Research Article

Morphological and Morphometric Analysis of the male flower crab (*Portunus armatus*) in Selected Coastal Areas of Misamis Occidental, Philippines

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Abstract

The male flower crab (*Portunus armatus*) distinguishes itself by its morphological traits, which highlight its abundance. A crab's emphasis is precisely determined by a number of coloration features, most notably the pattern on its carapaces. The aim of this study is to provide accurate information about the morphological and morphometric characteristics of male flower crabs in the selected coastal areas in Misamis Occidental. The sampling locations were Barangay Canubay, Oroquieta (30 crabs), Barangay Sinonoc, Sinacaban (30 crabs) and Barangay Maquilao, Tangub (30 crabs). A total of ninety (90) crabs were collected, thirty (30) per sampling site. The morphological analysis of crabs was determined based on the color and white patterns on their carapace. The morphometric characteristics were determined by measuring the length and width of the crabs' carapaces and meri. These data were further analyzed using one-way ANOVA. The collected crab samples from Oroquieta, Sinacaban, and Tangub showed different patterns with 9, 7, and 6 variations, respectively. Among the morphometric characteristics, only the major cheliped merus width showed a significant difference in all study areas with a p-value of < 0.05. Furthermore, it shows that the male flower crab population from Tangub is significantly different from Sinacaban but not in Oroquieta and the population from Sinacaban is significantly different from Tangub in terms of major cheliped merus width. Findings of this research showed the variation in the morphology and morphometrics of the same species occupying different locations which may indicate diversity of traits within species that may lead to speciation. The researchers recommend conducting further research on geometric morphometrics analysis to compare the relative positions of landmarks between individuals or groups that focuses on shape variation and is accomplished through the "Procrustes paradigm."

Keywords: *flower crab, morphology, morphomterics, carapace*

Introduction

Crustaceans are widely used in morphological and morphometric studies due to their rigid exoskeleton, which allows accurate and repeatable measurements of body structures. Morphometric analyses are commonly applied to crustaceans for taxonomic identification, population and stock discrimination, assessment of sexual dimorphism, and evaluation of growth and ontogenetic patterns (Alencar et al., 2014). When integrated with external morphological traits, these approaches provide important insights into phenotypic variation and population structure across geographic areas.

The flower crab or blue swimming crab, Portunus armatus (formerly Portunus pelagicus), is a commercially valuable portunid crab widely distributed throughout the Indo–West Pacific region (Lai et al., 2010). This species exhibits distinct morphological characteristics, including a broad spined carapace, swimming paddles, and pronounced sexual dimorphism, with males generally larger and more vividly colored than females (Lai et al., 2010; Dyson, 2020). Owing to its high market demand, P. armatus supports important coastal fisheries and contributes significantly to local economies (WWF, 2018). However, intense fishing pressure has raised concerns regarding overexploitation and declining wild populations (Mehanna et al., 2013; Kunsook et al., 2014).

Previous studies have reported substantial variation in carapace coloration, white spot patterns, and morphometric traits of P. armatus across different regions, suggesting possible population differentiation and phenotypic plasticity (Lai et al., 2010; Fujaya et al., 2016; Weerasekera & Bandaranayake, 2021). While morphometric analyses have been shown to be effective in detecting population-level differences related to habitat and environmental conditions, most existing research has focused on females or mixed-sex populations, with limited attention given specifically to male crabs (Ravi et al., 2008; Johnson et al., 2010; Ewers-Saucedo et al., 2015).

In the Philippines, despite the economic importance of P. armatus, there is a lack of published studies documenting the morphology and morphometric variation of male individuals. This study aims to address this gap by analyzing the morphological characteristics and key morphometric traits of male P. armatus from selected coastal areas of Misamis Occidental, Philippines, providing baseline data relevant to species assessment, fisheries management, and conservation.

Materials and Methods

Research Design

The study utilized a descriptive quantitative research design. This aims to accurately and systematically answer questions about the morphological characteristics of the shell of male flower crabs, rather than questions about their function or purpose.

Quantitative design was employed to quantify the morphometrics of the shells of male flower crabs, including carapace width, deep carapace width, carapace length, major cheliped merus width, and major cheliped merus length, which would be further used for statistical analysis.

Study Area

The study was conducted in selected coastal areas of Misamis Occidental, particularly in Barangay Canubay, Oroquieta City; Barangay Sinonoc, Sinacaban; and BarangayMaquilao, Tangub City (Figure 1).

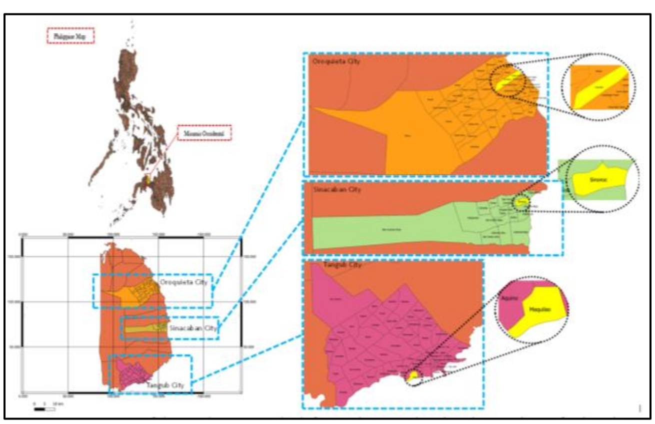

Figure 1. Map of the Study area: In the left was the map showing the province of Misamis Occidental. In the right side was the map of the Misamis Occidental emphasizing the three sampling locations

The coordinates of Canubay, Oroquieta city were roughly 8.4952, 123.7961. The coordinates' elevation was calculated to be 7.7 meters, or 25.3 feet, above mean sea level. Maquilao, Tangub was located somewhere at 8.0507 and 123.7267. At these coordinates, the elevation was calculated to be 4.7 meters, or 15.4 feet, above mean sea level. The location of Sinonoc, Sinacaban was roughly 8.3034, 123.8474. At these locations, the elevation was calculated to be 7.2 meters (23.6 feet) above mean sea level.

The researchers chose the three sampling areas as they see a great abundance of caught flower crab in these areas. These communities are near the coast and commonly caught different crabs; one of these was the flower crab. In the city of Oroquieta, most of the coastal area was occupied however some areas were designated as mangrove protected area. Moreover, in Sinacaban, there were also areas designated as mangrove protected areas. It also provides habitats and rich environment for many marine species. People maintain cleanliness to the shorelines as they have a tourist spot so called Aquamarine Park. Furthermore, in Tangub City, their Mangrove plantation was lesser than in Sinacaban because most of the areas were occupied by the people. The researchers believed that these three areas are suitable for collecting samples and chosen in purpose because of its geographical distance from each other.

Sample Collection Method

A total of 90 crab samples were collected, with 30 crabs from each of the 3 sampling sites was also divided into 3 replicates (10 per replicate) that were bought from local fishermen in Barangay Canubay Oroquieta, Sinonoc Sinacaban, and Maquilao Tangub. The samples were placed in an ice box and immediately transported to the laboratory for further processing. The images of the samples were photographed using DSLR Nikon D5100. All data collected were recorded and used to support for morphological characteristics and morphometric findings.

Morphological Characteristics

The images of the sample were used to evaluate the morphological characteristics of male flower crabs. Researchers examine the colors and patterns of the white spots on the carapace in detail. The coloration of the crabs was evaluated using Toca Color Finder (TCF) tool (Ayi et.al., 2018) and the common patterns of white spots on the carapace were scrutinized to identify the variations of the three sampling areas (Figure 2). Based on the color of the carapace and the arrangement of the white dots, the samples in each sampling location were categorized. The general categories of samples were organized using the same methodology.

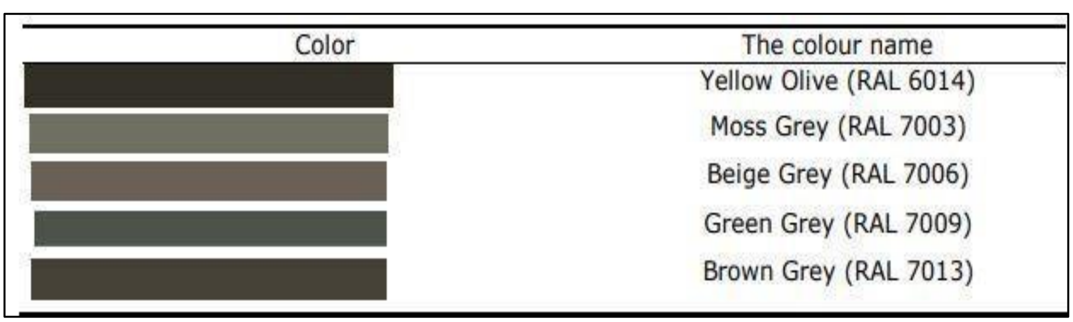

Figure 2. Color scale of the Toca Color Finder tool used to identify the color of the carapace and the pattern of the white spots (Ayi et. al., 2018).

Morphometric Data

The morphometric data of the collected crabs include outer carapace width, deep carapace width, carapace length, major cheliped merus width, and major cheliped merus length (Figure 3) . The measurements were obtained using a plastic ruler.

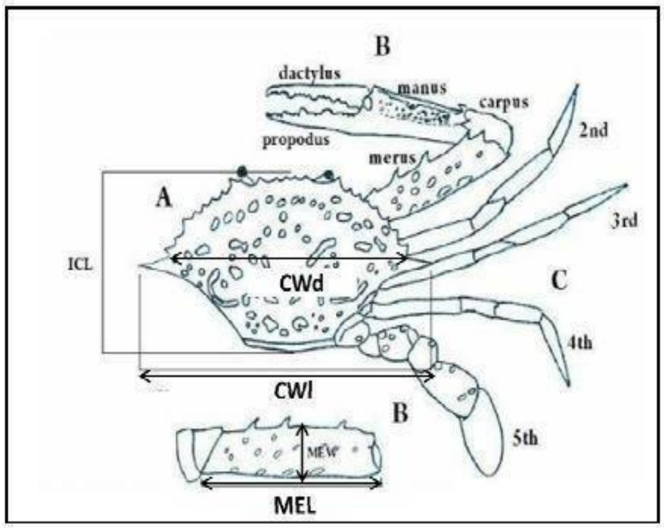

Figure 3. Body parts of Portunus armatus for morphometric measurement. *A. Carapace and appendages; B. Cheliped; CWl = outer carapace width; CWd= deep carapace width; ICL = carapace length; MEW = major cheliped merus width; MEL = major cheliped merus length (Lai et. al., 2010).*

Statistical analysis

The morphometric data which include outer carapace width, deep carapace width, carapace length, carapace length, major cheliped merus width and major cheliped merus length were subjected to statistical analysis. One-way analysis of variance (ANOVA)was carried out using the software PAST version 5 to determine if there is a significant difference among the three population of male flower crabs from different sampling areas.

Results and Discussions

Morphological Characteristics

The collected crab samples from Oroquieta, Sinacaban and Tangub showed different patterns with 9, 7 and 6 variations respectively. Based on the Toca Color Finder (TCF) scale, O1 variation of the carapace had a moss grey color with white spot patterns, and the variation had a smaller number of white spots. The O2 variation of the carapace was brown and grey in color with larger white spots in the anterolateral and posterior areas of the carapace. The O3 variation of the carapace features a beige-grey color with a white spot pattern that is found on the entire carapace. The O4 variation of the carapace had yellow olive with white spots in the anterolateral and posterior areas of the carapace. The O5 variation of the carapace had a brown-gray color with the same variation of white spots as O4. The O6 variation of the carapace had beige-gray color with a white spot that appeared in a line at the anterolateral and cardiac areas of the carapace. The O7 variation of the carapace had a brown-gray color with the same variation of white spots as O6. The O8 variation of the carapace had yellow olive with the same variation of white spots as O7. The O9 variation of the carapace had yellow olive with large white spot patterns that spread across the entire carapace. However, the white spots appeared alone in the anterolateral area of the carapace (Figure 5).

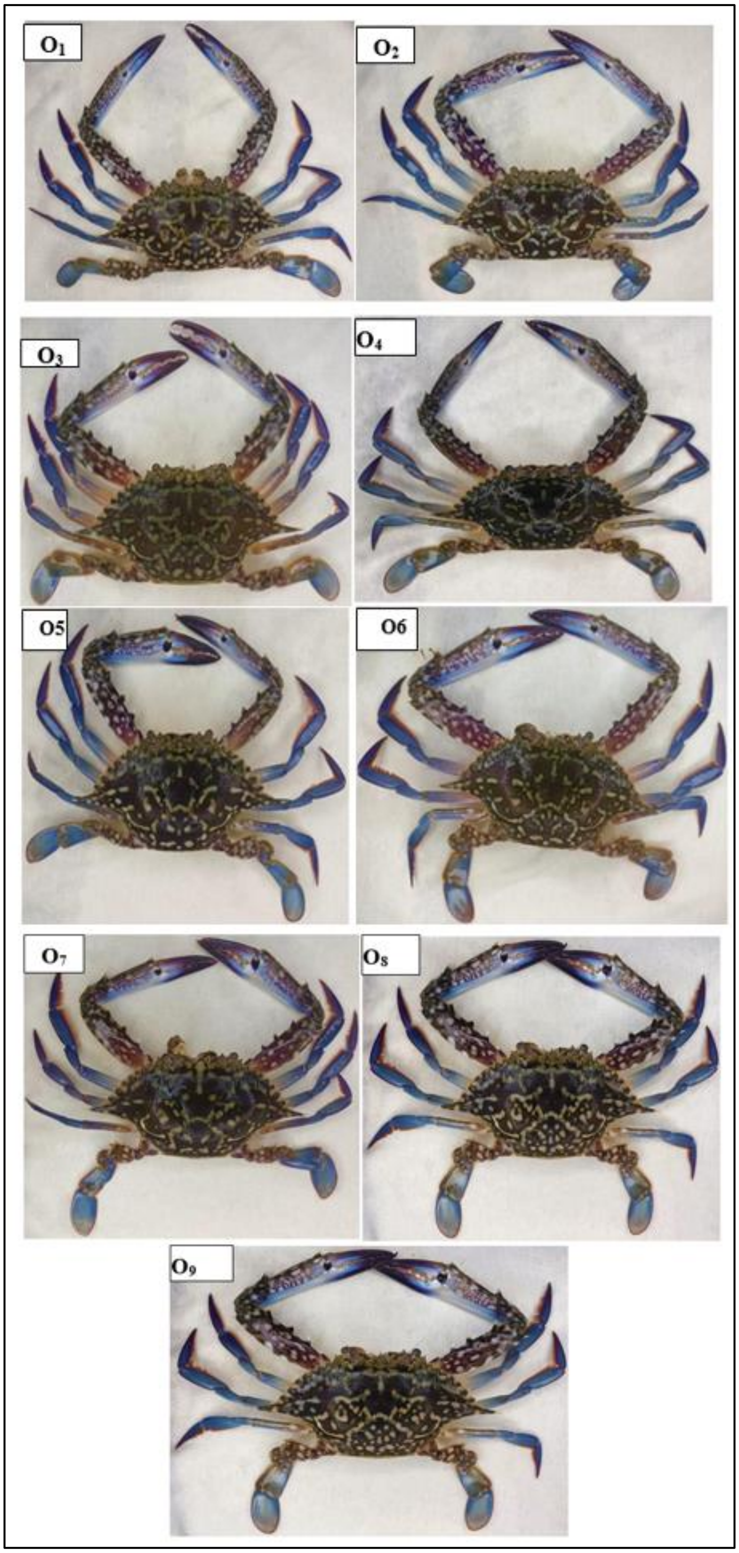

Figure 5. Color of the carapace and pattern of the white spots of the male (Portunus armatus) collected from Oroquieta City, (O indicating the sampling location (Oroquieta) and Number 1– 9 indicating the variation of color and white spot pattern)

Table 1. Variation based on the color of the carapace and the pattern of the white spots of male *P. armatus* from Oroquieta City.

Variation Type	Number of Individuals	Percentage (%)
O_1	5	16.67
O_2	2	6.67
O_3	3	10.00
O_4	4	13.33
O5	4	13.33
O_6	4	13.33
O_7	4	13.33
O_8	3	10.00
O_9	1	3.33
TOTAL	30	100

Table 1 shows the frequency of individual samples of P. armatus from Oroquieta belonging to different variation types. Out of 30 samples from this area, the variation of O1 had the highest number of individuals (5 individuals or 16.67%) followed by O4, O5, O6 and O7 variation with 4 number of individuals (13.33%), O8 and O3 variation with 3 samples (10.00%), O2 variation with 2 samples (6.67%) and O9 has the lowest number frequency which has 1 sample (3.33%).

Figure 6 shows the color of the carapace and pattern of the white spots of the male flower crabs collected from Tangub. Out of 30 samples from Tangub there are 7 variations of color of the carapace and white spot patterns. The T1 variation of the carapace had yellow olive color with white spot patterns that spread from the posterior and anterolateral parts of the carapace. The T2 variation of the carapace had yellow olive color with larger white spots that spread across the entire carapace. However, the white spots appeared in a line in the anterolateral area in the carapace. The T3 variation of the carapace had brown grey color with white spots that in the anterolateral and posterior areas of the carapace. The T4 variation of the carapace had green grey with same white spots of T3. However, the size of white spots was larger than T3. The T5 variation of the carapace had yellow olive with white spots that in the anterolateral and posterior areas in the carapace. The T6 variation of the carapace had beige grey color with same large spots of T2. The T7 variation of the carapace had beige grey with white spots that appeared in a line at the anterolateral and cardiac areas of the carapace.

Table 2 shows the frequency of individual samples of *P. armatus* from Tangub belonging to different variation types. Out of 30 samples from this area, the variation of T_7 had the highest number of individuals (7 individuals or 23.33%) followed by T_2 variation with 6 number of individuals (20.00%), T_1 variation with 5 samples (16.67%), T_3 and T_5 variation with 4 samples (13.33%), T_4 and T_6 has the lowest number frequency which has two samples (6.67%).

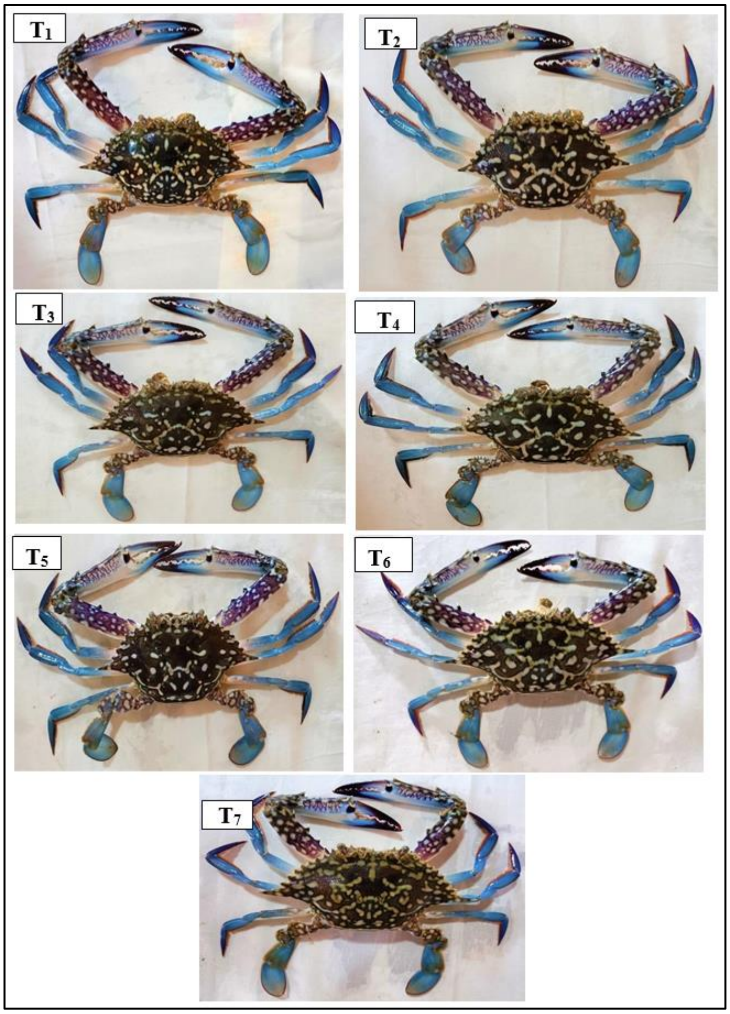

Figure 6. The carapace and pattern of the white spots of the male (*Portunus armatus)* collected from Tangub, (T indicating the sampling location (Tangub) and Number 1 – 7 indicating the variation of color and white spot pattern)

Table 2. Variation based on the color of the carapace and the pattern of the white spots of male *P. armatus* from Tangub City.

Variation Type	Number of Individuals	Percentage (%)
T_1	5	16.67
T_2	6	20.00
T_3	4	13.33
T_4	2	6.67
T_5	4	13.33
T_6	2	6.67
T_7	7	23.33
TOTAL	30	100

In Figure 7, the Color of the carapace and pattern of the white spots of the male (Portunus armatus) collected from the Sinacaban (S indicating the sampling location, Sinacaban, and the Numbers 1 –6 indicating the variation of color and white spot patterns). Out of 30 samples from Sinacaban there are 6 variations of color of the carapace and white spot patterns.

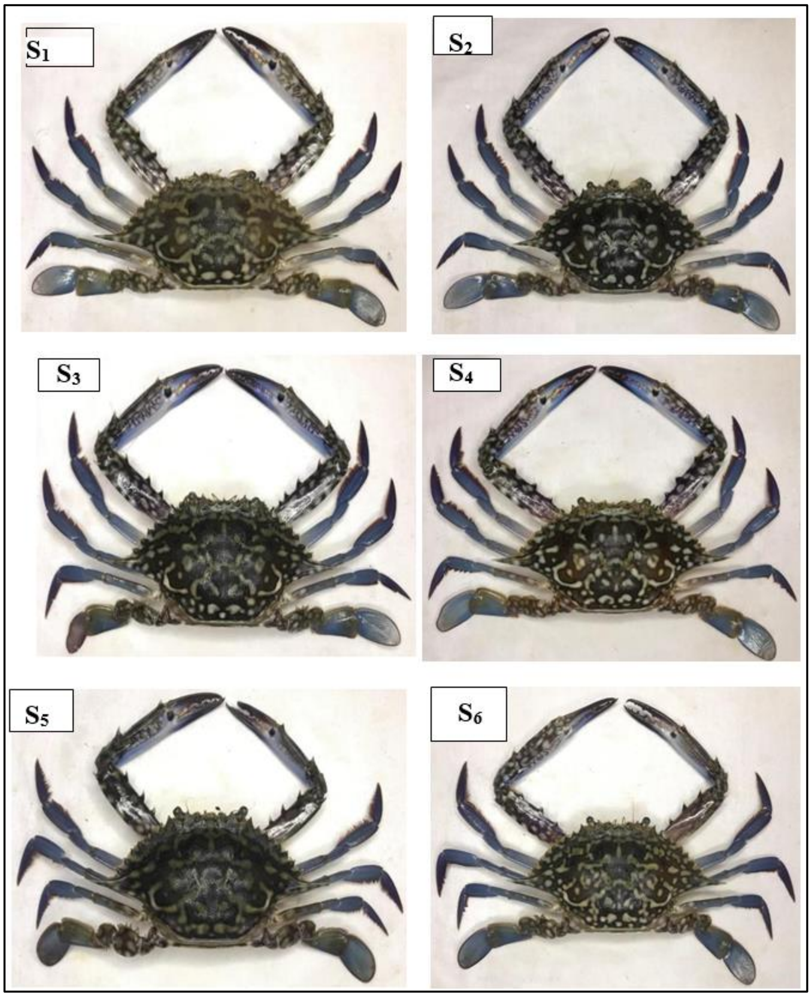

Figure 7. Color of the carapace and pattern of the white spots of the male (*Portunus armatus)* collected from the Sinacaban (S indicating the sampling location, Sinacaban, and the Numbers 1 –6 indicating the variation of color and white spot patterns).

As presented in Figure 7, the crab samples from Sinacaban had 7 variations of color and white spot patterns. The S1 variation of the carapace had moss grey color with white spots that appeared in a line at the anterolateral and cardiac areas of the carapace.

S2 variation of the carapace had yellow olive with white spot patterns that spread from the posterior and anterolateral part of the carapace. The S3 variation of the carapace had yellow olive color with same white spots pattern of S1. The S4 variation of the carapace had brown grey color with white spot patterns that were dense in the posterior and anterolateral ends of the carapace. The S5 variation of the carapace had yellow olive color with white spot pattern that spread from the posterior and anterolateral part of the carapace and had a rough surface. The S6 variation of the carapace had moss grey color with white spots that spread across the entire carapace.

Table 3. Variation based on color of the carapace and pattern of the white spots of male *P. armatus* from Sinacaban

Variation Type	Number of Individuals	Percentage (%)
S_1	8	19
S_2	2	16
S_3	5	17.50
S_4	7	18.50
S_5	2	16
S_6	6	18
TOTAL	**30**	**100**

Table 3. Shows the frequency of individual samples of P. armatus from Sinacaban belonging to different variation types. Out of 30 samples from this area, the variation of S1 had the highest number of individuals (8 individuals or 26.67%) followed by S4 variation with 7 number of individuals (23.33%), S6 variation with 6 samples (20.00%), S3 variation with 5 samples (16.67%), S2 and S5 has the lowest number frequency which has two samples (6.67%).

Table 4. Overall groupings of *P. armatus* based on carapace color and white spot patterns of male flower crab from 3 sampling areas.

Variation Type	Oroquieta City	Tangub City	Sinacaban	Percentage (%)
Variation 1	5	0	0	5.56
Variation 2	2	0	0	2.22
Variation 3	3	0	0	3.33
Variation 4	4	0	0	4.44
Variation 5	4	4	0	8.89
Variation 6	4	7	0	12.23
Variation 7	4	0	0	4.44
Variation 8	3	0	5	8.89
Variation 9	1	0	0	1.11
Variation 10	0	5	2	7.78
Variation 11	0	6	0	6.67
Variation 12	0	2	0	2.22
Variation 13	0	4	0	4.44
Variation 14	0	2	0	2.22
Variation 15	0	0	8	8.89
Variation 16	0	0	7	7.78
Variation 17	0	0	2	2.22
Variation 18	0	0	6	6.67
Total	**30**	**30**	**30**	**100**

Table 4. Shows the frequency of P. armatus samples from Sinacaban that belong to each category of variation. The variant 6 had the most individual (4 in total) out of the 90 samples from the three sampling

regions (7 or 12.23%) were recorded in Oroquieta and Tangub City. Variation 5 with a sample size of four individuals in Oroquieta and Tangub (8.89%) came next. Variation 8 had 3 individuals (8.89%), variation 17 contained 8 individuals (8.89%), and both variations were found in Oroquieta City and Sinacaban.

Variation 10 had the number of individuals (5 in Tangub City and Sinacaban had 2 or 7.78%), while variation 20 had the number of individuals (7 in Sinacaban or 7.78%). Six individuals, or 6.67%, were present in variation 11 at Tangub City. Variation 18 had 6 numbers of people (6.67% in Sinacaban), whereas variation 1 had 5 individuals (5.56% in Oroquieta City). There were individuals in variations 4 and 7 (4 in Oroquieta City, or 4.44%). Variation 13 had the individuals (3 in Oroquieta City, 3.33%), while variation 3 had the individuals (4 in Tangub City, 4.44%). The number of individuals was present in variation 2 (2 in Oroquieta City, or 2.22%), variation 12 and 14, and variation 14 (2 in Tangub City, or 2.22%). The highest number of individuals was in variation 17 (2 in Sinacaban, or 2.22%), and the lowest number was in variation 9 (1 in Oroquieta City, or 1.11%). Additionally, only variations 5 and 6 out of all the variation types in Oroquieta and Tangub had variations, with 8.89% and 12.23%, respectively. While there was only variant 10 in Tangub and Sinacaban, with 5 and 2 individuals totaling 7, or 7.78%. The results of the variation type analysis only indicated that Tangub and Sinacaban had variants that Oroquieta did not, but Tangub and Sinacaban also had variations that Oroquieta did not.

Morphometric Variables

The morphometric variables were also taken which include outer carapace width (CWI), deep carapace width (CWD), carapace length (CL), major cheliped merus width (MEW) and major cheliped merus length (MEL).

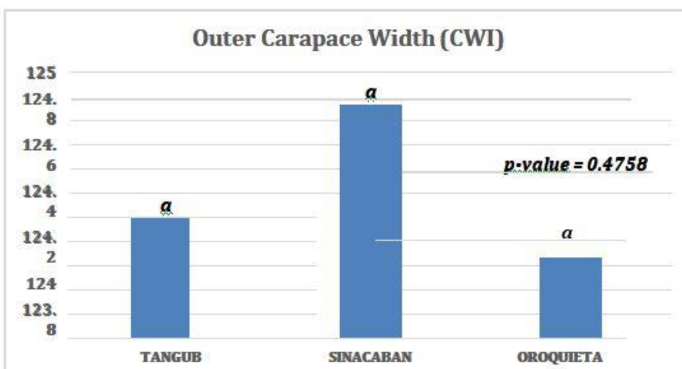

Figure 8. Analysis of Variance (ANOVA) of the outer carapace width of male flower crabs

Figure 8 shows the Analysis of Variance (ANOVA) of the outer carapace width of male flower crabs from Oroqueita, Sinacaban and Tangub. It further showed that the p-value is greater than 0.05 alpha values which mean that there is no significant difference in the outer carapace width of the male flower crabs from the three sampling areas. In addition, they might be caused by the hatchery they lived in (Johnston et. al., 2016; Rodriguez et. al., 2007).

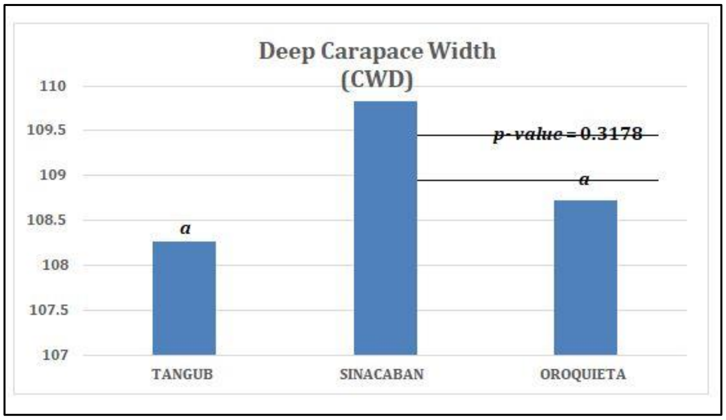

Figure 9. Analysis of Variance (ANOVA) of the Deep carapace width of male flower crabs

Figure 9 shows Analysis of Variance (ANOVA) of the Deep carapace width of male flower crabs from Tangub, Sinacaban and Oroquieta. It further showed that the p- value is more than 0.05 which means that there is no significant difference among the three areas of male flower crabs in terms of the outer carapace width. Growth is shown to be dependent upon temperature. Crabs kept at high temperatures grow faster than those kept at lower temperature (Jenkins, 2018).

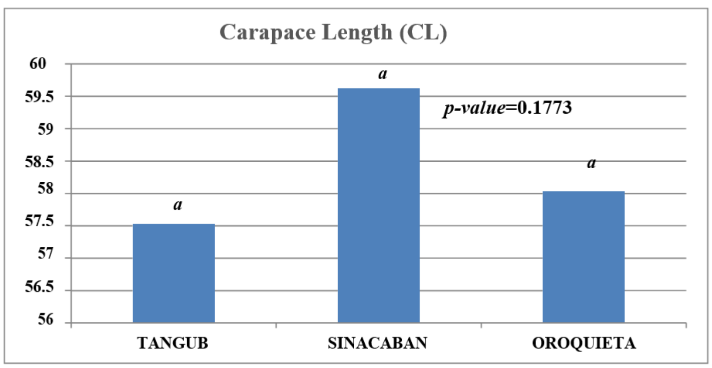

Figure 10. Analysis of Variance (ANOVA) of the carapace length of male flower Crabs

Figure 10 shows the Analysis of Variance (ANOVA) of the carapace length of male flower crabs from Oroquieta, Sinacaban and Tangub. It further showed that the p- value is more than 0.05 which means that there is no significant difference of thethree populations of male flower crabs in terms of the deep carapacewidth. Mangrove functions as crab activities that increased the amount of food sources in mangroves via consumption of mangrove leaves (Hannah & Shuhaida, 2017).

Figure 11 shows the Analysis of Variance (ANOVA) of the major cheliped merus width of male flower crabs from Tangub, Sinacaban and Oroquieta. It further showed that the p-value is less than 0.05, which means that there is a significant difference among the three populations of male flower crabs in terms of the major cheliped merus width. Additionally, it shows that the male flower crab population from Tangub is significantly different from Sinacaban but not in Oroquieta and the population from Sinacaban is significantly different from Tangub in terms of major cheliped merus width it was also because of the abundance of food supply (Hannah & Shuhaida, 2017) and the temperature they are live in (Johnston et. al., 2016; Rodriguez et. al., 2007).

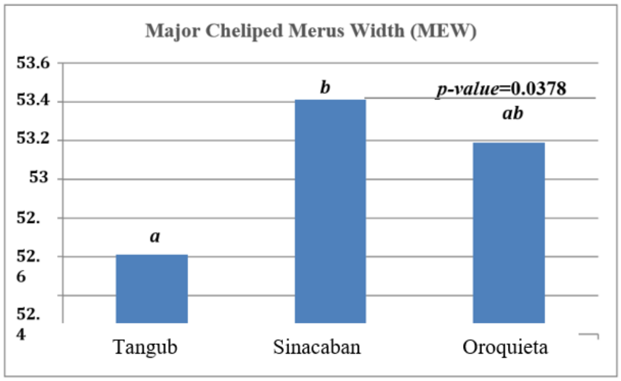

Figure 11. Analysis of Variance (ANOVA) of the major cheliped merus width of male flower crabs.

Figure 12. Shows the Analysis of Variance (ANOVA) of the major cheliped merus length of male flower crabs from Tangub, Sinacaban, and Oroquieta. It further showed that the p-value is more than 0.05 which means that there is no significant difference among the three populations of male flower crabs in terms of the major cheliped merus length. In addition, it may be due to the food scarcity they had experienced (McLean & Todgham, 2015).

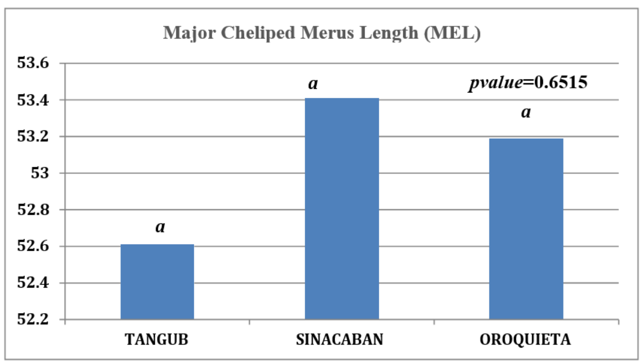

Figure 12. Analysis of Variance (ANOVA) of the major cheliped merus length of male flower crabs

In Figure 8, Analysis of variance (ANOVA) of the outer carapace width of male flower crabs from Tangub, Sinacaban, and Oroquieta shows that there was no significant difference among the three populations of male flower crabs. In Figure 9, the Analysis of variance (ANOVA) for the Deep carapace width of male flower crabs from Tangub, Sinacaban, and Oroquieta reveals no significant difference among the three sites. The same also in Figures 10 and 12, Analysis of variance (ANOVA) of the carapace length and Major cheliped merus length of male flower crabs from Tangub, Sinacaban, and Oroquieta shows that there was no significant difference among the three populations. This might be due to the fact that the study areas are not that geographically far from each other, and with a little variation in terms of their habitat. Thus, this population is probably experiencing the same pressures (Marchese, 2015).

On the other hand, the ANOVA of the major cheliped merus width of male flower crabs from Tangub, Sinacaban and Oroquieta showed a significant difference. Moreover, the male flower crab population from Tangub is significantly different from that of Sinacaban, but not in Oroquieta, and the population from Sinacaban is significantly different from that of Tangub. Previous research on the size and structure of the cheliped of predatory crabs has primarily focused on how they are employed for foraging.

Additional evidence that the development of crab chelae was not solely influenced by feeding requirements is provided by the usage of these structures in feeding, reproduction, and agonistic interactions. Although individuals with larger cheliped can eat a wider variety of prey types and sizes, C. maenas had a relatively low proportion of hard bodied prey in their diet. However, larger chelae of fur provide selective benefits by improving mate competitiveness and intra-specific agonistic interactions (Beattie, Pitt & Conolly, 2012). Physical and chemical pollutants, predators, and symbiotic plants- and animals with the blue crab are all part of the environment that must be acknowledged as actual or potential factors affecting the rates of reproduction, growth and survival, as well as the behavior and distribution of the blue crab population. In addition, most of the parameters were the water quality on the various life history stages of the blue crab, and their secondary effects on a crab's behavior, caused by the destruction or alteration of the habitat or the depletion of the food supply (Zainal 2014).

Conclusion

Based on morphological characteristic findings, there were 9, 7, and 6 variations in terms of color and white spot patterns between the crab samples from our sampling locations in Oroquieta, Sinacaban, and Tangub City. Based on morphometric analysis, only Figure 11, the Analysis of Variance (ANOVA) of the major cheliped merus width of male flower crabs from Tangub, Sinacaban, and Oroquieta showed that the $p< 0.05$, which means that there is a significant difference among the three populations of male flower crabs in terms of the major cheliped merus width. Additionally, it shows that the male flower crab population from Tangub is significantly different from Sinacaban, but not in Oroquieta, and the population from Sinacaban is significantly different from Tangub in terms of major cheliped merus width.

Recommendations

The researcher recommends conducting further research on geometric morphometrics analysis to compare the relative positions of landmarks between individuals or groups that focus on shape variation, and is accomplished through the “Procrustes paradigm”. Landmark-based geometric morphometric analysis is a valuable tool for various studies, particularly in taxonomic contexts. Additionally, the researcher recommends incorporating environmental parameters and adhering to the standard sampling method.

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