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Exploratory 2
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Visual Stimulus Triggers Feeding of Tidepool Sculpin *Oligocottus maculosus*

Introduction

Oligocottus maculosus, commonly known as the tidepool sculpin, is one of the most widely distributed sculpins in the Northern hemisphere, and may be found in nearly any tide pool located in the intertidal zones. Since the sculpin live in exposed tide pools, they have evolved to be highly tolerant of elevated temperature (Morris 1960; Nakamura 1968). One of the most amazing abilities of this species is that the fish is able to find its way back home after being displaced from its home tide pool (Green 1970; Yamashita 1992). The species has a low movement rate because immobility helps the fish avoid being detected by its visual predators. The fish shows a large decrease in movement especially when its color matches to the substrate (Houtman and Dill 1994). Immobility certainly reduces risk of predation, but it also considerably limits the feeding opportunities. Feeding strategy of *O. maculosus* is very opportunistic; the fish remains still and wait for preys to come into its territory. But how does it know if the prey is in its territory? Hugie et al. (1991) reported that the tidepool sculpin responds to the chemical signals sent by injured conspecifics. Therefore, it is likely that the sculpin relies on chemicals to detect its preys as well. To determine if the sculpin relies largely on chemicals for feeding, I formulated the hypothesis that feeding behavior of *O. maculosus* is triggered by a chemical stimulus instead of a visual stimulus.

Methods and Materials

I collected 20 tidepool sculpin (*O. maculosus*) at North Cove, Coos County, Oregon. I conducted 2 experiments to determine whether *O. maculosus* uses a visual or chemical stimulus for feeding. I stopped feeding the 20 sculpin for 2 days prior to each experiment so the response of the fish to either the visual or chemical stimulus would appear more obviously.

Visual experiment

In this experiment, I used 10 tidepool sculpin randomly chosen from the population of the 20 fish. I put two prey samples, an amphipod (Gammaridae) and a mussel, in two different test tubes so that chemicals as well as waves generated by the prey were effectively blocked. I collected the gammarids (unknown species) at the beach in front of the OIMB boathouse and the California mussels (*Mytilus californinus*) at the docks in Coos bay, Oregon. The shells of the mussels were broken, and their mantle cut into a small piece (approx.1cm^2) so it could fit into the test tube. I used a large finger bowl (radius=9.4cm) with a circle of a radius 7.1 cm drawn on the base (Fig.1). The circle drawn on the finger bowl was used to maintain an approximately constant distance from the prey and the sculpin.

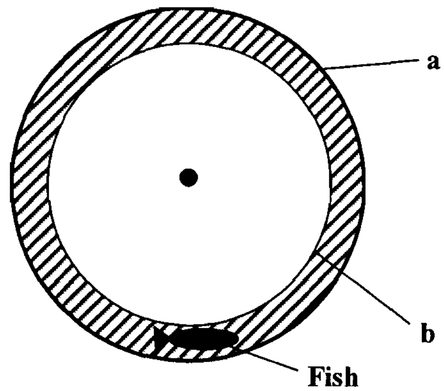

Fig.1 Experimental set-up of the finger bowl. **a.** the edge of the finger bowl (r=9.4); **b.** the circle (r=7.1) drawn on the bottom of the finger bowl. A black dot in the center of the bowl represents the test tube.

A tidepool sculpin was placed into the finger bowl. When the fish swam in the space between the circle and the edge of the finger bowl, I placed the test tube with either the gammarid or the mussel piece in the center of the bowl. Each fish was given 1 trial, each a maximum of 3 minutes starting at the moment the test tube was placed into the bowl. I recorded the color and size of the fish, the time the fish responded to the prey, and the time the fish attacked the test tube. I defined "the fish detected the prey" as when it showed a sudden and quick approach toward the test tube or quickly turned its face toward the test tube.

Y-maze experiment (experiment for chemoreception)

Flow rates of both Y-arms were adjusted by using a dye until they were approximately equal. I used the soft tissue of mussels as a prey sample, and it was placed randomly in either the left or right side of the Y-maze. Six randomly chosen tidepool sculpin were used in this experiment, and each had 5 trials (a maximum of 3 minutes per trial). I defined "the fish made a decision" as when it swam to the very end of the Y-arm. Color and size of the fish and time when the fish made a decision were recorded.

Results

In the experiment testing the ability of the tidepool sculpin (*O. maculosus*) to search for prey by means of visual information, 9 out of the 10 sculpin responded to the test tube with an amphipod. Of the 9 sculpin, 7 actually attacked the test tube (Table 1). The time the sculpin took to detect the prey varied (mean = 57.9; range = 2-138; n = 9). Once the sculpin recognized the prey, they usually attacked within 5 to 10 seconds (mean = 7.29; range = 1-30; n=7). None of the sculpin recognized the mussel. The mobility of the prey determined whether or not it was attacked by *O. maculosis*, hence the difference in amphipod and mussel attack rates.

Table 1. Response of the tidepool sculpin (*O. maculosus*) to test tube with either the amphipod or mussel soft tissue.

	Color	Size	Prey	Time of detection (s)	Time of attack (s)
1	Green	Small	Amphipod Mussel	11 Not observed	14 Not observed
2	Green	Small	Amphipod Mussel	65 Not observed	68 Not observed
3	Gray	Small	Amphipod Mussel	26 Not observed	32 Not observed
4	Green	Medium	Amphipod Mussel	138 Not observed	Not observed Not observed
5	Green	Small	Amphipod Mussel	22 Not observed	25 Not observed
6	Gray	Small	Amphipod Mussel	2 Not observed	7 Not observed
7	Gray	Small	Amphipod Mussel	136 Not observed	Not observed Not observed
8	Green	Small	Amphipod Mussel	17 Not observed	18 Not observed
9	Gray	Large	Amphipod Mussel	Not observed Not observed	Not observed Not observed
10	Gray	Small	Amphipod Mussel	104 Not observed	134 Not observed

Thirty trials were carried out in the Y-maze experiment. There were only 8 trials in which the sculpin actually swam to the end of the Y-arm. Of the 8 trials, 5 were successful; the accuracy rate was about 0.63 (Table 2). Four out of the 6 sculpin swam to the mussel juice. But none of them had more than 3 successful trials (out of 5 trials). The behavior of the sculpin during the experiment was passive. In all 22 trials in which the fish failed to make a decision, the fish did not move at all.

Table 2. Decisions made by the 6 tidepool sculpin in the Y-maze experiment.

	Color	Size	Trials	Prey (L/R)	Observed (L/R)	Time (s)
1	Gray	Large	1st	L	L	78
			2nd	R	R	65
			3rd	R	-	-
			4th	L	-	-
			5th	L	-	-
2	Green	Medium	1st	L	R	50
			2nd	R	-	-
			3rd	L	-	-
			4th	L	-	-
			5th	R	-	-
3	Green	Small	1st	L	-	-
			2nd	R	-	-
			3rd	L	-	-
			4th	R	-	-
			5th	L	-	-
4	Green	Medium	1st	L	-	-
			2nd	R	-	-
			3rd	L	-	-
			4th	R	-	-
			5th	R	-	-
5	Gray	Small	1st	R	-	-
			2nd	R	R	137
			3rd	L	R	134
			4th	L	R	71
			5th	R	R	58
6	Gray	Large	1st	R	R	110
			2nd	L	-	-
			3rd	L	-	-
			4th	R	-	-
			5th	L	-	-

Discussion

The 9 tidepool sculpin used in the visual experiment successfully detected the prey by visually "seeing" the environment. My result also suggests the sculpin sort out visual stimuli and tend to respond particularly to a moving object. In the experiment, the sculpin strongly responded to the amphipod moving in the test tube. The immotile mussel soft tissue, on the other hand, was completely ignored by the sculpin, just as the amphipod was ignored when it was not moving. My result shows that the interval of time between the beginning of the trial and initial detection (range=2–138) varied more greatly than did the interval between detection and attack (range=1-30). This is because the interval of time trial start and detection depends completely on the movement of the prey, whereas the interval of time between detection and attack depends more on the condition (e.g. starvation) of the fish and participation in feeding. Once feeding behavior is triggered by the visual stimulus, the fish begins actively searching the preys.

The tidepool sculpin did not do well on the Y-maze experiment. All 6 sculpin failed to have more than 3 successful trials (out of 5 trials). Two of the fish did not show any response at all. The result is not strong enough to conclude that tidepool sculpin relies on chemicals from the prey for feeding. This is not consistent with my hypothesis; my results indicate that chemicals are less important in feeding of *O. maculosus*.

For intertidal fishes, a visual clue may be more reliable than a chemical clue. The primary reason is that the speed of light is much faster than the diffusion rate of chemicals in water. Tide pools in which sculpins are often trapped have less water circulation than does open water, and thus the diffusion rate is expected to be low. Intertidal fishes may react to the presence of a prey much faster when they use visual information. Especially for opportunistic predators such as tidepool sculpin, a fast response to the prey is important to increase opportunities for successful predation.

Potential errors may change my results; the Y-maze that I used for my experiment may not be suitable for the sculpin. The Y-maze made of clear plastic works pretty well for invertebrates with poorly developed "eyes." But fishes with well-developed eyes, such as the tidepool sculpin, may be distracted by visual stimuli, which continuously enter in the maze through the transparent wall. In fact, I noticed that 3 of the sculpin used swam into the clear wall of the Y-maze, trying to swim through it. The sample size might also affect the result. I used only 10 samples for the visual experiment and 6 samples for the Y-maze experiment. A larger sample size will produce more credible results. There is still a strong possibility that *O. maculosus* uses chemical cues for predation since 2 freshwater sculpins in Alaska, *Cottus aleuticus* and *C. cognatus*, do require chemical cues for detecting their prey (Dittman et al. 1998). Thus, to confirm my findings, I would re-do the experiments with a larger sample size and a Y-maze that has opaque walls.

My findings have the potential to generate further questions. If *O. maculosus* relied more on visual information than chemicals from the prey for feeding how far would it be able to "see" the prey? If the sculpin relied totally on the mobility of an object, would the shape of the moving object (prey) matter? The study of predation is important to understand the interaction among organisms in a community. The study of feeding behaviors of the intertidal fishes contributes to a better understanding of the intertidal ecosystem.

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