Adaptations for defense by the Nudibranch *Aeolidia papillosa*

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An important objective for any predator is to survive its prey's defenses. Many nudibranchs, for example, feed on sea anemones whose nematocysts can injure or even kill a predator. In order to survive such dangerous prey, nudibranchs have evolved several behavioral and morphological adaptations which allow them to cope with the dangers of their cnidarian prey. Of particular interest in nudibranch research has been the protective nature of nudibranch mucus and its possible adaptation to nematocysts. Hypotheses have ranged from suggesting that mucus viscosity may be responsible for nudibranch protection (Salvini-Plawen, 1972) to suggesting that nudibranchs may produce or acquire components from their prey, which could adapt mucous defense to inhibit nematocysts of specific prey (Mauch and Elliott, 1997). Mauch and Elliott (1997) observed that mucus from the nudibranch *Aeolidia papillosa* was more effective at inhibiting nematocyst discharge from its sea anemone prey, *Anthopleura elegantissima*, than mucus from other nudibranchs. However, because the mucus was tested on only one species of prey, nothing could be inferred about the adaptive properties of predators which feed on more than one species of prey.

To resolve this dilemma, Greenwood *et al* (2004) investigated the inhibitory effectiveness of mucus from the nudibranch *Aeolidia papillosa* on different species of sea anemones, as well as whether the inhibitory nature of the mucus adapted to different prey species. Specimens of *A. papillosa*, living among four different species of sea anemone (*Metridium senile*, *Urticina felina*, *Aulactinia stella*, and *Anthopleura elegantissima*) were collected from three different sites and set up in aquaria. To quantify nematocyst discharge, the researchers made gelatin probes which retained discharged nematocysts from sea anemone tentacles. Experimental probes were coated with mucus from *A. papillosa* and were touched to the tentacles of the sea anemones in filtered seawater with N-acetylneuraminic acid (NANA). NANA, which is similar to molecules found on normal sea anemone prey, was included because it is known to heighten the mechanical sensitivity of sea anemone nematocytes and would therefore determine whether the mucus actually prevented nematocyst discharge or merely lacked a firing stimulus.

To test whether a nudibranch's mucus inhibits its prey species' nematocysts, Greenwood *et al.* (2004) compared nematocyst discharge into experimental and control (non-mucus-coated gelatin) probes from samples of *A. papillosa* that had been feeding on different sea anemone species. Mucus-coated probes from *A. papillosa* that had been feeding on *U. felina*, when tested on sea anemones *M. senile* and *A. stella*, showed a 67% decrease in nematocyst discharge over control probes. Experimental and control discharges of *A. stella* and *M. senile*, while noticeably higher than that of *U. felina*, were not significantly different from each other. Similarly, mucus-coated probes from *A. papillosa* that had been feeding on *M. senile*, when tested on sea anemones *U. felina* and *A. stella*, showed a much weaker defense response from *M. senile* relative to control probes. In comparison, responses of *U. felina* and *A. stella* were stronger for both control and experimental probes. In either case, the prey species' nematocyst discharge into experimental probes was significantly less than that of control probes and non-prey species' discharge, indicating that a nudibranch's mucus does specifically inhibit nematocyst firing in prey species.

In another experiment, the researchers tested the adaptation of a nudibranch's mucus from one prey species to another. Samples of *A. papillosa* were fed *U. felina* for 16 days after which the prey species was switched to *M. senile*. After testing mucus against both prey species, results showed that the nudibranch's inhibitory effectiveness became increasingly more effective against *M. senile* and less effective against *U. felina*. In addition, Greenwood *et al* (2004) showed that if a nudibranch is fed two prey species, its mucus becomes effective against the nematocysts of both prey species. Individuals of *A. papillosa* fed with only *M. senile* were subsequently offered both *M. senile* and *A. elegantissima* resulting in a 34% decrease in nematocyst discharge from *M. senile* and a 64% decrease in nematocyst discharge from *A. elegantissima* after 14 days. These findings showed that the inhibitory effectiveness of nudibranch mucus can change as the prey species changes. Researchers also observed that mucus produced by *A. papillosa* 45 minutes after having been wiped clean was just as effective in nematocyte inhibition as mucus produced before being wiped clean. This indicates that a nudibranch's ability to inhibit nematocyst discharge from prey species is not due to simply becoming covered in anemone mucus.

This study produces the first evidence that nudibranch mucus can inhibit nematocyst discharge from sea anemones. Furthermore, nudibranch mucus is adaptable to different prey species and can inhibit nematocyst discharge from more than one prey species if more than one species is being consumed. Although this study did not investigate the specific mechanisms involved in alteration of nudibranch mucus, it is possible that *A. papillosa* alters mucus itself or simply incorporates substances obtained from its prey into its mucus. In any case, a nudibranch's adaptability to the defenses of different sea anemone species is an important factor in this predator's survival and continuity.

Literature Cited

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