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# Length-weight and Carapace Width-weight Relationships of *Portunus pelagicus* (Linnaeus, 1758) in Gillnet Fisheries along the Ramanathapuram Coast (Palk Bay and Gulf of Mannar), India

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## ABSTRACT

**Background:** The blue swimming crab, *Portunus pelagicus* (Linnaeus, 1758), supports an important export-oriented fishery along the Ramanathapuram coast, covering the Palk Bay and Gulf of Mannar. Information on sex-specific and seasonal growth patterns is essential for stock assessment and sustainable management of this commercially valuable species.

**Methods:** A total of 1,131 specimens of *P. pelagicus* (677 females and 454 males) were collected from two major landing centers along the Ramanathapuram coast. Carapace length-weight (CL-W) and carapace width-weight (CW-W) relationships were estimated using regression analysis. Deviation in sex ratio was tested using the chi-square ($\chi^2$) test. Growth patterns were assessed through allometric coefficients and monthly variations in growth parameters and condition factor were analyzed.

**Result:** The overall sex ratio was significantly female-biased (1:1.49; $\chi^2$ = 49.21, p<.001). Strong morphometric relationships were observed in both sexes and pooled samples, exhibiting negative allometric growth. The CW-W relationship showed *b* values of 2.874 in females and 2.712 in males, while the CL-W relationship yielded *b* values of 2.891 in females and 2.763 in males; all values differed significantly from the isometric coefficient (p<.001). Monthly analysis revealed consistently higher growth exponents and condition factors in females, with peak values during May and October, likely linked to reproductive activity.

**Key words:** Blue swimming crab, Carapace width-weight relationship, Condition factor, Isometric value, Negative allometric growth.

## INTRODUCTION

The blue swimmer crab, *Portunus pelagicus* (Linnaeus, 1758), is a commercially valuable portunid species widely distributed across the Indo-pacific region (Keenan *et al*., 1998). In India, it plays a dominant role in marine crab fisheries, especially along the southeast coast, including Tamil Nadu's Ramanathapuram district, where it supports vibrant artisanal fisheries using gillnets, traps and trawl nets (Sukumaran and Neelakantan, 1997). Saroj *et al*. (2020) reported that the Gulf of Mannar is one of the most productive marine regions. Kanaga *et al.* (2025) identified Ramanathapuram as the most vulnerable district in the Gulf of Mannar region, primarily due to intense overfishing and significant habitat degradation.

As the second most important marine crustacean group after penaeid shrimps, crabs contributed 62,696 tonnes-14.08% of India's marine crustacean landings in 2023-with the east coast alone accounting for 56.7% of this catch (CMFRI, 2024; Josileen *et al*., 2019). In Ramanathapuram, *P. pelagicus* constitutes 95% of the crab landings in the Gulf of Mannar and is the sole species harvested from Palk Bay (Rajamani and Palanichamy, 2010), mirroring its dominance in adjacent Sri Lankan waters (Haputhantri *et al*., 2021). This region includes the Gulf of Mannar and Palk Bay, which are characterized by diverse habitats such as coral reefs, seagrass beds and mangroves that support rich marine biodiversity and productive fisheries. Globally, the species contributes

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approximately 298,000 tonnes annually, representing 5% of total crustacean fisheries (FAO, 2020).

Despite its economic importance, significant knowledge gaps remain regarding the growth dynamics and population structure of *P. pelagicus* along the Ramanathapuram coast. While several studies have investigated the length-weight relationships (LWR) of this species in other Indian regions-including negative allometric growth in Kerala (Josileen, 2011), isometric growth in Gujarat (Kumar *et al*., 2019) and sex-specific growth patterns in Andhra Pradesh (Sajeevan and Ramachandran, 2016)-the biologically distinct Palk Bay-gulf of Mannar region remains underexplored. This lack of region-specific morphometric data hampers accurate stock assessments and hinders sustainable management of a fishery increasingly threatened by high exploitation pressure (Pillai and Thirumilu, 2011). Moreover, rising export demand, intensified fishing and reports of declining crab sizes (CMFRI, 2022) underscore the urgent need to establish baseline biological parameters for evidence-based management interventions, such as size limits and seasonal closures.

This study addresses this critical knowledge gap by providing the first comprehensive analysis of the carapace length-weight and carapace width-weight relationships of *P. pelagicus* from the Gulf of Mannar and Palk Bay regions of Ramanathapuram district. Using standardized methods (Le Cren, 1951; Pauly, 1993), the study evaluates sex-specific and seasonal growth patterns, providing vital reference data for regional comparisons and stock monitoring. The present study investigates the carapace length-weight relationship of the blue swimming crab *Portunus pelagicus* with the aim of informing conservation efforts. The study quantified the relationships between carapace length, carapace width, body weight and condition factor of *P. pelagicus* collected from the Gulf of Mannar and Palk Bay regions of Ramanathapuram District. The outcomes are expected to support science-based conservation strategies and enhance the long-term sustainability of this economically and ecologically significant fishery.

## MATERIALS AND METHODS

The study was conducted across two primary blue swimming crab (Portunus pelagicus) landing centres along the Ramanathapuram district - Thirupalaikudi (09°32.764′N 78°55.033′E) in Palk Bay and Vedhalai (09°27.23′N 79°10.40′E) in the Gulf of Mannar - from April 2023 to March 2024 (Fig 1). These sites were selected based on their ecological distinctiveness and importance in regional crab fisheries as established in previous studies (Rajamani and Palanichamy, 2010; CMFRI, 2024). Sampling was conducted for five days each month using a random sampling approach from the selected landing centres during peak landing times to ensure representative coverage of seasonal variations in crab populations (Pillai and Thirumilu, 2011).

The bottom set gillnet dominates the crab fishery throughout the entire Gulf of Mannar region (Sahu *et al*., 2025). In the Ramanathapuram district crab fishery, crab gill nets account for the majority of the catch (approximately 95%). Accordingly, samples of *Portunus pelagicus* were collected from crab gill net operations conducted 5-10 nautical miles offshore along the Ramanathapuram coast and specimens were obtained directly from fishing vessels at the time of landing. A total of 1,131 *Portunus pelagicus* specimens (677 females, 454 males) were sampled, reflecting the natural sex ratio observed in the fishery. Each specimen was immediately processed to record carapace

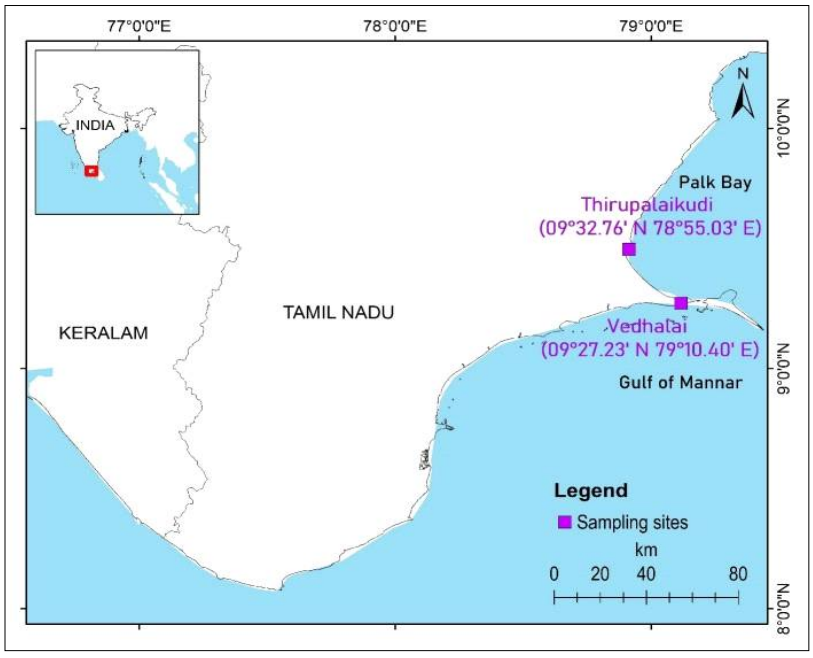



**Fig 1:** Map showing study area.

width (CW), defined as the distance between the tips of the posterior-most lateral spines and carapace length (CL), measured dorsally along the midline from the frontal notch to the posterior carapace margin, using Vernier calipers with 0.5 mm precision. Total weight was measured to the nearest gram using an electronic balance after blotting excess moisture.

The length-weight and width-weight relationships were analyzed using the power function:

$$W = aL^b$$

Where
W = Represents expected weight (g).
L = Denotes either carapace length or width (mm).
'a' = Y-intercept (initial growth coefficient).
'b' = Slope (growth coefficient).

Parameters were calculated through least squares regression after logarithmic transformation of the data to linearize the relationship, following standard crustacean biometric protocols (Hartnoll, 1982). The strength of each morphometric relationship was assessed using Pearson's correlation coefficient (r). Sexual dimorphism in growth patterns was evaluated through one-way ANOVA comparing the carapace width-weight relationships between sexes, with statistical significance set at 5% level ($P<0.05$) using SPSS software (v.25). The body weight (W) is identified as the dependent variable, while sex is specified as the grouping factor for the comparison of carapace width-weight relationships. In addition, the normality assumption was tested using the Shapiro-Wilk test prior to conducting the ANOVA. This analytical approach allowed for direct comparison with established growth parameters from other regional populations while accounting for potential sex-specific growth variations characteristic of portunid crabs (Keenan *et al*., 1998).

The condition factor (K) of *Portunus pelagicus* was calculated to assess the general health, robustness and physiological status of individuals across sexes and seasons. The condition factor was determined using the formula:

$$K = \frac{W}{L^b}$$

Where
*W* = Total body weight (g).
*L* = Carapace length (mm).
*b* = Exponent obtained from the length-weight relationship regression equation;

$$W = aL^b$$

This method accounts for allometric growth and provides a standardized measure of well-being relative to body size (Le Cren, 1951). The condition factor was computed separately for males and females on a monthly basis to evaluate seasonal variation.

## RESULTS AND DISCUSSION

A total of 1131 crabs were sampled during the study period, comprising 677 females and 454 males. The carapace width of crabs ranged from 43 to 192 mm, while the weight varied between 28 and 474 g and carapace length ranged from 19 to 84 mm. Female crabs exhibited a broader size range (CW: 43-192 mm; W: 28-474 g; CL: 19-84 mm) compared to males (CW: 49-185 mm; W: 32-381 g; CL: 22-83 mm). The observed sex ratio was 1.49:1 (F:M), significantly deviating from the expected 1:1 ratio ($\chi^2 = 49.21$, $P<0.001$), indicating a female-biased population (Table 1). These measurements show broader size ranges than those reported by Vidhya *et al*. (2016) in the Gulf of Mannar (females: 24-460 g, 45-200 mm CW; males: 34-340 g, 74-182 mm CW) and substantially exceed the size ranges documented in Thai populations (Tina, 2015: 83.8-122 mm CW). The observed female-biased sex ratio recorded in this study contrasts with the 1:1 ratio reported by Josileen and Menon (2007) in Mandapam, potentially indicating regional variations in reproductive behavior or fishing pressure. The predominance of females in the catch may be related to factors such as seasonal migration, reproductive behaviour, habitat preference and gear selectivity, which can influence the capture probability of each sex. In many portunid crabs, females migrate to specific areas for feeding and spawning, increasing their susceptibility to fishing gears (Sukumaran and Neelakantan, 1997). Variations in sex ratio may also result from differences in growth, mortality and exploitation between sexes (King, 2007). However, these factors were not directly examined in the present study and should be considered as possible explanations rather than definitive causes.

Growth pattern analysis revealed females were heavier than males below 110-113 mm CW, beyond which males showed significantly faster weight gain pattern consistent with findings by Sukumaran and Neelakantan (1997) along the Mangalore coast but occurring at smaller size thresholds in our population. This transition size is notably smaller than the 115-125 mm CW reported by Josileen (2011), suggesting possible environmental influences on growth dynamics. The male-dominant growth pattern at larger sizes aligns with observations by Potter *et al*. (1983) in Australian waters and Thomas (1984) along the Cochin coast, though contrasts sharply with Dhawan *et al*. (1976) findings of consistently heavier females in Goan waters. The observed differences in the b values between males and females may be related to sex-specific biological processes. In many portunid crabs, females allocate significant energy to gonadal development and egg production, which can influence body weight relative to size and lead to differences in growth patterns between sexes. Similar sex-based differences in LWR parameters have been reported in previous studies on swimming crabs (Sukumaran and Neelakantan, 1997; Josileen, 2011).

The regression analysis of carapace width and body weight (Table 2A) revealed a negative allometric growth pattern in both sexes as well as in the combined population. For females ($n = 677$), the equation was $W = 0.00042 \times CW^{2.874}$ with a coefficient of determination ($r^2 = 0.96$), indicating a strong correlation. Males ($n = 454$) also exhibited a negative

allometric growth ($W = 0.00051 \times CW^{2.712}$; $r^2 = 0.95$). The combined population ($n = 1131$) followed the equation $W = 0.00046 \times CW^{2.803}$ with the highest correlation ($r^2 = 0.97$). In all cases, the slope ($b$) was significantly different from the isometric value of 3, as indicated by t-test values ranging from -4.38 to -8.71 ($P<0.001$), confirming the prevalence of negative allometric growth. Similarly, the carapace length-weight relationship also indicated negative allometric growth in all groups (Table 2B). The regression equation for females was $W = 0.018 \times CL^{2.891}$ ($r^2 = 0.97$) and for males, it was $W = 0.021 \times CL^{2.763}$ ($r^2 = 0.96$). The combined data yielded the equation $W = 0.019 \times CL^{2.834}$ with a very high coefficient of determination ($r^2 = 0.98$). All $b$ values significantly deviated from 3 (isometric value), as confirmed by t-test values ranging from -4.217 to -9.000 ($P<0.001$), reaffirming the negative allometric growth pattern across sexes and pooled data. Although Kumar *et al*. (2019) reported negative allometric growth commonly in less exploited populations, the pattern observed in the present study may also be influenced by local environmental conditions, resource availability and fishing pressure in the Ramanathapuram waters.

The regression analysis of weight against carapace dimensions revealed strong morphometric relationships in *Portunus pelagicus*, with tight clustering of data points following clear parabolic trends. Weight-carapace regressions in *Portunus pelagicus* showed negative allometry (Vidh ya *et al*., 2016; Anjum *et al*., 2024), whereas positive allometry was reported in Mandapam and Karnataka (Josileen, 2011; Sukumaran and Neelakantan, 1996) (Table 3). The variation in growth patterns may be due to differences in habitat, food availability and environmental conditions. Overall, the present estimates fall within the reported range for the species across different regions.

The monthly variations in the growth exponent ($b$) and condition factor ($K$) of *Portunus pelagicus* revealed that females consistently showed higher $b$ values than males, with significant positive allometric growth observed in May (2.98±0.03) and October (3.01±0.02). The condition factor was also higher in females throughout the year, peaking in October (K = 1.96±0.03), indicating better well-being compared to males (Table 4). These findings suggest that females tend to invest more in body mass, possibly linked to reproductive cycles. Compared to earlier studies, the seasonal patterns align with Vidhya *et al*. (2016) and Josileen (2011), who also reported sex-specific growth and better condition in females during pre-spawning months. The lower $b$ values observed during the monsoon months (June-July) in both sexes may reflect reduced feeding activity or physiological stress due to environmental fluctuations, as noted by Sukumaran and Neelakandan (1996). Similar growth patterns have been reported in other studies on *P. pelagicus*. For instance, negative allometric growth has been documented in populations from the northern Arabian Sea and other coastal waters, indicating that environmental variability and regional ecological conditions can influence the growth dynamics of this species (Chandravanshi *et al*., 2024). However, the near-isometric growth observed in females during October (b = 3.01±0.02) suggests a temporary shift in growth pattern during that period. Such seasonal deviations from the general growth trend have been reported in crustaceans and are often associated with reproductive activity, gonadal maturation, or improved feeding conditions. Seasonal variations

**Table 1:** Descriptive summary of carapace width, weight and carapace length of *P. pelagicus.*

| Sex | n | CW (mm) | Weight (g) | CL (mm) | Sex Ratio (F:M) | $\chi^2$ | p-value |
|---|---|---|---|---|---|---|---|
| Female (♀and) | 677 | 43-192 | 28-474 | 19-84 | 1.49:1 | 49.21 | <0.001*** |
| Male (♂and) | 454 | 49-185 | 32-381 | 22-83 | | | |
| Combined | 1131 | 43-192 | 28-474 | 19-84 | | | |

N: Sample size;♀ : Female;♂ Band: Male, F:M: Female-to-male ratio, $\chi^2$: Chi-square test for deviation from 1:1 ratio, ***: Highly significant female bias ($P<0.001$).

**Table 2:** Estimated parameters of Width-weight and Length-weight relationships for the *P. pelagicus* sampled.

**A. Carapace Width-weight (CW-W) Relationship (Equation: $W = a \times CW^b$)**

| Sex | N | a (95% CI) | b (95% CI) | $r^2$ | t-test | P-value | **Growth type** |
|---|---|---|---|---|---|---|---|
| Female | 677 | 0.00042 (0.00038-0.00046) | 2.874 (2.802-2.946) | 0.96 | -4.38 | <0.001*** | Negative allometric*** |
| Male | 454 | 0.00051 (0.00046-0.00056) | 2.712 (2.637-2.787) | 0.95 | -7.89 | <0.001*** | Negative allometric*** |
| Combined | 1131 | 0.00046 (0.00043-0.00049) | 2.803 (2.764-2.842) | 0.97 | -8.71 | <0.001*** | Negative allometric*** |

CW = Carapace width (mm), W = Body weight (g), a = Intercept of the regression equation, b = Slope of the regression equation, $r^2$ = Coefficient of determination (indicates goodness of fit), $P<0.001$ = Statistically highly significant, Negative allometric = b<3.

**B. Carapace Length-weight (CL-W) Relationship (Equation: $W = a \times CL^b$)**

| | | | | | | | |
|---|---|---|---|---|---|---|---|
| Female | 677 | 0.018 (0.015-0.022) | 2.891(2.812-2.970) | 0.97 | -4.217 | <0.001*** | Negative allometric |
| Male | 454 | 0.021 (0.017-0.025) | 2.763(2.681-2.845) | 0.96 | -8.332 | <0.001*** | Negative allometric |
| Combined | 1131 | 0.019 (0.017-0.021) | 2.834(2.788-2.880) | 0.98 | -9.000 | <0.001*** | Negative allometric |

CL= Carapace length (mm), W = Body weight (g), a = Intercept of the regression equation, b = Slope of the regression equation, $r^2$ = Coefficient of determination (indicates goodness of fit), $P<0.001$ = Statistically highly significant, Negative allometric = b<3.

**Table 3:** Comparative Length-weight relationship parameters of *P. pelagicus* from different localities.

| Author/Year | Locality | Sex | A | b | $r^2$ |
|---|---|---|---|---|---|
| Present Study | Ramanathapuram, Tamil Nadu, India | Male | 0.00051 | 2.712 | 0.95 |
| | | Female | 0.00042 | 2.874 | 0.96 |
| Vidhya *et al*. (2016) | Gulf of Mannar, India | - | 0.145 | 2.668 | 0.72 |
| | | - | 0.381 | 2.278 | 0.703 |
| Josileen (2011) | Mandapam Coast, India | Male | 0.00000341 | 3.609 | 0.9691 |
| | | Female | 0.00002 | 3.293 | 0.93 |
| Anjum *et al.* (2024) | Mangaluru, Karnataka | Male | 0.9939 | 2.7908 | 0.7522 |
| | | Female | 1.5729 | 2.5681 | 0.7377 |
| Sukumaran and Neelakandan (1996) | Karnataka Coast, SW India | Male | - | 3.6167 | 0.985 |
| | | Female | - | 3.2327 | 0.988 |
| Pramithasari *et al.* (2017) | Karachi Coast, Pakistan | Male | - | 3.0278 | 0.9936 |
| | | Female | - | 2.9864 | 0.9961 |
| Abdallah *et al*. (2022) | Bardawil Lagoon, Egypt | - | 0.0502 | 3.1653 | 0.9609 |
| | | - | 0.0445 | 3.2117 | 0.963 |

a: Intercept of the length-weight relationship equation ($W = a \times LG^b$), b: Slope (growth exponent), $r^2$: Coefficient of determination, Missing data or unspecified sex is marked as "–".

**Table 4:** Monthly variation in allometric coefficient (b) and condition factor (K) of female ♀ and male (♂) of *P. pelagicus*.

| Month | ♀ b (SE) | ♂ b (SE) | (K) ♀ | K♂ |
|---|---|---|---|---|
| Jan | 2.95±0.04* | 2.82±0.05 | 1.88±0.05 | 1.70±0.04 |
| Feb | 2.93±0.03* | 2.79±0.04 | 1.85±0.04 | 1.67±0.03 |
| Mar | 2.81±0.05 | 2.71±0.06 | 1.76±0.06 | 1.59±0.05 |
| Apr | 2.87±0.04* | 2.68±0.05 | 1.82±0.05 | 1.62±0.04 |
| May | 2.98±0.03** | 2.85±0.04* | 1.94±0.04 | 1.75±0.03 |
| Jun | 2.76±0.06 | 2.62±0.07 | 1.72±0.07 | 1.55±0.06 |
| Jul | 2.72±0.07 | 2.58±0.08 | 1.68±0.08 | 1.52±0.07 |
| Aug | 2.89±0.04* | 2.74±0.05 | 1.84±0.05 | 1.66±0.04 |
| Sep | 2.94±0.03* | 2.80±0.04 | 1.87±0.04 | 1.69±0.03 |
| Oct | 3.01±0.02** | 2.88±0.03** | 1.96±0.03 | 1.78±0.02 |
| Nov | 2.91±0.04* | 2.77±0.05 | 1.83±0.05 | 1.65±0.04 |
| Dec | 2.83±0.05 | 2.69±0.06 | 1.79±0.06 | 1.61±0.05 |

in growth parameters have also been documented in blue swimming crab populations from Sri Lanka and other Indo-Pacific regions, where growth patterns varied between sexes and seasons (Haputhantri *et al*., 2021). Overall, the present results highlight seasonal shifts in growth dynamics and body condition, emphasizing the influence of reproductive and environmental factors.

## CONCLUSION

The present study highlights clear seasonal and sex-specific variations in the growth patterns and condition factor of *Portunus pelagicus* along the Ramanathapuram coast. Females consistently exhibited higher growth exponents and better condition factors compared to males, particularly during the pre-monsoon and post-monsoon months, suggesting a strong link to reproductive and environmental cycles. The observed variations reflect the influence of seasonal factors on energy allocation and growth dynamics in this species. These findings can contribute to improved biological understanding and inform sustainable management strategies for *P. pelagicus* in the Gulf of Mannar region. The findings from highlight the urgent need for immediate and region-specific fisheries management measures.

Implementing minimum landing sizes and regulating fishing during peak breeding periods could help protect reproductive individuals and maintain stock productivity. Fishers can be encouraged to use crab traps instead gill nets, which are more selective and help reduce the capture of undersized and berried crabs. These measures would contribute to the long-term sustainability of crab fisheries along the Ramanathapuram coast near the Gulf of Mannar and Palk Bay.

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### Disclaimers

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### Informed consent

Not applicable. This study did not involve any live specimen.

### Conflict of interest

The authors declare that there are no conflicts of interest regarding the publication of this article. No funding or

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