Sex ratio, carapace width-weight relationship, and relative condition factor of three-spotted crabs *Portunus sanguinolentus* (Herbst, 1783) from Northwestern San Miguel Bay, Camarines Norte, Philippines

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Abstract. Understanding the biological characteristics of commercially important species is essential for effective stock management and aquaculture development. This study presents the first record of some biological aspects of the three-spotted swimming crab (*Portunus sanguinolentus*) in the Philippines. A total of 500 individuals were randomly collected monthly from crab trap fishers in Northwestern San Miguel Bay (NSMB), Camarines Norte, between September 2024 and January 2025. This study examined the sex ratio (SR), carapace width-weight relationship (CWWR), and condition factor (CF) of *Portunus sanguinolentus*. The sex ratio was evaluated using the Chi-square goodness-of-fit test (α = 0.05), the CWWR was determined through the allometric growth equation, and the CF was calculated using the relative condition factor. The results showed a balanced sex ratio of 1:1 (χ^2, p > 0.05), suggesting a healthy population with good mating and reproductive potential. The CWWR analysis revealed a strong and highly significant positive relationship ($p < 0.05$) for both sexes and the pooled data. The calculated b-values for pooled, male, and female crabs were 3.57, 3.38, and 3.68, respectively, indicating an allometric growth pattern. Furthermore, analysis of covariance showed a significant difference ($p < 0.05$) between males and females in their carapace width-weight relationship. The relative condition factor, which remained close to 1 for both sexes and the pooled samples, suggests that the crabs are in good biological condition, likely benefiting from adequate nutrition and favourable environmental conditions. These findings indicate that the *P. sanguinolentus* population in Northwestern San Miguel Bay is thriving, with healthy growth patterns and strong potential for sustainable use. To maintain resource sustainability and support conservation efforts, implementing science-based harvesting regulations and conducting regular stock monitoring are recommended.
Key Words: allometric growth, biological condition, Pandawan fishport, Portunidae, regression.

Introduction. Three-spotted crabs (TSC) *Portunus sanguinolentus* (Herbst, 1783) belong to the family Portunidae under the phylum Arthropoda and infraorder Brachyura (WoRMS 2024). TSC is distinguished from other portunids due to its three distinct color markings on its carapace (Carpenter & Niem 1998). It is a commercially important marine crab in the Philippines, locally known as "Tres Marias" or "Arungan," particularly in San Miguel Bay in the Bicol Region (Nieves et al 2013). *P. sanguinolentus* are commonly caught using local fishing gears such as gillnets, pots, and traps alongside highly prized major target species such as the blue swimming crabs (*Portunus pelagicus*) and Christian crabs (*Charybdis feriatus*). The *P. sanguinolentus* is often treated as a minor commercial fishery product next to *P. pelagicus* and other swimming crabs. Three-spotted crabs (TSC) in the San Miguel Bay are often consumed and marketed within the coastal communities and rarely treated as an export product. Data on the production of this crab species are also unknown due to the lack of separate reporting of production by species, and *P. sanguinolentus* is often recorded as part of blue swimming crab production (Williams & Primavera 2001).

Despite its economic contribution to local communities, this species remains understudied. While extensive research has been conducted in countries such as India (Reeby et al 1990; Sarada 1998; Dineshbabu et al 2007; Pillai & Thirumilu 2012; Dash et al 2013; Soundarapandian et al 2013), Taiwan (Lee & Hsu 2003), Australia (Sumpton et al 1989), Pakistan (Rasheed & Mustaquim 2010; Rasheed & Mustaquim 2014; Rasheed & Mustaquim 2018), Japan (Ariyama 1996), China (Yang et al 2014), Sri Lanka (Wimalasiri & Dissanayake 2016), and the USA (Wenner 1972), there is a notable lack of studies focusing on the population in San Miguel Bay and other fishing grounds in the Philippines. Without comprehensive information on the species' biology and fisheries, developing and implementing effective strategies for sustainable management, conservation, and aquaculture potential remain constrained (Waiho et al 2022). Understanding key aspects of population ecology—such as sex ratio, length-weight relationships, and condition factors—is essential for effective fisheries management. These biological parameters provide valuable insights into aquatic biology, physiology, stock assessment, and overall species health (Abobi 2015; Hamid & Wardiatno 2018; Rohmayani et al 2018).

The sex ratio (SR) plays a crucial role in determining a population's reproductive potential and overall stock size (Oliveira et al 2012). Meanwhile, length-weight relationships (LWR) are widely used to estimate biomass, assess condition indices, and analyze population dynamics in crustaceans. These factors are key to managing populations and evaluating meat yield (Atar & Seçer 2003; Largler 1968). Standard measurements such as body weight, total length, and carapace length offer critical insights into stock composition, health, and productivity (Sukumaran & Neelakantan 1997; Abobi 2015; Rohmayani et al 2018). Additionally, LWR plays an important role in population assessments, the design of fishing gear, and the establishment of legal size limits (Josileen 2011).

Another essential parameter is the condition factor (CF), which helps evaluate the overall health and well-being of marine organisms. It is based on the idea that individuals of the same length should be heavier if they are in good physiological condition (Bagenal 1978). The CF is influenced by both external factors, such as environmental conditions, and internal factors, including feeding rate, growth, parasitism, and reproductive cycles. These variations can cause fluctuations in CF across different seasons and populations (Froese & Binohlan 2000; Pinheiro & Fiscarelli 2009). Collecting this biological information is essential to realizing the species' full potential.

Therefore, this pioneering work aims to assess the sex ratio, carapace-width relationships, and condition factor of three-spotted crabs (*P. sanguinolentus*) in Northwestern San Miguel Bay, Camarines Norte, Philippines, as the basis for future management intervention to sustain the fishery in the area.

Material and Method

Description of time and study sites. The three-spotted crabs were collected at Pandawan Fishport in Mercedes, Camarines Norte (MCN) (Figure 1). Local fishers caught these crabs in the Northwestern part of San Miguel Bay (SMB), Camarines Norte, Philippines. SMB is a highly productive coastal fishing ground in the Bicol Region (Soliman & Dioneda 1997). The San Miguel Bay is considered the most productive coastal fishing ground along Luzon's eastern coast (Bailey 1982; Mines et al 1982). The coastal waters of MCN in SMB lie between 14° 5' north latitude and 123° 3' east longitude, with a land area of 173.69 km^2 and a 95 km-long coastline. Coastal waters around SMB, including the coastal waters around MCN, are relatively shallow (Bailey 1982), with estuarine bodies of water spanning 1,115 km^2. Its seabed is predominantly soft (muddy and sandy), covering about 95% of the bay (Silvestre 1996; Silvestre & Hilomen 2004). These characteristics make the entire bay suitable for trawling (Mines et al 1982; Lim et al 1995), a unique feature along the country's Pacific coast (Mines et al 1982). The area was chosen considering the following reasons: (1) Mercedes is one of the major fishing areas and landing points in San Miguel Bay for *Portunus sanguinolentus* (Nieves et al

2013) and is known as the" Fishbowl Capital" of the Bicol Region due to its abundant marine fisheries resources (Lim et al 1995); (2) crabbing and fishing are the major extractive income sources of the most coastal residents; and (3) no data for biology and catch metrics of the species is available as a basis for management and conservation.

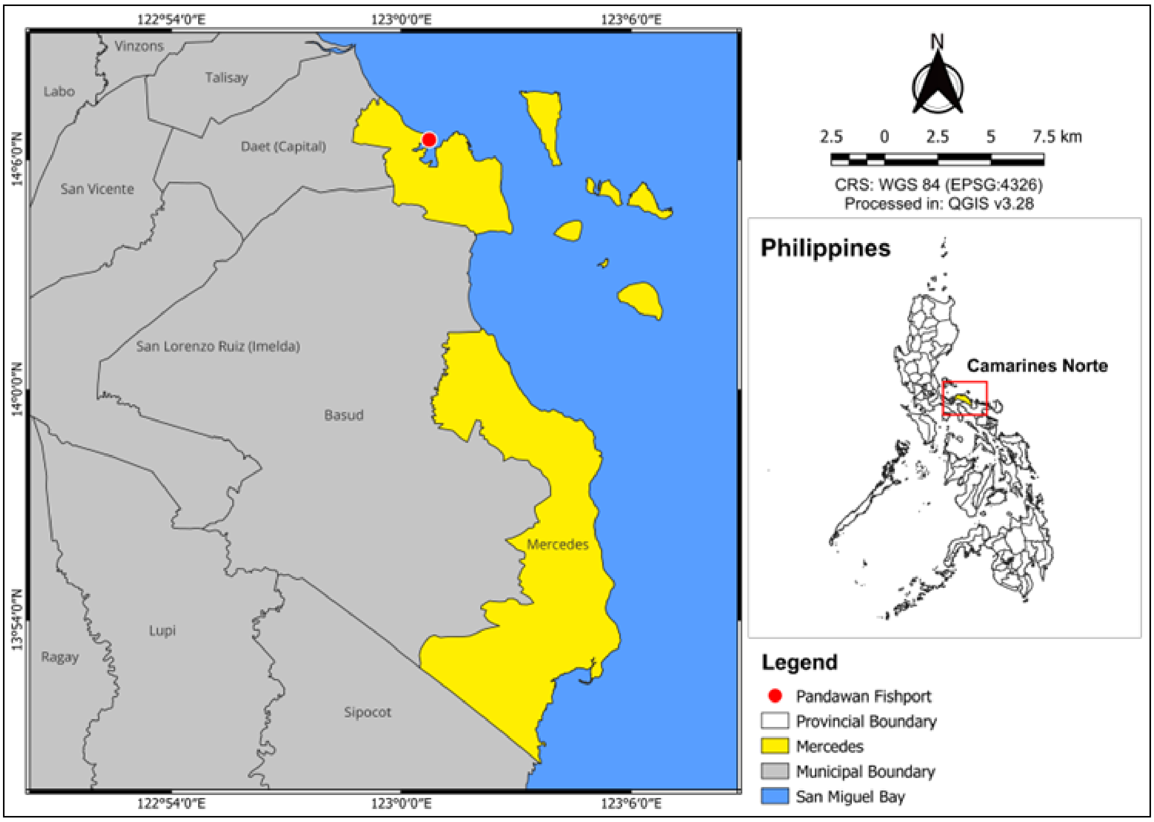

Figure 1. Map of the Philippines, San Miguel Bay, and location of the Pandawan Fishport, where three-spotted crabs from Northwestern San Miguel Bay, Camarines Norte, Philippines are landed (map generated using QGiS 3.2).

Sampling and data collection. A total of 500 randomly selected three-spotted crab samples were collected from September 2024 to January 2025 at Pandawan Fishport, Mercedes, Camarines Norte. The landed crabs were caught by local fishers using crab traps. To ensure that all three-spotted crabs (TSC) caught and landed by fishers in Mercedes had an equal chance of being selected, simple random sampling was applied, a widely used method for fisheries data collection (Pope et al 2010; Geethalakshmi 2018). Crab collection was done early in the morning to ensure the freshness of the crabs. Crabs with incomplete appendages, damaged body parts (e.g. damaged lateral spines), barnacle infestation, bearing eggs (ovigerous/berried crabs), or disease were rejected as samples for the study (Trigg & Perry 1997; Rohmayani et al 2018; Haputhantri et al 2021). The sorted crab samples were packed with ice with a crab-to-ice ratio of 1:1 (Balasaraswathy et al 2008) in sealed containers to ensure the quality of the crabs for subsequent laboratory examination.

The sex of the crabs was determined through a visual examination of the abdominal flap shape. Male three-spotted swimming crabs exhibited a V-shaped abdomen, while the female counterpart had a broad and rounded abdomen (Kumar et al 2000; Soundarapandian et al 2013). However, if there is a presence of "bakla" or immature female crabs showing both rounded and pointed abdominal flaps, it was noted as part of the female crab samples. Carapace width (CW) was measured as the distance between the posteriormost lateral spine tips (Josileen 2011) using a digital vernier caliper (0.1 cm accuracy), while the individual body weight (BW) of TSC was measured using a digital weighing scale (0.01 g accuracy).

Statistical analysis. The sex ratio was determined based on the proportion of males and females in the datasets. The Chi-square goodness-of-fit test (α = 0.05) was used to test the significant differences from the expected 1:1 (male-to-female ratio) with a probability level of 0.05 (Rohmayani et al 2018). The carapace length-weight relationship (CLWR) was calculated using the log form of the allometric growth equation $W = aL^b$ (Ricker 1973), where W = body weight (g), L = carapace width (cm), a is the y-intercept or the initial growth coefficient, and b is the slope or growth coefficient. The a and b values were estimated using the least squares method. A b-value of three indicates isometric growth, while b-value greater than three reflects positive allometric growth, and a value less than three suggests negative allometric growth. The relationships between carapace width and weight for male and female TSC were analyzed using analysis of covariance (ANCOVA) at 0.05 level of significance (Zar 1999). The relative condition factor (Kn) was estimated using $Kn = W/aL^b$, where W is the body weight (g), L carapace width (cm), a is the intercept and b is the slope, or briefly $K_n = W_o / W_e$, where W_o is the observed weight and W_e is the expected weight gleaned from the length-weight regression equation (Jisr et al 2018). Mann-Whitney U Test was used to compare the condition factor of male and female TSC at 0.05 probability level. A significant difference between the male and female relative condition factors was estimated using Student's t-test. All statistical analyses were performed using Microsoft Office Excel and Jamovi 2.3.28.

Results

Sex ratio. The overall sex ratio (male : female) of three-spotted crabs (*Portunus sanguinolentus*) in the Northwestern San Miguel Bay was 1.06:1, showing a slightly male-biased sex ratio. Additionally, TSC's sex ratio was found to vary across months. Among the sampling periods, December has a different ratio wherein the number of females was higher than males (0.92:1). However, the results of the Chi-square test (p > 0.05) showed that the *Portunus sanguinolentus* population in all sampling months including pooled months was balanced between males and females (Table 1).

Table 1

The monthly and total sex ratio of three-spotted crabs (*Portunus sanguinolentus*) of Northwestern San Miguel Bay, Camarines Norte, Philippines

Month	*Male*	*Female*	*Male : Female*	x^2	*p*	*Remarks*
September	57	43	1.33:1	1.96	0.162	NS
October	50	50	1:1	0.00	1.00	NS
November	51	49	1.04:1	0.04	0.841	NS
December	48	52	0.92:1	0.16	0.689	NS
January	50	50	1:1	0.00	1.00	NS
Total	256	244	1.06:1	0.29	0.592	NS

Note: NS – not statistically significant.

Carapace width-weight relationship. The carapace width-weight (CW-W) regression analysis of three-spotted crabs from Northwestern San Miguel Bay is shown in Table 2 and Figure 2. Results revealed that the values of the coefficient of determination (R^2) are positive and highly significant (p < 0.05) for male (0.97), female (0.98), and combined sexes (0.98) of *P. sanguinolentus*. It shows that the carapace width is a reliable predictor of weight for *P. sanguinolentus.* The low values of "*a*" for male (0.02) and female (0.01) TSC indicate that both sexes start with relatively low body weights at small carapace widths. The slightly higher "*a*" value for male crabs might have a marginally higher initial body weight at the same carapace width compared to females. In terms of growth pattern, the CW-W data for male (b = 3.38), female (b = 3.68), and combined sexes (b = 3.57) showed a positive allometry (b > 3). The result of positive allometry for both sexes indicates that the increase in body weight is faster than the increase in carapace width. Analysis of covariance (ANCOVA) revealed a significant difference between sexes

(p < 0.05) in the carapace width-weight relationship. The higher b values in female TSC showed that females gain weight faster than males as their carapace width increases.

Table 2
The carapace width-weight regression analysis of male, female, and mixed sex three-spotted crabs in Northwestern San Miguel Bay, Philippines

Sexes	*n*	*CW (cm)*	*BW (g)*	*a*	*b*	R^2	*Growth type*
Male	256	10.53 ± 0.91	58.69 ± 14.85	0.02	3.38	0.97	+A
Female	244	10.35 ± 1.15	56.53 ± 0.67	0.01	3.68	0.98	+A
CS	500	10.44 ± 1.04	57.64 ± 17.63	0.01	3.57	0.98	+A

Note: CS – combined sexes, n – crab samples, CW – carapace width; BW – body weight; a = y-intercept, b = growth coefficient, R^2 = sample correlation coefficient; +A – positive allometric growth.

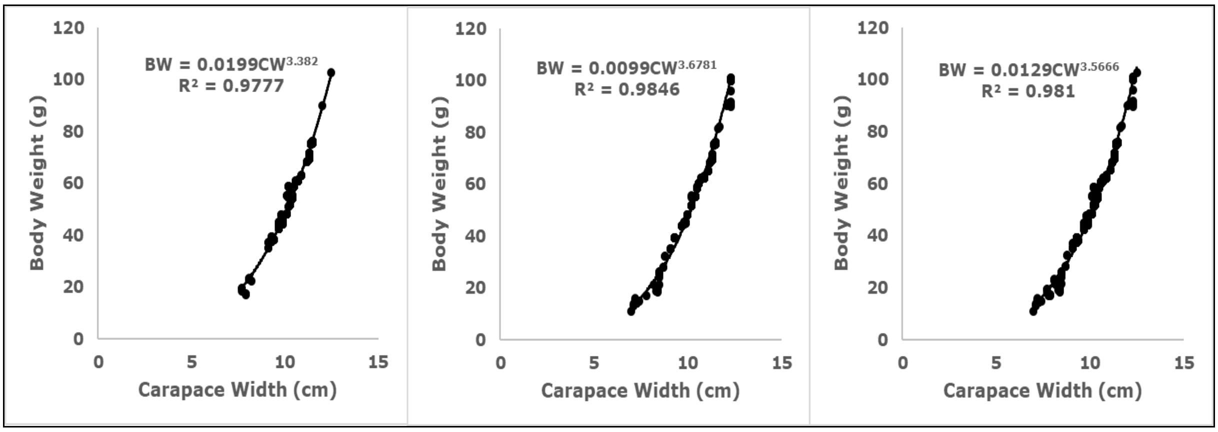

Figure 2. Carapace width-weight relationship of male (left), female (center), and combined sexes (right) of three-spotted crabs in Northwestern San Miguel Bay, Philippines.

Relative condition factor (K_n). The values of the relative condition factor (K_n) of three-spotted crabs caught from Northwestern San Miguel Bay are shown in Table 3. Results revealed that the K_n value of male TSC (1.0018) is slightly higher than that of female TSC (0.9927). The sex-biased K_n indicates that male TSC crabs may be in slightly better condition or slightly heavier for their carapace width compared to female crabs. However, Student's t-test result showed no significant difference (p > 0.05) between the K_n variation of male and female TSC crabs. In general, the K_n values closer to 1 for both sexes showed that TSC in Northwestern San Miguel Bay are in healthy condition.

Table 3
The relative condition factor of three-spotted crabs (*Portunus sanguinolentus*) from Northwestern San Miguel Bay, Camarines Norte, Philippines

Sex	*n*	K_n *(range)*	K_n *(Mean ± SD)*	*Remarks*
Male	256	0.79-1.14	1.0018 ± 0.0471[a]	Good condition
Female	254	0.70-1.09	0.9927 ± 0.066[a]	Slightly poorer condition
Total	500	0.78-1.14	1.0018 ± 0.047	Good condition

Note: n – crab samples; K_n – relative condition factor; SD – standard deviation; different lowercase superscript letters in the same column indicate significant treatment differences (p <0.05).

Discussion. The sex ratio plays a key role in understanding crustaceans' population dynamics and reproductive health (Cheewasedtham 1990; Wardiatno 2004; Wardiatno & Mashar 2010). In the present study, the overall sex ratio of three-spotted crabs (*Portunus sanguinolentus*) in Northwestern San Miguel Bay (NSMB) was found to be balanced (1:1), suggesting that different sampling periods do not significantly affect the sex ratio of the crab population. Additionally, the fishing gear used in NSMB, such as crab traps, was found to be unselective towards males and females (Xiao & Kumar 2004; Sato & Goshima 2006). A balanced sex ratio in the population also provides an opportunity for

P. sanguinolentus to select their mates, with males playing a critical role in the success of mating (Sato & Goshima 2006). Similar balanced sex ratios of three-spotted crabs have been reported in several Indian waters, including the South Karnataka Coast (Dineshbabu et al 2007), the Calicut Coast (Sarada 1998), Malpe and Mangalore (Sukumaran et al 1986), and the Kakinada Region (Lalitha Devi 1985) (Table 4). However, male-biased or female-biased sex ratios have been observed in other regions. For instance, a male-biased sex ratio was noted in Hawaii, United States of America (Wenner 1972), Queensland Waters, Australia (Sumpton 1989), Honghai Bay, China (Yang et al 2014), and the west coast of Sri Lanka (Wimalasiri & Dissanayake 2016). Conversely, a female-biased sex ratio was observed in Chennai Coast, India (Pillai & Thirumilu 2012).

Table 4

The sex ratio analysis of *Portunus sanguinolentus* in other studies

Location	*Year*	*n*	*Sex ratio (M:F)*	x^2	*p*	*Source*
Hawaiian Waters, USA	1970 - 1971	354	1:1.1	-	-	Wenner 1972
Kakinada Region, India	1979 - 1980	1060	1.10:1	1.9962	$p > 0.05$	Lalitha Devi, 1985
Mangalore, India	1979 - 1980	2379	1.28:1	3.0209	$p > 0.05$	Sukumaran et al 1986
Mangalore, India	1980 - 1981	2274	1.09:1	15.1187	$p < 0.05$	Sukumaran et al 1986
Mangalore, India	1981 - 1982	1631	1.13:1	10.4491	$p > 0.05$	Sukumaran et al 1986
Malpe, India	1980 - 1981	560	1.03:1	7.3019	$p > 0.05$	Sukumaran et al 1986
Calicut Coast, India	1987 - 1991	1149	1.07:1	23.3388	$p > 0.05$	Sarada 1998
Mangalore, India	1998 - 2005	-	1:1	-	$p > 0.05$	Dineshbabu et al 2007
Malpe, India	1998 - 2005	-	1.13:1	-	$p > 0.05$	Dineshbabu et al 2007
Chennai Coast, India	1997 - 2008	681	1:1.41	-	-	Pillai & Thirumilu 2012
Queensland, Australia	1989	1008	1.69:1	50.23	$p < 0.001$	Sumpton 1989
Honghai Bay, China	2012 - 2013	1467	1.26:1	52.785	$p < 0.01$	Yang et al 2014
Negombo, Sri Lanka	2014 - 2015	1085	1.01:1	-	$p > 0.05$	Wimalasiri & Dissanayake 2016
NSMB, Camarines Norte, Philippines	2024 - 2025	500	1.06:1	0.29	$p > 0.05$	Present study

Sex ratios in marine species can be influenced by various factors, including fishing methods, food availability, differences in mortality rates among populations, habitat segregation by sex, and the possibility of single-sex migrations (Wenner 1972; Davanso et al 2013; Yang et al 2014; Alam et al 2018). Environmental conditions at the sampling site, such as water depth and other physical factors, may also contribute to the observed imbalances in the sex distribution of *Portunus sanguinolentus*. Like other marine portunid crabs, female *P. sanguinolentus* tend to prefer deeper waters with higher salinity, while males are more commonly found in shallower areas (Campbell & Fielder 1986). During the breeding season, berried females migrate inshore to locate sandy substrates essential for egg extrusion.

This study provides a snapshot of the sex ratio of crab catches using crab traps over a five-month sampling period. To gain a more comprehensive and conclusive understanding of the sex ratio and other biological parameters of *P. sanguinolentus* in Northwestern San Miguel Bay, year-round monitoring is recommended.

The length-weight relationship (LWR) is a widely used tool for assessing biomass, condition indices, and population dynamics in crustaceans—critical factors in population management and evaluating meat yield (Atar & Seçer 2003; Suhalya & Rashan 1986; Olmi & Bishop 1983; Largler 1968). Measurements such as body weight, total length, and carapace length provide valuable insights into stock composition, overall health, and productivity (Sukumaran & Neelakantan 1997; Abobi 2015; Rohmayani et al 2018). Additionally, LWR plays a key role in population evaluation, fishing gear design, and the establishment of legal size limits (Josileen 2011). According to Allen (1938), in an ideal organism that consistently maintains its shape, the value of 'b' would equal 3. However, in some organisms, the 'b' value typically falls between 2.5 and 4.0 (Martin 1949). In the present study, the carapace-width weight relationship of TSC in Northwestern San Miguel Bay showed a positive and highly significant coefficient of determination (R^2) of 0.9 and 'b' values greater than 3, showing positive allometry for male, female, and combined sexes of TSC. The findings of the present study agreed with other studies showing a high degree of positive correlation ($R^2 \geq 0.81$) and positive allometry (b > 3) for TSC (Sukumaran et al 1986; Yang et al 2014) (Table 5). However, other studies reported different findings, showing negative allometry for male and female TSC (Sarada 1998; Suyani et al 2021; Sahu et al 2024; Josileen et al 2025) (Table 5).

Table 5
The carapace width-weight regression analysis of male, female, and mixed sex three-spotted crabs in other studies

Location	*Sexes*	*A*	*B*	*R^2*	*GT*	*Source*
South Kanara Coast, India	Male	-4.46	3.09	0.96	+A	Sukumaran et al 1986
	Female	-4.10	2.89	0.97	+A	
	CS	-	-	-	-	
Calicut Coast, India	Male	0.00	2.79	0.88	-A	Sarada 1998
	Female	0.00	2.82	0.81	-A	
	CS	0.00	2.80	0.88	-A	
Honghai Bay, China	Male	0.00	3.05	0.99	+A	Yang et al 2014
	Female	0.00	3.01	0.99	+A	
	CS	-	-	-	-	
Northwest Coast of India	Male	0.54	2.20	0.98	-A	Suyani et al 2021
	Female	0.81	2.01	0.97	-A	
	CS	0.67	2.10	0.97	-A	
Gulf of Mannar, India	Male	0.09	2.00	0.96	-A	Sahu et al 2024
	Female	0.72	2.45	0.95	-A	
	CS	0.09	2.22	0.95	-A	
Southeastern Arabian Sea	Male	0.00	2.97	0.92	-A	Josileen et al 2025
	Female	0.00	2.80	0.86	-A	
	CS	0.00	2.89	0.89	-A	
Northwestern San Miguel Bay, Philippines	Male	0.02	3.38	0.97	+A	Present study
	Female	0.01	3.68	0.98	+A	
	CS	0.01	3.57	0.98	+A	

Note: a = y-intercept, b = growth coefficient, r^2 = sample correlation coefficient; GT – growth type; +A – positive allometric growth; -A – negative allometric growth.

The difference in 'b' values can be attributed to changes in body contour and specific gravity, which cause deviations from the cube law (Rounsefell & Everhart 1953). Additionally, age-related morphological changes can result in the coefficient of the logarithmic relationship between weight and length differing significantly from the ideal value of 3.0 (Sahu et al 2024). Furthermore, ecological factors such as food availability, water quality, sample size, and length range may influence various species' slope (b) (Mommsen 1998; Ighwela et al 2011). Internal and external factors can also affect this variability, including samples' length and size range, sexual dimorphism, molting, maturity, food supply, temperature, and salinity (Ecoutin & Albaret 2003; Ernawati et al 2014).

The relative condition factor (K_n) indicates an organism's health by comparing its actual weight to the expected weight for a given size (Blackwell et al 2000; Lloret et al 2013). It is commonly used to evaluate growth and feeding efficiency (Fagade 1979). Studies have shown that K_n tends to decrease as length increases (Bakare 1970; Fagade 1979) and may also be influenced by the reproductive cycle in organisms (Welcomme 1979). In the present study, the relative condition factor of TSC is closer to 1, indicating that TSC in the bay is in good and healthy condition. Similar results have been reported by several studies on K_n values for TSC in other fishing grounds (Table 6), such as in the Northwest Coast in India (Suyani et al 2021), the Gulf of Mannar in India (Sahu et al 2024), and Southeastern Arabian Sea (Josileen et al 2025). However, regarding sex-based K_n of TSC, the present study showed different results from the other studies (Suyani et al 2021; Josileen et al 2025), wherein the K_n of male TSC was higher than that of females. The fluctuations in the relative condition factor of TSC can be influenced by varying environmental conditions, food availability, feeding behavior, predator pressure, and crab behavior (Muchlisin et al 2010).

Table 6

The relative condition factor (K_n) of three-spotted crabs (*Portunus sanguinolentus*) in other studies

Location	*Sex*	*N*	*K_n (Mean ± SD)*	*Source*
Southeastern Arabian Sea	Male	2470	0.942 ± 0.145	Josileen et al 2025
	Female	2995	1.371 ± 0.255	
	CS	-	-	
Gulf of Mannar, India	Male	145	-	Sahu et al 2024
	Female	147	-	
	CS	292	0.8899	
Northwest Coast, India	Male	72	1.00461 ± 0.0191	Suyani et al 2021
	Female	84	1.00908 ± 0.0317	
	CS	156	1.00768 ± 0.0186	
Northwestern San Miguel Bay, Philippines	Male	256	1.0018±0.0471	Present Study
	Female	254	0.9927±0.066	
	CS	500	1.0018±0.047	

Note: n – crab samples; CS – combined sexes; K_n – condition factor.

Conclusions. This study provides baseline data on the sex ratio, carapace width-weight relationship, and relative condition factor of *Portunus sanguinolentus* in Northwestern San Miguel Bay. A balanced sex ratio across sampling months suggests non-selective fishing practices and minimal seasonal or migratory influence, allowing for mate selection, with males playing a key role in mating success. Positive allometric growth indicates that weight increases faster than carapace width, while relative condition factor values near 1 suggest a healthy population. These findings are crucial for effective management and conservation strategies. Continuous monitoring and further research on environmental factors are recommended to enhance understanding of the species' growth and ecological responses, with science-based harvesting regulations and regular stock monitoring essential for sustainability.

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Conflict of interest. The authors declare that there is no conflict of interest.

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