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Ecology of a specialized nudibranch predator (*Phyllodesmium poindimiei*) and implications for potential biocontrol of an invasive octocoral *(Carijoa riisei)* in Hawaii

Rob Toonen, Hawaii Institute of Marine Biology
Daniel Wagner, Hawaii Institute of Marine Biology
Sam Kahng, University of Hawaii at Manoa

Introduction

The objective of this project was to investigate the potential application of *P. poindimiei* as an agent of biological control for *C. riisei*. Work commenced in October of 2005, when the first cultures of *C. riisei* and *P. poindimiei* where established at the Hawai'i Institute of Marine Biology. A total of 73 SCUBA collections and surveys were performed throughout the project. The interactions between *P. poindimiei* and *C. riisei* where studied through observations of these two species in laboratory cultures at the Hawai'i Institute of Marine Biology, as well as time-series observations of three field sites with both *P. poindimiei* and *C. riisei* populations and contrasting environments. As part of this project, another nudibranch predator, never before reported from Hawaii and never before reported preying on *C. riisei* anywhere else in the world, was discovered. Specimens of this species were sent to Dr. Gosliner at the California Academy of Sciences and where identified as *Tritoniopsis elegans* by a taxonomic authority.

1) Effects of *P. poindimiei* on *C. riisei*

The effects of *P. poindimiei* on *C. riisei* have been assessed in terms of measuring feeding rates of *P. poindimiei* in the laboratory, and observing natural rates of predation in the field at three sites with different densities.

- Observations of the feeding behavior of *P. poindimiei* on *C. riisei* indicate that predation is mostly sub-lethal. The nudibranch preferentially preys on the fleshy lateral polyps of the octocoral, whereas it does not readily feed on stolonal mats. In the laboratory, *C. riisei* is able to recover from predation events if given enough food, as the stolonal mats can regenerate after predation events.
- In the laboratory, the daily number of *C. riisei* polyps consumed by 20 different *P. poindimiei* individuals in the size range of 5mm-50mm was measured during a period of two months. The daily number of lateral polyps consumed by *P. poindimiei* varies with the size of the individual. Small juveniles (5-6 mm) have only been observed consuming detritus around *C. riisei* polyps. The average feeding rates of larger juveniles (10mm) is approximately 0.8 polyps/day, 3.5 polyps/day for small sized adults (18-20 mm), 3.5-5.0 polyps/day for medium sized individuals (22-27 mm), and 6.0-7.0 polyps/day for the largest individuals (30-50 mm).
- A number of sponges that grow on the tissues of *C. riisei*'s significantly depress the feeding rate of *P. poindimiei.* When only provided with sponge covered *C. riisei*, *P. poindimiei* individuals starve within 1-2 weeks, indicating that sponge cover might provide a refuge from predation.
- Only one outbreak of *P. poindimiei* at a study site on the North Shore of Oahu was observed throughout the duration of the project. Significant reduction of biomass of *C. riisei* was observed as a consequence of this outbreak. However, the outbreak appeared to be short-lived as most *P. poindimiei* individuals where gone within 2 weeks of the onset of the outbreak. These observations suggest that the densities of *P. poindimiei* are controlled by a combination of episodic recruitment events and post-larval mortality through predation.

- The fish species *Chaetodon miliaris, Lutjanus kasmira, Thalassoma duperrey, Forciper longrinostris* and *Forciper flavissimus,* which have been seen in locations inhabited by *C. riisei,* where tested as potential predators of *P. poindimiei*. These species all exhibited very similar behavior in that they initially ingested *P. poindimiei* but rapidly spit them back out and consequently avoided ingesting other individuals. This suggests that *P. poindimiei* is protected either chemically or mechanically from predation by these species.
- The portunid crab *Thalamita integra*, which can be observed living directly on *C. riisei* on a number of shallow water populations, was also tested as a potential predator of *C. riisei.* This crab did consume *P. poindimiei* juveniles and adults. This suggests that the densities of *P. poindimiei* in the field might be controlled, at least in part, through predators.

2) Life history traits of *P. poindimiei*

The life history traits of *P. poindimiei* where investigated through daily observations of larval and adult cultures in the laboratory, with special attention given to oviposition, hatching of eggs, larval development and larval nutrition.

- *P. poindimiei* reproduces through free-swimming planktotrophic larvae, which hatch from eggs 4-6 days after oviposition. The duration of the larval phase was not resolved, due to the difficulty of having larval cultures. Larvae have been observed viable for up to 4 weeks indicating that this species might have a prolonged larval stage.
- Evidence from the field suggest that larvae appear to be able to disperse at least along intra-island distances, as *P. poindimiei* have been found on the north, east and south shore of Oahu, and on west Maui. Additionally, *P. poindimiei* has been found on Kauai, were *C. riisei* has only recently spread. This widespread distribution of *P. poindimiei* might indicate that it can possibly also disperse along inter-island distances.
- *P. poindimiei* has been reported from several widespread locations in the Western Pacific (Okinawa to Southern Australia), indicating that it might be able to disperse along inter-island distances.
- All nudibranchs including *P. poindimiei* are simultaneously hermaphroditic requiring reciprocal copulation. When individuals are raised in isolation they do not produce eggs, indicating that they are not able to self-fertilize. Furthermore, the male reproductive system appears to mature faster than the female reproductive system. On several occasions a small individual was observed mating with a much larger one, and afterwards only the large individual laid eggs. This differential onset of sexual maturity is described in the literature for several aeolid nudibranchs.
- The minimum size of sexual maturity appears to be around 15 mm as this is the size of the smallest individual observed laying eggs in the laboratory.
- A total of 25 individuals *P. poindimiei* where kept in aquaria. Their body length and the number of eggs laid was recorded on a weekly basis in order to study the longevity and fecundity of this species. The maximum

post-larval longevity recorded was over 9 months with a mean of 4 months and a standard deviation of 2.4 months.

- The amount of eggs in one egg mass was counted using a binocular microscope and ranged between 1300-1700eggs. The maximum amount of egg masses laid by an individual was 16, with a mean of 8 and a standard deviation of 4.6.
- Egg laying events of *P. poindimiei* individuals have been observed occurring over 3 months apart from each other, indicating that this species is not semelparous. This finding is significant, as nudibranchs are described as semelparous taxa in the literature.

3) Potential non-target effects

Feeding assays on potential non-target effects of *P. poindimiei* on the local octocoral and hexacoral fauna have been performed in the laboratory using *Sarcothelia edmonsoni*, *Sinularia densa, Pocillopora meandrina, Pocillopora damicornis, Porites lobata and Montipora capitata* in the presence and absence of *C. riisei*. As part of this project, another nudibranch predator, *Tritoniopsis elegans*, of *Carijoa riisei* was discovered.

- In the absence of *C. riisei* prey *P. poindimiei* quickly starves within 1-2 weeks even when offered alternative prey species. *P. poindimiei* has always chosen *C. riisei* when given a choice between *C. riisei* and either of the octocoral species *Sarcothelia edmonsoni* or *Sinularia densa.*
- Non-target feeding assays with *P. poindimiei* and the scleractinian corals *Pocillopora meandrina, Pocillopora damicornis, Porites lobata and Montipora capitata* confirmed the specialized feeding behavior of *P. poindimiei,* as it does not prey on any of these species. These results suggest that *P. poindimiei* is a specialized predator of *Carijoa* and most likely followed it in colonizing Hawaii.
- Non-target feeding assays with *Acabaria bicolor* were not performed due to the inability of locating this species in the field. No source colonies in the field could be located despite of over 70 SCUBA collection surveys and interviews with local divers.
- In contrast to the feeding behavior of *P. poindimiei, T. elegans* readily preys on *C. riisei*, but also preys on the native octocoral species *S. densa* and *S. edmonsoni*. This suggests that *T. elegans* is cryptogenic or native to Hawaii.

4) Dissemination of results

- The research results to date were summarized in the form of an oral presentation at the following events:
    - General meeting of the Coordinating Group of Alien and Pest Species (CGAPS) on April 26th 2006
    - Hawaii Conservation Conference on June 28th 2006
    - University of Hawaii at Manoa Albert L. Tester Memorial Symposium on March 23rd 2007

- *Environment Hawaii* published an article on the contents of the oral presentation given at the 2006 Hawaii Conservation conference in October 2006 (Volume 17, number 4).
- An oral presentation summarizing the results of this study will be given at the Hanauma Bay Outreach program on July 5th, 2007.
- A manuscript to a peer-reviewed scientific journal has been submitted and accepted. The article is available in the online first version of *Coral Reefs* (http://dx.doi.org/10.1007/s00338-007-0232-z) and will appear in the next issue of the journal.
- An additional manuscript on the life history and feeding behavior of *P. poindimiei* is currently in preparation and will be submitted to a peer-reviewed scientific journal within this summer. Additionally an article on biological control using this research as a case study is also in preparation for a popular literature source.