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Behavioral Ecology of Territorial Aggression in Uca pugilator and Uca pugnax

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Abstract

The nature of animal aggression has long been a research interest in many different scientific fields. Resources, including food, shelter, and mates are all common assets for which animals compete. Two species of fiddler crabs, the Atlantic Sand Fiddler Crab (*Uca pugilator*) and the Atlantic Marsh Fiddler Crab (*U. pugnax*) were studied in regards to their aggression shown when competing for shelter. One crab was placed in a contained shelter for two days, and then a second of the same species was introduced. Aggressive interactions were scored and compared with claw and carapace size to ascertain if aggression correlated with size. Overall, it was found that the Sand Fiddler Crabs displayed more aggressive behaviors compared to the Atlantic Marsh Crabs and that these behaviors were also linked with claw and carapace size.

Introduction

Within the discipline of environmental science, there are five major fields of study that include biology, chemistry, earth science, social sciences, and humanities. Each of the major fields can be broken down into subfields. The three subfields of biology are ecology, botany and zoology. Ecology is the biological science that studies how living things interact with their biotic and abiotic environment and each other (Miller and Spoolman, 2009). There are many types of ecology including population ecology, ecosystem ecology, behavioral ecology, and many more. Behavioral ecology can be defined as the study of how behavioral and morphological traits affect the survival and reproduction of animals and plants under different environmental conditions (Caro, 1998). Behavioral traits can be things like aggression or submission when it comes to obtaining food, water, mates, or shelter. While the morphological traits include things like presence or absence of claws, wings, webbed feet, or beaks. Due to the wide range of possibilities when it comes to studying behavioral ecology, there are many species that can be used to observe this biological science.

Aggression has been widely studied and observed in many species of invertebrates. Due to their highly structured, yet easily evoked behavioral systems, invertebrates serve as excellent model systems for the study of aggression. Invertebrate examples of aggression including ants, dragon flies, and crabs have all been observed. Crustaceans have been anatomically and physiologically studied for over 100 years. Aggression, in regards to social behavior, was the logical next step in the observations of crustaceans. Two major species of crustaceans, lobsters and crayfish, have been labeled ideal for the observance of aggression. These two species have mapped neurons that have been defined, their behavior has been mapped, and their amine levels can be monitored. Crustaceans also live a fundamentally solitary existence, and establish dominance through physical superiority. These types of invertebrates are also easily accessible, and are known for their social behavior (Kravitz and Huber, 2003).

Aggressive behavior was observed in two populations of blue crabs, *Callinectes sapidus* in a study done by Reichmuth et al. in 2011. This study pegged two different populations against each other to observe their response to a threatening stimulus and predator avoidance. The scientists in this study were trying to determine if one population was more aggressive than the other, which would signal an advantage when in contact with predators. These two populations were also studied to determine their tendency to enter crab pots (traps). During this part of the study, the scientists wanted to see if the crabs inside of the pots would keep other crabs out through aggressive behaviors (Reichmuth et al., 2011). Both adults and juveniles have been documented to show signs of aggression, especially toward conspecifics. These encounters between blue crabs can leave an individual injured, missing appendages, and even dead in more extreme cases. The presence of strong, sharp chelae, a pair of hinged claws, is the blue crab's best defensive weapon. These claws are what is most often used against predators and conspecifics (Reichmuth et al., 2011). Further studies have been completed using blue crabs due to their documented aggressive behaviors. One study, done by Jachowski in 1974, found that these aggressive behaviors in blue crabs were regulated by food and mate availability. Another study even found that some adult crabs spend up to 40% of their time engaged in combative behaviors (Clark et al., 1999).

Another commonly studied crustacean studied in regards to aggressive behaviors is the mantis shrimp, *Gonodactylus bredini.* This species of shrimp are predatory marine crustaceans that are known for their alertness, and it is suggested that they are capable of complex behaviors. The aggressive territorial behavior of the mantis shrimp was studied in an experiment by Caldwell and Dingle in 1969. The species within the genus of *Gonodactylus* live in cavities found in rocks, coral, sponges, and empty mussel shells in which they defend them aggressively. This aggressive territorial behavior includes physical combat between conspecifics. This physical combat comes in the form of a strike delivered with the raptorial second maxillipeds. This territoriality is also not found to be a pattern associated with breeding season, which gave rise to the question of what causes this aggression. Thus this experiment wanted to study the aggressive behavior found in this species of mantis shrimp (Caldwell and Dingle, 1969).

The environments in which organisms reside offer shelter, food, areas for mating, birthing grounds, and nurseries. Salt marsh environments are coastal grassland areas that are flooded regularly by seawater. These environments play a crucial role in Atlantic coastal systems and are prevalent in low-lying areas of South Carolina. In the United States, salt marshes account for about 41% of all coastal wetlands that provide habitats for estuarine species and nurseries for marine species (Beck and Gustafson, 2012). Two of those marine species are the Sand Fiddler Crab (*Uca pugilator)* and the Atlantic Marsh Crab (*U. pugnax)*.

Fiddler crabs, under the genus *Uca,* are semi-terrestrial crustaceans that are known to be highly sociable. They inhabit beaches, mangroves, and marshes. Individuals create burrows in their environment and those burrows become the center of their day to day activities. Burrows also provide protection for the crab as their shelter. These burrows are a necessity for the crabs as they need protection from predators, extreme climate conditions, and during high tide when they go completely underground. Crabs are very defensive from intrusions by conspecifics and have been known to actively protect their burrows. Territory is a valuable resource for crabs, and males specifically have been known to be extremely defensive regarding their burrow (Hyatt and Salmon, 1978).

Males have an enlarged claw (major claw) that is used for multiple things, defense being one of them. This major claw is used to signal females and to threaten/fight other males over burrow possession. The male to male combat is known to peak during mating season. Only one species of fiddler crab, *U. rapax*, has been studied quantitatively concerning their aggressive behavior. This led scientists to form an experiment in order to compare the combat of two ecologically different species of fiddler crab, *U. pugilator* and *U. pugnax*. Fights between males were observed for each species and the fight outcomes were correlated. The goal was to determine the evolutionary and ecological forces that have shaped aggression in these species of fiddler crab (Hyatt and Salmon, 1978).

For this study, the behavioral trait of aggression was studied using the Sand Fiddler Crab, *U. pugilator,* and Atlantic Marsh Crab, *U. pugnax*. The resource of shelter/territory was used in order to observe potential acts of aggression between two crabs of the same species. The goal was to determine if species or size showed higher or lower amounts of aggression. Sand fiddler Crabs and Atlantic Marsh Crabs were chosen for this study because of their easy accessibility, ease of maintenance, and longevity once brought back to the lab.

There were six main hypotheses tested in this experiment. The first hypothesis was to determine if the asset of shelter caused aggressive behaviors between the Resident Crab and the Intruder Crab. The second one was to figure out if the aggressive behaviors, when present, of the Resident Crab and Intruder Crab correlated with the major claw lengths of the Resident Crab minus the Intruder Crab (A-B). The third one was to figure out if the aggressive behaviors, when present, of the Resident Crab and Intruder Crab correlated with the carapace widths of the Resident Crab minus the Intruder Crab (A-B). The fourth hypothesis was to determine if there was a significant difference between major claw lengths of the Resident Crab and the Intruder Crab. The fifth hypothesis was to determine if there was a significant difference between carapace widths of the Resident Crab and the Intruder Crab. The sixth hypothesis was to determine if the mean difference between the aggression levels of the Resident Crab and Intruder Crab equaled zero.

Materials and Methods

Study Site

Waites Island is a barrier island located along the northern coast of South Carolina (Figure 1). This is a protected barrier island, so it is underdeveloped and experiences low anthropogenic changes. The coordinates for Waites Island are 33°50’56.38”N 78°35”17.74 W. Barrier Islands are split up into multiple parts. These parts include the beach, upland forest, salt marsh, and the mainland. The salt marsh separates the beach from the upland forest of the barrier island, and the mainland lies behind the marsh.

Sample Collection

Waites Island, and more specifically the salt marsh, was surveyed on multiple occasions between the months of October-November of 2019, and in March of 2020. Figure 2 is the area of the marsh that was sampled. Groups of students collected Sand Fiddler Crabs, *U. pugilator* and Atlantic Marsh Fiddler Crabs, *U. pugnax.* The crabs were collected in two ways. The first way was through catching the crabs while they were on the surface of the marsh. The second way was through digging up the mud where burrow holes were present and looking for a crab. The crabs that were collected were placed into buckets to be transferred back to the lab. Before going back to the lab, the crabs were taken down to the ocean, rinsed off, and sorted to ensure only sand/marsh crabs were collected. Approximately two inches of water was placed into the buckets with the crabs. While on the beach, buckets of water and dune sand were collected to take back to the lab with the crabs. The lab was located in the Science 2 building at Coastal Carolina University in Conway, South Carolina. The crabs were fed and the water in the buckets was changed every few days.

Trial Setup

Before any tests were run, the trial containers had to be set up. First, a 6 quart clear storage tote was cleaned out and dried. Next, dry dune sand was dumped into the container while making an incline within the tote. About 2-3 inches of the tote was left without sand for water. Water was then poured onto the sand to make sure the ramp remained stable, and to give the crabs' access to water while in the container. Finally, a piece of 1-in x 1-in x 1-in x 1-in Tee PVC Fitting was placed into the container on the top part of the sand ramp. Figure 3a and Figure 3b are examples of the set up used in trials 10-21. Trials 1-9 did not have the ramp design. Those trials had the same container and piece of PVC pipe, but not the ramp. There were 3 containers used throughout the trial, and the setup was re-done every 2 trials. Water was poured into the container every day to make sure the sand and crabs did not dry out.

An aggression ranking scale was created in order to rank the territorial aggression of each crab. This scale can be found in Table 1 with the description of each number on the scale. The scale ranged from -3 to +3.

Data Collection

Each trial consisted of two parts that were completed 48 hours apart. Two crabs, of the same species, were used in each trial. During the first part, a crab (either sand or marsh) was taken from the bucket and the major claw length and carapace width was measured using a 6 inch manual utility caliper. These measurements were recorded into an excel file along with the crab type, date, and trial number. This first crab, labeled as Crab A, was called Resident Crab in each of the trials. Crab A was then placed into the container and the lid was placed partially on the container to allow for air to flow in/out of the tote.

The second part of each trial occurred 48 hours after Crab A was placed into the container. Crab B, also known as the Intruder Crab, was taken out of the bucket and the major claw length and carapace width was measured. Before the Intruder Crab was placed into the container, a GoPro HERO3 Silver Edition (HD3.02.03.00) was set up on a tripod to record each trial. The GoPro started recording and the Intruder Crab was placed into the container. A timer was set for 20 minutes. At the 20 minute mark, the recording was stopped and both crabs were removed from the container. The used crabs were placed into a separate bucket from the unused crabs to be taken back to the marsh to be released.

Once the crabs were placed into the bucket, the GoPro was connected to a cord with a USB end. The videos were then uploaded to a laptop and watched in order to assign an aggression ranking to each crab. The aggression ranking was only assigned after watching the videos from beginning to end to ensure the most accurate ranking was given.

Data Analysis

In total, there were 23 trials run throughout the course of this experiment. The division of species was 14/23 Atlantic Marsh Crabs and 9/23 Sand Fiddler Crabs. However, in two of the trials (2 and 7) the Resident Crab (Crab A) died before the second part of the trial could be run with the Intruder Crab (Crab B). The two trials that were excluded from data analysis were both Atlantic Marsh Crabs. First, the major claw lengths were compared to determine the claw length ratio between Crab A and Crab B for each of the 21 trials. Next, the carapace widths were compared to determine the carapace width ratio between Crab A and Crab B for each of the 21 trials.

Statistical analyses were completed in order to test for five of the six hypotheses listed above. First, a T-Test Assuming Equal Variances was used to test the fourth hypothesis of determining if there is a significant difference between the major claw lengths of the Resident Crab (A) and the Intruder Crab (B). A second T-Test Assuming Equal Variances was used to test the fifth hypothesis of determining if there is a significant difference between carapace widths of the Resident Crab and the Intruder Crab. A Pearson Correlation was completed to test for the second hypothesis to determine if the aggressive behaviors of the Resident Crab and Intruder Crab correlated with the major claw lengths of the Resident Crab minus the Intruder Crab (A-B). Another Pearson Correlation was completed to test for the third hypothesis to determine if the aggressive behaviors of the Resident Crab and Intruder Crab correlated with the carapace widths of the Resident Crab minus the Intruder Crab (A-B). A Paired Samples T-Test was used for the sixth hypothesis to determine if the mean difference between the aggression levels of the

Resident Crab and Intruder Crab is equal. A Wilcoxon Signed Ranks Test was also completed to determine if the population mean ranks differed between the samples.

Results

The Aggression Ranking Scale that was created for this experiment is shown in Table 1. The aggression rankings for each individual crab are located in Table 10 along the trial numbers and species. The ratios of major claw lengths and carapace widths (Crab A: Crab B) for each trial that was included in calculations are located in Table 2. There was not a significant difference found between the major claw lengths of the Resident Crab (A) and the Intruder Crab (B) (t-stat = 0.756, df = 40, p-value = 0.454 >0.05). Figure 4 demonstrates the averages and standard deviations of the major claw lengths measured for the Resident Crabs and the Intruder Crabs. There was not a significant difference found between the carapace widths of the Resident Crab and the Intruder Crab (t-stat= 1.32, df= 40, p-value= 0.194 > 0.05). Figure 5 displays the averages and standard deviations of the carapace widths measured for the Resident Crabs and Intruder Crabs. The Pearson Correlation test, located in Table 6, was not a significant result (N = 21, t-stat = 0.342, p-value = 0.129 > 0.05). The Pearson Correlation, located in Table 7, was also not a significant result (N = 21, t-stat = 0.323, p-value = 0.154 > 0.05). The Pearson Correlation test, located in Table 8, was not a significant result (N = 21, t-stat = 0.342, p-value = 0.129 > 0.05).The Pearson Correlation test, located in Table 9, was not a significant result (N = 21, t-stat = 0.323, p-value = 0.154 > 0.05). The mean difference between the aggression levels of the Resident Crab and the Intruder Crab was not found to equal zero (t-stat= 1.323, df= 20, p-value= 0.201 > 0.05). The Paired Samples T-Test can be seen in Table 3. The Wilcoxon Signed-Ranks Test had a p-value of 0.156 >0.05, and this can be seen in Table 5.

There were also some qualitative results that were seen throughout the course of this experiment. With the orientation of the testing containers always set up with the PVC pipe on the left side, the Intruder Crabs seemed to favor the top right corner during many of the trials. The Intruder Crab was placed into the container, and would immediately go to that corner even if the Resident Crab was hidden in a burrow. The Sand Fiddler Crabs also had a higher amount of +3 rankings on the aggression scale compared to the Atlantic Marsh (Mud) Crabs, which can be seen in Table 10.

Discussion

There was no relationship found between the major claw lengths of the Resident Crab and the Intruder crab, nor was there a relationship found between their carapace widths. No correlations were found between the aggressive behaviors and major claw lengths between the Resident and Intruder Crabs. There were also not correlations found between the aggressive behaviors and the carapace widths between the two groups of crabs. The mean difference between the aggression rankings of the Resident Crab and the Intruder Crab was not found to be zero as well. These findings can possibly be explained due to the alpha value chosen for this experiment. The value was set to 0.05 in order to make the margin of error as small as possible. However, in a behavioral study, the range is often chosen for $p = 0.10$ because of the complexity of animal behavior. Another possible explanation for these findings could be the sample size. There were initially 23 trials, but after eliminating the 2nd and 7th trials due to Crab A dying in each case, there were only 21 trials. Thus there were only 21 pairs, 42 individual, crabs tested. If the sample size were larger, then lower p-values could have been calculated to see clearer relationships.

Throughout every trial during this experiment, some sort of interaction was observed between the two male crabs used in each assessment. Even if the interaction was submissive for the Intruder Crab and non-existent with the Resident Crab, the submissive motion showed that the Intruder sensed the Resident Crab had dominance. There were a few instances where both the Resident and Intruder Crabs showed no movement toward the other, ranking each one a zero on the scale. However, the majority of the interactions observed had an aggressor and a submissive. These observations are similar to the Caldwell and Dingle, 1969 study using *Gonodactylus bredini*. When two individuals, of the same sex, came into contact with one another aggression behaviors were found. Over the course of their hour trials, it was observed that one mantis shrimp would become dominant over the other mantis shrimp within 10-20 minutes of the trial. This aligned with the data collected over the course of this experiment. Two male fiddler crabs, of the same species, were used and they expressed aggressive behaviors once they came into contact with each other. Trials were also only 20 minutes long, which fits within the window of dominance found in the mantis shrimp experiment.

The Resident Crab (A) was observed to dig a burrow in some of the trials over the course of the 48 hours when it was alone in the container. Upon entrance of the Intruder Crab (B), the Resident Crab did not come out of the burrow they had dug. The Resident Crab would only come out of the burrow once the Intruder Crab came near or tried to go into their burrow. This finding also aligns with results found in the Caldwell and Dingle, 1969 study. The mantis shrimp were found to leave their cavities only to fend off an intruder, attack prey, or to limit anything else from entering. The aggression observed in the mantis shrimp was determined to fully focus on defending their territory from conspecifics. The Caldwell and Dingle, 1969 study proposed that dominance can be influenced by size, stage in the molt cycle, and stage in the reproductive cycle for females. The fiddler crabs in this experiment were seen only to defend burrows once an intruder crab entered the burrow itself.

Similar findings were observed in the Hyatt and Salmon, 1978 study in regards to fiddler crabs defending their owned burrows. The aggressive behaviors of *U. pugilator* and *U. pugnax* were observed in their natural environments in this 1978 experiment. Out of the 400 fights observed between the two species, most of them were between residents and intruders. The intruders would attempt to take over the burrows of the residents, which caused fights to occur. This aligns completely with the fights observed between the fiddler crabs in the lab during this experiment. Differences were found between length and tempo of the fights observed in the Hyatt and Salmon experiment. These were not variables that were recorded in this experiment. However, future studies with this data could look at tempo and length of fights as indicators of which species/crab is more aggressive.

Overall, aggressive behaviors were seen in both the Atlantic Marsh Fiddler Crab and the Sand Fiddler Crab. The Sand Fiddler Crabs were observed to be more aggressive due to their higher rankings on the aggression scale with mostly positive threes. The Resident Crabs were seen to defend their burrows they made against the Intruder Crabs every time a burrow was present. The Intruder Crabs seemed to favor the top right corner of the testing container, but this action was not found to influence their aggression. There were instances where the Intruder Crab attempted to establish dominance immediately after being placed into the container. Establishing dominance in this case would be taking over the PVC pipe or burrows present. However, the Intruder Crab was not often successful in doing so. Further studies may show more significant relationships between carapace width and major claw length, but I think the relationships found in this experiment provide evidence that size does play a role in aggression.

Future examinations of this study could include a larger sample size. For example, a sample size of 100 crabs (50 trials) could result in smaller p-values which would amount to significant relationships being found. Completing this experiment on other species of crabs could also provide new information and relationships to be found. The presence of a predator could also be examined in a further study to determine if this new addition would cause a change in behavior or even the aggression levels between the Resident Crab and Intruder Crab. Temperature could also be explored in a future study as a variable of interest. Manipulating the temperature of the testing environment could affect the aggression levels potentially. Recording the body temperature before and after the 20 minute trials could possibly add new information as well. Females could also be explored in a future study to discover if they exhibit any aggressive tendencies in regards to a resource.

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Figures and Tables

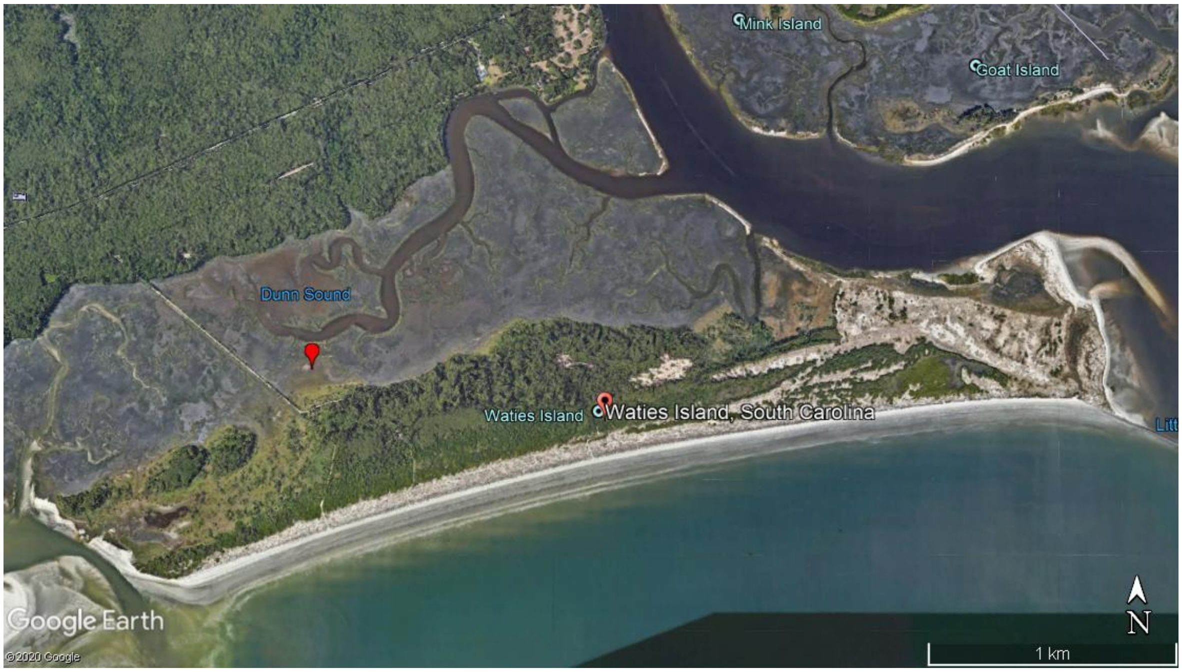

Figure 1. Overview of the study site: Waites Island, South Carolina (33°50’56.38”N 78°35”17.74 W). The solid red marker represents the saltmarsh in which the crabs were collected.

Figure 2. Aerial view of the saltmarsh at Waites Island, South Carolina used to collect the Sand Fiddler Crabs (*Uca pugilator*) and the Atlantic Marsh Fiddler Crab (*Uca pugnax*).

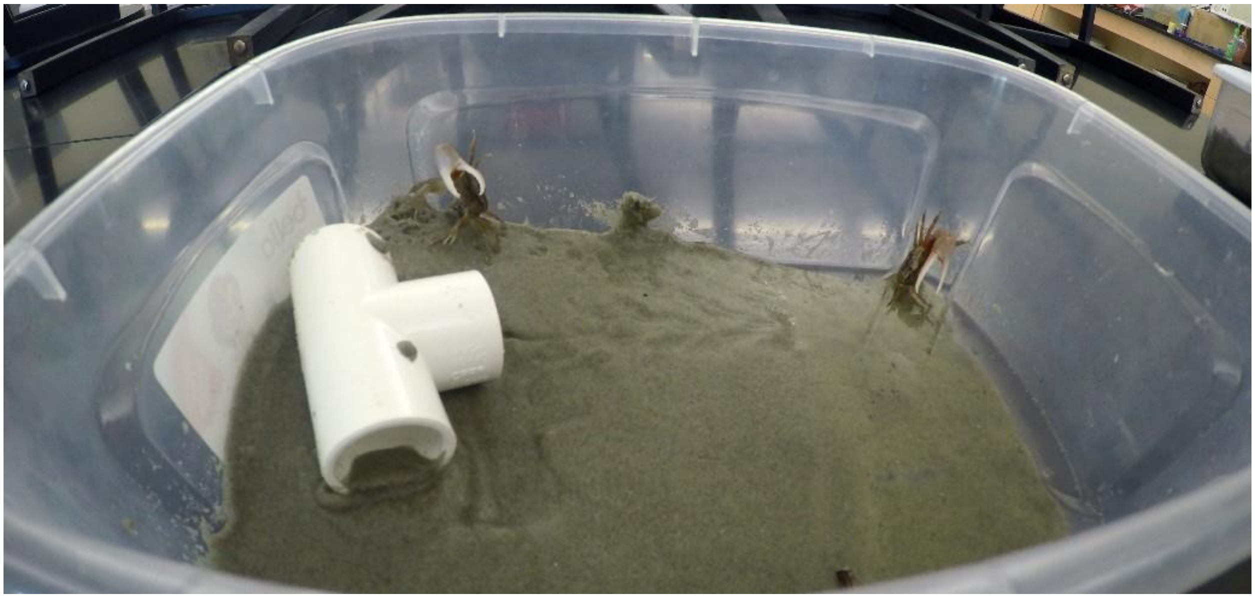

Figure 3a. Example of the trial setup used throughout the experiment. This trial was an example of a Sand Fiddler Crab (*Uca pugilator*).

Figure 3b. Example of a trial setup used throughout the experiment. This was an example of an Atlantic Marsh Crab (*Uca pugnax*). There is also evidence of a burrow hole in the bottom left that was dug by the Resident Crab.

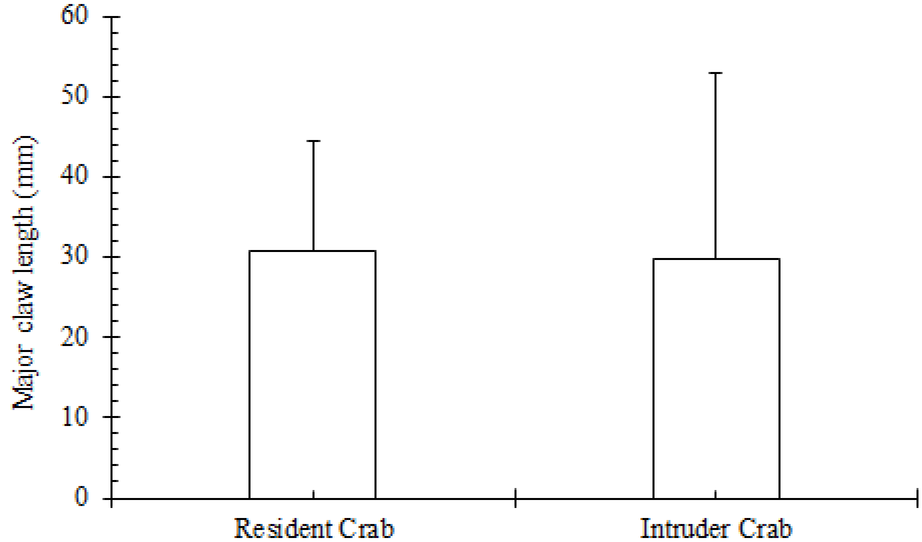

Figure 4. Average major claw lengths of the Sand Fiddler Crabs (*Uca pugilator*) and the Atlantic Marsh Crabs (*Uca pugnax*) collected at Waites Island, South Carolina (t-stat= 0.756, df= 40, p-value= 0.454 > 0.05). Both species were used as the Resident Crabs and Intruder Crabs.

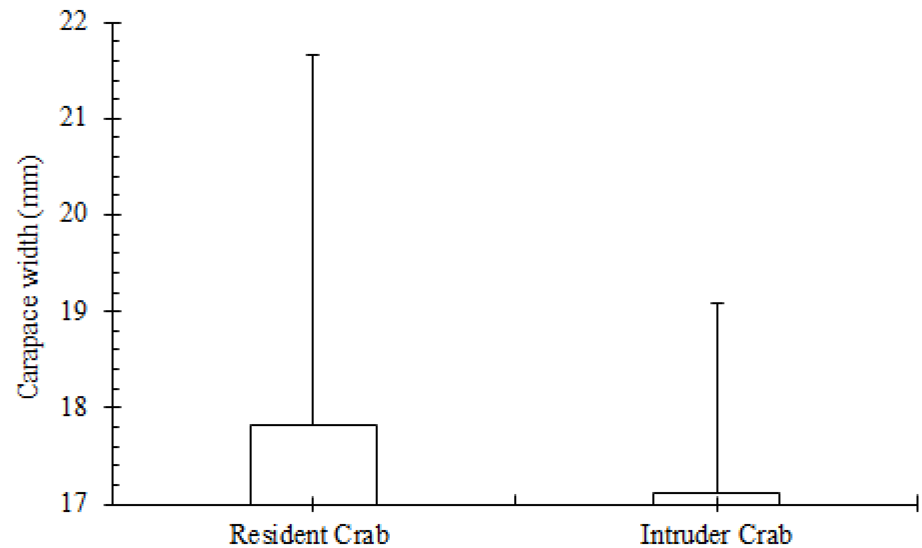

Figure 5. Average carapace widths of the Sand Fiddler Crabs (*Uca pugilator*) and the Atlantic Marsh Crabs (*Uca pugnax*) collected at Waites Island, South Carolina (t-stat= 1.32, df= 40, p-value= 0.194 > 0.05). Both species were used as the Resident Crabs and Intruder Crabs.

Table 1. Aggression Ranking Scale created for this experiment. This chart was used to assign an aggression rank to each individual crab for all 21 trials.

-3	-2	-1	0	1	2	3
Submissive movement and quick retreat	Submissive movement and slow retreat	Orientation with no movement	NA	Movement toward Crab A/B with retreat	Movement toward Crab A/B with contact	Movement toward Crab A/B with combat

Table 2. Ratios of Major Claw Lengths (mm) and Carapace Widths (mm) between the Resident Crab (A) and the Intruder Crab (B) aligned with the trial numbers.

Trial Number	Ratio of Claw Length A:B	Ratio of Carapace Widths A:B
1	1.03030303030303:1	1.11388888888889:1
3	1.03088235294118:1	0.975675675675676:1
4	1:1	0.972222222222222:1
5	0.970588235294118:1	1.02631578947368:1
6	0.985714285714286:1	1.02857142857143:1
8	0.931034482758621:1	0.875:1
9	0.948275862068966:1	1.03030303030303:1
10	0.878378378378378:1	0.96969696969697:1
11	1.07142857142857:1	1.1875:1
12	2.14705882352941:1	1.33333333333333:1
13	1.03030303030303:1	1.05263157894737:1
14	1:1	0.947368421052632:1
15	0.873239436619718:1	1.05882352941176:1
16	1.13333333333333:1	0.914285714285714:1
17	1.17391304347826:1	1.03030303030303:1
18	1.25:1	1.16666666666667:1
19	1.10869565217391:1	1.06666666666667:1
20	0.896551724137931:1	1.125:1
21	0.904761904761905:1	0.894736842105263:1
22	1.07692307692308:1	1.21428571428571:1
23	0.888888888888889:1	0.9375:1

Table 3. Paired Samples T-Test between the average aggression ranks of Crab B subtracted from the average aggression ranks of Crab A (t-stat= 1.323, df= 20, p-value= 0.201 > 0.05).

Paired Samples Test

		Paired Differences			
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference Lower
Pair 1	AGG_Crab_A - Agg_crab_B	.33333	1.15470	.25198	-.19228

Paired Samples Test

		Paired Differences			
		95% Confidence Interval of the Difference Upper	t	df	Sig. (2-tailed)
Pair 1	AGG_Crab_A - Agg_crab_B	.85895	1.323	20	.201

Table 5. Wilcoxon Signed Ranks Test completed to check for normalcy of the data (p-value = 0.156 > 0.05).

Ranks				
		N	Mean Rank	Sum of Ranks
VAR00008 - VAR00007	Negative Ranks	7[a]	6.93	48.50
	Positive Ranks	4[b]	4.38	17.50
	Ties	6[c]		
	Total	17		

a. VAR00008 < VAR00007
b. VAR00008 > VAR00007
c. VAR00008 = VAR00007

Test Statistics[a]	
	VAR00008 - VAR00007
Z	-1.417[b]
Asymp. Sig. (2-tailed)	.156

Table 6. Pearson Correlation test used to determine if the aggressive behaviors of the Resident Crabs correlated with the carapace widths of the A-B (N = 21, t-stat = 0.342, p-value = 0.129 > 0.05).

Correlations

		AminusB	CrabA_Agg
AminusB	Pearson Correlation	1	.342
	Sig. (2-tailed)		.129
	N	21	21
CrabA_Agg	Pearson Correlation	.342	1
	Sig. (2-tailed)	.129	
	N	21	21

Table 7. Pearson Correlation used to test to determine if the aggressive behaviors of the Intruder Crabs correlated with the carapace widths of A-B (N = 21, t-stat = 0.323, p-value = 0.154 > 0.05).

Correlations

		AminusB	CrabB_Agg
AminusB	Pearson Correlation	1	.323
	Sig. (2-tailed)		.154
	N	21	21
CrabB_Agg	Pearson Correlation	.323	1
	Sig. (2-tailed)	.154	
	N	21	21

Table 8. Pearson Correlation test used to determine if the aggressive behaviors of the Resident Crabs correlated with the major claw lengths of the A-B (N = 21, t-stat = 0.342, p-value = 0.129 > 0.05).

Correlations			
		MC_diff	AGG_Crab A
MC_diff	Pearson Correlation	1	.342
	Sig. (2-tailed)		.129
	N	21	21
AGG_Crab A	Pearson Correlation	.342	1
	Sig. (2-tailed)	.129	
	N	21	21

Table 9. Pearson Correlation used to test to determine if the aggressive behaviors of the Intruder Crabs correlated with the major claw lengths of A-B (N = 21, t-stat = 0.323, p-value = 0.154 > 0.05).

Correlations			
		MC_diff	AGG_Crab B
MC_diff	Pearson Correlation	1	.323
	Sig. (2-tailed)		.154
	N	21	21
AGG_Crab B	Pearson Correlation	.323	1
	Sig. (2-tailed)	.154	
	N	21	21

Table 10. Aggression rankings for each individual crab tested in this experiment. In total there were 9 trials (13-21) with Sand Fiddler Crabs. There were 14 trials with Atlantic Marsh Crabs, labeled as "Mud" in the chart (1-12, 22-23).

Species	Trial Number	Aggression Ranking Crab A	Aggression Ranking Crab B
Mud	1	3	3
Mud	3	2	1
Mud	4	1	1
Mud	5	0	0
Mud	6	2	2
Mud	8	1	-1
Mud	9	0	-2
Mud	10	-3	-3
Mud	11	0	0
Mud	12	3	3
Sand	13	3	3
Sand	14	2	3
Sand	15	3	2
Sand	16	0	-2
Sand	17	0	0
Sand	18	1	2
Sand	19	2	3
Sand	20	0	0
Sand	21	0	2
Mud	22	-1	-3
Mud	23	0	-2