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The transcriptomic signature of cold and heat stress in benthic foraminifera - Implications for range expansions of marine calcifiers

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Global warming permits range expansions of tropical marine species into mid-latitude habitats, where they are, however, faced with cold winter temperatures. Therefore, tolerance to cold temperatures may be the key adaptation controlling zonal range expansion in tropical marine species. Here we investigated the molecular and physiological response to cold and heat stress in a tropical symbiont-bearing foraminifera that has successfully invaded the Eastern Mediterranean. Our physiological measurements indicate thermal tolerance of the diatom symbionts but a decrease of growth for the foraminifera host under both cold and warm stress. The combined ("holobiont") transcriptome revealed an asymmetric response in short-term gene expression under cold versus warm stress. Cold stress induced major reorganization of metabolic processes, including regulation of genes involved in photosynthesis. Analyses limited to genes that are inferred to belong to the symbionts confirm that the observed pattern is due to changes in the regulation of photosynthesis-related genes and not due to changes in abundance of the symbionts. In contrast to cold stress, far fewer genes change expression under heat stress and those that do are primarily related to movement and cytoskeleton. This implies that under cold stress, cellular resources are allocated to the maintenance of photosynthesis, and the key to zonal range shifts of tropical species could be the cold tolerance of the symbiosis.