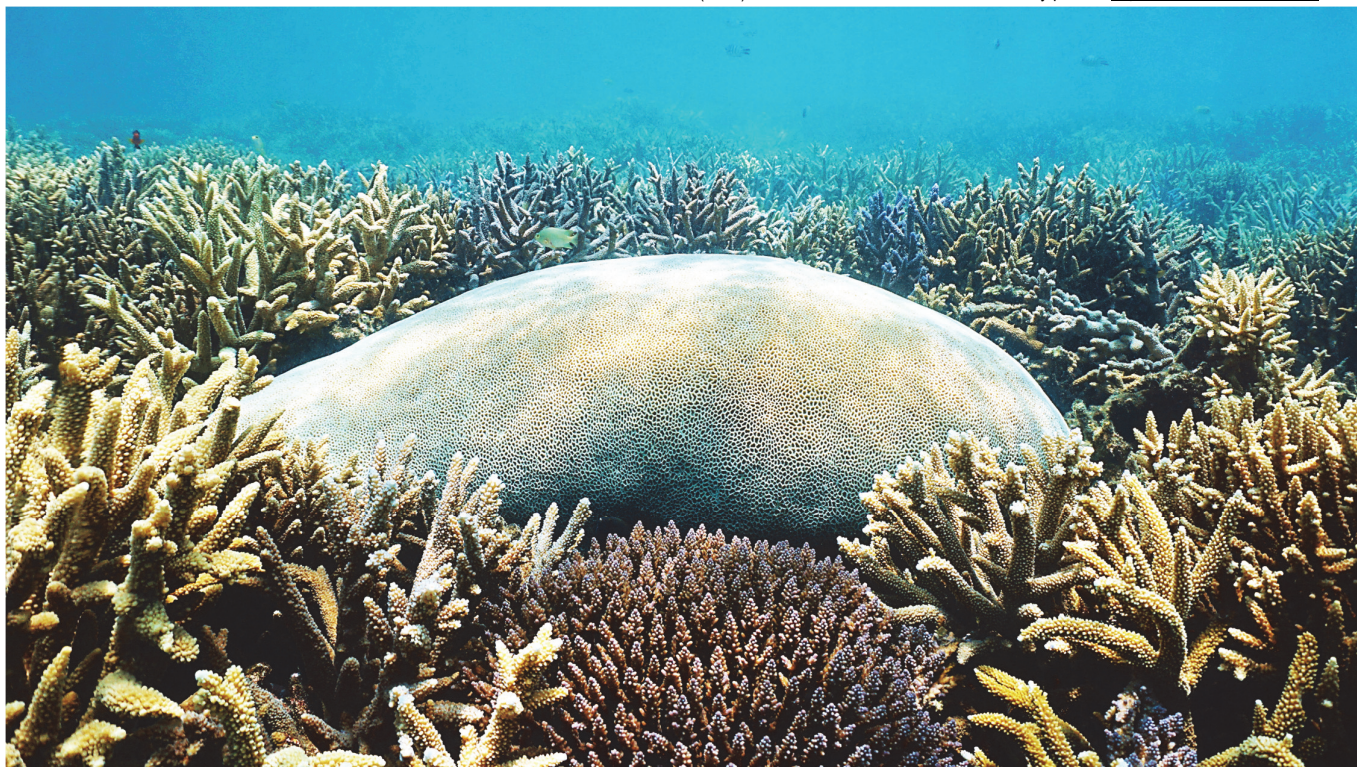




Teach a Person to Fish... SPS Academy part XI

Chris Aslett

The previous editorial discussed some unwelcome organisms that “stowaway” on new specimens while herein we explore parasites that consume SPS colonies, which can arrive on or within anything from another system or non-gamma irradiated foods. Exploit the recommended dilution of CoralRX Pro in aged seawater for new corals, where the final stage of any acclimation drip-dries specimens for a second or two. Cover the eyes of fish and do not expose sponges to air but *never* mix a supplier’s water with your own. See Part X.

Vegetable-eating copepods manifest as tiny white specks on the glass of established aquaria, albeit remarkably, two-thirds of all copepods are external (ecto-) or internal (endo-)parasites of fish and invertebrates where over 400 species impact more than 350 Cnidaria (Humes 1994). Another study concluded most are planktonic while ~50 percent are symbionts (Boxshall 2005). Widespread in temperate and colder seas, most inhabit the tropics (Rigby et al. 1999; Tucker et al. 2000; Johnson et al. 2004; Riddle 2010a; Fajer-Avila et al. 2011; Ismail et al. 2013; Osman et al. 2014; Nagasawa 2015; Soler-Jiménez et al. 2019).

Copepods are multicellular animals of the phylum Arthropoda, the subphylum Crustacea, the superclass Multicrustacea, and the class Copepoda comprising ~11,500 species. Members of the orders Harpacticoida, Siphonostomatoida, Cyclopoida, and Monstrilloidea range from partially to exclusively parasitic (Boxshall 2005).

Podoplea superorder affiliates are cyclopiform where their anterior wider prosome transitions into their thinner urosome immediately before the fifth segmented somite which carries their final appendages (pedigera), while the urosome commences immediately after in non-parasitic Gymnoplea (Ho & Kim 2001). All are gonochoric where larger females carry egg sacks adhered to their genital somite formed from the fusion of two subdivisions of their tail (ramus; Fig 1.; Fig 2.; Boxshall 2005).

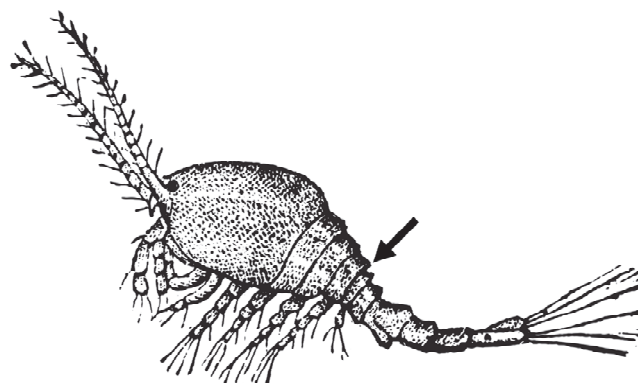


Fig 1. All parasitic copepods adhere to podoplean (cyclopiform) architecture, but imprecisely so, with the amorphous bag of female species of *Sarcotaces* that parasitise fish (Aitken 1942; Osman et al. 2014).

Nearly 40 genera infest corals such as *Humesiella*, *Orstomella*, *Stockella*, and *Zazaranus*; however, the genera *Alteuthellopsis*, *Xarifia*, *Tegastes*, and *Parategastes* infest SPS corals where the latter two are known as “red” or “black bugs” (Riddle 2010).

The extensive variety that parasitise fish are beyond the scope of this series yet their multiplicity is illuminated in Aslett 2024. Amphipod-like, laterally compressed, *Tegastes* species are gold with a single red eye with claw-like mandibles (Shimek 2002; Riddle 2010) where females carry red-punctuated unocular embryos (Riddle 2010). *Acropora* species are susceptible to *Tegastes acroporanus* (Podoplea: Tegastidae; Fig 4.; Fig 5.; Christie & Raines 2016) where females often appear absent and thus infestations must be non-proliferative (Shimek 2002). *Stylophora pistillata* (Hexacorallia: Pocilloporidae) become home to *Xarifia obesa* (Podoplea: Xarifiidae; Cheng & Dai 2009) while “black bugs” may target *Montipora* (Riddle 2010).

Species of *Parategastes* and *Tegastes* are nested in the infraclass Neocopepoda, the order Harpacticoida, and the family Tegastidae (WoRMS 2020c).



Fig 2. A micrograph of female cyclopiform copepods carrying developing larvae attached to their genital somites.

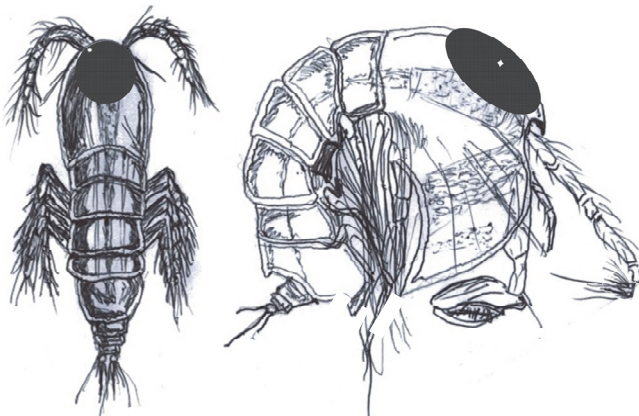


Fig 3. Illustrations of Tegastidae drawn from the accurate biological representations within Riddle 2010a and World of Copepods, Walter & Boxshall 2020.



Fig 4. The genus *Tegastes* infesting *Acropora*. Image courtesy of Gregory HO ©, Ximina's Photography. www.ximinasphotography.com
Alteuthellopsis corallina are western Indo-Pacific

endoparasites of *Acropora exigua* (taxon inquirendum; Hexacorallia: Acroporidae), *Astreopora* species, *Montipora verrilli*, *Pocillopora damicornis*, *Goniastrea retiformis* (Merulinidae), *Merulina ampliata*, *Platygyra daedalea*, and other species of *Platygyra* (Humes 1981). The lineages of *Alteuthellopsis* and *Parategastes/Tegastes* diverge merely at the rank of family and subfamily (Peltidiinae; WoRMS 2020d).



Fig 5. "Red bugs" (*Tegastes* species) infesting *Acropora* (Fig 4.). Image courtesy of Gregory HO ©, Ximina's Photography. www.ximinasphotography.com

The afflicted will likely exhibit limited polyp extension and diminished colouration (Shimek 2002; Riddle 2010a) while the exoskeletal microbiome of several comprise pathogenic bacteria of the genus *Vibrio*. They are typically <0.5 mm (<0.02") where several amass coral pigments and are thus challenging to discern (Riddle 2010a).

Species of *Tegastes* are palatable to network pipefish (*Corythoichthys flavofasciatus*; Teleostei: Syngnathidae; Fig 6.; Delbeek & Sprung 2005) and most likely acropora crabs. See Part X. Elevated temperatures and enriched nutrients exacerbate pathology because they weaken corals (Ben-Haim & Rosenberg 2002; Ben-Haim et al. 2003) where most coral ailments cannot manifest at a steady 23.5°C (Aslett 2005; Riddle 2010).

Vigorous flow minimises coral boundary layers which optimises carbonate uptake, skeletal deposition, and photosynthesis (Riddle 2016; Munn 2019) whereas powerful currents dislodge, which thwarts colonisation (Riddle 2010).

Dilutions of CoralRX Pro and ReVive comprise non-toxic natural plant extracts that irritate and expedite parasite dissociation through the sloughing of surplus mucus (Riddle

2010; Danireef 2017). The mucosal microbiome is the colonies first line of defence and these immersion therapies are undoubtedly stressful, yet they are preferable to a systemic treatment of a veterinary medicine that by necessity, must eradicate a vast cross-section of the ecosystem and annihilate diversity. Briefly purge corals in ReVive- or CoralRX Pro-free seawater before system introduction.

As with any potentially dangerous procedure, the reader uses these chemotherapeutics at their own risk, because the author, Reef Ranch Publishing Ltd, websites hosting this article, and their owners cannot be held responsible for any harm to pets, people, possessions, or properties.

Novartis AG's milbemycin oxime is the active ingredient of Interceptor® which is licenced in the UK for merely dogs with heartworm or mange, whereas Interceptor® Plus contains both praziquantel and milbemycin oxime. Praziquantel is a useful wormer that *helps* eradicate the "eye parasite" *Neobenedenia melleni*, but it is non-copepodocidal. Both these drugs are controlled in the UK and as such, must be supplied by a veterinary surgeon if they are not used under licence for the intended animal. Please adhere to national legislation. However, if milbemycin oxime *is not* controlled nationally, then hobbyists are free to source the chemical from elsewhere.

Milbemycin oxime will kill all members of the phylum Arthropoda including amphipods, barnacles, copepods, crabs, lobsters, and shrimp and will thus destabilise ecology and initiate reef malfunction, inasmuch as fish will require eutrophy-instigating supplementary nutrition, so this drug could permanently disrupt SPS mariculture. Do not use casually or as a prophylactic, and only administer if a systemwide infestation has been robustly substantiated microscopically. Move all ornamental Arthropods to quarantine, yet they may serve as re-inoculating vectors (Delbeek & Sprung 2005a).

Like praziquantel, milbemycin oxime requires dissolving in a

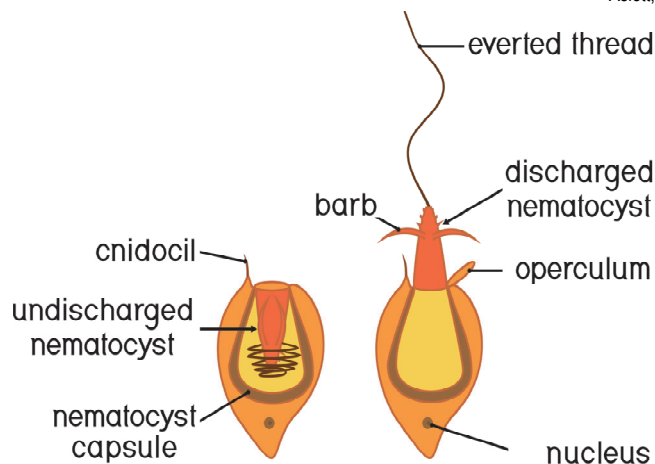
small quantity of high-purity ethanol (drinkable alcohol) to make it water soluble, while more concentrated stock solutions or graduated syringes may assist accurate dosing in the absence of a costly analytical balance. See Part VI & VII. Ethanol feeds microaerophilic bacteria in suboxic zones which may create anaerobia, hence calcium reactors and denitrifiers may generate deadly toxins. Ensure the throughput of such reactors remains a rapid dribble. If water becomes suddenly grey, exploit GAC remembering to wash in copious amounts of R/O water beforehand and avoid flow-downregulating wavemaker cycles for up to 24 hours post-administration.

Remove granular activated carbon (GAC) and turn off UV sterilisation and protein skimmer air but maintain systemwide circulation. Raise systemic milbemycin oxime to 0.015 mg l⁻¹ (ppm) for six hours during which the water should remain clear. Whereupon reinstate protein skimmer air and UV sterilisation and force water through fresh GAC. Deceased copepods may adhere to corals for up to 24 hours post-treatment after which a 25 percent water change was advised by the authors. The life cycles of *Tegastes* species remain enigmatic (Delbeek & Sprung 2005a) and thus readminister the therapeutic on day seven and 14 (Riddle 2010).



Fig 6. Network pipefish (*Corythoichthys flavofasciatus*; Teleostei: Syngnathidae) ostensibly consume parasitic species of *Tegastes* (Podoplea: Tegastidae).





cnidocyte

Fig 7. An illustration of a cnidarian cnidocyte comprising a stinging nematocyst.

Nematocysts are capsular components of cnidocytes which comprise a stinging barbed tube-like tip and an eversible thread. Cnidarians including jellyfish and corals use nematocysts to inject venom where displacement of the cnidocil explosively everts the thread and expels the barbed tip (Fig 7.).

The “*Acropora*-eating” flatworms (AEFW; flukes; turbellarians) *Prosthlostomum acroporae* were recognised parasites of captive *Acropora* which rapidly multiplied in recirculating systems to denude their skeletons, yet they remained an enigma in the wild until they were spotted off Lizard Island on GBR in 2011 (Rawlinson & Stella 2012; Barton et al. 2019).

AEFW appear immune to *Acroporidae*'s nematocyst venom (Rawlinson & Stella 2012) while their gut- and parenchyma-

bound host zooxanthellae, cnidocytes, and fluorescent proteins (FPs) amass to confer their eminent camouflage (Rawlinson et al. 2011; Rawlinson & Stella 2012; Hume et al. 2014). Temperature impacts adult length which ostensibly exceeds 4 millimetres (mm; 0.157”; Barton et al. 2019).



Fig 8. “*Acropora*-eating” flatworms (AEFW; *Prosthlostomum acroporae*; Polycladida: Prosthlostomidae). Image courtesy of Beau Henschen, Coral RX, Phillip Root ©.

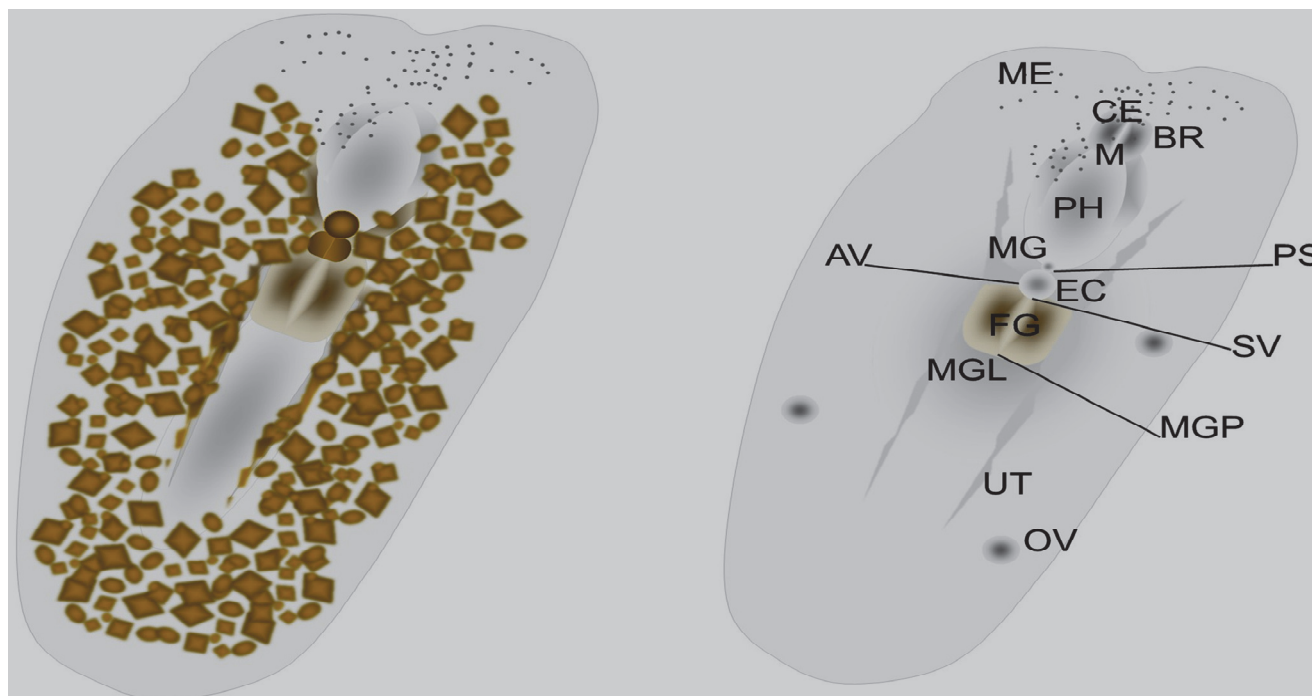


Fig 9. Illustrations of an adult (left) and juvenile of the “*Acropora*-eating” flatworm (AEFW) *Prosthlostomum acroporae* (Polycladida: Prosthlostomidae) which are greater and less than 4 mm in length, where labels include both adult and juvenile organelles at merely approximate locations: [AV] accessory vesicle; [BR] brain; [CE] cerebral eye; [EC] egg chamber; [FG] female gonopore; [M] mouth; [ME] marginal eye; [MG] male gonopore; [MGL] Mehlis gland or shell gland; [MGP] Mehlis gland pouch; [OV] ovary; [PH] pharynx; [PS] penis stylet; [SV] seminal vesicle; [UT] uterus. Drawings from the accurate anatomical representations within Rawlinson et al. 2011 and Rawlinson & Stella 2012.

Life Cycle of *Prosthiosomum acroporae*

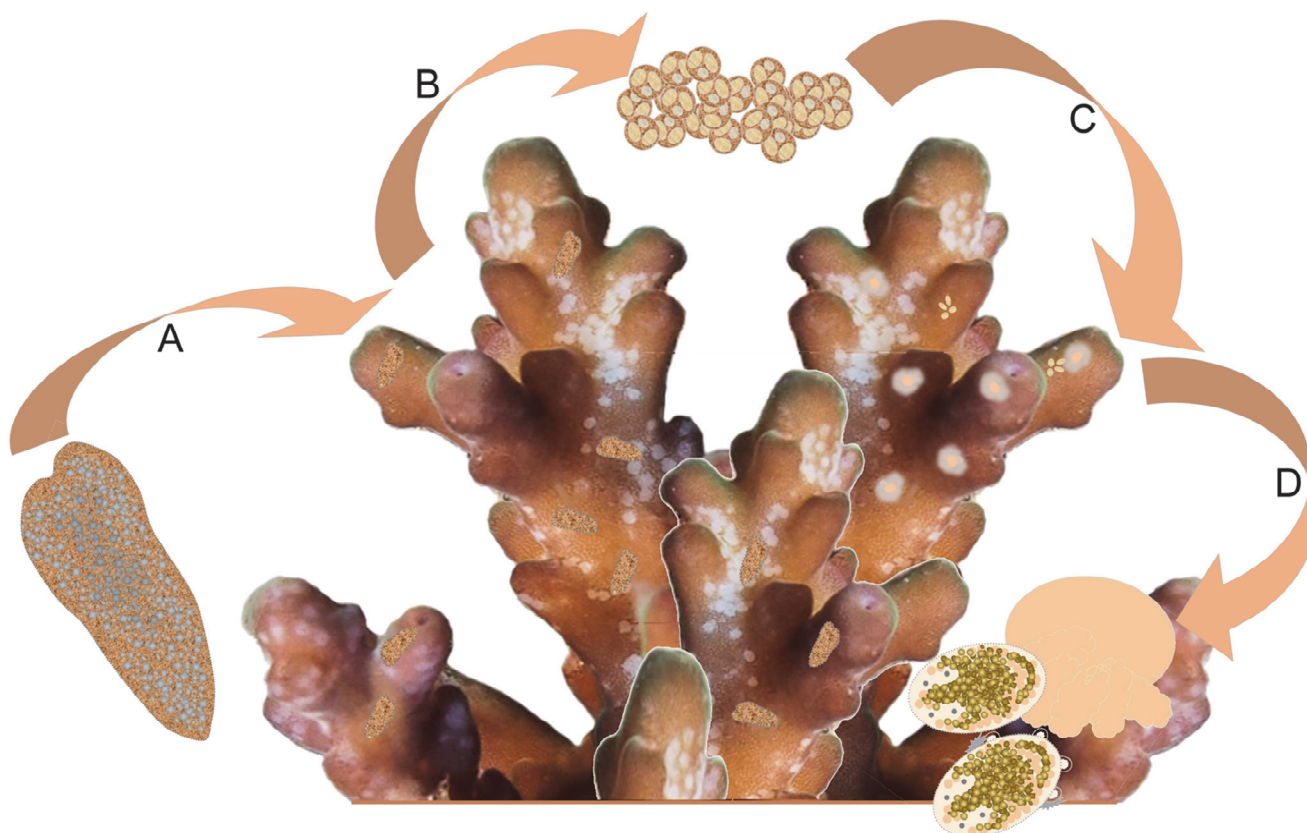


Fig 10. The life cycle of *Prosthiosomum acroporae*. [A] adult worms feed on coral and generate circular scars whilst they lay their eggs on bare skeleton. [B] egg masses are chemotherapeutic resistant, where embryonation and hatching occur in approximately 11 days at 27°C (~81°F) while two larvae emerge from each egg. [C/D] swimming lobes and ciliated tufts are present or absent, yet all competently swim and crawl. Hatchlings remain on the parent colony or seek a new host where they initially mature into males, and later oviparous hermaphrodites (Rawlinson & Stella 2012; Barton et al. 2019). Drawings from the accurate representations in Rawlinson et al. 2011, Rawlinson & Stella 2012, and Barton et al. 2019. Image of parasitised species of *Acropora* with genuine feeding scars courtesy of Beau Henschen, Coral RX, Phillip Root ©.

Corals infested with *P. acroporae* cannot radiance-adapt insofar as photoinhibiting intensities do not elicit excitation-dissipating fluorescence like they do in parasite-free specimens, while they preferentially colonise *Acropora valida* (Hume et al. 2014).

Comparative 28 svedberg (28S) ribosomal deoxyribonucleic acid (rDNA) sequence analyses and morphology recommended *Amakusaplana* should be nested within *Prosthiosomum* (Rawlinson et al. 2011; Litvaitis et al. 2019; Tyler et al. 2020; WoRMS 2020a; WoRMS 2020b) and an unclassified AEFW was discovered that was 10 times smaller than *P. acroporae* (Wang et al. 2019).

The morphology and occurrence of their sperm glands, seminal vesicles, Mehlis glands, and anterior indentation combined with ocular number and 16S ribosomal ribonucleic acid (rRNA) sequence analyses discerned *P. acroporae* from *P. ohshima*, whereas the ventral suckers of settling larvae facilitate substrate recruitment in all but *Prosthiosomum* (Rawlinson et al. 2011).

Prosthiosomum are ranked in the phylum Platyhelminthes, the subphylum Rhabditophora, the order Polycladida, the suborder Cotylea, and the family Prosthiosomidae (Worms 2020b) and thus scientists often refer to members of this taxon as cotylean polyclad worms (Barton et al. 2019).

Egg deposition to hermaphrodite adult takes 64 and 38 days at 21°C (~70°F) and 27°C (~81°F), while elevated temperatures

enhance egg viability and hatchling survivorship. Flukes proliferate wildly and overwhelm captive *Acropora* between 27°C and 30°C (86°F) while they subsist nine days without a host (Fig 10.; Barton et al. 2019).

Chemotherapeutic-impervious embryonated ova are deposited in clusters on denuded skeleton (Barton et al. 2019) where the lobes and ciliary bands of hatchlings augment their planktonic phase (Rawlinson et al. 2011; Rawlinson 2014). Two juveniles emerge from each egg with or without such buoyancy-assisting features because all can proficiently swim and crawl (Fig 10.; Barton et al. 2019).

Prosthiosomum montiporae of “*Montipora*-eating” flatworm (MEFW) parasitise corals of the genus *Montipora* in poor conditions (Jokiel & Townsley 1974) because they are commensals that become opportunistic pathogens (Rawlinson et al. 2011). *P. montiporae* are slender compared with *P. acroporae* which may reach 12 mm (0.47”) but are usually 4 to 8 mm (0.16 to 0.3”) while their photophobia constrains them to shaded regions (Jokiel & Townsley 1974). Nevertheless, the diminished upwellings of LEDs may expedite infestations of plating colonies.

Cnidarian cells are found in the gut of several polyclads, yet apart from AE- and ME-FWs, merely *Stylochoplana inquilina* (Polycladida: Stylochoplanidae) is a recognised predator of the anemone *Calliactis armillatus* (Hexacorallia: Hormathiidae; Poulter 1975; Rawlinson et al. 2011).

Six-line wrasse (*Pseudocheilinus hexataenia*) bioremediate 100 percent of worms but eggs remain unharmed, yet unconventional peppermint shrimp (*Lysmata vittate*) ingested 60 and 80 percent of eggs and worms (Barton et al. 2019a). Chemotherapeutics must synchronise with worm life cycles because their encapsulated embryos are resistant, where embryonation and larval settlement occur on day 13 at 28°C (82.4°F). Hence treatments are repeated on the 13th and 38th day.



Fig 11. Six-line wrasse (*Pseudocheilinus hexataenia*) ostensibly eat AE- and ME-FWs but ignore their eggs.

The controlled veterinary medicine levamisole hydrochloride (HCl) is efficacious (Barton et al. 2019; Barton et al. 2021) which is licenced for merely cattle and sheep in the UK. It must therefore be supplied by a veterinary surgeon for aquarium use. Please adhere to national legislation, whereas aquarists may source the compound from elsewhere in countries where its use remains unrestricted. 99.8 percent purity and above powders are most suitable, where levamisole HCl and praziquantel work synergistically to clear 90 percent of platyhelminths (Barton 2021). Many of which will be key players that benefit captive reef ecology. PraziPro is a praziquantel-comprising fluke remedy, and Salifert® Flatworm eXit is effective and obviates quarantine (Ehlers 2017) whereas Coral RX Pro detaches worms (Henschen 2018b). See Part X.

To be clear, the author **does not** endorse levamisole HCl yet has included a therapeutic protocol for completeness, while HCl stands for hydrochloric acid which may adversely impact pH. The drug is dosed at 4.4 mg l⁻¹ in reefs where it circulates for 4 to 5 hours without GAC, protein skimmer air, or an energised UV steriliser, while supplementary aeration is provided by streams of 1-cm (0.4") air bubbles (Delbeek & Sprung 2005; James404 2011).

4.4 mg l⁻¹ is the absolute upper threshold (James404 2011) whereas alternative literature suggests a concentration of 4 mg l⁻¹ (Delbeek & Sprung 2005). Painstakingly ascertain system volumes, calculate dosages, and weigh accurately using stock solutions and serial dilutions when necessary. Notwithstanding, aquarists have imparted anecdotes of fish, coral, and invertebrate demise (Bug 2009).

25 mg l⁻¹ of levamisole HCl in aged seawater may prove helpful as a 10-minute prophylactic dip (Wijgerde et al. 2013) while flukes are dislodged by vigorous flow so direct currents with a turkey baster.



Fig 12. Aquarium Solutions PraziPro® is a proprietary medication containing praziquantel.



Fig 13. The reef exhibit at Eilat's Coral World Underwater Observatory in Israel.

Horseshoe crabs, mites, scorpions, and sea spiders are animal arthropods of the subphylum Chelicerata, which have a jointed exoskeleton with a ventral central nervous system (CNS). Their blood is duck-egg blue copper-based haemocyanin like that of crustaceans, molluscs, octopuses, and squid (Stromberg 2014). Haemocyanins are sizeable oxygen-transporting metalloproteins that exploit six residues of the amino acid histidine where their imidazole ring sidechains electrostatically coordinate with two cuprous (Cu^+) or cupric ions (Cu^{2+}) when either deoxygenated or oxygenated (Conant et al. 1933; Shimek 2003; Rannulu & Rodgers 2005). Which happens to be one reason why copper-based remedies are so lethal to invertebrates.

Sea spiders lack antennae but have claw-like chelicerae which are analogous to cheliforms (Fig 14.; Waloszek & Dunlop 2002; Brenneis et al. 2008; Shimek 2015). Their surface-area optimised exterior facilitates gas exchange while their six side vesseled, single arteried, primitive tubular heart disseminates oxyhaemocyanin (Shimek 2003; Shimek 2015). They require liquified prey or those comprising tiny particles because their tubular three-lipped muscular proboscides penetrate and macerate cells with their ridgelike armature through which they drink (Shimek 2003). Proboscis lumens integrate a pharynx, a hairy debris filter, and a particulate grinder called the reusenapparat (Fahrenbach & Arango 2007; Dietz et al. 2018). The oesophagus progresses into a rudimentary gut where nutrients are absorbed in their upper legs (Fahrenbach & Arango 2007). Some species remain as larvae for a year and live up to nine (Shimek 2015).

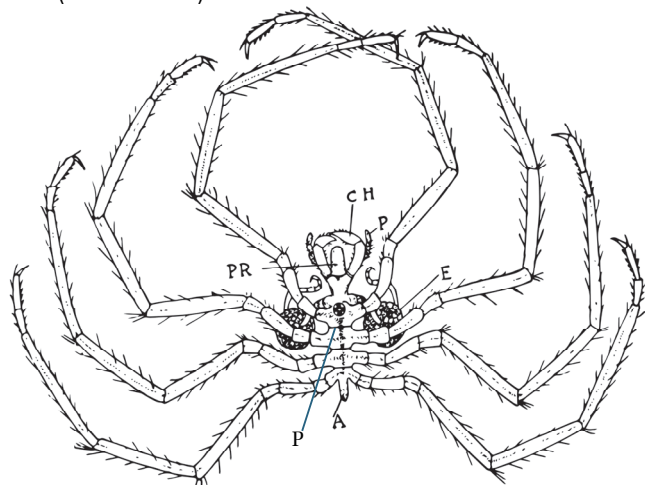


Fig 14. "SPS coral-eating" sea spider anatomy: [A] opisthosoma (abdomen); [CH] chelicera; [E] eggs brooded by an ovigerous leg; [P] palp; [PR] proboscis; [P] prosoma (head/thorax).

With over 1,500 species, they drink anything soft enough like anemones, corals, gastropods, hydroids, polychaetes, sponges, tunicates, and sea stars (Arnaud & Bamber 1987; Bain 1991; Shimek 2015; Dietz et al. 2018). Aquarists have reported parasitisations of *Acropora* and *Pocillopora* (Melev's Reef 2019), whereas Floridian *Oculina varicosa* (Hexacorallia: Oculinidae) where infested by 15 species of distantly related Pycnogonidae (Child 1998).

According to the fossil record, they emerged around five hundred million years ago during the Cambrian (Waloszek & Dunlop 2002) while their phylogeny remains tenuous inasmuch as Ammotheidae and Callipallenidae require reclassification. Austrordecidae, Colossendeidae, and Pycnogonidae are the lowest ranking clades (Arango & Wheeler 2007) while all are

order Pantopoda and class Pycnogonida affiliates (WoRMS 2020e).



Fig 15. A "SPS coral-eating" sea spider consistent with the observations of Melev's Reef 2019.

Their head and thorax-analogous prosoma is frequently abridged to an unsegmented tube which may bear four pairs of legs yet some have five or six pairs. Their long pedipalps are sensory which assist motility while their unappendaged abdomen-like opisthosomas may comprise vestigial respiratory organs (Shimek 2003).



Fig 16. A brooding male sea spider.

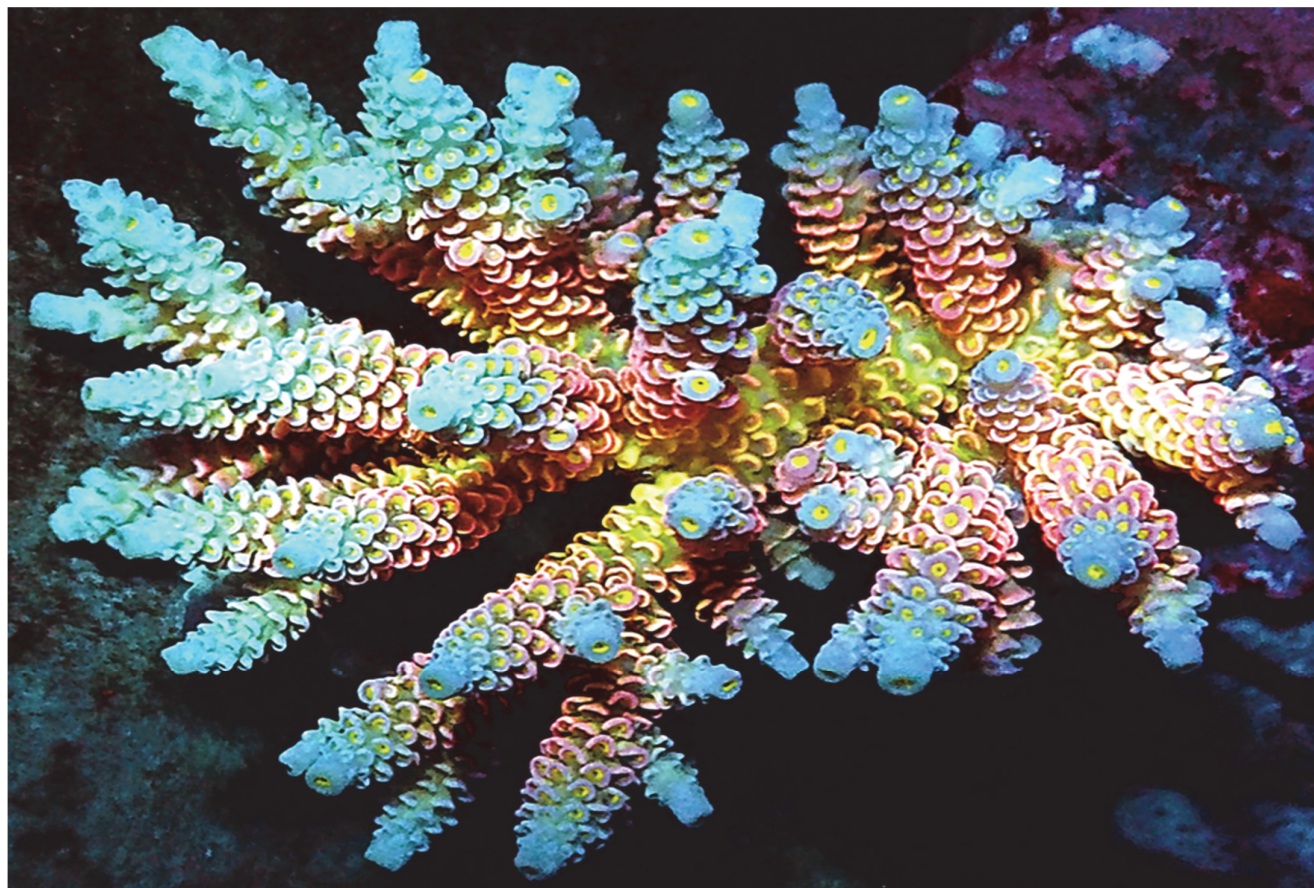
Frequently well camouflaged, their locomotion and sexual reproduction are unhurried (Shimek 2003; Shimek 2015). They are gonochoric where spermatozoa and eggs are produced from the base of male and female limbs. Eggs are gathered, fertilised, and brooded by adapted male appendages called ovigers (Fig 14.; Fig 16.; Bain & Govedich 2004; Shimek 2015; Brenneis et al. 2017). Embryos develop into parasitic suckling larvae with two limbs and six appendages (Shimek 2008; Shimek 2015) where each moult has cheliforms, ovigers, and palps (Dietz et al. 2018). Protonymphon larvae shed several times on one kind of host

which they may switch when they reach adulthood (Shimek 2003). Chorion-associated attaching larvae are brooded by males until free-swimming where 12 or more moults may be required before sexual maturity (Bain 2003; Shimek 2015).

Sea spiders are detached using tweezers (Henschen 2018a); however, most exhibit a lack of host fidelity and as such, leave a wake of destruction. Infested colonies are best discarded

(Shimek 2003) and submerge new specimens in the prescribed dilution of Coral RX Pro in aged seawater (Henschen 2018a) and ruthlessly sustain oligotrophy and moderate temperature.

Photon flux, spectral cohesion, component wavelengths and their application, are decisive in SPS mariculture where next we commence to reveal the practical application of light within reef displays.

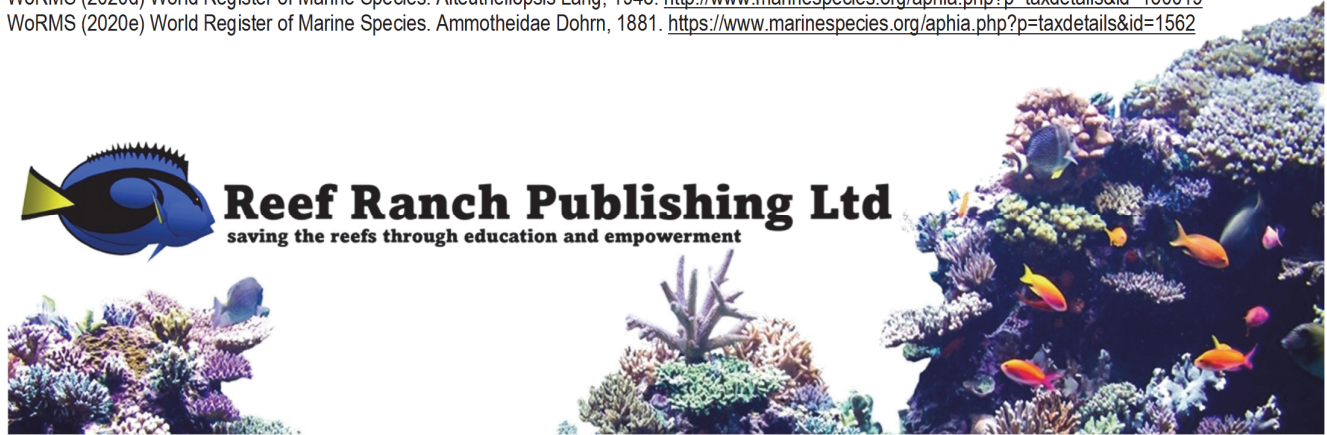


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