Differential aggression between aggregations of the clonal sea anemone Anthopleura elegantissima on the Oregon Coast

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Position = Caste?



Acrorhagi



White Scar







Questions

1. Are warriors more effective than reproductives at fighting?

2. Does fighting reduce the energy available for reproduction?

3. Are these roles fixed or can they be induced?

Hypotheses and Predictions

- 1. Warriors are better fit at fighting.
 - 1. Warriors will outcompete reproductives.
- 2. Reproductives are able to use their resources on sexual/gonadal maturation.
 - 2. Reproductives will have a higher gonadal index.
- 3. As the Aggregation grows, warriors get further from the edge and become reproductives.
 - 3. Reproductives will show warrior phenotypes if fought.

Boiler Bay and Seal Rock

- Collection of A. elegantissima
 - Collect 4 experimental anemones
 - Collect from 4 different clonal aggregations:
 - 3 Reproductive
 - 3 Warriors
 - Collect, from each of the 4 aggregations, tissue sample of
 - 3 Reproductive, not from those collected
 - 3 Warriors, not from those collected



Measurements



In the lab



Are warriors more effective than reproductive at fighting?



7/8/14

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Anemone Match Up				
BB vs BB	SR vs SR	SR vs BB		
 3 RvsR 3 WvsW 2 RvsW 	 3 RvsR 3 WvsW 2 RvsW 	 3 RvsR 3 WvsW 2 RvsW 		

- 24 Matches
- Anemones were chosen using a random number generator
- 1, 2, 3, 4, 5, 10, 20, 30, 60 min and 2, 6, 24 hrs

Trials

- What to expect?
 - Using experimental anemones
 - Put them in close proximity of each other
- Observations
 - Some attacked quickly
 - Others retreated after an hour
 - Some did not attack and retreated
 - Some retracted and later retreated
 - One sided fights



Declaring a winner

- Least time spent retracted
- Least amount of white scars
- First to attack
- Standing ground



Scoring Winners

Score	Description
1	Clear loser
2	Loser
3	Tied
4	Winner
5	Clear winner





Average Win/Loss of R and W from BB



Average Win/Loss of R and W from SR



Size = Outcome

Poisson regression comparing the effects of size differential				
	Estimate	Std. Error	Z score	P value
Intercept	1.07889	0.08495	12.700	<2e^-16*
Differential	0.05458	0.02275	2.399	0.0164*

- With each additional 1 cm² increase in size differential, the anemone is 1.056 x more likely to win the fight.
- No significant effect of being a warrior or reproductive when removing the effect of size.
- No significant effect of reproductive status
- No significant effect of number of individuals in a clone
- No significant effect of the distance to other clones

Does fighting reduce the energy available for reproducing?



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Mature male (left) and female (right







Gonad Maturity

Used maturity stage described by Bingham et al.

Gonad index	Gonad appearance	Gonad visible	Sex obvious
0	no identifiable gonad	-	-
1	bumps on mesenteries	100x	100x
2	Swollen mesenteries	40x	100x
3	Single-lobed masses	40x	40x
4	Multi-lobed masses	1x	40x
5	Multiple plump masses	1x	1x

Sexed clones 1 and 3 from both Boiler Bay and Seal Rock



Can we induce the warrior phenotype?



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- 11 Matches total
- Half in constant contact for 7 days
- Rest in constant contact for 9 days



No effect

There is NO effect of winning the first fight on winning the second in a binomial regression.

Binomial regression comparing first fight with second

	Estimate	Std. Error	Z score	P value
Intercept	0.3147	1.06	0.297	0.767
Second fight	-0.105	0.326	-0.325	0.746

There was an effect of size differential on fighting ability though.

Poisson regression comparing second fight with size differential				
	Estimate	Std. Error	Z score	P value
Intercept	-1.14	0.43	-2.61	0.008*
Size Difference	0.72	0.27	2.66	0.0077*

Conclusions

- 1. Warriors are better fit at fighting.
 - 1. CONCLUSION 1: Size influenced fighting ability with larger anemones winning
- 2. Reproductives are able to use their resources on sexual/gonadal maturation.
 - 2. CONCLUSION 2: Reproductives have higher reproduction
- 3. As the Aggregation grows, warriors get further from the edge and become reproductives.
 - 3. CONCLUSION 3: Reproductives were no better than warriors (all explained by size).

Future Research

- Clones: identical genomes.
 - Differences in castes may be due to differences in gene expression
- Collect, from each of the 4 aggregations, tissue sample of
 - ▶ 3 Reproductive, not from those used in the experiments
 - 3 Warriors, not from those used in the experiments
- Took tissue samples from the anemones that fought for a week
- Look for transcriptional differences between warriors and mothers: initial and after stressful fighting

Work Cited:

- Bringham, Brian L. Dimond, James L. Muller-Parker, Gisele. Symbiotic state influences life history strategy of a clonal Cnidarian.
- Ayre, David J. Grossberg, Richard K. 1996. EVects of social organization on interclonal dominance relationships in the sea anemone Anthopleura elegantissima. Animal Behavior, 1996, Vol. 51, 1233-1245.
- Ayre, David J. Grossberg, Richard K. 2005. Behind anemone lines: factors affecting division of labour in the social cnidarian Anthopleura elegantissima. Animal Behavior, 2005, Vol. 70, 97-110.
- Ford, Charles E Jr. 1964. Reproduction in the aggregating sea anemone, Anthopleura elegantissima. Pac Sci 18(2): 138-145.
- Francis Lisbeth. 1973. Intraspecific aggression and its effect on the distribution of Anthopleura elegantissima and some related sea anemones. Biological Bulletin, Vol. 144, No.1, 1973, pp. 73-92.
- Francis Lisbeth. 1976. Social Organization within Clones of the sea anemone Anthopleura elegantissima. Biological Bulletin. Vol. 150, No.3, 1976, pp. 361-376.

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