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A study on Nutritional analysis of commercially important marine brachyuran crabs of Gujarat state, India

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Abstract

In the present study, three commercially important species of brachyuran crabs viz., *Portunus (Portunus) segnis* (Forskal, 1775), *Charybdis (Charybdis) feriatus* (Linnaeus, 1758) and *Portunus (Portunus) sanguinolentus* (Herbst, 1783) were analysed to know their nutritive value. Thus, biochemical components like moisture, protein, carbohydrate and total lipid content were measured in body and claw muscles of the crab specimens using standard protocols. The results showed variations in moisture, protein, carbohydrates and total lipid content of the body and claw muscles of these three commercially important brachyuran crab species. The higher values of moisture (78.80 %) and protein (31.41 %) content were recorded for body muscle of *P. segnis*, while a higher value of carbohydrate content was recorded in claw muscle of *P. segnis* (4.95 %). In contrast, a higher value of lipid content was found in claw muscle of *P. sanguinolentus* (3.26 %). Protein content was recorded higher in both muscle tissues of all the species, as compared to the other biochemical components. In conclusion, this study revealed that *P. segnis* is highly nutritious, in comparison with other studied species of brachyuran crabs.

Keywords: Commercially important brachyuran crab, Portunidae,biochemical composition, nutritional value

1 Introduction

Nutritional analysis is important to know the biochemical composition of commercially important species. Biochemical processes and nutrients play a vital role in physical growth, development and maintenance of normal body function (Nagabhushanam & Mane, 1978). Biochemical component

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of a species may vary due to variation in size, sex, season, feeding behaviour, reproductive stage and different stages of life cycle (Kyomo, 1988; Jeckel et al., 1989; New, 2003; Kanwal & Saher, 2016). Shellfish is good source of nutrition containing higher amount of protein, carbohydrate, lipid, vitamins and some amount of minerals. Among shellfish, crab's nutritive value is higher and they are the cheapest source of protein, compared with other animals. Crabs rank third after shrimps and lobsters in marine fishery, because of their esteemed seafood delicacy as their body muscles and claw muscles are very nutritious (Enzenross et al., 1997; Saved & Rahavan, 2001; Sudhakar, 2011; Kanwal & Saher, 2016). Crabs contain different nutritive materials like protein, carbohydrates and other nitrogenous compounds like lipids, vitamins, minerals, etc. (Naczk et al., 2004; Chen et al., 2007). Their nutritional content can be determined by estimating the levels of protein, carbohydrate and fat in their body tissues (Sudhakar, 2011).

Overall, information regarding complex mixture of compounds in edible organism is very critical due to the nutritive quality of commercially important species along with their biochemical composition. So after evaluation of nutritional quality, various species are suggested to consume as a dietary molecule for human in recent era (Soundarapandian et al., 2013). Globally, biochemical composition and nutritional value of commercially important brachyuran crabs and shrimps have been evaluated (Adeyeye et al., 2010; Moronkola et al., 2011; Jimmy & Arazu, 2012; Omotayo et al., 2013; Abdel-Salam, 2013). Biochemical estimation of some commercially important brachyuran crab species like *Carcinus maenas* (Heath & Barnes, 1970), *Portunus pelagicus* (Badawi, 1971), *P. pelagicus* and *P. sanguinolentus* (Pillai & Nair, 1973), *Scylla serrata* (Prasad & Neelakandan, 1989; Zafar et al., 2004), *Scylla tranquebarica* (Thirunavukkarasu, 2005), *Charybdis lucifera* (Murugesan et al., 2008) and *P. sanguinolentus* (Sudhakar et al., 2009a) have been studied. Around 147 species of brachyuran crabs have been recorded from coastal regions of Gujarat (Trivedi et al., 2018), amongst which crabs belonging to family Portunidae are commercially important and used as food by local people (Samuel et al., 1999). Nonetheless, the available information on the biochemical composition of commercially important brachyuran crabs of Gujarat state is very rare. Therefore, the current study was carried out to determine nutritional value of body muscle and claw muscle of three commercially important brachyuran crab species: *Portunus (Portunus) segnis* (Forskal, 1775), *Charybdis (Charybdis) feriatus* (Linnaeus, 1758) and *Portunus (Portunus) sanguinolentus* (Herbst, 1783).

2 Materials and Methods

Total 20 individuals of similar size and weight of each species were bought from fish market of Okha port located in Devbhumi Dwarka district of Gujarat state, India. Specimens were kept in icebox and brought to the laboratory for further analysis. Specimens were dissected using sharp forceps then after their body muscle and claw muscle were harvested. Muscles were stored in refrigerator at -20°C for further biochemical estimation. Biochemical components like moisture content, protein, carbohydrate and lipid concentration were estimated using standard protocols. Moisture content was determined by calculating the difference between tissue weight before drying and after drying. For that, known amount of muscle tissue were kept in oven at 75°C for 24 hours. Lowry method was opted to determine protein content (Lowry et al., 1951) and BSA was used as a standard. To estimate carbohydrate content, anthrone method was used (Hedge & Hofreiter, 1962) and, to measure the total lipid content, Barnes & Blackstock (1973) method was used.

The values of protein, carbohydrate and lipid content have been converted into percentage dry weight basis. Mean variation in biochemical content was checked using one way- ANOVA (Kanwal

& Saher, 2016).

3 Results

In present study, moisture content in muscle tissue of crab species was ranging from 75 % to 79 %. Maximum moisture content was recorded in body muscle of *P. segnis* (78.80 %) followed by *C. feriatus* (76 %) and *P. sanguinolentus* (75.60 %) (fig. 1). While in claw muscle, maximum moisture content was measured in *C. feriatus* (76.80 %) followed by *P. sanguinolentus* (75.80 %) and *P. segnis* (75.80 %) (fig. 2). Significant variation was not found between the mean values of moisture content of body muscle (ANOVA; F = 2.93, P = 0.07) as well as claw muscle (ANOVA; F = 0.32, P = 0.72) of studied crab species.

Maximum protein content was recorded in body muscle of *P. segnis* (31.41 %) as compared to *P. sanguinolentus* (24.60 %) and *C. feriatus* (22.81 %) (fig. 1).While for claw muscle, protein content was recorded maximum in *P. segnis* (26.71 %) followed by *P. sanguinolentus* (23.72 %) and *C. feriatus* (21.69 %) (fig. 2). Mean values of protein content in body muscle varied significantly between the studied species (ANOVA; F = 15.14, P<0.001). Whereas significant variation was not found between mean values of protein content in claw muscle of the studied brachyuran crab species (ANOVA; F = 1.69, P = 0.2).

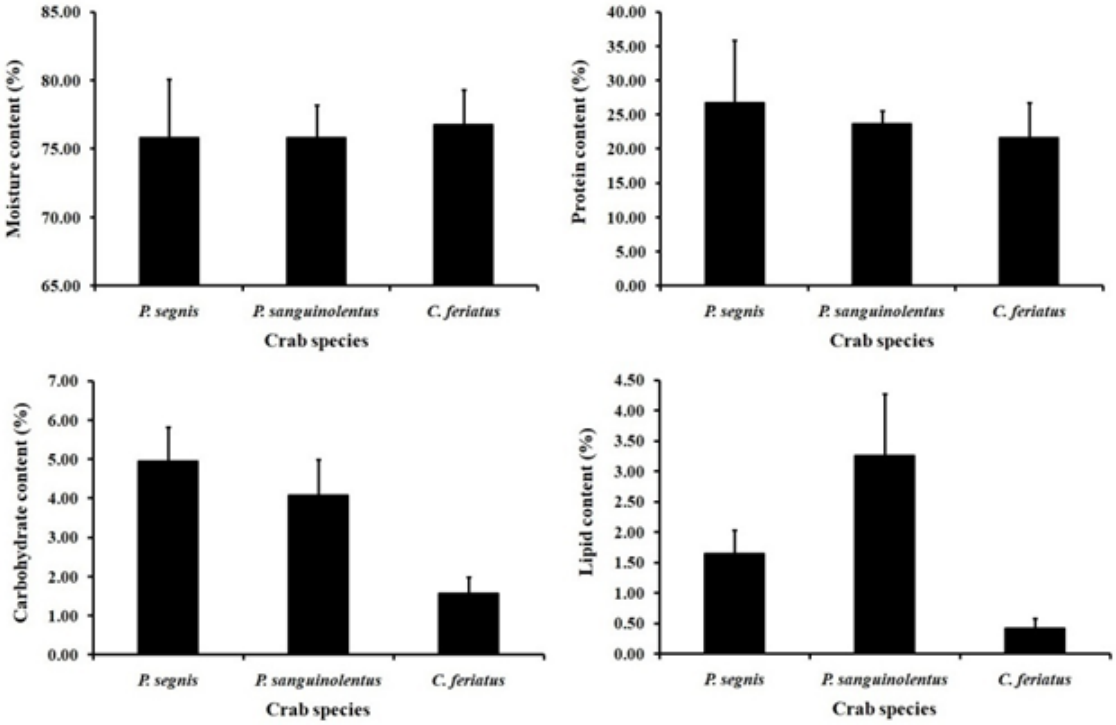

Figure 1. Dry weight bases (%) values of different biochemical parameters of body muscle of brachyuran crab species.

Body muscle of *P. segnis* had high carbohydrate content (4.77 %), moderate carbohydrate content was measured for body muscle of *P. sanguinolentus* (3.74 %) and minimum carbohydrate content was recorded in body muscle of *C. feriatus* (1.57%) (fig. 1). In claw muscle, maximum carbohydrate content was recorded for *P. segnis* (4.95 %) followed by *P. sanguinolentus* (4.09 %) and *C. feriatus* (1.39 %) (fig. 2). Significant variation was found in the mean value of carbohydrate

of body muscle (ANOVA; F = 40.52, P<0.001) and claw muscle (ANOVA; F = 52.33, P<0.001) of the studied crab species.

Body muscle of *P. sanguinolentus* had maximum lipid (3.18 %) content as compared to the *P. segnis* (2.35 %) and *C. feriatus* (0.50 %) (fig. 1). In claw muscle, lipid content was recorded maximum in *P. sanguinolentus* (3.26 %) followed by *P. segnis* (1.65 %) and *C. feriatus* (0.43 %) (fig. 2). Significant variation was found between the mean values of lipid content of body muscle (ANOVA; F = 12.32, P<0.01) as well as claw muscle (ANOVA; F = 15.11, P<0.01) of studied crab species.

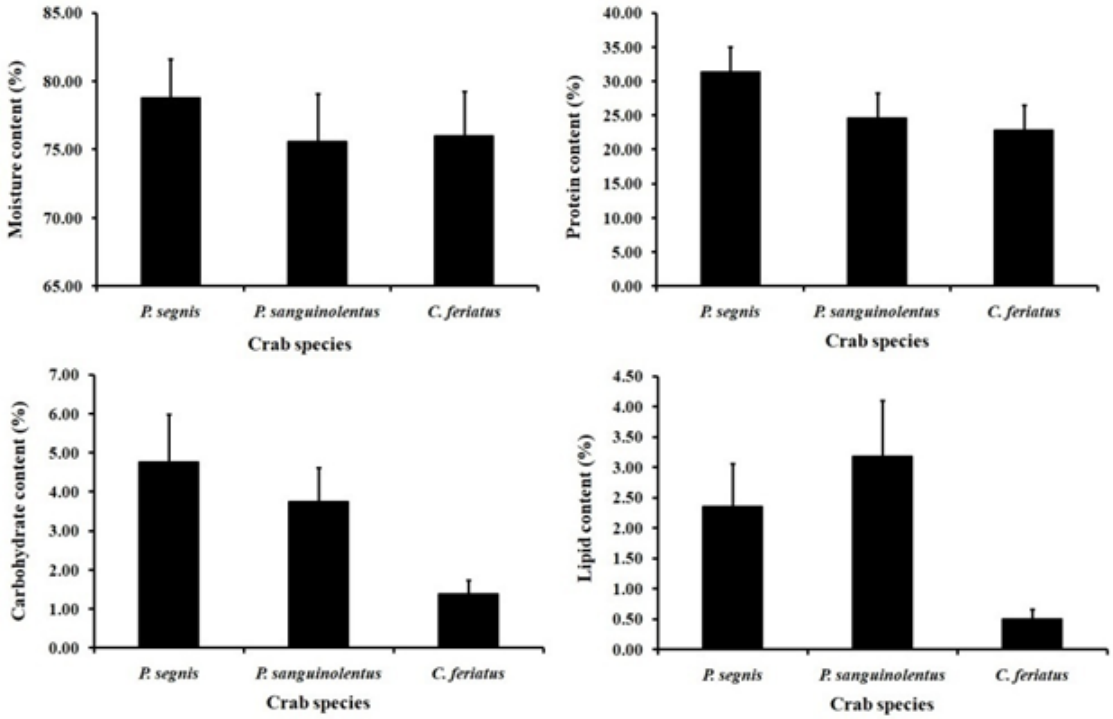

Figure 2. Dry weight bases (%) values of different biochemical parameters of claw muscle of brachyuran crab species.

4 Discussion

Biochemical studies are very important to understand nutritional value of any commercially important edible faunal species. Nowadays, demand of good quality animal protein has been increased and because of that effective exploitation of the aquatic resources has been carried at a great extent (Rao et al., 1973; Okuzumi & Fujii, 2000). Crab protein is very valuable due to its acceptability and easy digestibility. In present study, biochemical compositions of body muscle and claw muscle of three commercially important crab species were analysed which are commonly occurring in coastal region of Gujarat state, India. Variation in moisture was recorded in body muscle as well as claw muscle of studied crab species (figs. 1 and 2). Similar kinds of results were reported in various studies carried out in muscle tissue of different commercially important crustacean species (Radhakrishnan & Natarajan, 1979; Prasad & Neelakandan, 1989; Zafar et al., 2004). Moisture content of any species depends on the dietary material they consumed (Manivannan et al., 2010; El-Gendy et al., 2018). High moisture content is characterised as a benefit due to its involvement

in the balance of the marine organisms during the movements (Eddy et al., 1974). Moisture content of any species affects and influences the taste, texture and weight of food (Vigneshwari & Gokula, 2018). According to Singh et al. Biochemical studies are very important to understand nutritional value of any commercially important edible faunal species. Nowadays, demand of good quality animal protein has been increased and because of that effective exploitation of the aquatic resources has been carried at a great extent (Rao et al., 1973; Okuzumi & Fujii, 2000). Crab protein is very valuable due to its acceptability and easy digestibility. In present study, biochemical compositions of body muscle and claw muscle of three commercially important crab species were analysed which are commonly occurring in coastal region of Gujarat state, India. Variation in moisture was recorded in body muscle as well as claw muscle of studied crab species (figs. 1 and 2). Similar kinds of results were reported in various studies carried out in muscle tissue of different commercially important crustacean species (Radhakrishnan & Natarajan, 1979; Prasad & Neelakandan, 1989; Zafar et al., 2004). Moisture content of any species depends on the dietary material they consumed (Manivannan et al., 2010; El-Gendy et al., 2018). High moisture content is characterised as a benefit due to its involvement in the balance of the marine organisms during the movements (Eddy et al., 1974). Moisture content of any species affects and influences the taste, texture and weight of food (Vigneshwari & Gokula, 2018). According to Singh et al. (2012), seasonal variation in moisture content depends on reproductive cycle, physiological state and nutritional condition of an organism. Water content remains low when the gonads are fully developed while during spawning season the water content increases (Singh et al., 2012).

Protein is essential for rapid growth and maintenance of animal muscle tissue (Okuzumi & Fujii, 2000). Protein content was higher in all studied species as compared to other biochemical parameter (figs. 1 and 2) because proteins are essential molecules used in various crucial functions of all living systems (Kanwal & Saher, 2016). Similar trend was also observed for protein content of muscle tissue of various brachyuran crab species (Radhakrishnan & Natarajan, 1979; Balasubramanian & Suseelan, 2001; Kannupandi et al., 2003; Sudhakar et al., 2009b). In animals, protein plays an important role in various physiological activities like catalysis, transportation, give protection to the immune system, helps in generating movement, to control the nerve impulses and growth (Sudhaker et al., 2011; Fredrick et al., 2013). Okuzumi & Fujii (2000) commented that protein content in brachyuran crabs may vary due to seasons, availability of food, pollution etc. According to Bello-Olusoji et al., (1995), high protein content was measured in crustaceans having omnivorous feeding habit. High protein content is necessary for the continuation and stability of different biological processes of life (Okuzumi & Fujii, 2000; Kanwal & Saher, 2016). Since protein concentration was higher in all studied species, they can be used in daily food items instead of fish or other seafood items. It can also be used for infant to speed up their growth and development (Ackman & Mcleod, 1989).

Carbohydrates make up only a slight proportion of total biochemical composition (figs. 1 and 2). Similar kind of results was found in muscle tissue of various brachyuran crab species (Raymont et al., 1964; Thirunavukkarasu, 2005; Sudhakar et al., 2009a; Kanwal & Saher, 2016). Okuzumi & Fujii (2000) commented that carbohydrate is ready to use energy source which is found in the form of glycogen in crustaceans. Besides that trace amount of glucose, fructose, sucrose and other mono and disaccharides also found within muscle tissue of crustaceans. Carbohydrates are primarily stored within gonads, hepatopancreas and muscle tissue of crustaceans (Love, 1980). Carbohydrate content was low in all the studied species as compared to other biochemical components (figs. 1 and 2); this may be due to the scarcity of carbohydrates in the natural aquatic food web (Adeyeye, et al., 2010). Carbohydrate content was recorded lesser in other brachyuran crab species by various scientists as compared to our study (Radhakrishnan & Natarajan, 1979; Prasad & Neelakantan,

1989; Radhakrishnan, 2000; Sudhakar et al., 2011). Krishna kumari et al. (1997) commented that carbohydrate content increases during pre-spawning mainly for the proliferation of sex cells while decrease in the amount of carbohydrate during post spawning may be due to release of gametes from gonad.

In present study, lipid value ranged between 0.4 to 4 % among the tested three species, maximum lipid concentration was found in *P. sanguinolentus* (figs. 1 and 2). Our results showed similarities with lipid content of different commercially important brachyuran crabs (Prasad & Neelakantan, 1989; Radhakrishnan, 2000; Thirunavukkarasu, 2005). The high lipid content could be attributed to active feeding and optimum availability of food (Kanwal & Saher, 2016). Lipid is important constituent of diet, as it is required for protoplasm formation and their content varies from species to species (Parate, 2013). Lipid is important dietary molecule, as it serves as reserved food and organic energy sources. Energy produced from lipid is higher than other molecules and also crucial to maintain the cellular integrity. Lipids are highly efficient source of energy because they contain more energy as compared to the protein and carbohydrates (Nagabhushanam & Faroogii, 1982; Kala & Chandran, 2014). In present study, protein content was recorded maximum in all studied species followed by carbohydrate and lipid. Baby et al. (2010) reported that variation in protein and carbohydrate content may be due to differences in species, region, diet and environment. In the current study, muscle tissue of *Portunus* species had high nutritive value as compared to *Charybdis* species. Present study shows similarities with other studies which were conducted on muscle tissue of *Portunus* species (Radhakrishnan, 2000; Sudhakar et al., 2009; Kanwal & Saher, 2016; Shibana et al., 2018). Evaluation of biochemical component of muscle tissue of these species indicates their high nutritive quality and value. Gujarat coast is having good diversity and abundance of portunid crabs but very less information is available about its nutritive values. So, the present study will provide some baseline information about nutritional value of some commercially important crab species. More studies are required to evaluate nutritional values of commercially important marine organisms to fulfil the nutritional needs of humans in an effective way and also to check their role in pharmaceutical industries, specific health balanced foods etc.

Conflict of interests

The authors declare that they have no conflicts of interest.

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References

Abdel-Salam, H. A. (2013). Assessment of biochemical compositions and mineral contents of carapace of some important commercially crustaceans and mollusks organisms from Egyptian and Saudi Arabia coasts as a new animal feed. American Journal of BioScience, 1, 35–43.

Ackman, R. G. & Mcleod, M. (1989). Nutritional composition of fat in sea food. International Journal of Food Science and Technology, 21, 390–398.

Adeyeye, E. I., Olanlokun, J. O. & Falodun, T. O. (2010). Proximate and mineral composition of the whole body, flesh and exoskeleton of male and female common in West African freshwater crab *Sudananautes africanus africanus*. Polish Journal of food and Nutrition Sciences, 60, 213–216.

Baby, R. L., Hasan, I., Kabir, K. A. & Naser, M. N. (2010). Nutrient Analysis of Some Commercially Important Molluscs of Bangladesh. Journal of Scientific Research, 2, 390–396.

Badawi, H. K. (1971). On the chemical composition of the red crab *Portunus pelagicus*. Marine Biology, 11, 198–200.

Balasubramanian, C. P. & Suseelan, C. (2001). Biochemical composition of the deep water crab *Charybdis smithii*. Indian Journal of Fisheries, 48, 333–335.

Barnes, H. & Blackstock, J. (1973). Estimation of lipids in marine animals and tissues. Detail investigation of the Sulpho-Phosphovanilin method for total lipids. Journal of Exploratory Marine Ecology, 12, 103–118.

Bello-Olusoji, B., Fagbenro, O. A. & Ugbaja, N. (1995). Food and feeding studies of the African river prawn. In: Proceedings of Fish and Shellfish Larviculture Symposium. Lavens P., Japan E. and Roelants, I. (Eds.). European Aquaculture Society, 24, 425–427.

Chen, H. P. & Zhang, N. R. (2007). Scan statistics with weighted observations. Journal of Advanced Statistics, 102, 592–602.

Eddy, R. L., Eddy, P. F., Gilliland, J. D., Ibarra J. F. & Mc Murry, J. Q. (1974). Thompson human growth hormone release: comparisons of provocative test procedures. Thompson human growth hormone release: comparisons of provocative test procedures, 56, 179–185.

El-Gendy, A. M., El-Feky, F., Mahmoud, N. H. & Elsebakhy, G. S. (2018). Evaluation of nutritional quality of green tiger prawn, *Penaeus semisulcatus* from land fisheries (Alexandria) and market (India). Egyptian Journal of Hospital Medicine, 31, 1–11.

Enzenross, R., Enzenross, L. & Bingel, F. (1997). Occurrence of blue crab, *Callinectes sapidus* (Rathbun, 1896) (Crustaceae, Brachyura) on the Turkish Mediterranean Adjent Aegean Coast and its size distribution in the Bay of Iskenderun. Turkish Journal of Zoology, 21, 113–122.

Fredrick, W. S., Kumar, S. V. & Ravichandran, S. (2013). Protein analysis of the crab haemolymph collected from the Trash. International Journal of Pharmacy and Pharmaceutical Science, 5, 304–308.

Heath, J. R. & Barnes, H. (1970). Some changes in biochemical composition with season and during the moulting cycle of the common shore crab, *Carcinus maenas* (L). Journal of Experimental Marine Biology and Ecology, 5, 199–233.

Hedge, J. E. & Hofreiter, B. T. (1962). Carbohydrate chemistry 17 (Eds., Whistler, R. L. and Be Miller, J. N). Academic press New York.

Jeckel, W. H., Moreno, J. E. & Moreno, V. J. (1989). Biochemical composition, lipid classes and fatty acids in the male reproductive system of the shrimp *Pleoticus muelleri* bate. Comparative Biochemistry and Physiology, 93(B), 807–811.

Jimmy, U. P. & Arazu, V. N. (2012). The proximate and mineral composition of two edible crabs *Callinetes amnicola* and *Uca tangeri* (Crustacea: Decapoda) of the cross River Nigeria. Pakistan Journal of Nutrition, 11(i), 78–82.

Kala, J. K. L. & Chandran, M. (2014). The chemical composition of brachyuran crabs from various environments. International Journal of Pharma and Bio Sciences, 5, 612–620.

Kannupandi, T., Vijayakumar, G. & Soundarapandian, P. (2003). Yolk utilization in a mangrove crab *Sesarma brockii*. Indian Journal of Fisheries, 50, 199–202.

Kanwal, N. & Saher, N. (2016). Comparative biochemical composition of commercially important brachyuran crabs along Pakistan coast. International Journal of Research, 4, 83–88.

Krishna Kumari, K. L., Rajagopal, M. D. & Vijayaraghavan, S. (1977). Some aspects on biology and biochemistry of the backwater clam, *Meretrix casta* (Chemnitz). Mahasagar, 10(3&4), 157–163.

Kyomo, J. (1988). Analysis of the relationship between gonads and hepatopancreas in males and females of the crab *Sesarma intermedia*, with reference to resource use and reproduction. Marine Biology, 97, 87–93.

Love, R. M. (1980). The Chemical Biology of Fishes. Academic Press, New York, 2, 943.

Lowry, O. H., Rosebrough, N. J., Farr, A. L. & Randall, R. J. (1951). Protein measurement with the Folin- Phenol reagents. Journal of Biological Chemistry, 193, 265–275.

Manivannan, K., Sudhakar, M., Murugesan, R. & Soundarapandian, P. (2010). Effect of Feed on the Biochemical Composition of Commercially Important Mud Crab *Scylla tranquebarica* (Fabricius, 1798). International Journal of Animal and Veterinary Advances, 2, 16–20.

Moronkola, B. A., Olowu, R. A., Tovide, O. O. & Ayejuyo, O. O. (2011). Determination of proximate and mineral contents of crab (*Callinectes amnicola*) living on the shore of Ojo river, Logos, Nigeria. Chemical Communication, 1, 1–6.

Murugesan, R., Soundarapandian, P. & Manivannan, K. (2008). Effect of Unilateral Eyestalk Ablation on the Biochemical changes of edible portunid crab *Charybdis lucifera* (Fabricus). Journal of Fisheries and Aquatic Sciences, 3, 82–86.

Naczk, M. & Shahidi, F. (2004). Extraction and analysis of phenolics in food. Chromatography, 1054(1-2), 95–111.

Nagabhushanam, R. & Faroogii, V. M. (1982). Mobilization of protein, glycogen, and lipid during ovarian maturation in marine crab *Scylla serrata* (Forskal). Indian Journal of Marine Sciences, 11, 184–189.

Nagabhushanam, R. & Mane, I. (1975). Reproductive and breeding of the clam *Katelysia opima* in the Kalbadevi estuary at Ratnagiri west coast of India. Journal of Marine Science, 4, 1–86.

New, M. (2003). The role freshwater prawns in sustainable aquaculture. Freshwater prawns International symposium. Kerala Agriculture University, Kochi, India. 10–13 pp.

Okuzumi, M. & Fujii, T. (2000). Nutritional and Functional Properties of Squid and Cuttle Fish. 35th Anniversary of Commemorative Publication, 223 pp.

Omotayo, F., James O., James, A., Folasade, M., Adesola, O. & Olawale, A. (2013). Quality analysis of freshwater crab *Cardisoma armatum* and marine blue crab *Callinectes amnicola* collected from Yaba, Lagos Nigeria. Journal of Natural Sciences, 11, 22–29.

Parate, S. K. (2013). Effect of cypermethrin on lipid level of freshwater crab *P. jacquemontii* Hepatopancreas and Muscle.. Bioscience Discovery, 4, 128–132.

Pillai, K. K. & Nair, N. B. (1973). Observation on the breeding biology of some crabs from south west coast of India.

Prasad, P. N. & Neelakantan, B. (1989). Proximate and essential amino acid composition in edible crab *Scylla serrata*. Comparative Physiology and Ecology, 14, 34–37.

Radhakrishnan, C. K. & Natarajan, R. (1979). Nutritive value of the crab Nutritive value of the crab *Podophthalamus vigil* (Fabricius) (Fabricius). Fishery Technology, 16, 37–38.

Radhakrishnan, C. K. & Natarajan, R. (2000). The eggs of marine crab an unexploited resource, ICLARM Quarterly, 23, 4–5.

Rao, P. V., Thomas, M. M. & Rao, G. S. (1973). Crab Fishery Resources of India. Proceeding of Symposium on Living Resources of the Seas around India, pp: 581–591 .

Raymont, J. E. G., Austin, J. & Linford, E. (1964). Biochemical studies on marine zooplankton. I. The biochemical composition of *Neomysis integer*. Journal of Marine Science, 28, 354–363.

Samuel, M. J., Kannupandi, T. & Soundarapandian (1999). Nutritional effects on male for total lipids. isolation and quantification of *Macrobrachium malcolmsonii* (H. Milne Edwards). Journal of Exploratory Marine Ecology, 12, 103–118.

Savad, M. A. & Ragavan, P. R. (2001). Mud crab-culture and fattening techniques, status and prospects. Seafood Export Journal, 32, 25–29.

Shibana, C., Subavathy, P. & Thilaga, R. D. (2018). Biochemical composition of the Marine crab *Portunus pelagicus* from Gulf of Mannar. International Journal of Scientific Research and Review, 7, 318–337.

Singh, Y. T., Krishnamoorthy, M. & Thippeswamy, S. (2012). Seasonal changes in the biochemical composition of wedge clam, *Donax scortum* from the Padukere beach, Karnataka. Recent Research in Science and Technology, 4, 12–17.

Soundrapandiyan, P. & Ananthan G. (2008). Effects of unilateral eyestalk abalation and diets on the biochemical composition of commercially important juveniles of *Macrobrachium malcomsonii*. International Journal of Zoological Research, 4, 106–111.

Sudhakar, M. (2011). Biodiveristy, resources, nutrition status and shell utilization of crabs from cuddalore coast, southeast coast of India. PhD thesis, Annamalai University, p: 230.

Sudhakar, M., Manivannan, K. & Soundarapandian, P. (2009a). Nutritive value of hard and soft shell crabs of *Portunus sanguinolentus* (Herbst). International Journal of Animal and Veterinary Advances, 1, 44–48.

Sudhakar, M., Manivannan, K., Soundarapandian, P. & Ananthan, G. (2009b). Effect of Unilateral Eyestalk Ablation on the Biochemical Changes of Edible Portunidae Crab *Portunus sanguinolentus*. International Journal of Animal and Veterinary Advances, 4, 153–157.

Sudhaker, M. K., Raja, G. & Sampathkaumar, P. (2011). Compositional characteristics and nutritional quality of *Podopthalmus vigil* (Fabricius). Asian Journal of Biological Sciences, 4, 166–174.

Thirunavukkarasu, N. (2005). Biology, nutritional evaluation and utilization of mud crab *Scylla tranquebarica* (Fabricius, 1798). Ph.D. Thesis, Annamalai University, India, 126pp.

Trivedi, J. N., Trivedi D. J., Vachhrajani, K. D. & Ng, P. K. L. (2018). An annotated checklist of the marine brachyuran crabs (Crustacea: Decapoda: Brachyura) of India. Zootaxa, 4502, 1–83.

Vigneshwari, S. & Gokula, V. (2018). Proximate composition of cooked meat and exoskeleton of *Portunus pelagicus* (linnaeus, 1758). Journal of Life Sciences Bioinformatics Pharmaceutical and Chemical Sciences, 4, 574–585.

Zafar, M., Siddiqui, M. Z. H. & Hoque, M. A. (2004). Biochemical composition in *Scylla serrata* (Forskal) of Chakaria. darban area, Bangladesh. Pakistan Journal of Biological Sciences, 7, 2182–2186.