Morphometric Analysis of Asian Shore Crab *hemigraspus sanguineus*

by

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Abstract

Hemigrapsus sanguineus (Asian Shore Crab) is an invasive species that arrived from the Western Pacific in the late 1980s. Hemigraspus sanguineus dominated the Northeast after it arrived and decimated native populations of crab. There are many differences between male and female individuals. A morphometrical analysis was done to determine if certain characteristics grow isometrically or allometrically compared to the rest of the body. The following characteristic features were analyzed and compared: carapace width and crab biomass, carapace width and carapace length, carapace width and propodus height, crab biomass and propodus mass, carapace width and total egg mass, and crab biomass and total egg mass. Crabs are known to show sexual dimorphism. Female individuals had a larger carapace width while males had a larger right propodus. A larger carapace width for females will allow them to brood more eggs.

Introduction

Hemigrapsus sanguineus is a crustacean known by the common name Asian Shore Crab. Hemigraspus sanguineus is native to the Western Pacific Ocean with a range spanning from Russia, along the Korean and Chinese coasts to Hong Kong, and the Japanese archipelago (Epifanio et al, 2013). The Asian Shore Crab arrived in the late 1980s on the New Jersey coast (Brousseau et al, 2014). It is believed that ballast water, from commercial ships inadvertently transferred H. Sanguineus through trade routes coming from Japan to the Eastern United States (Blakeslee et al, 2017). Ballast water is the largest factor behind non-native species transfer today (Ruiz et al, 1997). Non-native species can greatly impact the native population ecologically and evolutionary (Brousseau et al, 2014). The generalist diet of H. sanguineus allows them to out compete and prey on the native species of crab (Blakeslee at al, 2017). Invasive species can disrupt the food web and changed the biodiversity of invaded ecosystems (Ruiz, 1997). H. sanguineus became the dominant species along shores between Maine and North Carolina a few years after being introduced (Griffen et al, 2020). The population has grown large enough that one hundred to two hundred individual per m^{-2} have been documented in many areas along the east coast (Griffen et al, 2020). H. sanguineus has dominated due to its high terrestrial mobility and fecundity (AHL et al, 1999).

Characteristics develop differently dependent on the needs of the species. Fiddler crabs use its larger claw for fighting and its minor claw for feeding (Rosenberg, 2002). In mammals, limbs grow with a larger positive allometric rate so they can have faster mobility (Kilbourne et al, 2013). This study focuses on the morphometry of H. Sanguineus. A morphometric analysis was performed with quantitative measurements of carapace width and length along with propodus height to determine if males develop differently than females.

Total biomass and propodus mass were measured in grams to analyze how morphological characteristics compare allometrically or isometrically. Characteristics of H. sanguineus could have a negative or positive allometric growth rate compared to the rest of the body. A positive allometric growth rate occurs when a characteristic feature has a growth rate that is greater than the rest of the body. A negative allometric growth rate is the opposite and occurs when a characteristic feature has a growth rate slower than the rest of the body. When characteristic features grow at the same rate as the rest of the body, the growth rate is isometric. Egg mass was weighed in grams and compared with carapace width to determine if females grow a larger carapace width for the ability to hold more eggs. Breeding season lasts from late April to late September (McDermott, 1998). This study was conducted in August and most of the females found were gravid. It is important to understand how the characteristics of H. Sanguineus affect the overall population and its habitat.

Materials and Methods

The Asian Shore Crabs were collected at Edith G. Read Natural Park and Wildlife Sanctuary, Rye, NY. The low tide must be less than 1 ft. for collection to occur. All crabs were collected on Wednesday, August 19, 2020 when low tide was under 1 ft. Collection began at 6:15 a.m. and lasted for 50 minutes. Rocks were flipped over on the shoreline and as many crabs as possible were collected randomly and put into a bucket. Rocks of all sizes were moved or turned over to collect crabs of all sizes. When the bucket had approximately three dozen crabs, they were placed into Ziploc bags and then a cooler. Crabs were larger and more abundant under larger rocks or closer to the water. The largest crabs were found 5-15 feet from the edge of the Long Island Sound. A few hundred crabs were collected and 123 were measured.

In the lab, the crabs were kept in a freezer until the time of measurement. Crabs were thawed, placed on a tray, and separated between males, females, and gravid females (Fig. 1 ,2, 3). Each crab received a number and was weighed. The length and width of the carapace was measured on each crab (Fig. 4). Each crab was weighed for its full body mass. The right propodus was cut off and weighed on its own (Fig.5). A weighing boat was measured prior to weighing each crab and was subtracted later to get the true weight of the crab or propodus. All measurements were completed in grams. For the gravid females, the abdomen was pulled back and the eggs were scraped off. The eggs were put in a drying oven to release all moisture and get a dry weight. All measurements were done in mm.

Figure 1- Male Asian Shore Crab

Males have a pyramid shaped abdomen.

Figure 2- Non-gravid female Asian Shore Crab

Females have a shovel shaped abdomen.

Figure 3- Gravid female, Asian Shore Crab

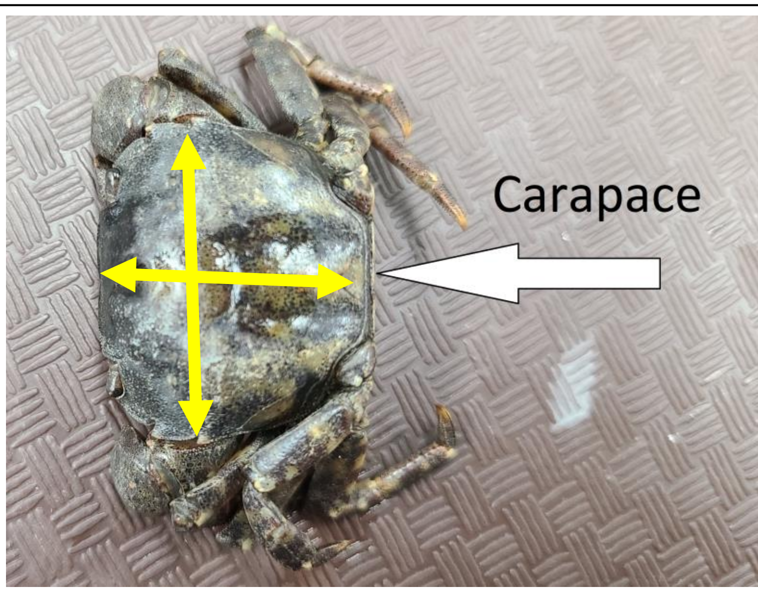

Figure 4- Carapace of Asian Shore Crab

Yellow arrows represent the width and length of the carapace that was measured.

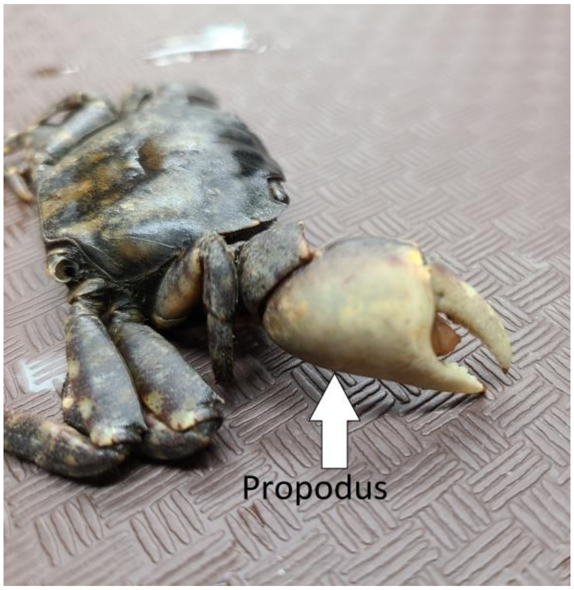

Figure 5- Propodus of an Asian Shore Crab

Figure 6- Eggs of an Asian Shore Crab

Results

The range of carapace width and length for males is larger than that of females but females averaged a larger size (Fig. 7). In males and females, carapace width is always greater than carapace length. The average carapace width of males was 16.3 mm while females were 17 mm. The average carapace length for males was 14.6 mm while females was 15mm. Using a t-test for males and females between 10-15 mm showed a high significance level with a P value<.0005(Fig. 8). At the 10-15 mm carapace width females are significantly larger than males. 70% of females in this range were ovigerous. Females in the range 5-10 mm, 15-20 mm, and greater than 20 mm all had a P value>0.0005.

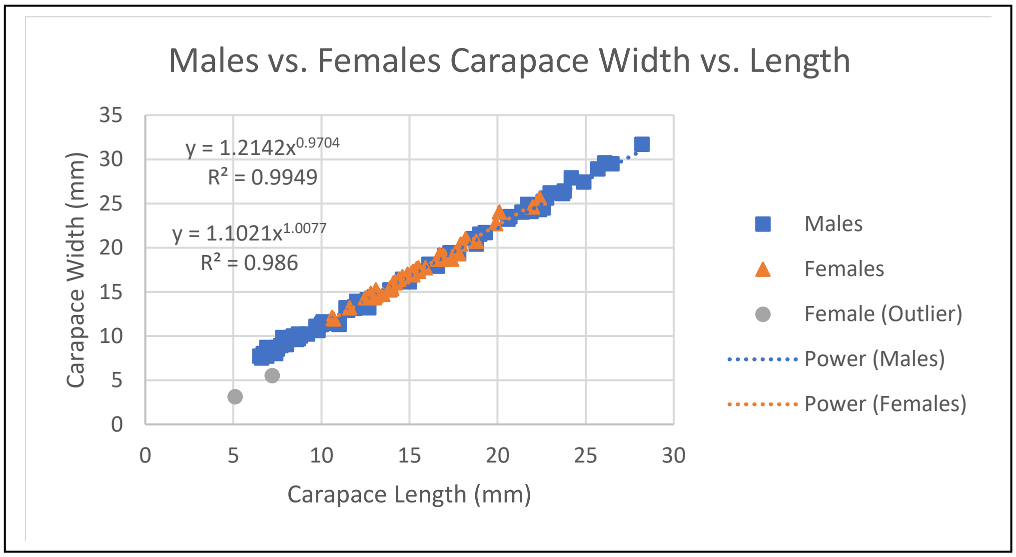

Figure 7- Males v. female carapace width v. length

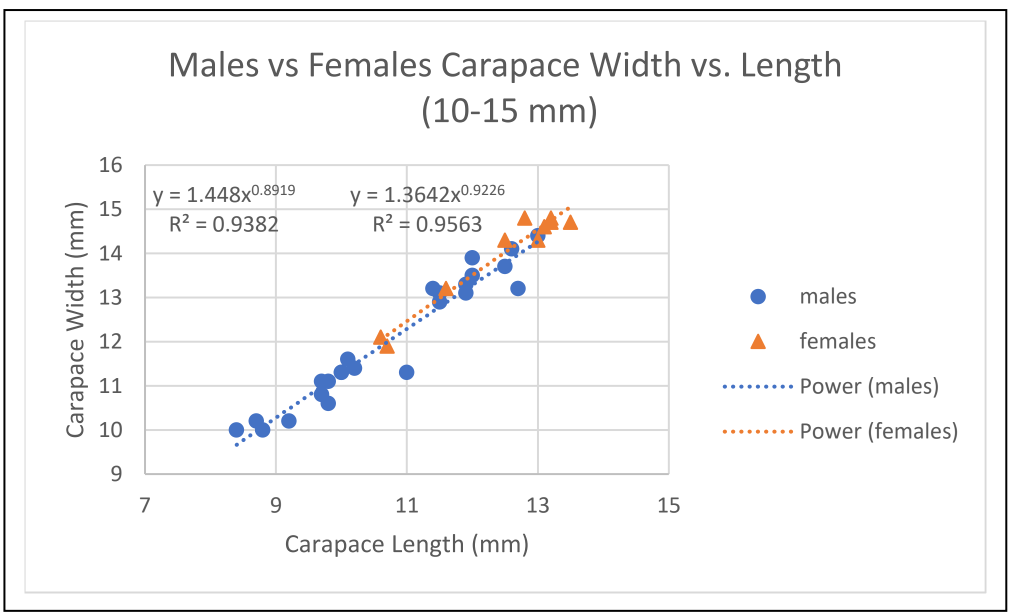

Figure 8- Males v. female carapace width v. length

(10-15 mm)

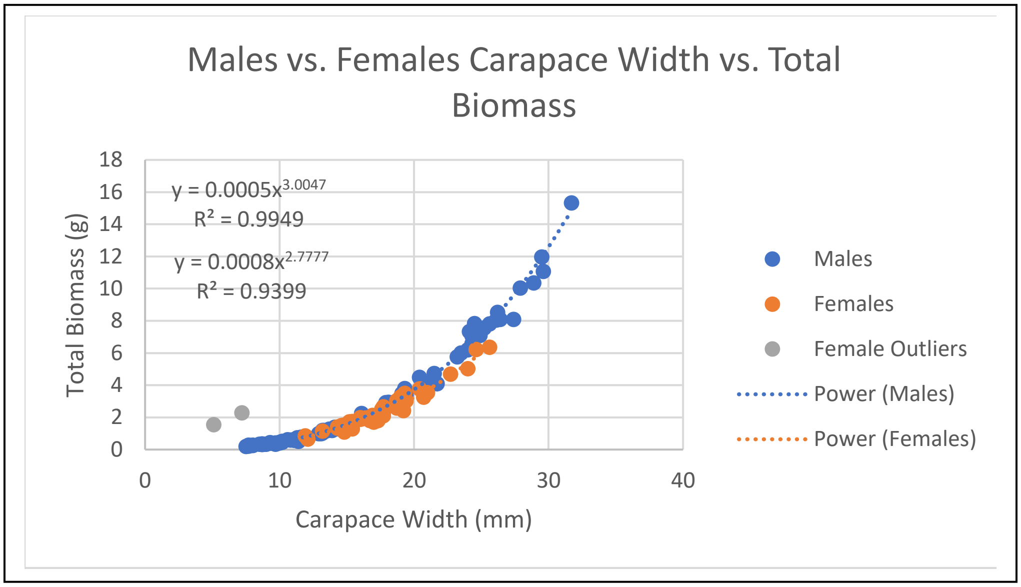

Figure 9- Male v. female carapace width v. total biomass

Males had an overall larger body mass weight than females. Males had an average body mass weight of 3.2 grams opposed to females at 2.4 grams. As the carapace width gets larger, so does the biomass (Fig. 9).

A linear regression of carapace width versus total biomass of males and females showed a high significant result with a P<.0001. There was a high correlation, an r^2 value of 0.877877 and a df value of 1 (Fig. 9). There were two female outliers that could have been from experimental error. As the male individual's carapace width got wider, the total biomass became larger. The biomass of female individuals also rose but not at a steady rate and would not be as easily predictable. Regression for only males had an r^2 value of 0.9245, a df value of 1, and a P value less than 0.0005 which is highly significant. Females had an r^2 value of 0.6490, a df value of 1, and P value of less than 0.0005 which is also highly significant.

Male propodus height grew as carapace width grew. Females propodus height only grew slightly compared to carapace width (Fig. 10). The propodus height for male individuals can easily be predicted through the model in Fig. 10. Propodus height and weight are both larger in males. The propodus in male individuals was thicker as the total biomass grew compared to the females in which the propodus remained relatively the same size (Fig. 11). The regression between total biomass and the percent of propodus mass was highly significant with a P value less than 0.0001, a df value of 1, and an r^2 value of 0.2536.

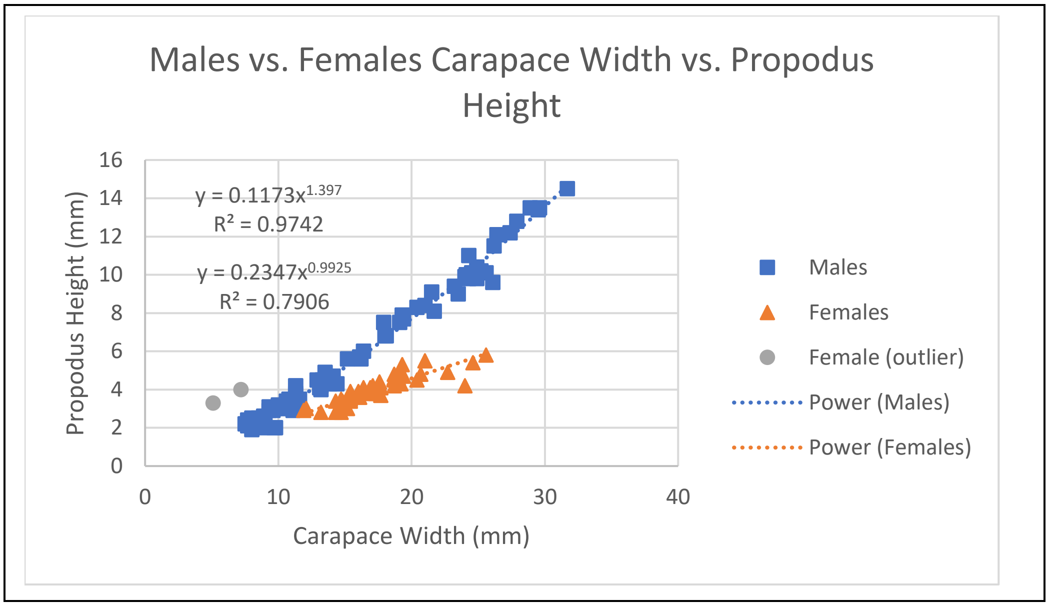

Figure 10- Male v. female carapace width v. propodus height

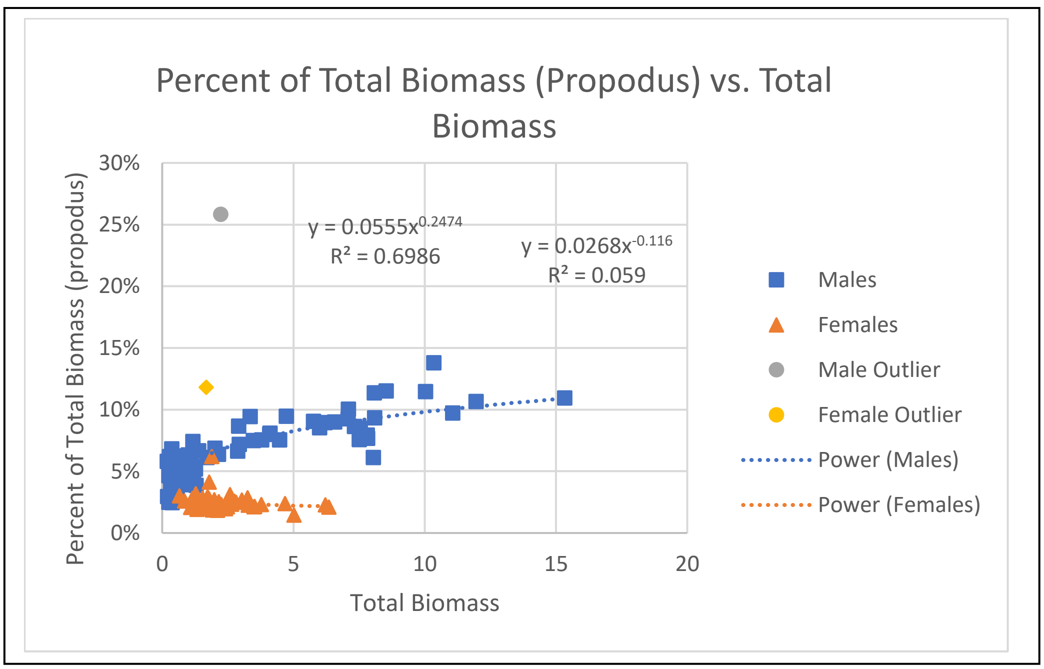

Figure 11- Percent of propodus v. total biomass

(n=123)

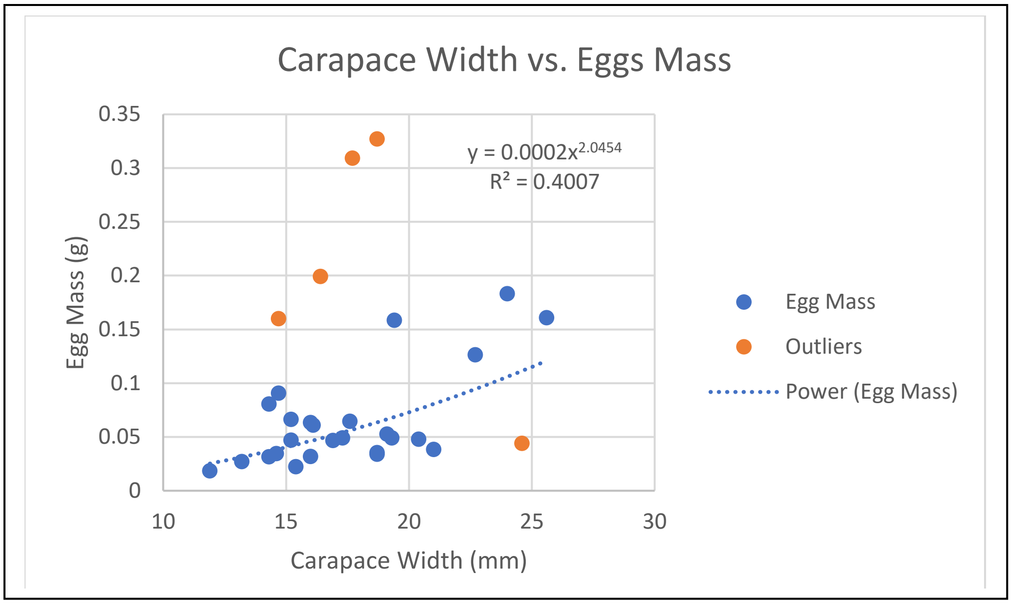

Figure 12- 31 gravid females, carapace width v. egg mass

The egg mass grew as the carapace width of ovigerous females grew (Fig. 12). There were a few outliers from possible experimental error. This may have caused the R^2 value to be low enough that the information may be insignificant. A T-test between carapace width and egg mass showed a high significant P value less than 0.0005. Egg mass rose as the total biomass expanded (Fig. 13). The mean total biomass of gravid females was 2.6388. A T-test between total biomass and egg mass showed a high significant P value less than 0.0005.

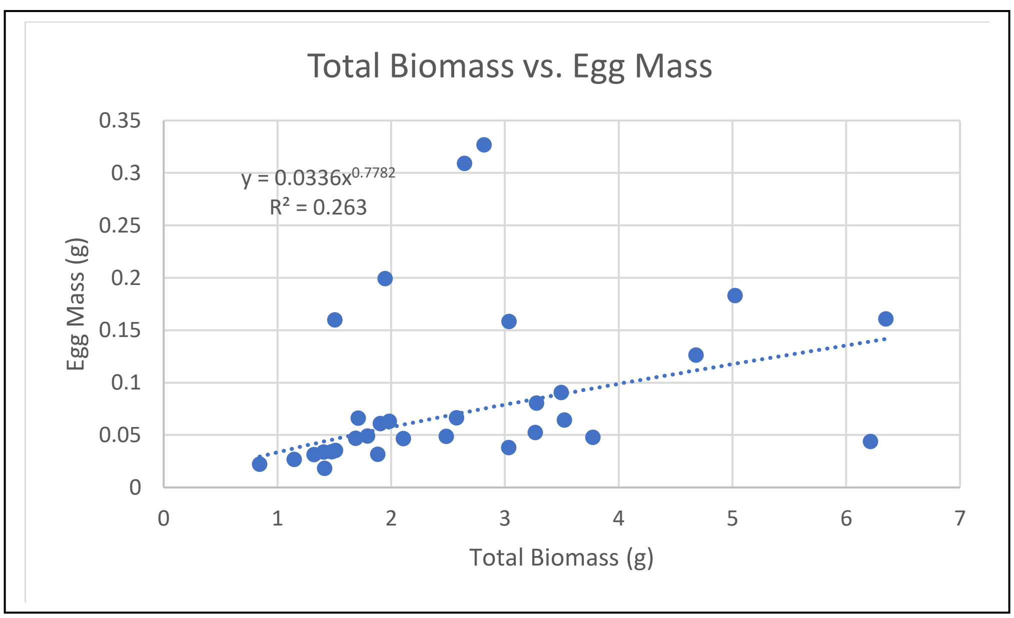

Figure 13- Total biomass v. egg mass

Ovigerous female individuals showed a larger carapace width than non-ovigerous females. There were two outliers from possible experimental error (Fig. 14). The mean carapace width of ovigerous female individuals was 17.7 mm compared to 15.7 mm for non-ovigerous female individuals.

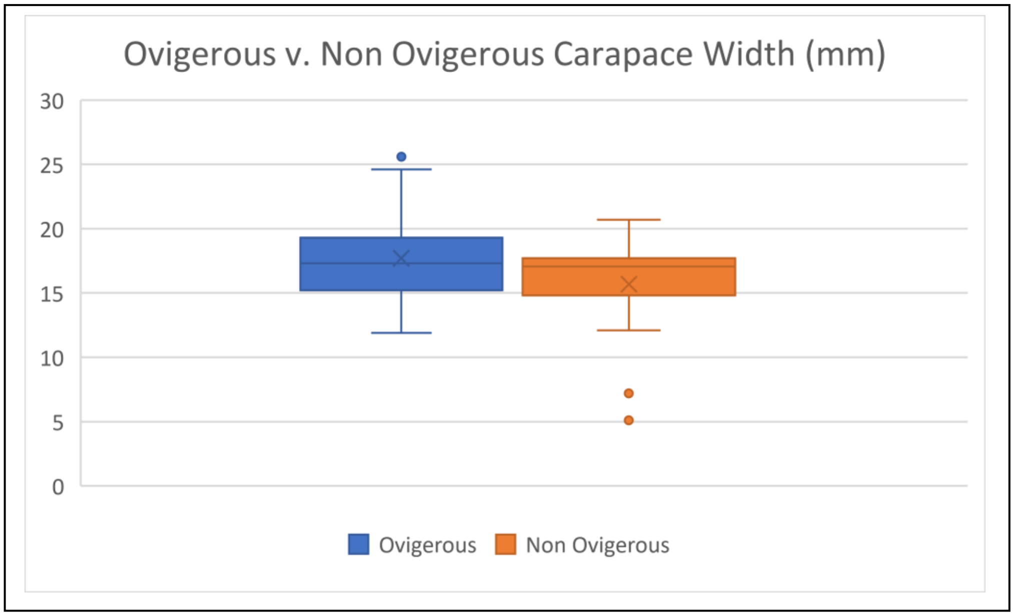

Figure 14- Ovigerous v. Non-ovigerous reproductive state

Discussion

Due to the collection being during the breeding season, it was no surprise that most females collected were gravid. According to McDermott (1998), males were more abundant than females during the collection which aligned with this study. Overall, females had averaged a larger carapace width over males, but males had a larger CW range than females. The conclusion of AHL et al (1999) found this also to be true. A larger female carapace allows for more eggs (Fig. 15). Carapace width was positively correlated with the number of embryos in broods. (McDermott, 1998). This study had a few outliers in the egg mass data due to the nutritive structures in some of the broods not being removed, but the results overall fit with this trend. Some ovigerous females show a larger carapace width than non-ovigerous females. Females reach maturity at a carapace width around 12mm (AHL et al, 1999). The egg mass of females enlarged as the carapace grew but there were too many outliers to give sufficient evidence. The total biomass of female individuals does affect the weight of the egg mass but not as significantly as the carapace width.

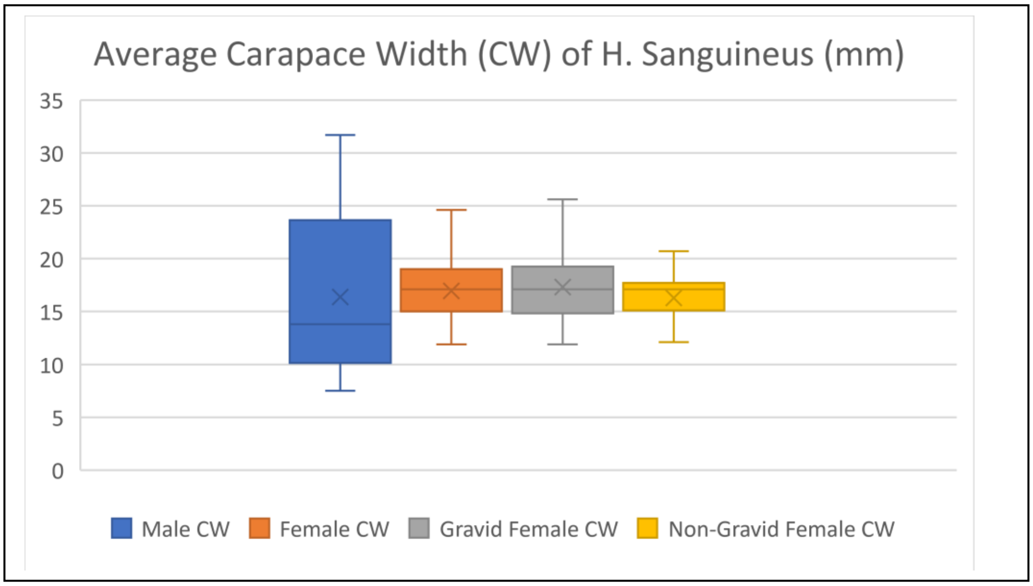

Figure 15- Average carapace width of H. sanguineus

Male individuals averaged a higher biomass than females (Fig. 16). Other studies such as McDermott (1998) also found males to average a larger biomass than females. This would suggest the allometric growth of the female carapace is greater than the male individual carapace growth rate. With a P value of less than 0.0005, there is a high significant difference between male and female carapace width and length. Eguchi et al (1989) and McDermott (1998) both showed a strong linear correlation between carapace width and length with an R>.99. This study showed a R value greater than .99 in males but slightly lower in females due to the two outliers (Fig. 7). It was predicted from the data that increased growth reflects increased age and there were no sexual differences in the measurements (Eguchi et al, 1989). This is comparable to the data in this study which shows an isometric growth between the carapace width and length (Fig. 7).

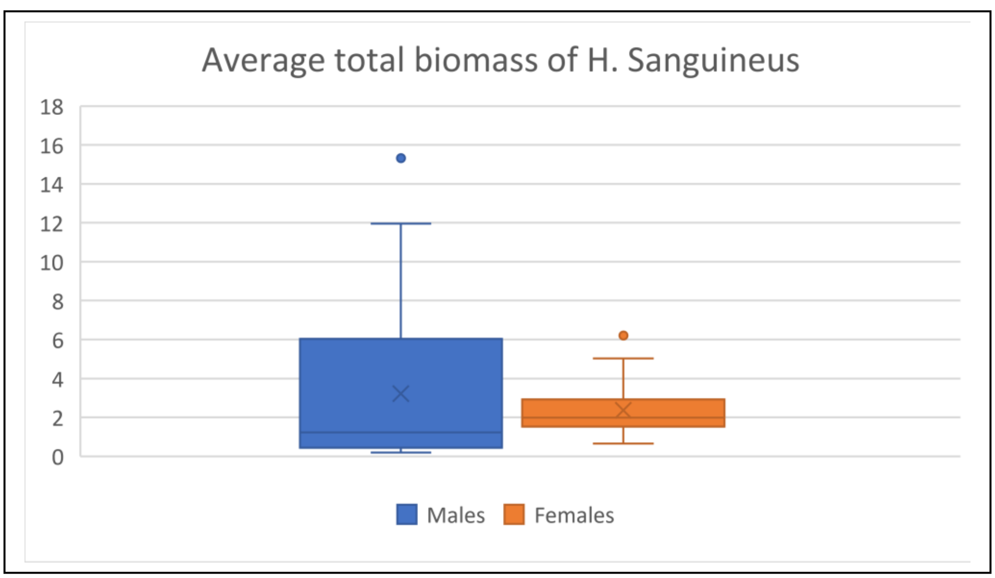

Figure 16- Average total biomass between males and females

A smaller carapace width shows similar total biomass between males and females but as the carapace width grew, the total biomass for males started to increase. Due to males having larger chelipeds they should weigh more than females of similar CWs (McDermott, 1998). This study showed a similar biomass at lower levels of CW, but the males differentiated from the females at larger CW levels (Fig. 11). Species with larger chelipeds can outcompete other species for food and shelter (Baillie et al, 2018), and better defend themselves against predators.

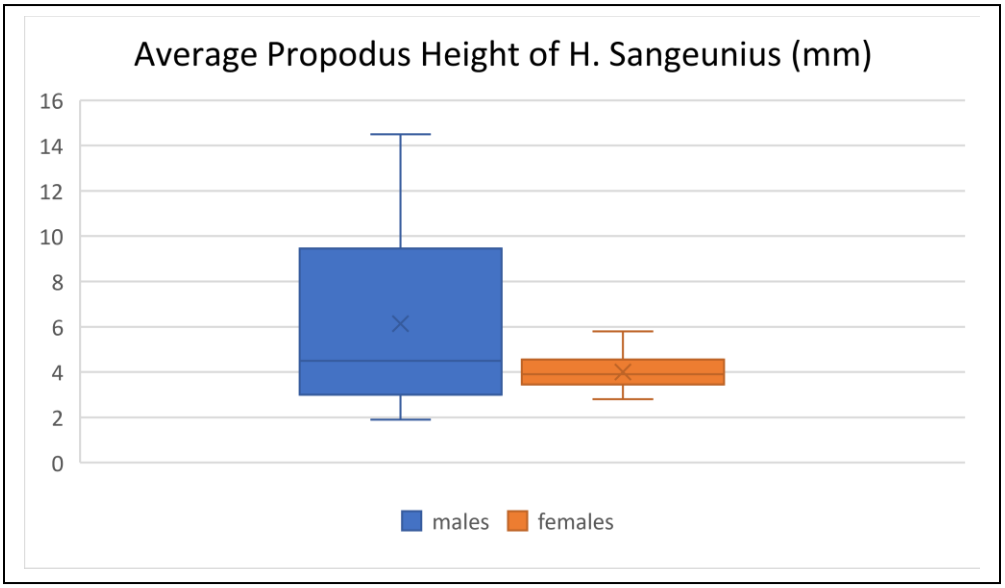

Figure 17- Average propodus height males v. females

Male individuals showed a faster growth rate of the right propodus with a larger percent of its biomass (Fig.11). The average propodus height of males was significantly larger than females which exhibits sexual dimorphism (Fig. 17). In comparison to other crabs such as the fiddler crab which show sexual dimorphism and body asymmetry in a much more extreme way (Rosenberg, 2002). The male propodus of H. sanguineus averages larger than female, although the left and right propodus of each sex is relatively the same size. This is not the case in all crabs. The male fiddler crab has a minor claw for feeding and a major claw for defense that is four times larger, compared to females who have both claws approximately the size of the males minor claw (Rosenberg, 2002). A larger biomass and propodus in males give them the ability to consume larger prey. Hemigraspus Sanguineus have been known to exhibit highly aggressive behavior (Baillie et al, 2018). As the carapace width increases so does the propodus for both males and females. As percentage of biomass, the propodus in female individuals stayed relatively flat which suggests an isometric growth rate of the right propodus (Fig. 11).

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