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Assessments of random walk tests: a computer simulation study on stratophenetic series

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Organic evolution is a cumulative change in biological properties over time. Time series of cumulative change commonly show apparent trends through random drift. Hence, to assess whether the dynamics of the change is biased or random requires a statistical test by using a model for random walk as a null hypothesis. However, a variety of random walk tests currently available are not robust enough to allow us indiscriminate use of the methods. Some simulation studies revealed that the rate of erroneous failure to reject a null hypothesis in random walk tests fairly increases with increase of stratigraphic incompleteness. In contrast to the stratigraphic incompleteness, influences of error of mean estimate on stratophenetic analysis have little been considered. Paleontological samples commonly consist of small numbers of individuals, and mean value of each sample is often unreliable in terms of inferential statistics. When within-sample variation is greater than chronological change, a great error of mean estimate might conceal the long-term trend of evolution.

In the present study, I simulated evolution of a phenetic character in imaginary populations using random walk models. I produced hypothetical stratophenetic series by random sampling of data from the populations generated by unbiased or biased random walk with varying range of phenetic variation and stratigraphic incompleteness. 1,000 stratophenetic series with 200 iterations were simulated in each condition. Two kinds of random walk tests were performed for each stratophenetic series: 1) Bookstein's test, which is based on the expected distribution of the maximum excursion of a random walk; and 2) Hurst exponent, which is a measure of its persistent or anti-persistent deviation from overall trend and is based on the relationship between rescaled range of a variable and interval of equally divided subseries.

The results revealed that application of Bookstein's test to a population with great variation increases the risk of commitment of Type II errors, while the analysis using Hurst exponent is robust against error of estimate of mean. On the other hand, Hurst exponent tends to lead the assessment to committing Type I errors, i.e., incorrect rejection of a null hypothesis, if stratigraphic sampling is sparse enough.