Advances in Bioresearch
Adv. Biores., Vol 12 (6b) November 2021: 244-250

Print ISSN 0976-4585; Online ISSN 2277-1573
Journal's URL:http://www.soeagra.com/abr.html
CODEN: ABRDC3
DOI: 10.15515/abr.0976-4585.12.6b.244250

Advances in Bioresearch

REVIEW ARTICLE

Detailed analysis of nutritional value, reproductive biology and fecundity of freshwater crabs of India

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ABSTRACT
The most peculiar characteristic of the Earth is the continued survival of life on it and the presence of diverse organisms is a remarkable attribute of life. One-fifth of all the world's Brachyuran crabs are represented by freshwater crabs. These crabs are ecologically and economically important as they are requisite for succouring prey-predator relationships and are used for consumption by humans. The present study reviews the nutritional value, breeding cycle, and fecundity of the various freshwater crabs that are found in different ecosystems of the country. The nutritional status of the species greatly determines its importance in aquaculture field and precise evaluation of the reproductive ability is essential for the stock assessment and planning various breeding programs.
Keywords: *aquaculture, breeding, crustaceans, fecundity, freshwater crabs, nutrition*

Received 09.08.2021 Revised 21.10.2021 Accepted 14.11.2021

How to cite this article:
M Dhar and S Langer. Detailed analysis of nutritional value, reproductive biology and fecundity of freshwater crabs of India. Adv. Biores. Vol 12[6] November 2021: 244-250

INTRODUCTION

Brachyuran crabs are the most alluring organisms among Decapods. Diversity of crustacean species vary between 35000 and 36000. So far, only 2934 species of crustaceans have been reported in India, that account for 8.2% of total worldwide species of crustacean. Globally, 6700 species of crabs are on record, out of these there are 1306 species are freshwater crabs, 600 are marine and brackish water crabs and the rest are undescribed. [29]. Approximately, 125 species accommodated in two families *viz.,* Gecarcinucidae and Potamidae inhabit the freshwater ecosystems of India [34, 35, 26]. Freshwater crabs belong to infraorder-Brachyura, order-Decapoda, class-Malacostraca, and sub-phylum-Crustacea. These freshwater crabs can complete their entire lifecycle in or near the freshwater environment. In Brachyura, body size of the female is an index of the fecundity of a particular species [16]. The commercial value of any species depends upon its fecundity as this factor determines the reproductive ability of the species [24].

The present review paper would certainly provide cognizance in understanding the nutritional status and breeding behavior of various freshwater crab species that inhabit the lakes, rivers, streams, paddy fields, betel nut plantations of the different areas of the country. The elucidation of the breeding behavior and fecundity of these crabs allows for a comprehensive look into their life cycle. They are of great ecological importance at the global level. The nutritional status of the crabs varies from species to species and is dependent upon the season, temperature of a water body and spawning cycle [30]. Crustaceans such as crabs, prawns, shrimps, crayfishes, lobsters are considered as the major source of nutrition. Crabmeat is a good source of proteins, minerals, and vitamins and is used for the treatment of various diseases like asthma and chronic fever [39]. The Biate tribe of Dima Haso district in Assam consume the whole cooked freshwater crab, *Paratelphusa sps.,* Alcock,1919 for the treatment of jaundice [2].

Available literature suggests that extensive studies have been conducted with respect to varied aspects of marine crabs but similar studies are considerably lacking if fresh water crabs are looked upon. In this context, present communication is an attempt to compile a detailed review of the two vital aspects of crab

biology *i.e.,* nutritional status and reproductive biology of the freshwater crabs of India, both the aspects being very crucial to establish the status of a species as culturable one.

DISCUSSION

Nutritional analysis: The proteins of the carapace of *Sartoriana spinigera* (Wood-Mason,1971), which was profusely found in wetlands and freshwater bodies of Ranchi, Jharkhand state, India were analyzed quantitatively [36]. Arthropodins and sclerotins were the two predominantly significant proteins present in the carapace. The average concentration of protein in the dry weight of carapace and demineralised carapace of the species was estimated to be 14.44±6% and 29.17±11.6%. The calcium content in 1gm of tissue of *Paratelphusa eduntula* from Assam, India was found to be about 11.6 to 15.5 mg [31]. Biochemical composition of freshwater crab, *Sartoriana spinigera* (Wood-Mason,1971) from Odisha state, India [33]. The crabmeat was found to be high in protein content that ranged from 30.03% to 59.29% thus indicating that the consumption of this crab would definitely offer health benefits to the consumers. After the spawning season, percentage of protein, lipid, and ash content was found to be relatively low as compared to the pre-spawning phase. Dietary value of the tissues of the freshwater crab, *Travancoriana schirnerae* (Bott, 1969) collected from the paddy fields in Mananthavady, Kerala, and found that the crab meat was low in carbohydrate content. Carbohydrate was found to be negatively correlated to the protein content in both males and females. Fat content was found to be more in claw meat as compared to the body meat [5]. Water content was higher in males than females. The meat of the crab species had low-fat content and high protein content. Protein, carbohydrates and free fatty acids were noticed to be higher in females than males, thus depicting the more nutritive value of females than males. Fluctuations in the proximate body composition of female freshwater crab, *Paratelphusa masoniana,* collected from the Gho-Manhasan stream, J&K Union Territory was recorded [22]. During the spawning period, the lipid content decreased in the muscles due to high energy demand for the gonad maturation. Moisture content was higher in muscles during spawning season (December-January and July-August). Ash content increased in the post-spawning period. They concluded that during non-spawning period of the crab, protein, lipid, moisture and ash content are in a higher proportion.

The nutritional status of freshwater crab, *Spiralothelphusa hydrodoma* that inhabits the paddy fields of Parangipetti, Southeast coast of India was evaluated [47]. Maximum and minimum protein content was recorded in the cephalothorax and walking legs respectively. Protein content in the crab was found to be excellent and thus it can be used as the complement of cereals. Similarly, carbohydrate, lipid, ash, and mineral content were recorded to be higher in cephalothorax and lesser in swimming and walking legs. However, the carbohydrate content was found to be less as compared to the protein and fat content.The lipids and fatty acids in the flesh and hepatopancreas of freshwater crab, *Varuna litterata* (Fabricius, 1798) that were collected from the local ponds of Howrah, West Bengal were assessed. The major lipids present in the flesh and hepatopancreas of the crab were neutral lipids and phospholipids respectively. It was estimated that this crab species has a good amount of lipid and poly-unsaturated fatty acid content and thus can be consumed for protection from various cardiovascular diseases [4]. The nutritional status of the freshwater crab, *Maydelliathelphusa masoniana*, collected from the tributary of river Chenab was studied [23]. It was concluded that during the spawning period (December-January and July-August), the protein content decreases due to increased catabolic activities whereas protein and lipid content increases during non-spawning period (February-April and August-September). Lipid and protein content was found to be higher in male crabs than in females due to mobilization of these components for gonadal development. Moisture content is inversely related to protein, lipid, and glycogen content. Variation in the lipid content and ascorbic acid of the crab, *Barytelphusa guerini,* collected from the Godavari river near Aurangabad, Maharashtra, India [42]. It was found that the lipid content increases in gonads and decreases in hepatopancreas during the breeding season (in summer). Low values of ascorbic acid were recorded from the tissues of the crab. During maturation of the ovary, lipid content of crab, *Barytelphusa cunicularis,* exhibits marked variation [15]. It was perceived that during the breeding season, lipid content of the gonads increases, and that of hepatopancreas decreases due to mobilization of lipid content from hepatopancreas (fat storage organ) to the ovaries. Lipid was found to be higher in gonads and hepatopancreas during the preparatory phase

Analysis of the proximate composition and elemental content of freshwater crab, *Barytelphusa cunicularis,* collected from the northern region of Maharashtra state, India, revealed the protein to be in the highest concentration. Moisture content was inversely related to ash content. Among macro elements, potassium was found to be in the highest concentration and similarly, among microelements, zinc and strontium showed higher concentration. High protein content depicted that this species has good nutritional value and so is advantageous for human consumption [3].

Reproductive Biology: Brachyuran crabs that inhabit the tropical waters are continuous breeders and those that inhabit the temperate waters breed in particular months. The breeding occurs continuously in tropical waters as the environmental conditions for the development of gonads are favorable [10, 41]. The structure of spermatid and sperm of the crab, *Paratelphusa spinigera* collected from the freshwater stream in Kapurthala, Punjab was studied [28]. It was concluded that the spermatozoan of crab is like a typical sperm having cup-shaped nucleus and acrosome is fused with margin of nucleus. No chromatoid bodies were found in primary spermatocyte of *Paratelphusa spinigera*. Production of crablings is directly related to their size as witnessed by a smaller number of young ones produced by small sized female species. Abdominal segments and pleopods are used to hold the young in compact masses. After the complete development of young ones, the adult female comes out of their burrows. He reported the direct development in *Barytelphusa guerini* [25]. Each crabling of this crab species measures about 3mm across its carapace. Breeding occurs before the onset of the spring season and following the rainfall, most commonly females laden with young ones were found in the localities. The reproductive biology of freshwater crab, *Barytelphusa cunicularis* collected from Kham river, Aurangabad was studied. The maximum breeding activity was observed from June to September. By the end of September, till February spawning ceased and gonads entered into resting phase. Glycogen, fat, and protein contents increased during the process of gonad maturation. Maximum size of testes and ovaries was found in August. Active sperms and ripe eggs were found when the breeding activity was at its peak level. Rapid development of gonads occurred during the months from March to May [9]. The sexual maturity and breeding behavior in the freshwater crab, *Barytelphusa guerini* (Milne Edwards, 1853) collected from Maharashtra was studied [12]. In the immature crabs, posterior part of testis was small and translucent and on the other hand, they were opaque and white in mature crabs. Similarly, the ovaries of female crab depicted variation in color and appearance. They were thin and translucent in immature ones and thick and bulky in mature ones. Species with chela width of less than 40mm, 40-60mm, and more than 60mm were categorized as juveniles, sexually mature, and older respectively. Breeding was found to be at its peak level during June and July. Berried females were observed in June and females carrying young ones were noted in July.

The variations in biochemical composition with respect to the reproductive cycle in *Barytelphusa guerini* (H. Milne Edwards) from Maharashtra were reported. The reproductive cycle of this crab has been categorized as: pre-reproductive (January to April), reproductive period (May to August), and post-reproductive *(*September to December). Glycogen, fat, and protein content depicted a significant decline during the reproductive period. The study indicated that biochemical composition of species varies with the phases of reproductive cycle [13]. Morphological structure of the testes of freshwater crab, *Potamon koolooense* (Rathbun) was studied [18] in Pithorgarh, Uttarakhand. Testes were found to be H-shaped. The process of spermatogenesis proved to be seasonal which begins in January and February and culminates by the end of November. Minimum gonadal index was observed in November-December and maximum was observed in April. Discontinuous spermatogenetic cycle was exhibited by *Potamon koolooense*. Seasonal changes in the ovary of freshwater crab, *Potamon koolooense* (Rathbun) were observed [17]. Oogonium, pre-meiotic oocyte, pre-vitellogenic oocyte, vitellogenic oocyte, and ripe ovum were the different stages of maturation of ova. Eggs were released during May or June. Gonad index was recorded to be minimum in spawning season during June and it reached its peak value in April. *Paratelphusa hydrodromus,* collected from Madraswas found to be an annual breeder. Eggs are released by the end of June or beginning of July. Mean incubation period was 41±12.38 days. Yolk deposition and release of eggs took place at peak temperature conditions [38].

Reproductive biology of freshwater crab, *Paratelphusa spinigera* collected from Kawar Lake and agricultural fields of Bhagalpur, Bihar was studied [20]. According to their analysis, *Paratelphusa spinigera* is a monovoltine species. Average fecundity was 699±217. May-June was recorded as their breeding season. Maturation of gonads occurred from March to June. Eggs begin to hatch in the first week of June. Fecundity depicted a positive correlation with carapace width and bodyweight of female crab species. Breeding cycle and fecundity of freshwater crab, *Barytelphusa cunicularis*, collected from the backwaters of Jayakwadi Dam were investigated [32]. According to them, *Barytelphusa* is a continuous breeder and maximum percentage of male and female crabs were observed in June, July, and August. Fecundity showed positive correlation with carapace width, abdomen depth, abdomen width, and length of pleopods. Gonads were well developed in the crab during the breeding season. In Malacostracans, male reproductive organs are present in cephalothorax [21] and include the paired testes and genital ducts. Anatomy of male freshwater crab, *Barytelphusa cunicularis* (Westwood, 1836) revealed the presence of a pair of H-shaped testes, a pair of vas deferens, and a pair of penis. Two pairs of gonopods were also present in the species that helps in the transfer of spermatophores from male to female. A large number

of spermatophores were present in vas deferens that is lined by the layer of glandular epithelium from the inner sides [45].

The freshwater crab *Paratelphusa masoniana*, collected from the tributary of river-Chenab was found to breed during June-July and December-January and thus it is a seasonal breeder. Well marked gonadal cycle was observed in the species. Color of the testes varied from transparent to creamy white to milky white while the colour of ovaries varied from transparent to pink to orange-red. Females attained gonadal maturity at a smaller size as compared to females [43]. In *Spiralothelphusa hydrodoma,* found in Tamil Nadu state testes are H-shaped and vas deferens emerge from testes which showed the presence of spermatophores, thus indicating their assistance in the maturation of spermatozoids [1]. The mating period of *Travancoriana schirnerae* (Bott, 1969), collected from the areca plantations in Kerala, was observed from June to October. Gonadosomatic index was found to be high before spawning in April. Breeding season prolonged from Feb to May. Berried females were spotted in March and eggs were bright yellow. Mean fecundity and mean egg diameter was found to be 222±43 and 2.38±0.33mm respectively. *T. schinerae* was observed to be an annual breeder and spawn only once a year [6]. The structure and secretory activity of androgenic gland in freshwater crab, *Travancorina schirnerae* collected from the paddy fields, banana plantations of Wayanad, Kerala was studied [7]. The androgenic gland was found to be attached to one side on wall of the ejaculatory duct and showed the secretory activity that changes with the reproductive cycle of male crabs. The gland got decreased in size during inactive season and was small in immature crabs. Androgenic gland secretes androgenic hormone that modulates male sexual differentiation in crustaceans [19, 37].

Table1: Comparative account of the breeding season in different species of freshwater crabs of India

S.No.	Species	Place of collection	Breeding season	References
1.	*Barytelphusa guerini*	Bombay coast	Before the onset of spring season	Mecan (1937)
2.	*Barytelphusa cunicularis*	Khom river, Aurangabad, Maharashtra	June-September	Diwan and Nagabhushnam [9]
3.	*Barytelphusa guerini*	Maharashtra	June-July	Gangotri *et.al.* [12]
4.	*Paratelphusa hydrodromus*	Madras, Tamil Nadu	Annual breeder	Pillai and Subramoniam [38]
5.	*Paratelphusa spinigera*	Kawar Lake, Bhagalpur, Bihar	May-June	Kaur *et.al.* [20]
6.	*Barytelphusa cunicularis*	Backwaters of Jayakwadi Dam, Aurangabad, Maharashtra	Continuous Breeder	Pathre and Meena [32]
7.	*Paratelphusa masoniana*	Tributary of river Chenab, J&K UT	June-July & & December-January	Sharma and Gupta [43]
8.	*Travancoriana schirnerae*	Paddy fields, Banana plantations, Wayanad, Kerala	February- March	Devi and Smija [6]
9.	*Oziothelphusa senex senex*	Rice fields & Irrigation canals, Tirupati, Andhra Pradesh	September -October	Swetha *et.al.* [46]
10.	*Barytelphusa guerini*	Maharashtra	May -August	Gangotri [13]
11.	*Potamon koolooense*	Khoh tributary, Ganga river, Uttarakhand	Annual breeder, on arrival of monsoon season	Rana *et al.* [40]
12.	*Barytelphusa cunicularis*	Shirsatwadi & Kuttarwadi dam, Ahmednagar,Maharashtra	August-September	Ghorpade, [14]
13.	*Maydelliathelphusa masoniana*	Gho-Manhasan stream, tributary of river Chenab, J&K UT	Biannual breeder	Sharma *et al*. [44]
14.	*Himalayapotamon emphysetum*	Jhajjar stream,tributary of river Chenab, J&K UT	Continuous breeder	Sharma *et al.* [44]
15.	*Arcithelphusa cochleariformis*	Betel nut plantations, paddy fields, Wayanad, Kerala	August	Dineshan and Devi [8]

The reproductive cycle of freshwater crab, *Oziotelphusa senex senex* (Fabricius, 1798) collected from rice fields and irrigation canals in Tirupati were studied. Fecundity was closely related to the bodyweight of the crab. Ovaries when mature were thickened and orange in color and oocytes were visible at this stage. Yolk globules migrated from the periphery towards the centre of the oocyte. Mean diameter of the mature oocyte was found to be 198µm. Reproductive cycle of *O.senex* is independent of the climatological factors.

A large number of berried females were found in September and October [46] Reproductive cycle of male *Barytelphusa cunicularis*, collected from Shirsatwadi and Kuttarwasi dam in district Ahmednagar of Maharashtra state was observed. Maximum percentage of immature, maturing, and matured male crabs were found in January, September, and August respectively. Spermatozoa of the crab species were funnel-like or conical cup-shaped. Maximum carapace length was observed in August and September [14]. Carapace length can be used to determine the reproductive maturity in crustaceans. Fecundity of freshwater crab, *Potamon koolooense* (Rathbun, 1904) collected from the hill stream Khoh, a tributary of river Ganga in district Pauri Garhwal, Uttarakhand was studied [40]. They evaluated that fecundity is positively correlated to carapace width, carapace length, abdominal width, and total weight. It was found to be an annual breeder that breeds at the arrival of monsoon season. Positive correlation among fecundity, carapace width, abdominal width, and weight of crab was found in *Maydelliathelphusa masoniana* (Henderson) and *Himalyapotamon emphysetum* (Alcock) that were collected from the Gho-Manhasan stream and Jhajjar stream, both the tributaries of river Chenab [44]. Moreover, they evaluated that *M. masoniana* is a biannual breeder *whereas H. emphysetum* is a continuous breeder. When compared *to H. emphysetum*, fecundity was found to be higher in *M.masoniana*. The morphology of the male reproductive system in freshwater crab, *Acithelphusa cochleariformis* was elucidated [8] by collecting adult intermoult male crabs from betel nut and paddy fields in Wayanad districts of Kerala state. Spermatogenesis was highest during June-July. Vas deferens indicated the presence of spermatophores during the active phase (June-July). At the end of the mating season, there was a considerable decrease in the number of spermatophores. The study suggested the presence of yearly testicular cycle with the highest activity in June and July, mating in August, resting phase from September to February, and revival period from March to May.

CONCLUSION

Knowledge about various aspects of the reproductive biology of any species is of prime importance for its commercial utilization. Studies on the various aspects of freshwater crabs in India have gained very little attention as compared to the explorations on marine decapod crustaceans. The very same is evident from the present review paper which depicts that despite the ubiquity of freshwater crab species in India, nutritional and reproductive aspects of only a few species have been studied in detail. Data available on the nutritional quality, breeding cycle, and fecundity of freshwater crabs of India vindicates their candidature as a future food resource. With the increasing human population, the consumer demand for shellfish will increase in the next few years as they are rich in protein and other essential nutrients.

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