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***Hemigrapsus nudus* and *Pachygrapsus crassipes*: A comparison of speed due to structural differences**

Introduction

The Oregon coastline has many intertidal species of crab, ranging from small anomuran porcelain crabs, to large *Cancer productus* and *magister* crabs. Most of these crabs are fairly distinct in their appearance, but two stand out because of their similarity. *Hemigrapsus nudus* (purple shore crab) and *Pachygrapsus crassipes* (lined shore crab) are fairly similar in shape and size, and usually it takes a close look to distinguish between the two species. The most apparent difference is that *Hemigrapsus* has purple spots with a white background on its chelipeds, while *Pachygrapsus* has a striped carapace and un-dotted chelipeds.

Since the two species are so similar in appearance, it would be expected that both crabs would have similar speeds when avoiding capture, but this is not the case. When a rock is overturned and a *Hemigrapsus* is exposed, it is fairly easy to capture before it reaches cover. When a *Pachygrapsus* is exposed in a similar manner, it is very difficult to catch the crab before it finds a crevice or other rock to hide in. The difference in speed between the two crabs is considerable.

The purpose of this experiment is to test the hypothesis that the difference in speed arises from a physical difference between the two crabs. Three factors will be explored to try to find a physical difference between the two crabs that could at least partially explain the difference in speed between the two crabs. First, the relationship

between body mass and leg mass will be tested. Perhaps a crab with a higher leg mass to total body mass ratio would have an advantage through higher leg strength. The second test will be overall leg length compared to carapace width. Since the crabs will all be different size, the ratio of leg length to carapace width will hopefully give a way of comparing relative leg length between species. The third will be individual segments of the leg compared to the carapace width, to see if leg composition plays a role in speed.

Methods

Five *Hemigrapsus*, and five *Pachygrapsus* crabs were collected over a several day period (July 5-8) from the rocks across Boat Basin road from OIMB, and from South Cove at Cape Arago State Park. Selecting factors for the crabs were size (the largest 5 of each species collected were used) and the crabs needed all their limbs intact. The crabs were frozen and thawed for handling purposes. A digital scale accurate to .01g was used for weight measurements, and a hand caliper marked at 1mm intervals was used for all distance measurements. The crab was dried of all excess moisture and weighed. Carapace width and total leg length for the four walking legs was then measured by caliper. Each of the five walking leg segments was then measured by caliper. The eight walking legs were then removed by hand, and weighed. A diagram of leg number and measurement methods is on page 5.

Results

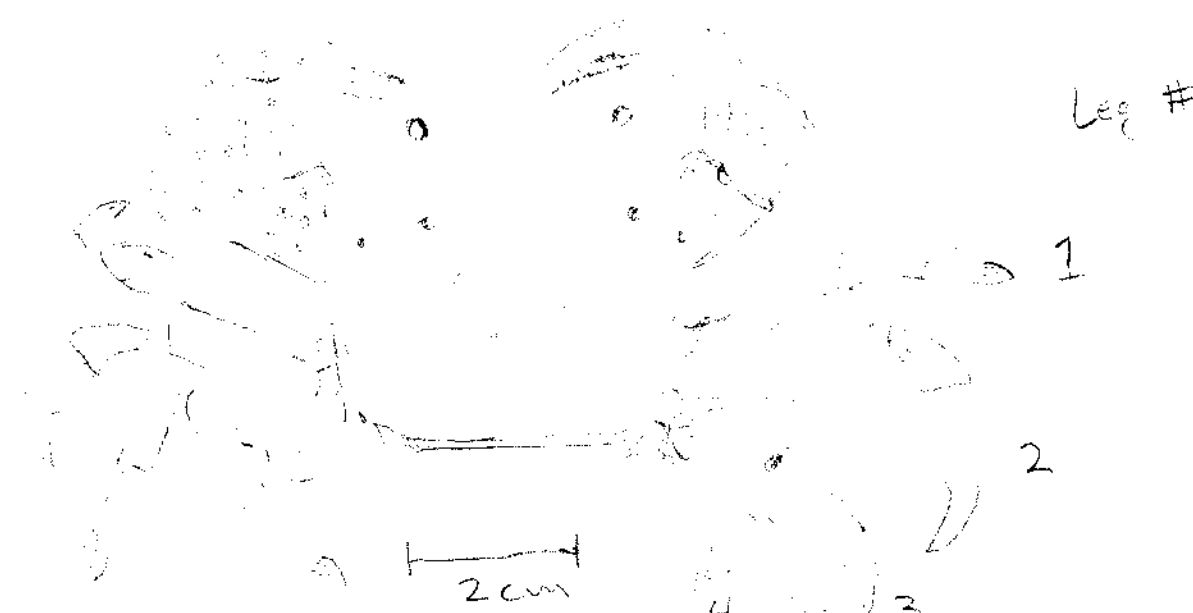
The first of the three tests was the leg weight / body weight test. Both crabs had an average of 23% for leg/body weight. (See top of page 6 & bottom of page 10 for graph) The second test was overall leg length compared to carapace width. For the *Pachygrapsus*, leg one on average was 109% the width of the carapace, leg two, 131%, leg three, 125%, and leg four at 108%. The *Hemigrapsus* results were 101% for leg one, 122% for leg two, 119% for leg three, and 88% for leg four. (See bottom of page 6 & top of page 10 for graph) The third test was leg segment / carapace width. Page 7 details the average segment/carapace ratio by leg segment and leg number for each species. Pages 8-9 graph the average ratios by species and leg number. Pages 11-15 show individual *Hemigrapsus* data, summarized on page 16. Pages 17-21 show individual *Pachygrapsus* data, summarized on page 22. On average, *Hemigrapsus* has a longer dactyl except on leg 4. *Pachygrapsus* has a longer propodus on each of the legs. *Hemigrapsus* has a longer carpus on legs 1 & 2, but *Pachygrapsus* has a longer caprus on legs 3 & 4. *Pachygrapsus* has an equal merus on legs 2 & 3, and a longer merus on 1 & 4. *Hemigrapsus* has an equal Ischium on legs 1 & 2, and a longer ischium on legs 3 & 4.

Conclusion

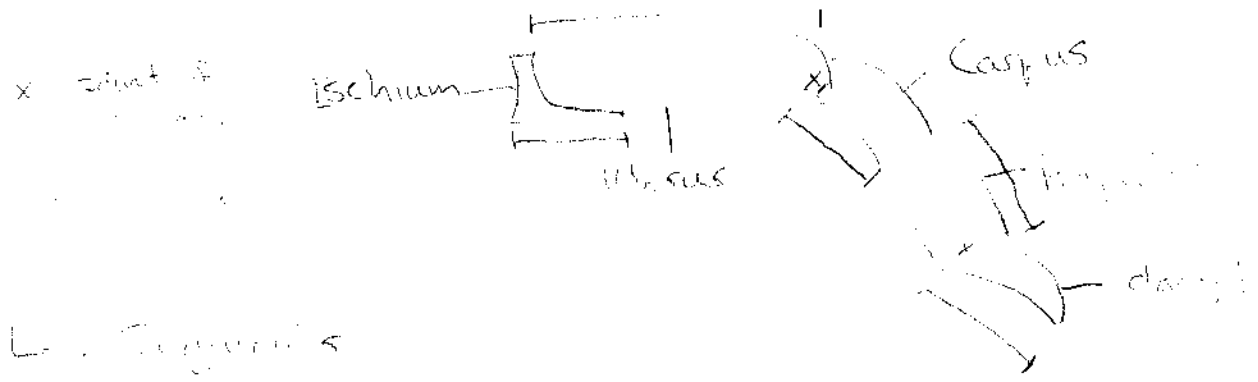
It seems logical to discard leg weight as a factor that could explain the difference in speed between the two species. In this test the ratio was the same to a hundredth of a gram, a fairly convincing statement. Overall leg length is a more likely possibility. The *Pachygrapsus* in all legs had longer legs proportional to its carapace. Every step the *Pachygrapsus* takes, it covers more ground (assuming that each leg rotates an equal number of degrees) and should make its motion faster. Coupled with a shorter ischium

on average (which could increase muscle leverage for rotation) this is a plausible explanation. The *Pachygrapsus* also has a longer merus on average. The merus contains the muscle that is connected to the carpus, the other main joint the leg. The longer merus may give *Pachygrapsus* more muscle mass to extend and contract the carpus. This would give *Pachygrapsus* another advantage in speed over *Hemigrapsus*. The other joints are less important in locomotion, since they do not pivot to the degree that the ischium-body joint and merus-carpus joint do. It is probable that a large amount of the difference is behavioral, *Pachygrapsus* is a higher intertidal animal than *Hemigrapsus*, and is probably subject to predation by mammals and birds more than *Hemigrapsus* is. Quick reflexes and speed would seem to be more important for *Pachygrapsus*' survival than *Hemigrapsus*. A test on behavior, specifically predator avoidance would shed more light on the issue.

The difference in speed between *Pachygrapsus crassipes* and *Hemigrapsus nudus* is, at least in part, due to physical differences. Specifically overall leg length and ischium and merus lengths. Weight is equivalent between the crabs and is not a significant factor.



Stomatopoda nuchus



L. Tigrinus



Parastomatopoda (Stomatopoda)

weights and total leg lengths

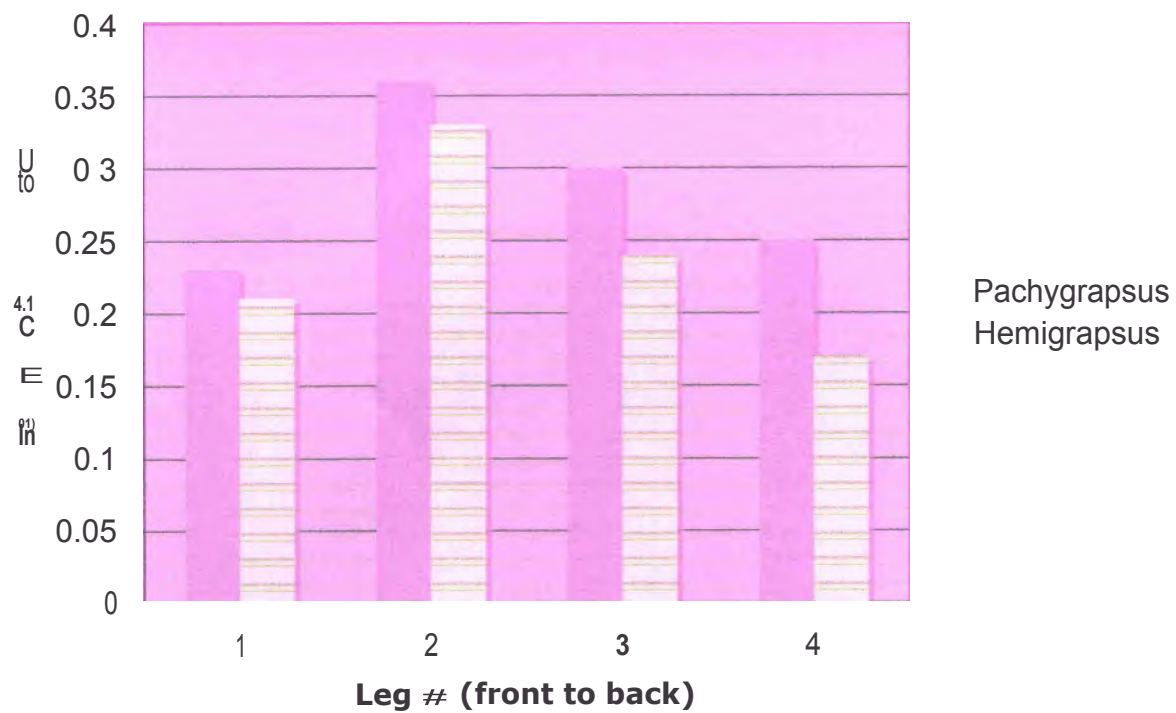
all units in mm or g

Pachygrapsus			Ratio (bodyffeg-)		averages
(rah 0	Body weight	Leg weight	Columnl		
1.00	18.14	4.06	0.22		
2.00	18.16	4.00	0.22		
3.00	21.76	4.58	0.21	eggs	
4.00	12.80	3.22	0.25		
5.00	10.76	2.56	0.24	eggs	0.23
Hemigrapsus					
C,3L	Body weight	Leg weight			
1.00	29.33	7.08	0.24		
2.00	41.24	8.63	0.21		
3.00	22.18	4.41	0.20		
4.00	12.22	3.11	0.25		
5.00	14.46	3.81	0.26		0.23
Pachygrapsus overal leg length (mm)					
	front	second	third	fourth	carapice
1.00	30.90	36.00	36.50	30.90	29.90
2.00	38.00	42.10	34.90	32.00	33.80
3.00	38.00	48.20	46.00	39.80	35.90
4.00	33.60	39.90	39.80	33.50	28.80
5.00	30.10	37.80	38.90	32.10	27.90
average	34.12	40.80	39.22	33.66	31.26
	1.09	1.31	1.25	1.08	
Hemigrapsus overal leg length (mm)					
1.00	38.55	46.50	44.50	32.00	37.00
2.00	45.30	55.00	51.90	38.00	43.50
3.00	36.90	44.20	42.50	32.50	36.20
4.00	30.00	34.00	38.00	26.00	31.00
5.00	33.00	42.30	40.10	30.90	34.00
average	36.75	44.40	43.40	31.88	36.34
avg ratio	1.01	1.22	1.19	0.88	

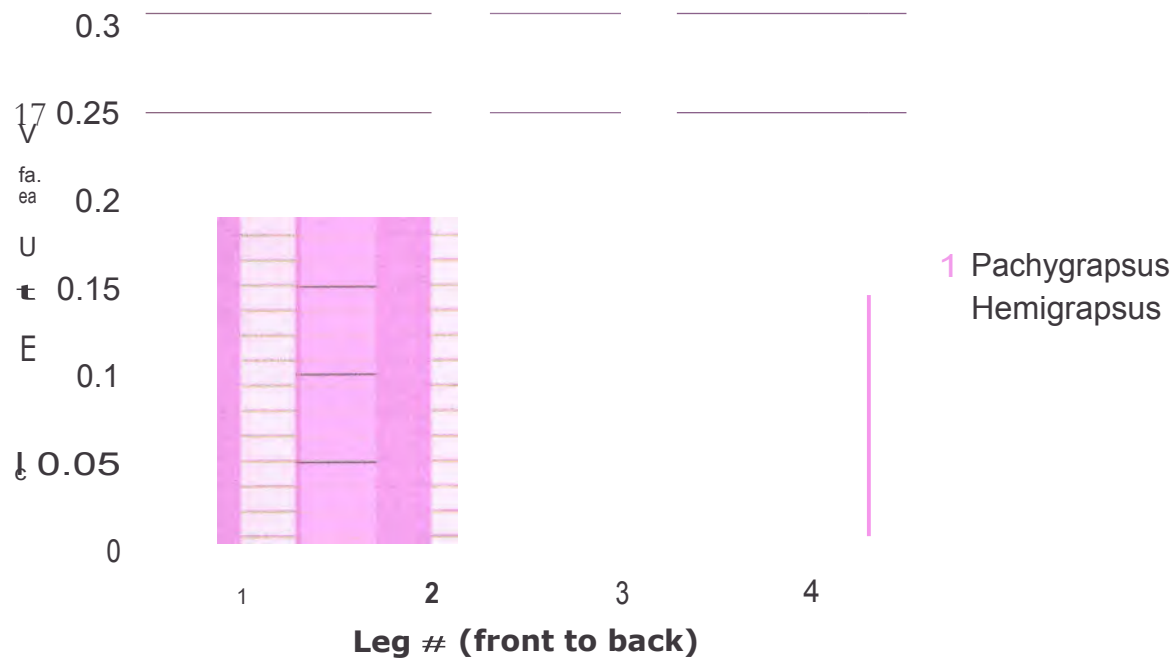
Pachygrapsus vs. Hemigrapsus se ment cari ice ratio

	Pachygrapsus	Hemigrapsus
lattluni	Pachygrapsus	Hemigrapsus
	0.2	<u>0.2</u>
2	0.2	0.2
	0.18	0.2
4	0.17	0.19
merus	Pachygrapsus	Hemigrapsus
1	0.4	<u>0.35</u>
2	0.45	0.45
3	0.42	0.42
4	0.4	0.33
carpus	Pachygrapsus	Hemigrapsus
1	0.2	0.21
2	0.22	0.23
3	0.22	0.21
	0.21	0.2
propodus	Pachygrapsus	Hemigrapsus
1	0.23	0.21
2	0.36	0.33
3	0.3	0.24
4	0.25	0.17
dactyl	Pachygrapsus	Hemigrapsus
1	0.19	0.23
	0.24	0.27
3	0.24	0.26
4	0.21	0.16

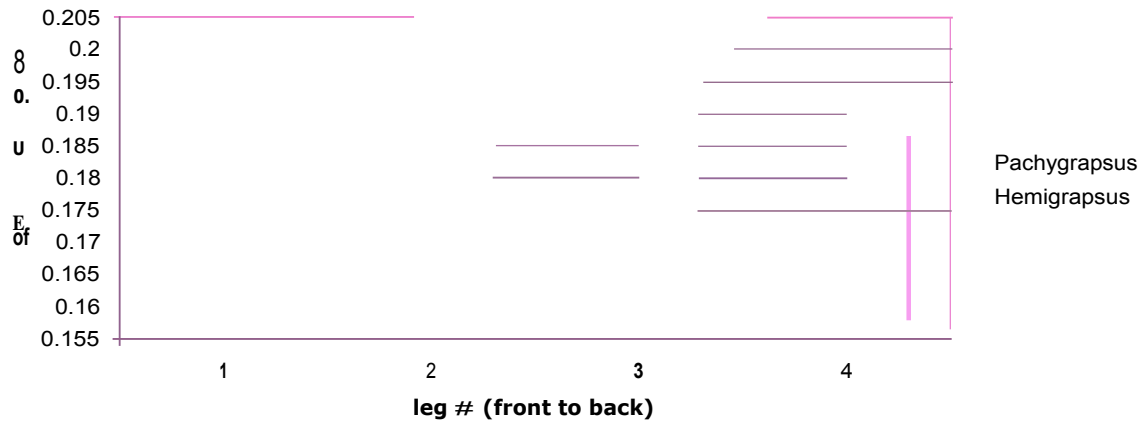
propodus segment/carapace



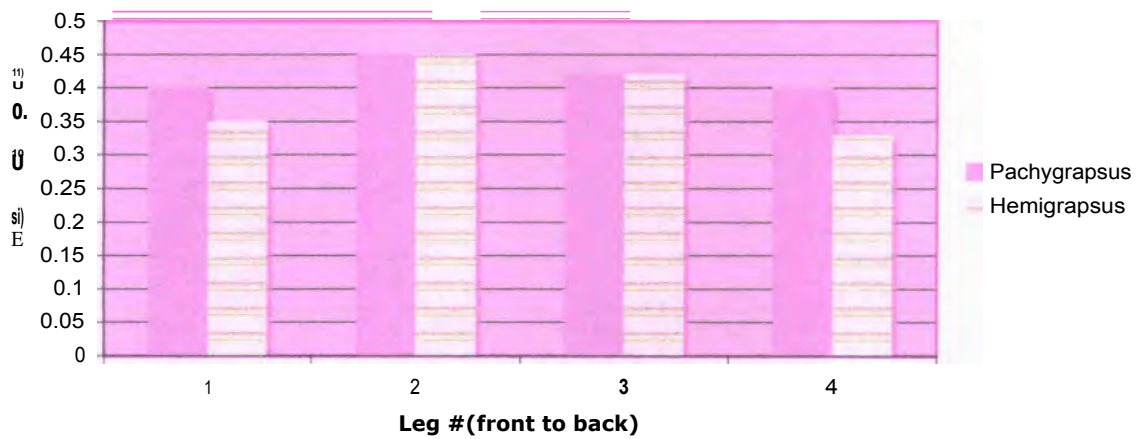
dactyl segment/carapace



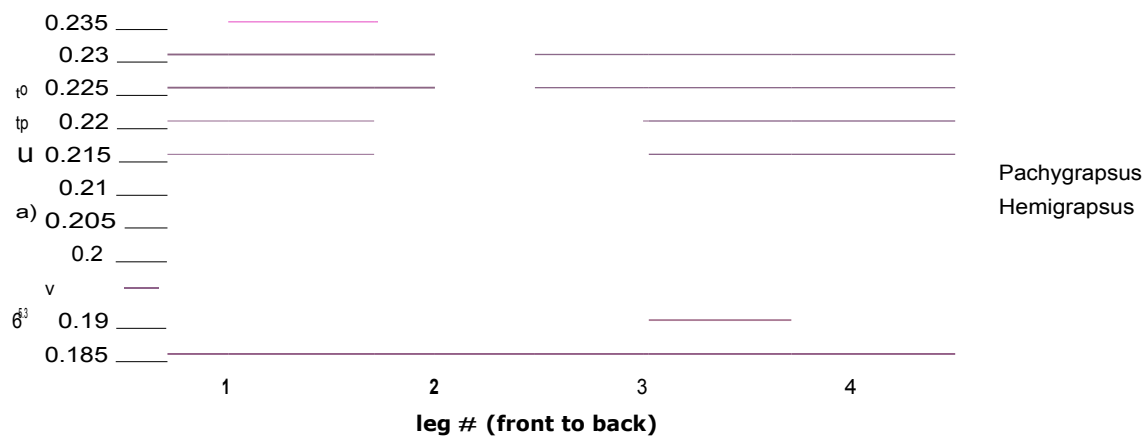
Ishium segment/carapace



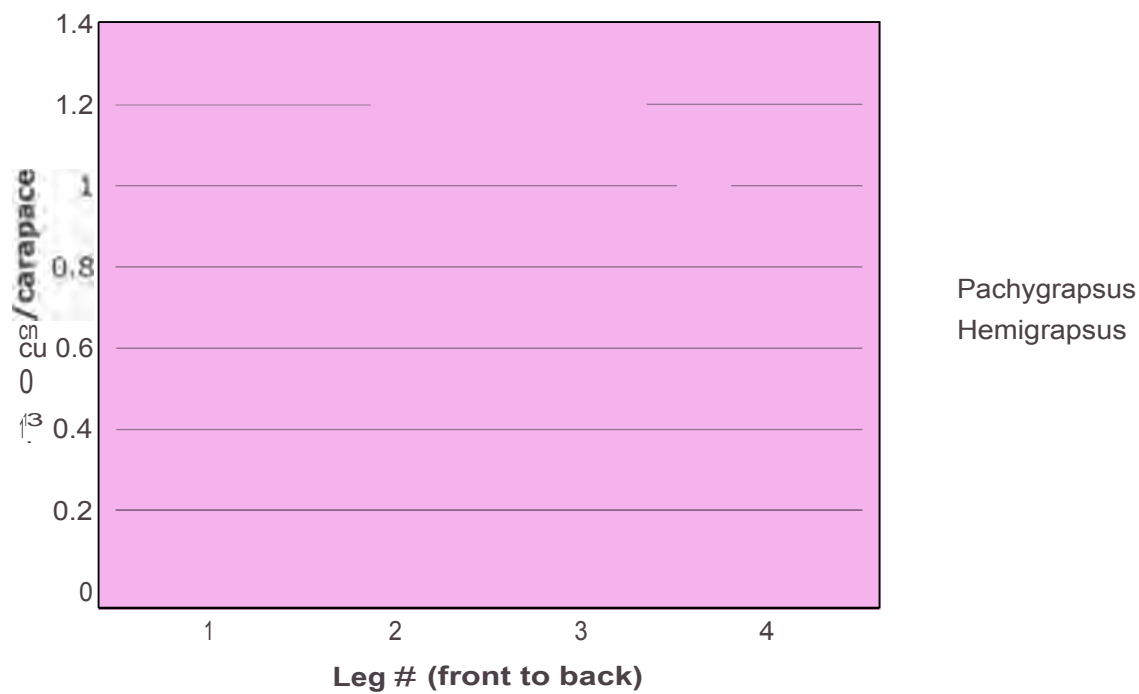
Merus segment/carapace



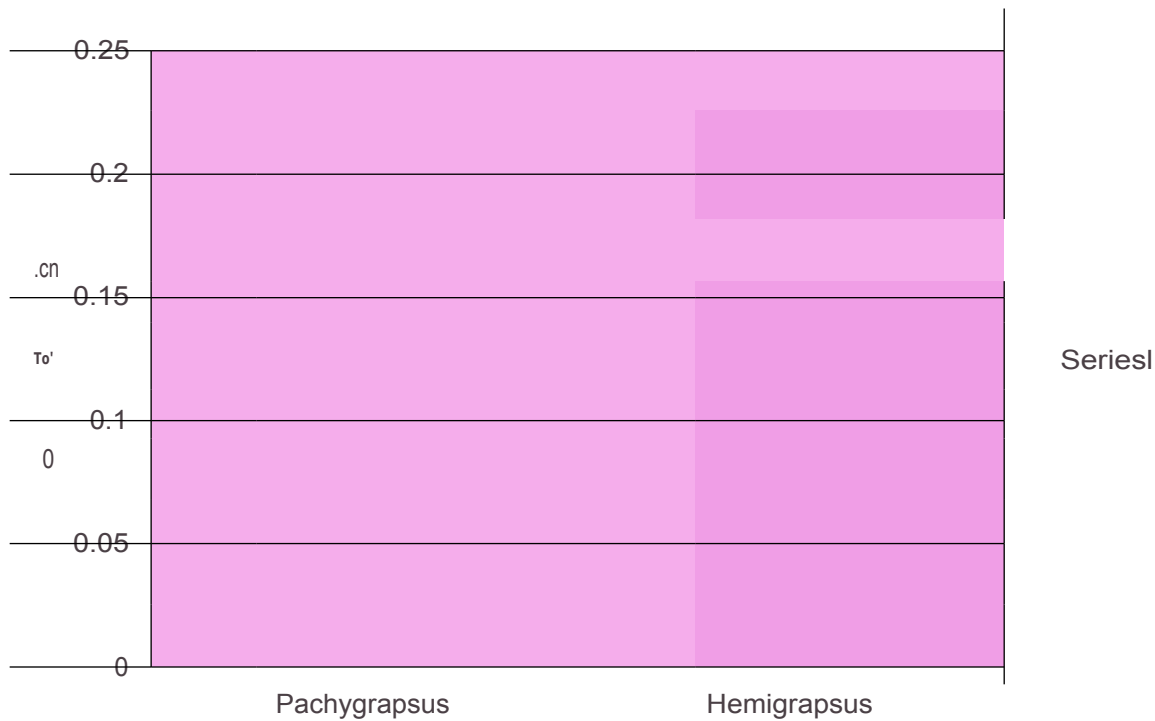
Carpus segment/carapace



Overall Leg Length



Leg weight



Hemigrapsus data

Crab them	length(mm)	ratio(segment/carapice)	
Carapice	37.00		
ischium	7.90	0.21	
merus	14.00	0.38	
carpus	9.50	0.26	
propodus	7.00	0.19	
dactyl	7.00	0.19	
leg 2	length(mm)	ratio (seg ment/ca ra pice)	
Carapice	37.00		
ischium	8.20	0.22	
merus	18.50	0.50	
carpus	8.00	0.22	
propodus	10.00	0.27	
dactyl	10.00	0.27	
leg 3	length(mm)	ratio(segment/carapice)	
Carapice	37.00		
ischium	6.90	0.19	
merus	14.50	0.39	
carpus	8.00	0.22	
propodus	8.00	0.22	
dactyl	9.00	0.24	
leg 4	length(mm)	ratio (segment/ca ra pice)	
Carapice	37.00		
ischium	8.00	0.22	
merus	13.00	0.35	
carpus	8.10	0.22	
propodus	6.50	0.18	
dactyl	6.00	0.16	

Hemigrapsus data

Crab 2hem	length(mm)	ratio(segment/carapice)	
Carapice	43.50		
ischium	8.10	0.19	
merus	15.50	0.36	
carpus	9.00	0.21	
propodus	9.90	0.23	
dactyl	10.00	0.23	
leg 2	length(mm)	ratio (segment/cara pice)	
Carapice	43.50		
ischium	8.40	0.19	
merus	19.00	0.44	
carpus	9.50	0.22	
propodus	11.00	0.25	
dactyl	11.60	0.27	
leg 3	length(mm)	ratio(segment/carapice)	
Carapice	43.50		
ischium	8.50	0.20	
merus	19.00	0.44	
carpus	9.00	0.21	
propodus	10.00	0.23	
dactyl	11.90	0.27	
leg 4	length(mm)	ratio(segment/carapice)	
Carapice	43.50		
ischium	8.90	0.20	
merus	13.20	0.30	
carpus	8.00	0.18	
propodus	8.00	0.18	
dactyl	7.00	0.16	

Hemigrapsus data

Crab 3hem	length(mm)	ratio(segment/carapice)	
Carapice	36.20		
ischium	7.00	0.19	
merus	12.10	0.33	
carpus	7.00	0.19	
propodus	7.90	0.22	
dactyl	8.50	0.23	
leg 2			
Carapice	36.20		
ischium	7.30	0.20	
merus	16.20	0.45	
carpus	8.10	0.22	
propodus	9.50	0.26	
dactyl	10.50	0.29	
leg 3			
Carapice	36.20		
ischium	7.10	0.20	
merus	15.60	0.43	
carpus	8.10	0.22	
propodus	9.00	0.25	
dactyl	10.10	0.28	
leg 4			
Carapice	36.20		
ischium	6.10	0.17	
merus	12.00	0.33	
carpus	6.90	0.19	
propodus	6.90	0.19	
dactyl	6.00	0.17	

Hemigrapsus data

Crab 4hem	length(mm)	ratio(segment/carapice)	
Carapice	31.00		
ischium	6.00	0.19	
merus	10.60	0.34	
carpus	6.10	0.20	
propodus	6.50	0.21	
dactyl	7.10	0.23	
leg 2	length(mm)	ratio(segment/carapice)	
Carapice	31.00		
ischium	6.20	0.20	
merus	11.50	0.37	
carpus	6.20	0.20	
propodus	8.50	0.27	
dactyl	7.50	0.24	
leg 3	length(mm)	ratio(segment/carapice)	
Carapice	31.00		
ischium	6.00	0.19	
merus	13.10	0.42	
carpus	5.60	0.18	
propodus	8.00	0.26	
dactyl	8.00	0.26	
leg 4	length(mm)	ratio(segment/carapice)	
Carapice	31.00		
ischium	5.50	0.18	
merus	9.90	0.32	
carpus	6.00	0.19	
propodus	5.00	0.16	
dactyl	5.00	0.16	

Hemigrapsus data

Crab 5hem	length (mm)	ratio(segment/	carapice)
Carapice	34.00		
ischium	8.00	0.24	
merus	11.90	0.35	
carpus	6.70	0.20	
propodus	7.50	0.22	
dactyl	8.50	0.25	
leg 2			
Carapice	34.00		
ischium	6.60	0.19	
merus	16.00	0.47	
carpus	9.10	0.27	
propodus	9.50	0.28	
dactyl	9.10	0.27	
leg 3			
Carapice	34.00		
ischium	8.50	0.25	
merus	15.00	0.44	
carpus	8.20	0.24	
propodus	8.10	0.24	
dactyl	9.00	0.26	
leg 4			
Carapice	34.00		
ischium	6.20	0.18	
merus	11.90	0.35	
carpus	7.00	0.21	
propodus	5.00	0.15	
dactyl	5.90	0.17	

Hemigrapsus data

Average Hemigrapsus leg segment length ratios

leg	avg. ratio
ischium	
1	0.20
2	0.20
3	0.20
4	0.19
merus	
1	0.35
2	0.45
3	0.42
4	0.33
carpus	
1	0.21
2	0.23
3	0.21
4	0.20
propodus	
1	0.21
2	0.33
3	0.24
4	0.17
dactyl	
1	0.23
2	0.27
3	0.26
4	0.16

Pachygrapsus data

Crab 1. ac	length mm	ratio seement	
Carapice			
ischium			
merus			
carpus			
propodus			
dactyl			
.	.	.	
Carapice			
carpus			
propodus			
dactyl			
.	.	.	н
Ca rap ice	29.90		
ischium	6.10		
merus	9.50		
carpus			
propodus			
dactyl			
le ^g		.	u
Carapice	29.90		
ischium	5.60	0.19	
merus	12.90	0.43	
carpus	5.90	0.20	
propodus	8.10	0.27	
dactyl	6.90	0.23	

Pachygrapsus data

crab 2pac	length(mm)	ratio(segment/carapice)	
Carapice	33.80		
ischium	7.00	0.21	
merus	12.90	0.38	
carpus	6.20	0.18	
propodus	7.20	0.21	
dactyl	6.90	0.20	
leg 2	length(mm)	ratio (seg ment/ca ra pice)	
Carapice	33.80		
ischium	6.50	0.19	
merus	14.80	0.44	
carpus	7.20	0.21	
propodus	10.00	0.30	
dactyl	7.90	0.23	
leg 3	length(mm)	ratio(segment/carapice)	
Carapice	33.80		
ischium	6.20	0.18	
merus	14.00	0.41	
carpus	7.20	0.21	
propodus	9.90	0.29	
dactyl	9.10	0.27	
leg 4	length(mm)	ratio(segment/carapice)	
Carapice	33.80		
ischium	6.00	0.18	
merus	13.10	0.39	
carpus	6.10	0.18	
propodus	8.20	0.24	
dactyl	6.20	0.18	

Pachygrapsus data

crab 3pac	length(mm)	ratio(segment/carapice)	
Carapice	35.90		
ischium	7.00	0.19	
merus	13.00	0.36	
carpus	7.00	0.19	
propodus	7.00	0.19	
dactyl	7.10	0.20	
leg 2	length(mm)	ratio(segment/carapice)	
Carapice	35.90		
ischium	6.90	0.19	
merus	14.90	0.42	
carpus	7.10	0.20	
propodus	9.90	0.28	
dactyl	8.10	0.23	
leg 3	length(mm)	ratio (segment/cara pice)	
Carapice	35.90		
ischium	6.30	0.18	
merus	15.60	0.43	
carpus	7.00	0.19	
propodus	10.90	0.30	
dactyl	8.30	0.23	
leg 4	length(mm)	ratio(segment/carapice)	
Carapice	35.90		
ischium	6.00	0.17	
merus	13.10	0.36	
carpus	7.00	0.19	
propodus	7.90	0.22	
dactyl	7.20	0.20	

Pachygrapsus data

crab 4pac	length(mm)	ratio (seg ment/cara pice)	
Carapice	28.80		
ischium	5.20	0.18	
merus	12.50	0.43	
carpus	6.20	0.22	
propodus	7.10	0.25	
dactyl	5.50	0.19	
leg 2	length(mm)	ratio(segment/carapice)	
Carapice	28.80		
ischium	6.00	0.21	
merus	13.00	0.45	
carpus	6.10	0.21	
propodus	8.10	0.28	
dactyl	6.70	0.23	
leg 3	length(mm)	ratio(segment/carapice)	
Carapice	28.80		
ischium	5.10	0.18	
merus	14.00	0.49	
carpus	6.00	0.21	
propodus	8.60	0.30	
dactyl	6.90	0.24	
leg 4	length(mm)	ratio(segment/carapice)	
Carapice	28.80		
ischium	4.40	0.15	
merus	11.10	0.39	
carpus	6.10	0.21	
propodus	6.20	0.22	
dactyl	6.10	0.21	

Pachygrapsus data

crab 5pac	length(mm)	ratio(segment/carapice)	
Carapice	27.90		
ischium	5.00	0.18	
merus	10.20	0.37	
carpus	5.10	0.18	
propodus	6.10	0.22	
dactyl	5.00	0.18	
leg 2	length(mm)	ratio(segment/carapice)	
Carapice	27.90		
ischium	5.00	0.18	
merus	12.80	0.46	
carpus	6.80	0.24	
propodus	7.90	0.28	
dactyl	7.10	0.25	
leg 3	length(mm)	ratio(segment/carapice)	
Carapice	27.90		
ischium	4.60	0.16	
merus	13.00	0.47	
carpus	7.20	0.26	
propodus	8.90	0.32	
dactyl	6.90	0.25	
leg 4	length(mm)	ratio(segment/carapice)	
Carapice	27.90		
ischium	4.40	0.16	
merus	11.80	0.42	
carpus	6.90	0.25	
propodus	8.00	0.29	
dactyl	6.80	0.24	

Pachygrapsus data

Average Pachygrapsus leopoldi segment length ratios

leg	avg. ratio
ischium	
1	0.20
2	0.20
3	0.18
4	0.17
merus	
1	0.40
2	0.45
3	0.42
4	0.40
carpus	
1	0.20
2	0.22
3	0.22
4	0.21
propodus	
1	0.23
2	0.36
3	0.30
4	0.25
dactyl	
1	0.19
2	0.24
3	0.24
4	0.21

Sources:

Pachygrapsus crassipes and Hemigrapsus nudus: A Structural Comparison,. Lundeen, Roslyn. 2004 OIMB student reports.

The Beachcombers guide to seashore life in the Pacific Northwest, Sept. J. 1999 Harbour publishing