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Structural Comparison of Intertidal *Polyplacophora*

Introduction

Pacific Northwest chitons are located in all intertidal zones of rocky shorelines. Part of the phylum *Mollusca*, their scientific class is *Polyplacophora*. According to *The beachcomber's guide to seashore life in the Pacific Northwest*, "all mollusks possess a fold of soft flesh (mantle) which encloses several glands" and in particular, chitons "have a series of eight plates or valves held together by an outer girdle" (Sept 1999). Chitons move by propelling themselves with a foot structure characteristic of mollusks. *Intertidal invertebrates of California* describes this ventral foot as "commonly broad and muscular, well suited to creeping upon, and clinging to, the substratum," specifically rocks on which their food source is located (Morris *et al.* 1980). This project was inspired by a question relating the ratio of specimen foot area to overall area based on shelter from strong surf, which is determined by its location in the intertidal zone. Specifically, research on this topic led us to an article by Linsenmeyer where he stated that the *Nuttallina* chiton "which inhabits rocks subject to heavy surf, exhibited a mean resistance to removal of 237 g/cm^2. This was more than double the resisting force of the three species occupying the most protected habitats" (1975). The preferential tidal ranges of different species of chitons led to the hypothesis of this exploratory project. Since we believed chitons would require a larger foot to cling to the substratum successfully, a hypothesis emerged stating that chitons living in an environment more exposed to high wave action would have a large ratio of foot area to overall ventral area.

Materials and Methods

All specimens were collected at Middle Cove over two days. A total of five species were collected and separated in the salt water tables. Table 1 lists the chitons gathered for the experiment along with their location in the intertidal zone.

Table 1: Locations of Experimental Chitons

Common Name	Scientific Name	Location
Blue-Line chiton	*Tonicella undocaerulea*	50 meters to low intertidal zone
Gumboot chiton	*Cryptochiton stelleri*	20 meters to low intertidal zone
Katy chiton, Leather chiton	*Katharina tunicata*	Low to middle intertidal zones
Woody chiton	*Mopalia Lignosa*	Low to middle intertidal zones
Gould's Baby chiton	*Cyanoplax dentiens*	Middle intertidal zone

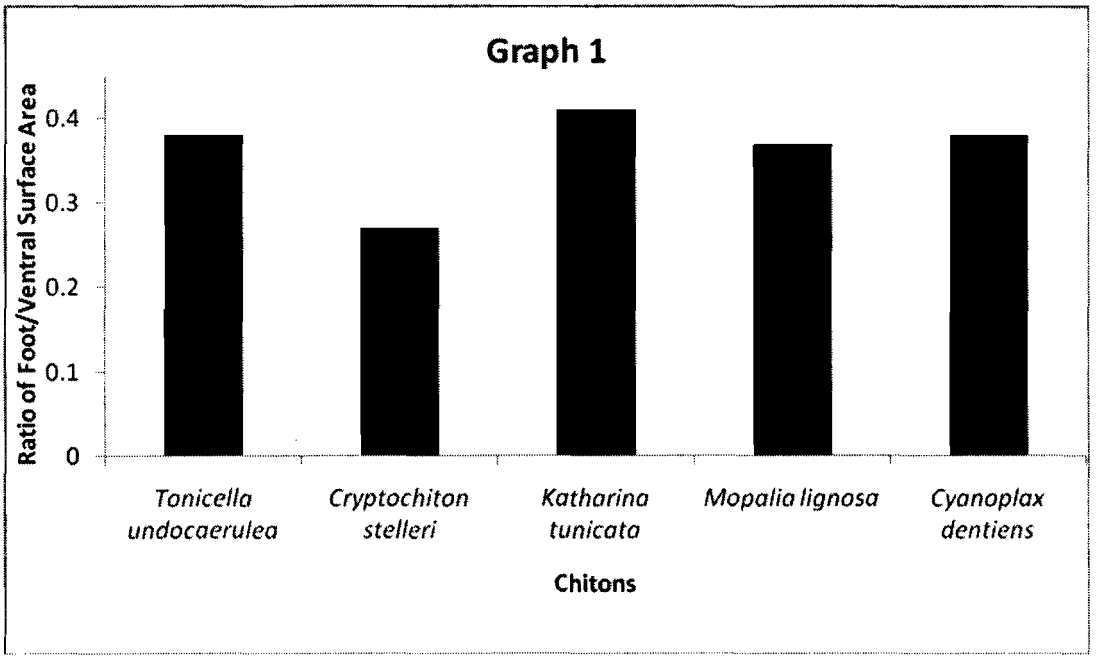
In order to calculate the surface areas for comparison, each one was individually placed on a clear plastic plate and allowed to acclimate. The plate was turned over and a centimeter ruler was used to measure the length and width of both the foot and ventral surface of the chiton. These values were tabulated and the overall areas were calculated. A simple length x width equation was used as the chitons were treated like rectangular shapes. A minimum of five specimens were collected for each species.

Results

Table 2 shows that the ratio of foot to ventral surface area of both *Tonicella undocaerulea* and *Cyanoplax dentiens* was 0.38, that of *Cryptochiton stelleri* was 0.27, *Katharina tunicata* was 0.41, and *Mopalia lignosa* was 0.35 respectively.

Table 2: Ratio Values

Name of Chiton	Ratio (foot/ventral surface)
Tonicella undocaerulea	0.38
Cryptochiton stelleri	0.27
Katharina tunicata	0.41
Mopalia Lignosa	0.35
Cyanoplax dentiens	0.38



Graph 1 is a visual representation of the ratios of foot to ventral surface area of the chitons measured for this project.

Conclusion/Discussion

Contrary to our original hypothesis, our data shows that the Gumboot chiton actually has the smallest foot to ventral surface ratio and the Katy chiton has the largest. A complete analysis of all of the ratios show close numerical similarities to each other excluding the

Gumboot. A reason for this result could be explained from our personal observations at Middle Cove as well as the *Encyclopedia of Tidepools & Rocky Shores*. We found that Katy chitons seemed to receive more wave action than the other species based on their placement in the intertidal zone. Although texts indicate Gumboot chitons are low in the zones, they have the smallest foot/ventral surface ratio and were in areas expected to have surf that is less intense. We often located them in regions of complete submersion in the low tides and never on vertical surfaces, which could indicate that a small ratio is advantageous to this species. Normally when a chiton is touched, they respond by latching onto the substrate with powerful muscles, and "to maintain such a tight grip indefinitely would be a waste of energy. Instead a chiton chooses when and where to cling the tightest" (Ed. Denny *et al* 2007). We believe that a chiton's ability to fall off of a rock face could mean falling into water, which would keep the animal from desiccation danger. Also, the Gumboot weighs excessively more than the other species collected and may let go of rock faces in an effort to minimize the energy needed to stay attached.

Sources of error in this exploratory may have arisen from mistakes in measurement, not enough specimens, and a lack of beach variety. When we were measuring the chitons on the plastic surfaces, some of them may not have been fully extended which would have shortened measurements. Also, we were using a 15 cm ruler for chitons that were lengthier than this distance, resulting in some slight distance estimations. We collected a minimum of five specimens from each species, but used more for calculating some of the ratios, a contribution that may have also skewed the results. Finally, only one setting was visited during data collection and our results can only be generalized for this area.

Directions for Future Research

It is interesting to note that the Gumboot chiton has a considerably large girdle in comparison to its foot area. This may be due to reasons unrelated to a natural intertidal environment, but we thought it would be worthy of further exploration.

Appendix

The following tables show raw data for each of the chitons collected.

Table A-1: Blue-Line chiton (*Tonicella undocaerulea)*

Specimen #	L foot (cm)	W foot (cm)	Area foot (cm)	L ventral surface (cm)	W ventral surface (cm)	Area (cm^2)	Ratio (foot/ventral surface)
1	1.6	0.7	1.12	2.3	1.4	3.22	0.35
2	1.6	0.7	1.12	2.4	1.4	3.36	0.33
3	1.5	0.7	1.05	2.2	1.3	2.86	0.37
4	1.1	0.5	0.55	1.6	1.1	1.76	0.31
5	1.4	0.7	0.98	2.0	1.1	2.20	0.45
6	1.5	0.7	1.05	2.1	1.1	2.31	0.45
7	1.2	0.5	0.60	1.4	0.9	1.26	0.48
8	1.8	1.0	1.80	2.7	1.9	5.13	0.35
9	2.5	1.2	3.00	3.9	2.5	9.75	0.31
10	1.6	0.7	1.12	2.3	1.2	2.76	0.41
11	2.0	0.8	1.60	2.6	1.4	3.64	0.44
12	2.1	0.9	1.89	3.0	1.9	5.70	0.33

Table A-2: Giant Pacific chiton, Gumboot chiton (*Cryptochiton stelleri*)

Specimen #	L foot (cm)	W foot (cm)	Area foot (cm)	L ventral surface (cm)	W ventral surface (cm)	Area (cm^2)	Ratio (foot/ventral surface)
1	15.5	5.5	85.25	23.5	17.7	414.95	0.20
2	17.8	5.5	97.90	22.8	12.9	273.60	0.36
3	22.3	4.5	100.35	28.7	15.4	441.98	0.23
4	19.2	4.3	82.56	24.9	14.4	358.56	0.23
5	21.0	5.6	117.60	28.0	14.7	411.60	0.29
6	17.1	5.7	97.47	22.5	11.7	263.25	0.37
7	17.8	5.0	89.00	22.7	16.5	374.55	0.24
8	14.4	4.0	57.60	20.0	14.0	280.00	0.21

The following figures are illustrations of the ventral surfaces of each of the *Polyplacophora* species collected for this experiment.

Table A-3: Katy chiton, black leather chiton (*Katharina tunicata*)

Specimen #	L foot (cm)	W foot (cm)	Area foot (cm)	L ventral surface (cm)	W ventral surface (cm)	Area (cm^2)	Ratio (foot/ventral surface)
1	9.0	3.8	34.20	12.0	6.3	75.60	0.45
2	7.3	3.2	23.36	11.9	6.9	82.11	0.31
3	9.6	3.5	33.60	12.1	6.4	77.44	0.43
4	9.7	3.2	31.04	12.2	6.0	73.20	0.42
5	8.7	3.3	28.71	12.0	6.6	79.20	0.36
6	6.2	2.4	14.88	8.4	4.8	40.32	0.37
7	7.4	2.9	21.46	9.1	4.5	40.95	0.52

Table A-4: Woody chiton (*Mopalia lignosa*)

Specimen #	L foot (cm)	W foot (cm)	Area foot (cm)	L ventral surface (cm)	W ventral surface (cm)	Area (cm^2)	Ratio (foot/ventral surface)
1	3.4	1.9	6.46	5.0	3.8	19.00	0.34
2	3.8	1.8	6.84	5.4	3.7	19.98	0.34
3	2.9	1.4	4.06	4.1	2.6	10.66	0.38
4	4.7	2.2	10.34	6.3	4.9	30.87	0.33
5	2.1	1.2	2.52	3.1	2.4	7.44	0.34

Table A-5: Gould's Baby chiton (*Cyanoplax dentiens*)

Specimen #	L foot (cm)	W foot (cm)	Area foot (cm)	L ventral surface (cm)	W ventral surface (cm)	Area (cm^2)	Ratio (foot/ventral surface)
1	0.8	0.4	0.32	1.2	0.8	0.96	0.33
2	0.9	0.3	0.27	1.3	0.7	0.91	0.30
3	1.1	0.5	0.55	1.6	0.9	1.44	0.38
4	1.2	0.5	0.60	1.6	0.9	1.44	0.42
5	1.7	0.6	1.02	2.1	1.0	2.10	0.49

Works Consulted and Cited

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