High Zooxanthellae Densities and Turnover Correlate with Low Bleaching Tolerance in Kenyan Corals

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When a coral bleaches, the obligate symbiosis between the coral polyp and the micro-algal zooxanthellae is disrupted and the zooxanthellae are expelled from the polyp. Although a bleached coral does not necessarily die, it is more vulnerable to disease, algal overgrowth, bioerosion and eventually mortality. Mass bleaching and mortality events in the last decade have prompted increased research into zooxanthellae, and it is possible that zooxanthellae population strategies affect a coral's tolerance to bleaching stress.

Variation in zooxanthellae density and mitotic index was studied in eleven species of scleractinian coral (*Acropora* sp., *Echinopora gemmacea, Favia* sp., *Galaxea fascicularis, Hydnophora microconos, Montipora aequituberculata, Pavona decussata, Pocillopora damicornis, Pocillopora eydouxi Porites cylindrica* and *Porites lutea*) from the Mombasa Marine Park, from 1998 and 2006. This data was compiled with average and standard deviations of monthly SSTs and radiation levels in a Canonical Correlation Analysis (Fig. 1).

The Canonical axes shows that zooxanthellae density and mitotic index are nearly orthogonal, ie. independent from one another, and neither align very strongly with any of the environment axes. Of the coral species, *Pocillopora damicornis* and *Pocillopora eydouxi* display the lowest zooxanthellae densities and the highest mitotic indices. By contrast, *Galaxea fascicularis, Porites cylindrica* and *Porites lutea* display the highest zooxanthellae densities but low mitotic indices. Looking at Canonical axis 1, which aligns with zooxanthellae density, species at the low end (*Pocillopora* spp, *Acropora* spp.) tend to be more susceptible to bleaching, and those to the right end (*Porites* spp) more resistant. Species clustered near the center of the distribution with intermediate zooxanthellae densities and mitotic indices tend to have intermediate responses to bleaching. Highest mitotic indices are shown by *Pocillopora*, among the most susceptible of corals to bleaching.

Our results broadly agree with Stimson et al.'s (2002) findings of an inverse correlation between bleaching susceptibility and zooxanthellae density, and the conclusion that species with high densities and low mitotic indices (low zooxanthellae turnover) are more tolerant to bleaching, while species with low densities

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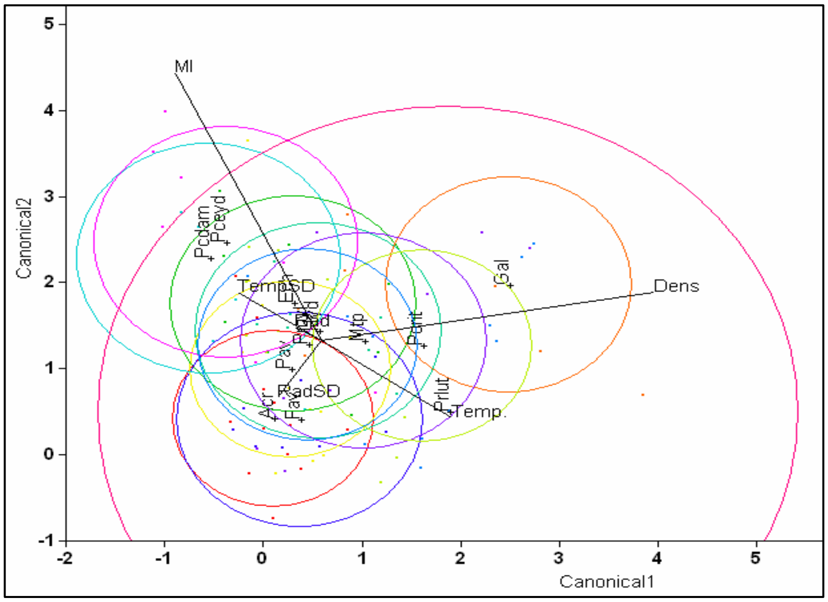

Figure 1. Canonical Correlation Analysis between monthly zooxanthellae density, mitotic index, temperature, standard deviation of temperature, radiation and standard deviation of radiation. Den = Density, MI = Mitotic index, Rad = Radiation, Rad SD = Standard deviation of radiation, Temp = Water temperature, Temp SD = Standard deviation of water temperature. Species names abbreviated. Biplot rays have been lengthened by a factor of three for clarity.

and high mitotic indices (high zooxanthellae turnover) are more susceptible. This apparent relationship between bleaching tolerance and zooxanthellae density may be explained by several hypotheses:

- -higher densities of zooxanthellae could lead to higher self-shading and thus protection from light stress (Warner et al., 1999);
- -higher zooxanthellae densities could mean higher concentrations of UV-absorbing compounds such as mycosporine-like amino acids (MAAs);
- -higher zooxanthellae densities correlate with higher amounts of coral tissue per square centimeter of corallum surface, and coral tissue depth protects zooxanthellae from light stress (Hoegh-Guldberg, 1999);
- -finally, turnover rates and zooxanthellae regulation may simply mean that high biomass/low turnover species bleaching slowly, while low biomass/high turnover species bleaching more rapidly, simple as a result of the turnover dynamics.

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