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Growth and Breeding Behavior of *Macrobrachium gangeticum* in River Ganga Around Varanasi

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ABSTRACT

The importance of prawn as one of the beneficial food items for man because of having easily digestive high protein and iron and a low fat content is well known. The river Ganga having diversified fish fauna is considered to be the back bone of capture fishery in India. The present study was conducted on the growth, maturation and breeding behavior of Ganga river prawn, *Macrobrachium gangeticum* in the middle stretch of river Ganga in and around Varanasi, India. Specimens, 65-205 mm in size, were recorded during May to October. Percentage of males was found dominant in the month of May whereas females in months, July to October. Maximum males were recorded in the size range of 166-205 mm. Prawns started breeding in May which continued till October.

Key words: Ganga river, *Macrobrachium gangeticum*, breeding behavior, varanasi

INTRODUCTION

The river Ganga has diversified fish fauna and is considered to be the back bone of capture fishery in India (Jhingran, 1956). Recently, many investigators studied the different aspects of *Macrobrachium* spp. (Manush *et al*., 2007; See *et al*., 2008; Das and Tiwari, 2008; Soundarapandian, 2008; Soundarapandian *et al*., 2008; Akintola and Bakare, 2011; Shanju and Geraldine, 2011; Sriputhorn and Sanoamuang, 2011). Freshwater prawns, *M. malcolmsonii*, *M. gangeticum* and some other larger species present in the riverine system have great aquaculture potential. Among them, several species are available in the river Ganga, Padma, Hooglin and Brahmaputra (Kanaujia, 2003). Earlier, the distribution, migration, growth, maturation and breeding behavior of different marine and fresh water prawn species have been studied by several workers (Ibrahim, 1962; Rajyalakshmi, 1980; Rao, 1986; Ahemad, 1984, 1999; Kanaujia, 1989, 2003; Kanaujia *et al*., 2001; Mohapatra, 2001) with a great deal of variation in their reports. Such studies have not been made in Ganga river around Varanasi till date. The significance of prawn as one of the lucrative food items for man because of having easily digestive high protein and iro, and low fat contents is well known. Therefore, the present study was carried out to investigate growth, maturation and breeding behavior of a larger prawn species, *M. gangeticum* both under natural and hatchery conditions for the improvement of hatchery technology and its establishment in land regions for prawn fishery.

MATERIALS AND METHODS

Collection and transportation of prawns: The study of growth, maturarion and breeding behavior of *M. gangeticum* has been undertaken at the middle stretch of Ganga river around Varanasi. The sources of prawn capture were fishermen who collected them during fishing. The prawn samples were collected from different landing centres during 2003 and 2004. The prawn species available in river Ganga at different centres were identified following Kurian and Sebastian (2001). The berried females were collected at the sites through local fishermen and conditioned for few days in a cotton happa. The fishermen were advised to catch the berried prawns with utmost care to prevent the developing embryos from any stress/hurt. The natural breeding and spawning of *M. gangeticum* occurred during May to October. However, to initiate breeding, spawning and larval rearing trials, the adults and berried females were transported during August, the peak season for their breeding in this region. The transportation of the prawns was done under oxygenated polythene bags kept inside packed tins. A minimum of two adults/berried prawns were kept in each packet having 6 L good quality of freshwater. The transportation was made by road/railways from Varanasi to the hatchery of Central Institute of Freshwater Aquaculture (CIFA) covering a distance of about 1050 km. Much care was taken to protect the packet from raising temperature during transportation.

Breeding biology: The study on the breeding biology of *M. gangeticum* was carried out with the adult males, females and berried females collected from different centres of river Ganga around Varanasi. Two prawns in the size range of 120-150 mm, were packed in a tin inside polythene bag with 6 L river water and transported to CIFA by railways which took around 18 h to reach there. Packing was opened just after arrival at CIFA and prawns were released in 1000 L FRP tanks half filled with pond water.

Rearing of berried females: Soon after arrival at CIFA, the packets were opened and berried females after giving a dip in 0.5 ppm potassium permanganate solution for few minutes were released into rearing tanks half filled with 5 ppt brackish water. Prawns were fed *ad libitum* with egg custard and mussel meat twice daily. Proper aeration and cleaning of the tank was done to remove the refused food and metabolites and water was changed daily.

Data analysis: The data was subjected to the statistical analysis by using Student's t-test. Microsoft Excel 2007 software was used to analyze the data.

RESULTS

Breeding biology: *M. gangeticum* males and females collected during summer and monsoon months ranged between 65-205 mm (Table 1). While the maximum size of males was 205 mm, females were a little smaller having maximum 190 mm size. The percentage of females in the size range of 65-165 mm was always higher than that of the males. The percentage composition of males and females has also shown a great deal of variation. While, males were prevalent during May and June, females were found in abundance from July to October. The berried females which appeared from the last week of May onward were recorded maximum during middle of the monsoon i.e., in the months of August and September. Occurrence of fully mature males, females and berried females was found during receding flood water. The adults and berried females that were recorded in May continued till the end of October.

Table 1: Total number and percentage composition of males and females in different size groups of M. gangeticum observed in the catches (Values represent mean±SD of 5 replications)

				Percentage	
Size group	No. of males	No. of females	Total	Male	Female
65	31	90	121	25.61	74.38
66-70	28	113	141	19.85	80.14
71-75	29	99	128	22.65	77.34
76-80	52	79	131	39.69	60.30
81-85	49	115	164	29.87	70.12
86-90	63	116	179	35.19	64.80
91-95	47	69	116	51.00	59.48
96-100	55	81	136	40.44	59.55
101-105	47	103	150	31.33	68.66
106-110	64	136	200	32.00	68.00
111- 115	40	120	160	25.00	75.00
116-120	45	123	168	26.78	73.21
121-125	66	137	203	32.51	67.48
126-130	24	114	138	17.39	82.60
131-135	25	97	122	20.49	79.50
136-140	32	95	127	25.19	74.80
141-145	30	93	123	24.39	75.60
146-150	55	90	145	37.93	62.06
151-155	58	93	151	38.41	61.58
156-160	78	118	196	39.79	60.20
161-165	45	55	100	45.00	55.00
166-170	108	71	179	60.33	39.66
171-175	80	23	103	77.66	22.33
176-180	78	14	92	84.78	15.21
181-185	50	10	60	83.33	16.66
186-190	39	5	44	88.63	11.36
191-195	22	-	22	100.00	00.00
196-200	17	-	17	100.00	00.00
201-205	18	-	18	100.00	00.00

External features: *M. gangeticum* showed a distinct sexual dimorphism. Males were found considerably larger than the females and have a pair of long and stout second walking legs, a big head, compact abdomen with a very little space between lateral abdominal pleura and genital openings at the base of fifth walking legs.

Live aged males were found with slightly dark brown palm and finger whereas in females these were somewhat greyish. The color was missing in the coxal joint though found comparatively darker on the upper than the lower surface. Younger males were generally grey or milky in colour or transparent (translucent). The colour of the telson, uropods, carapace, dorsal region of the body and chelate legs of adult males was brown. Females, on the other hand, were found with a medium sized head and a spacious brood chamber below the abdomen formed by the downward prolongation of abdominal pleurae. Genital apertures are found on the inner side of coxa of third pair of walking legs. The carapace is transparent through which mature gonads and feed inside the stomach are visible. The abdominal segments are found slightly light in colour with transverse bands. Different set up of dorsal and ventral rostral serrations and rostral formulae in *M. gangeticum* are presented in Table 2.

Table 2: Different set up of dorsal and ventral rostral serrations and rostral formulae in *M. gangeticum* (Values represent mean±SD of 5 replications)

No. of males	No. of females	Total No. of prawns	No. of dorsal serrations	No. of ventral serrations	Rostral formulae
10	18	28	9	3-5	9/3-5
12	18	30	10	2-8	10/2-8
20	22	42	11	2-6	11/2-6
11	15	26	12	3-7	12/3-7
13	12	25	13	5-6	13/5-6
11	10	21	14	8	14/8

Rostrum: The rostrum is prominently curved with highly elevated and convex dorsal crest in most of the specimens. It was with 9-14 dorsal teeth which, on the elevated crest, were closely set up whereas ventral teeth, 2-8 in number, were separate from each other. The rostral formula was 9-14/2-8 which varied from one prawn to another. The length of the body in relation to rostrum and carapace has been shown in Table 3. The rostrum in younger specimens was longer which gradually reduced as the prawn ages. Relationship in the body length, the lengths of carapace and rostrum was found in a ratio of 1:2:4, 1:2:5 and 1:2:6 in prawns in the size range of 65-150 mm, 151-195 mm and 195 mm and above, respectively. The increase in the body length was followed by the decrease in length of the carapace and rostrum (Table 3). The general observations on the nature of food and feeding habit indicated the occurrence of various feed-items in the gut of adult prawns. The food comprises mud and sand particles, detritus dominated by macro-vegetation, insects and insect parts, crustacean appendages, phytoplanktons associated with desmids, filamentous algae and diatoms.

Growth and maturation: The size of prawns ranging from 65 mm and above was considered their first year growth during monsoon. Adults and berried females in the size range of 75-130 mm were also considered as their first year growth. The second year growth during monsoon was found between 125-155 mm. But the specimens 155 mm and above in size found in pre and post-monsoon periods were considered as third year growth. The identification of sex was based on secondary sexual characters. Males possessed appendix masculina and bulged propodus whereas most of the females (55-70%) were either with fully mature gonads or under berried condition and were considerably more in number and percentage composition than the males in 91-165 mm size group. Males within 170-205 mm size group dominated the females during pre-monsoon. Mature females possessed fully developed and ripe ovaries which can be seen through transparent carapace. The abdominal pleurae are bent slightly inwards and the pleopods became slightly distended and arched out-ward to form an enlarged brood chamber to accommodate large number of eggs being spawned during breeding. The basal segments of the pleopods especially first four pairs were elongated and have soft long setae, the ovigerous setae bear eggs.

Breeding and spawning: Occurrence of berried females in the catches during May indicated the onset of breeding. The berried females were recorded in the size range of 100-190 mm however, smaller prawn specimens above 75 mm were recorded during middle of the monsoon. Sexually mature females were characterized by having fully developed green yellow ovaries occupying a major portion of the lateral part of the transparent carapace. Once the ovary in females gets

Table 3: Body length in relation to length of carapace and length from rostral tip to rostral spine of *M.gangeticum* (Values represent mean±SD of 5 replications)

Length range	Body length (mm)	Length of carapace (mm)	Length from rostral tip to Rosted spine
65	61	24	13
66-75	72	29	19
76-85	82	33	21
86-95	93	37	22
96-105	102	41	25
106-115	110	43	27
116-125	121	49	28
126-135	137	58	30
136-145	145	61	31
146-155	152	63	33
156-165	161	65	34
166-175	175	68	35
176-185	183	72	36
186-195	189	77	39
196-205	205	78	38

matured, pre-mating moult occurred shortly before mating. The freshly moulted females which were weak and sluggish in built try to search shelter for hiding to protect themselves from predators. The new body covering (shell) became sufficiently hard after few hours. Perhaps, it secreted a hormone which strongly attracted the males for mating. Several males were released in glass aquarium for mating but only one victorious male took part in mating. Male and female took few minutes to get acquainted with each other and male tried to catch the female and started courtship, displaying masculine grace and strength by lifting its head, raising body, waving feeler and pronounced gesture accompanied with intermittent jerking movements. Such activities lasted for few minutes before the female was successfully owned over. Male chased the female and kept arresting it within the long second chelate legs. Courtship and copulation continued for few minutes and male actively cleaned the ventral portion of the female thoracic shell with its other legs. It took about few minutes to complete such act and final mating lasted only for a few seconds. Sperms ejected from the male were deposited as a gelatinous mass on the female thoracic region between the bases of third thoracic legs. Soon after mating, the males and females separate from each other and then the female moved to a safer place for spawning. During spawning, the body of the female bends forward to keep contact with the ventral thoracic region and in turn, forms U shaped structure. Therefore, the eggs were extruded directly into the brood chamber passing through female genital pores present at the base of third pair of thoracic legs. The eggs were held in bundles like grapes through some thin and elastic membranous substance and adhered tightly to the fine ovigerous setae of the first to third pairs of pleopods. The release of eggs from the ovary to the brood chamber was observed in a tubular form which became rounded after leaving the genital pore. Female released the eggs in brood sac formed with downward prolongation of first to fourth pleura.The colour of freshly spawned eggs in *M. gangeticum* was green yellow. The eggs carried by the females and their correlation with body length/weight has been given in Table 4. The number of eggs carried by the females was corelated with their body weight and egg mass.

Incubation and hatching: The berried females carried the eggs in brood chamber and cared them till hatching. During incubation period, the pleopods beat back and fourth intermittently for

Table 4: Number of eggs carried by *M. gangeticum* females in relation to their body weight and weight of egg-mass (Values represent mean±SD of 5 replications)

Size group	Weight of prawn (g)	Weight of egg mass (g)	Total No. of eggs carried by female	No. of eggs g^{-1} of body weight	Body weight in relation to egg mass
75	5.55	1.59	7,500	1,391	1:3.7
85	5.95	1.62	8,496	1428	1:3.7
91	6.98	1.59	8,213	1177	1:4.6
95	7.95	1.85	7,965	1002	1:4.2
100	8.99	1.95	8,671	985	1:4.5
102	13.15	2.45	10,200	779	1:5.8
112	15.55	3.10	14,005	901	1:5.1
118	16.95	3.75	13,967	824	1:4.3
120	18.55	2.65	13,496	728	1:7.0
125	19.95	3.05	12,100	609	1:6.9
130	20.98	2.85	15,350	732	1:7.1
135	28.96	7.95	52,005	1796	1:3.5
140	32.98	10.85	53,250	1615	1:3.0
145	34.55	12.75	70,200	2032	1:2.6
150	42.75	12.55	63,000	1474	1:3.6
155	40.55	11.65	59,200	1460	1:3.4
165	52.75	13.75	69,950	1326	1:4.0
170	50.25	12.65	63,560	1365	1:4.0
180	52.75	11.85	61,895	1173	1:4.3
185	65.85	21.75	75,250	1143	1:3.0

providing aeration to developing embryos. The incubation period in *M. gangeticum* was recorded as 12-13 days. During this period, the female carefully removed the dead eggs and foreign materials with the help of sensitive and versatile first pair of chelate legs. The colour of the eggs gradually became lighter. When the larvae inside the egg-shell were found fully developed, the colour became slaty grey.

The process of hatching of developing embryo removed from the brood sac was studied through hand lens and compound microscope. Once the first stage zoea larva inside the egg found fully developed, the larva was ready to come out of the egg-shell to start active life. The continuous vibration of mouthparts of the larva accompanied with its rolled body, forces the egg-shell to elongate gradually. Vibrations of mouthparts become more and more vigorous followed by further stretching of the body. About an hour later, the thoracic appendages started to vibrate vigorously and continuously though intermittently for about few minutes with increasing length of periopods vibration. The body continued to stretch the rostrum and telson started outwardly. Suddenly, the egg-shell was broken and the telson thrashed out followed by the head with a forceful flex and stretch of the body and the newly hatched zoea larvae started swimming actively in water column.

DISCUSSION

Growth, maturation and breeding behaviour of *M. gangteticum* are more or less similar to *M. rosenbergii* and *M. malcolmsonii* (Ibrahim, 1962; Rajyalakshmi, 1980; Kanaujia, 1989, 1999). The maximum size of *M. gangeticum* recorded in present study is 205 mm whereas Tiwari (1949), Tiwari and Holthuis (1996) and Kanaujia *et al.* (2005) reported that the total length and weight

in males varied between 200-250 mm and 50-100 g and 150-200 mm and 35-75 g in females, respectively.

The rostrum in *M. gangeticum* is highly convex and slightly upturned extending up to antennal peduncle. However, its elevation is comparatively more than in *M. malcolmsonii*. The rostral formula 9-14/2-8 observed in *M. gangeticum* differed both from *M. malcolmsonii* with 8-11, 0-3 dorsal and 2-8 ventral and *M. rosenbergii* with 12-15 dorsal and 10-15 ventral serrations separated from each other (George, 1969). The little variation in body coloration, size and external morphological characters between *M. malcolmsonii* and *M. gangeticum* creates confusion in their identification under field condition. The elevated dorsal crest is thus the only recognizing character of *M. gangeticum* (Kanaujia, 1989; Kanaujia *et al.*, 2005).

Prawn food comprises mainly the detritus, mud and sand, body parts of crustaceans/insects, bits of aquatic plants, diatoms, algae etc., Therefore, it is considered both carnivorous as well as omnivorous similar to *M. malcolmsonii* and *M. rosenbergii* (Rajyalakshmi, 1968). *M. gangeticum* is nocturnal in habit, calm, non-aggressive decapod and some times found fighting among themselves due to their strong territorial behavior. Larger prawns often prevent the smaller ones from taking food within their own jurisdiction. Some times they become vulnerable to others at the time of food shortage and ecdysis and prey upon the weakers due to their cannibalistic nature. Ibrahim (1962) reported that *M. malcolmsonii* are omnivorous in habit. Raman (1967), Rao (1969), Ling (1969) and Bhimachar (1960) found the related prawn species including *M. gangeticum* and *M. malcolmsonii* as bottom feeders and carnivorous. On the other hand, Rajyalakshmi (1980), Ibrahim (1962), Raman (1984) and Rao (1986) reported *M. malcolmsonii* as an omnivorous and bottom feeder prawn species. Chopra (1939) and Ibrahim (1962) reported that the prawn consumes all types of food, living or dead that comes in way viz., mud, sand grains and debris.

The studies on the age and growth of different size groups of *M. gangeticum* revealed that the males grow faster and attain larger size whereas, the growth rate of females is comparatively slower. Similar observations have been made in *M. malcolmsonii* by a number of workers (Henderson and Mathai, 1910; Ibrahim, 1962; Rajyalakshmi, 1968, 1980; Kurian and Sebastian, 2001). *M. gangeticum* males have been recorded with 205 mm and females with 190 mm size similar with those of *M. malcolmsonii*. The size of males up to 230 mm and females 133 mm of *M. malcolmsonii* were recorded by Henderson and Mathai (1910) whereas, Ibrahim (1962) recorded the size of males up to 230 mm and females 197 mm in the river Godavary. George *et al.* (1998) made a record of 165 mm females with 150 g body weight and 200 mm males with 170 g weight in river Cauvery. Fully grown males, 240 mm in total length and 160 g in weight and females 159 mm in length and 90 g weight were recorded by Rajyalakshmi (1968) in river Godavary. Kurian and Sebastian (2001) reported the size of males 240 mm and females 210 mm. A comparative study of *M. malcolmsonii* from river Hooghly and Godavary made by Rajyalakshmi (1980) indicated the five year group in males and four-year group in females in river Godavary whereas three year group in males and two year in females in river Hooghly. Similar observations were made by Raman (1984) from the river Mahanadi at Cuttack. In present study, the growth rate of *M. gangeticum* is recorded similar to *M. malcolmsonii*. In males, it was recorded between 65 mm-205 mm whereas, between 65-190 mm in females. Tiwari and Holthuis (1996) reported the length of adult males between 165 and 188.5 mm and adult females around 130 mm. Whereas, Bate (1868) recorded the total length up to 6 inches (150 mm) in *M. gangeticum*. Brown (1957) examined and categorized the extent of growth in different parts of life and concluded that in most of the animals, the specific growth rate is highest in early life but slowed

down with the increasing age. The specific growth rate was recorded highest in younger stage and declined slowly with the age and index at zero (Minto, 1908; Brown, 1957; Rajyalakshmi, 1966). The growth rate in crustacean depends upon three factors i.e., environment (mostly water temperature), food and water quality. The different growth rates in two different sexes reported in prawns revealed that the males grow faster than the females (Rajyalakshmi, 1980).

In present study, it was found that *M. gangeticum* with 75 mm and above size showed maturity. In *M. malcolmsonii* also maturity was recorded at 83 mm in river Hooghly, 68 mm in river Godavary and 81-85 mm in Kolleru lake (Rajyalakshmi, 1980; Rao, 1986). Ibrahim (1962), Ahemad (1984, 1999), Patel *et al.* (1984) and George *et al.* (1998) have recorded a smaller size range from 41-58 mm in the river Godavary, Mahanadi, Cauvery and Ojat (Gujarat). Mohapatra (2001) recorded the maturity at 60 mm and above under pond condition in *M. malcolmsonii* and *M. rosenbergii*. The testicular maturity in *M. gangeticum* is attained at 75 mm though secondary sexual characters were recorded with the presence of appendix masculina on the second pair of pleopods at 60 mm size. The occurrence of berried females during last weak of May indicated maturation and breeding of the prawn which continued till the end of October. The numbers of berried females were recorded more during the months of August and September which were the peak periods for breeding in this stretch. However, prolonged breeding period of nine months from April to December with peak during August to November was observed in *M. malcolmsonii* in Kolleru lake by Rao (1986). Ibrahim (1962) made similar observations in the river Godavary. However, this period was restricted to 6 months from May to October in river Mahanadi and Ganga as well as under pond condition (Kanaujia, 1989, 1999; Kanaujia and Mohanty, 1994; Mohapatra, 2001). Rao (1986, 1991), Kanaujia *et al.* (1999) and Mohapatra (2001) studied the maturity stages of ovary in *M. malcolmsonii* and *M. rosenbergii* and reported four stages of the ovarian development based on the colour and size of the ovary in relation with carapace cavity and diameter of the ova.

The multiple breeding has been recorded in *M. gangeticum*. Just after spawning, ovary was in stage I. On one hand, the embryonic development proceeded inside the fertilized egg in brood chamber while on the other, egg development took place inside the ovary. Just after hatching of zoea stage I, the spent female having matured ova inside the ovary was ready for pre-mating moult corresponding to breeding and spawning. Therefore, prawns breed and spawn three to four times within one season. In present study, the breedings were recorded from May to October as is evident from the occurrence of berried females in the catch. But occurrence of breeding in *M. malcolmsonii* in different river systems as well as lakes like Chilka in Orissa and Kolleru in Andhra Pradesh, depends upon the climatic conditions mostly water temperature. The prawns may also be induced for breeding year round under controlled conditions by maintaining water temperature, food and water quality (Kanaujia, 1998, 1999; Kanaujia *et al.*, 1999; Mohapatra, 2001). The breeding process has been found similar to other prawn species as reported by other workers (Ling and Merican, 1961; Kanaujia *et al.*, 1999, 2001). Appearance of berried females 190 mm size in this stretch indicated no migration for breeding which has also been reported by Ibrahim (1962) in the stretches of Godavary river system. The phenomenon of breeding activity throughout the year in Kolleru lake reported by Rao (1986) indicated that *M. malcolmsonii* do not perform the breeding migration towards the estuary as reported in *M. rosenbergii*. Though, breeding and embryonic development in present prawn species take place in freshwater under river system, the newly hatched zoea stage I drifted out along with water current and reached the estuary and complete their larval stages in brackish water as has been reported in *M. malcolmsonii* and in

M. gangeticum also by earlier workers (Ibrahim, 1962; Rajyalakshmi 1980; Rao, 1986; Kanaujia, 1989, 1999, 2003; Kanaujia *et al.*, 2001).

Recently, many investigators studied the different aspects of *Macrobrachium* spp. (Manush *et al.*, 2007; See *et al.*, 2008; Das and Tiwari, 2008; Soundarapandian, 2008; Soundarapandian *et al.*, 2008; Akintola and Bakare, 2011; Shanju and Geraldine, 2011; Sriputhorn and Sanoamuang, 2011). The fecundity in *M. gangeticum* was assessed by counting the fertilized eggs carried by the different sizes of berried females in their brood sac. Minimum 7,500 eggs in females of 75 mm size and the maximum 75,250 eggs in females of 190 mm size were recorded. The fecundity of present sp. is more or less similar to *M. malcolmsonii* bearing minimum number of eggs (8100) in females of 75 mm size and maximum (81,200) in females of 190 mm size. The number of eggs carried by a female is related with the size of prawn (Mansuri *et al.*, 1988) and a fluctuation in minimum egg number from 3465-8300 was reported in *M. malcolmsonii* under different riverine systems. Ibrahim (1962) recorded 3465-63,080 eggs from the females of 54-64 mm size in the river Godavary whereas, Rao (1986) recorded 12,556-77440 eggs from the female prawns of 83-156 mm size in Kolleru lake. Maximum fecundity (5100-83000 eggs) was reported by Mansuri *et al.* (1988) in females of 63-204 mm length from the Ojat river (Gujarat) while Kanaujia (1989) found 1200-78,000 eggs in prawns of 70-195 mm size from the river Ganga around Buxur. Further, a higher fecundity 80,000 to 1,00,000 has been reported in the females 150-165 mm in size by George *et al.* (1998) from the river Cauvery. The fecundity in *M. gangeticum* recorded in present study is found similar with the reports of Kanaujia (2003) and Kanaujia *et al.* (2001) which is comparatively less than that in *M. rosonbergii* carrying maximum 1.6 lakh eggs (Chacko, 1955). Year round mating in this species may easily occur under captivity having similarity with natural environment and culture conditions of freshwater and brackish water. Pre-mating periods are rather seasonal depending on the presence of favourable environmental conditions like monsoon rain and weather temperature. Kanaujia *et al.* (1999) reported mating and spawning in *M. malcolmsonii* year round under captivity by maintaining water temperature. Mating behaviour in this species is found similar to *M. malcolmsonii* and *M. rosenbergii* as reported earlier by Ling (1969) and Mohapatra (2001). *M. gangeticum* has shown four breedings during one season and the number of eggs in first breeding was found less which increased moderately in second and third breeding and reduced further in fourth breeding. The colour of freshly spawned eggs in *M. gangeticum* is yellowish green whereas, in *M. rosonbergii* orange yellow, in *M. malcolmsonii* yellow and in *M. lamarrei* and *M. lamarrei* lamarrei green (Rajyalakshmi, 1960; Uno and Sao, 1969; Kanaujia, 1998, 1999, 2003). The fertilized eggs carried by the females underwent embryonic development till the hatching of zoea stage I. Thereafter, hatching occurred on 12-13th day in *M. gangeticum*. Whereas, comparatively longer duration of 10-15 days has been recorded in embryonic development of *M. malcolmsonii*, 18-25 days in giant freshwater prawn, *M. rosenbergii* (Uno and Sao, 1969; Kanaujia *et al.*, 2001). However, hatching duration is prolonged from midnight till next day morning (12 h) in *M. gangeticum*. Whereas in *M. malcolmsonii*, it starts mostly during night and completed before morning (5-6 h) much longer duration is reported in *M. rosenbergiii* where hatching starts during night (24 h) and completed on 2nd night or 2nd day (24-36 h) (Ling, 1969; Fujimura and Oamoto, 1972; Kanaujia *et al.*, 2001; Kanaujia, 2003). This period may further fluctuate depending upon the water temperature as reported by New and Singholka (1985), Kanaujia and Mohanty (1992) and Kanaujia (1998, 1999).

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REFERENCES

Ahemad, S.M.J., 1984. Fishery of freshwater prawns *Macrobrachium malcolmsonii* in Sambalpur district and prospects of its culture in Western Orissa. Proceedings of the Souvenir of the Seminar on Freshwater Fisheries and Rural Development, April 6-7, 1984, Rourkela, Orissa, pp: 1-7.

Ahemad, S.M.J., 1999. Freshwater Prawn Fisheries Resources and Opportunities for their Developments. Allied Printers, New Delhi, pp: 136.

Akintola, S.L. and S.B. Bakare, 2011. Microbiological changes in freshwater prawn (*Macrobrachium vollenhovenii*, Herklots 1857) stored in ice. Am. J. Food Technol., 68: 500-506.

Bate, C.S., 1968. On a new genus with four new species of freshwater prawn. Proc. Zoologl. Soci. London, 1868: 363-368.

Bhimachar, B.S., 1960. Studies of distribution and biology of freshwater prawn in Gangetic ecosystems. Indian J. Fish., 3: 133-140.

Brown, M.E., 1957. The Physiology of Fishes. Academic Press Inc., New York, pp: 571.

Chacko, P.I., 1955. Prawn fisheries of Madras state, India. Contribution from the Marine Biological Station, West Hill, Malabar, Coast, No. 3, Madras Government Publications, India.

Chopra, B.N., 1939. Some food prawns and crabs of India and their fisheries. J. Bombay Nat. Hist. Soc., 41: 221-234.

Das, T. and G.N. Tiwari, 2008. Heat and mass transfer of greenhouse fish drying under forced convection mode. Int. J. Agric. Res., 3: 69-76.

Fujimura, T. and H. Oamoto, 1972. Notes on Progress Made in Developing a Mass Culturing Technique for *Macro brachium rosenbergii* in Hawaii. In: Coastal Aquaculture in Indo-pacific Region, Pillay, T.V.R. (Ed.). Fishing News Books Ltd., Surrey, England, pp: 313-327.

George, M.J., K. Vijayaraman, P. Sivakumar and R.R. Mohamed, 1998. Observations on the life history and breeding behaviour of *Macrobrachium malcolmsonii* of the River Cauvery. Fishing Chimes, 18: 21-24.

George, M.J., 1969. VII Genus Macrobrachium Bate 1868. In: CMFRI Bulletin No.14, Prawn Fisheries of India, Jones, S. (Ed.). CMFRI, Mandapam Camp, India, pp: 179-215.

Henderson, J.R. and G. Mathai, 1910. On certain species of *Palaemon* from south India. Rec. Indian Museum, 5: 277-306.

Ibrahim, K.H., 1962. Observations on the fishery and biology of the freshwater prawn *Macrobrachium malcolmsonii* (H.M. Edwards) of river Godavari. Indian J. Fish., 9: 433-467.

Jhingran, V.G., 1956. The capture fishery of river Ganga at Buxar (Bihar, India) in the years 1952-1954. Indian J. Fish., 3: 197-215.

Kanaujia, D.R., 1989. Biology of Freshwater prawn *Macrobrachium malcolmsonii* of river Ganga, Buxar, Bihar. Proceedings of the National Seminar on Freshwater Aquaculture, November 7-9, 1989, CIFA Kaushalyaganga, Bhubaneswar, pp: 51-54.

Kanaujia, D.R. and A.N. Mohanty, 1992. Breeding and large scale seed production of the Indian river prawn *Macrobrachium malcolmsonii* (H.M. Edwards). J. Aqualt. Trop., 2: 7-16.

Kanaujia, D.R. and A.N. Mohanty, 1994. Role of temperature in larval growth and seed production of *Macrobrachium malcolmsonii* (H.M. Edwards). Proceedings of the Status of Freshwater prawn Farming in India, March 17-18, 1994, CIFE Bombay, India, pp: 28.

Kanaujia, D.R., 1998. Emerging Technologies in Seed Production of *Macrobrachium malcolmsonii* (H.M. Edwards). In: Current and emerging Trends in Aquaculture, Thomas, Thomas, P.C. (Ed.). Daya Publishing House, New Delhi, pp: 148-159.

Kanaujia, D.R., 1999. Seed production of Indian river prawn *Macrobrachium malcolmsonii* (H. M. Edwards). In: Aquaculture, Mahapatra, B.C., P.G. Ingole and G. M. Bharad (Eds.). Panjabrao Deshmukh Krishi Vidyapeeth, Akola, Maharastra State, India, pp: 212-227.

Kanaujia, D.R., A.N. Mohanty and S.D. Tripathi, 1999. Year round breeding and seed production of Indian river prawn *Macrobrachium malcolmsonii* (H.M. Edwards) under controlled conditions. J. Aquat. Trop., 14: 27-36.

Kanaujia, D.R., J. Mahapatra, M. Mohanty and A.N. Mohanty, 2000. Effect of unilateral eyestalk ablation on molting and ovarian development in *Macrobrachium malcolmsonii*. Aquaculturel, 1: 153-160.

Kanaujia, D.R., A.N. Mohanty and S. Soni, 2001. Breakthrough in Seed production of Ganga River Prawn *Macrobrachium gangeticum* (Bate, 1868): A milestone in Aqua-farming. Fishing Chimes, 21: 28-30.

Kanaujia, D.R., 2003. Indian river prawn *Macrobrachium malcolmsonii* and minor species of commercial importance. Proceedings of the Souvenir, International Symposium of Freshwater Prawns 2003, College of Fisheries, August 21-23, 2003, Kerala Agricultural University,Kochi, pp: 51-56.

Kanaujia, D.R., A.N. Mohanty, G. Mitra and S. Prasad. 2005. Breeding and seed production of Ganga river prawn *Macrobrachium gangeticum* (Bate) under captive conditions. Asian Fish. Sci., 18: 371-388.

Kurian, C.V. and V. Sebastian, 2001. Prawn and Prawn Fisheries of India. Hindustan Publ. Corp., Delhi, India, pp: 310.

Ling, S.W. and A.B.O. Merican, 1961. Notes on the life and habits of the adults and larval stages of *Macrobrachium rosenbergii*. Proc. Indo-Pac. Fish. Coun., 9: 55-60.

Ling, S.W., 1969. The general biology and development of *Macrobrachium rosenbergii*. FAO Fish. Rep., 57: 589-606.

Mansuri, A.P., R.I. Patel, R. Kundu, S. Krishnan and R. Parvez, 1988. Reproductive potential in *Macrobrachium malcolmsonii* (H.M. Edwards) from river Ojat, Navibandar, Saurastra India. Indian J. Fish., 35: 205-206.

Manush, S.M., A.K. Pal, T. Das, N. Chatterjee, K. Sarma and S.C. Mukherjee, 2007. Ultrastructural alterations in the gills of *Macrobrachium rosenebergii* acclimated to three temperatures. Asian J. Cell Biol., 2: 1-10.

Minto, C.S., 1908. The Problem of Age, Growth and Death. John Murray, London.

Mohapatra, J., 2001. Studies on the comparative breeding and larval biology of Indian river prawn *Macrobrachium malcolmsonii* (H. Milne Edwards) and giant freshwater prawn, *Macrobrachium rosenbergii* (de Man). Ph.D. Thesis, Utkal University, Vani Vihar, Bhubaneswar Orissa.

New, M.B. and S. Singholka, 1985. Freshwater Prawn Farming: A Manual for the Culture of *Macrobrachium rosenbergii*. 2nd Edn., Food and Agriculture Organization of the United Nations, Rome, Italy, ISBN: 9789251022504, Pages: 118.

Patel, R.I., M.N. Prasad and A.P. Mansuri, 1984. Length-weight relationship and relative condition factor of prawn, *Palaemon malcolmsonil* (Edwards), from river Ojat of Saurashtra (Gujarat). Indian J. Fish., 31: 171-175.

Rajyalakshmi, T., 1960. Studies on the maturation and breeding of some estuarine palaemonid prawns. Proc. Natl. Inst. Sci. India, 27: 179-188.

Rajyalakshmi, T., 1966. On the age and growth of some estuarine prawns. Proc. Indo-Pac. Fish. Coun., 11: 52-83.

Rajyalakshmi, T., 1968. Try prawn in tanks and inland waters. Indian Farming, 18: 37-43.

Rajyalakshmi, T., 1980. Comparative study of the biology of the freshwater prawn *Macrobrachium malcomsonii* of Godavari and Hooghly river systems. Proc. Indian Natl. Sci. Acad., 46: 72-89.

Raman, K., 1967. Observations on the fishery and biology of the giant fresh water prawn *Macrobrachium rosenbergii* de Man. Proceedings of the Symposium on Crustacea, Part 2, MBAI, January 12-16, 1965, Ernakulam pp: 649-669.

Raman, K., 1984. Studies on the biology and ecology of some freshwater prawns in relation to pond culture. Ph.D. Thesis, Utkal University, Vani Vihar, Bhubaneswar, Odisha, India.

Rao, K.J., 1986. Studies on maturation, breeding, fecundity and sex ratio in *Macrobrachium malcolmsonii* (H. Milne Edwards) from Kolleru lake. J. Aquat. Biol., 4: 62-72.

Rao, K.J., 1991. Breeding and larval rearing of the freshwater prawn *Macrobrachium malcolmsonii* (H. Milne Edwards). J. Aquacult. Trop., 6: 99-106.

Rao, R.M., 1969. Studies on the prawn fisheries of the Hooghly estuarine system. Proc. Nat. Inst. Sci. India, 35B: 1-27.

See, L.M., R. Hassan, S.G. Tan and S. Bhassu, 2008. Genetic characterization of wild stocks of prawns *M. rosenbergii* using random amplified polymorphic DNA Markers. Biotechnology, 7: 338-342.

Shanju, S. and P. Geraldine, 2011. Quantitative protein profile of three *Macrobrachium* species during reproductive cycle. Asian J. Anim. Vet. Adv., 6: 731-737.

Soundarapandian, P., 2008. Breeding behavior and effect of salinity and osmolarity on incubation and hatching of *Macrobrachium malcolmsonii* (H. Milne Edwards) under laboratory conditions. Int. J. Zool. Res., 4: 81-84.

Soundarapandian, P., K. Balamurugan and N.J. Samuel, 2008. Preliminary observations on freshwater prawn farming of *Macrobrachium rosenbergii* (De Man) in Tamil Nadu. Int. J. Zool. Res., 4: 72-76.

Sriputhorn, K. and L. Sanoamuang, 2011. Fairy shrimp (*Streptocephalus sirindhornae*) as live feed improve growth and carotenoid contents of giant freshwater prawn *Macrobrachium rosenbergii*. Int. J. Zool. Res., 7: 138-146.

Tiwari, K.K. and L.B. Holthuis, 1996. The identity of *Macrobrachium gangeticum* (Bate), 1868 (Decapoda, Caridea, Palaemonidae). Crustaceana, 69: 922-925.

Tiwari, K.K., 1949. On a new species of *Palaemon* from Banaras with a note on *Palaemon lanchestri* (de Man). Rec. Indian Museum, 45: 333-345.

Uno, U. and K.C. Sao, 1969. Larval development of *Macrobrachium rosenbergii* (de Man) reared in the laboratory. J. Tokyo Univ. Fish., 55: 179-190.