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Ancient foraminiferal DNA: A new paleoceanographic proxy.

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Until now, the assessment of past climate impacts on marine biodiversity was based exclusively on taxa preserved in the fossil record. However, most marine species do not leave any fossilized remains that could be identified morphologically. Hence, our current view of the evolution of marine biodiversity is fragmentary and limited to a few skeleton-bearing taxa only. Recent advances in environmental genomics have the potential to change this situation radically. In particular, the analysis of environmental DNA, defined as genetic material obtained directly from environmental samples (soil, sediment, water, etc.), has proven to be an efficient method to monitor biodiversity changes over time and space. A demonstration that DNA can be preserved in marine sediments across geological timescales opened new avenues to using ancient DNA (aDNA) in paleoceanographical studies. Numerous studies report the preservation of DNA in marine sediments over the tens to hundred thousand years, showing that the marine sediments are an underexplored DNA repository that can be used to assess marine biodiversity.

Our research on foraminiferal aDNA illustrated the presence of aDNA in Late Quaternary sediments in the Nordic Seas. Our studies revealed extremely diverse foraminiferal assemblage, with a diversity that exceeds what is recorded in the fossil record. In particular, the aDNA studies revealed a huge diversity of non-fossilized monothalamous foraminifera, which comprise several new potential proxy species. We distinguished monothalamous taxa that are potential indicators of changes in glacial activity, sea-ice coverage, and productivity. Although microfossil and aDNA records are complementary rather than overlapping, in combination, they reveal more detailed information than inferred from the individual approach. Furthermore, our results suggest that molecular analysis at finer levels can provide valuable information about the occurrence of different foraminifera genotypes over time. These genotype-level changes can be related to environmental conditions, implying that the genotypes have different ecological preferences and could potentially be used as paleoceanographic proxies in the future.

The analysis of aDNA requires various precautions to avoid contamination when isolating aDNA from environmental samples, and there is a need to consider several limitations resulting from the degraded nature of DNA and potential technical biases. Although, the advantage of paleogenomics to provide complementary insight into biodiversity changes beyond what is shown by fossil records is indisputable. The ancient DNA approach may provide a powerful means to reconstruct paleoenvironments more comprehensively and better understand past climatic and environmental changes.

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