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# Carapace Length/Width-Weight Relationships and Relative Condition Factor of Two Commercially Important *Charybdis* Species of the Gulf of Mannar, Southeast Coast of India

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## ABSTRACT

**Background:** This study represents Carapace length-weight (CLW) and Carapace width-weight (CWW) relationships with relative condition factor (Kn) for two commercially important portunid crab species of genus *Charybdis viz., Charybdis feriata* (Linnaeus, 1758) and *Charybdis hellerii* (Milne-Edwards, 1867) collected from the Gulf of Mannar, Southeast coast of India.

**Methods:** A total of 876 specimens were collected and measured for a period of one year from July 2022 to June 2023. The two species' CLWR and CWWR were determined using the least square linear regression equation $W = aL^b$, where "W" is body weight in gm, "L" for carapace length/width in centimetres, "a", the intercept and "b", the slope of the regression curve. Regression analysis was used to determine the parameters "a" and "b," as well as their statistical significance and 95% confidence limits by using MS Excel.

**Result:** The slope (*b*) for the CLWR and CWWR of the species *C. feriata* is 3.2196 and 3.1901 respectively and for the species *C. hellerii*, the same was found to be 2.3427 and 2.3720 respectively. The relationship of the studied two parameters namely CLW and CWW were found to be significant for both the selected species at 1% level (P>0.01). The Relative Condition factor (Kn) for the species *C. feriata* was determined to be 0.64 and 0.51 for CLWR and CWWR respectively and for the species *C. hellerii*, the same was found to be 1.45 and 0.86 respectively. The importance of studying the relationship in Portunid crab species with regard to the parameters carapace length and carapace width and the relative condition factor studies in the studied crabs were discussed and suggestion were also given for the management and conservation of the resources and selected species of Gulf of Mannar. This study presents the first reference on CLWR and CWWR for these species from the Gulf of Mannar along the Southeast coast of India.

**Key words:** Carapace length/width-weight relationship, *Charybdis feriata*, *Charybdis hellerii*, Gulf of Mannar, Relative condition factor.

## INTRODUCTION

Finfish and brachyuran crab form a significant component of the nation's shellfish industry, generating a significant revenue for the economy. The edible crabs of the family Portunidae, mostly represented by the genera *Portunus* and *Charybdis*, contribute a massive fishery of marine crabs. The portunid crab species *Charybdis feriata* (Linnaeus, 1858) is widely distributed throughout the Indo-Pacific region, spanning Pakistan, India, Sri Lanka and Indonesia in the west and stretching from Australia and Japan in the east to eastern and southern Africa, the Gulf of Oman and the Arabian Gulf in the west (Stephenson *et al*., 1957; Stephenson, 1972; Ng, 1998; Apel and Spiridonov, 1998). According to Ng (1998), it occurs in sublittoral at depths of roughly 10-60 metres on muddy and sandy bottoms as well as rocky and stony beaches, including coral reef flats. This species is often marketed as frozen, having a high commercial value. The Indo-West Pacific Ocean is the natural habitat of the portunid crab *Charybdis hellerii* (Milne Edwards, 1867). Although this crab's native habitat is soft bottom substrates, it does occur in rocky bottoms and among live coral reefs down to 51 metres in the intertidal zone (Stephenson *et al*., 1957; Crosnier, 1962).

If the fishing resources are properly managed, the resources will be naturally sustainable and self-renewing

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resources. In order to determine the growth rate and population size status, the study is important, further in population studies, this study enable for the conversion of growth-in-length equations to growth-in-weight (Afzaal *et al.,* 2018). Morphometric analysis offers a potent complement to genetic and environmental stock identification approaches (Cadrin, 2000). To determine the size of a stock for the purpose of exploitation, it is crucial to have knowledge about the correlations between individual body weight and length/width in populations (Moutopolos and Stergiou, 2002). It is believed that the length-width/weight relationships are better suited for assessing populations of crustaceans (Phinney, 1977; Adegboye, 1981; Olmi and Bishop, 1983; Suhalya and Rashan, 1986; Prasad and Neelakantan, 1988; Prasad *et al*., 1989; Sukumaran and Neelakantan, 1997; Atar and Sector, 2003; Gorce *et al.,* 2006; Sangun *et al.,* 2009). Present study focuses on the carapace length - weight and carapace width-weight relationship of male, female and both sexes combined for *Charybdis feriata* and *Charybdis hellerii.*

## MATERIALS AND METHODS

### Study area

The Gulf of Mannar (GoM) connects the northwest and southeast of Sri Lanka, spanning 8°35′ N - 9°25′ N latitude to 78°08′E - 79°30′ E longitude in the Indian Ocean (Vidya *et al.,* 2018). It is well known for its remarkable biological diversity and serves as a global storehouse for aquatic life. Two commercially important portunid crab species of genus *Charybdis i.e*., *Charybdis feriata* (Linnaeus, 1758) and *Charybdis hellerii* (A. Milne-Edwards, 1867) covering a wide size range were collected weekly from the four major landing centres of the Gulf of Mannar namely Vedalai, Keelakarai, Therespuram and Thiruchendur for a period of one year from July 2022 to June 2023 (Fig 1). The bottom set gillnet, which dominates the crab fishery throughout the entire Gulf of Mannar region, was one of the fishing gears used to collect crab samples. Other fishing gears were trawl nets and trammel nets. The bottom set gillnet used in Vedalai and Keelakarai has a mesh size variation of 70-110 mm, while in Therespuram and Tiruchendur, it varies between 28-40 mm. It is observed that the trammel net and trawl net mesh sizes in the study area were 40-80 mm and 15-20 mm, respectively. In the Gulf of Mannar region, the crabs were gathered at a depth range of 6 to 12 metres and as far out as 7 to 15 nautical miles towards the seaward side.

### Identification of the selected species

The collected portunid crab samples were sorted and identified up to species level using FAO species identification sheet (Fischer *et al*., 1943); ICAR - CMFRI (Josileen, 2022) and with key manual on 'Identification of Brachyuran crabs' (Sethuramalingam and Khan, 1991) The collected specimens were washed in clean portable water and preserved in refrigerator for further studies. Fig 2 shows the dorsal view of *Charybdis feriata* and *C. hellerii.*

### Data collection

The distance between the ends of the posterior most lateral carapace spines was used to measure the carapace width and the carapace length was measured from the front tooth of the rear end of the carapace along the midline. Using a sensitive electronic scale and a vernier calliper, the body

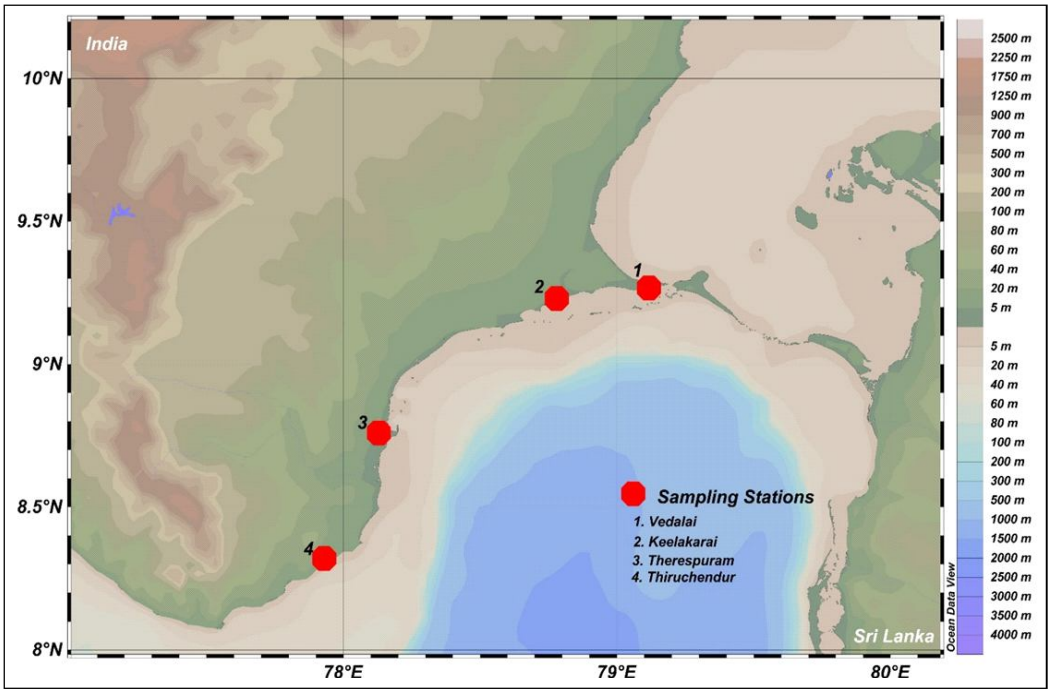


**Fig 1:** Study area at Gulf of Mannar.

weight was measured to the nearest 0.01 g and the carapace length/width to the nearest 0.1 cm. In the present study, the carapace length of *C. feriata* ranged from 25 mm to 80 mm; carapace width ranged from 44 mm to 129 mm and weight ranged from 10.5 gm to 322 gm. The carapace length of *C. hellerii* ranged from 30 mm to 58 mm; carapace width ranged from 42 mm to 80 mm and weight ranged from 24 gm to 105 gm.

### Statistical analysis

The two species' CLWR and CWWR were determined using the least square linear regression equation $W = aL^b$. The sexes were separately treated. In this equation, "W" stands for body weight in grammes, "L" for carapace length/ width in centimetres, "a", the intercept and "b", the slope of the regression curve. The coefficient, or $R^2$, was determined to calculate the degree of correlation between the variables. The linear regression analysis was conducted after removing outliers. Regression analysis was used to determine the parameters "a" and "b," as well as their statistical significance and 95% confidence limits by using MS Excel (Microsoft Office, 2016) tool for all computations.

## RESULTS AND DISCUSSION

### Carapace length/width - weight relationship

Samples were taken along the entire coast of Gulf of Mannar from the selected four landing centres on a weekly basis. Statistical description of the parameters including sample size (n) (number of specimens observed), carapace length (CL) / carapace width (CW) range (cm), total body weight (W) range (gm), length weight relationship (LWR) parameters 'a' and 'b' with 95% confidence limits, coefficient of determination ($R^2$) and relative condition factor (Kn) with regard to both carapace length - weight relationship and carapace width - weight relationship for both the selected *Charybdis* species are shown in Table 1. A positive allometry was evident in sexes between carapace length and body weight for *C. feriata* with high degree of correlation. However, a negative allometry growth in sexes was evident for *C. hellerii* with a high degree of corelation. With regard to carapace width - body weight, a positive allometry was evident in female and pooled *C. feriata* and a negative allometry was recorded in both the sexes of *C. hellerii.* The graphical representation of CLWR and CWWR of pooled sex of *C. feriata* and *C. hellerii* is given in Fig 3 to 6.

### Relative condition factor

The overall well-being condition (Kn) was found to be high in *C. hellerii* with regard to carapace length - weight relationship and with carapace width - weight relationship the same was found to be less for *C. feriata*. The reason behind the high Kn value for *C. hellerii* may be due to landing of higher female sex ratio during the study period (Noori *et al.,* 2015) as study shows that mean condition factors always higher in females than in males, due to the heavier gonads in the female (Noori *et al.,* 2015).

There is a wide range of applications for the carapace length - weight and carapace width - weight relationships. They serve as condition indicators and are estimated to be useful in calculating biomass and recovering edible meat from crabs of different sizes. Carapace length and width are the most commonly used dimensions in crustacean research (Dineshbabu, 2011).

The carapace width of *C. feriata* ranged from 44 mm to 129 mm and weight ranged from 10.5 gm to 322 gm, which size is smaller compared to the observation made by Dineshbabu (2011) at Mangalore coast where it ranged from 26 to 170 mm of which the majority landed was 60-95 mm. In the present study, carapace width of male *C. feriata* was ranged from 45 mm to 129 mm and for female, it was ranged from 44 mm to 124 mm. Dineshbabu (2011) measured a size range of 46 - 170 mm in males and 46 - 120 mm in females at Mangalore fishing Harbour, which implies larger in size for male and similar in size range for female. Padayatti (1990) measured a size range of 60-154 mm in males and 65 -119 mm in females landed at Cochin in 1989, which also describe larger in size compared to the present study.

In the present study, the carapace length of *C. hellerii* was ranging from 30 mm to 58 mm; carapace width ranged from 42 mm to 80 mm and weight ranged from 24 gm to 105 gm. Carapace width of *C. hellerii* was measured and the range was between 47-80 mm and for female, it was ranged from 42-78 mm in Paraguacu River estuary (Todos os Santos Bay, Brazil), the carapace length was ranged from 16 - 52 mm and carapace width was ranged between

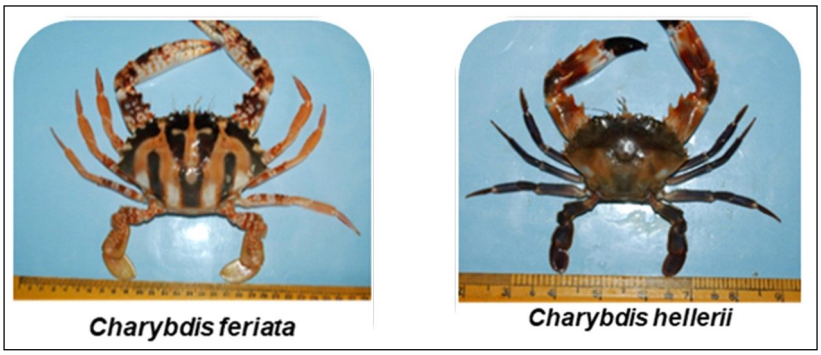


**Fig 2:** Figure showing dorsal view of *C. feriata* and *C. hellerii*

26 - 75 mm and weight was ranged between 4.2 - 79.2 gm (Carvalho-Souza, 2023), which describes smaller sized specimen in comparison to the present study. In the present study, the carapace width of the male and female of *C. hellerii* ranged from 47 to 80 mm and 42 to 78 mm which describes larger in size compared to the study conducted by Carvalho-Souza (2023) in Brazil, where carapace width range of 32.3 - 75.2 mm in male and 26.1 - 70.0 mm in female was recorded.

The coefficient of determination ($R^2$) for CLWR and CWWR for both sexes of all the selected two species was very close to one in the regression analysis (Table 1). Thus, the nature of the relationship between CL and BW and CW and BW can be expressed as highly significant. The value of exponent (b) is a very important indicator for judging the growth pattern of a species. However, ecological factors (*i.e*., food availability, water quality parameters, sample size and length range) can also cause variation in slope (b) value in the case of any species (Mommsen, 1998; Ighwela *et al*., 2011).

In most decapod crustaceans, the length-weight relationship has a slope value (b) of three. However, because specific gravity and body contour form might change, the cube rule may not hold true (Rounsefell and Everhart, 1953). In the present study, the slope value is more than three for *C. feriata i.e*., showing a positive allometric growth and slope value is less than three for *C. helleri* show negative allometric growth for both carapace length - weight and carapace width-weight relationship (Table 1).

In the present study, for male *C. feriata* the slope (b) value was recorded as 2.99 (almost 3) and for female the value recorded was 3.41 for carapace - width relationship which is in agreement with the study conducted in Mangalore coast by Dineshbabu (2011) where the same was recorded as 3.078 for male and 3.005 for female. Negative allometric growth was recorded for *C. feriata* in Veraval waters, north-west coast of India (Dash *et al*., 2014) where, slope (b) value for male was 2.94 and for female, it was 2.97 for carapace width-weight relationship; which is slightly lesser than the present study. In the present study, for pooled *C. helleri*, slope value (b) was recorded 2.3428 for carapace length-width relationship and 2.3720 for carapace width-weight is in agreement with study conducted in Brazil by Carvalho-Souza, 2023 where, the same was recorded as 2.89 and 2.87 respectively.

Slope value for the genus *Charybdis* (*C. lucifera* and *C. annulata*) from the intertidal region of Maharashtra was recorded as 1.841 and 1.844 respectively for carapace length-weight relationship and 1.803 and 2.323 respectively for carapace width-weight relationship (Khot and Jaiswar, 2018); which are quite lesser than the present study. The carapace width-weight relationship of male and female *C. anisodon* showed negative allometric growth with 'b' value of 2.642 and 1.996 respectively and for carapace length-weight relationship, the slope (b) value recorded

**Table 1:** Estimated CLW and CWW parameters for two commercially important *Charybdis* species from Gulf of Mannar, India.

| Species | n | CL (mm) | | CW (mm) | | BW (gm) | | Regression parameters (CLW) | | | | | | Kn value (CLW) | Regression parameters (CWW) | | | | | | Kn value (CLW) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | Min | Max | Min | Max | Min | Max | a | 95% CI a | | b | 95% CI b | | $R^2$ | a | 95% CI a | | b | 95% CI b | | $R^2$ | |
| *Charybdis feriata*(Male) | 215 | 30 | 80 | 45 | 129 | 12.5 | 322 | 0.5921 | 3.1206 | - 0.9389 | 2.8155 | - 3.4255 | 0.89 | 0.7160 | 0.4786 | 0.3510 | -0.6524 | 2.9956 | 2.6623 | - 3.3288 | 0.86 | 0.3487 |
| *Charybdis feriata*(Female) | 195 | 25 | 76 | 44 | 124 | 10.5 | 320.5 | 0.5260 | 3.3306 | - 0.7949 | 2.9969 | -3.6642 | 0.90 | 0.5903 | 0.3308 | 0.2499 | - 0.4377 | 3.4173 | 3.0657 | - 3.7690 | 0.89 | 0.5077 |
| *Charybdis feriata*(Pooled) | 410 | 25 | 80 | 44 | 129 | 10.5 | 322 | 0.6062 | 3.2196 | – 0.7887 | 3.0293 | – 3.4098 | 0.92 | 0.6471 | 0.3980 | 0.3317 | – 0.4775 | 3.1901 | 2.9803 | – 3.3999 | 0.90 | 0.5195 |
| *Charybdis helleriі*(Male) | 206 | 33 | 58 | 47 | 80 | 25 | 104 | 0.0186 | 2.1559 | – 0.7443 | 1.5961 | – 2.7155 | 0.74 | 0.9876 | 0.9177 | 0.6085 | – 1.3839 | 2.3173 | 1.8026 | - 2.8319 | 0.78 | 0.9218 |
| *Charybdis helleriі*(Female) | 231 | 30 | 48 | 42 | 78 | 24 | 105 | 0.7829 | 2.8311 | – 1.2631 | 2.4225 | – 3.2395 | 0.83 | 1.0094 | 0.8488 | 0.6270 | – 1.1491 | 2.4174 | 2.0140 | – 2.8208 | 0.88 | 0.8206 |
| *Charybdis helleriі*(Pooled) | 437 | 30 | 58 | 42 | 80 | 24 | 105 | 0.0697 | 2.3428 | – 0.4685 | 2.0214 | – 2.6641 | 0.83 | 1.4567 | 0.8773 | 0.6836 | – 1.1259 | 2.3720 | 2.0525 | – 2.6915 | 0.84 | 0.8645 |

n, sample size; CL, carapace length; CW, carapace width; BW, total body weight; a, intercept; b, slope; CI, confidence intervals; $R^2$, co-efficient of determination

for male and female was 3.021 (positive allometric) and 2.244 (negative allometric) respectively in Lasongko Bay, Indonesia (Hamid and Wardiatno, 2018); which is in agreement with *C. hellerii* (negative allometric growth), in the present study.

Fisheries scientists have used condition factor as a means of assessing the overall "well-being or fitness" of the population (Fafioye and Oluajo, 2005). According to Tesch (1968), the condition factor employed to estimate the robustness or degree of wellbeing of fish led to conclude that bigger fish are in better condition than leaner fish. Furthermore, the lean fish are thought to be vulnerable to harsh environmental circumstances (Jones *et al.,* 1999). Feeding intensity is a growth index that affects condition factor (Fagade, 1979). The key biological characteristic that indicates whether a particular body of water is suitable for fish growth is the relative condition factor (Kn) (LeCren, 1951). In the present study, Kn value for *C. feriata* was ranged between 0.59-0.71 for carapace length-weight relationship (CLWR) and 0.34-0.51 for carapace width-weight relationship (CWWR). 'Kn' value for *C. hellerii* ranged between 0.98-1.45 for CLWR and the range between 0.82-0.92 for CWWR. The reason behind the high Kn value for *Charybdis hellerii* may be due to landing of higher female sex ratio during the study period as study showed that mean condition factors always higher in females than in males, due to the heavier gonads in the former (Noori *et al*., 2015). The 'Kn' value for *C. lucifera* and *C. annulata* was found to be 0.05 and 0.10 for CLWR and 0.02 and 0.01 for CWWR from the intertidal region of Maharashtra coast (Khot and Jaiswar, 2018); which is quite lesser with the present study. The study on Kn has not been attempted for studied species in Indian water.

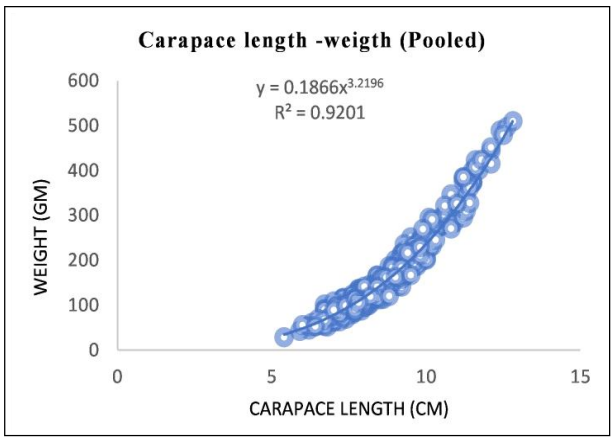


**Fig 3:** Carapace length-weight relationship of *C. feriata.*

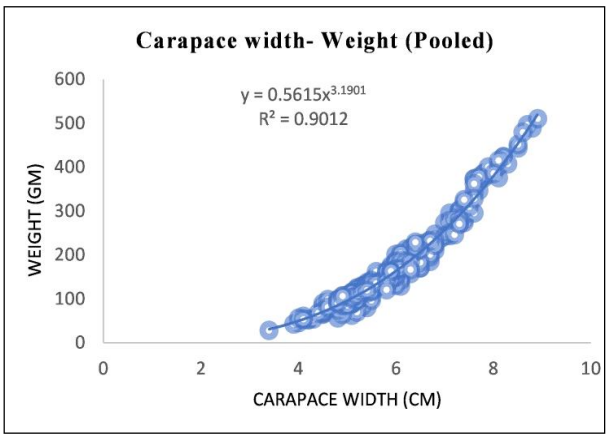


**Fig 4:** Carapace width-weight relationship of *C. feriata.*

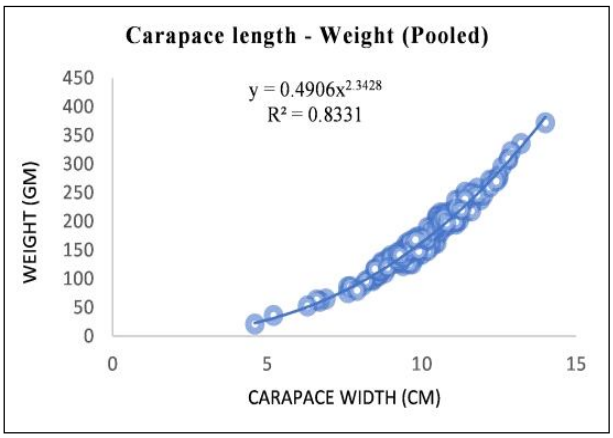


**Fig 5:** Carapace length-weight relationship of *C. hellerii.*

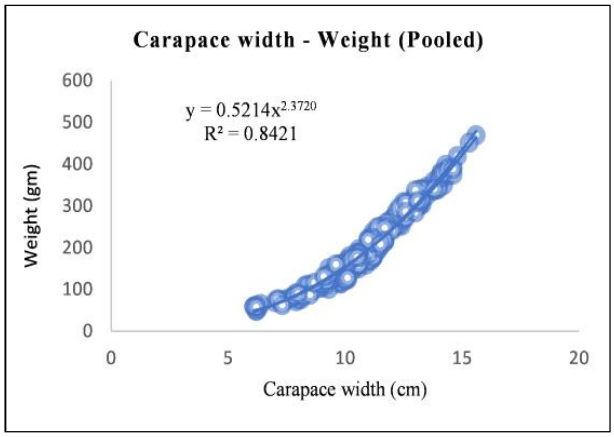


**Fig 6:** Carapace width-weight relationship of *C. hellerii.*

## CONCLUSION

The present study provides the first detailed information on carapace length/ width-weight relationship of *C. feriata* and *C. hellerii* along the Gulf of Mannar coast. Though catch of the studied species is less in the Gulf of Mannar coast, they play very important role in functioning of aquatic ecosystem especially intertidal. The estimation of Kn value is essential for fisheries management and conservation efforts, providing baseline data for monitoring the health of portunid crab populations. Long-term studies assessing changes in condition factor values over time can offer valuable indicators of ecosystem health and the impact of human activities on these marine crustaceans. Fisheries

biologists and conservation biologists can use it as a roadmap for future research in order to ensure successful development, management strategies and productivity. According to the evaluation of the condition factor, there were generally more females than males during the dry season, which suggests that the conditions were favourable for the species of crustaceans (Carvalho-Souza, 2023). An additional tool that the relative condition factor offers to help crab biologists better understand the developmental biology of portunid crabs is the status of the individuals over the course of the study.

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### Ethical statement

No live specimens here used in the present study.

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### Author contributions

Sample collection, species identification and preparing the manuscript: Adyasha Sahu; Formal analysis and critical reviewing the draft of manuscript: Dr. V. K. Venkataramani; Literature collection and reviewing of the manuscript: Sanjay Chandravanshi; Visualization and investigation: Sudhan Chandran; Conceptualization and technical contribution on data analysis: Roshan Kumar Ram; Laboratory observation and data curation: Narsingh Kashyap and Lavkush.

### Conflict of interest

The authors have declared no conflict of interest.

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