

Ecology, 99(10), 2018, pp. 2400–2401

© 2018 The Authors. *Ecology* published by Wiley.

This is an open access article under the terms of the Creative Commons Attribution License, which permits use, distribution and reproduction in any medium, provided the original work is properly cited.

Protocooperation among small polyps allows the coral *Astroides calycularis* to prey on large jellyfish

The coral *Astroides calycularis* (Scleractinia: Dendrophylliidae) is endemic to the Mediterranean Sea (Terrón-Sigler et al. 2016), where it can be reef forming (Musco et al. 2017; Fig. 1). In shallow water, it may cover up to 90% of rocky substrate from the surface down to 15 m depth where it is found in caves and on vertical walls. *Astroides calycularis* colonies frequently occur in dense aggregations (Goffredo et al. 2011), possibly favored by limited dispersion ability of both sexual (Goffredo et al. 2010) and asexual propagules (Serrano et al. 2017). High water movement promotes massive colony shapes with closely connected polyps usually forming continuous orange surfaces, leaving little space for the settlement of other benthic organisms (Casado-Amezua et al. 2013). *Astroides calycularis* is “polystomatous,” forming small colonies composed of polyps connected to each other as a single organism bearing several mouths. Colony morphology is also strongly controlled by food availability (Goffredo et al. 2011). Polyps are typically 4–5 mm in length but larger polyps can grow up to 8 mm long. Like other azooxanthellate corals, *A. calycularis* is an obligate suspension feeder (Cebrian and Ballesteros 2004) and it is assumed to feed primarily on zooplankton transported by water movement, although the identity of its most preferred prey is unknown.

The venomous mauve stinger *Pelagia noctiluca* is a holoplanktonic jellyfish with a phosphorescent bell 3–12 cm wide. It is typical of warm water but currents may transport smacks of jellyfish into temperate and cold seas. Thus, it can be found from the tropics to the north Pacific and Atlantic, including the Mediterranean Sea. *Pelagia noctiluca* is usually pelagic and performs diel vertical migrations, albeit occasionally reaching the coast in large quantities. In the western Mediterranean, it forms persistent populations where it can be a nuisance to bathing people during periodic blooms in the warm season, raising increasing concerns as these blooms become more frequent (Canepa et al. 2014). *Pelagia noctiluca* is known to be preyed upon by fishes and turtles and parasitized by crustaceans. So far only one published picture of *P. noctiluca* seized by a polyp of a polystomatous coral is known (Aguilar 2007:30).

Observations of predation of the mauve stinger, *P. noctiluca*, by the orange coral, *A. calycularis*, were made in 2010, 2014, and 2017 during three field survey campaigns carried out in different localities of the Mediterranean Sea (Appendix S2). Capture and ingestion of 20 observed jellyfish involved several polyps belonging to different colonies

(Fig. 1a, Appendix S1: Fig. S1A–D, Video S1). The feeding behavior begins when a *P. noctiluca* jellyfish becomes trapped under an overhang with abundant *A. calycularis*. The pulsating swimming of the jellyfish moves the bell repeatedly against the overhang ceiling. Here *A. calycularis* polyps first adhere to the bell after which several polyps rapidly engulf the oral arms of the jellyfish, a process lasting between 1 and 5 minutes. Single polyps are able to ingest the oral arm tips preventing the jellyfish from escaping, while other polyps collaborate in ingesting pieces of jellyfish arms and umbrella (Fig. 1b, Appendix S1: Fig. S1D). Some jellyfish escape these attacks or become released as many were observed lying dead on the seafloor, with a hole on the top of the bell possibly caused by the predators. A similar behavior is shown when jellies are pushed by waves or currents onto colonies living on vertical walls along the shore (Appendix S1: Fig. S1A–D).

Present data and available information do not allow us to quantify the predation pressure exerted by *A. calycularis* on the mauve stinger. It seems unlikely that predation by the

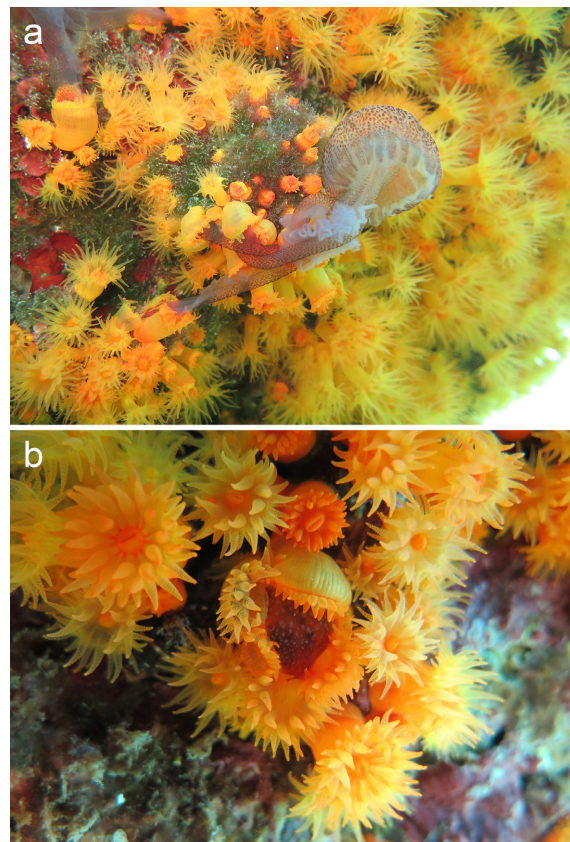


FIG. 1. *Pelagia noctiluca* jellyfish trapped among coral colonies of *Astroides calycularis* during *P. noctiluca* blooms in Italy. (a) Polyps preying singularly or in groups of the same or different colonies at Favignana Island (8 May 2017). (b) Close-up view of coral polyps swallowing a piece of jellyfish umbrella at Pantelleria Island (23 May 2014).

coral significantly affects jellyfish populations, since these normally complete their life cycle in the pelagic realm. However, the incidental availability of *P. noctiluca* accumulated along the shoreline is arguably an important resource for the coral, as there may also be other macroscopic gelatinous plankton, such as ctenophores and salps.

Previous observations of monostomatous mushroom corals have reported their ability to eat large gelatinous plankton owing to their big mouth or large gape in the Red Sea (Alamaru et al. 2009), Malaysia (Hoeksema and Waheed 2012), and Thailand (Mehrotra et al. 2016). Capture of *P. noctiluca* by the polystomatous coral *Phyllangia mouchezii* has been illustrated (Aguilar 2007:30). However, the provided picture is hardly interpretable and it is unclear if collective behavior is involved. Here we describe how several small colonies of a polystomatous coral with tiny mouths and small gapes cooperate to do so analogously. Indeed, the ecological and evolutionary advantage for some Dendrophylliidae of having many small polyps has remained elusive (Arrigoni et al. 2014). Collective predation among relatively small polyps allows *A. calycularis* to access food resources well beyond its gape, thereby exploiting ephemeral, highly abundant patches of large prey.


The coral colonies display synchronized capture of the jellyfish. Collective synchronization of foraging provides immediate benefits to the fitness of engaged individuals with relatively little cost. These attributes allow for the selection of the observed behavior over evolutionary time (Clutton-Brock 2009) through, e.g., the tendency of colonies to form aggregations. Thus, we consider the observed facultative mutualistic behavior a case of “protocooperation” (sensu Allaby 1998).

ACKNOWLEDGMENTS

This research was supported by two grants from the Ministry of Education, University and Research, Italy grant F81J 120003 80001; grant C62F16000170001). Authors thanks the authority of the Egadi Islands MPA for logistic support, and the anonymous reviewers for very helpful comments.

LITERATURE CITED

- Aguilar, R. 2007. The corals of the Mediterranean. Fondazione Zegna, Oceana, Biella.
- Alamaru, A., O. Bronstein, Y. Loya, and G. Dishon. 2009. Opportunistic feeding by the fungiid coral *Fungia scruposa* on the moon jellyfish *Aurelia aurita*. *Coral Reefs* 28:865.
- Allaby, M. 1998. A dictionary of ecology. Page 440. Oxford University Press, Oxford.
- Arrigoni, R., Y. F. Kitano, J. Stolarski, B. W. Hoeksema, H. Fukami, F. Stefani, F. Galli, S. Montano, E. Castoldi, and F. Ben-zoni. 2014. A phylogeny reconstruction of the Dendrophylliidae (Cnidaria, Scleractinia) based on molecular and micromorphological criteria, and its ecological implications. *Zoologica Scripta* 43:661–688.
- Canepa, A., V. Fuentes, A. Sabatés, S. Piraino, F. Boero, and J. M. Gili. 2014. *Pelagia noctiluca* in the Mediterranean Sea. Pages 237–266 in K. A. Pitt and C. H. Lucas, editors. *Jellyfish blooms*. Springer Netherlands, Dordrecht, The Netherlands.
- Casado-Amezua, P., G. Gasparini, and S. Goffredo. 2013. Phenological and morphological variations in the Mediterranean orange coral *Astroides calycularis* between two distant localities. *Zoology* 116:159–167.
- Cebrian, E., and E. Ballesteros. 2004. Zonation patterns of benthic communities in an upwelling area from the western Mediterranean (La Herradura, Alboran Sea). *Scientia Marina* 68:69–84.
- Clutton-Brock, T. 2009. Cooperation between non-kin in animal societies. *Nature* 462:51–57.
- Goffredo, S., G. Gasparini, G. Marconi, M. T. Putignano, C. Pazzini, and F. Zaccanti. 2010. Gonochorism and planula brooding in the Mediterranean endemic orange coral *Astroides calycularis* (Scleractinia: Dendrophylliidae). Morphological aspects of gametogenesis and ontogenesis. *Marine Biology Research* 6:421–436.
- Goffredo, S., E. Caroselli, G. Gasparini, G. Marconi, M. T. Putignano, C. Pazzini, and F. Zaccanti. 2011. Colony and polyp biometry and size structure in the orange coral *Astroides calycularis* (Scleractinia: Dendrophylliidae). *Marine Biology Research* 7:272–280.
- Hoeksema, B. W., and Z. Waheed. 2012. It pays to have a big mouth: mushroom corals ingesting salps at northwest Borneo. *Marine Biodiversity* 42:297–302.
- Mehrotra, R., C. M. Scott, and B. W. Hoeksema. 2016. A large gape facilitates predation on salps by *Heteropsammia* corals. *Marine Biodiversity* 46:323–324.
- Musco, L., F. Prada, G. D’Anna, N. M. Galasso, C. Pipitone, T. Vega Fernández, and F. Badalamenti. 2017. Turning casualty into opportunity: fragmenting dislodged colonies is effective for restoring reefs of a Mediterranean endemic coral. *Ecological Engineering* 98:206–212.
- Serrano, E., R. Coma, K. Inostroza, and O. Serrano. 2017. Polyp bail-out by the coral *Astroides calycularis* (Scleractinia, Dendrophylliidae). *Marine Biodiversity* [Epub ahead of print]. <https://doi.org/10.1007/s12526-017-0647-x>
- Terrón-Sigler, A., D. León-Muez, P. Peñalver, R. Gálvez-César, and F. Espinosa Torre. 2016. Geographic distribution of *Astroides calycularis* (Scleractinia: Dendrophylliidae) as a baseline to assess future human impacts on the Southern Iberian Peninsula. *Journal of the Marine Biological Association of the United Kingdom* 96:1181–1189.

LUIGI MUSCO,¹ TOMÁS VEGA FERNÁNDEZ ^{1,2,5},
ERIK CAROSELLI,³ JOHN MURRAY ROBERTS⁴, AND
FABIO BADALAMENTI^{1,2,4}

Manuscript received 12 September 2018; revised 11 May 2018; accepted 19 May 2018. Corresponding Editor: John Pastor.

¹Stazione Zoologica Anton Dohrn, Naples, Italy.

²Consiglio Nazionale delle Ricerche - Istituto per l’Ambiente Marino Costiero, Castellammare del Golfo, Italy.

³Marine Science Group, Department of Biological, Geological and Environmental Sciences, University of Bologna, Bologna, Italy.

⁴School of Geosciences, Grant Institute, King’s Buildings, University of Edinburgh, Edinburgh, United Kingdom.

⁵Corresponding author: E-mail: tomas.vegafernandez@szn.it

Additional supporting information may be found in the online version of this article at <http://onlinelibrary.wiley.com/doi/10.1002/ecy.2413/supinfo>