Quantifying the Ecological Response of Brachiopods during the Ordovician Extinction

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Extinction events are morbidly fascinating to both scientists and the public alike, with catastrophic events and death occurring on vast scales. The current biodiversity crisis is being hailed as the next mass extinction, and the need to understand the processes and patterns of extinction grow as the rate of species loss rises. Extinction events are recognized by taxonomic loss; however the ecological impact of these events is more difficult to quantify. This study applies rank-abundance curves (RACs), a modern ecological tool used in measuring ecosystem health, to quantify the changing community structure of brachiopods during the two pulses of the end Ordovician mass extinction. By applying RACs and measuring the shape with kurtosis, communities can be compared before and after the extinction event to recognize any early warning signs as well as the point of ecological recovery for communities which may be offset from the recovery of taxonomic diversity.

Brachiopod communities were sampled from Paul Copper's collection from Anticosti Island located at the Geological Survey of Canada's Ottawa office. Anticosti Island is the most complete, shallow water, fossiliferous record of the Ordovician-Silurian boundary in North America. Upper Ordovician through lowermost Silurian samples were collected from the surface of limestone slabs that showed no evidence of taphonomic overprinting. Stratigraphic position (within 10 members), lithology (Dunham carbonate classification scheme), and surface area of all samples were noted. Individuals were identified to the lowest taxonomic level (species in most cases), and both abundance and biovolume data were collected. RACs were generated for every sample with taxonomic richness greater than two. Samples dominated by one taxon were noted, and the frequency of these communities was compared to the kurtosis of the RACs from that member.

The average kurtosis for each member shows a distinct pattern through both pulses of the extinction. The members directly below each extinction pulse show increasing stress, and the members following the extinction pulse have significantly lower stress (t-test, $p<0.05$). The frequency of communities dominated by one taxon shows the same pattern as the average kurtosis. While the taxonomic recovery has not been identified until the Middle Silurian, there is an ecological recovery relatively quickly after the increased stress levels before each extinction pulse. These findings support previous qualitative work that suggests that the ecological impact of the end Ordovician extinction is not as severe as the taxonomic impact which ranks this extinction as the second worst in the history of life on Earth. RACs have been successfully used in modern systems, and now this technique can be applied to the fossil record to better understand the progression of and recovery from extinction events.