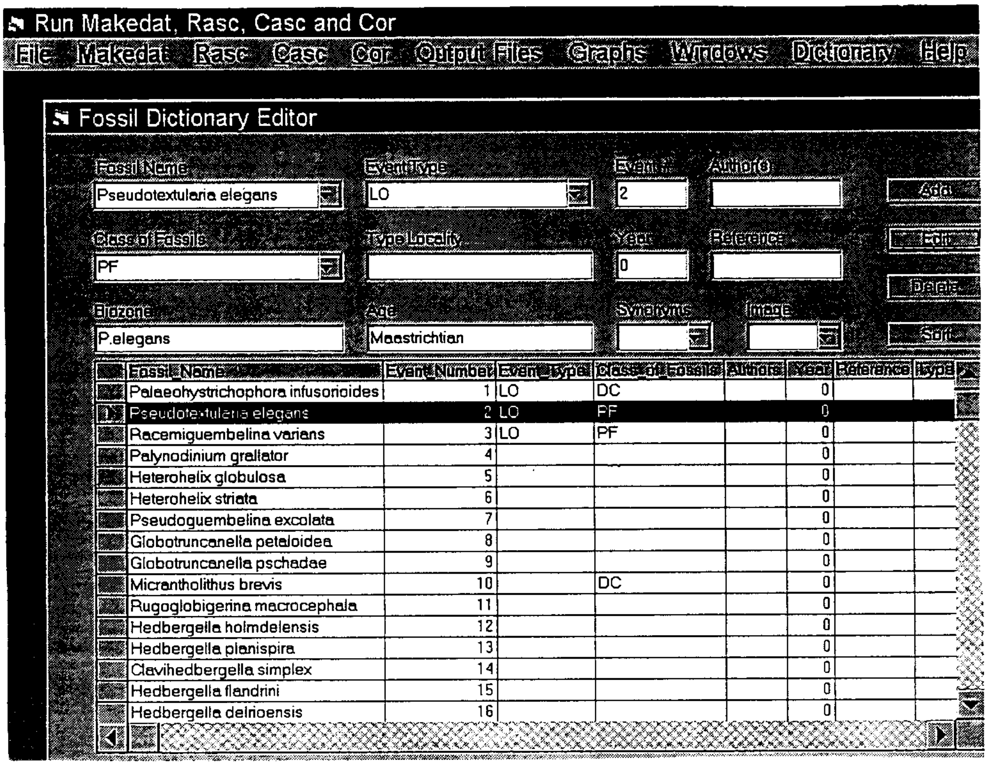

Figure 2. Example of MAKEDAT screen. The Dictionary menu contains a Fossil Dictionary Editor with twelve information windows, where information may be entered fast. The columns corresponding to each item may be sized for convenience.

Figs. 3 and 4 exemplify graphic output from RASC under Windows, showing parts of ranked and scaled optimum sequences, respectively. The Cretaceous microfossil data for this example are from Gradstein *et al.* (1999). They are largely Last Occurrences of microfossils observed in 31 offshore wells. In total, the database contained 1753 records on occurrences of 517 stratigraphic events. Stratigraphic uncertainty in Fig. 3 is expressed by means of a cross-over range (cf. Van Buggenum, 1991). The vertical and horizontal scales show the ranked optimum sequence with average positions along a straight line. Each horizontal bar extends from the stratigraphically lowest event with which an optimum sequence event shows one or more inconsistencies to the stratigraphically highest event with one or more inconsistencies.

In Fig. 4, intervals between successive events in the corresponding scaled optimum sequence are plotted in the horizontal direction and connected by vertical lines as in a dendrogram. Events with short interevent distances form clusters. In individual sections, events that cluster show many inconsistencies in their superpositional relationships. For example, events that cluster may be observed to be coeval in a number of sections, or they occur above other events in some sections but below these other events in other sections. Relatively long interevent distances in Fig. 4 coincide with stratigraphic hiatuses. Ranking and scaling are statistical techniques in the sense that large samples consisting of many records produce better average values. For this reason, minimum sample size thresholds are introduced at the beginning of a RASC run. However, this procedure may result in the exclusion of important marker events observed in one or a few sections only. Such rare events can be re-introduced in the ranked optimum sequence as well as the scaled optimum sequence. In Fig.4 interevent distances involving such rare events are not plotted because estimates of them are relatively imprecise.

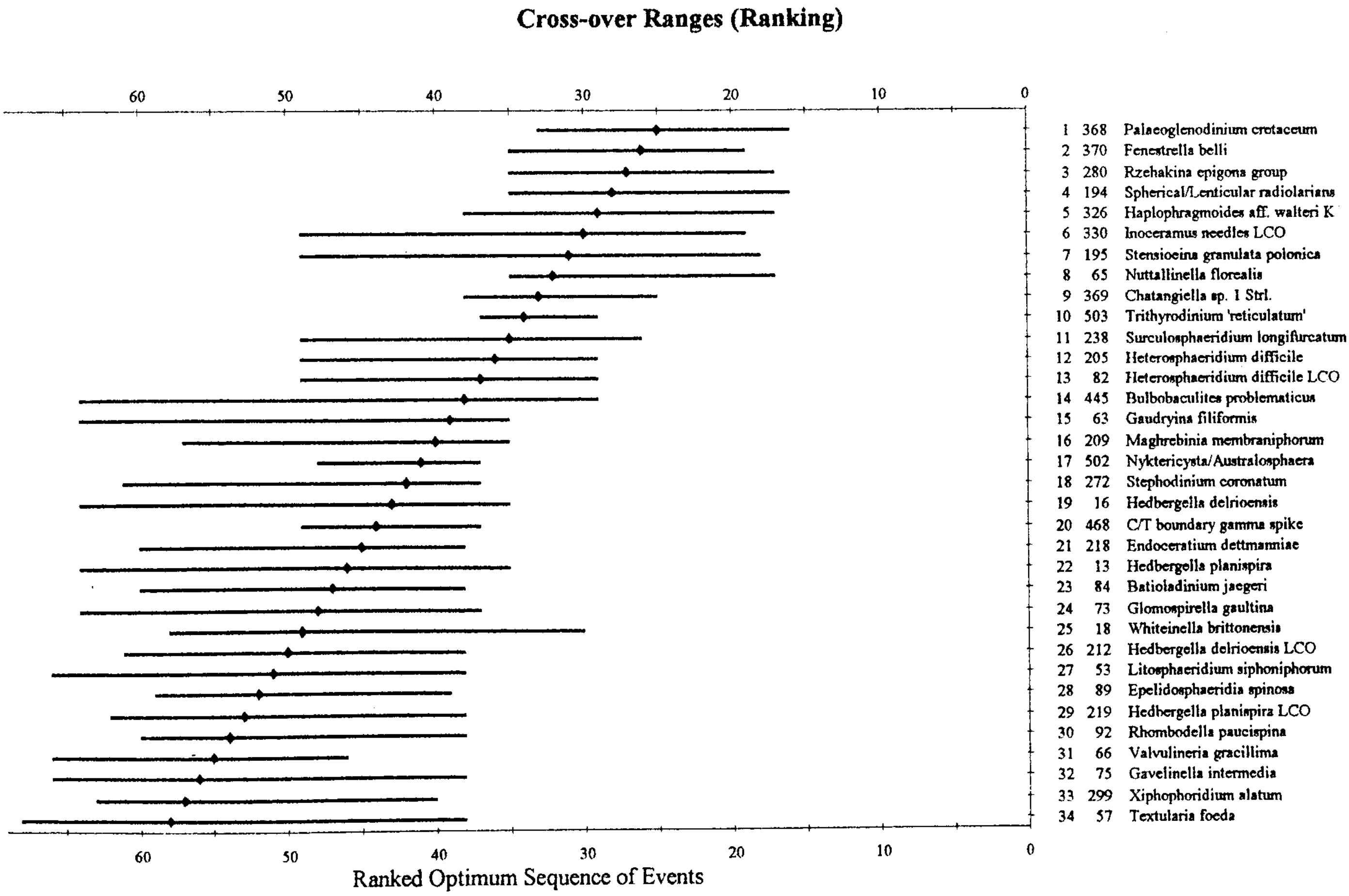

Figure 3. Crossover ranges for a ranked optimum sequence. Each event range extends to the stratigraphically highest and lowest event in the optimum sequence with which it shows inconsistency. Arrow of time points upwards and to the left.

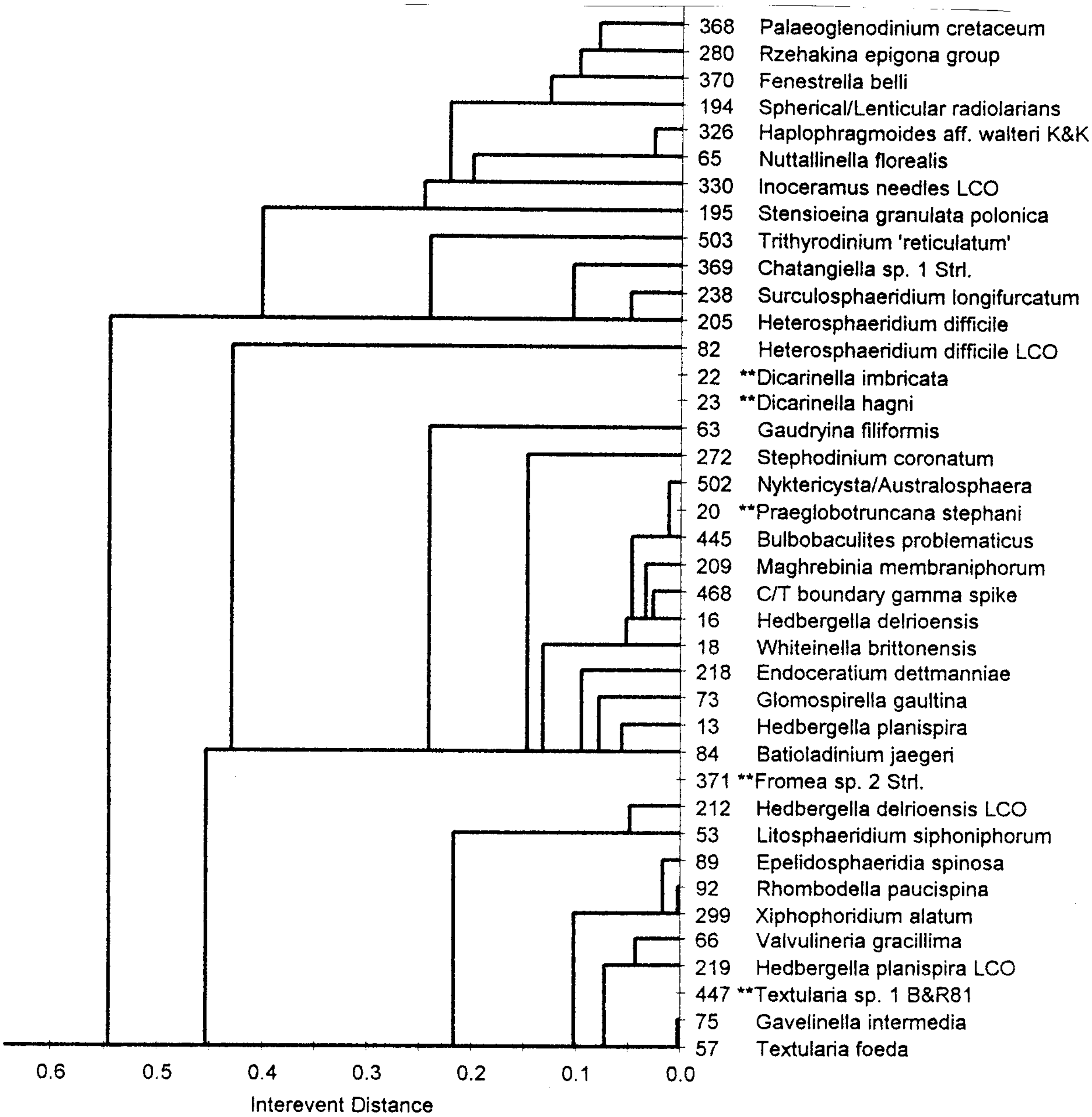

Figure 4. Dendrogram for scaled optimum sequence corresponding to data used for Fig. 3. Because of minor reordering, the sequence of events differs from the ranked optimum sequence. Interevent distances involving rare events (marked by double asterisk) are not plotted, because estimates of them are relatively imprecise. This diagram represents central part of Fig. 5 in Gradstein *et al.* (1999).

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