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SIZE AND WEIGHT RELATIONSHIPS FOR THE GOLDEN CRAB, *CHACEON FENNERI*, AND THE RED CRAB, *CHACEON QUINQUEDENS*, FROM THE EASTERN GULF OF MEXICO

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ABSTRACT: Carapace length, carapace width, and weight relationships are discussed for the golden crab, *Chaceon fenneri*, and the red crab, *Chaceon quinquedens*, from the eastern Gulf of Mexico. Males of both species were significantly larger than females in comparisons of means of all measured parameters. Relationships between carapace length and carapace width, carapace length and weight, and carapace width and weight were similar between Atlantic and Gulf of Mexico populations for both species.

INTRODUCTION

Deep water crabs of the family Geryonidae are widely distributed throughout the world oceans. Crabs of the genus *Chaceon* (formerly *Geryon*) are fished for human consumption along both sides of the Atlantic Ocean, including the coastal areas of southwest Africa (Melville-Smith 1988), the eastern United States (Ganz and Herrmann 1975, Erdman and Blake 1988), and Bermuda (Luckhurst 1986). Two species of *Chaceon* have been reported from the Gulf of Mexico, the golden crab, *Chaceon fenneri*, and the red crab, *Chaceon quinquedens* (Lockhart et al. 1990). Red crabs are found throughout the deep waters of the U. S. Gulf of Mexico with reported abundance centered in the northcentral Gulf of Mexico east of the mouth of the Mississippi River (Lockhart et al. 1990, Waller et al. 1995). Although golden crabs have been reported from slope waters west of the Mississippi River (Waller et al. 1995), population densities are highest in the eastern Gulf of Mexico adjacent to peninsular Florida (Otwell et al. 1984, Lockhart et al. 1990).

The minimum size for harvest of red crabs in the Atlantic fishery has been set at a carapace width of 114 mm (Armstrong 1990). A minimum carapace width of 121 mm has been proposed for golden crabs in the southeast Atlantic Ocean by the South Atlantic Fishery Management Council. Reproductive maturity, fecundity, and size at harvest of brachyuran crabs, as well as other relevant, management-related biological characteristics are associated with external, morphometric features. Additionally, the relationships between various exoskeletal features have taxonomic value in many brachyuran groups, including the Geryonidae. This study examined the relationships between carapace length, carapace width, and total wet weight for male and female *C. fenneri* and *C. quinquedens* from the eastern Gulf of Mexico and compared findings with similar data for these species from the eastern Atlantic Ocean.

MATERIALS AND METHODS

Red and golden crabs were collected in August and September 1995 in conjunction with an EPA/Gulf of Mexico Program grant to investigate trace element contaminants in sediments and in selected tissues of *C. quinquedens*. Red crabs used in this study were collected west of Tampa, FL (27°46' N, 85°35' W) in 952 m and south of Pensacola, FL (28°17' N, 87°32' W) in 732 m. Golden crabs were captured at a single site west of Tampa, FL (27°48' N, 85°24' W) in 732 m. Crabs were trapped using twelve Fathoms Plus commercial crab traps which are designed to retain adult crabs and to prevent the retention of juvenile crabs. Capture protocol followed Waller et al. (1995). Crabs were maintained at sea in refrigerated seawater systems and returned to the laboratory alive. All weights and linear measurements were taken in the laboratory. Ovigerous females and crabs with missing appendages were not included in analyses. Carapace width (CW) was determined by measuring the distance between the tips of the fifth lateral spines. Carapace length (CL) was measured as the midline distance from the diastema between the rostral teeth to the posterior edge of the carapace. Carapace width and length were measured to the nearest millimeter with electronic calipers. A Sartorius electronic balance (model MP 9) was used to determine wet weight (Wt) in grams.

Statistical analyses were performed using StatGraphics® Plus Version 7.1 and Clinstat® computer software. The mean and standard deviation were calculated for each measured character for male and female crabs of both species. A t-test ($\alpha = 0.05$) was used to compare character means. An analysis of covariance procedure (ANCOVA, $\alpha = 0.05$) with carapace length as the covariate was used to test for significant differences between the sexes in the slopes and intercepts of the carapace width/carapace length relationship for both species. Analysis of

covariance was used to test for significant differences between the sexes in the slopes and intercepts of the weight/carapace length and weight/carapace width relationships for each species. Separate analyses were conducted using carapace length and carapace width as covariates. Data were log-log transformed for the weight analyses. In the figures of the weight/carapace length and weight/carapace width regressions, linear scales rather than logarithmic scales were used to aid in visual interpretations of relationships. The equations of Wenner et al. (1987), Erdman and Blake (1988), and Erdman (1990) for golden crabs, and the equations of Haefner (1978) for red crabs were solved over the size range of animals in the present study to determine whether their predicted measurements were within the 95 % prediction limits for crabs from the eastern Gulf of Mexico. Both Wenner et al. (1987) and Erdman (1990) predicted carapace length based on carapace width for *C. fenneri* from the Atlantic Ocean. To allow comparison of these characters between Gulf and Atlantic specimens, their methodology was followed and equations which predicted carapace length based on carapace width were derived and solved.

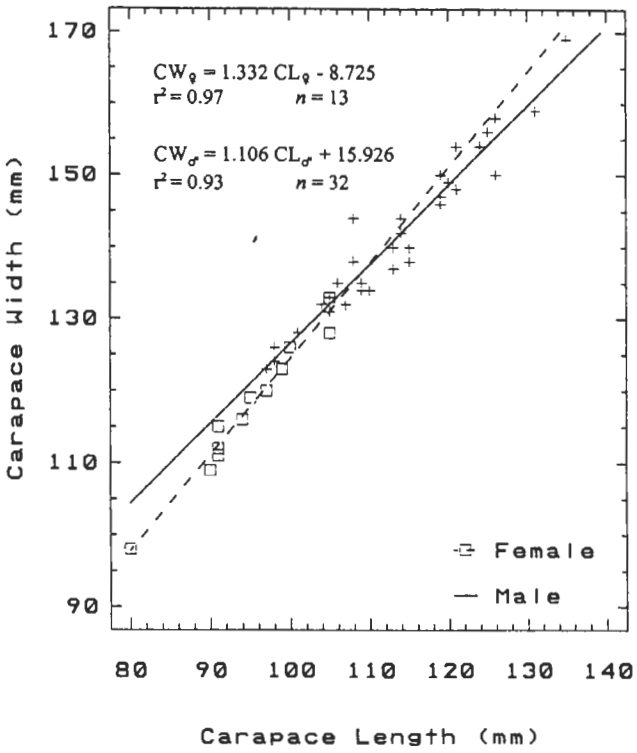

Figure 1. Regression of carapace width (CW) vs carapace length (CL) for male and female *C. fenneri*.

RESULTS

Chaceon fenneri

Means of carapace length (♂ = 114 ± 10 mm, ♀ = 95 ± 7 mm), carapace width (♂ = 142 ± 11 mm, ♀ = 118 ± 9 mm), and weight (♂ = 787 ± 206 g, ♀ = 390 ± 242 g) were greater for males (n = 32) than for females (n = 13). Results of t-tests comparing the means of characters for males and females showed statistically significant differences for carapace length ($t = -6.34$, $p = 6.29 \times 10^{-7}$), carapace width ($t = -6.86$, $p = 2.04 \times 10^{-8}$), and weight ($t = -9.39$, $p = 5.70 \times 10^{-12}$).

Coefficients of determination were high for CW/CL regressions for males ($r^2 = 0.93$) and females ($r^2 = 0.97$), indicating a strong linear relationship between carapace length and width for both sexes (Figure 1). When regressions of carapace width against carapace length were compared for males and females, no significant differences were found in the slopes or intercepts of the regression lines (slope $F = 3.29$, $p = 0.08$; intercept $F = 4.13$, $p = 0.049$). Thus, this relationship was considered equal for males and females. Coefficients of determination were high for the log-log transformed Wt/CL and Wt/CW regressions for males ($r^2 = 0.96$ and $r^2 = 0.95$, respectively) and females ($r^2 = 0.96$ and $r^2 = 0.95$, respectively). This indicated a strong exponential relationship between weight and carapace length and between weight and carapace width for both sexes (Figures 2 & 3). ANCOVA of the log-log transformed Wt/CL data showed no significant difference in the slopes of the regression lines ($F = 0.37$, $p = 0.55$); however, a significant difference was found in the intercepts ($F = 46.63$, $p < 0.0001$), indicating that for a given carapace length males were heavier than females. In contrast, the weight and carapace width relationship between males and females showed significant differences in both regression slopes and intercepts of the log-log transformed data (slope $F = 8.40$, $p = 0.006$: intercept $F = 19.02$, $p < 0.0001$). However, for a given carapace width within the size range of this study males were always heavier than females.

Chaceon quinquedens

Means of carapace length (♂ = 107 ± 12 mm, ♀ = 95 ± 8 mm), carapace width (♂ = 128 ± 13 mm, ♀ = 114 ± 9 mm), and weight (♂ = 614 ± 185 g, ♀ = 416 ± 95 g) were greater for males (n = 49) than for females (n = 24). Results of t-tests to compare the means of characters for males and females showed statistically significant differences for carapace length ($t = -4.92$, $p = 6.84 \times 10^{-6}$), carapace width ($t = -5.19$, $p = 2.92 \times 10^{-6}$), and weight ($t = -6.04$, $p = 6.29 \times 10^{-8}$).

Coefficients of determination were high for CW/CL regressions for males ($r^2 = 0.94$) and females ($r^2 = 0.94$),

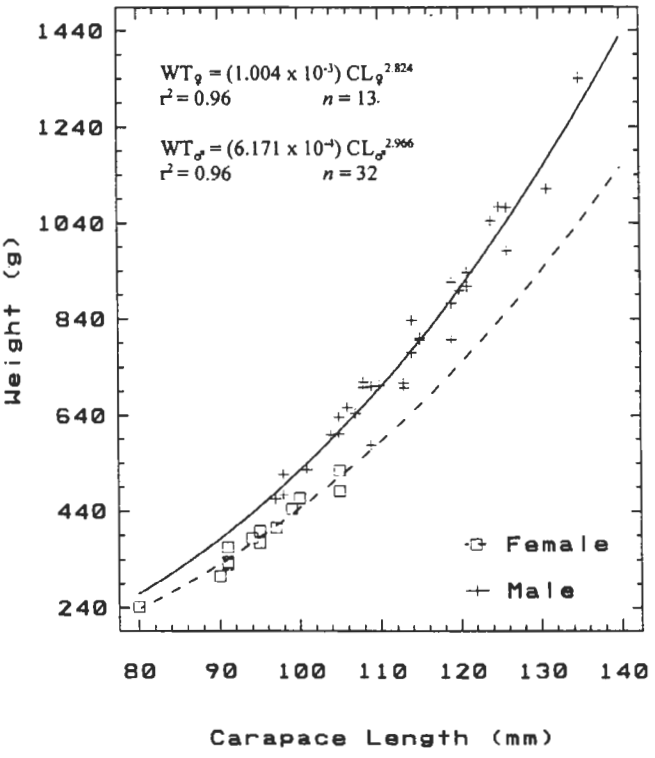

Figure 2. Regression of weight (Wt) vs carapace length (CL) for male and female *C. fenneri*.

indicating a strong linear relationship between carapace length and width for both sexes (Figure 4). When regressions of carapace width against carapace length were compared for males and females, no significant difference in the slopes or intercepts of the regression lines was found (slope $F = 0.18$, $p = 0.67$; intercept $F = 2.29$, $p = 0.13$). Thus, this relationship was considered equal for males and females. Coefficients of determination were high for the log-log transformed Wt/CL and Wt/CW regressions for males ($r^2 = 0.98$ and $r^2 = 0.94$, respectively) and females ($r^2 = 0.93$ and $r^2 = 0.89$, respectively), indicating a strong exponential relationship between weight and carapace length and between weight and carapace width for both sexes (Figures 5 & 6). ANCOVA of the log-log transformed Wt/CL and Wt/CW data showed no significant difference in the slopes of the regression lines (carapace length $F = 0.00$, $p = 0.98$; carapace width $F = 0.12$, $p = 0.73$). However, a significant difference was found in the intercepts (carapace length $F = 5.41$, $p = 0.023$; carapace width $F = 0.54$, $p = 0.47$), indicating that for a given carapace size male red crabs were heavier than females.

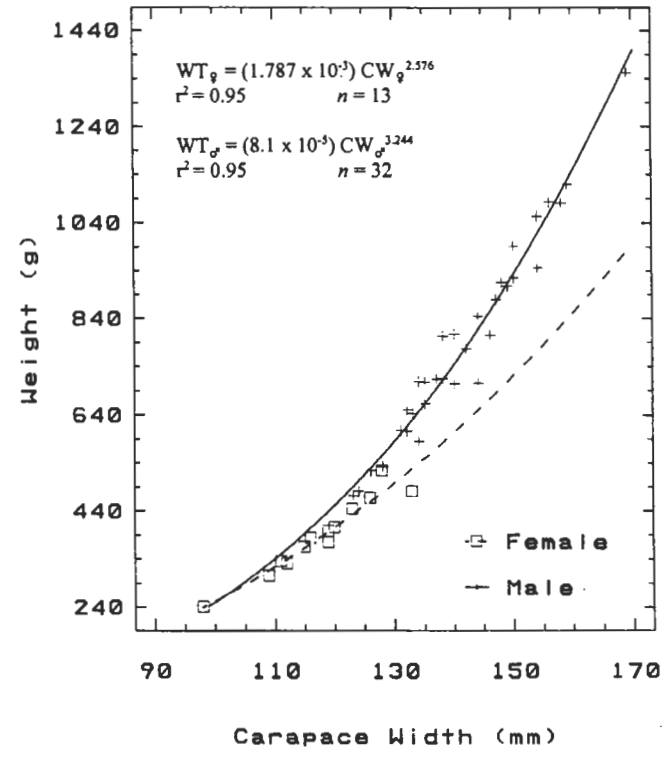

Figure 3. Regression of weight (Wt) vs carapace width (CW) for male and female *C. fenneri*.

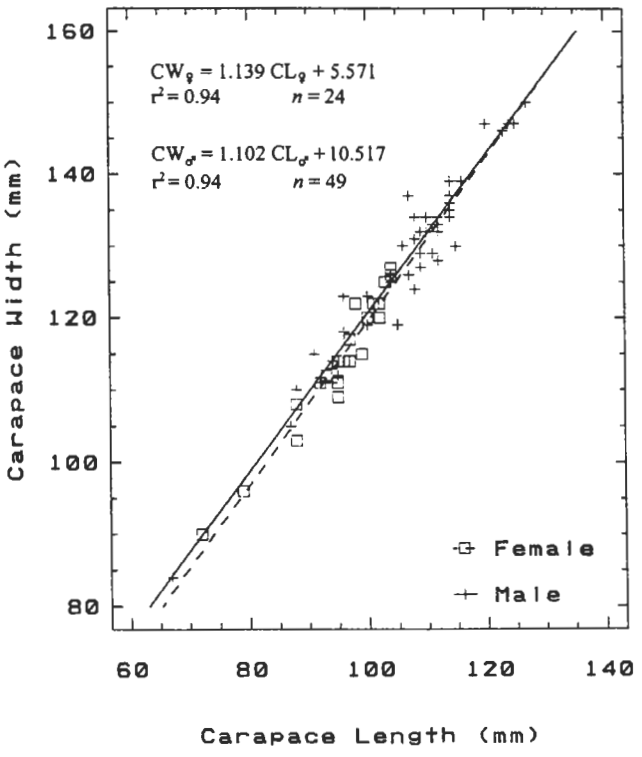

Figure 4. Regression of carapace width (CW) vs carapace length (CL) for male and female *C. quinquedens*.

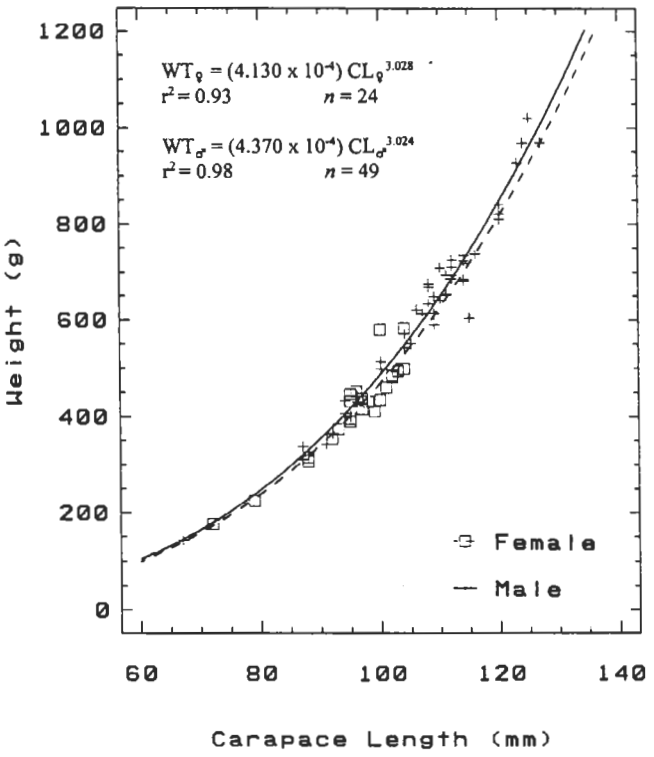

Figure 5. Regression of weight (Wt) vs carapace length (CL) for male and female *C. quinquedens*.

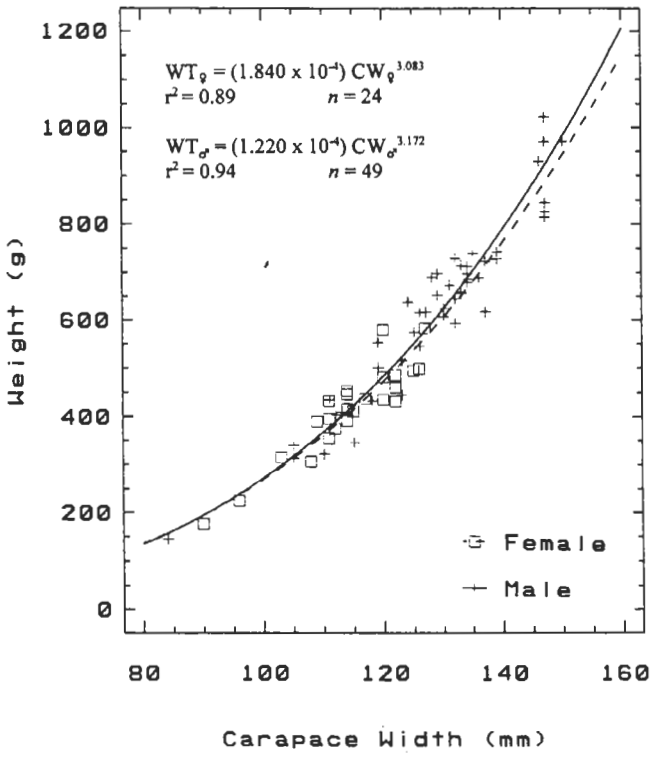

Figure 6. Regression of weight (Wt) vs carapace width (CW) for male and female *C. quinquedens*.

DISCUSSION

There were no significant differences in the carapace width/carapace length relationships between males and females for golden and red crabs in this study. Weight/carapace length and weight/carapace width relationships were each highly correlated for both males and females of each species. Our findings were generally consistent with studies of golden and red crabs from the Atlantic Ocean. Male golden crabs from the eastern Gulf of Mexico were larger and heavier than females per unit carapace width. Both Wenner et al. (1987) and Erdman and Blake (1988) found that mean carapace width and weight of golden crabs were greater for male than for female crabs collected off South Carolina and southeast Florida, respectively.

The equations of Wenner et al. (1987) and Erdman (1990) were solved to predict the carapace lengths of male and female golden crabs over the range of carapace widths observed in the present study. Without exception, their predicted carapace lengths fell within the 95 % prediction limits for carapace length of golden crabs from our study. Weight/carapace width relationships for male and female golden crabs were determined by Wenner et al. (1987) and Erdman and Blake (1988). The weight/carapace width relationships for male golden crabs in their studies were similar to relationships observed for male golden crabs taken from the eastern Gulf of Mexico. Resultant weights based on selected carapace widths were within the 95 % prediction limits of weight for male golden crabs taken in the present study. Predicted weights for female golden crabs taken off southeastern Florida (Erdman and Blake 1988) were within the 95% prediction limits of weight for female golden crabs in the eastern Gulf of Mexico. Calculated weights using the equation of Wenner et al. (1987) were within our 95 % prediction limits for female golden crabs $\geq$ 121 mm CW; however, calculated weights were below our 95 % predictions for crabs < 121 mm CW. Of the measured parameters, carapace width and weight are the more variable, and this may account for this discrepancy. The location (sea or laboratory) and means by which weight was determined were not noted by Wenner et al. (1987).

Survey data from distributional studies of red crabs from Atlantic waters are in agreement with our size and weight data for red crabs in the Gulf of Mexico. Haefner (1978) noted that male red crabs taken from Norfolk Canyon, Virginia, were larger and heavier than females. Similar observations were made by Ganz and Herrmann (1975) for New England red crabs and by Stone and Bailey (1980) for red crabs on the western Scotian Shelf. Equations relating carapace width to carapace length and weight to carapace length for male and female red crabs were

provided by Haefner (1978). Predicted carapace widths for male and female red crabs from his study were within our 95 % prediction limits for this species. Weights derived for male and female crabs using his regression equations were comparable to our predicted weights and were within our 95 % prediction limits.

Acknowledging our small sample size for golden and red crabs, it would still appear that in regard to the size and weight relationships examined, there is little difference between Atlantic and Gulf populations.

ACKNOWLEDGMENTS

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