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## Exploratory #1: Structural Comparison of Tube Feet Length in *Pisaster ochraceus, Pisaster brevispinus* and *Pycnopodia helianthoides*

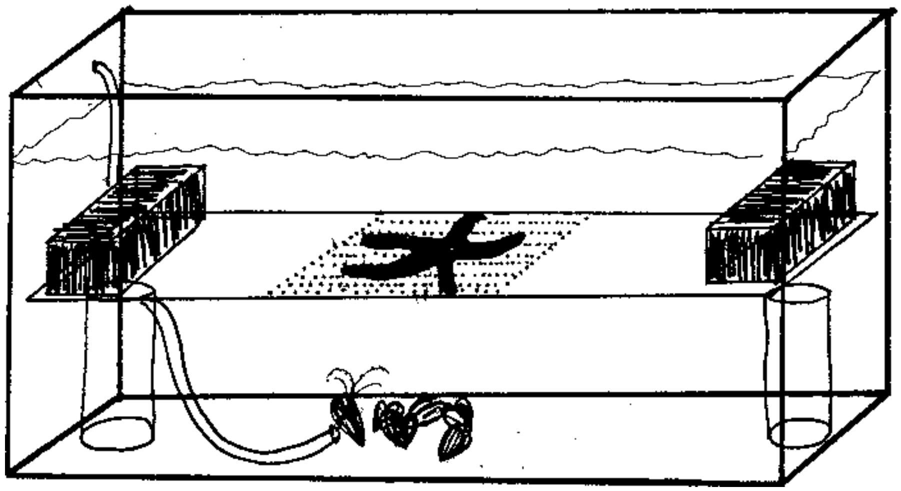
**Introduction:** Within the class *Asteroidea,* several sea stars exhibit different feeding strategies. Each species within the class uses tube feet to grab onto prey, although each species utilizes their tube feet to a different extent. In this exploratory I compared the ability to stretch tube feet in three *species—Pisaster ochraceus, Pisaster brevispinus, and Pycnopodia helianthoides.* In an effort to draw a correlation between tube feet stretch and habitat, these species were chosen based on their differences in intertidal location. *Pisaster ochraceus* lives in the mid- to low-intertidal zones, in rocky areas with high wave action. It is the most non-specific in terms of prey, feeding on mussels, barnacles, snails, limpets and chitons. *Pisaster brevispinus* is found in the low-intertial zone on sand and mud bottoms. It feeds mainly on living clams, snails and sand dollars burrowed in the sand. *Pycnopodia helianthoides* lives in the low intertidal zone on rock, sand and mud substrate rich with seaweeds (Morris).

The habitat of each species greatly influences its feeding strategy. The habitat of each species of sea star, and thus location of its prey, directly affects how far its tube feet will stretch.

**Methods:**

A variety of methods were employed to assess tube feet stretch in the three sea stars. Although two methods were unsuccessful, I have included their description to provide a more thorough representation of this experiment. Each method was tried at least once with one individual of each species described above. The individuals used were of comparable size to ensure that differences in tube foot length were not due to overall different body sizes.

*Method 1:* A plexiglass platform which had holes 0.25in in diameter spaced 0.75in apart was placed 15cm from the bottom of a rectangular glass tank. The platform was held in place by two upside-down glass jars and two bricks. The bottom half of the tank contained crushed up mussels, with a small hose pointing upward to create a flow of mussel "scent" toward the top of tank. The sea star was placed on the platform and monitored for ten to thirty minutes, or until it crawled into the corner of the tank. Ideally the sea star would have recognized the scent of the mussels and extended its tube feet through the holes in an effort to reach the food, however this did not happen See picture below of tank.



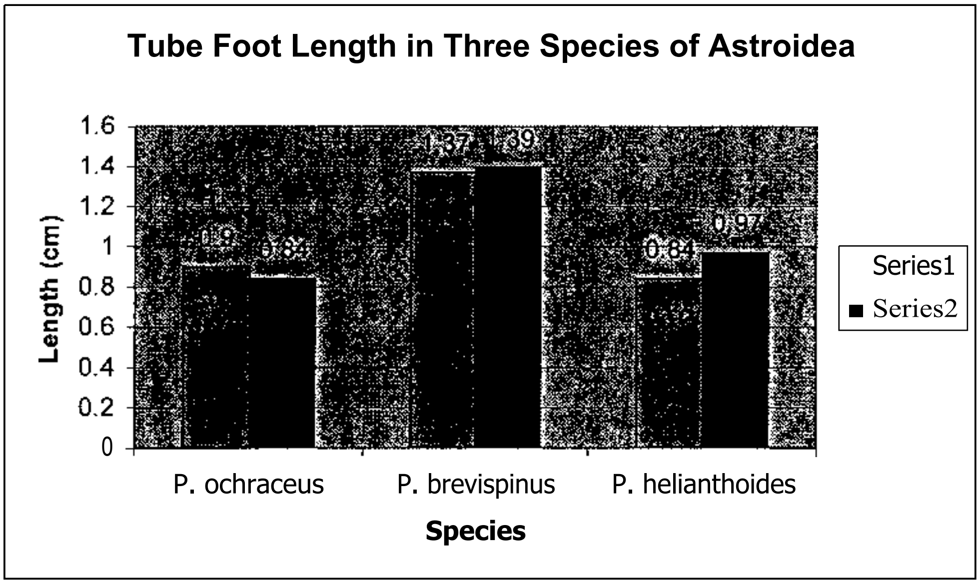
This method did not yield valid results, as each sea star headed for the corner of the tank as soon as it was placed in the tank. Occasionally a tube foot would extend through one of the holes in the platform, however this did not happen enough to be considered suitable data. This method was attempted with the platform at approximately 6cm above the bottom of the tank, and also with the platform in contact with the mussels. This method was also tried with live mussels. Each time the sea stars moved directly to the corner of the tank.

*Method 2:* In this method, the sea star was hung from the top of the tank by fishing line, with its oral surface at the surface of the water. It was thought that the sea star would extend its tube feet in an effort to find something to grab onto, but in each case the sea star would essentially fold on itself and remain suspended in the water. In one trial *P. ochraceus* escaped from the fishing line and crawled to the corner of the tank, however all other results were inconclusive.

*Method 3:* Each sea star was flipped onto its aboral surface in a 23x23x6cm plastic container. In the first series of trials, there was no water in the container. In the second series, the container was filled with water so the sea star would be initially submerged. Every minute, for ten minutes, the longest tube foot extended was measured with a millimeter ruler. These values were recorded and averaged over the ten minutes. In cases where the sea star flipped over before the ten minutes had passed, the data collection ended with the most recent measurement.

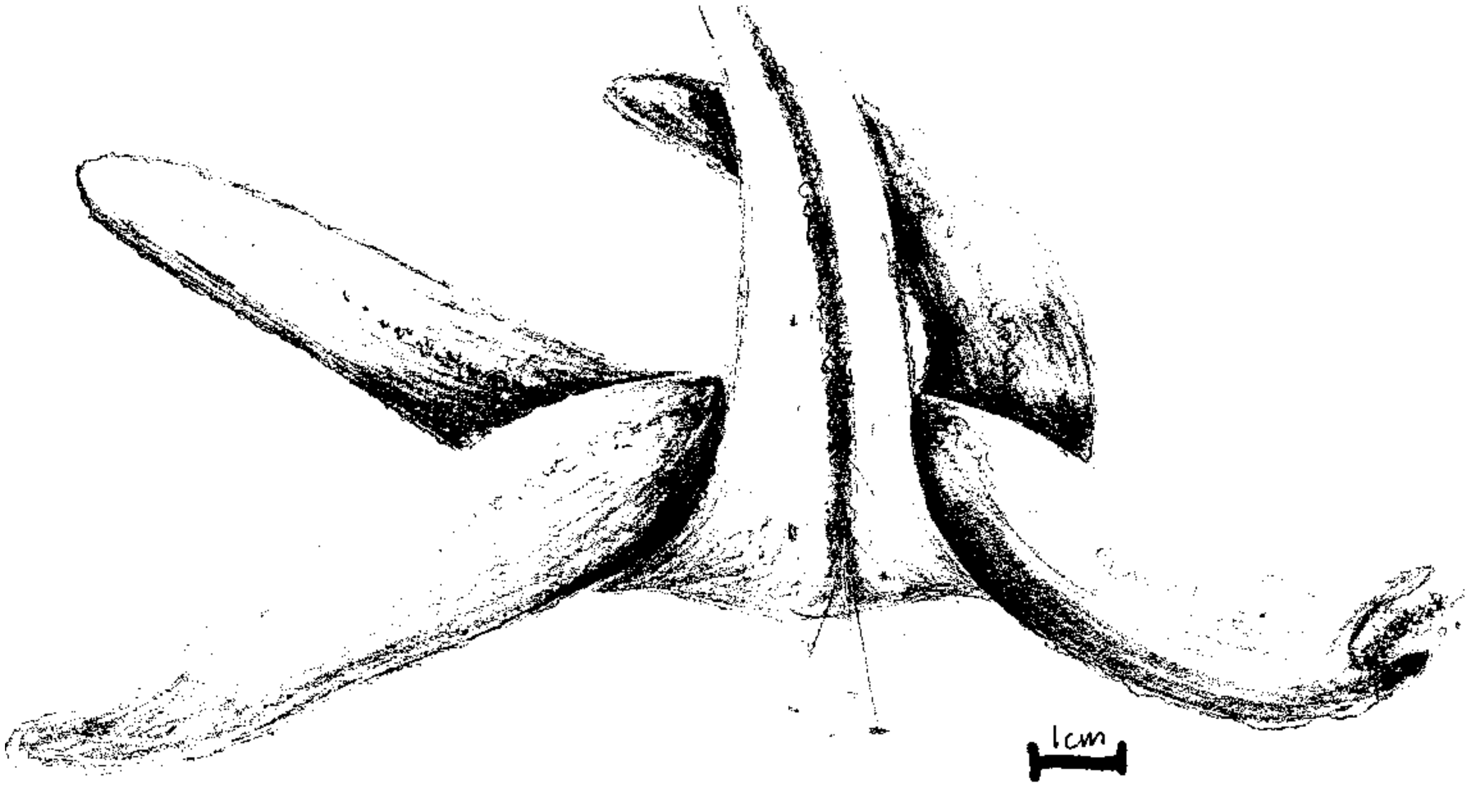
**Results:**

Only the trials that lasted the entire ten minutes were used for comparison. All of the dry trials lasted the full ten minutes, while only one submerged trial (with *P. helianthoides)* lasted the required time. Table 1 below illustrates the results of the two dry series of tests:




This chart shows that *P. brevispinus* consistently showed a greater tube foot length in each of the trials. The two other species did not show a consistent trend in length compared each other.

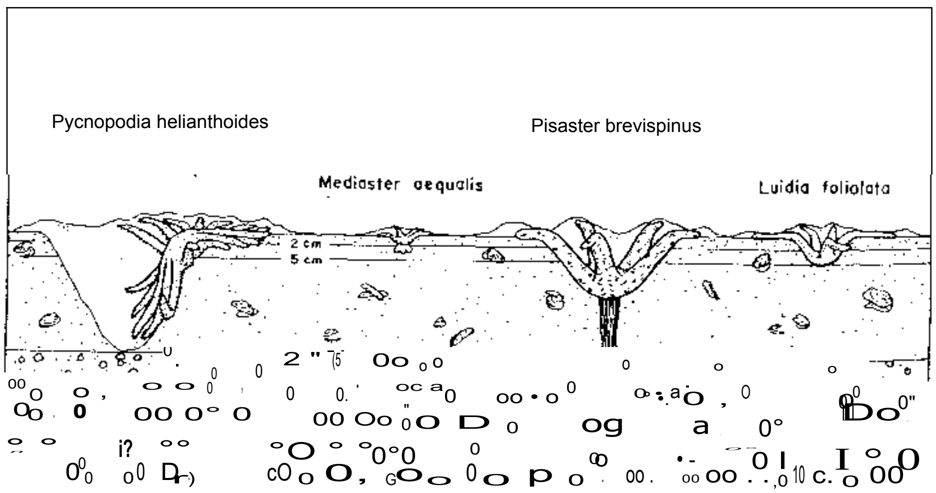
There was no consistent trend observed in the location of the most active feet within each ray. Both of the *Pistaster* species exhibited the longest tube feet around the oral surface. The *P. helianthoides* showed significantly more overall activity in the tube feet than both of the *Pisaster* species, however did not show a pattern in where the longest tube feet were located. All species showed significant activity in the sensory tube feet at the end of each ray. In all of the species, the tube feet stretched the longest on the ray that was last to be flipped back to its proper orientation. See picture below.




**Discussion:**

*P. brevispinus* demonstrated the ability to stretch its tube feet longer than *P. ochreceus* and *P. helianthoides* in turning itself over. One can draw a correlation between the stretch demonstrated in this experiment and the habitat from which each species gets its food. While the experiment does not directly examine tube feet stretch in the presence of prey, the results provide a valid base for the conclusion that *P. brevispinus* has the longest tube feet out of the three species. This adaptation is especially helpful in the sandy habitat in which it resides, because it stretches its tube feet deep into the sand to reach clams (Van Veldhuizen and Phillips, 1978).

By this same logic we can assume that *P. helianthoides* would similarly exhibit relatively long tube feet, since it also is found on sand and mud (along with low rocky intertidal zones). However this experiment did not show a significant difference between tube foot stretch in *P. helianthoides* and *P. ochraceus,* which lives higher up in the rocky intertidal. The following picture shows the difference in excavating postures of *P. helianthoides* and *P. brevispinus.* According to a study in 1983, *P. brevispinus* is the only sea star species capable of extending its circum-oral tube feet deep into the sand to excavate prey (Sloan and Robinson, 1983). Despite occasionally living on sand and mud bottoms, *P. helianthoides* feeds on more surface-dwelling prey.

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The main source of error in this exploratory was that the most effective method for measuring tube foot stretch did not actually involve stretching for food, as the original goal intended. Instead the results simply provide support for the hypothesis that *P. brevispinus* has longer tube feet in order to excavate prey from sand. In order to confirm this hypothesis further, an experiment would have to be designed that causes the sea stars to extend their tube feet in response to the presence of prey.

## Works Cited

Morris, Robert H. Intertidal Invertebrates of California. Stanford, CA: Stanford University Press, 1980.

Sloan, N.C. and S.M.C. Robinson. "Winter Feeding by Asteroids on a Subtidal Sandbed in British Columbia." Ophelia 22(2): 125-140, December 1983.