# Crab Leg Segment Length as a Variation of Environmental Specialization

**Ben Perry**
*Oregon Institute of Marine Biology, Charleston, Oregon 97420-0605, USA.*

## Introduction

Over the course of time, many species of crab have evolved to better suit their environment and make the most of their genetic limitations. One of the more novel adaptations of many crabs is the structural variation within their legs depending on their habitat and preferred feeding substrates. For instance, the family *Majidae* is recognized for their long, spindle-like legs and their resemblance to spiders [1]. Members of this family, such as *Pugettia producta* and *Pugettia gracilis* (appendix 1) are known for clinging to the kelp that they so often choose to devour, at depths ranging from the intertidal down past 128 meters [2]. On the other hand, the family *Grapsidae* is more familiar to those who leave no stones unturned at the seashore. *Hemigrapsus nudus* (appendix 2) is a very representative species of this family, very quick out of water compared to many other crabs. It has a very varied diet as an omnivore, from feeding on smaller animals to scavenging and scraping diatoms and algae off of rocks [1]. *H. nudus* even occasionally ravages freshly seeded oysters at oyster farms, bestowing on it quite the reputation as a pest [3]. *H. nudus* is also found fairly high in the intertidal zone, necessitating more efficient travel in both aqueous and sandy environments [2].

*Porcellanidae* is both a different family from both previously mentioned, as well as a different sub-order. Crabs in this family are Anomurans whereas the two previously mentioned families are Brachyuran [4]. The most important distinction to be made at this point is that Anomurans have only three pairs of walking legs to examine versus four pairs in the Brachyuran species examined. Notably, in this family, *Petrolisthes cinctipes* (appendix 2) is suited for a completely different lifestyle than any of the species mentioned earlier. It is a filter feeder, found under rocks and in mussel beds, in the high and mid-intertidal zones [4]. Each species examined thrives in its particular environment, and I believe that differences in the length of the dactyls of the species compared to total leg length are the reasons for this. Longer dactyls would allow for better grasping, aiding *P. producta* and *P. gracilis* in grasping the kelp they live on and devour. Shorter dactyls would allow *H. nudus* and *P. cinctipes* to travel more quickly on land and rocky intertidal areas, for both avoiding predation and finding sustenance.

## Methods

All specimens examined were collected from Coos County, Oregon. They were collected at several locations to minimize local variables that were out of experimental control. In addition, the specimens were not of the same size, both because finding identically sized individuals is extremely difficult and because the results would be more conclusive if they are determined to be independent of the size of the individual. The measurements taken were of the walking legs of the animals, not the chelopeds, and always with the same calipers. The lengths of the ischium, merus, carpus, propodus, and the dactyl segments were measured in centimeters for all specimens. The carapace length and width of each individual were also recorded in centimeters. Finally, the average segment length for each crab was compared to the average total leg length to give representative component percentages.

## Results

The complete data tables are shown in appendices 3 & 4, but some notable results follow. The average segment lengths per species versus total leg length are shown below.

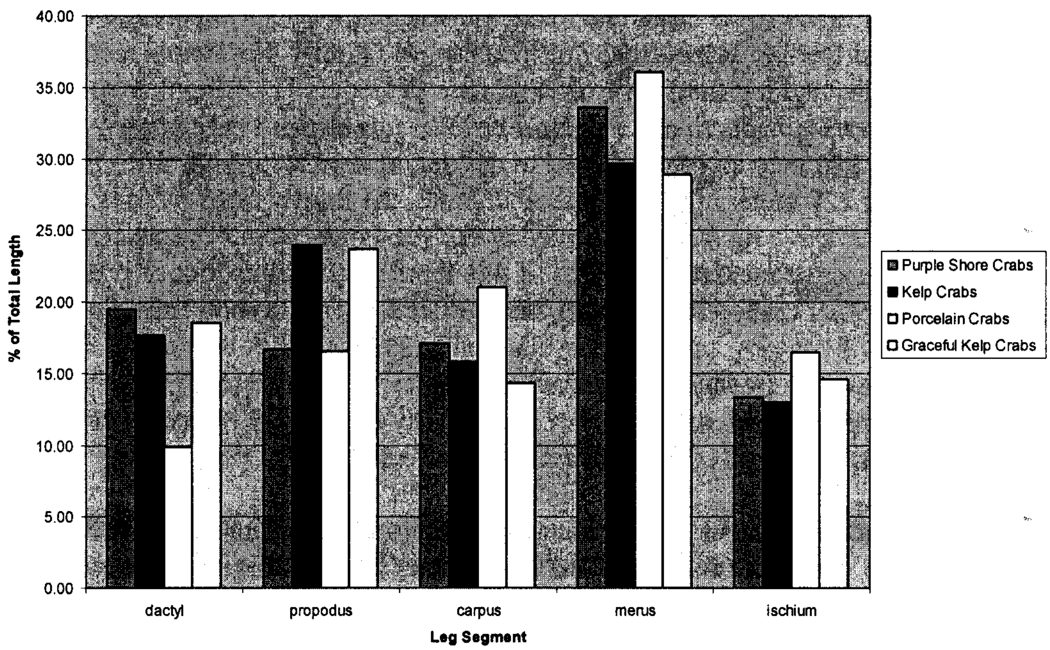



Fig. 1. Graph of % of Total Leg Length vs. Leg Segment

For *H. nudus,* the dactyl was 19.46%, the propodus was 16.68%, carpus was 14.99%, merus was 33.55%, and the ischium was 13.28% of the total leg length. For *P. producta,* the dactyl length was 17.63%, propodus was 23.96%, the carpus was 15.81%, the merus was 29.61%, and the ischium was 12.99% of total leg length. For *P. gracilis,* the dactyl length was 9.92%, propodus was 16.55%, the carpus was 21.03%, the merus was 36.02%, and the ischium was 16.48% of total leg length. Finally, for *P. cinctipes*, the dactyl length was 18.53%, the propodus was 23.69%, the carpus was 14.32%, the merus tallied 28.90%, and the ischium was 14.56%.

## Discussion

From the data collected, it would appear that the hypothesis has been falsified, at least to a point. The only species that showed significant deviation from the larger pattern was *P.*

*cinctipes*, which could have been for several reasons, other than actual truthful results. The specimens collected could have been aberrations compared to the standard morphology, there could have been operator error in utilizing the calipers (precision-wise or visual misreading), or almost as likely the calipers could have been improperly calibrated by improper storage and usage among other things.

The measurements quantified in regards to the merus leg segment are somewhat tainted in terms of this experiment, so it is not as easy to make conclusions. The crabs were agitated upon being measured, and with the segment being so close to the body, it would have been easy to accidentally short-change a measurement. In some cases, the crab's flailing made overestimating the leg segment a very likely mistake by taking into account part of the ischium segment's measure.

However, an interesting pattern arose that was unforeseen in this experiment. It seems that the proportional length of the propodus leg segment varied much more between species than any other segment. There was close to a 10% range in variation between the four species tested. This makes sense, because the propodus segment would be advantageous as a longer segment in the species from family *Majidae*, as they are known to grasp onto the kelp they eat. The longer segment would allow for the legs to completely wrap around the outside of the kelp segment and utilize the dactyls on the reverse side to dig in and grasp firmly to resist dislodging and wave action. In *H. nudus* and *P. cinctipes*, there is less grasping necessary, and more general terrestrial motion required, so a shorter propodus is much more beneficial towards creating short compact movements that require little grasping action. This is by no means a final conclusion, and it would be incredibly beneficial to expand the sample size and include many more species from varied habitats to see if the results stand up to the idea presented in this exploratory experiment.

References

1. Jensen, Gregory. Pacific Coast Crabs and Shrimps. Monterery, CA: Inter Print, 1995.

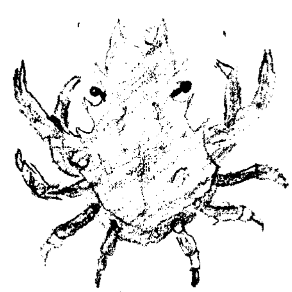
2. Lamb, Andy, and Bernard P. Hanby. Marine Life of the Pacific Northwest: A Photographic Encyclopedia of Invertebrates, Seaweeds and Selected Fishes. Madeira Park, BC, Canada: Harbour Publishing, 2005.

3. Yamada, Sylvia Behrens and Elizabeth G. Boulding. "Claw morphology, prey size selection and foraging efficiency." Journal of Experimental Marine Biology and Ecology 1998 191-211. 14 07 2007.

4. Sept, J. Duane. The Beachcomber's Guide to Seashore Life in the Pacific Northwest. Madeira Park, BC, Canada: Harbour Publishing, 1999.

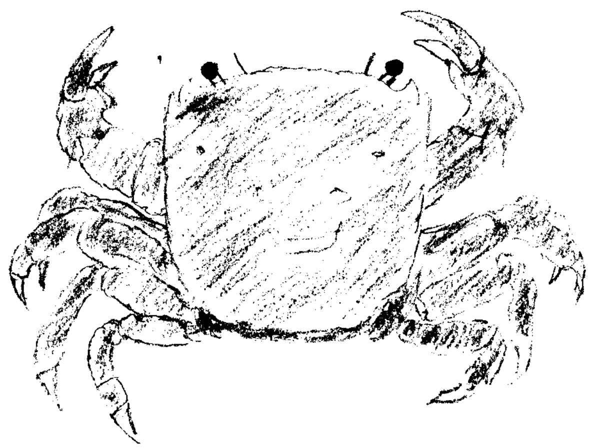
# Appendix 1

Kelp Crab
(*Pugettia producta*)
At 1X plate magnification

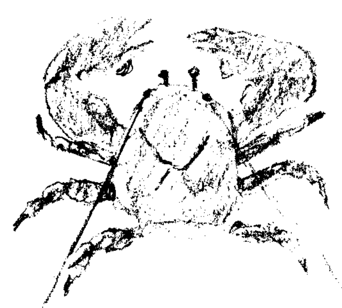


Grateful Kelp Crab
(*Pugettia gracilis*)
At 1x plate magnification

# Appendix 2



Purple Shore Crab
(Hemigrapsus nudus)
At 1X plate magnification



Flat Porcelain Crab
(Petrolisthes cintipes)
At 1X plate magnification

# Appendix 3

| | Handicapable Purple Shore Crab | Larger Purple Shore "Killer" | Large Muddy Kelp Crab | Handicapable Kelp Crab |
|---|---|---|---|---|
| carapace | carapace | carapace | carapace | carapace |
| W | W: 2.9cm | W: 3.75cm | W: 3.9cm | W: 2.4cm |
| L | L: 2.85cm | L: 3.22cm | L: 5.08cm | L: 3.3cm |
| **Dactyl** | | | | |
| 1 | 0.45 | 0.49 | 0.85 | 0.48 |
| 2 | 0.80 | 0.90 | 1.01 | 0.59 |
| 3 | 0.89 | 1.00 | 1.11 | 0.67 |
| 4 | 0.50 | 0.85 | 1.25 | 0.69 |
| 5 | 0.40 | 0.60 | 0.89 | X |
| 6 | 0.70 | 0.89 | 0.94 | X |
| 7 | 0.75 | 0.92 | 1.13 | 0.61 |
| 8 | 0.70 | 0.90 | 1.19 | 0.68 |
| A | 0.65 | 0.82 | 1.05 | 0.62 |
| **Propodus** | | | | |
| 1 | 0.32 | 0.54 | 1.25 | 0.72 |
| 2 | 0.72 | 0.90 | 1.29 | 0.76 |
| 3 | 0.60 | 0.88 | 1.36 | 0.80 |
| 4 | 0.55 | 0.62 | 1.55 | 1.02 |
| 5 | 0.41 | 0.49 | 1.26 | X |
| 6 | 0.65 | 0.88 | 1.28 | X |
| 7 | 0.51 | 0.90 | 1.39 | 0.90 |
| 8 | 0.48 | 0.69 | 1.60 | 1.04 |
| A | 0.53 | 0.74 | 1.37 | 0.87 |
| **Carpus** | | | | |
| 1 | 0.50 | 0.75 | 0.92 | 0.52 |
| 2 | 0.68 | 0.85 | 0.96 | 0.58 |
| 3 | 0.59 | 0.84 | 0.97 | 0.55 |
| 4 | 0.30 | 0.70 | 0.89 | 0.59 |
| 5 | 0.50 | 0.90 | 0.90 | X |
| 6 | 0.60 | 1.02 | 0.91 | X |
| 7 | 0.25 | 0.95 | 0.95 | 0.59 |
| 8 | 0.40 | 0.72 | 0.93 | 0.54 |
| A | 0.48 | 0.84 | 0.93 | 0.56 |
| **Merus** | | | | |
| 1 | 0.90 | 1.12 | 1.52 | 0.98 |
| 2 | 1.28 | 1.20 | 1.59 | 0.99 |
| 3 | 1.30 | 1.21 | 1.67 | 1.06 |
| 4 | 1.29 | 1.41 | 1.89 | 1.14 |
| 5 | 0.90 | 1.26 | 1.59 | X |
| 6 | 1.23 | 1.55 | 1.63 | X |
| 7 | 1.25 | 1.76 | 1.77 | 1.08 |
| 8 | 1.10 | 1.36 | 1.96 | 1.20 |
| A | 1.16 | 1.36 | 1.70 | 1.08 |
| **Ischium** | | | | |
| 1 | 0.41 | 0.56 | 0.68 | 0.48 |
| 2 | 0.50 | 0.72 | 0.72 | 0.52 |
| 3 | 0.45 | 0.61 | 0.69 | 0.50 |
| 4 | X | 0.64 | 0.73 | 0.49 |
| 5 | 0.32 | 0.65 | 0.72 | X |
| 6 | 0.29 | 0.61 | 0.69 | X |
| 7 | X | 0.71 | 0.71 | 0.53 |
| 8 | 0.27 | 0.74 | 0.70 | 0.47 |
| A | 0.37 | 0.66 | 0.71 | 0.50 |
| Avg Total Leg Length | 3.19 | 4.41 | 5.76 | 3.63 |

| Percentage of each part | | | | |
|---|---|---|---|---|
| dactyl | 20.36 | 18.56 | 18.18 | 17.09 |
| propodus | 16.64 | 16.72 | 23.85 | 24.07 |
| carpus | 14.99 | 19.07 | 16.14 | 15.48 |
| merus | 36.29 | 30.80 | 29.58 | 29.63 |
| ischium | 11.72 | 14.85 | 12.25 | 13.73 |

Appendix 4

| | Porcelain Crab A | Porcelain Crab Bluestripe | Small Graceful Kelp Crab | Larger Graceful Kelp Crab |
|---|---|---|---|---|
| carapace | W: 1.66cm<br>L: 1.75cm | W: 1.40cm<br>L: 1.60cm | W: 1.40cm<br>L: 2.00cm | W: 1.8cm<br>L: 2.35cm |
| **Dactyl** | | | | |
| 1 | 0.22 | 0.21 | 0.44 | 0.39 |
| 2 | 0.19 | 0.18 | 0.41 | 0.49 |
| 3 | 0.19 | 0.18 | 0.46 | 0.53 |
| 4 | NA | NA | 0.51 | 0.61 |
| 5 | 0.20 | 0.19 | 0.34 | 0.40 |
| 6 | 0.25 | 0.22 | 0.44 | 0.43 |
| 7 | 0.24 | 0.20 | 0.46 | 0.49 |
| 8 | NA | NA | 0.52 | 0.64 |
| A | 0.22 | 0.20 | 0.45 | 0.50 |
| **Propodus** | | | | |
| 1 | 0.29 | 0.31 | 0.38 | 0.59 |
| 2 | 0.31 | 0.34 | 0.44 | 0.62 |
| 3 | 0.39 | 0.31 | 0.52 | 0.64 |
| 4 | NA | NA | 0.73 | 0.87 |
| 5 | 0.37 | 0.34 | 0.42 | 0.56 |
| 6 | 0.40 | 0.32 | 0.48 | 0.65 |
| 7 | 0.38 | 0.36 | 0.51 | 0.68 |
| 8 | NA | NA | 0.72 | 0.91 |
| A | 0.36 | 0.33 | 0.53 | 0.69 |
| **Carpus** | | | | |
| 1 | 0.42 | 0.39 | 0.28 | 0.34 |
| 2 | 0.49 | 0.43 | 0.31 | 0.35 |
| 3 | 0.50 | 0.38 | 0.34 | 0.37 |
| 4 | NA | NA | 0.41 | 0.38 |
| 5 | 0.41 | 0.42 | 0.29 | 0.37 |
| 6 | 0.44 | 0.44 | 0.42 | 0.35 |
| 7 | 0.48 | 0.44 | 0.38 | 0.36 |
| 8 | NA | NA | 0.48 | 0.39 |
| A | 0.46 | 0.42 | 0.36 | 0.36 |
| **Merus** | | | | |
| 1 | 0.78 | 0.61 | 0.58 | 0.55 |
| 2 | 0.89 | 0.63 | 0.64 | 0.69 |
| 3 | 0.89 | 0.65 | 0.69 | 0.79 |
| 4 | NA | NA | 0.86 | 1.04 |
| 5 | 0.79 | 0.66 | 0.60 | 0.61 |
| 6 | 0.89 | 0.69 | 0.62 | 0.72 |
| 7 | 0.91 | 0.68 | 0.71 | 0.81 |
| 8 | NA | NA | 0.83 | 1.06 |
| A | 0.86 | 0.65 | 0.69 | 0.78 |
| **Ischium** | | | | |
| 1 | 0.42 | 0.18 | 0.31 | 0.39 |
| 2 | 0.43 | 0.26 | 0.36 | 0.33 |
| 3 | 0.47 | 0.29 | 0.35 | 0.41 |
| 4 | NA | NA | 0.37 | 0.44 |
| 5 | 0.41 | 0.19 | 0.31 | 0.38 |
| 6 | 0.48 | 0.28 | 0.38 | 0.36 |
| 7 | 0.49 | 0.32 | 0.39 | 0.39 |
| 8 | NA | NA | 0.35 | 0.42 |
| A | 0.45 | 0.25 | 0.35 | 0.39 |
| Avg Total Leg Length | 2.34 | 1.85 | 2.38 | 2.73 |

| Percentage of each part | | | | |
|---|---|---|---|---|
| dactyl | 9.20 | 10.63 | 18.80 | 18.26 |
| propodus | 15.26 | 17.84 | 22.06 | 25.32 |
| carpus | 19.54 | 22.52 | 15.28 | 13.35 |
| merus | 36.73 | 35.32 | 29.04 | 28.76 |
| ischium | 19.26 | 13.69 | 14.81 | 14.31 |