Ocean and Coastal Research

BRIEF COMMUNICATION

http://doi.org/10.1590/2675-2824073.24117
ISSN 2675-2824

Rocking together: a report on a biological interaction between a non-native sea anemone and a sea squirt in southeastern Brazil

Hellen Ceriello[1], Romulo A. O. Bazzo[1], Lucas D. Martinez[1], Barbara M.T. Chagas[1], Celine S.S. Lopes[2], Gustavo Muniz Dias[3], Sérgio N. Stampar[1]*

[1] Universidade Estadual Paulista – Bauru – Departamento de Ciências Biológicas – Laboratório de Evolução e Diversidade Aquática – LEDALab (Bauru – SP – Brazil).
[2] Universidade de São Paulo – Departamento de Genética e Biologia Evolutiva – Laboratório de Diversidade Genômica (São Paulo – SP – Brazil).
[3] Centro de Ciências Naturais e Humanas – Universidade Federal do ABC (São Bernardo do Campo – SP – Brazil).

* Corresponding author: sergio.stampar@unesp.br

ABSTRACT

This study provides an in-depth examination of the ecological interaction between the non-native *Diadumene lineata* (Verrill, 1869) sea anemone, and the *Polysyncraton amethysteum* Van Name, 1902 colonial ascidian. We documented the nature of their interactions using systematic field observations carried out in their natural habitat along the rocky shores of Ubatuba, located on the northern coast of São Paulo State, Brazil. Our findings reveal that these two species engage in a complex relationship that may offer several adaptation strategies and ecological benefits, such as increased habitat stability and enhanced nutrient availability. We discuss how the presence of ascidians may provide shelter for the sea anemone. Furthermore, this study highlights broader implications of non-native species on rocky shore ecosystems. The introduction of non-native species can disrupt existing relationships between native organisms, potentially altering community structures and ecological balances.

Keywords: Actiniaria, Ascidiacea, Symbiosis, Southern Atlantic, Non-native species

Fouling communities, i.e. assemblages of sessile organisms that attach to various substrates, play a significant role in marine ecosystems (Leclerc and Viard, 2018). These communities are characterized by their ability to recruit and use diverse materials, like rocks, artificial structures, and even other living organisms, to complete their life cycles (Monniot, 2016). However, suitable recruitment areas can be a limiting factor for many marine invertebrates, including ascidians (sea squirts) and sea anemones (Lozano-Cortés and Zapata, 2014; Floerl et al., 2016; Monniot, 2016). Ascidians, like *Polysyncraton amethysteum* Van Name, 1902, are typically found attached to rocky substrates. However, they have demonstrated remarkable adaptability by colonizing living organisms, including other ascidians and sea anemones (Ceriello et al., 2020). This flexibility highlights the importance of exploring diverse settlement options in response to limited resources (Berrill, 1932). On the other hand, when dealing with the opposite, that is, sea squirts as substrates

Submitted: 07-Oct-2024
Approved: 28-Dec-2024

Editor: Rubens Lopes

or hosts for infaunal and epifaunal organisms, most studies report ascidians, mainly from the family Didemnidae Giard, 1872, only associating with cyanobacterial species and benefiting from it (Pardy and Lewin, 1981; Pardy and Royce, 1992; Carpenter and Foster, 2002; Monniot, 2016). Sea anemones, like those from the *Diadumene* Stephenson, 1920 genus, are also known for forming associations with other marine organisms (Beneti et al., 2015). While most studies have focused on the role of ascidians as habitats for other organisms, this study presents a unique and less commonly documented phenomenon: the anchoring of a sea anemone, *Diadumene lineata* (Verrill, 1869), on the surface of a colonial didemnid ascidian, *P. amethysteum*. This interaction is significant not only because of its ecological relevance, but also because *D. lineata* is a non-native species to the coast of Brazil (Hancock et al., 2017). By examining this unique association, we can gain valuable information about the ecological strategies employed by these organisms to survive and thrive in competitive marine environments. Moreover, this study may shed light on the potential for unexpected and beneficial interactions between non-native species in fouling communities.

Specimens of the colonial *P. amethysteum* sea squirt hosting the *D. lineata* sea anemone were manually sampled in Praia Grande, Ubatuba, São Paulo, Brazil (23°28'00"S 45°03'35"W) on a rocky shore in the intertidal zone. The specimens were preserved in 92° ethanol and deposited in the Zoological collection at the São Paulo State University, Bauru. The identification of *Polysycraton amethysteum* and *Diadumene lineata* specimens followed the methodology presented in Oliveira et al., 2019 and Hancock et al., 2017, respectively.

Sea anemones are highly skilled at colonizing different types of substrates, including other organisms with which they can establish many kinds of relationships (Muller-Parker and Davy, 2001; Fautin and Goodwill, 2009; Gusmão and Daly, 2010). One of these relationships is epibiosis, as shown by Martin et al., (2015), who reported epibiosis between a sea anemone and a colonial ascidian. Similarly, we have observed a very unusual interaction between a native species of colonial sea squirt, *P. amethysteum*, and a non-native species of sea anemone, *Diadumene lineata* (Beneti et al., 2015; Newcomer et al., 2019).

Polysyncraton amethysteum occurs in the Atlantic and Indian Ocean (Millar, 1958; Monniot, 2016; Oliveira et al., 2019) and has a large phenotypic variation. In Brazil, this species is most often reported in intertidal zones and warmer waters (Rodrigues and Rocha, 1993; Rocha and Nasser, 1998; Rocha et al., 2005). On the other hand, *D. lineata* is a native species from the western North Pacific Ocean; however, its asexual reproduction potential allows it to have a cosmopolitan distribution and be a well-known successful invasive species (Ting and Geller, 2000; Newcomer et al., 2019).

In our study, *D. lineata* individuals were found inhabiting small holes on the surface of the ascidian colony (Figure 1). As we did not observe how these holes were formed, we can only hypothesize that: (1) they were created by ascidians growing around pre-existing anemones or (2) they were created by the anemones themselves. In the latter scenario, our observations suggest several possibilities. We noted size variations among individuals, including the presence of some juvenile sea anemones specimens within the ascidian colony. These data may suggest that asexual reproduction, primarily via longitudinal fission and/or pedal laceration, is the dominant mode of reproduction for these individuals. Clonal reproduction enables rapid population growth and expansion, potentially contributing to the invasive success of the species. Pedal laceration may enable the anemone to colonize new habitats by forming new individuals from fragments of its body. This strategy could facilitate adaptation to diverse environments and increase epibiosis potential, further enhancing its invasive capabilities. However, the potential for sexual reproduction cannot be entirely discounted. While no conclusive evidence of sexual reproduction has been observed outside East Asia to date, reports of both sexes in the Atlantic Ocean suggest that it may occur under specific circumstances or in certain populations (Newcomer et al. 2019).

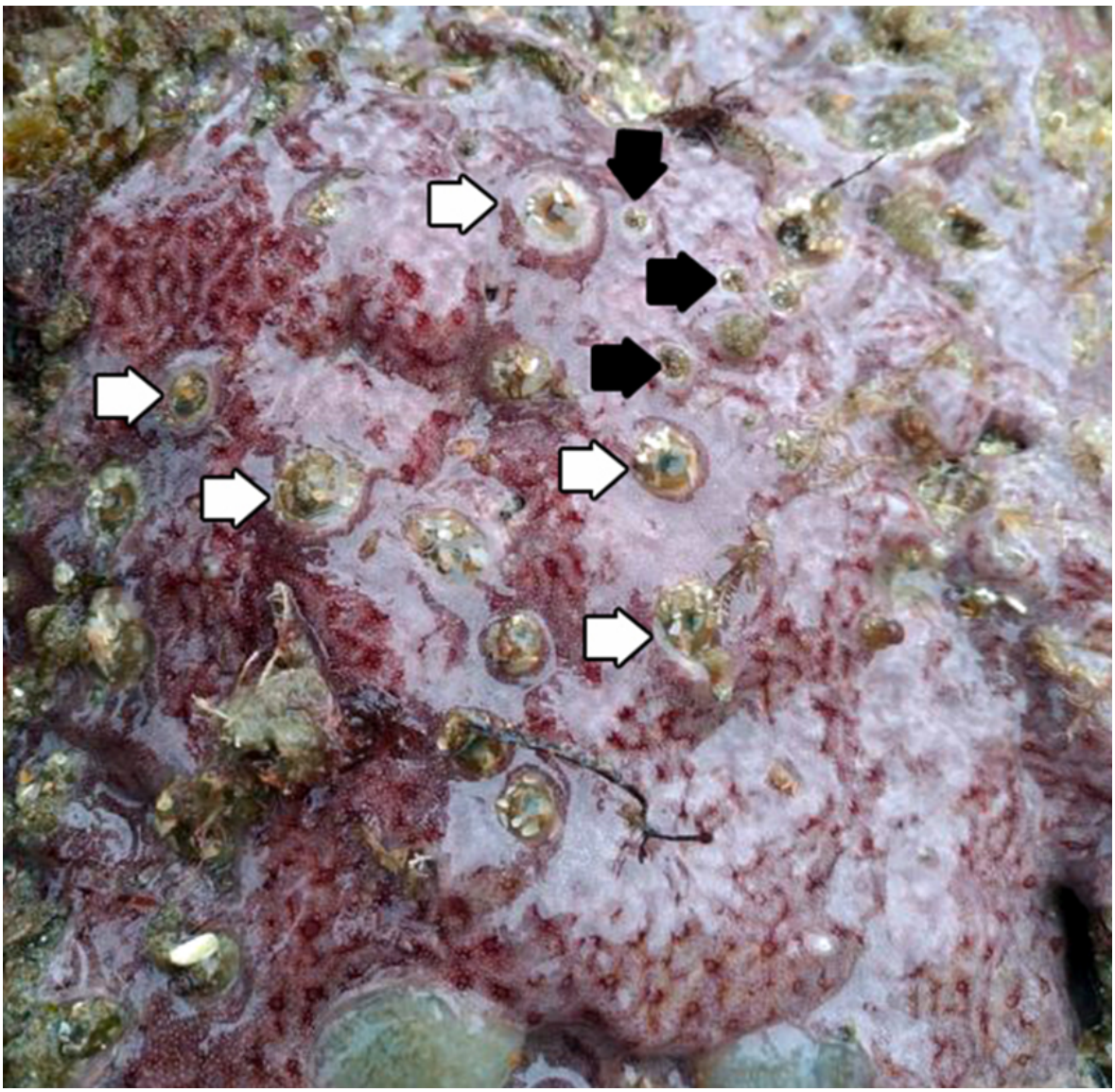

Figure 1. Several specimens of *Diadumene lineata* sea anemone living in holes in the *Polysyncraton amethysteum* ascidian colony. Arrows indicate anemones in holes: white arrows indicate juvenile specimens, while black ones, adult specimens.

While the exact mechanisms behind the formation of the observed holes remain speculative, *D. lineata* potential for both sexual and asexual reproduction highlights its adaptability and success as a non-native species. Furthermore, this interaction emphasizes broader impacts of non-native species on community structure and ecosystem function, particularly in rocky shore environments. Regardless of the structuring method of this relationship, the ecological implications are crucial.

Sebens (1986) defines that the dispute for space on rocky shores is vital for life maintenance because only after settling in a suitable region, can benthic organisms eat properly. Aside from the importance of competition over space, there are other ways to interpret the occurrence of a species in some locations, like successive historical processes that can also determine species fitness and diversity of communities. Nowadays, the transit of species across their biogeographical boundaries, mediated by man, creates a complex aspect for understanding the importance of biological interaction in rocky shores, since the establishment of foreign organisms in a particular

region changes the structure and functioning of communities, resulting in ecosystem damage (Wilcove et al., 1998). Interestingly, even though there were no other organisms around, and plenty of space/available substrate (rocks), anemones in our study were living in ascidian colonies. Thus, it is important to understand why this was happening; we have a few hypotheses: (1) *D. lineata* has no structures in its column to provide protection against desiccation (Ottaway, 1973; Konecny and Harley, 2019); thus, sea squirt tissues could protect anemones from air exposure in low tides; (2) *P. amethysteum* colonies are used by gastropods of the genus *Lamellaria* Montagu, 1816 as feeding grounds and reproduction sites, deploying their eggs inside the colony (Dias and Delboni, 2008). In this way, could anemones, like the gastropods, similarly benefit from living in ascidian tissues? (3) several Didemnidae ascidians are known for producing deterrent chemicals that discourage benthic predators (Tarjuelo et al., 2002). If this applies to *P. amethysteum*, anemones could also benefit from this chemical protection.

Data availability statement

This article is based on qualitative observations, and no quantitative data is available for sharing.

Supplementary material

This article does not include any supplementary materials.

Funding

This work was partly supported by the Fundação de Amparo à Pesquisa do Estado de São Paulo (FAPESP) 2022/16193-1, and the Conselho Nacional de Desenvolvimento Científico e Tecnológico (CNPq - Research Productivity Scholarship) 304267/2022-8 to SNS.

Author contributions

H.C.: Conceptualization, Data curation, Formal analysis, Methodology, Writing – Original draft.

C.S.S.L.: Conceptualization, Data curation, Formal analysis, Methodology, Writing – Original draft.

R.A.O.B.: Conceptualization, Data curation, Formal analysis, Methodology, Writing – Original draft.

L.D.M.: Conceptualization, Data curation, Formal analysis, Methodology, Writing – Original draft.

B.M.T.C.: Supervision, Methodology, Validation, Writing– Review & editing.

G.M.D.: Conceptualization, Methodology, Software, Validation, Writing – Review & editing.

S.N.S.: Supervision, Funding Acquisition, Methodology, Validation, Writing– Review & editing.

Conflicts of interest

The authors declare no conflicts of interest.

REFERENCES

Beneti, J. S., Stampar, S. N., Maronna, M. M., Morandini, A. C. & Silveira, F. L. D. 2015. A new species of Diadumene (Actiniaria: Diadumenidae) from the subtropical coast of Brazil. *Zootaxa*, 4021(1), 156–168. DOI: https://doi.org/10.11646/zootaxa.4021.1.6

Berrill, N. J. 1932. Ascidians of the Bermudas. *Biological Bulletin*, 62(1), 77–88. DOI: https://doi.org/10.2307/1537145

Carpenter, E. J. & Foster, R. A. 2002. Marine cyanobacterial symbioses. *In*: Rai A. N., Bergman B. & Rasmussen U. (Ed.). *Cyanobacteria in symbiosis*. Dordrecht: Springer. DOI: https://doi.org/10.1007/0-306-48005-0_2

Ceriello, H., Lopes, C. S. S., Reimer, J. D., Bakken, T., Fukuda, M. V., Cunha, C. M. & Stampar, S. N. 2020. Knock knock, who's there?: marine invertebrates in tubes of Ceriantharia (Cnidaria: Anthozoa). *Biodiversity Data Journal*, 8, e47019.

Dias, G. M. & Delboni, C. G. M. 2008. Colour polymorphism and oviposition habits of Lamellariamopsicolor. *Marine Biodiversity Records*, 1, e49. DOI: https://doi.org/10.1017/S1755267206005550

Fautin, D. G. & Goodwill, R. H. 2009. *Neoaiptasiamorbilla* new species (Cnidaria: Actiniaria), a sea anemone symbiont of sand-dwelling gastropods on Saipan, Mariana islands, with comments on some other such associations. *Micronesica*, 41(1), 101–115.

Floerl, O., Sunde, L. M. & Bloecher, N. 2016. Potential environmental risks associated with biofouling management in salmon aquaculture. *Aquatic Environmental Interactions*, 8, 407–417. DOI: https://doi.org/10.3354/aei00187

Gusmão, L. C. & Daly, M. 2010. Evolution of sea anemones (Cnidaria: Actiniaria: Hormathiidae) symbiotic with hermit crabs. *Molecular and Phylogenetic Evolution*, 56(3), 868–877. DOI: https://doi.org/10.1016/j.ympev.2010.05.001

Hancock, Z. B., Janelle, A. G. & Wicksten, M. K. 2017. A sea anemone of many names: a review of the taxonomy and distribution of the non-native actiniarian *Diadumene lineata* (Diadumenidae), with records of its reappearance on the Texas coast. *ZooKeys*, 706, 1.

Konecny, C. A. & Harley, C. D. G. 2019. The distribution of the orange-striped green anemone, *Diadumenelineata*, in relation to environmental factors along coastal British Columbia, Canada. *Invertebrate Biology*, 138(4), e12268. DOI: https://doi.org/10.1111/ivb.12268

Leclerc, J. C. & Viard, F. 2018. Habitat formation prevails over predation in influencing fouling communities. *Ecology and Evolution*, 8(1), 477-492.

Lozano-Cortés, D. F. & Zapata, F. A. 2014. Invertebrate colonization on artificial substrates in a coral reef at Gorgona Island, Colombian Pacific Ocean. *Revista de Biologia Tropical*, 62(1), 161–168.

Martin, J. P., Garese, A., Sar, A. & Acuña, F. H. 2015. Fouling community dominated by *Metridium senile* (Cnidaria: Anthozoa: Actiniaria) in Bahía San Julián (southern Patagonia, Argentina). *Scientia Marina*, 79(2), 211–221. DOI: https://doi.org/10.3989/scimar.04082.21A

Millar, R. H. 1958. Some ascidians from Brazil. *Annals and Magazine of Natural History*, 1(8), 497–514. DOI: https://doi.org/10.1080/00222935808650975

Monniot, F. 2016. Ascidians (Tunicata) of the French Guiana expedition. *Zootaxa*, 4114(3), 201–245. DOI: http://doi.org/10.11646/zootaxa.4114.3.1

Montagu, G. 1816. An account of some new and rare marine British shells and animals. *Transactions of the Linnean Society of London*, 11(2),179–204. DOI: https://doi.org/10.1111/j.1096-3642.1813.tb00047.x

Muller-Parker, G. & Davy, S. K. 2001. Temperate and tropical algal-sea anemone symbioses. *Invertebrate Biology*, 120(2), 104–123. DOI: https://doi.org/10.1111/j.1744-7410.2001.tb00115.x

Newcomer, K., Flenniken, M. M. & Carlton, J. T. 2019. Home and away and home again: discovery of a native reproductive strategy of the globally invading sea anemone *Diadumene lineata* (Verrill, 1869) in a satellite population. *Biological Invasions*, 21, 1491–1497. DOI: https://doi.org/10.1007/s10530-019-01940-y

Oliveira, L. M., Hoeksema B. W. & Rocha R. M. 2019. *Polysyncraton* (Ascidiacea, Didemnidae): a re-examination of some specimens and descriptions of three new species. *European Journal of Taxonomy*, 519, 1–25. DOI: https://doi.org/10.5852/ejt.2019.519

Ottaway, J. R. 1973. Some effects of temperature, desiccation, and light on the intertidal anemone, *Actinia tenebrosa* Farquhar (Cnidaria: Anthozoa). *Marine and Freshwater Research*, 24(1), 103–126. DOI: https://doi.org/10.1071/MF9730103

Pardy, R. L. & Lewin, R. 1981. Colonial ascidians with prochlorophyte symbionts: evidence for translocation of metabolites from alga to host. *Bulletin of Marine Science*, 31(4), 817–823.

Pardy, R. L. & Royce, C. L. 1992. Ascidians with algal symbionts. *In*: Reisser, W. (Ed.). *Algae and symbioses, plants, animals, fungi, viruses, interactions explored* (pp. 215–230). London: Biopress.

Rocha, R. M., Moreno, T. R. & Metri, R. 2005. Ascídias (Tunicata, Ascidiacea) da Reserva Biológica Marinha do Arvoredo, Santa Catarina, Brasil. *Revista Brasileira de Zoologia*, 22(2), 461–476. DOI: https://doi.org/10.1590/S0101-81752005000200024

Rocha, R. M. & Nasser, C. M. 1998. Some ascidians (Tunicata, Ascidiacea) from Paraná State, southern Brazil. *Revista Brasileira de Zoologia*, 15(3),633–642. DOI: https://doi.org/10.1590/S0101-81751998000300009

Rodrigues, S. A. & Rocha, R. M. 1993. Littoral compound ascidians (tunicata) from São Sebastião, Estado de São Paulo, Brazil. *Proceedings of the Biological Society of Washington*, 106(4), 728–739.

Sebens, K. P. 1986. Spatial Relationships among Encrusting Marine Organisms in the New England Subtidal Zone. *Ecological Monographs*, 56(1), 73–96. DOI: https://doi.org/10.2307/2937271

Tarjuelo, I., López-Legentil, S., Codina, M. & Turon, X. 2002. Defence mechanisms of adults and larvae of colonial ascidians: patterns of palatability and toxicity. *Marine Ecology Progress Series*, 235, 103–115. DOI: https://doi.org/10.3354/meps235103

Ting, J. H. & Geller, J. N. 2000. Clonal diversity in introduced populations of an asian sea anemone in North America. *Biological Invasions*, 2, 23–32. DOI: https://doi.org/10.1023/A:1010085406539

Van Name, W. G. 1902. The ascidians of the Bermuda Islands. *Transactions of the Connecticut Academy of Arts and Sciences*, 11, 325–412

Verrill, A. E. 1869. Synopsis of the polyps and corals of the North Pacific exploring expedition. *Communications of the Essex Institute*, 6, 51–104.

Wilcove, D. S., Rothstein, D., Dubow, J., Phillips, A. & LOSOS, E. 1998. Quantifying threats to imperiled species in the United States. *Bioscience*, 48, 607–615. DOI: https://doi.org/10.2307/1313420