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Biology and exploitation of the crucifix crab, *Charybdis* (*Charybdis*) *feriata* (Linnaeus, 1758) (Brachyura: Portunidae) from Karnataka coast, India

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ABSTRACT

Charybdis feriata supports trawl fishery of Karnataka coast and the entire catch is landed by multiday trawlers operating beyond 30 m depth zone. The highest landing was observed during 2003 (142 t). Fishing season for the species extend generally from September to June but peak fishing season of the species was during December-June. Size range observed in the fishery was 46 to 170 mm in males and 26 to 155 mm in females. Mean size ranged from 66 mm to 80 mm. Test of homogeneity of the sex ratio (χ^2 test) for the years, 2007-2009 showed that proportion conform to 1:1 ratio. Studies conducted on reproductive stages of the species show that the species is a continuous breeder with two peak breeding season, one during October–November and another during May-June. Size at maturity (50%) of females was estimated at 70 mm carapace width and age at 50% maturity was about 7 months. Carapace width-weight studies showed that males were heavier than females of similar size. By von Bertalanffy's growth plot, it was estimated that males and females reach 101mm, 99 mm (CW) respectively at the end of first year and reach 142 mm and 137 mm respectively in two years. Stock assessment studies of the species was conducted using sex pooled data for the period 2007-2009 so as to formulate management suggestions. The *Z, M* and *F* values estimated for the species were 6.04, 1.76 and 4.28 respectively. The exploitation ratio (*E*) was 0.71. MSY was estimated as 131t against the present annual average yield of 124 t. From 'Thompson and Bell yield prediction analysis' it is seen that any additional 10% effort from the present level will yield only less than 10% additional catch, indicating that increasing the effort for better catch of the resource will not be economical and it is suggested that restricting the catch to MSY level (131 t) will be the suitable management option for the sustainability of *C. feriata* fishery from the coast.

Keywords: Biology, *Charybdis feriata*, Crucifix crab, Exploitation, Karnataka coast

Introduction

Charybdis feriata (Linnaeus, 1758) is a portunid crab species widely distributed in the Indo-Pacific region from Japan and China to Australia in the east, to eastern and southern Africa, Gulf of Oman and Arabian Gulf in the west, encompassing Pakistan, India, Sri Lanka and Indonesia (Stephenson *et al.*, 1957; Stephenson, 1972; Ng, 1998; Apel and Spiridonov, 1998). It usually occurs sublittorally on muddy and sandy bottoms, as well as on rocky and stony coasts including coral reef flats, at depths of approximately 10-60 m (Ng, 1998). This species of *Charybdis* has a high commercial value being caught in trawl nets, traps and fixed nets, and is usually sold frozen. However with the recent expansion of live fish markets, this species is now maintained in aquaria and exported throughout eastern Asia (Ng, 1998). Its size and meat quality makes it a valuable target species for aquaculture (Parado-Estepa *et al.,* 2002).

In India, *Charybdis feriata* supports substantial commercial fishery especially trawl fishery of Karnataka (Dineshbabu *et al*., 2007; 2008). From the west coast of india, the information on the species was reported for the first time by Pillai and Nair (1968). From the east coast Lalithadevi (1985) reported that during 1979-80, 6.6 t of *C. feriata* was landed at Kakinada, which formed 0.86% of the crab landing. Padayatti (1990) reported the emergence of the species as a fishery in Kochi in 1989 and reported the size composition and reproductive characters of the species. Utilisation of *C. feriata* for edible purpose in local market is considered to be one of the reason for improvement in crab landing in recent years and by the year 2000 the species contributed 26% of the crab fishery of Mangalore and Malpe (Manissery and Radhakrishnan, 2003). Despite the economic significance, apart from the studies on fishery (Lalithadevi, 1985; Padayatti, 1990), morphometrics, food and feeding (Rameshbabu *et al.,* 2002a; 2002b) and reproductive biology (Pillai and Nair,

1968; 1973; Padayatti, 1990; Rameshbabu *et al*., 2006) population dynamics of the species remains poorly understood. The present study was aimed to understand the fishery, size distribution, sex-ratio, maturity, spawning season, growth and stock parameters of the species in Mangalore so as to assess the impact of present fishing pressure on the stock and thereby suggest management measures for the fishery.

Material and methods

Data on crab catch and effort were collected from Mangalore fishing harbour on an average of 8 days per month (2 days a week) during 2002-2009. Detailed studies on catch effort, size range of *Charybdis feriata* was carried out during this period with the help of catch and effort data and data on carapace width and bodyweight. From the GPS readings of the multiday trawlers, it was observed that the landings from these trawlers at Mangalore fisheries harbour represents the catch from a fishing ground spanning from north Kerala to off south Maharashtra. Maturity stages of females were determined by classifying the females into five categories, namely immature, early maturing, late maturing, mature and spent based on the fullness of the ovary and berried females were found to occur predominantly with spent and early maturing ovaries (Ryan, 1967). Homogeneity of the sex ratio was tested using χ^2 test (Snedecor and Cochran, 1967).

For deriving carapace width-weight relationship, linear equation (log W = log a + b log L) was fitted for the log transformed data. Regression analysis was performed to determine the constants a and b and relationship between carapace width and weight. Analysis of covariance (Snedecor and Cochran, 1967) technique was used to test for any significant difference in the relationship in the above parameters between the sexes at 1% level.

Data on carapace width-frequency distribution for a period of three years from January, 2007 to December 2009 were used for the growth and stock assessment studies. The length frequency data (carapace width) were grouped into 5 mm class interval. In the present study, the growth parameters were initially estimated by Powell-Wetherall plot, followed by ELEFAN I routine from FiSAT software (Gayanilo and Pauly,1997). Since ELEFAN I method is described as more reliable and highly recommended objective method for studying single species dynamics in a multispecies context (Pauly, 1982), the values obtained by this method were used to describe the growth of *C. feriata*. t_o was calculated by Pauly's empirical equation (Pauly, 1979), $Log(-t_0) = -0.392 - 0.275 \log L_\infty - 1.038K$. Growth was calculated using von Bertalanffy's growth formula. Since the growth parameters of both sexes did not vary much, stock assessment of the species was conducted using sex pooled data for the period 2007-2009. The total mortality coefficient (Z) was estimated using length-converted catch curve method of Pauly (1983) and natural mortality coefficient (M) was calculated by Srinath's (1990) empirical formula. The result of cohort analysis of length-frequency data was used as inputs for finding the yield and effort relationship in Thompson and Bell model.

Results and discussion

The species is caught exclusively by trawlers from a depth of 30 to 100 m. The fishing ground is generally characterised by muddy or loamy bottom. During 2002-2009, crab fishery of Mangalore was constituted by three edible species, *Portunus pelagicus*, *Portunus sanguinolentus* and *C. feriata.* Annual crab landing showed a declining trend from 2002 to 2009 *i.e.,* from 866 t to 239 t. Average annual crab production of Mangalore was 485 t. *C. feriata* formed 19% of the crab landing during the period and percentage composition of the species increased from 7% in 2002 to 26% in 2009. Highest landing of the species was recorded in 2003 (142 t) and the lowest during 2002 (59 t). Annual general crab catch and *C. feriata* catch at Mangalore fisheries harbour during 2002-2009 is given in the Fig.1.

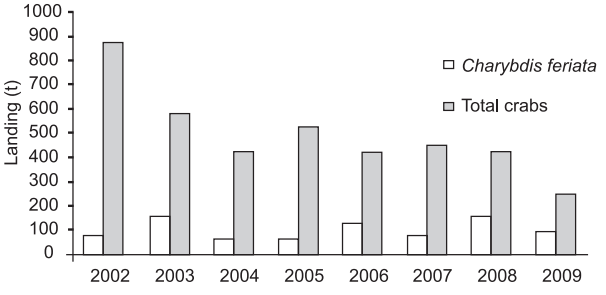

Fig. 1. Annual crab and *C. feriata* landing at Mangalore fisheries Harbour during 2002-2009

Seasonal abundance

Monthwise landing of the species at Mangalore Fisheries Harbour is shown Fig. 2. The species was found to occur in the fishery throughout the trawling season, *i.e.,* August to June. Peak fishery for the species commences from December and extends till June.

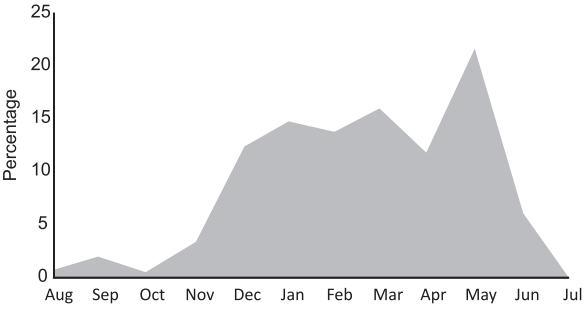

Fig. 2. Seasonal landing pattern *C. feriata* at Mangalore Fisheries Harbour during 2002-2009.

Size range and mean size

At Mangalore, size range observed (2007-2009) in the fishery was 26 to 170 mm and majority of the crabs landed were in the size class 60-95 mm. The sex-wise size composition and mean size of the species during 2007-2009 is given in Table.1. Padayatti (1990) measured a size range of 60-154 mm in males and 65-119 mm in females landed at Cochin in 1989. Though a wider size range was observed in the present study, the mean size observed (Table 1) was lower than those recorded at Cochin, *i.e.*, 99.8 mm for males and 88.9 mm for females. It was reported that the species has a maximum carapace width of 20 cm (Ng, 1998) with females weighing more compared to males, which may reach 1 kg (Parado-Estepa *et al.,* 2002).

Table 1. Size composition of *C. feriata* landed by multi-day trawlers at Mangalore Fisheries Harbour during 2007-2009

Year	Sex	Size range (mm)	Mode (mm)	Mean size (mm)
2007	Male	56-135	66-70	76
	Female	51-120	66-70	76
2008	Male	46-170	66-71	67
	Female	46-155	60-65	66
2009	Male	46-130	81-85	79
	Female	26-125	91-95	80

Sex ratio

At Mangalore Fisheries harbour, sex ratio in *C. feriata* during the period of study was found to be male dominated (59:41). During 2007, 2008 and 2009 the percentage of males in the fishery was 54%, 60% and 60% respectively. Homogeneity of the sex ratio (x^2 test) of pooled data for these period showed that the proportion conform to 1:1 ratio at 1% level. Padayatti (1990) also reported a male dominated population in Cochin throughout the fishing season, and overall male domination being much higher than the present study with male to female ratio of 67:33.

Maturity and spawning

Immature crabs were found throughout the fishing period and highest percentage of immature crabs were observed during June, accounting for 100%, 43% and 36% in 2007, 2008 and 2009 respectively. In trawl fishery of Cochin during 1989 (Padayatti, 1990), the entire fishery of the species was constituted by matured crabs. Immature crabs were not seen in the fishery. It was assumed that immature and mature crabs may not be coexisting and have different spatial distribution (Padayatti, 1990). The extension of fishing operation, exploiting every possible ground in recent years may be a reason for capture of more immature crabs in recent times. In the present study, spawners (late maturing and mature females) were found throughout the fishing period with two peaks in spawner and berried female occurrence and subsequent months after these two peaks witnessed spent males and females. Studies conducted on the percentage of occurrence of females of advanced ovarian maturity (females in reproductive stages of late maturing and matured) and berried females in the fishery show that the species is a continuous breeder with two peak breeding seasons, one during October –November and another one during May-June. Pillai and Nair (1968;1973) also observed that the species breeds throughout the year in Cochin with peak breeding activity from August onwards. Size at maturity (50%) of females was estimated (logistic curve method) at 70 mm carapace width (King, 1995) (Fig. 3). In Cochin, it was reported (Padayatti, 1990) that the smallest crab possessing 'berry' measured 66 mm and this is taken as minimum size at maturity.

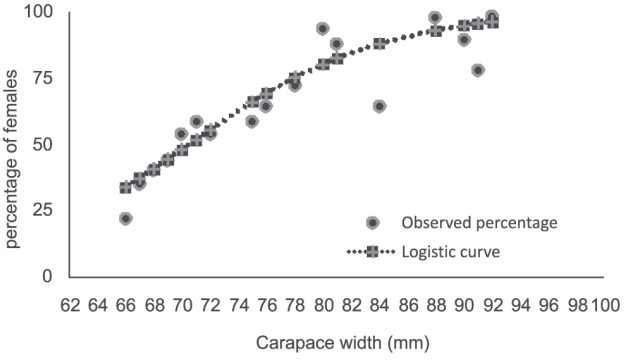

Fig. 3. Size at maturity (50%) of females of *C. feriata*

Carapace width-weight relationship

Carapace width-weight relationship in the frm $w=aL^b$ for male (n=232) was $W = 0.140\ CW^{3.078}$ ($r^2 = 0.924$) and that for females (n = 235) was, $W = 0.156\ CW^{3.005}$ ($r^2 = 0.876$), where W is the weight (in g) and CW the carapace width (in cm). The regression equations between male and female tested for equality through analysis of covariance showed that the values of slope and elevation differ significantly at 1% level. The males are heavier than the females of similar size, which is in accordance with the finding of Rameshbabu *et al*. (2002b) in *C. feriata* and the results of similar studies in Indian species of portunid crabs (Lalithadevi,1985).

Carapace width-weight relation for the sex pooled data (n = 467) in the of the form $W=aL^b$ was :

$W = 0.140\ CW^{3.078}$ ($r^2 = 0.924$) and that for females (n = 235) was, $W = 0.156\ CW^{3.005}$ ($r^2 = 0.876$), where W is the weight (in gm) and CW the carapace width (in cm). The regression equations between male and female tested for equality through analysis of covariance showed that

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Table 2. The scenarios from Thompson and Bell yield prediction model showing changes in yield and biomass by varying fishing efforts

Effort multiplying factor	Yield (t)	Biomass (t)	Percentage of increase in yield
X	Y	B	
0	0	92.7	…
0.2	49.7	77.2	100
0.4	82.2	65.3	39.5
0.6	103.1	56.1	20.2
0.8	116.1	48.9	11.2
1	123.9	43.3	6.3
1.2	128.2	38.8	3.4
1.4	130.2	35.3	1.6
1.6	130.8	32.4	0.4

Carapace width-weight relation for the sex pooled data (n = 467) in the of the form $W=aL^b$ was :

$W = 0.139CW^{3.071}$ ($r^2 = 0.910$)

Where W is the weight (in gm) and CW the carapace width (in cm).

Growth parameters

The estimated values for L_∞ and K during 2007-2009 period for males were 173 mm and 0.84 yr^{-1} respectively and for the females were 164 mm and 0.89 yr^{-1}. t_o values estimated by Pauly's (1979) empirical equation for males and females were -0.0546 and -0.0519 respectively. By von Bertalanffy's growth plot (Fig. 4), it was estimated that males reach 101 mm (CW) at the end of first year, 142 mm (CW) in second year and 159 mm (CW) in third year. Females reach 99 mm in first year and reach 137 mm in second year and 153 mm in third year. It can be assumed that majority of the catch belong to zero year class and the age at maturity (50%) is about 7 months. Padayatti (1990) also observed that males grow faster and grows to bigger size than females.

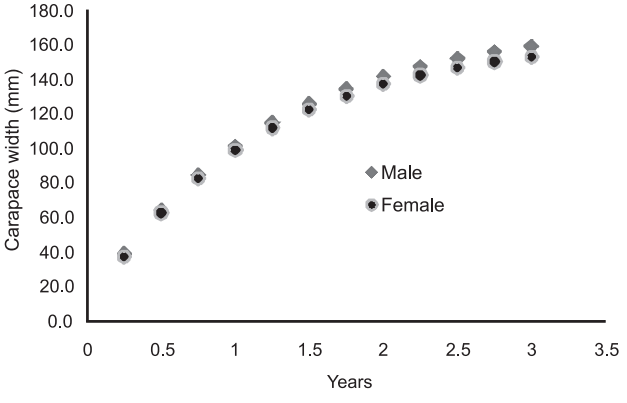

Fig. 4. von Bertalanffy's growth plot of male and female *C. feriata*

Stock assessment

The estimated values for L_α and K for the period was 173 mm and 0.88yr^{-1}.

t_o values estimated by Pauly's (1979) empirical equation was -0.0518.

Mortality and selection parameters

The total mortality coefficient (*Z*) estimated by 'linearised length-converted catch curve' was 6.04. The natural mortality coefficient (M) estimated by Srinath's formula was 1.76 and fishing mortality coefficient (F) estimated was 4.28. The exploitation ratio (E) was 0.71.

Using the results obtained from length structured 'virtual population analysis' as input, maximum sustainable yield was calculated from Thomson and Bell prediction model (Table 2), the MSY was estimated at 131 t as against the present annual average yield of 124 t. It is observed that during the years 2007 and 2008 the catch was higher than the MSY(154 and 140 t respectively) and the fishing beyond MSY level during this period might have caused sudden reduction of the fishery in 2009 (85 t).

Thompson and Bell yield prediction analysis showed that, restricting the fishing effort at the present level or 20% below the present fishing effort is the management policy to be advocated for feasible exploitation of the resource. The prediction model indicate that any additional 10% effort from the present level will yield only less than 10% additional catch which is a loss from economical point of view. It is practically difficult to suggest cut off levels in exploitation of the species, since the trawling is targeted for many other commercial species and also the fishing ground is being extended every year. However, looking at all the available stock parameters to predict the fishery, it can be suggested that restricting the fishery to MSY level (131 t) will be a suitable management option for sustainable production of the species from the Mangalore coast.

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References

Apel, M. and Spiridonov, V. A. 1998. Taxonomy and zoogeography of the portunid crabs (Crustacea: Decapoda: Brachyura: Portunidae) of the Arabian Gulf and adjacent waters. *Fauna of Arabia,* 17: 159-331.

Dineshbabu, A. P., Sridhara, B. and Muniyappa, Y. 2007. Fishery, growth and stock assessment of *Portunus sanguinolentus* (Herbst) from south Karnataka coast, India. *J. Mar. Biol. Ass. India*, 49 (2):141-147.

Dineshbabu, A. P., Sridhara, B. and Muniyappa, Y. 2008. Biology and exploitation of the blue swimmer crab, *Portunus pelagicus* (Linnaeus, 1758), from south Karnataka coast, India. *Indian J. Fish*., 55(3) : 215-220,

Gayanilo, Jr. F.C. and Pauly, D. 1997. The FAO-ICLARM Stock Assessment Tools (FiSAT) Reference Manual. *FAO Computerised Information Series (Fisheries)*-8. FAO, Rome, 262 pp.

King, M. 1995. *Fisheries biology, assessment, and management*. Fishing News Books/Blackwell Scientific Books. Oxford, England, 352 pp.

Laithadevi, S. 1985. The fishery and biology of crabs of Kakinada region. *Indian. J. Fish.,* 32 (1): 18-31.

Manissery, M. K. and Radhakrishnan, E.V. 2003. Marine crabs, In : Mohan Joseph. M and Jayaprakash, A. A. (Eds.). *Status of exploited marine fisheries resources of India.* Central Marine Fisheries Research Institute, Kochi, p. 188-194.

Ng, P. K. L. 1998. Crabs. In: Carpenter, K.E. and Niem, V. H. (Eds.) *The living marine resources of the Western Central Pacific,* Vol. 2. Food and Agriculture Organization of the United Nations, Rome, p. 1046-1155.

Padayatti, P. S. 1990. Notes on population characteristics and reproductive biology of the portunid crab *Charybdis (Charybdis) feriatus* (Linnaeus) at Cochin. *Indian. J. Fish.,* 37 (2): 155-158.

Parado-Estepa, F. D., Quinitio, E. T. and Rodriguez, E. M. 2002. Seed production of the crucifix Crab, *Charybdis feriatus*. *Aqua KE Government Documents,* 7(3): 37.

Pauly, D. 1979. Gill size and temperature as governing factors in fish growth: A generalisation of von Bertalanffy's growth formula. *Berichte des Instituts für Meereskunde an der,* Univ. Kiel., No. 63: xv +, 156 pp.

Pauly, D. 1982. Studying single-species dynamics in a tropical multi-species context. In: Pauly, D. and Murphy, G. I. (Eds.). *Theory and management of tropical fisheries. ICLARM Conf. Proc*., 9: 33-70.

Pillai. K. K. and Nair, N. B. 1968. Observations on the reproductive cycles of some crabs from south-west coast of India. *J. Mar. Biol. Ass. India*, 10: 384-385.

Pillai, K. K. and Nair, N. B. 1973. Observations on the breeding biology of some crabs from south-west coast of India. *J. Mar. Biol. Ass. India*, 15(2): 754-770.

Pauly, D. 1983. Length converted catch curves. A powerful tool for fisheries research in the tropics (Part I). *ICLARM Fishbyte,* 1 (2): 9-13.

Rameshbabu, K. V., Benkappa, S. and Chandra Mohan, K. 2002a. Food and feeding habits of *Charybdis (Charybdis) feriatus* (Linnaeus) from Mangalore region, *Indian Hydrobiol.,* 5 (1): 1-7.

Rameshbabu, K. V., Benkappa, S. and Chandra Mohan, K. 2002b. Length - weight relationship in *Charybdis (Charybdis) feriatus* (Linnaeus) from Mangalore region. *Indian Hydrobiol.,* 5 (1): 9-14.

Rameshbabu, K. V., Benkappa, S. and Chandra Mohan, K. 2006. Breeding biology of *Charybdis (Charybdis) feriatus* (Linnaeus) from Mangalore. *Indian. J. Fish.,* 53 (2): 182-184.

Ryan, E. P. 1967. Structure and function of the reproductive system of the crab *Portunus sanguinolentus* (Herbst) (Brachura, Portunidae) II. The female system. *Proceedings of the Symposium of the Marine Biological Association of India,* Part II, Marine Biological Association of India, Ernakulam p. 522-544.

Snedecor, G. W. and W. G. Cochran, 1967. *Statistical methods*. Oxford and IBH Publishing Co., New Delhi, 6th edn., 539 pp.

Srinath, M. 1990. Letters to the editor. *ICLARM, Fishbyte,* 9 (1): 1-2.

Stephenson, W., Hudson, J. J. and B. Campbell 1957. The Australian portunids (Crustacea: Portunidae) II. The genus Charybdis. *Australian J. Mar. Freshwat. Res*., 8(4): 491-507.

Stephenson, W. 1972. An annotated check-list and key to the Indo-west-Pacific swimming crabs (Crustacea: Decapoda: Portunidae). *Bull. Royal Soc. New Zealand,* 10: 1-64.

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