



**Università Politecnica delle Marche
Department of Life and Environmental Sciences**

PhD course in Marine Ecology and Biology

XXXVI cycle

The Value of Neighbourhood:

**Collective predation upon large prey by benthic Cnidaria
and its influence on individual predator behaviour,
group fitness and population dynamics**

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Summary

Cnidarian polyps, including Anthozoa and the sessile stage of Medusozoa, rely on several food sources. In addition to heterotrophic suspension-feeding and capture of small planktonic organisms such as mero- and holoplankton, they can capture and ingest animals many times larger than the size of the single individual. This form of predation implies the extension of the mouth, column and tentacles. Additionally, when polyps are many times smaller than the prey, they have been observed while sharing the capture efforts, with many polyps simultaneously engaged in this process.

The PhD thesis aims at investigating the predatory feeding modality played by cnidarian polyps for the predation of large prey, and its influences and consequences on trophism, behaviour, population dynamics, and fitness. The objective was to evaluate to what extent these organisms benefit from aggregations to exploit a large prey, in a long-lasting and energetically expensive process, and, when the capture is shared among many polyps, what are the costs and advantages of cooperation over competition for resources.

In the introduction chapter, the main features of group-living in animal taxa are summarized, considering benefits and costs on growth and reproduction, that drive decision-making processes and influence individual behaviour in relation to the group. Theories on the evolution of cooperation among conspecifics will be briefly exposed to outline the possible reasons that lead animals to behave altruistically rather than to compete for resources. The benthic environment offers a peculiar habitat to study inter- and intraspecific interactions, due to the strong competition determined by the limitation of available substrate. However, cooperative behaviours have been detected in sessile organisms, such as the collective predation of large prey by small-sized cnidarian polyps. The phylum Cnidaria is constituted by relatively simple metazoans that share some features with Bilateria, being therefore considered sister-groups. They represent model subjects for studies on genetic, phylogeny, neurology, physiology, trophic ecology, among others. Sessile cnidarian species often dominate the benthic community in several geographic areas at different

depths, shaping the biodiversity of the sea from the intertidal zone to the seafloor, and contributing to the nutrient cycle of the benthic boundary layers.

At the end of the introduction, the aims of the PhD thesis are presented. The report of the project activities starts with a review on published literature, to shed light on state of the art about the scientific research on this topic. Afterwards, a set of photos collected during field work are reported together with a brief description of the field-work location and of the species involved in the predatory actions. The review and field work provided a general overview on the large-prey capture and ingestion, highlighting some common features shared by most observed species. In parallel to the literature review and field work, a set of experiments were designed and carried out at the Zoology Lab of the Polytechnic University of Marche. Three manuscripts report three experimental tests carried out in the framework of the PhD work: these manuscripts have been submitted to Q1 peer-reviewed journals and are currently under review. By using cnidarian model organisms, each experiment investigated a different topic related to collective predation.

The first experiment deals with the influence of the large-prey collective predation on fitness and on level of aggregation of *Aurelia coerulea* polyps and relies on the hypothesis that the capture and consumption of large prey is beneficial for the fitness of neighbouring polyps, thus overcoming the costs of competition and encouraging polyps to keep proximity to access the large food resource.

The second manuscript presents the behavioural description of proto-cooperation among *A. coerulea* polyps and afterwards tests the hypothesis that non-associative learning is involved in triggering their proto-cooperation. This second experiment also tests the hypothesis that the complex behaviour required for the capture of large prey is induced by feeding stimuli (*i.e.*, the detection of chemical cues produced by the prey) and implies memorization.

The third manuscript deals with the trophic ecology of anthozoans: based on the evidence that the heterotrophic feeding is increased by symbiotic cnidarians as a strategy to recover from bleaching, the model organism *Exaiptasia diaphana*, a sea anemone hosting symbiotic zooxanthellae, was used to test the

success of collective predation upon large prey in bleached individuals compared to unbleached ones. Bleaching consists in the expulsion of symbiotic zooxanthellae due to stress events (*e.g.*, anomalous increase in seawater temperature or long-lasting turbidity), leading to the deficiency of photoautotrophically derived nutrients for the cnidarian host.

In conclusion, the final part summarizes the main findings and concepts resulted by this project.