

Chemical ecology of the antarctic spongivorous sea star *Perknaster fuscus*

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Figure 1. *In situ* photograph of the antarctic sea star *Perknaster fuscus* taken at a depth of 30 meters in McMurdo Sound. Arm radius is approximately 8 centimeters.

The antarctic sea star *Perknaster fuscus* (figure 1) is abundant in the shallow continental-shelf waters of Antarctica (Clark 1962, 1963). In McMurdo Sound, *P. fuscus* is common below the zone of ice scour and anchor ice (33 meters), where it preys on sponges (Dayton et al. 1974). As a juvenile *P. fuscus* consumes a variety of sponges, including *Tetilla leptoderma*, *Haliclona dancoi*, *Polymastia invaginata*, *Kirkpatrickia variolosa*—and primarily, the slimy sponge *Mycale acerata* (Dayton et al. 1974). As an adult, spongivory becomes even more specialized with 95 percent of its dietary energy intake attributable to *M. acerata* (Dayton et al. 1974). This specialized feeding behavior has a significant impact on the benthic community structure, since the feeding activities of *P. fuscus* complement those of another sea star (*Acodonaster conspicuus*) in regulating the abundance of *M. acerata*, a rapidly growing and potentially benthos-dominating sponge (Dayton et al. 1974). Thus, factors such as chemical defense, which may determine the abundance of *P. fuscus*, are important in indirectly mediating the structure of sponge populations.

Although antarctic sea stars are consumed by benthic invertebrate predators (e.g., the sea star *Odontaster validus* feeding on the sea star *Acodonaster conspicuus*, and the sea anemone *Urticinopsis antarcticus* feeding on the sea stars *O. validus* and *A. conspicuus*), no observations of predation on *P. fuscus* have been made (Dayton et al. 1974; Dearborn 1977; McClintock et al. personal observation).

During the austral spring and summer of 1989, collections of *P. fuscus* were made to test the hypothesis that the body-wall tissues are chemically defended. Body-wall tissues were dissected and homogenized in an equal volume of cold seawater. Following filtration, the aqueous homogenate was diluted with seawater, and four concentrations were tested for cytotoxicity, using the mature gametes of the antarctic sea urchin *Sterechinus neumayeri* (McClintock et al. 1990, 1991; Heine et al. 1991). The body wall homogenate was found to be toxic to sea urchin sperm at a concentration of 3 percent. No cytotoxicity was detected at concentrations of 0.003, 0.03, or 0.3 percent aqueous homogenate or in response to controls (seawater alone). The body wall homogenate was also tested for its ability to inhibit righting behavior in the antarctic sea star *O. validus*. Individuals placed into finger bowls with seawater containing a 10 percent concentration of body wall homogenate required significantly longer ($P < 0.01$; Students-*t*-test) to right themselves than individuals placed in seawater alone (mean of 44 minutes vs. 20). This reduction in

the ability to right is indicative of physiological stress (Watts and Lawrence 1990).

Feeding deterrence was indirectly evaluated using aqueous body wall homogenates of *P. fuscus* exposed to the terminal sensory tube feet of antarctic sea stars (McClintock et al. 1990, 1992). Extracts released across the sensory tube feet of the sea stars *O. validus*, *O. meridionalis*, *A. conspicuus*, and *Diplasterias brucei* all caused significant sustained tube-feet retraction responses when compared with seawater controls (figure 2). With the exception of *A. conspicuus*, all sea stars also showed consistent arm retraction in response to homogenates. These results suggest that a chemical irritant is present in the body wall and may also incite that the body wall is noxious to potential predators.

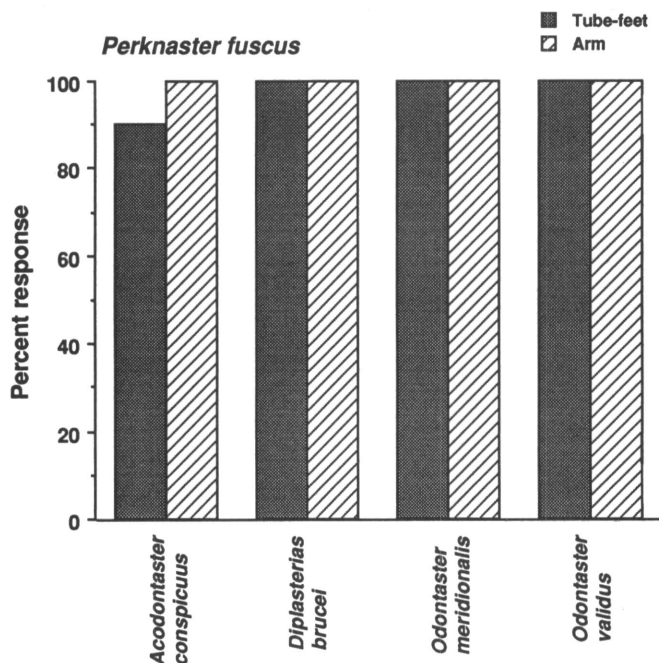


Figure 2. Tube-feet and arm-retraction responses of four species of antarctic sea stars exposed to crude whole extracts of body wall tissues of *Perknaster fuscus*. Each bar represents the percent of individuals showing a retraction response among ten trials. No response was elicited by the release of sea water across the tube feet in any of the sea stars.

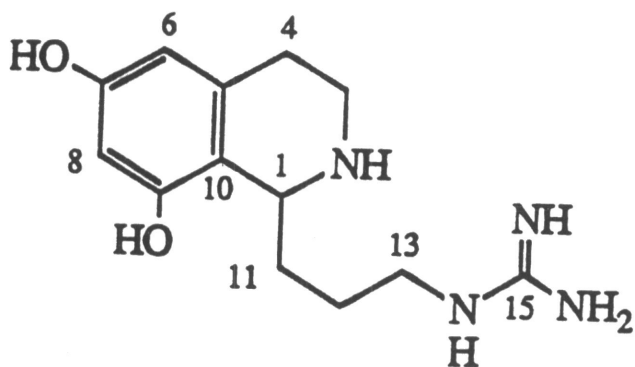


Figure 3. The chemical compound fuscusine, a tetrahydroisoquinoline alkaloid isolated from the body wall tissues of *Perknaster fuscus* (from Kong, Harper, and Faulkner 1992).

Body-wall tissues of *P.fuscus* were placed in ethanol and shipped to the natural products laboratory of Dr. John Faulkner at Scripps Institute of Oceanography, La Jolla, California. Bioassay-directed fractionations of the ethanolic body-wall extract resulted in the isolation of a novel tetrahydroisoquinoline alkaloid (figure 3), which was named fuscusine (Kong, Harper, and Faulkner 1992). This is only the second isoquinoline alkaloid ever to be isolated from a marine invertebrate. These compounds had previously been isolated only from plant tissues (Pathirana and Anderson 1986). The benzyltetrahydroisoquinoline alkaloid, imbricatine, was isolated from the sea star *Dermasterias imbricata* from the west coast of North America and causes an escape response in sea anemones (Pathirana and Anderson 1986; Burgoyne et al. 1990). Fuscusine, which is probably produced *de novo* (Faulkner personal communication), is likely to be responsible for the bioactivity detected in antarctic bioassay organisms. Future bioassays conducted with purified compound will provide an assessment of this hypothesis.

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