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Breeding and Seed Production of the Ganga River Prawn *Macrobrachium gangeticum* (Bate) Under Captive Conditions

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Abstract

The Ganga river prawn *Macrobrachium gangeticum* (Bate 1868) inhabits the rivers Ganga and Brahmaputra in the Northeast region of India. The post-larvae (PL) production and grow-out culture techniques developed for *M. rosenbergii* and *M. malcolmsonii* are being practiced all over the country but hatchery technology for PL production of *M. gangeticum* is currently lacking. This work was conducted at Central Institute of Freshwater Aquaculture (CIFA) Kausalyaganga, Bhubaneswar during 2000 to develop mass culture of *M. gangeticum* post-larvae. The juveniles, adults and berried females were transported by land from the collection sites on the river Ganga (at Patna and Farakka) and its tributary, the Padma (at Lalgola). The juveniles and adult prawns were reared under laboratory and out-door conditions using air-lift bio-filter recirculatory system. Females attained maturity at 85 mm (8g) size and bred and spawned under captive condition. The hatching of zoeae occurred within 12-13 days of spawning. First stage zoeae were reared in brackish water of 10-18 ppt salinity for larval growth and development. The zoea first larvae passed through 18 molts, showing the characteristics of 11 distinct larval stages before attaining post-larval stage within 22 – 26 days. A total number of 7,997 post larvae was produced in four rearing trials lasting 60 days. The number of PL's produced, percentage of PL recovery and the rate of production (PL/l) at the end of 60 days was: Trial 1: 2798 PL, 96.05%, 9.3 PL/l; Trial 2: 2042 PL, 98.98%, 6.75 PL/l; Trial

3: 2487 PL, 80.09%, 8.64 PL/l; Trial 4: 670 PL, 94.49%, 2.22 PL/l. These results indicated commercial culture potential of this species.

Introduction

The farming of giant freshwater prawn, *M. rosenbergii* is practiced in many countries (New and Valenti 2000). This is known as " scampi" in commercial trade. Other freshwater prawn species, *M. acanthurus* (Wiegmamm), *M. amazonicum* (Heller), *M. americanum* (Bate), *M. carcinus* (Lennaeus), *M. formosense* (Bate), *M. lar* (Fabricius), *M. ohione* (Smith) that have commercial value, are available locally in different countries and could be used to develop better market (New and Valenti 2000). Small-scale research and development on these species are in progress along with *M. rosenbergii* in Thailand, Indonesia, Canada, Dominica, Grenada, Haiti, Saint Kitts, Saint Vincent and Trinidad, Tobago, Dominican Republic, Mexico, Brazil, Colombia and Venezuela. In India, research and development of freshwater prawn species includes *M. equidens*, *M. idae*, *M. idella*, *M. lanchesterii*, *M. rosenbergii*, *M. malcolmsonii* and *M. nobilli* (Tripathi 1991; New and Valenti 2000).

There are approximately 40 prawn species in India, of which 15 are considered important for cultivation in commercial scale to augment prawn production (Tiwari 1949). Among these *M. rosenbergii*, *M. malcolmsonii* and *M. gangeticum* are the largest and are cultured commercially. *M. gangeticum* is considered to be a potential candidate for commercial farming through the development of seed production and grow-out culture technologies (New 1995). *M.gangeticum* occurs in the stretches of river Ganga and Brahmaputra draining through West Bengal, Bihar, Uttar Pradesh and Assam (Tiwari 1949, 1955; Tiwari and Holthuis 1996). The total length and weight of the species ranged from 200 - 250 mm and 50 – 100 g in males and 150 - 200mm and 35 - 75 g in females respectively (Tiwari 1949; Tiwari and Holthuis 1996; Kanaujia et al. 2001). *M. gangeticum* was first described as *Macrobrachium gangeticum* by Bate during 1868. Further, Tiwari (1955) conducted a detailed investigation and described its distribution in the stretches of Ganga and Bharmaputra river systems and described the species as "*Palaemon choprai*". Tiwari and Holthuis (1996) reviewed this finding and made it clear that the appropriate taxonomic designation was *M. gangeticum*, (synonym of *Macrobrachium birmanicum choprai*). Since *M. gangeticum* is large in its natural habitat, it is a suitable candidate species for commercial farming.

Efforts have been made to develop the hatchery technology for seed production of *M. gangeticum* along with two other larger prawn species, *M. rosenbergii* and *M. malcolmsonii* but with limited success (Jhingran 2003). Since this species is available in the middle and upper stretches of Ganga river system, some reports during 1976-1979 indicated its PL production in freshwater under pond conditions. Also some

reports during 1984–1985 indicate that the post-larval (seed) production of this species could be done in synthetic seawater (Jhingran 2003). Kanaujia conducted a biological survey of *M.gangeticum* in the river Ganga during 1982-1986 and concluded that the *M.gangeticum* larvae attained Vth larval stages within 7 days in salinity at 50% natural seawater. Since the demand for shrimp and scampi are increasing in the international market, the production trials were conducted during 2000 to develop the hatchery technology for PL production of *M.gangeticum* under controlled conditions at the Central Institute of Freshwater Aquaculture, Kausalyaganga, Bhubaneswar. The results of this effort are presented herein.

Materials and Methods

Collection of prawns

For Trial 1, adult males and females of 60–80 mm total length of the Ganga river prawn *M. gangeticum* were caught in bamboo cages from the river Padma near the Indo-Bangladesh border around the city of Lalgola in Murshidabad district of West Bengal and transported by land over a distance of 800 km to the Central Institute of Freshwater Aquaculture (CIFA), Kausalyaganga, Bhubaneswar, using oxygen packing. Re-packing was done once during this transport after 14 hours. The second and third larval rearing trials were undertaken with the stage I zoeae obtained from the berried female directly collected and transported from the Ganga River system located in and around Farakka (W.Bengal) and Patna (Bihar) at a distance of 450 and 750 km respectively by land. The management practices in Trials 2 and 3 were the same as that of Trial 1. Trial 4 was also made with the zoeae stage I obtained from a berried female collected from the Ganga river near Farakka and mated with the adult male collected from the Padma river maintained at CIFA in out door tanks.

Development of broodstock

The adult prawns, transported from Padma river were maintained at a ratio of 1 male and 4 females (1:4) in 1000 l fiberglass tank (180 cm dia x 90 cm h), half filled with aged freshwater at stocking density 10 prawns /m3. Prawns were fed ad libitum daily with egg custard and chopped mussel meat. Water quality of the tank was monitored at regular interval. An air-lift device was installed to provide aeration in the tank. Leftover food and metabolites were siphoned out daily in the morning and 40% water was exchanged at weekly intervals. Water temperature was recorded daily in the morning (6.00 a.m.) and evening (6.00 p.m.) hours. Growth, molting and gonadal maturation were observed visually with the help of hand net and lens.

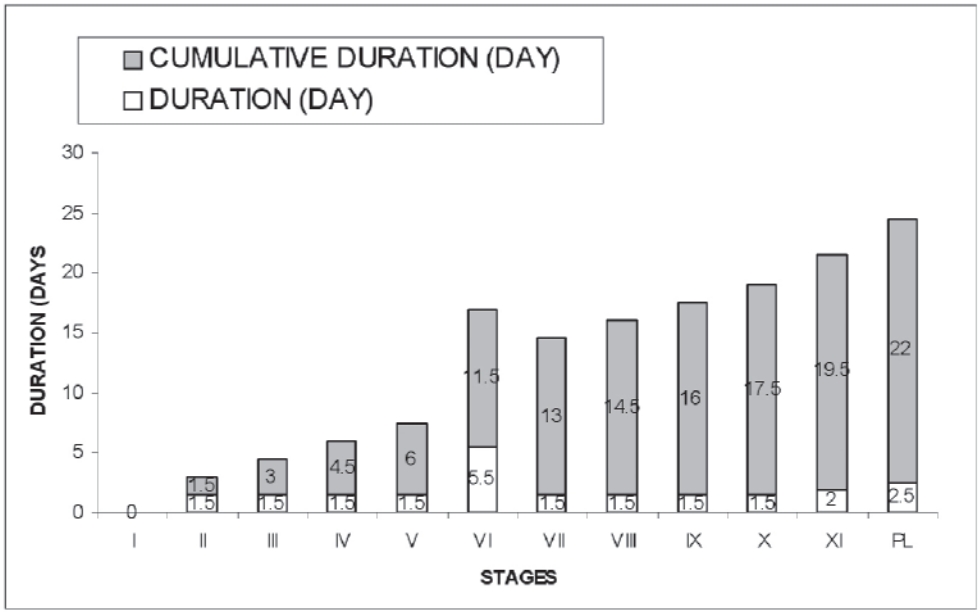

Fig. 1. Duration (clear area) between each stage and cumulative duration (hatched area of *M. gangeticum*)

Larval rearing system

Air-lift biofilter recirculatory system as described by Kanaujia and Mohanty (1992) was used for larval rearing of *M. gangeticum*. The larval rearing unit consisted of one 300 l plastic circular tank (90 cm dia. X 60 cm h) and a plastic "drum" of similar height (60 cm) with 80 l water holding capacity, which housed the bio-filter. The bio-filter tank was fabricated with 30 cm layers of gravel, oyster shells and coarse sand placed on top of another. A 25 mm diameter PVC pipe served as an air-lift pipe located vertically one inch above to the bottom of the bio-filter drum. At the bottom end of the pipe, an aeration tube (6 mm dia) was inserted through a small hole. A 2 HP air compressor provided compressed air to this tube. The other end of the pipe was placed horizontally on one side of the larval rearing tank. Another flexible nylon pipe (25 mm dia) was used as a siphon for water recirculation. One end of the siphon pipe was placed inside the bio-filter tank and rested on the surface of the filter bed. The other end of the siphon pipe was kept in the larval rearing tank connected to a perforated plastic basket wrapped with bolting silk cloth (24 micron mesh size), which contained the prawn larvae and its *Artemia* nauplii food. The airlift bio-filter recirculatory system was started one week prior to stocking of the larvae.

Breeding, spawning and hatching

Breeding and spawning of *Macrobrachium gangeticum* was carried out

in transparent 180 litre glass aquarium filled with freshwater. Female's dams with matured gonad (stage V) were released in aquarium before their pre-mating molt. After a dam has undergone her pre-mating molt a matured male (total length 140mm and weight 25 gm) was introduced into the aquarium with her. Mating and spawning activities between the dams were observed. After mating and spawning, the "berried" female carrying fertilized eggs was placed in a glass aquarium filled with 5 ppt brackishwater and fed daily with egg custard and mussel meat *ad libitum*. Left out food and other debris were siphoned out daily. Aeration was provided continuously. Once the hatching of the first stage zoea occurred very often, the colour of the eggs became grey. The "spent" female was removed from the aquarium and aeration was stopped. A light beam from a table lamp was directed at an aquarium side to congregate the positive phototactic larvae in one place of the aquarium. These larvae were siphoned out in a 5 l enamel basin using a flexible PVC pipe of 5 mm dia. containing 10 ppt brackishwater. Air diffusion stones were used to distribute the larvae uniformly in the water column. The total number of larvae present in the tank was estimated through extrapolation by manually counting all the larvae in the 10 samples collected in 100 ml beaker.

Feeding and husbandry

The larvae were fed twice daily with freshly hatched *Artemia* nauplii for one week in the morning (6.00 a.m.) and evening (6.00 p.m.) hours @ 10 nauplii / prawn larva. Thereafter, feed was supplemented with egg custard and mussel meat, four times a day. Egg custard was prepared with a mixture of three hen's eggs, 30 g milk powder and 200 ml water and steam cooked together and mussel meat was chopped using sharp knives and graded in suitable sizes using desired size sieves. These feed items were provided 6 hourly a day between 5-6 a.m., 11–12 p.m., 17-18 p.m. and 23-24 p.m. at 25 ml / feeding. Once PL was observed in the tank, the egg custard and mussel meat were provided at every 2 hours interval. Left out food, metabolites and molting shells present in the larval rearing tank were siphoned out daily between 6 -7 a.m. to maintain proper water quality. The water level in the tanks was maintained by adding fresh brackishwater medium. Water quality parameters such as temperature, salinity, dissolved oxygen; total hardness, pH, ammonical-nitrogen and nitrite-nitrogen were monitored at regular intervals following the methods of APHA (1985).

Larval growth and molting

The classes of characteristics stages were observed for each larva: 1) presence of chromatophores at different regions of the body, 2) development of external appendages and organs and 3) general activity. These characteristics were

examined for the larval stages under a compound microscope. The general activity of larvae was also observed visually in the tank. The growth increment at different larval stages was measured through ocular and stage micrometer. The number of larval stages and size from zoea stage I to post-larvae (PL), were observed.

Harvesting

"Shell strings" consisting of freshwater mussel shells, plastic beads and nylon threads, developed at CIFA (Kanaujia et al. 2002) were hung into the tank to provide shelter and hiding place to newly metamorphosed post larvae. The string shells were removed from the tank daily in the morning and stored in 10 l plastic tub filled in brackishwater of the same salinity as that of the larval rearing tank. Post larvae, hiding in between the shells came out and started moving into the water column of the tub. Ninety five per cent of the newly metamorphosed post larvae were harvested daily and the "shell string" were replaced in the larval rearing tank.

Acclimatization

The post larvae, produced in 18 ppt brackishwater were acclimatized to freshwater by gradual dilution of brackishwater by freshwater. This process was continued for about 1 hour until the salinity was zero. Thereafter post larvae were counted and released into the nursery tank for raising to juveniles.

Statistical Analysis

The data of PL production were subjected to Duncan Multiple Range Test (DMRT) to find out the significant variations among the four trials following Gomez and Gomez 1984.

Results and Discussion

Maturation

The Ganga river prawn *M. gangeticum* attained maturity at a minimum size of 85 mm total length and 15 g wt. The male and female breeding activities occur from June to October. The first berried female was recorded in the first week of June, with a peak in August and continued until the end of October. The first distinct sign of maturity in individual female was observed at a minimum size of 85 mm. The entire process of ovarian development observed is presented in table I. This is categorized

into five stages (0, I, II, III and IV) based on coloration and relative size of ovaries in the cephalothorax with stage IV indicative of the empty ("spent") ovary following spawning. The immature (stage 0) and initial maturing ovaries (stage I) were small, transparent, slightly faint and milky in colour. This could be easily observed dorsally at the juncture between cephalothorax and first abdominal segment after bending female from cephalothorax and tail region. The developing ovaries at stage II were visible externally as a bright yellow colour mass extended anteriorly to the base of the last rostral spine. The fully mature gonads during stage III were a pair of fused large ovaries with yellow green coloured mass occupying the entire dorso-lateral region of cephalothorax. The posterior ends started from the first abdominal segment penetrated between the muscular masses whereas the anterior ends extended up to the base of the last rostral teeth.

Table 1. Colour and relative size of the ovaries during different developmental stages in *M. gangeticum* females

Stage	Ovary stage	Colouration	Relative size
0	Immature	Clear and transparent	Very small
I	Early maturating	White	Small
II	Maturing and developing	Light yellowish green	Moderately occupied 3/4th portion of carapace, large, extended to the base of the last spine of rostrum
III	Mature (ripe)	Deep yellow green	Large, occupying the entire space of carapace cavity
IV	Spent	White and transparent	Very small

The ovaries remain immature during regular non-nuptial molt (stage 0). The ovary was immature just before the nuptial pre-mating molt and its colour changed to a light "milky white" (stage I). After stage I, ovarian development progressed quickly. It took approximately 9.5 days to reach stage II and the developing ovarian masses become visible through carapace. Approximately 4 days later the anterior end of the ovaries reached to the base of the last spine of the rostrum (stage III). The fully matured ovaries (stage III) attained an average size of 12.1 ± 4.1 mm and the anterior end of ovaries prolonged to the base of the second or third last spine of the rostrum. After the female released her eggs, her ovaries displayed either stage 0 or I characteristics. The entire process of ovarian development was found to be similar to *M. rosenbergii* and *M. malcolmsonii*, which have also been classified into five stages (including the "spent" 1st stage) based on coloration and relative size of the ovaries occupied to the cephalothorax (Kanaujia et al. 2000).

The maturation and breeding of *M. gangeticum* recorded under captive conditions from June to October is similar to that of *M. malcolmsonii* in a

natural riverine environment (Ibrahim 1962; Rajyalaxmi 1980; Kanaujia 1989). However, the maturation and breeding procedure was slightly different from that of *M. rosenbergii* which breeds and spawns year-round in natural riverine habitat depending on the environment temperature (New and Singholka 1985). All the three larger *Macrobrachium* species may breed and spawn year-round under captive condition when the ambient temperature is controlled (Kanaujia 1999). The size at which *M. gangeticum* matured in this work was approximate 85 mm (5.4g) under captive rearing after transportation of the stock from river Padma (Lalgola). The berried females 65-75 mm size collected from the river Ganga around the city of Farrakka were found to mature under similar condition. These observations are similar to that of *M. malcolmsonii*, which mature, breed and spawn at the size of 60–75mm (Ibrahim 1962; Rajyalaxmi 1980; Kanaujia, 1989). *M. rosenbergii* grows, matures and spawns at a minimum size of 80 mm (New and Singholka 1985). Some other large prawn species attain maturity at the same size but differed in breeding and spawning activities (Wickens 1972). The stages of ovarian development and maturation in *M. gangeticum* are similar to that of *M. rosenbergii* as reported by Damrongphol et al. (1991). The colour of eggs just after spawning in *M. gangeticum* was found to be mostly yellow or yellowish green whereas in *M. rosenbergii* it is orange yellow (Damrongphol et al. 1991; Kanaujia and Mohanty 1992; Kanaujia et al. 2000). In both *M. gangeticum* and *M. malcolmsonii* the colour of eggs are mostly yellow (Kanaujia 1995, 1999; Kanaujia et al.2000).

Breeding and spawning

Individual female of *M. gangeticum* did not breed during March, April and May. Breeding started in June and reached a maximum in August and September, continuing until the end of October. The mating behaviour was observed as follows. Once the female had undergone the pre-mating molt, the matured female was “inactive” for a few seconds. The male then approached the female as she became active and the pair moved together. At the time of mating, the male chased the female and captured her and encompassed the female between his two long second chelate legs. The male then ejaculated a sticky gelatinous spermatophore mass between the female’s third thoracic appendages near the gonophore. The male and female then separated and moved to a corner of the aquarium. During this time, the body of the female bends slightly dorso-ventrally to form an open ‘U’ shaped structure. In addition the elongated ventro-lateral pleura of the abdominal segments exposed to form a “brood chamber”. At the time of spawning, the female releases her eggs into the brood chamber located on the ventral surface of her body. The release of the eggs is initiated when a yellow mass can be seen in the oviduct tube leading from the ovary to the genital pore opening. The eggs became rounded after leaving the female genital

pore during spawning process. The extruded eggs first accumulates near the fourth pleopods with the help of appendix interna and continue to accumulate along the abdominal surface to be deposited up to the first pleopods. Once spawning is complete and the brood chamber is filled with eggs, the female carrying fertilized green yellow eggs is termed a "berried female". In the brood chamber a sticky substance holds the eggs together so that the egg mass resembled a "bunch of grapes".

The breeding and spawning behaviour observed in *M. gangeticum* was similar to that observed in *M. rosenbergii*, *M. malcolmsonii* and other *Macrobrachium* spp. (Uno and Sao 1969; Kanaujia and Mohanty 1992). The fertilized eggs carried by the females were displayed for embryonic development until the hatching of first stage zoea appeared on the 13th day after the spawning. Hatching occurred during night hours and continued until the middle of the next morning. The hatching process of *M. gangeticum* was different from those of *M. rosenbergii* and *M. malcolmsonii*. In *M. rosenbergii*, hatching starts at night and is completed on second night or second day. Whereas, in healthy *M. malcolmsonii* berried females, hatching starts at night and is completed during the same night (Ling 1969; Fujimura and Okomoto 1972; Kewalramani et. al. 1971; New and Sigholka 1985; Kanaujia and Mohanty 1992; Kanaujia 1995, 1999).

Embryonic development and hatching

In this study, berried females were transferred to a 100 l glass aquarium containing brackishwater of 5 ppt salinity. The embryonic development in the eggs was accompanied by a gradual change in the colour of eggs from green yellow to grey by the 11th day. The hatching process started during the middle of the night between 23-24 hrs and completed on the next day in approximately 12 hrs. The hatching of zoea I started on the 13th day and continued during the night hours. At the time of hatching, movement of zoea could be observed inside the eggshell; the zoea was appeared to stretch its body. Ultimately the eggshell was broken under the pressure created by the rostrum and appendages of the larvae. The zoea hatched with a powerful flex into the water column and then started moving actively. The zoeae are planktonic in nature and are attracted to light.

Larval activity

The larvae were transparent, translucent and displayed spots of red and blue chromatophores during the early developmental stages. The colour deepened in later stages and was found only on some portions of the body. The larvae displayed a "churning movement" during the early stages. In the later stages, the larvae were found to move along the side of the tank as well as in the water column. The later

stage larvae were very active and displayed darting movements along the side of the tank. The advanced larvae appeared to be more active compared to similar stages in *M. rosenbergii* and *M. malcolmsonii* whose larvae display "calmer" moving behavior. (Fujimura 1969; Kanaujia 1995).

The larvae of *M. gangeticum* in all their 11 larval stages were active and displayed the "churning" movement moved up side down with their tail up and the head down obliquely into the water column in the tank. Such behavior was similar to those of *M. rosenbergii* and *M. malcolmsonii* (New and Singholka 1985; Kanaujia and Mohanty 1992). The "shooting" movement in advanced stage larvae (stages X and XI) observed in *M. gangeticum* is not as extensive as that observed in *M. rosenbergii* and *M. malcolmsonii* (Ling 1969; Uno and Sao 1969; Kanaujia 1999; Kanaujia and Mohanty 1992). Mortality of the advanced larvae due to their being stranded above the water column on the side of the tank, in the *M. gangeticum* was comparatively less than *M. rosenbergii* and *M. malcolmsonii*. This mortality can be prevented by providing aeration along the side of the tank to discourage the larvae from coming near to the side (Kanaujia and Mohanty 1992; Kanaujia 1995, 1999; Kanaujia et al. 1998b).

Larval food and feeding

Initially early larvae were fed with *Artemia* nauplii for one week applied with light on at one corner of the tank. The larvae are phototropic and concentrated at one place, which allowed them to catch the *Artemia* nauplii easily and frequently. After one week the larvae were fed with fine cut pieces of mussel meat and egg custard sieved through appropriate mesh. The Artemia nauplii and fine particles of egg custard and mussel meat (0.006 – 2.2 mm) used as food were readily accepted by the larvae. The larvae feed voraciously, grew faster and passed through all 11 larval stages to display the first post-larval stage within 22 and 30 days. This is more or less similar to *M. rosenbergii* (New and Singholka 1985). However, such propensity in feeding is not observed in the larval stages of *M. malcolmsonii*, whose larval growth can be prolonged for 40-60 days before attaining post-larval stage (Kanaujia and Mohanty 1992). Even though the three feed items used in this study have shown good results, other foods such as rotifer – *Brachionus plicatilis*, the frozen copepods *Cyclops* sp. *Diaptomus* sp. *Moina*, and processed encapsulated diets could prove to be effective in small hatcheries (New and Singholka 1985).

Water quality

Water quality parameter values were recorded bi-weekly and were found to be similar during four experimental trials. The ambient temperature ranged from 27-

31°C with an average of 29.0°C. The water salinity was maintained between 16-18 ppt. Dissolved oxygen levels varied from 2-6 ppm. Ammonia nitrogen and pH levels were maintained within 0.10 – 0.02 ppm and 7.5-9.0 respectively with the air-lift bio-filter recirculatory system. Initially the total hardness was found to be 2000 ppm as $CaCO_3$ but increased up to 5000 ppm following the water provision, feed and $CaSO_4$ treatment. A slight increase in salinity due to water evaporation was observed and slight decreases in dissolved oxygen from the saturation level was noticed from time to time. However, with the additional use of more air diffusion stones for the aeration the DO level remained at desired levels, the water pH remained at 7.8 – 8.2. The ranges of water quality parameters recorded in this study were very close to those used in *M. malcolmsonii*. The salinity range from 16-18ppt accounted for the best survival and growth of the larvae of *M. gangeticum* in this study. Salinity ranges of 12 – 16 ppt and 18 – 20 ppt reported to be of optimal ranges (Kanaujia and Mohanty 1992; Kanaujia 1995, 1999; Kanaujia et al. 1996, 1998) for *M. rosenbergii* and *M. malcolmsonii* respectively.

Larval growth and development

The distinguishing characteristics of each larval stage observed under a compound microscope are presented in table 2. These are more or less similar to those observed in *M. rosenbergii* and *M. malcolmsonii*. However, the presence of red chromatophore on the entire merus region of the 2nd chelate legs from stage V to stage XI, an important distinguishing characteristic of *M. gangeticum* is absent in *M. rosenbergii* and *M. malcolmsonii*. (Uno and Sao 1969; Kanaujia and Mohanty 1992). The data relating growth increment, molting and duration of each larval stage are presented in table 2 and figure 1. As many as 18 molts were recorded during its larval life cycle. The larvae underwent one molt from each subsequent stage from stage I to stage V, five molts between stage V and stage VI, one molt between each stage from stage VI to XI and two molts between stage XI and PL. The larval growth rate was slower at early stage from stage I to VI, and thereafter increased gradually up to post larval stage. The appearance of the first post larvae (scout PL) in the experimental trails was between 22 – 26 days. This duration was prolonged in smaller units undertaken in 250 – 500 ml beakers. The size of the first stage zoea ranged from 1.55 – 2.05 mm with a mean of 1.8 mm. Subsequently a gradual increase in size was recorded from stage VI onward. The growth increment was found much higher from stage V to VI registering maximum frequency of molting. The larvae gained maximum growth at stage VI as larval stage V had undergone more than five molts. The increase in length increment at each larval stage was a minimum 0.2 mm at stage VII, 0.4 mm at stage II, maximum of 1.1 mm in stage VI and 1.3 mm in PL. The total duration from stage I to PL was 22 days, out of which the larvae spent 5.5

days at stages V to VI, by 2.0 days at stages X to XI and 2.5 days at stages XI to PL (Table 2 and Fig. 1).

Comparison with other species

The progressive increase in size from stages I – V and stages V – VI and the attainment of the stage PL in *M. gangeticum* is found to be similar to those reported in *M. malcolmsonii* and *M. rosenbergii* (New and Singholka 1985; Rao 1991; Kanaujia and Mohanty 1992; Kanaujia 1999). As indicated in table 2 and figure 1, the duration taken for attainment of stage V was 6 days in *M. gangeticum*. *M. gangeticum* attained stage VI in 11.5 days in contrast to the attainment of a similar stage *M. malcolmsonii* and *M. rosenbergii* which took as long as 17 days (Uno and Sao 1969; Kanaujia and Mohanty 1992). The duration in *M. gangeticum* from stage I to PL was more or less uniform in each stage and the PL stage was reached within 22 days of hatching whereas in *M. malcolmsonii* and *M. rosenbergii* the larval cycle duration was reported around 30 and 40 days respectively.

The rates in the increase in size of the larvae of *M. gangeticum*, *M. malocomsonii* and *M. rosenbergii* are uniform up to stage V approximately. Thereafter these species displayed PL stage sizes of 8.5 mm (*M. gangeticum*), 10 mm (*M. malcolmsonii*) and 7.4 mm (*M. rosenbergii*). These variations in size at different larval and PL stages could be due to fluctuation in amount of food, nutrients value, size and health of mother (New and Singholka 1985; New and Valenti 2000; Kanaujia 1999). Kewalramani et al. (1971), Rao (1991) and Kanaujia and Mohanty (1999) recorded 11 – 16 molts and eleven zoeal stages in *M. malcolmsonii*, *M. rosenbergii* displays 10 molts during larval stages development including the molt from the terminal larval stage X to PL stage (New and Singholka 1985). In some Palaemon species, 7 – 10 zoeal stages are reported before attainment of post-larvae (Gamba 1998). The number of molts appears to be influenced by water quality, temperature and feeding management in *M. malcolmsonii* and *M. rosenbergii* (New and Singholka 1985; Kanaujia and Mohanty 1992, 1999; New and Valenti 2000).

Post-larval production

Daily harvests of post-larvae of *M. gangeticum* were obtained from the four trails. Each trial lasted for a period of 60 days representing the duration of the larval cycle. The daily post-larval metamorphosis, cumulative PL harvest and percentage of post-larval production on each 5th day of *M. gangeticum* were recorded during the larval cycle and presented in table 3, and figures 2 and 3. Maximum post larvae metamorphosis occurred within 36 – 37 days (Table 3). The occurrence of the scout PL was observed between the 22nd and 26th days. The cumulative percentage of

Table 2 . Progressive increase in size, growth increment, age (days) and characteristic features of each larval stages in *M. gangeticum* in this study

Stages	Size (mm)	% growth increment	Duration (day)	Cumulative duration (day)	Distinguishing characteristic features of each larval stage
I	1.8	0.0	0	0	Eyes sessile, black in the middle, periphery brownish; telson triangular, fan shaped.
II	2.2	5.97	1.5	1.5	Eyes stalked
III	2.7	7.96	1.5	3.0	One dorsal rostral tooth, uropod appeared.
IV	3.3	8.95	1.5	4.5	Two dorsal rostral teeth, uropod biramous.
V	3.7	5.97	1.5	6.0	Two dorsal rostral teeth, telson narrower elongated, red chromatophore on entire merus region of second chelate legs.
VI	4.8	16.42	5.5	11.5	Telson narrowed and elongated terminally, buds of pleopod appeared (2, 3 & 4 more prominent), red chromatophore on entire merus region.
VII	5.0	2.98	1.5	13.0	Pleopods biramous, bare and 2, 3 & 4 are more prominent, red chromatophore on entire merus region of second chelate legs.
VIII	5.5	7.46	1.5	14.5	Pleopods with setae and red chromatophore on entire merus region of second chelate legs
IX	6.0	7.46	1.5	16.0	Endopods of pleopod with appendices internas and red chromatophore on entire merus region of second chelate legs
X	6.5	7.46	1.5	17.5	Two big dorsal rostral teeth and one small tooth between tip of the rostrum and second big dorsal rostral teeth. Red chromatophore is persisting on entire merus region of the second chelate legs.
XI	7.2	10.44	2.0	19.5	Rostral teeth on its entire dorsal region of rostrum. Red chromatophore is peristing on entire merus region of the second chelate legs. Larva is fully developed at this stage and ready to transform into post larvae.
PL	8.5	19.40	2.5	22.0	Entire dorsal and ventral side of rostrum covered with teeth, behaviour of swimming like adult.

larvae achieving the PL stage varied among the four Trials on the fifth day of larval rearing (16.3% in trial 1, 62.72% in trial 2, 7.21% in trial 3 and 32.44% in trial 4). By the end of 50 days of rearing, the percentages of PL metamorphosis were 79.74%, 95.73%, 66.47% and 85.19% in trials 1, 2, 3 and 4 respectively and at the 60th day, a little over 90% PL were metamorphosed in the four trials (Table 3). These PL

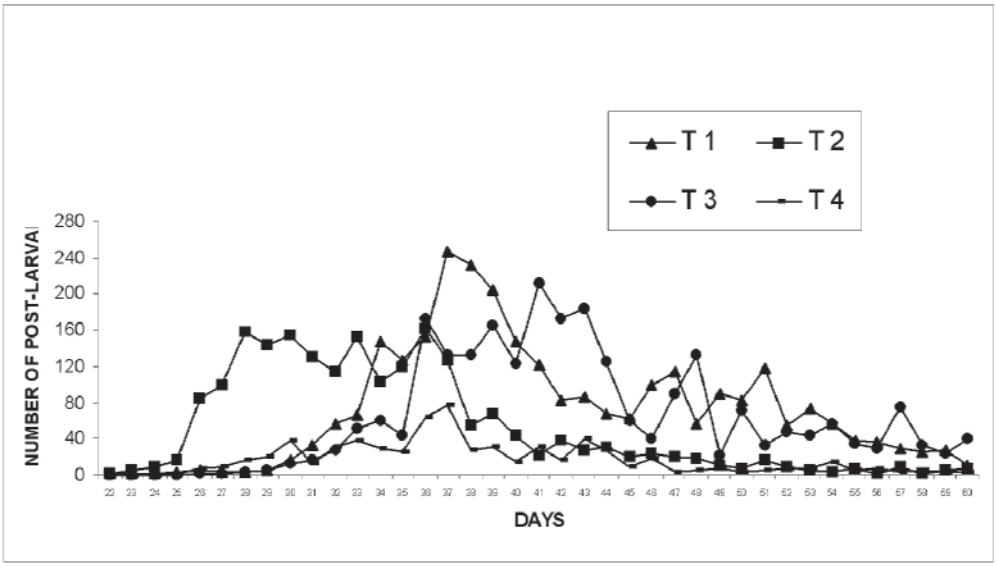

Fig. 2. The number of post-larva harvested each day after the first appearance of a scout PL (day 22) until the completion of trial (day 60) of *M. gangeticum*

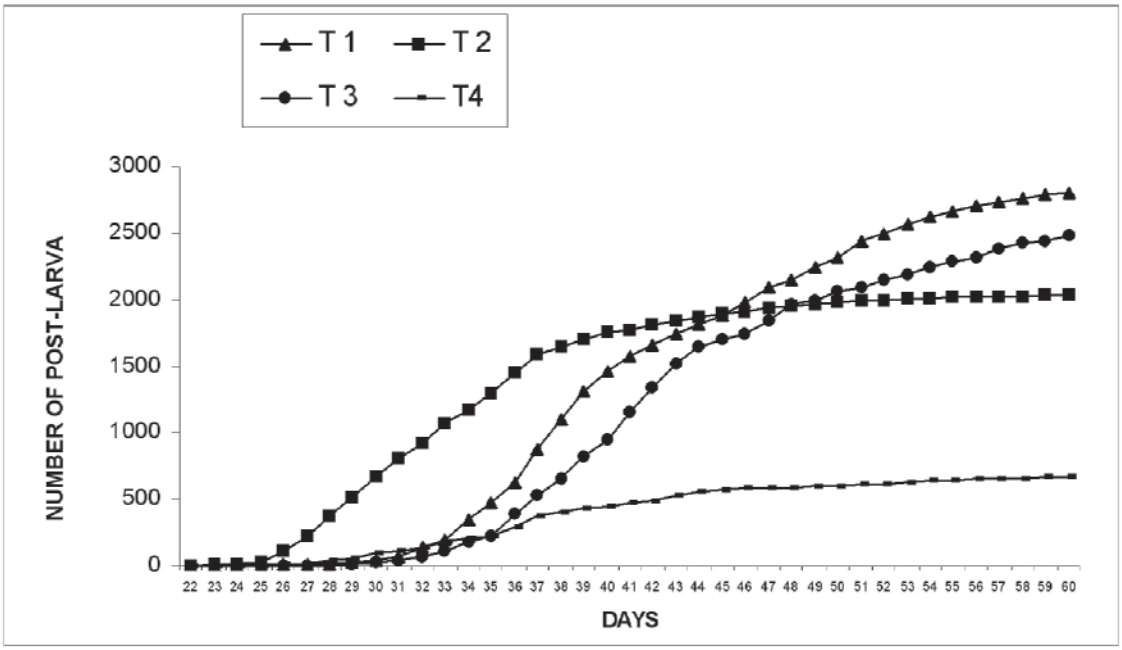

Fig. 3. Cumulative number of post-larvae in four trials in *M. gangeticum*

Table 3. Post–larval (PL) production in four larval culture Trials of *M. gangeticum*

Days	Trial -1 (Lalgola, River Padma)			Trial -2 (Patna,River Ganga)			Trial -3 (Farakka,River Ganga)			Trial - 4 (Farakka female X Lalgola mal		
	PL	C.PL	%	PL	CPL	%	PL	C.PL	%	PL	C.PL	%
22	1 (OFPL)	1		2(OFPL)	2							
23	1	2		5	7							
24	2	4		10	17							
25	3	7	0.24	16	33	1.59			0	1 (OFPL)	1	0.14
26	5	12		84	117		1(OFPL)	1		7	8	
27	3	15		100	217		2	3		10	18	
28	4	19		159	376		3	6		17	35	
29	6	25		143	519		5	11		20	55	
30	16	41	1.40	154	673	32.62	12	23	0.74	38	93	13.11
31	34	75		130	803		17	40		12	105	
32	58	133		115	918		27	67		32	137	
33	66	199		153	1071		51	118		38	175	
34	148	347		104	1175		61	179		30	205	
35	128	475	16.30	119	1294	62.72	45	224	7.21	25	230	32.44
36	153	628		163	1457		173	397		64	294	
37	247	875		128	1585		133	530		77	371	
38	232	1107		55	1640		132	662		27	398	
39	204	1311		69	1709		166	828		31	429	
40	148	1459	50.08	45	1754	85.02	123	951	30.62	14	443	62.48
41	121	1580		22	1776		211	1162		31	474	
42	82	1662		38	1814		173	1335		16	490	
43	86	1748		27	1841		184	1519		40	530	
44	68	1816		31	1872		126	1645		27	557	
45	62	1878	64.46	21	1893	91.75	61	1706	54.94	9	566	79.83
46	99	1977		24	1917		41	1747		19	585	
47	115	2097		21	1938		91	1838		3	588	
48	58	2150		18	1956		132	1970		5	593	
49	91	2241		11	1967		23	1993		8	601	
50	82	2323	79.74	8	1975	95.73	71	2064	66.47	3	604	85.19
51	118	2441		17	1992		34	2098		6	610	
52	56	2497		9	2001		48	2146		8	618	
53	74	2571		5	2006		45	2191		7	625	
54	58	2629		3	2009		57	2248		14	639	
55	39	2668	91.58	8	2017	97.77	35	2283	73.52	5	644	90.83
56	37	2705		2	2019		30	2313		8	652	
57	29	2734		9	2028		75	2388		4	656	
58	25	2759		2	2030		34	2422		6	662	
59	28	2787		5	2035		24	2446		4	666	
60	11	2798	96.05	7	2042	98.98	41	2487	80.09	4	670	94.49
Total	2798 + 115 AL = 2913 9.3 PL / L			2042 + 21 AL = 2063 6.8PL / L			2487 + 618 AL = 3105 8.64 PL / L			670 + 39 AL = 709 2.22 PL / L		

PL/L = Post larvae per litre,
AL = Advance larvae,
CPL = Cumulative post larvae,
OFPL = Occurrence of first post larvae

production data were consistent in each trial and the small variations among the trials were most likely due to random error and management differences. The production (PL/l) was somewhat consistent among the four trials (2.22-9.31 PL/l) but much lower than the 30 – 50 PL/l reported for other species (Malecha 1983; New and Valenti 2000).

The scout PL emerged between the 22nd and 26th days in *M. gangeticum*. The average number of PLs harvested per day was significantly different ($P<0.05$) among the four individual tanks (Table 3 and Figure 3). The duration for hatching of zoea stage I in individual berried females usually occurred within 18 hrs but, wide variations (35 – 40 days) were observed. Three of the four trials showed very little variation in post-larval production (PL/l) expect in the fourth trial, which was significantly less ($P<0.05$) than the others. In Trial 1, the berried female used was raised under outdoor conditions and yielded maximum post-larval production (2798 PL). The female in Trial 3 from the river Ganga near Farakka yielded 2487 PL followed by the female in Trial 2 collected near Patna (2042 PL) and the cross bred berried female in Trial 4 which yielded 670 PL. The number of PLs obtained from the cross bred berried female (Trial 4) was significantly lower than in the other trials of the female mother prawn which was very small. Gomez-Diaz and Ohno (1986) and Angell (1992) have shown that parental history affects larval performance.

Conclusion

The major contribution of this work is the first production of 7997 post-larvae of *M. gangeticum* in India, with considerably shorter duration (22 – 50 days) larval cycles and scout PL appearance times of 22 days as compared to *M. rosenbergii* (30 – 50 days) and much ahead of *M. malcolmsonii* (40- 60 days). This suggests that *M. gangeticum* species could be used for commercial freshwater prawn production.

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References

Angell, C. L. 1992. Inland freshwater prawn hatcheries: introducing a new technology in Bangladesh. Bay of Bengal News 48 : 15-18.

APHA. 1985. Standard methods for the examination of water and wastewater 16th edn. American Public Health Association, Washington D.C. 1260pp.

Bate, C.S. 1868. On a new genus with four new species of freshwater prawn. Proceedings Zoological Society, London 1868: 363 – 368, pls. 30, 31.

Damrongphol, P., N. Eangchuan and B. Poolsanguan. 1991. Spawning cycle and oocyte maturation in laboratory maintained giant freshwater prawn (*Macrobrachium rosenbergii*). Aquaculture 95 : 347 – 357.

Fujimura, T.and H. Okamoto. 1972. Notes on progress made in developing a mass culturing technique for *Macrobrachium rosenbergii* in Hawaii. In: Coastal aquaculture in the Indo – Pacific Region (ed. T.V.R. Pillay). West Byfleet, England, Fishing News Books Ltd., for IPFC/ FAO, pp. 313 – 327.

Gamba, A.L.1998. The larval development of a freshwater prawn *Palaemon pandaliformis* (Stimpson.1871) under laboratory condition (Decapoda, Palaemonidae). Crustaceana 71(1): 1–35

Gomez, A. K. and A. A. Gomez. 1984. Statistical Procedures for Agricultural Research, 2nd edition, a Wiley-Interscience Publication, New York, 680 pp.

Gomez Diaz G. and A. Ohno. 1986. Possible significance of rearing conditions of ovigerous *Macrobrachium rosenbergii* In: Proceedings of the first Asian Fisheries Forum, Manila Philippines, 26 – 31 May 1986 (ed. J.L. Maclean.,L.B. Dizon and L.V. Hosillos). Asian Fisheries Society. Manila Philippines pp. 45 – 48.

Ibrahim, K.H. 1962. Observations on the fishery biology of the freshwater prawn *Macrobrachium malcolmsonii* (H.M.Edwards) of river Godavari. Indian Journal of Fisheries. 9(2) A: 433-467.

Jhingran,V. G. 2003. Fish and Fisheries of India. (revised 3rd edition) Hindustan Publishing Corporation (India) Delhi.725pp.

Kanaujia, D.R. 1989. Biology of *Macrobrachium malcolmsonii* (Ed.) from river Ganga, In: Proceedings National Semimar on Freshwater Aquaculture. Central Institute of Freshwater Aquaculture Bhubaneswar (India): 54 – 55.

Kanaujia, D.R. 1995. Emerging technologies in seed production of *Macrobrachium malcolmsonii* (H.M. Edwards), In: Proceedings National Seminar in Current and Emerging Trends in Aquaculture and its Impact on Rural Development, 14 – 16 Feb, College of Fisheries, OUAT, Rangailunda: 48 - 59.

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

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

Kanaujia, D.R. and A.N. Mohanty. 1999. Role of temperature variation on larval growth and post larval production of *Macrobrachium malcolmsonii* (H.M. Edwards) Journal of Aquaculture in Tropics. 14 (3) : 187 – 192.

Kanaujia, D.R., K.C. Pani and A.N. Mohanty. 1996. Seed production of *Macrobrachium malcolmsonii* (H.M. Edwards) in synthetic seawater. Journal of Aquaculture in Tropics. 11 : 259 –262.

Kanaujia, D.R., A.N. Mohanty and K.M. Das. 1998b. Recycling of used water for seed production of *Macrobrachium malcolmsonii* (H.M. Edwards). Journal of. Aquaculture in Tropics.13

(3): 223 – 232.
Kanaujia, D.R., B.K. Das and A.N. Mohanty. 1998a. Mass larval mortalities in Indian river prawn *Macrobrachium malcolmsonii* (H.M.Edwards) under hatchery condition and their control by application of antibiotics. Journal of. Aquaculture in Tropics. 13(3): 171-179.
Kanaujia, D.R., J. Mahapatra, M. Mohanty and A.N. Mohanty. 2000. Effect of uni-lateral eyestalk ablation on molting and ovarian development in *Macrobrachium malcolmsonii*. Aquacult. 1 (2) :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 (1): 28 – 30.
Kanaujia, D.R., A.N. Mohanty and S. Soni, 2002. Trends in post-larval metamorphosis of Indian river prawn *Macrobrachium malcolmsonii* and Ganga river prawn *Macrobrachium gangeticum* and technique for effective harvesting of post-larvae under hatchery condition, Fishing Chimes.22 (1): 117-119.
Kewalramani, H.G., K.N. Sankolli and S.S. Shenoy 1971. On the larval life history of *Macrobrachium malcolmsonii* (H.M.Edwards) in captivity. Journal of Indian Fisheries Association. 1(1) : 1-25.
Ling, S. W. 1969. The general biology and development of *Macrobrachium rosenbergii* (de Man) FAO Fisheries Report. 57 : 589 – 606.
Malecha, S. R. 1983. Commercial seed production of freshwater prawn *Macrobrachium rosenbergii* in Hawaii. CRC Handbook of Mari culture. Crustacean Aquaculture. (ed. J.P. Mc Vey) pp. 205-230. CRC Press Plve. BOCA Raton, Fl. USA.
New, M.B. 1995. Status of freshwater prawn farming: a review; Aquaculture research, 26: 1 - 54
New, M.B. and S. Singholka. 1985. Freshwater Prawn Farming. A Manual for the Culture of *Macrobrachium rosenbergii*. FAO Fisheries Technical Paper. (225) Rev. 1: 118pp.
New, M.B. and W.C. Valenti. 2000. Freshwater Prawn Culture. The farming of *Macrobrachium rosenbergii*. Blackwell Science. Ltd. Oxford, London, England. 443 pp.
Rajyalaxmi, T. 1980. Comparative study of the biology of the freshwater prawn *Macrobrachium malcolmsonii* of Godavari and Hoogly river system. In : Proceeding Indian National Science Academy. 46 (1) : 72-89.
Rao, K.J. 1991.Breeding and larval rearing of the freshwater prawn *Macrobrachium malcolmsonii* (H.Milne Edwards), Journal of Aquaculture in Tropics. 6 : 99-106.
Tiwari, K.K. 1949. On a new species of Palaemon from Banaras with a note on *Palaemon lanchesteri* (de Man). Records Indian Museum. 45 (4): 333-345.
Tiwari, K.K. 1955 . Distribution of the Indo-Burmese freshwater prawns of the genus *Palaemon* (Fabr) and its bearing on the Satpura hypothesis. Bulletin National Institute Sciences India, 7: 230-239, Figs. 1-3.
Tiwari, K.K. and L.B. Holthuis. 1996. The identity of *Macrobrachium gangeticum* Bate 1868 (Decapoda, Caridea, Palaemonidae). *Crustaceana*. 69 (7): 922 - 925.
Tripathi, S. D. 1991. Status of Freshwater prawn fishery and farming in India. Proceeding on the National Symposium on Freshwater prawn (Macrobrachium species), Kerala Agriculture Univercity , Faculty of Fisheries Kochi, 12-14 December, pp42-49.
Uno, U. and K. C. Sao. 1969. Larval development of *Macrobrachium rosenbergii* (de Man) reared in the laboratory . Journal of. Tokyo. Univ. Fish., 55 (2) : 179 – 190.
Wickins, J.F. 1972. Experiment on the culture of the spot prawn *Pandalus platyceros* and the giant freshwater prawn *Macrobrachium rosenbergii*. Fisheries Investigation Ministry of Agriculture. Fish Food G.B. (2 Sea Fish.), 27 (5): 23p.