Aposematism and Defense Mechanisms of the Nudibranch

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Introduction

Aposematism, or 'warning colouration', is observed in many animals that aim to deter predators. Aeolidioidean nudibranchs, a subfamily of (shell-less) opisthobranch gastropods, exhibit this trait and utilise a high diversity of morphological colour variation as a defense mechanism via 'predator conditioning' [1].

Nudibranchs prey upon cnidaria, such as anemones, absorbing nematocysts (toxins) which are transferred and stored in brightly coloured cnidosacs. When a nudibranch is disturbed these toxins are secreted, associating a specific colouration pattern with a high potential cost to the predator.

Figure 1: Chromodoris Sp. (*Source: David Doubilet, National Geographic*).

Across the many species of nudibranch defense mechanisms are not limited to aposematism and use of toxins.

Species such as *Rostanga Pulchra* prey exclusively on red sponges so as to obtain the natural biological pigments known as carotenoids. In contrast to other nudibranchs that use chemicals obtained from their prey as toxins, *Rostanga Pulchra* uses the carotenoids for camouflage [2].

Despite its formidable natural defenses, nudibranch behaviour also plays an important role. The Nudibranch mollusk *Tritonia Diomedea* has been observed to avoid predator sea stars, by means of an 'escape swim' or an 'avoidance crawl' [3].

Overall, nudibranchs have few natural predators, such is the success of their defense.

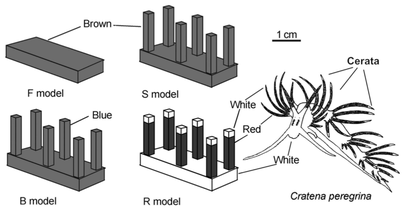

Figure 2: Artificial aeolid models made with carrageenan and cuttlefish and coloured with liquid food dyes. (*Source: [1]*).

It is believed that nudibranchs lost their shell after pre-adaption, once these defense mechanisms became sufficiently daunting to predators [2].

Investigation of Aposematism

Figure 3: Cratena Peregrina (*Source: Jordi Benitez, ouramazingplanet.com*). An example nudibranch with orange tipped rhinophores and red cerata tipped with bright blue cnidosacs.

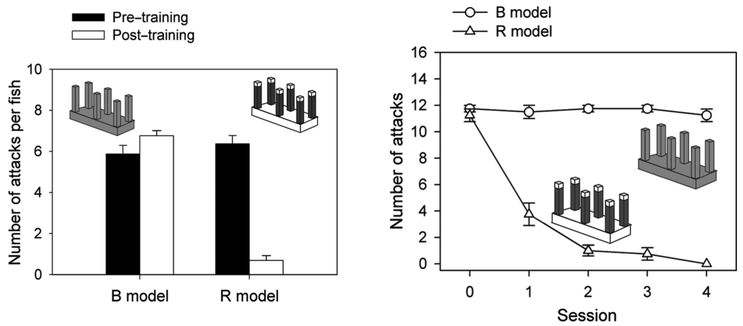

Figure 4: Laboratory (a) and field (b) assays of artificial aeolids. (a) Results show mean number of attacks to each model ($n = 7$) pre and post training. (b) Mean number of attacks per model during 5 sessions: 0 - pre-training, 1–3 - training & 4 - post training. (*Source: [1]*).

In the study by Aguado [1], 4 different artificial models of *Cratena Peregrina* (F, S, B & R) were used to examine conditioning of predators based upon nudibranch aposematism and nematocysts.

The 4 models used were: 1 – flat brown (F), 2 – brown dorsal protuberances with brown base (S), 3 – orange dorsal protuberances with white base & 4 – blue protuberances with blue base (B). The aim of the experiment was to test whether fish (*wrass*) learn to avoid aeolids because of their shape and colour. Two treatment groups were used, palatable and distasteful, and the number of attacks made by the fish in a 15 minute period was recorded.

The experimentors found *wrasses* began to learn the shape of the unpalatable S model and also colour variation between the B and R models in the training sessions, indicated by a reduction in number of attacks. In post-training there was a significant difference between number of attacks on R and B models (paired t-test $P < 0.001$, see *Figure 4*) indicating fish learn to avoid the white/orange colour pattern.

Figure 5: Nembrotha Kubaryana (*Source: David Doubilet, National Geographic*).

Conclusion

Nudibranchs effectively employ various defense mechanisms to both avoid and deter predators. Across species, colouration is used to either camouflage, or to condition fish to their 'unpalatability', a resultant effect of nematocyst absorption.

The loss of the shell, resulting from the pre-adaption of chemical defenses, is the defining feature of the nudibranchs within the mollusk family. This evolutionary trait has evolved due to the success of defensive mechanisms of the nudibranch, and this in turn has led to over 3000 species extant worldwide today.

[1] F. Aguado and A. Marin. Warning coloration associated with nematocyst-based defences in aeolidiodean nudibranchs. *Journal of Molluscan Studies*, 73(1):23–28, 2007.
[2] D. Faulkner and M. Ghiselin. Chemical defense and evolutionary ecology of dorid nudibranchs and some other opisthobranch gastropods. *Marine ecology progress series. Oldendorf*, 13(2):295–301, 1983.
[3] R. Wyeth and A. Willows. Field behavior of the nudibranch mollusc tritonia diomedea. *The Biological Bulletin*, 210(2):81–96, 2006.

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