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Adaptations of Marine Animals

Exploratory 1

7-11-08

Righting Behavior of Sea Stars

Introduction:

The ability of sea stars to flip themselves from having the ventral side up to having the dorsal side up is a skill that must be highly refined, but in different ways in different species. Sea stars all feed with the stomach exposed on the ventral side of the animal facing down and digesting what is below it. When a sea star is on its back, it not only not able to feed, but it is also much more susceptible to predation. The morphology of different species varies greatly and thus the stresses of the body are different in each. We compared the righting behavior of three different species of sea stars and compared the righting behavior and time of righting. The three species that were studied were the *Pycnopodia helianthoides*, *Henricia leviuscula*, *Asterina miniata* and the *Leptasterias aequalis*. These species were selected on the basis of their availability, and size. We hypothesized that the smaller the arm length to body size ratio that faster and better the star could right itself.

The *Pycnopodia* is one of the largest sea stars found on the Pacific Northwest coast. They can reach up to 3 feet in some places, with 18-24 legs in maturity. They are predators of many creatures on the sea floor, eating almost everything they come across, including sea urchins, sea cucumbers crabs and more. They can be found from the low intertidal zone to the sub-tidal zone. They have over 1500 tube feet lining the ventral surface and are one of the fastest of the sea stars, moving as fast as 1 meter per minute.

The *Henricia*, also known as the blood star are found in the intertidal zone to sub-tidal zone down to 400m. It is bright red or orange and has 5 legs. They are found in mostly protected waters, like under rocks, in holes and generally away from strong wave action. The adults are usually about 10-12 cm across. Henricia generally feeds on bacteria and other small particles. The ventral side of the animal has far less tube feet, found only in a line down the medial surface of each leg.

The *Leptasterias*, or six-ray star, are found in the intertidal zone on rocky shores. As the common name suggests, it has 6 legs, bringing it to an average of 6.5- 7 cm across the entire body surface. They can be found mostly on exposed rocks and usually in areas with a moderate amount of wave action. It feeds on a variety of species including but not constrained to barnacles, muscles and sea cucumbers. The ventral surface of the animal is covered completely, excluding the mouth, with tube feet.

The *Asterina minata* is found from Sitka Alaska through Baja California, Mexico. The bat star as it is commonly known can be found in the low intertidal out to a depth of 290m. It feeds on surf grass, bryozoa and algae among other things. It has 5 arms and can reach a diameter of 20cm. the tube feet cover a strip down the center of each leg, but have a much wider distribution than the blood star.

Materials and methods:

We collected 6 *Leptasterias, 1 Asterina* and 3 *Henricia* and used a *Pycnapodia* that was in the open tank room. The *Leptasteria, Asterina* and the *Henricia* were collected from middle cove in Cape Arago State Park on the southern Oregon coast. They were collected at a low tide at approximately 8:00 in the morning and the tests were performed 2 days later.

We took each individual of each different species and placed them with their dorsal side down, opposite of the way they are found in nature. Then each individual was timed and observed for how long it took and the way that it righted itself. This was repeated 3 times with different Henricia individuals and 2 times with each Leptasteria individual. The Pycnapodia was placed on the dorsal side a total of 4 times, but one of the trials was miss timed so there is only data for 3 trials. The time was taken from the moment that the star was placed on its back to the time that the ventral side became totally in contact with the substrate again. This means that the star could be mostly or partially flipped back to ventral side down but the time did not stop until the most distal tube foot hit the substrate.

Each individual was measured with a 15cm ruler and the longest distance straight across the animal, from the tip of leg to the tip of opposite leg. Then each individual leg was measured as well as the size of the body itself, measuring between each leg to the opposite side of the main body area. The results were then recorded.

Results:

The *Pycnopodia helianthoides* originally moved all of its arms up toward the top of the water until its podia were in the air and formed a basket formation. Then it moved them back down toward the bottom of the tank and twisted half of its arms and body underneath itself and flipped the other half up toward the water. Ultimately, it had an average righting time of 2.36 minutes, and we measured its arm length to body diameter ratio to be 1.12 cm.

The *Henricia leviuscula* twisted arms 1 and 3 toward each other, used arms 4 and 5 to support itself on the bottom of the tank, and moved arm 2 up so it was in a sitting-like position, and began to flip itself over. Overall, it had an average righting time of 15.22 minutes and we measured its arm length to body diameter ratio to be 2.27 cm.

The *Leptasterias hexactis* twisted arms 5 and 2 so that the podia were facing arms 3 and 4. It then flipped arms 1 and 6 up toward the water and flipped over arms 3 and 4. In the end, it had an average righting time of 3.68 minutes, and an arm length to body diameter ratio of 2.8 cm.

The *Asterina miniata* righted itself almost like a human sitting up. It kept arms 3 and 4 flat at the bottom of the tank, and brought arms 1, 2, and 5 up out of the water, and flipped them over arms 3 and 4. Then it pulled arms 3 and 4 from under itself and moved them into the right position. Overall, we measured the average righting time to be 2.96 minutes, and the arm length to body size ratio to be 4.44 cm.

Table 1:

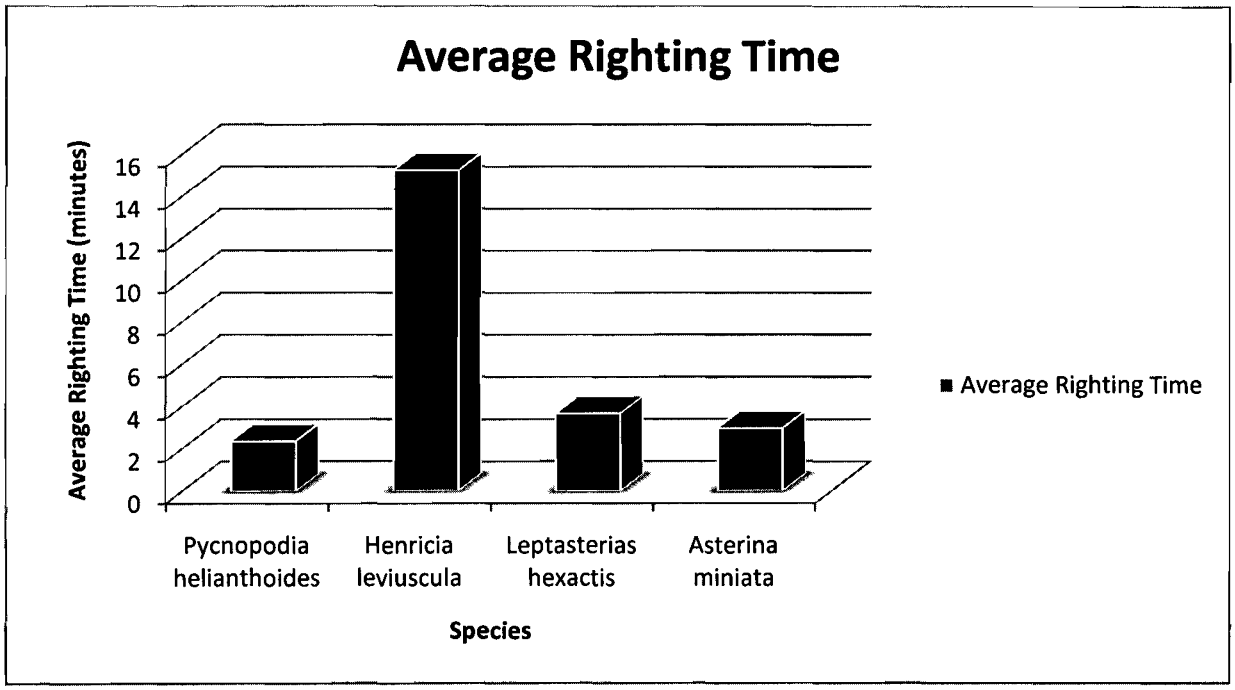

Table 1 shows the average righting time of the 4 different species.

Table 2:

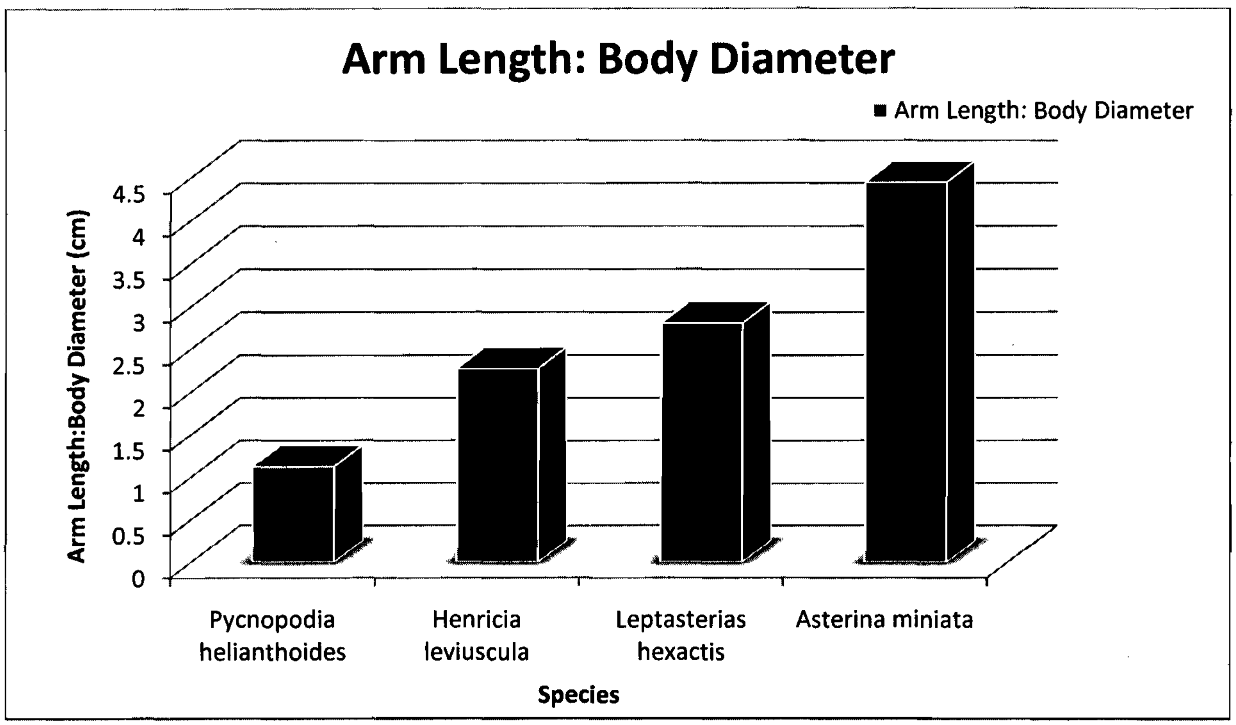

Table 2 shows the average arm length to the body diameter of the 4 different species.

Table 3:

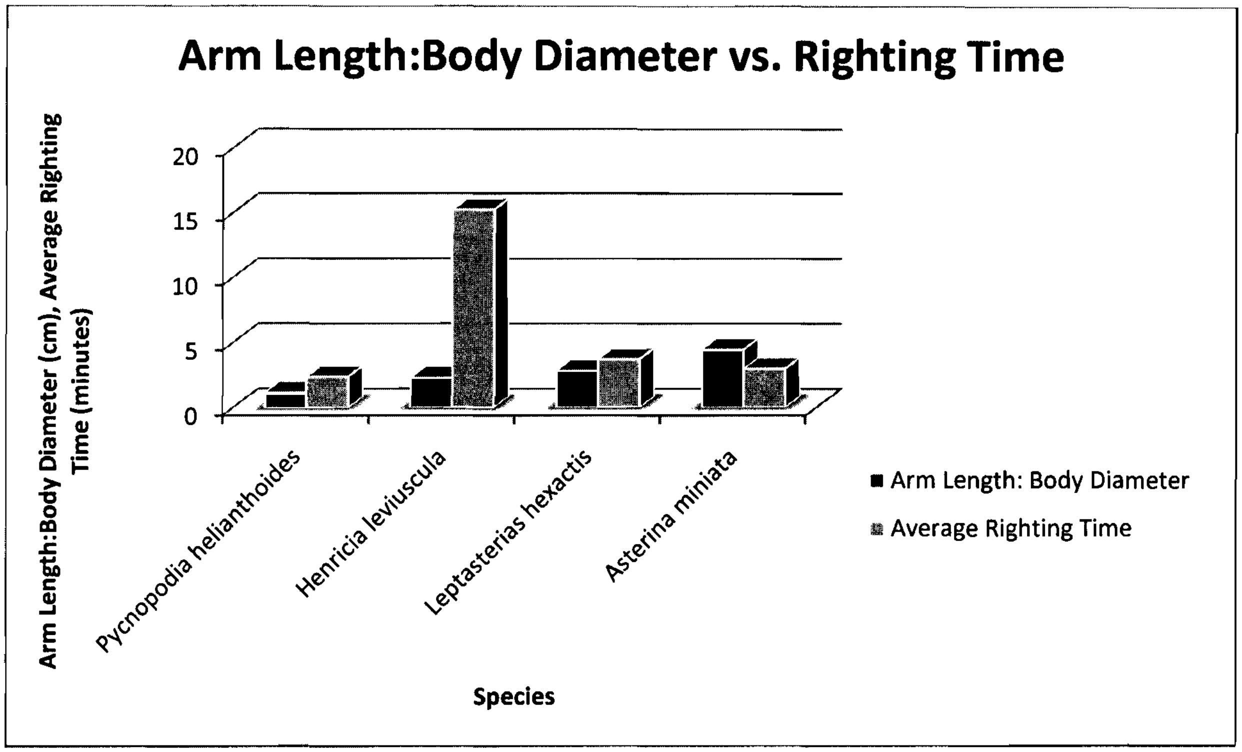

Table 3 shows the arm length to body diameter ratio compared to the average righting time of the 4 different species.

Discussion:

Ultimately, our hypothesis was incorrect. We hypothesized that the smaller the arm length to body diameter ratio, the faster the individual would be at righting itself. However, it turned out that there is no correlation between the arm length to body diameter ratio and the average righting time. The *Pycnopodia helianthoides* had the smallest arm length to body diameter ratio of 1.12 cm, and the fastest average righting time behavior of 2.36 minutes, which supports our hypothesis. However, *Henricia leviuscula* had the next smallest arm length to body diameter ratio of 2.27 cm, and the longest average righting time of 15.22 minutes. This was followed by *Leptasterias hexactis,* which had an arm length to body diameter of 2.80 cm, and the third longest average righting time of 3.68 minutes. Lastly, *Asterina miniata* had the largest arm length to body diameter ratio of 4.44 cm, and the second fastest average righting time of 2.96 minutes. So, even though the *Pycnopodia helianthoides* supports our hypothesis, the *Henricia leviuscula, Leptasterias hexactis,* and *Asterina miniata* do not.

We concluded that sea star righting behavior is due to its habitat and lifestyle, and not to its structure. We came to this conclusion because the *Pycnopodia helianthoides* is considered to be a predator, and therefore needs to be quick in locomotion, including righting itself. And it should therefore have the fastest righting time, which it did. The sea star that had the second fastest righting time was *Asterina miniata.* This also made sense because this sea star is mainly found in low intertidals in exposed areas. If this sea star is always exposed, then it is vulnerable to predation and therefore needs to be quick at righting itself if it finds itself in an unfortunate position. The third fastest sea star was the *Leptasterias hexactis*, which is usually found on the sides of rocks, sometimes exposed, and sometimes protected. So it makes sense that it would have a slower righting time than the *Asterina miniata*, but still a faster righting time than the *Henricia leviscula* which is usually found under rocks and in highly protected areas. Since it is in highly protected areas, there is no need for this sea star to adapt to having a fast righting time because it would rarely find itself in the position where it would need to right itself in a fast manor.

Since we concluded that sea star righting behavior is in fact due to behavior and lifestyle, we could further investigate this new hypothesis by collecting sea stars from various habitats and that exhibit various lifestyles. For example, sea stars that are in highly protected areas all the way to sea stars that are in fully exposed areas, and sea stars that are found in the rocky intertidal all the way to ones found deeper in the water. We could also collect species that are more susceptible to predation and species that act more as predators. Then perform the same experiment and correlate the results with the sea stars habitat and lifestyle rather than the structure of the sea star.

References:

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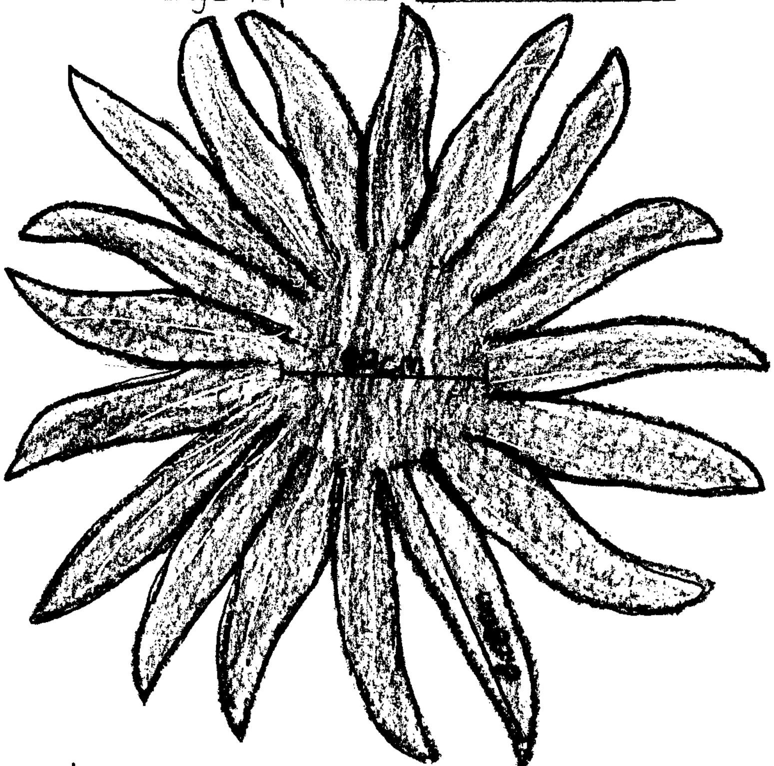
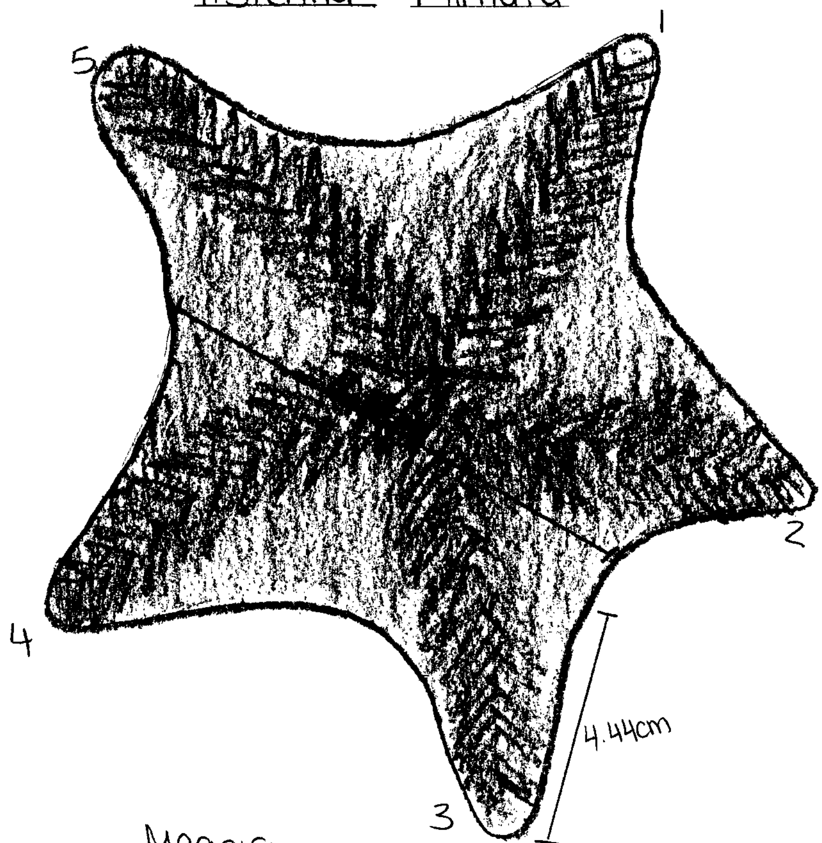
3) www.wallawalla.edu/academics/departments/biology/rosario/inverts/echinodermata/class%20asteroidea/leptasteria_aqualis.html. Cited 2008-07-10
4) http://www.wallawalla.edu/academics/departments/biology/rosario/inverts/Echinodermata/Class%20Asteroidea/Asterina_miniata.html. Cited 2008-07-10
5) Polls, I. and Gongor, J. behavioral aspects of righting in two Asteroidia from the Pacific Coast of North America. Bullbio [internet] 1975. Cited 2008-07-10.148. pg 68-84.

Pycnopodia helianthoides



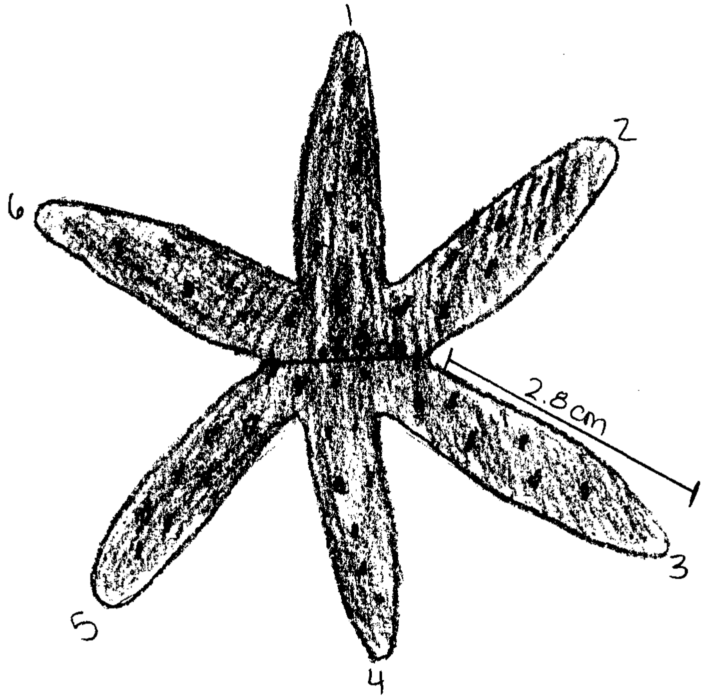
Magnification: 0.312

Asterina Miniata



Magnification: 0

Leptasterias hexactis



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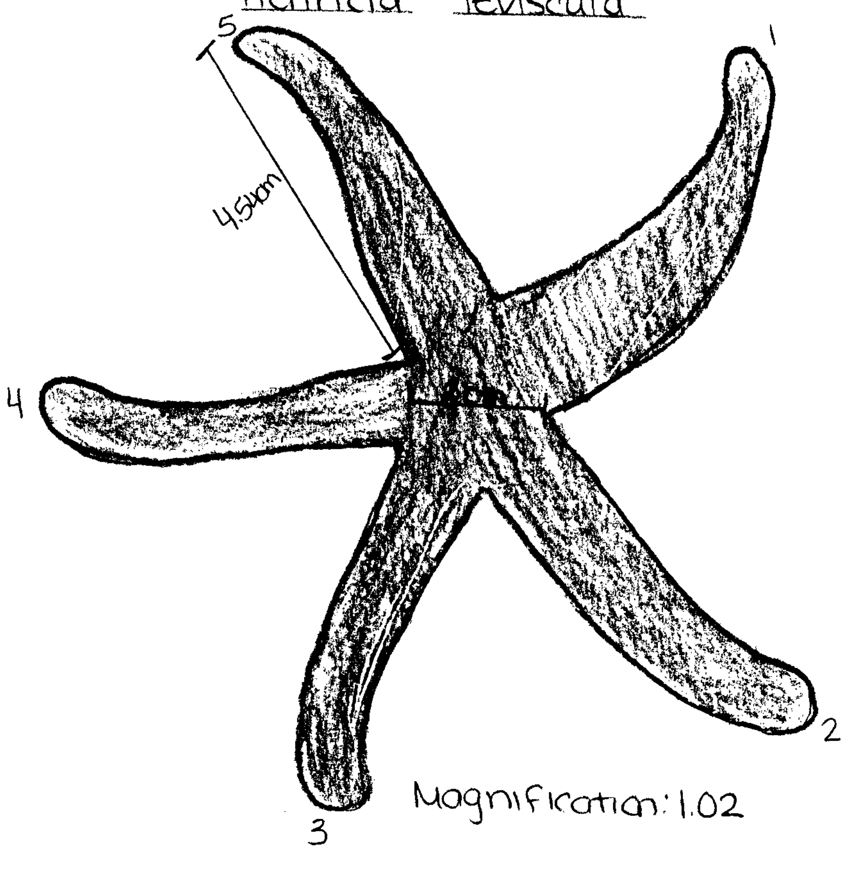
Henricia leviscula



Magnification: 1.02