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Hoeksema, Bert; Harper, Charlotte E.; Langdon-Down, Sean J.; van der Schoot, Roel J.; Smith-Moorhouse, Annabel; Spaargaren, Roselle; Timmerman, Rosalie F.

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Cryptogenic Worm Snail Causes Coral Damage in the Caribbean

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Host Range of the Coral-Associated Worm Snail *Petalococonchus* sp. (Gastropoda: Vermetidae), a Newly Discovered Cryptogenic Pest Species in the Southern Caribbean

Bert W. Hoeksema ^{1,2,3,*} , Charlotte E. Harper ^{1,2} , Sean J. Langdon-Down ^{1,2} , Roel J. van der Schoot ^{1,2} ,
Annabel Smith-Moorhouse ^{1,2} , Roselle Spaargaren ^{1,2}  and Rosalie F. Timmerman ^{1,2} 

¹ Taxonomy, Systematics and Geodiversity Group, Naturalis Biodiversity Center, P.O. Box 9517, 2300 RA Leiden, The Netherlands; c.harper@student.rug.nl (C.E.H.);

s.langdon-down@student.rug.nl (S.J.L.-D.); roel.vanderschoot@naturalis.nl (R.J.v.d.S.);

a.smith-moorhouse@student.rug.nl (A.S.-M.); r.spaargaren@student.rug.nl (R.S.);

r.f.timmerman@student.rug.nl (R.F.T.)

² Groningen Institute for Evolutionary Life Sciences, University of Groningen, P.O. Box 11103, 9700 CC Groningen, The Netherlands

³ Institute of Biology Leiden, Leiden University, P.O. Box 9505, 2300 RA Leiden, The Netherlands

* Correspondence: bert.hoeksema@naturalis.nl

Abstract: The presence of associated endofauna can have an impact on the health of corals. During fieldwork on the southern Caribbean island of Curaçao in 2021, the presence of an unknown coral-dwelling worm snail was discovered, which appeared to cause damage to its hosts. A study of photo archives revealed that the species was already present during earlier surveys at Curaçao since 2014 and also in the southern Caribbean island of Bonaire in 2019. It was not found in St. Eustatius, an island in the eastern Caribbean, during an expedition in 2015. The vermetid snail was preliminarily identified as *Petalococonchus* sp. Its habitat choice resembles that of *P. keenae*, a West Pacific coral symbiont. The Caribbean species was observed in 21 host coral species, more than reported for any other vermetid. Because *Petalococonchus* sp. is a habitat generalist, it is possible that it was introduced from an area with another host-coral fauna. The unknown vermetid is considered to be cryptogenic until future studies reveal its actual identity and its native range.

Keywords: coral damage; coral reef; host generalist; *Millepora*; scleractinia



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1. Introduction

Worm snails of the family Vermetidae are common inhabitants of coral reefs and rocky shores in tropical to warm-temperate marine coastal waters, where they live embedded in dead or live corals or attached to other hard substrata [1]. They have tube-shaped shells, mostly without the regular shell coiling [2,3], which in some species form dense, reef-building aggregations [4–6]. Because of their reef-building capacity in the intertidal or immediate subtidal zone, they play an important role as sea-level and sea-surface temperature indicators in the fossil record [6–8]. The history of Vermetidae systematics is complex, which is partly due to the confusion of their calcareous tubes with those of other organisms, such as serpulid worms [9].

Although there is much literature on coral-associated fauna in the Caribbean, vermetid snails are usually not included [10–13]. Apparently, all host-related information on coral-associated vermetids is from the Indo-Pacific, predominantly involving *Ceraesignum maximum* (G.B. Sowerby I, 1825), previously known as *Dendropoma maxima*, which dwells on scleractinians, blue corals, and fire corals [14–16]. This species is notorious because of its harmful effect on the growth, survival, and photophysiology of host corals [17–20]. There are only a few other coral-vermetid records from the Indo-Pacific, including *Petalococonchus*

keenae Hadfield & Kay, 1972 near Hawaii [21], *Thylacodes hadfieldi* (W.C. Kelly, 2007) near Guam [22], and *Thylacodes* spp. off the west coast of India [23].

During a recent survey of the coral-associated fauna of Curaçao, coral-dwelling worm snails were discovered for the first time in the Caribbean. In order to investigate their preferred habitats, all observed host coral species were recorded. Because the species appears to be cryptogenic, we discuss why no earlier records are known for the Caribbean. The present report serves to create awareness for this cryptogenic species for future research on its origin and its possible effect on the health of Caribbean coral reefs.

2. Materials and Methods

The survey of coral-associated fauna took place during October–December 2021 along the leeward side of the island of Curaçao. Because the coral-dwelling vermetid was not recorded before in the Caribbean and was overlooked by the first author during earlier surveys, his photo archive was checked for the presence of this snail during fieldwork at Curaçao in 2017, 2015, and 2014, Bonaire in 2019, and St. Eustatius in 2015. Curaçao and Bonaire are located in the southern Caribbean and St. Eustatius in the eastern Caribbean (Figure 1). All association records were listed per island and year (Table 1). Photographic evidence (showing a shell with the operculum present) is presented for each host (Supplementary Materials).



Figure 1. Map of the eastern part of the Caribbean showing the position of Curaçao, Bonaire and St. Eustatius, where the occurrence of coral-dwelling vermetids was investigated.

3. Results

A total of 21 host-coral species—19 scleractinians (Anthozoa) and two milleporids (Hydrozoa)—were recorded, divided over 11 families and 14 genera (Table 1). A few worm snail specimens were found on dead unidentified coral. All records were from the southern Caribbean islands Bonaire and Curaçao, with none from St. Eustatius in the eastern Caribbean. The worm snails with a clearly visible operculum were identified as *Petalconchus* sp. (Figures 2 and 3; Supplementary Materials Figures S1–S23). Its operculum has upward-folded margins, giving it a tapering appearance, and its diameter was smaller than that of the shells' aperture, which prevented a total shutting of the tube (Figure 3). A small, concave operculum is characteristic for the genus *Petalconchus* H.C. Lea, 1843 [24].

Table 1. Records of stony corals as host species (by family) for the vermetid gastropod *Petalococonchus* sp. based on photographs made at Curaçao (a: 2021; b: 2017; c: 2015; d: 2014), Bonaire (e: 2019), and St. Eustatius (2015).

Host Species	Curaçao	Bonaire	St. Eustatius
Anthozoa: Scleractinia			
Agariciidae			
<i>Agaricia agaricites</i> (Linnaeus, 1758)	a	e	–
<i>Agaricia humilis</i> (Verrill, 1901)	a	–	–
<i>Agaricia lamarcki</i> Milne Edwards & Haime, 1851	a	–	–
Astrocoeniidae			
<i>Stephanocoenia intersepta</i> (Esper, 1795)	a	–	–
Dendrophylliidae			
<i>Cladopsammia manuelensis</i> (Chevalier, 1966)	b	–	–
Faviidae			
<i>Colpophyllia natans</i> (Houttuyn, 1772)	a	–	–
<i>Diploria labyrinthiformis</i> (Linnaeus, 1758)	a	–	–
<i>Pseudodiploria strigosa</i> (Dana, 1846)	a,d	–	–
Meandrinidae			
<i>Eusmilia fastigiata</i> (Pallas, 1766)	d	–	–
<i>Meandrina meandrites</i> (Linnaeus, 1758)	a	–	–
Merulinidae			
<i>Orbicella annularis</i> (Ellis & Solander, 1786)	a	e	–
<i>Orbicella faveolata</i> (Ellis & Solander, 1786)	a	–	–
<i>Orbicella franksi</i> (Gregory, 1895)	a	e	–
Montastraeidae			
<i>Montastraea cavernosa</i> (Linnaeus, 1767)	a	e	–
Pocilloporidae			
<i>Madracis auretenra</i> Locke, Weil & Coates, 2007	a	–	–
<i>Madracis decactis</i> (Lyman, 1859)	d	e	–
<i>Madracis senaria</i> Wells, 1973	a	e	–
Poritidae			
<i>Porites astreoides</i> Lamarck, 1816	a,b	e	–
Rhizangiidae			
<i>Siderastrea siderea</i> (Ellis & Solander, 1768)	a	–	–
Hydrozoa			
Milleporidae			
<i>Millepora alcicornis</i> Linnaeus, 1758	a	–	–
<i>Millepora complanata</i> Lamarck, 1816	a,c	–	–
Unidentified dead coral	a	–	–

Owing to its symbiotic nature, the coral-dwelling worm snail of the present study cannot be confused with previously reported Caribbean species, such as the reef-building *Petalococonchus varians* (d'Orbigny, 1839) in Venezuela [5] and Brazil [25]. The invasive vermetid *Eualetes tulipa* (Chenu, 1843) has also been recorded in the West Atlantic and the Caribbean, but its operculum is much darker than that of our specimens and it has not been reported as a coral symbiont but as colonies on rock and artificial substrate [26,27]. *Dendropoma corrodens* (d'Orbigny, 1841) is a small worm snail species (ca. 1 cm long), known from the Caribbean and the mid-Atlantic, which forms aggregations on dead coral substrate [26].

Several snail tubes were covered by algae and surrounded by faecal pellets (Figure 3). Many were surrounded by dead coral tissue (Figure 3B,C,E) or attached to dead coral next to the host's margin (Figure 3A). A few snails showed remnants of mucus webs (Figures 2A and 3D,F). In some corals, the snail tube was killing the polyps underneath and did not become overgrown by coral tissue (Figure 2C,D; Supplementary Materials Figures S17 and S19). In other ones no damage was observed, such as in *Cladopsammia manuelensis*, *Eusmilia fastigiata*, *Madracis auretenra*, *M. decactis* and *Millepora alcicornis* (Figure 2A,B; Supplementary

Materials Figures S4 and S7–S9). *Cladopsammia manuelensis* has recently been discovered as a shallow-water coral in the Caribbean [28,29].

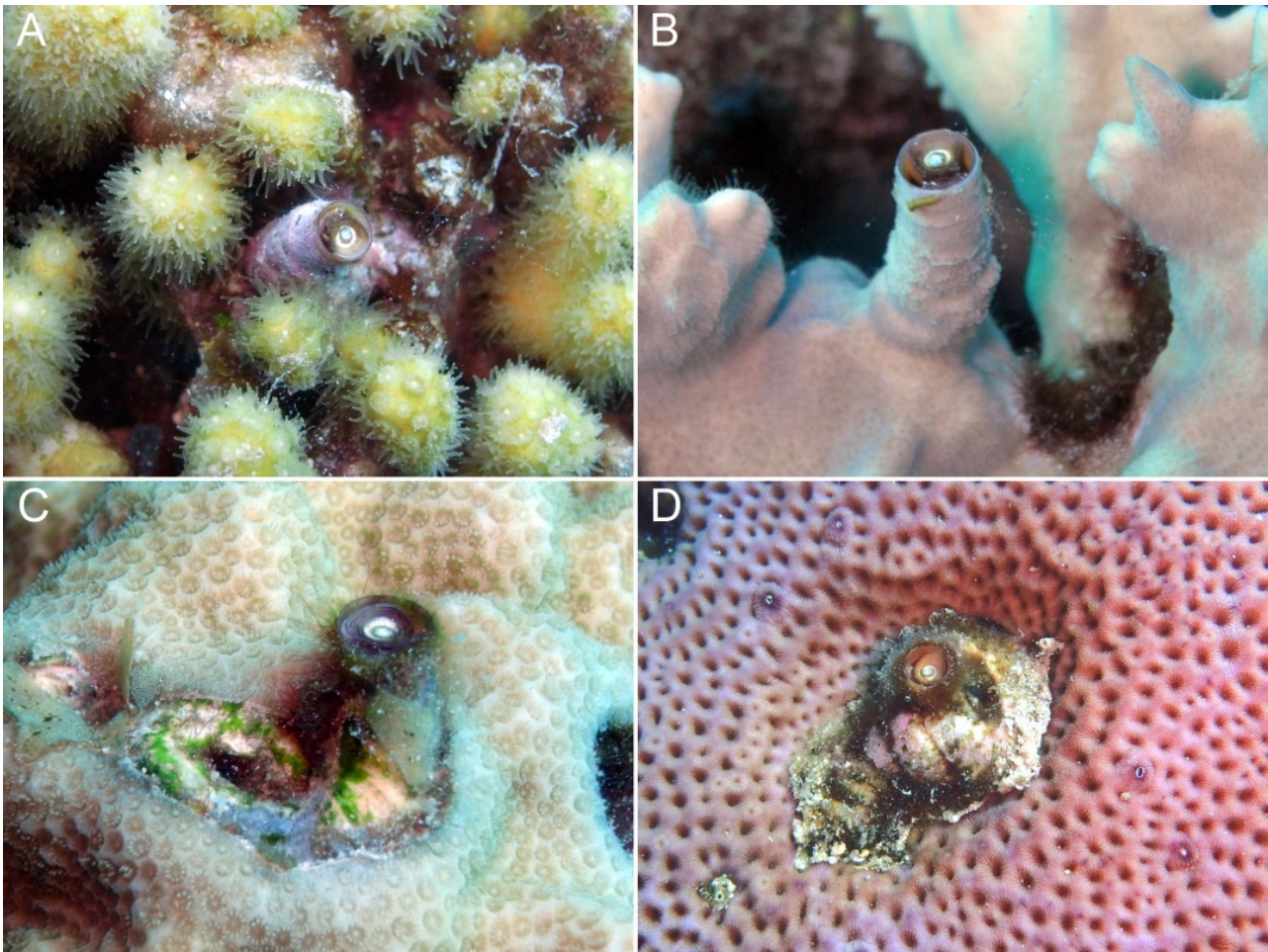


Figure 2. Worm snails (*Petalococonchus* sp.) hosted by the branching corals *Madracis auretenra* (A) and *Millepora alcicornis* (B), and the massive corals *Porites astreoides* (C) and *Siderastrea siderea* (D). The snail tube in *M. alcicornis* is entirely overgrown by the coral (B), whereas the snails in both massive corals have caused considerable damage to their hosts (C,D). Tube diameter: ca. 4 mm.

4. Discussion

Since Caribbean coral-dwelling vermetids previously were not recognized in the scientific literature, they may have become introduced recently or they may have been overlooked. The tubes of the snails can be confused with those of polychaete worms of the serpulid genus *Spirobranchus* Blainville, 1818, which are common in the Caribbean, where they have a wide host range [30]. Both groups, coral-dwelling worm snails and serpulid worms, have their tubes partially embedded in the coral skeleton and both possess an operculum that is used to close the tube for the protection of soft body-parts [2,31]. *Spirobranchus* worms are eye-catching because of their high densities and colorful, twin-conispiral branchiae [31,32]. Vermetid snails, on the other hand, use transparent mucus nets to catch food (Figure 3D,F) [33–35], which makes them less remarkable (Supplementary Materials Figure S19).

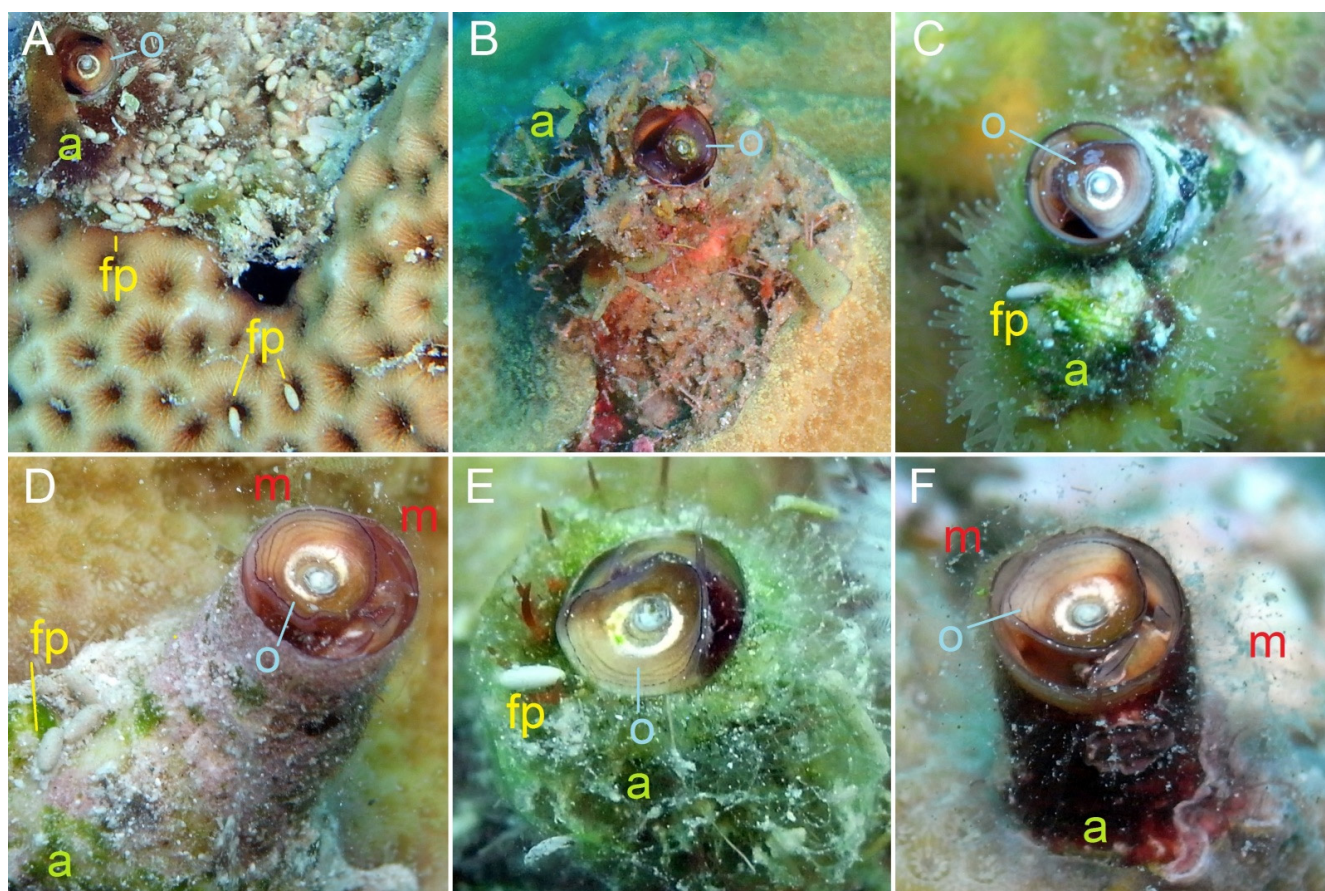


Figure 3. Close-up images of worm snails (*Petalococonchus* sp.) and their hosts: *Siderastrea siderea* (A), *Porites astreoides* (B,D–F), and *Madracis auretenra* (C). The tubes are partly or entirely overgrown or surrounded by green and red algae (a). The operculum (o) appears to be tapering towards one side because of the margins being turned upwards next to the tentacles. Some worms show remnants of mucus nets (m). Faecal pellets are common around the tubes (fp). Tube diameter: ca. 4 mm.

The habitat of *Petalococonchus* sp. resembles that of *P. keenae*, which has been reported as an associate of the Indo-Pacific coral genera *Porites*, *Montipora*, and *Pavona* at the Hawaiian islands [21], and possibly as *Petalococonchus* cf. *keenae* living in corals at Kwajalein Atoll in the Marshall Islands [36]. It is therefore reasonable to speculate that the coral-associated *Petalococonchus* sp. in the southern Caribbean is the same species and that it has been introduced from the tropical Indo-Pacific. As long as its identity cannot be confirmed by molecular analyses and morphological studies of the radula, protoconch, egg capsules, and coloration of shell and body [21,22], we consider the present species to be cryptogenic in the southern Caribbean. An earlier presence of such Caribbean worm snails could be verified with the help of coral collections in natural history museums [37]. Most museum collections of stony corals consist of dry specimens, but remnants of vermetid shells may still be present and recognizable.

Considering the poor knowledge of *Petalococonchus* sp. in the Caribbean, it is relevant to know of possible natural enemies that may be able to remove evidence of coral-dwelling vermetids. The carpiliid crab *Carpilius convexus* (Forskål, 1775) has been reported to prey on the vermetid *Ceraesignum maximum* in the Red Sea by breaking its shell and the coral in which it lives [38]. A possible predator of *Petalococonchus* sp. would therefore be *Carpilius corallinus* Herbst, 1783, which has been observed to crush large tubes of serpulid worms and also parts of the host coral [39].

The host-coral range in the present study (21 species) is more extensive than recorded for any other coral-associated vermetid. The host ranges of the Indo-Pacific vermetids *C.*

maximum and *P. keenae* (mentioned above) are based on miscellaneous records and might be much larger in reality. Previous field surveys specifically targeting host-coral ranges (and prey preferences) of gastropod families and genera also yielded various additional host records and showed that some species are very host-specific, e.g., *Leptoconchus* [40] and Epitoniidae [41], and that others are generalists, such as some species of *Coralliophila* [42] and *Drupella* [43,44]. Research on coral-dwelling nudibranchs, such as the well-camouflaged *Phestilla* spp., also demonstrates that an ongoing search for possible hosts results in new association records and species discoveries [45–47].

The occurrence of coral injuries (dead coral surface and shells overgrowing coral polyps) suggests that the snails are harmful to their hosts, which is relevant for coral reef conservation [48,49]. It is possible that coral polyps are killed by the snail's mucus webs (Figures 2A and 3D,F), which may smother and even poison them if the mucus is toxic, as reported for *Ceraesignum maximum* [50]. The occurrence of turf algae on the shells is expected to increase damage to the hosts, as observed in *Spirobranchus* tubes overgrowing coral polyps [31,32]. Future field research with a focus on reef-dwelling vermetids will likely result in more information on their densities and additional host records. Molecular analyses may reveal the actual identity of the present species and its native range, and also whether cryptic speciation has taken place across the various host corals.

Supplementary Materials: The following supporting information can be downloaded at: <https://www.mdpi.com/article/10.3390/d14030196/s1>, Supplementary S1: photographic host records of *Petalconchus* sp.: Figure S1: *Agaricia agaricites* at Bonaire (2019); Figure S2: *Agaricia humilis* at Curaçao (2021); Figure S3: *Agaricia lamarcki* at Curaçao (2021); Figure S4: *Cladopsammia manuelensis* at Curaçao (2017); Figure S5: *Colpophyllia natans* at Curaçao (2021); Figure S6: *Diploria labyrinthiformis* at Curaçao (2021); Figure S7: *Eusmilia fastigiata* at Curaçao (2014); Figure S8: *Madracis auretenra* at Curaçao (2021); Figure S9: *Madracis decactis* at Bonaire (2019); Figure S10: *Madracis senaria* at Curaçao (2021); Figure S11: *Madracis senaria* at Bonaire (2019); Figure S12: *Meandrina meandrites* at Curaçao (2021); Figure S13: *Millepora alcicornis* at Curaçao (2021); Figure S14: *Millepora complanata* at Curaçao (2015); Figure S15: *Montastraea cavernosa* at Bonaire (2019); Figure S16: *Orbicella annularis* at Bonaire (2019); Figure S17: *Orbicella faveolata* at Curaçao (2021); Figure S18: *Orbicella franksi* at Bonaire (2019); Figure S19: *Porites astreoides* at Curaçao (2021); Figure S20: *Pseudodiploria strigosa* at Curaçao (2021); Figure S21: *Siderastrea siderea* at Curaçao (2021); Figure S22: *Stephanocoenia intersepta* at Curaçao (2021); Figure S23: Unidentified dead coral at Curaçao (2021).

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Supplementary Materials

Hoeksema, B.W.; Harper, C.E.; Langdon-Down, S.J.; van der Schoot, R.J.; Smith-Moorhouse, A.; Spaargaren, R.; Timmerman, R.F. Host Range of the Coral-Associated Worm Snail *Petalococonchus* sp. (Gastropoda: Vermetidae), a Newly Discovered Cryptogenic Pest Species in the Southern Caribbean. *Diversity* **2022**, *14*(3), 196. <https://doi.org/10.3390/d14030196>

Appendix S1. Photographic host records of *Petalococonchus* sp.

- Figure S1.** *Agaricia agaricites* at Bonaire (2019).
- Figure S2.** *Agaricia humilis* at Curaçao (2021).
- Figure S3.** *Agaricia lamarcki* at Curaçao (2021).
- Figure S4.** *Cladopsammia manuelensis* at Curaçao (2017).
- Figure S5.** *Colpophyllia natans* at Curaçao (2021).
- Figure S6.** *Diploria labyrinthiformis* at Curaçao (2021).
- Figure S7.** *Eusmilia fastigiata* at Curaçao (2014).
- Figure S8.** *Madracis auretenra* at Curaçao (2021).
- Figure S9.** *Madracis decactis* at Bonaire (2019).
- Figure S10.** *Madracis senaria* at Curaçao (2021).
- Figure S11.** *Madracis senaria* at Bonaire (2019).
- Figure S12.** *Meandrina meandrites* at Curaçao (2021).
- Figure S13.** *Millepora alcicornis* at Curaçao (2021).
- Figure S14.** *Millepora complanata* at Curaçao (2015).
- Figure S15.** *Montastraea cavernosa* at Bonaire (2019).
- Figure S16.** *Orbicella annularis* at Bonaire (2019).
- Figure S17.** *Orbicella faveolata* at Curaçao (2021).
- Figure S18.** *Orbicella franksi* at Bonaire (2019).
- Figure S19.** *Porites astreoides* at Curaçao (2021).
- Figure S20.** *Pseudodiploria strigosa* at Curaçao (2021).
- Figure S21.** *Siderastrea siderea* at Curaçao (2021).
- Figure S22.** *Stephanocoenia intersepta* at Curaçao (2021).
- Figure S23.** Unidentified dead coral at Curaçao (2021).

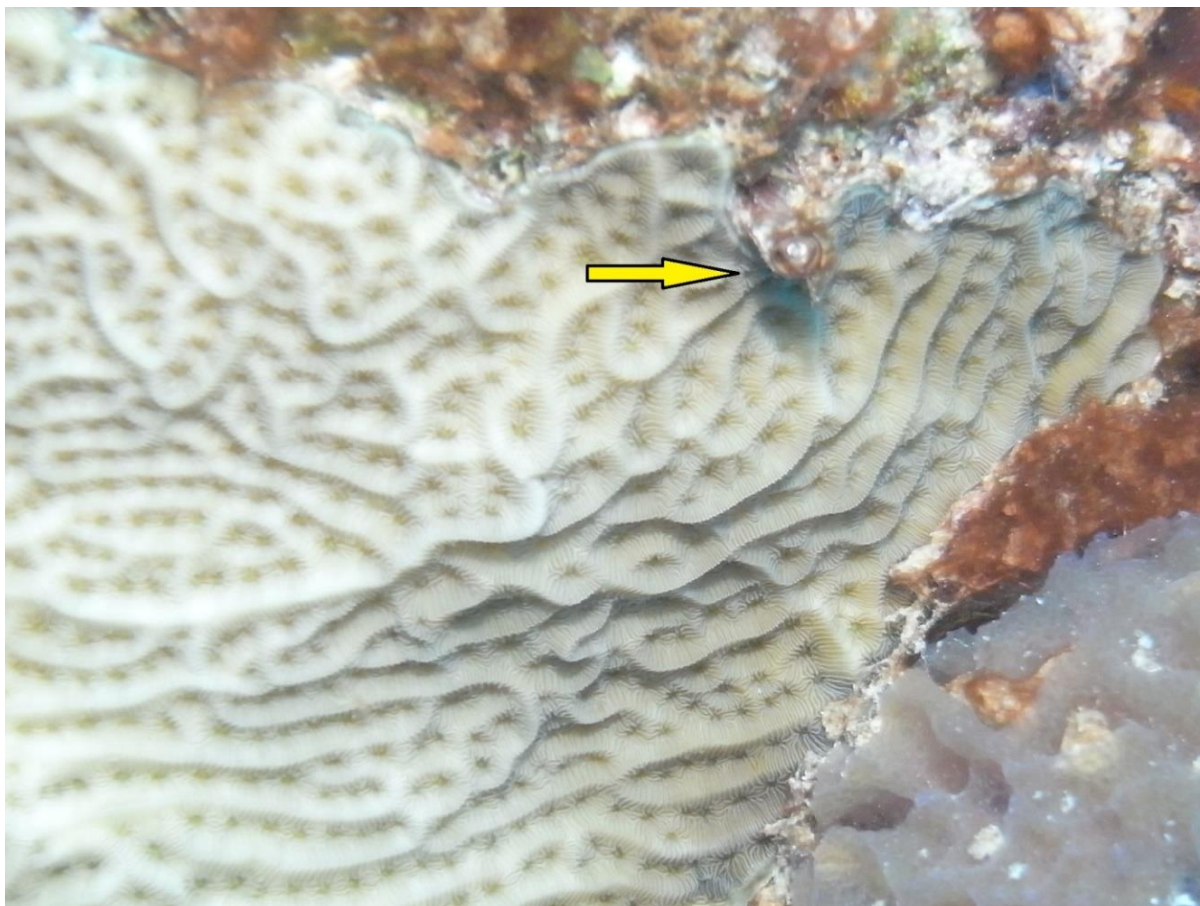


Figure S1. *Agaricia agaricites* at Bonaire (2019).



Figure S2. *Agaricia humilis* at Curaçao (2021).



Figure S3. *Agaricia lamarcki* at Curaçao (2021).



Figure S4. *Cladopsammia manuelensis* at Curaçao (2017).

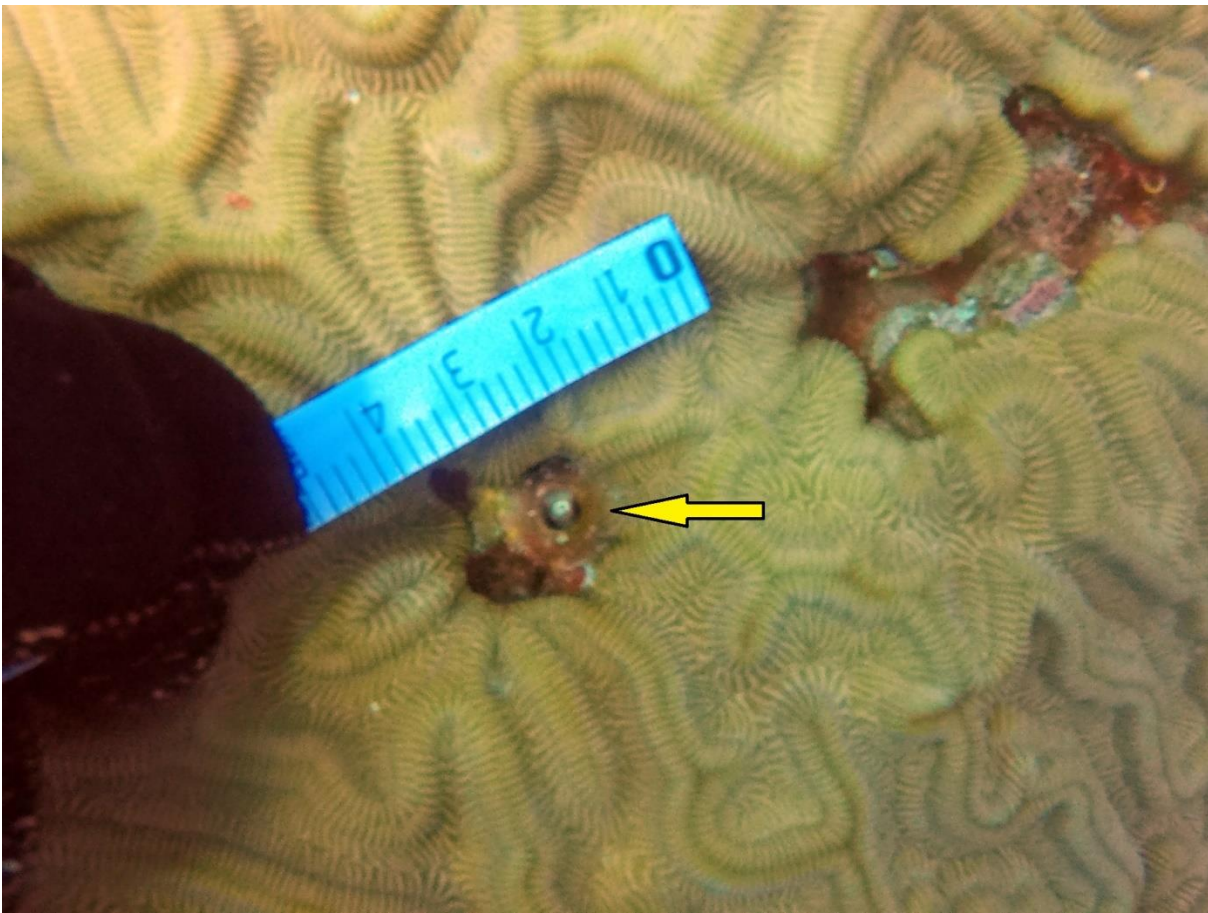


Figure S5. *Colpophyllia natans* at Curaçao (2021).

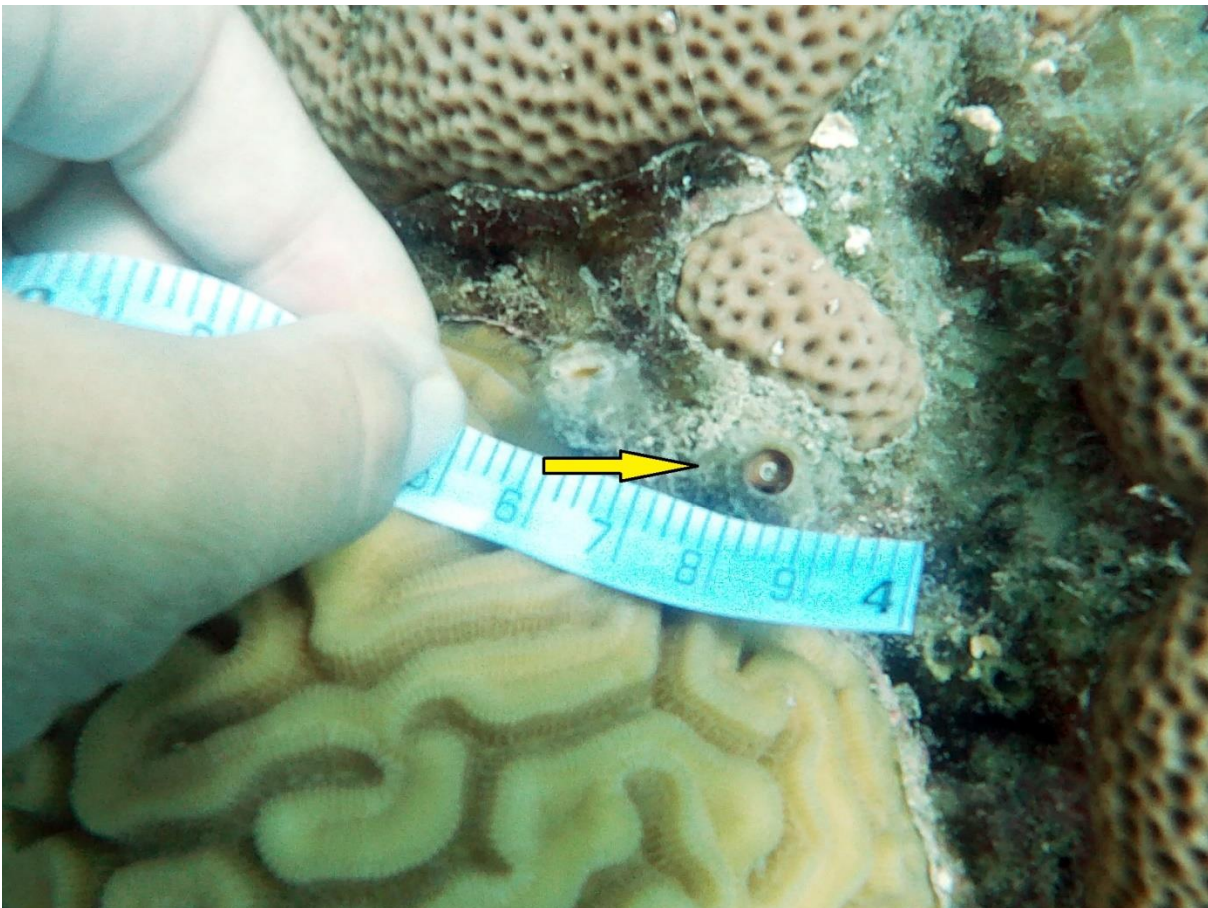


Figure S6. *Diploria labyrinthiformis* at Curaçao (2021).



Figure S7. *Eusmilia fastigiata* at Curaçao (2014).

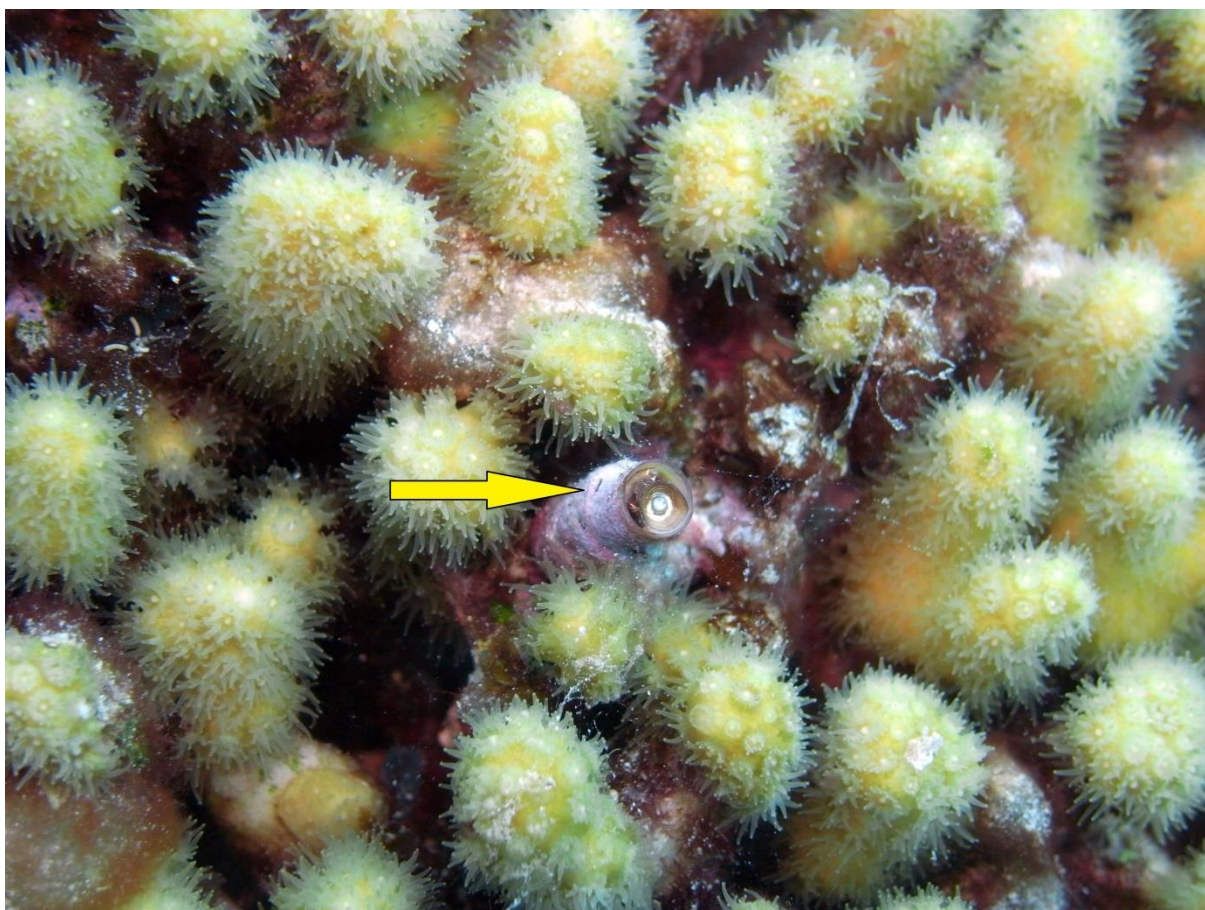


Figure S8. *Madracis auretenra* at Curaçao (2021).

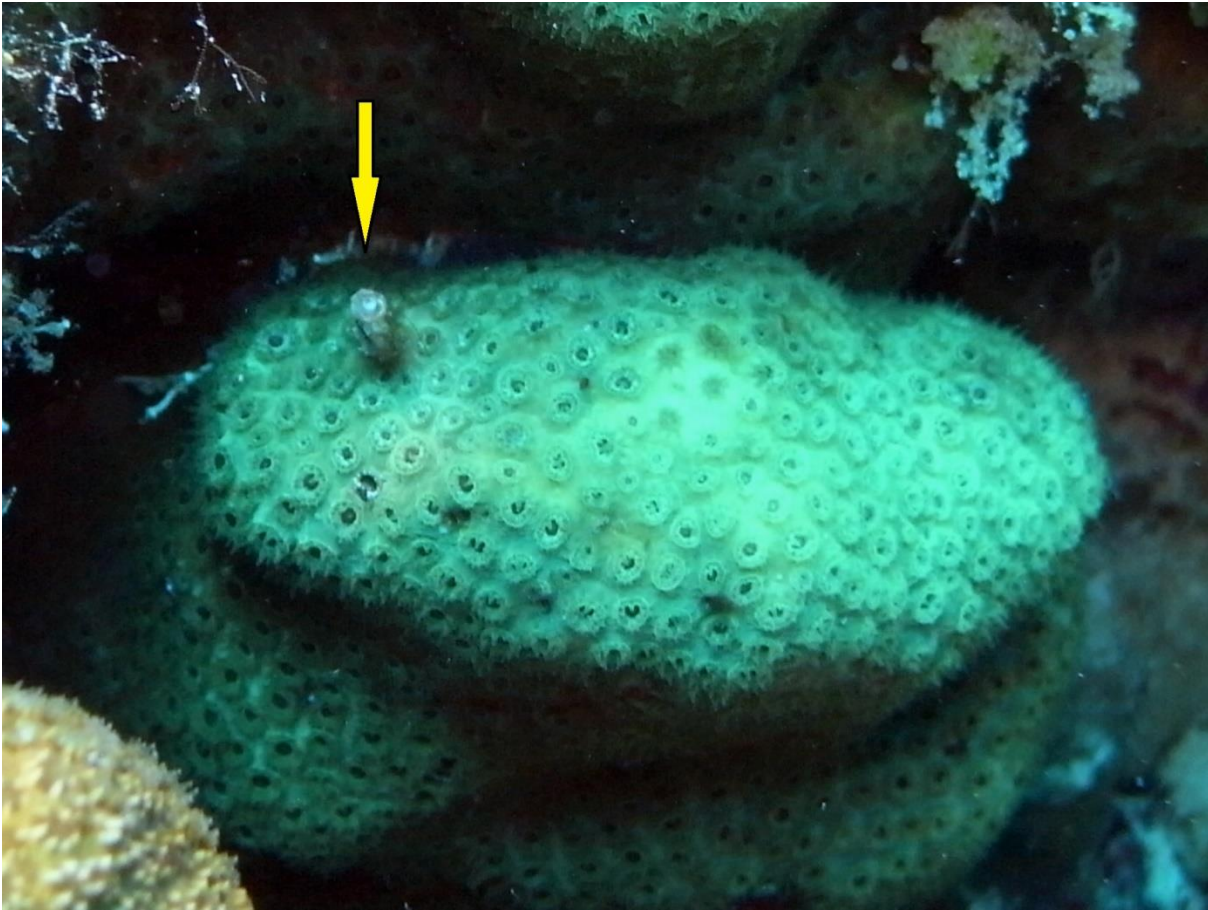


Figure S9. *Madracis decactis* at Bonaire (2019).



Figure S10. *Madracis senaria* at Curaçao (2021).

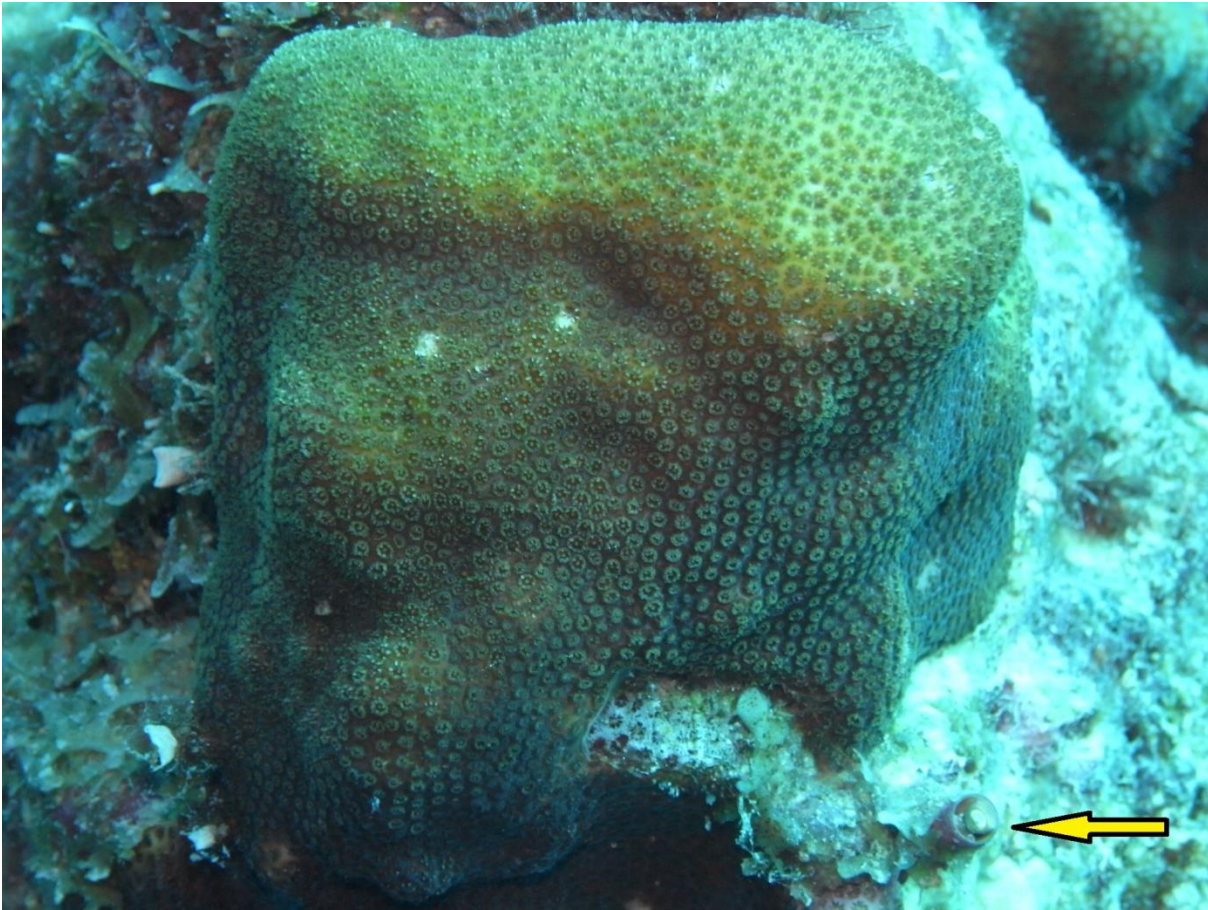


Figure S11. *Madracis senaria* at Bonaire (2019).



Figure S12. *Meandrina meandrites* at Curaçao (2021).

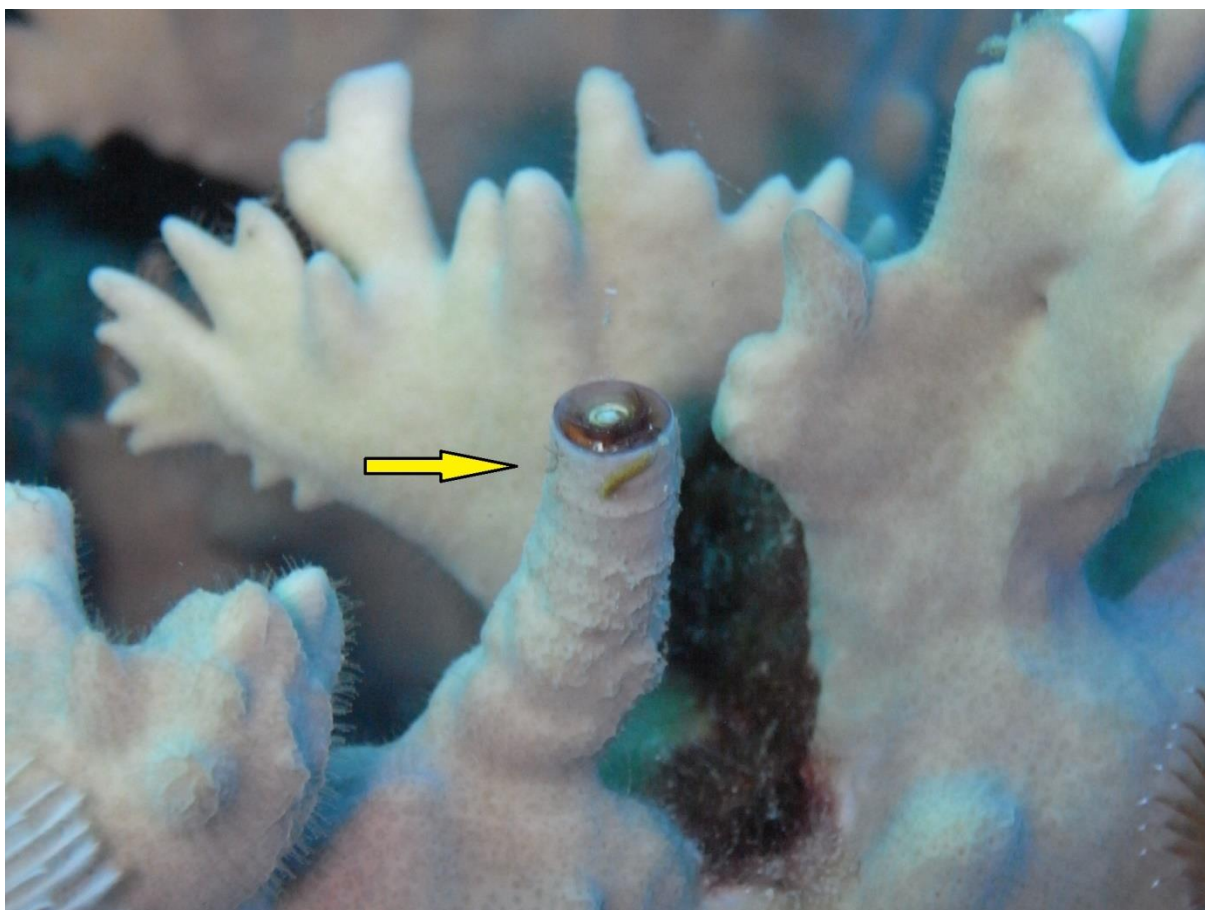


Figure S13. *Millepora alcicornis* at Curaçao (2021).

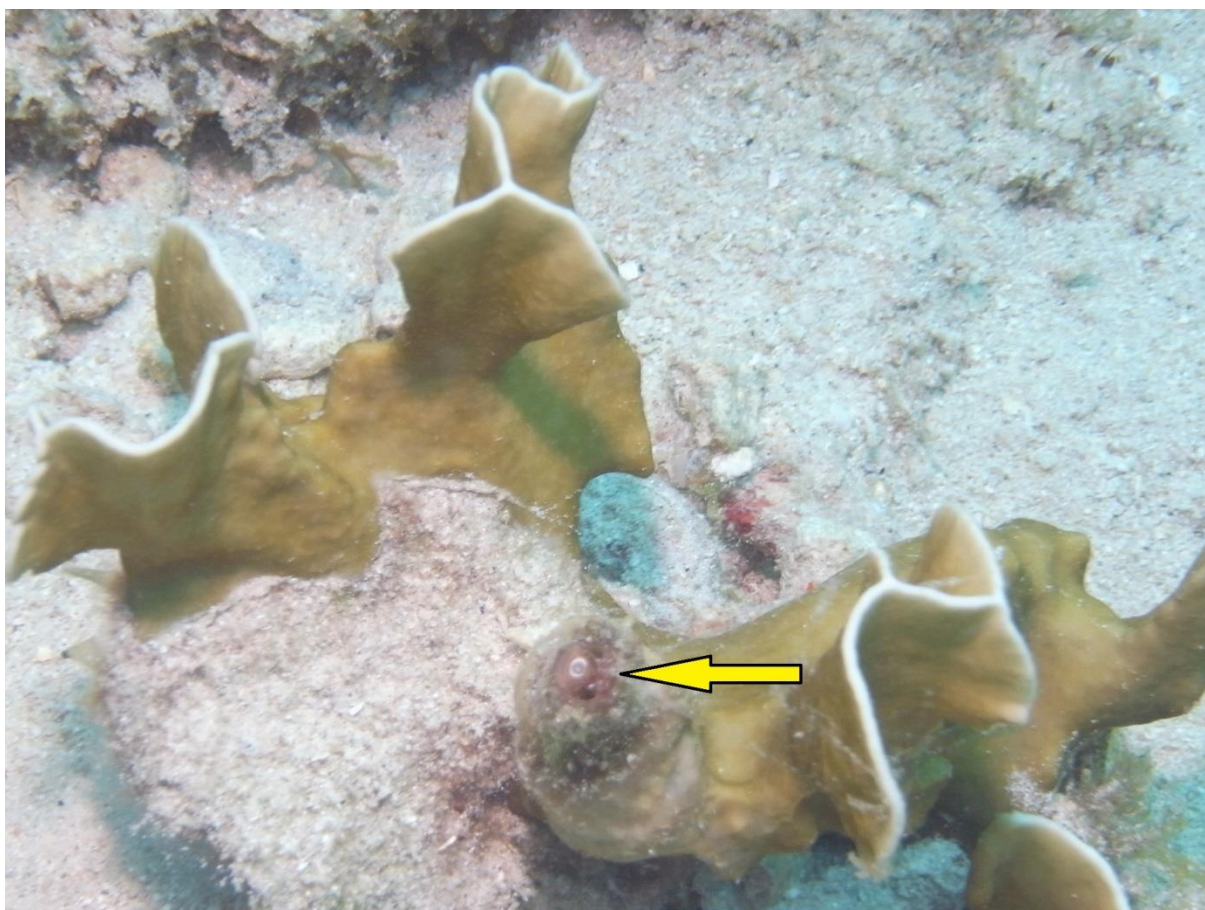


Figure S14. *Millepora complanata* at Curaçao (2015).

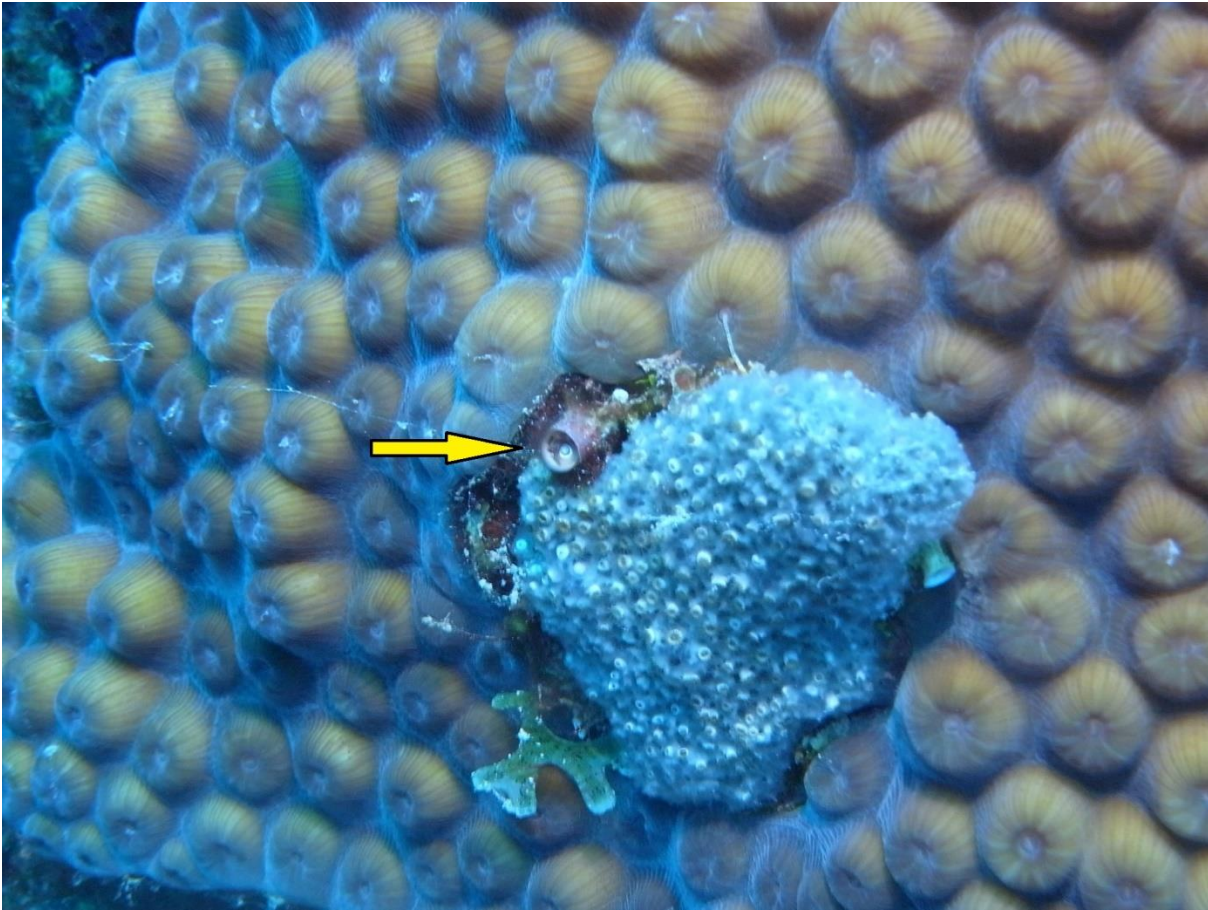


Figure S15. *Montastraea cavernosa* at Bonaire (2019).

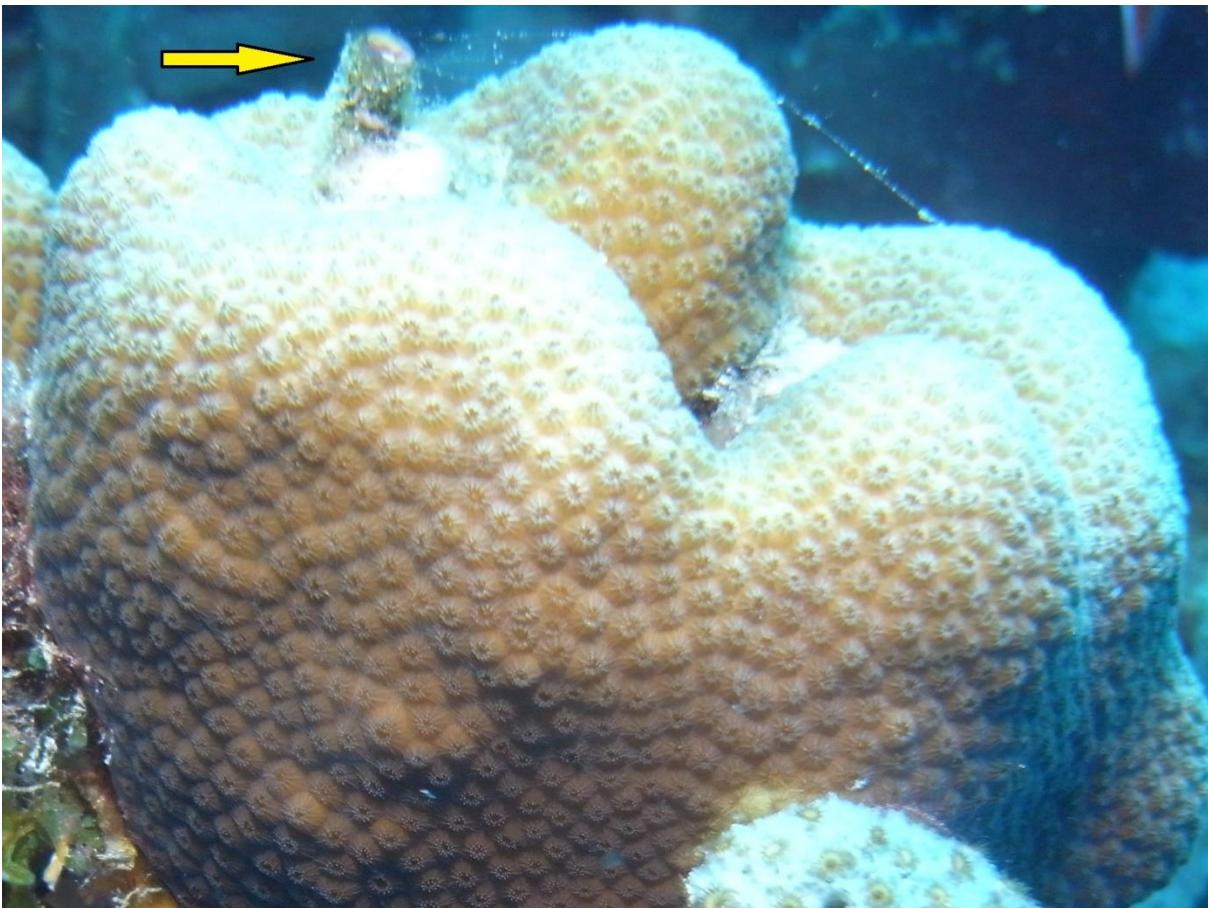


Figure S16. *Orbicella annularis* at Bonaire (2019).

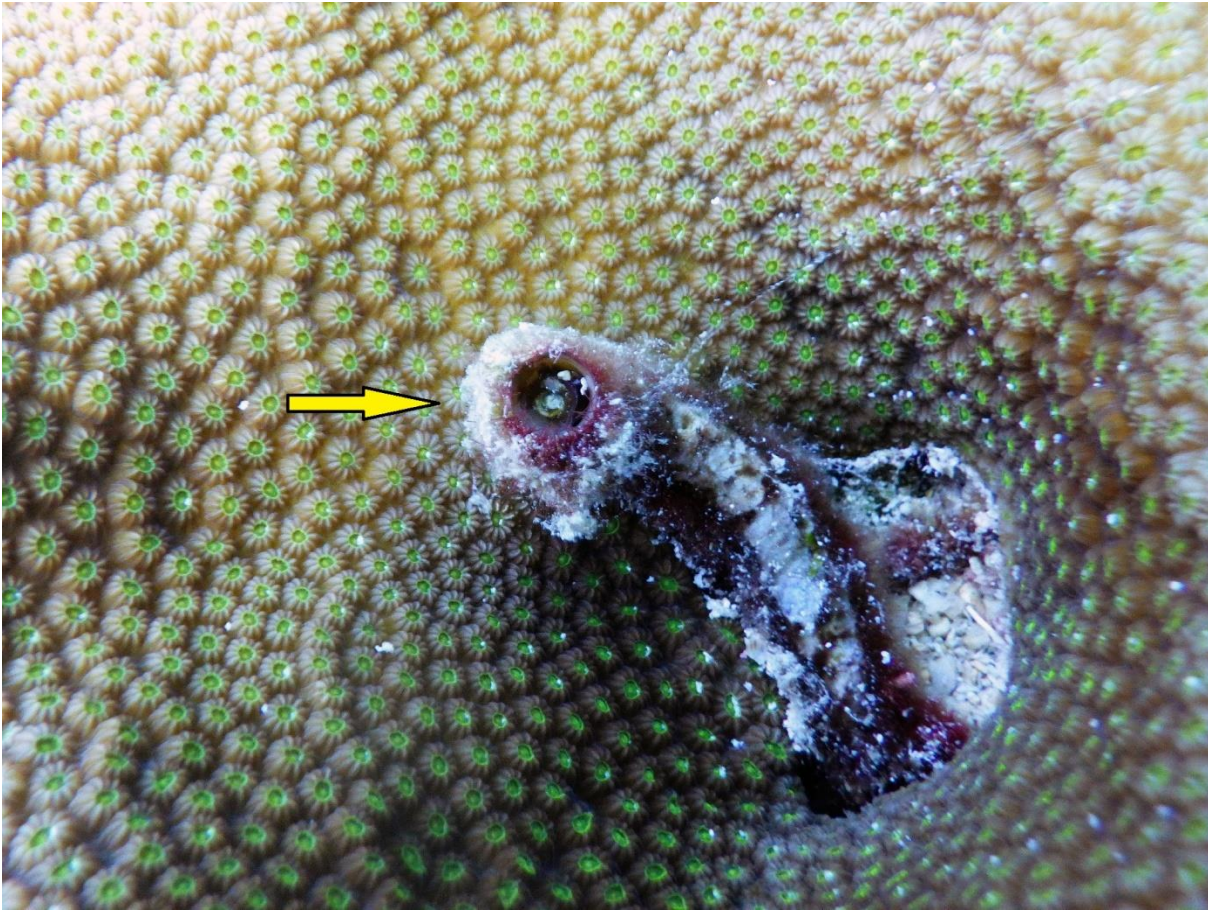


Figure S17. *Orbicella faveolata* at Curaçao (2021).

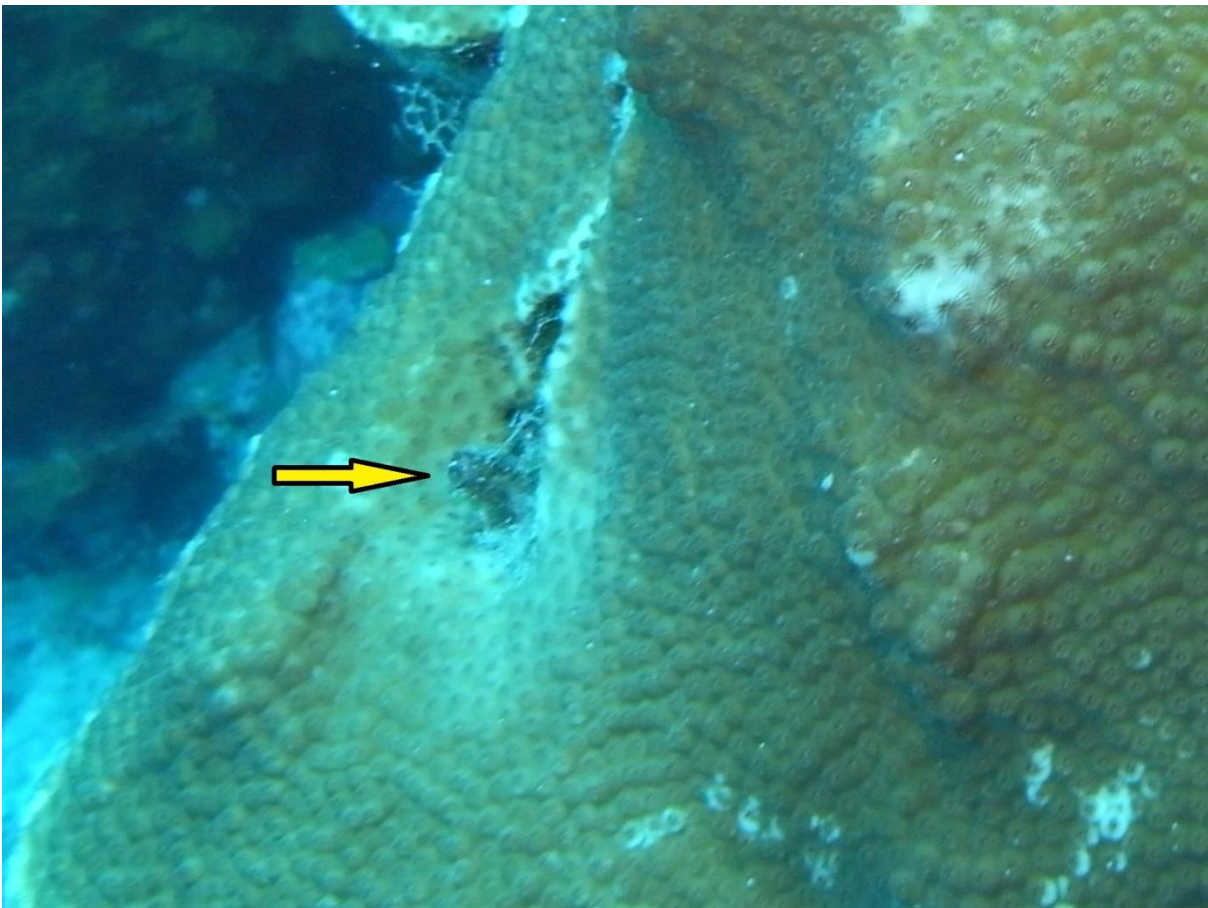


Figure S18. *Orbicella franksi* at Bonaire (2019).

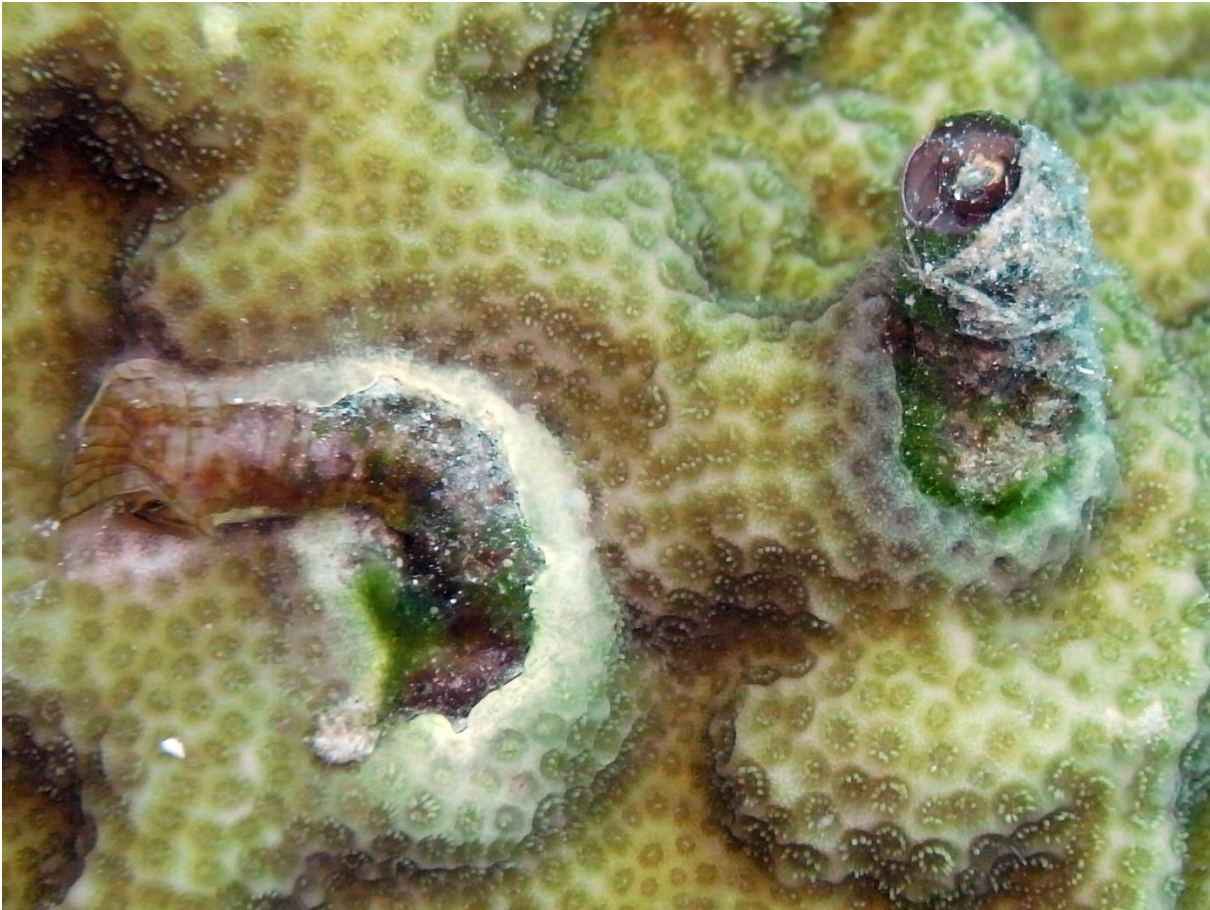


Figure S19. *Porites astreoides* at Curaçao (2021).

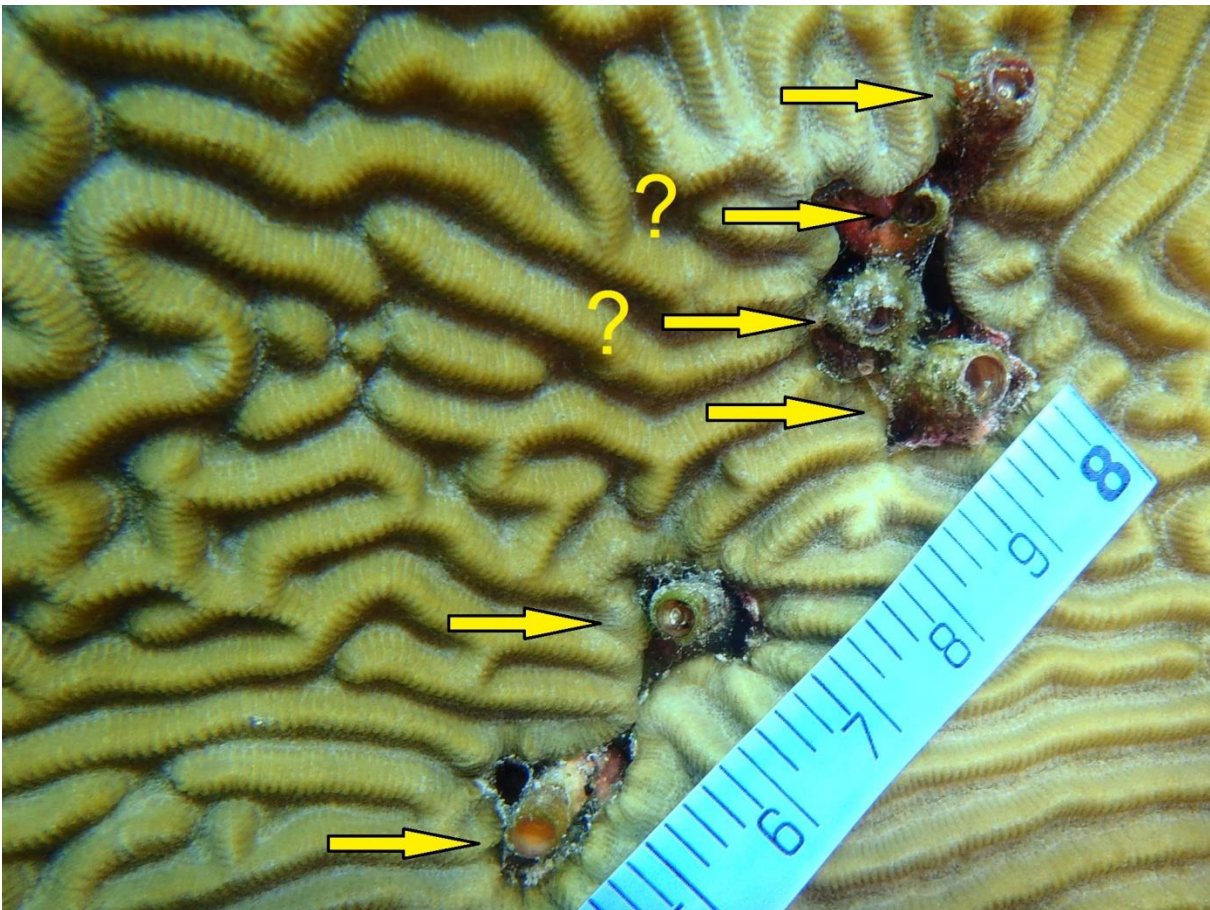


Figure S20. *Pseudodiploria strigosa* at Curaçao (2021).

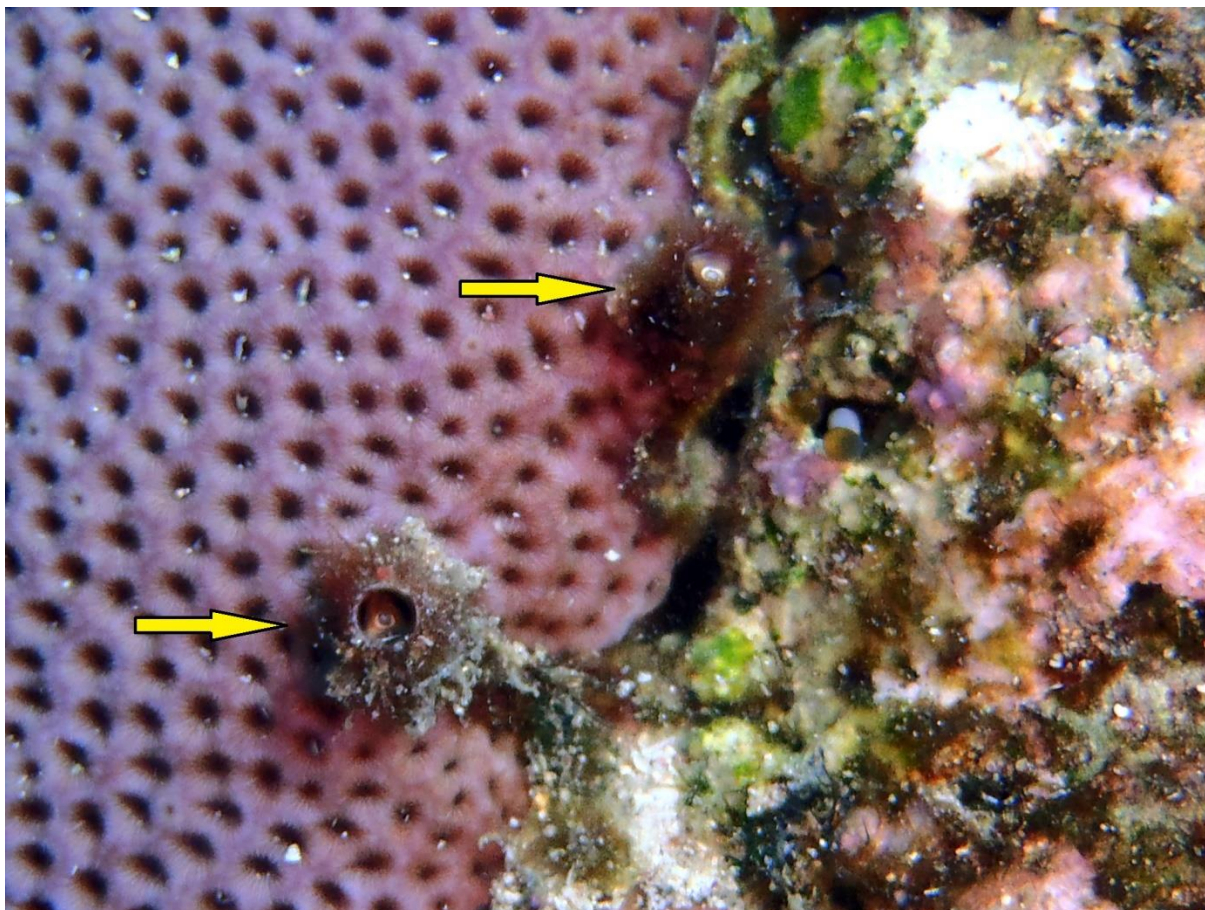


Figure S21. *Siderastrea siderea* at Curaçao (2021).



Figure S22. *Stephanocoenia intersepta* at Curaçao (2021).



Figure S23. Unidentified host (dead coral) at Curaçao (2021).