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Coral bleaching in extreme environments: speciesspecific thermal tolerance limits

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Increasing seawater temperatures are being measured worldwide, causing coral bleaching events during which the symbiosis between the coral host and its symbiotic zooxanthellae is disrupted, and a global decline in reef corals. In the Arabian Gulf where water temperatures are naturally extreme with summer maxima at 35°C and above and winter minima at 18°C and below, seawater temperature anomalies are repeatedly recorded in the summer. While Arabian Gulf corals have naturally evolved to survive at temperatures that would cause bleaching and mortality to most corals elsewhere, an increasing number of mortality events have been recorded in the Gulf (Qatar, Saudi Arabia, and the UAE) in the last decades, resulting in a substantial loss of biodiversity and coral cover, mostly in inshore environments. Efforts are being deployed locally to conserve remaining habitats and attempt the restoration of lost habitats, but to be successful, efforts need to incorporate regional species-specific traits such as the susceptibility and resistance to future bleaching. We here assess the tolerance and sensitivity of three ecologically important species from the Arabian Gulf, Acropora downingi, Porites lutea, and Dipsastraea pallida, sampled in Qatari offshore reefs in the mid-winter, by exposing them to heat stress in enclosed aquaria. Colonies were assigned to control aquaria maintained at 25°C, aquaria to be raised to 30°C, or aquaria to be raised to 36°C. After an acclimatization period, the 30°C and the 35°C aquaria were raised to their target temperature at a maximum rate of 1°C per day. During the warming period and for another three weeks, we monitored the photosynthetic activity of their symbiotic zooxanthellae twice a week with a diving-

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PAM fluorometer while checking for signs of bleaching. We found that the photosynthetic activity was not affected in any of the three species when the temperature was raised from 25°C to 30°C. At 34°C, the photosynthetic activity in A. downingi started declining. Once the temperature reached the 35°C target, all A. downingi colonies bleached, expelling their zooxanthellae, and died three days later. The photosynthetic activity in P. lutea and D. pallida started declining once the temperature reached 35°C and continued declining for an additional three weeks, after which P. lutea died and D. pallida recovered. The high tolerance of P. lutea and especially of D. pallida is promising for the survival of the two reef-builders in coming years, despite increasing seawater temperatures caused by climate change. However, the branching Acropora coral is not expected to respond well to any further increase of temperature, as reflected in its major regional decline in the past decades. Due to its high sensitivity, Acropora might also not be a good candidate in coral restoration projects, as it showed a high sensitivity to bleaching and the inability to survive bleaching events. However, aquarium conditions not being able to fully reflect natural conditions on the reef, further work would need to be conducted directly on the reef to determine whether other factors might be involved in assisting resistance to bleaching, survival under bleaching conditions, or recovery following bleaching. In any case, P. lutea and D. pallida would be excellent candidates in coral restoration projects, having showed a lower sensitivity to bleaching and the ability to survive for several weeks under thermal stress, therefore showing potential for a long-term survival even under warming conditions.