



Growth and mortality characteristics of *Charybdis natator* (Herbst, 1794) (Crustacea: Brachyura: Portunidae) along Gulf of Mannar, southeast coast of India

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Original Article

Abstract

Growth, mortality and size structure of the Ridged swimming crab *Charybdis natator* Herbst, 1789 was assessed based on samples collected from the Gulf of Mannar, southeast coast of India, between June 2015 to June 2016. The carapace width of the species ranged from 2.4 to 12.8 cm for males and 5.1 to 11.82 cm for females, the carapace length ranged from 2.3 to 9.5 cm for males and for females from 1.9 to 8.6 cm. Weight ranged from 20 to 659 g for males and 28 to 268 g for females. The estimated asymptotic length (L_{∞}) and growth co-efficient (K) for males and females were 14.18 cm and 13.20 cm and 1.20 y⁻¹ and 1.52 y⁻¹ respectively. The mortality parameters Z, M, F and E for males (Z=2.52; M = 2.51; F = 0.16; E = 0.063) and females (Z = 3.00; M = 2.99; F = 0.05; E = 0.016) were estimated. The factor explaining the relationship between natural mortality coefficient and physical factor M/K was 2.09 and 1.96 for males and females of *C. natator*. As the fishing mortality is less compared to the natural mortality, the results indicate that the population of *C. natator* in the Gulf of Mannar is underexploited.

Keywords: Size structure, growth parameters, mortality parameters, *Charybdis natator*, Gulf of Mannar

Introduction

Gulf of Mannar in the southeast coast of India extending from Rameswaram in the north to Tuticorin in the south along with its marine environment has been declared as India's first Marine Biosphere Reserve. Crustaceans form the major group in the overall faunal diversity of this region, with shrimps dominating crabs. Bults of the crab catches in Tamil Nadu are landed in Gulf of Mannar and Palk Bay (Rao *et al.*, 1973).

The Ridged swimming crab, *Charybdis natator* (Herbst, 1789) belonging to the family Portunidae is locally called as "Paarnandu" or "Kalanandu". It is a widespread Indo- West Pacific species, distributed along East Africa, Madagascar, Red Sea, India, China, Japan, Philippines, Thailand, Malaysia, Singapore, Indonesia and Australia (Stephenson *et al.*, 1959; Dai and Yang, 1991). The population biology of portunid crabs were studied by various authors. (Zafar *et al.*, 2006; Josileen and Menon, 2007; La Sara, 2010; Araujo *et al.*, 2012 and Türeli, *et al.*, 2016). However, among the portunid crabs studies on *Charybdis natator* is meagre (Fernando and Renata, 2001, Sant' Anna *et al.*, 2012, 2015). The population characteristics such as growth parameters and mortality parameters are needed to develop management strategies. Hence the present study was

aimed at obtaining requisite information on the population of *C. natator* in the Gulf of Mannar, for the assessment and management of the resource.

Material and methods

The study was carried out for a period of 12 months (June 2015 to June 2016) from Gulf of Mannar (8° 35' N-9° 25' N latitude and 78°08' E-79° 30' E longitude), southeast coast of India. The area is blessed with 21 coral islands covering 623 ha. For this study four landing centers namely Therespuram, Vellapatti, Vedalai and Periyapattinam were selected from the Gulf of Mannar coast. Main gear employed in crab fishery is the bottom set gill nets known as 'nanduvalai' which are operated by vallams and in trawlers they are landed as bycatch. Fishing activities are carried out throughout the year with the peak season being from June to October. Samples of *C. natator* were collected from the four landing centers randomly every fortnight and each specimen was measured and recorded for its sex, total length and body weight using Vernier calipers with an accuracy of 0.5 mm. A total of 1227 crabs were observed consisting of 758 males and 469 females.

Carapace width (CW) was grouped into 5 mm class interval for determining size frequency. The data were subjected to modal progression technique by splitting the modes using Bhattacharya's method (Gayanilo *et al.*, 1996) followed by linking of means. Growth curve was derived using analysis of growth increment data by Appeldoorn's method. The empirical equation by Pauly (1979) was used to estimate the to value of VBGF:

$$\log_{10} (-t_0) = -0.3922 - 0.2752 * \log_{10} L_{\infty} - 1.038 \log_{10} K$$

Finally generalized von Bertalanffy's model for growth was derived for this species sex-wise.



Fig. 1. Sampling stations at Gulf of Mannar.

$$L_t = L_{\infty} \{1 - \exp(-k(t - t_0))\}$$

The total instantaneous mortality rate (Z) was determined by length converted catch curve method in FISAT. The natural mortality (M) was derived by Pauly's (1980) equation considering mean annual habitat temperature (taken as 29°C in this study). L_{∞} and K were taken from the VBGR. Pauly's empirical equation (1980):

$$\log(M) = 0.0066 - 0.279 \log(CW_{\infty}) + 0.6543 \log(K) + 0.4634 \log(T)$$

The co-efficient of fishing mortality (F) was calculated using the relationship

$$Z = F + M$$

The exploitation rate (E) was computed from the formula:

$$E = F/Z$$

Results and discussion

During the study, a total of 1227 individuals of *C. natator* were recorded, of which males constituted 61.77% (n=758), whereas non-ovigerous females (n=324) and ovigerous females (n=145) constituted 26.40% and 11.81% respectively. Sex ratio observed was in favor of males. Similar observations were recorded in *Charybdis hellerii* in Brazilian waters (Sant' Anna *et al.*, 2012; 2015). In Gulf of Mannar, *C. natator* was recorded throughout the year with peak during the months of October and May for males and September for females. The crabs were recorded from the intertidal zone (especially juveniles) up to a depth of 35 m. Carapace width of *C. natator* ranged from 2.4 to 12.8 cm for males and 5.1 to 11.8 cm for females. Similarly, the carapace length (CL) ranged from 2.3 to 9.5 cm for males and for females it ranged from 1.9 to 8.6 cm. Weight ranged from 20 to 659g in males and 28 to 268 for females (Fig. 2, 3 and 4). Males were heavier than the females because of their fast growth rate and larger claw. Sallam and Gab- Alla, (2010) documented the CW of *C. natator* as 4.75 to 13.05cm for male and 7.0 to 14.8 cm for female in the trawl fishery of the Gulf of Suez. Sumpton (1990) reported the size range as 9.0 to 9.5 cm for males and 10.0 to 10.5cm for females in the Moreton Bay, Queensland. Kathirvel and Gopalakrishnan (1974) observed the size range of 5.1 cm in males of *C. hellerii* and that of 6.3 cm in females from the West coast. Dineshbabu (2011) reported size range in males of *C. feriatus* from 2.6 to 15.5cm and for females 4.6 to 17.0 cm in Karnataka. The variation in size range observed in this study might be due to the spatial variation or the type of gear employed for sampling. It is interesting to note that the male species dominated in most of the length class (Fig. 2 and 3).

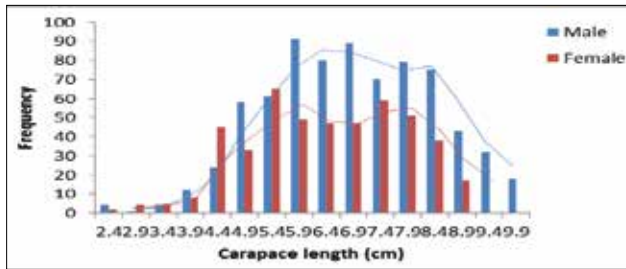


Fig. 2. Size distribution (Carapace width) for male and female *C. natator* from Gulf of Mannar (2015-2016).

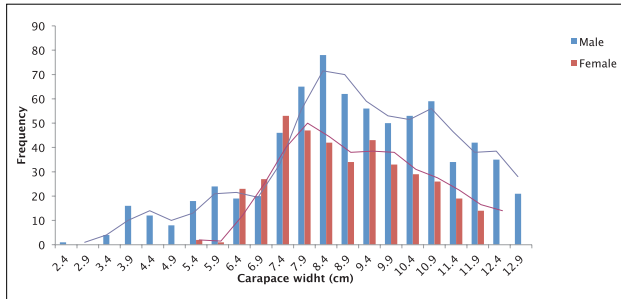


Fig. 3. Size distribution (Carapace length) for male and female for male and female *C. natator* from Gulf of Mannar (2015-2016).

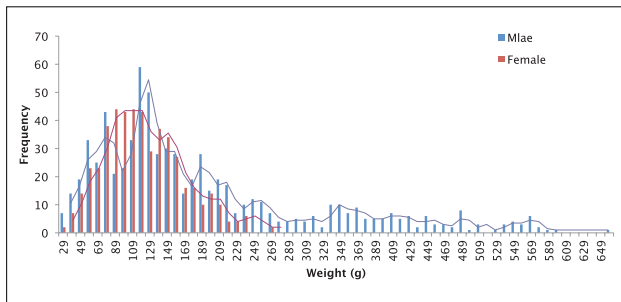


Fig. 4. Size distribution (weight (g)) for males and females of *C. natator* from Gulf of Mannar (2015-2016)

Growth parameters

The carapace width frequency distribution of females and males of *C. natator* was analyzed using ELEFAN I of FISAT statistical package. Growth parameters for male, female and sexes pooled were estimated and are shown in Table.1. The growth curve was derived using analysis of growth increment data by Appeldoorn's method (Gayaniilo *et al.*, 1996). The growth curves of male, female and sexes pooled are given in Fig. 5, 6 and 7. Males of *C. natator* attained CW of 7.65, 8.9, 10.4 and 12.41 cm at 0.6, 0.8, 1.1 and 1.7 years respectively

Table 1. Growth parameters of males and females of *C. natator* in Gulf of Mannar

Sex	L_{∞} (cm)	K	M/K	t_0
Male	14.18	1.20	2.09	-0.161
Female	13.20	1.52	1.96	-0.129
Pooled data	13.36	1.57	1.89	-0.124

and females reached 7.2, 8.8, 10.52 and 11.05 cm in 0.6, 0.7, 1.5 and 1.6 years. The estimated L_{∞} and K for males *C. natator* were 14.18 cm and 1.20 respectively and for females it was 13.20 cm and 1.52. The results indicate short life span and fast growth rate in males compared to females. The estimated t_0 for males and females of *C. natator* was around 0.1. The factor explaining the relationship between natural mortality coefficient and physical factor M/K was 2.09 and 1.96 for males and females. The generalized VBGF of males and females are given below.

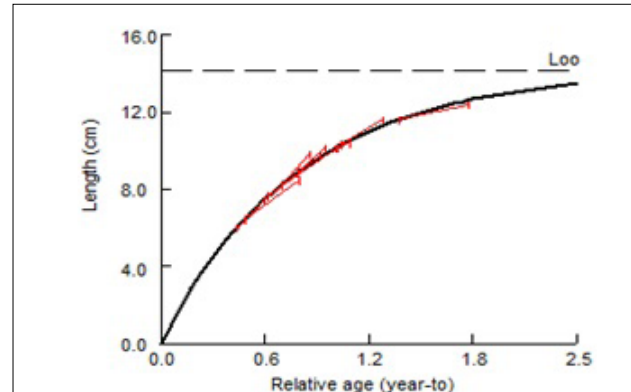


Fig. 5. Growth curve - Male.

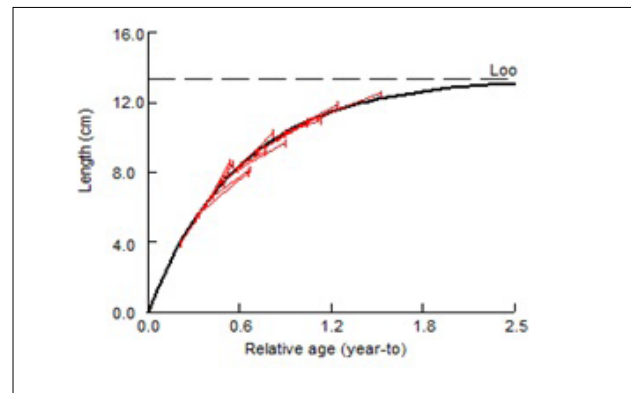


Fig. 6. Growth curve – Female.

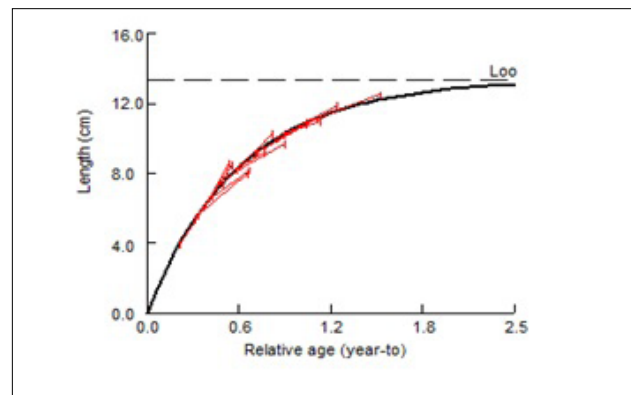


Fig. 7. Growth curve - Pooled data.

$CW(t) = 14.18 \{1 - \exp(-1.20(t + 0.1))\}$ for male

$CW(t) = 13.20 \{1 - \exp(-1.52(t + 0.1))\}$ for female

Dineshbabu *et al.*, (2011) reported the growth parameters L_{∞} (164 mm for female and 173 mm for male) and Ky^{-1} (0.89 for female and 0.84 male) in *C. feriata* in Karnataka waters. Dash *et al.* (2014) stated that the male *C. feriata* attained carapace width of 11.3 cm in 1st year, 14.9 cm in 2nd year and 16.3 cm in 3rd year, whereas the female crabs reached 11.1 cm in 1st year, 15.0 cm in 2nd year and 16.5 cm in 3rd year. The L_{∞} (175.5 mm for female and 171 mm for male) and K (0.91 y^{-1} for female and 0.98 y^{-1} male) were observed in *C. feriata* from Veraval waters, northwest coast of India. Sumer *et al.* (2013) analyzed the LFDA of the Blue Crab, *Callinectes sapidus* from the Beymelek Lagoon (Southwestern Coast of Turkey) and found that male crabs had higher L_{∞} and lower K and higher Φ' values (L_{∞} = 230.1 mm, K = 0.860 y^{-1}) than females (L_{∞} = 181.9 mm, K = 1.064 y^{-1}). In *C. sapidus* similar observation of higher L_{∞} in male than female was indicated by Tureli *et al.* (2016). The estimated asymptotic length (L_{∞}) and growth co-efficient (K) for the closely related species *C. feriatus* was 26.76 cm and 0.63 y^{-1} respectively (Plutomeo *et al.*, 2015). In the present observation also it has been confirmed that the male attains higher individual carapace width than the females. As reported by earlier authors *C. natator* males are larger than females, a common character for portunid crabs (Williams, 1974 and Araujo *et al.*, 2012). The growth coefficient was slightly higher than the closely related group which is attributed due to geographical area particularly the tropicalized stock (Castillo *et al.*, 2011 and Shinozaki-Mendes *et al.*, 2012).

Mortality parameters

The total instantaneous mortality rate (Z), natural mortality rate (M), fishing mortality (F) and exploitation ratio (E) for male, female and sex pooled data of *C. natator* were estimated (Fig. 8, 9 and 10). The Z calculated for males and females of *C. natator* were 2.52 and 3.00 and natural mortality (M) was 2.51 and 2.99 respectively. The fishing mortality co-efficient (F) for males and females were 0.16 and 0.05. The mortality parameter Z , M and F of *C. feriatus* was 3.7, 1.41 and 2.29 respectively (Plutomeo *et al.*, 2015). The estimated exploitation ratio of males and females of *C. natator* was 0.06 and 0.01 respectively. The present study indicates that the natural mortality of *C. natator* was less. The natural mortality rate (M) and the total mortality rate (Z) was found to be slightly higher in females when compared to males. The fishing mortality co-efficient (F) was less for both sexes and the exploitation ratio was almost same for the male and female of *C. natator* (Table. 2).

Zafar *et al.* (2006), observed that the Z for male and female of *Scylla Serrata* was 0.84 and 0.96 and natural mortality was 0.49

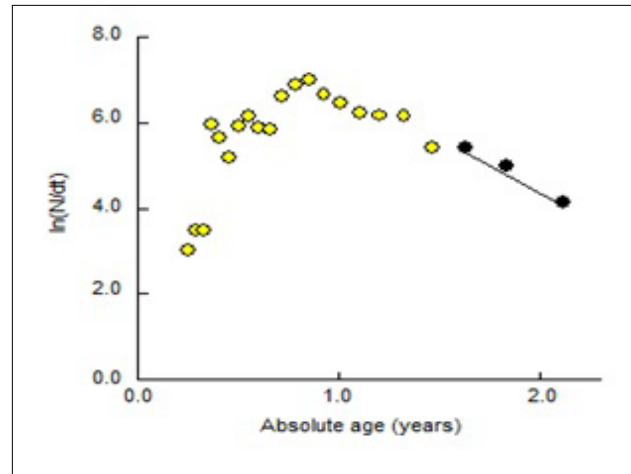


Fig. 8.Length –Converted catch Curve of male *C. natator*.

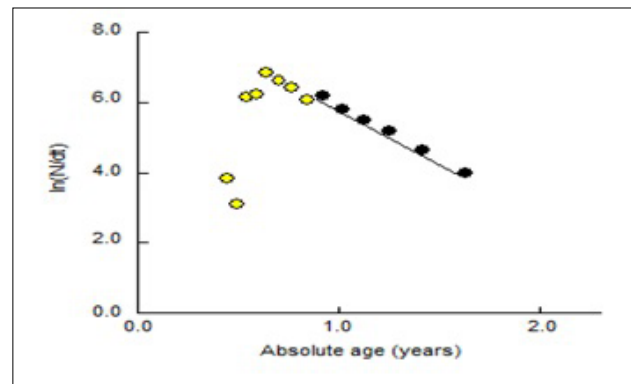


Fig. 9.Length –Converted catch Curve of female *C. natator*.

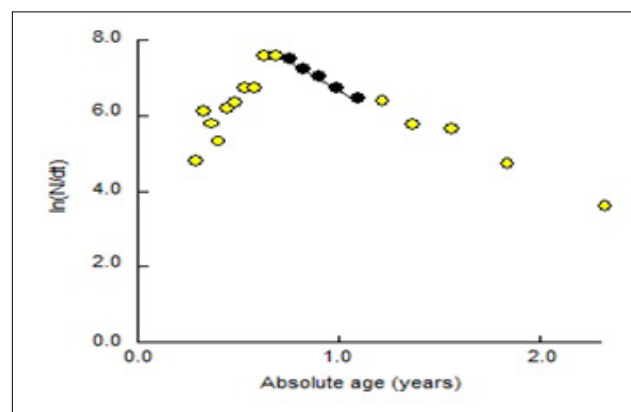


Fig. 10.Length - converted catch curve of sex pooled data of *C. natator*

and 0.58 respectively. Sara (2010) estimated that the natural mortality (M) in male as 2.48 and fishing mortality (F) in male as 1.2, while M for female was 1.78 and F for female was 0.75 from Indonesia and stated that *S. serrata* population is still under exploited. Dash *et al.* (2014) found that the natural mortality rate (M), fishing mortality rate (F) and the total mortality rate

Table 2. Mortality parameters of males and females of *C. natator* of Gulf of Mannar

Exploitation Ratio (E=F/Z)	Total instantaneous Mortality(Z)	Natural mortality (M)	Fishing mortality (F)	Sex
Male	2.51	0.16	2.52	0.0634
Female	2.99	0.05	3.00	0.0166
Pooled data	2.98	0.03	3.01	0.0099

(Z) was higher in males compared to females whereas, the current exploitation rate (E_{curr}) was same for both the sexes of *C. feriata* from Veraval. Dineshbabu (2011) stated that the Z, Mand F values estimated for the species of *C. feriata* were 6.04, 1.76 and 4.28 respectively and the exploitation ratio (E) was 0.71 from Karnataka coast.

The growth parameters revealed that the males are heavier than females and in the males we observed shorter life span and relatively faster growth rate than females. The M/K values indicate that the growth oscillation was found to be very less for both the sexes of *C. natator* at Gulf of Mannar. The mortality parameters and the exploitation ratio indicate that the crabs were under low fishing pressure. So the present effort may be increased for the species to tap this under exploited resource.

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