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The copepod microbiome in the Mediterranean Sea

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Abstract

The associations between marine invertebrates and microbes are widespread throughout the oceans. Microbiota can play crucial roles in digestion, nutrient uptake, reproduction, immune responses and defence mechanisms of almost all marine animals, thereby influencing their health and fitness. Despite the ecological importance of copepods as key components of marine food webs and biogeochemical cycles, information on their microbiomes remains limited. A better understanding of the diversity and dynamics of copepod microbiomes, is therefore needed. This is particularly relevant under ongoing global change, where unravelling copepod-microbe associations contributes to a broader comprehension of marine ecosystem responses.

This PhD thesis focused on marine copepods to investigate how habitat, geography, environmental conditions and host traits interact to shape copepod-associated microbiomes. Large-scale patterns across habitats ranging from marine to freshwater systems were characterised through a global meta-analysis of published datasets. Complementary field studies in the Mediterranean Sea revealed that microbiomes of dominant copepod species were strongly structured by basin, season, site, trophic source and environmental parameters. Fecal pellet analyses indicated that the microbial communities they host, which are strongly influenced by diet and food availability, can serve as a proxy for the gut microbiome of copepods and contribute significantly to biogeochemical cycles and carbon export. Finally, comparisons of wild copepods at different developmental stages, together with first-generation rearing experiments, indicated that copepod microbiomes were relatively stable over the life cycle, supporting the existence of a robust host-microbiome association. Signals of phylosymbiosis and the persistence of specific *core* taxa further suggested that vertical transfer and host-microbe associations may have contributed to copepod adaptation across contrasting environments. Altogether, these findings highlighted copepod-microbiome systems as sensitive components of pelagic ecosystems and underscored the importance of understanding their responses to warming, deoxygenation and pollution in order to better predict future trajectories of zooplankton productivity, biogeochemical cycling and marine ecosystem health.