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Protocooperation in *Tubastraea* cf. *micranthus* to catch large planktonic prey

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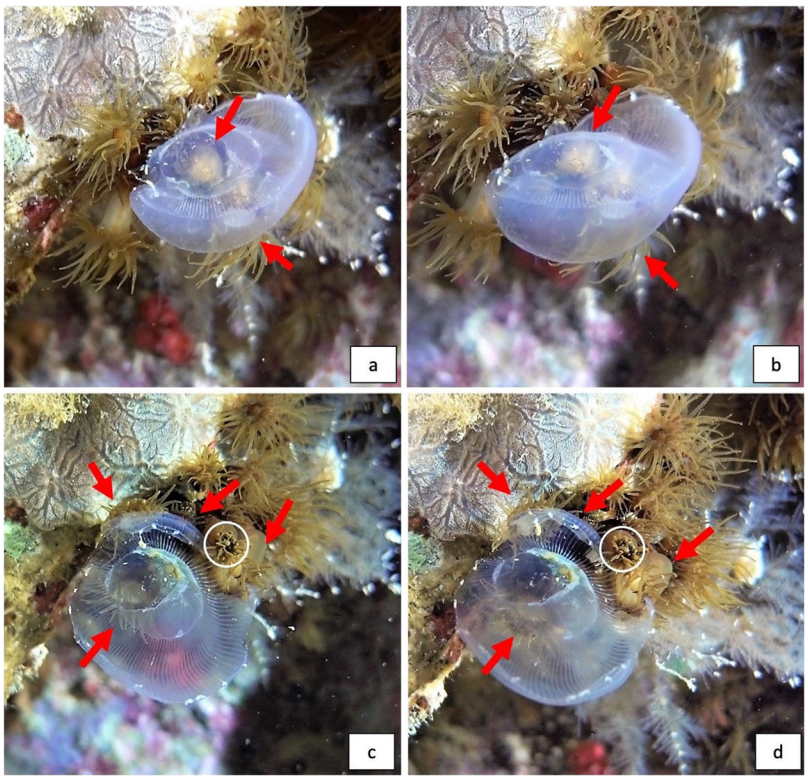

Fig. 1 Collective capture of an *Aequorea* sp. jellyfish by the dendrophylliid coral *Tubastraea* cf. *micranthus* (Ehrenberg, 1834) (Cnidaria, Anthozoa). Photos were taken in December 2021 at 17-m depth on the Thistlegorm wreck (27°48′30.6″N; 33°55′ 7.32″E, Suez Gulf, Red Sea). **a** and **b** 6.46 pm. Two polyps initially capture the prey (red arrows). The oral discs of the polyps are visible through the jellyfish bell, and their tentacles are engaged in holding the large prey. The jellyfish is still alive and moving (see supplementary video). **c** and **d** 6.58 pm. Two more polyps (four in total—red arrows) joint the action and completely block the jellyfish: their oral discs are wide open and tentacles folded up the jellyfish bell. The upper polyp in **a** and **b** (upper red arrow) detaches from the jellyfish bell and abandons the action, its mouth being closed and tentacles shortened and folded on it (**c**, **d**—white circle)

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Corals are considered suspension feeders extending their tentacles and catching particulate organic matter and small-sized zooplankton in the water column, although several papers reported unusual macrophagous feeding in scleractinian polyps; e.g. tropical fungiid and dendrophylliid corals were reported to eat jellyfish and salps (Alamaru et al. 2009; Hoeksema and Waheed 2012; Mehrotra et al., 2016). However, these papers describe the predatory activity performed by single coral polyps or by solitary species. In contrast, Musco et al. (2018) captured footage of the collective predation performed by polyps of the scleractinian *Astroides calycularis* (Pallas, 1766) upon *Pelagia noctiluca* (Forsskål, 1775) in the Mediterranean Sea. Musco et al. (2018) referred to this facultative

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mutualistic behaviour as "protocooperation", *sensu* Allaby (1998). Both zoo- and azooxanthellate species of Hexacorallia [*Parazoanthus axinellae* (Schmidt, 1862), *A. calycularis*, *Anemonia viridis* (Forsskål, 1775)] eating gelatinous macroplankton [*Aurelia aurita* (Linnaeus, 1758), *Rhizostoma pulmo* (Macri, 1778) and *P. noctiluca*] were documented with laboratory experiments (Cerrano et al. 2016) and field surveys (CG, personal observation), but eventual difference in protocooperation related to trophism of species has not been investigated so far. Similarly, three salpivorous colonial corals have been observed in the Caribbean Sea (ter Horst and Hoeksema 2021).

Reports on macrophagy in corals indicate that the capture occurs rapidly (minutes), while the ingestion phase can last up to hours depending on the prey/predator size ratio and the palatability of the prey, the latter being possibly rejected after partial consumption (Mehrotra et al. 2019). Collective predation occurs when the prey is several times larger than the oral disc of the single polyp, which would have difficulty in accessing the trophic resource alone. Thus, protocooperative predation is only possible when polyps are close to each other, sharing the capture effort. In natural conditions, anthozoans can form vast aggregations, building ecosystems and covering extended areas. Therefore, Musco et al. (2018) hypothesized that protocooperation could be intended as a driver of gregarism in benthic cnidarians, being a favourable characteristic allowing the benefit of ephemeral abundant resources.

To the best of our knowledge, this is the first record of *Tubastraea* cf. *micranthus* catching jellyfish, with a total of five polyps involved, three of them joining later and one abandoning the capture (Fig. 1c,d). Albeit still moving, the prey appeared damaged (see supplementary videos). Our data do not allow to determine if this damage occurred before or after the prey capture. *Astroides calycularis* appeared able to catch healthy jellyfish (Musco et al., 2018), but the present observation does not allow to demonstrate the same ability for *T.* cf. *micranthus*. We cannot confirm the ingestion of the prey; however, this observation suggests that jellyfish might represent a trophic resource also for *T.* cf. *micranthus*.

Earlier reports suggest that macrophagous predation may be a widespread feeding strategy among corals, being reported in tropical and temperate areas (Alamaru et al. 2009; Hoeksema and Waheed 2012; Cerrano et al. 2016; Mehrotra et al., 2016; Musco et al. 2018; ter Horst and Hoeksema 2021). Our observation revealed a form of cooperation among polyps that was seldomly observed, albeit suspected to be more common than expected (Musco et al. 2018). Protocooperation and the role of mega- and macrozooplankton in coral diets are still largely unexplored topics (Cerrano et al. 2016). Further research would shed light on coral macrophagous feeding strategy, mechanism of cooperation among polyps, prey preferences and possible differences linked to their trophism. In conclusion, our observation points out the need to further investigate the role of gelatinous macroplankton in anthozoan food webs, as well as the importance of protocooperation in the feeding behaviour of cnidarian polyps and its evolutionary relevance.

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Declarations

Conflict of interest The authors declare no competing interests.

Ethics approval No animal testing was performed during this study.

Sampling and field studies The study does not contain sampling material or data from field studies.

Data availability Data sharing not applicable to this article as no datasets were generated or analysed during the current study.

Author Contribution CG extrapolated pictures, conceptualized and wrote the paper. SP and LM supervised, reviewed and edited the manuscript.

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