

Global diversity of coral endosymbionts

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Introduction

- Corals are heterotrophic animals of the phylum Cnidaria. They can associate with symbiotic photosynthetic dinoflagellates of the family Symbiodiniaceae, which exchange nutrients with their coral host¹
- Diverse environmental conditions, such as seawater temperature and pH, influence the composition of the coral microbiome community (e.g., Symbiodiniaceae and bacteria)
- We sampled the most widespread *Palythoa* sibling species² (Hexacorallia: Zoantharia) as a model system to examine global diversity of symbionts in the same coral host across regions with different seawater conditions (Fig. 1)

1) How does the symbiont diversity differ across regions of the Atlantic and Indo-Pacific?

2) How does the symbiont diversity from the region with the warmest seawater temperature (Red Sea³) and low pH (Iotorishima⁴) differ from other locations?

Symbiodiniaceae (Figs. 2 and 4A)

- Species of *Cladocopium*, *Durusdinum* and *Symbiodinium*
- Coral samples from Atlantic and Indo-Pacific have different Symbiodiniaceae composition ($p<0.001$)
- Coral samples from Red Sea and Iotorishima have different Symbiodiniaceae composition ($p<0.001$) from other regions

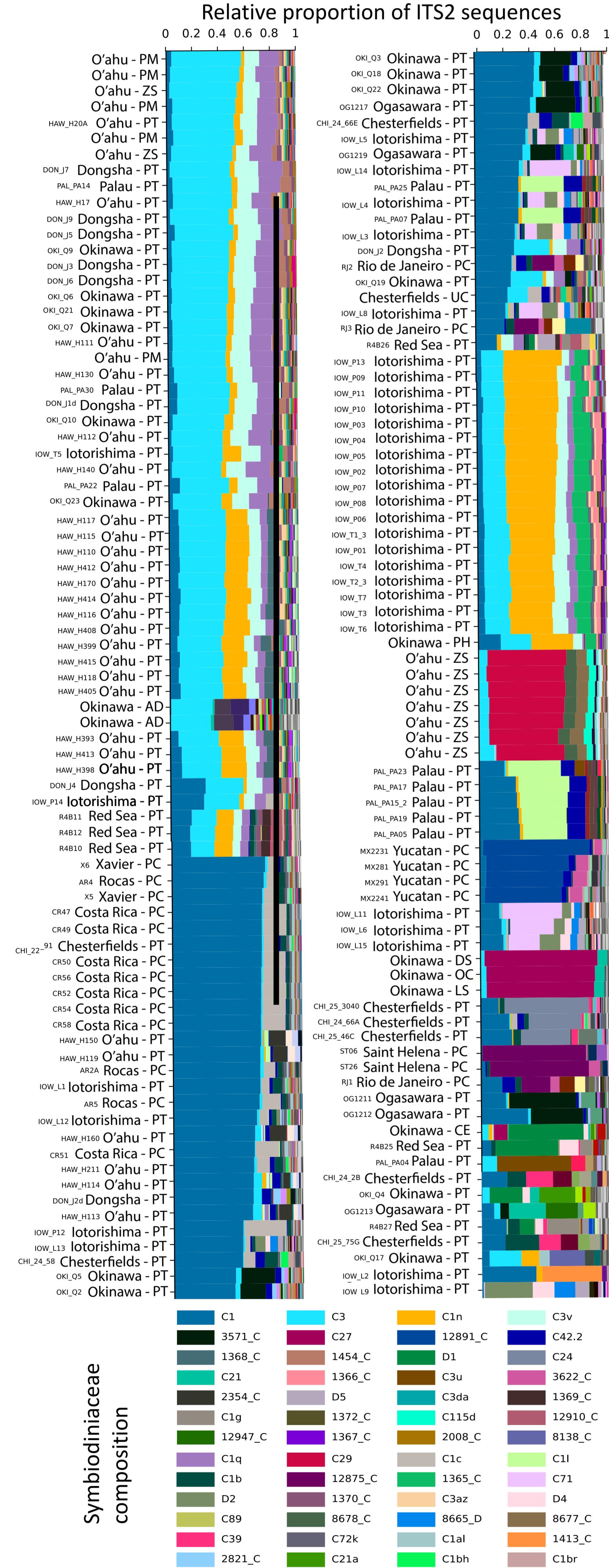


Figure 2: Relative proportion of ITS2 sequences of Symbiodiniaceae associated with each coral sample. Only the most abundant (>0.01% of all reads) sequences are displayed. Labels indicate the Symportal⁷ database ID number followed by the genus the sequence is from (C=Cladocopium and D=Durusdinum). Host *Palythoa* species codes are PT (*P. tuberculosa*) and PC (*P. caribaeorum*), in addition to outgroups PM (*P. mutuki*), PH (*P. heliodiscus*), AD (*Acropora digitifera*), CE (*Ctenactis echinata*), DS (*Danafungia scruposa*), LS (*Lytophyllum scabra*), OC (*Pobadacia crustacea*), UC (*Ulmianyanthus chanpuru*), ZS (*Zoanthus sansibaricus*). Symbiodiniaceae compositions was estimated using MiSeq sequencing of the ITS2 gene.

Methods

- Molecular analyses:
- DNA extraction of coral samples, PCR amplification (ITS2 for Symbiodiniaceae⁷ and 16SrRNA for bacteria⁸) and MiSeq sequencing
- Bioinformatics: Symportal⁷ (ITS2) and Dadaist2⁹ (16S-rRNA) pipelines
- Significance statistics tests and clusters: Bray-Curtis, PERMANOVA, SIMPROF-test (999 permutations)

Bacteria (Figs. 3 and 4C)

- Endozoicomonas*: likely mutualistic bacterium of corals⁴
- Vibrio* spp.: opportunistic pathogens⁵
- Coral samples from the Indo-Pacific analyzed so far (Dongsha, Iotorishima and Palau) have different bacterial composition ($p<0.001$)
- Most samples from Iotorishima had lower diversity than Dongsha and Palau

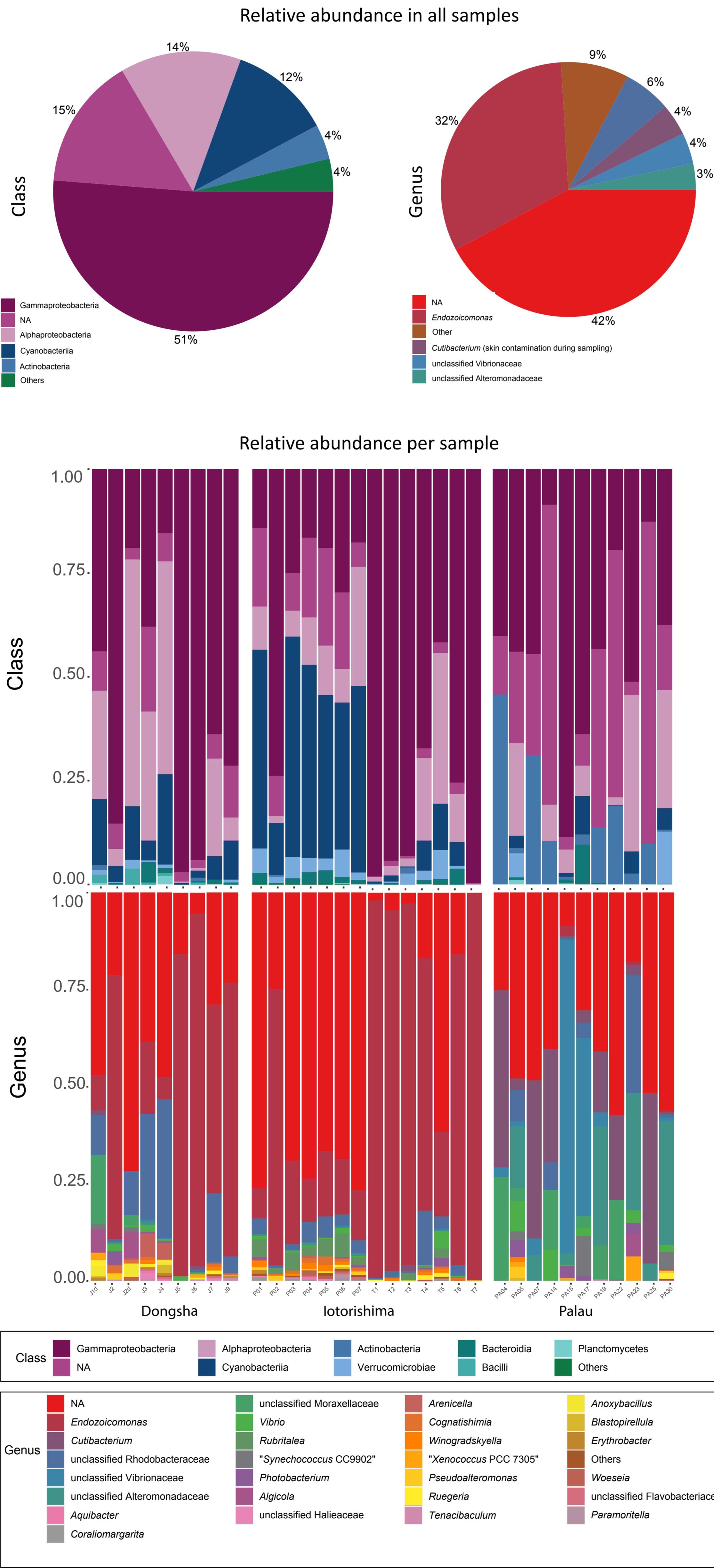


Figure 3: Relative abundance of the bacterial diversity found in all samples (pie charts) and per sample (bars). Bacteria diversity was estimated using MiSeq sequencing of the 16S rRNA gene.

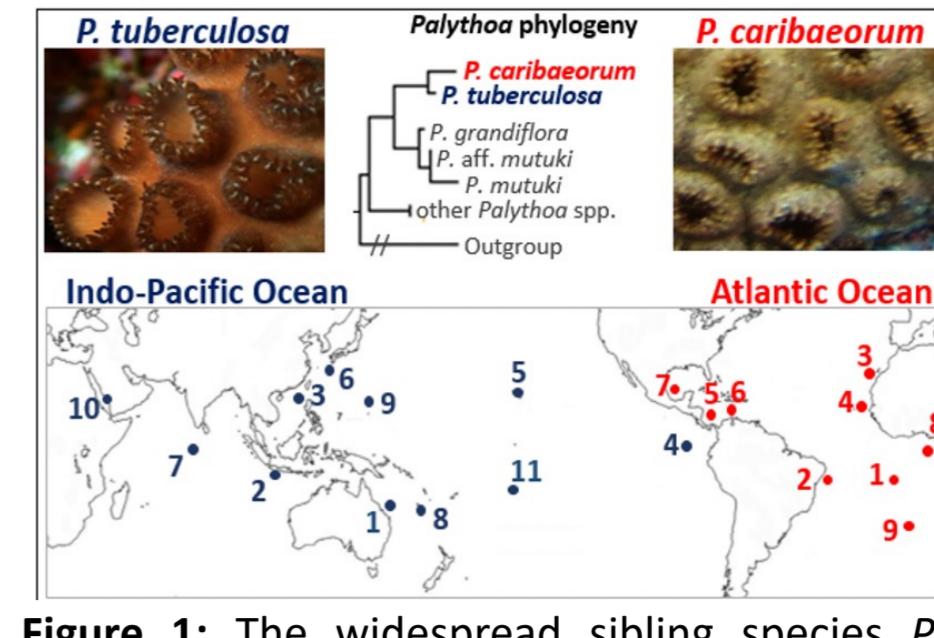


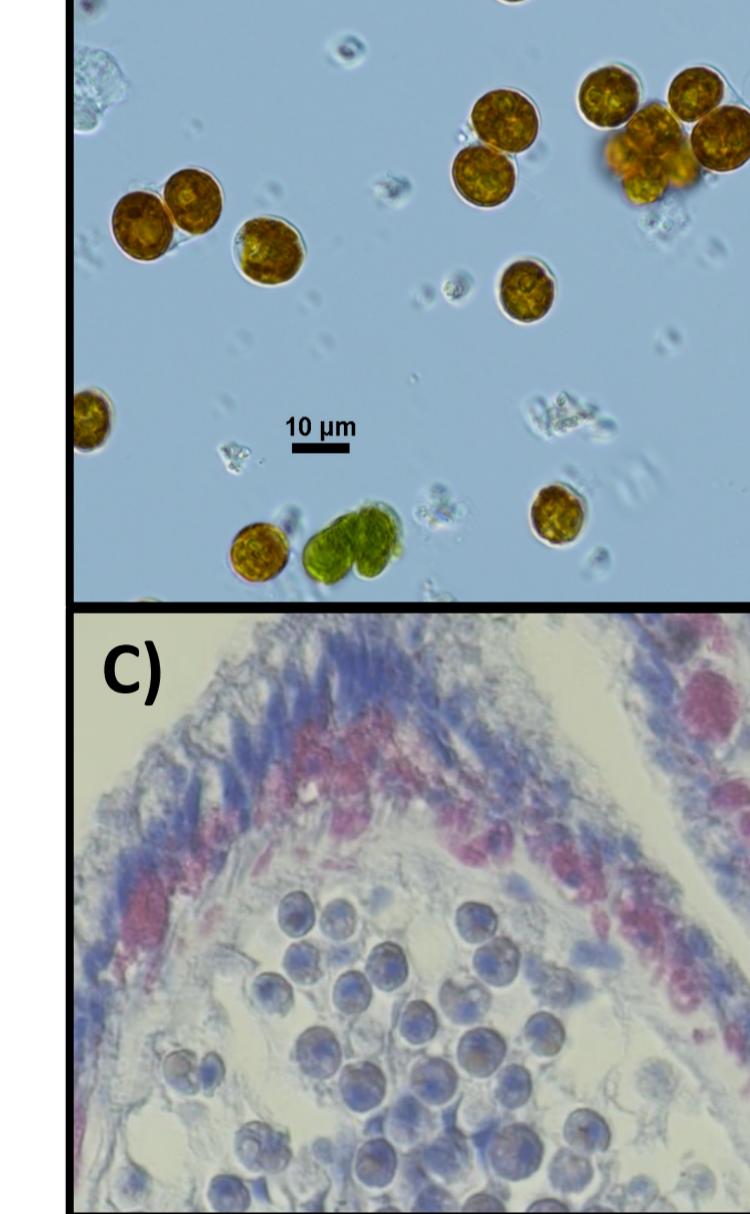
Figure 1: The widespread sibling species *P. tuberculosa* (Indo-Pacific) and *P. caribaeorum* (Atlantic) were sampled across the Indo-Pacific (blue) in Atlantic (1), Christmas Island (2), Dongsha Atoll (3), Galapagos Islands (4), Hawai'i Islands (5, O'ahu), Japan (6; Iotorishima**, Ogasawara* and Okinawa*), Maldives (7), New Caledonia (8**), Chesterfields, Palau (9**), Red Sea (10**), and French Polynesia (11); and in the Atlantic (red) were Ascension Island (1), Brazil (2*), Rio de Janeiro, Rocas, Xavier, Canaries Islands (3), Cape Verde Islands (4), Costa Rica (5), Curacao Island (6), Mexico (7); Yucatan, Principe Island (8), and Saint Helena Island (9*). Preliminary results are showed below for sites analyzed for both Symbiodiniaceae and bacteria (**) or only for Symbiodiniaceae (*) composition (1A).

Dendrogram of symbiont diversity across locations

A) Symbiodiniaceae



B) Symbiodiniaceae cells



D) Bacteria

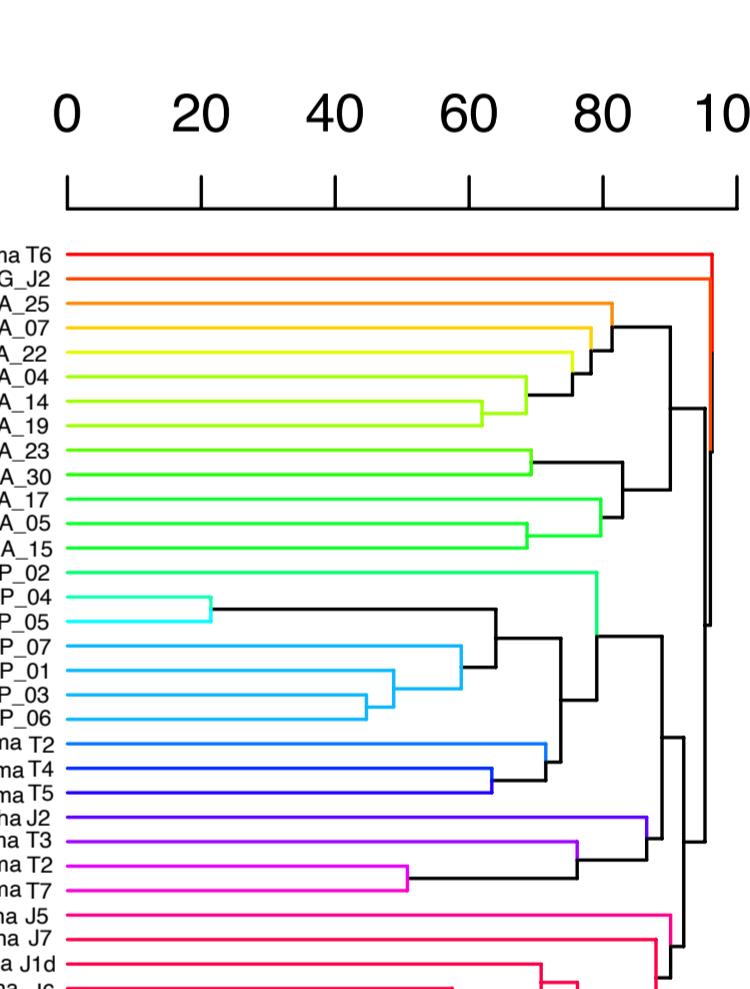


Figure 4: Cluster dendograms of the SIMPROF-test with Bray-Curtis similarity measure (x-axis) and coral samples (y-axis) for the microbial community of Symbiodiniaceae (A; ITS2) and bacteria (D; 16S rDNA). Colors indicate statistically significant clusters ($p<0.001$). Images of Symbiodiniaceae cells (B-C). Credits 4B: MEA Santos and 4C: Y Masukagami.

Diversity of coral endosymbionts

- Palythoa* associate with distinct microbial lineages in regions with different seawater conditions
- Stress tolerant symbionts (e.g., *Durusdium*) are found in several locations, including Red Sea and Iotorishima

Next steps

- Analyses of additional locations and the composition of eukaryotic endosymbionts other than Symbiodiniaceae
- Population genetics analyses of *Palythoa* hosts and their associated symbionts

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