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Comparison of the Growth Potential of *Macrobrachium rosenbergii* in Mono and Polyculture Conditions in Earthen Culture Ponds of Jammu, India

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Abstract

The study was conducted to assess the growth and survival of *Macrobrachium rosenbergii* in earthen culture ponds in order to know about the growth potential of *M. rosenbergii* in mono as well as polyculture conditions in Jammu. Polyculture experiments of prawn with some selected carps Indian Major Carps (*Cirrhinus mrigala* and *Labeo rohita*) and Exotic Carps (*Cyprinus carpio*) were undertaken in 3 freshwater ponds for duration of 4 months. Under the monoculture conditions, prawns attained an average size of 10.40 ± 0.17 cm weighing 23.84 ± 0.32 g in 4 months and the survival rate was found to be more than 75%. The growth rate of prawns was found to increase steadily during the first half (upto mid-October) after which a decline in the growth rate was evident as the mean temperature reached below 18°C. In the polyculture ponds the prawns attained an average size of 10.10 ± 0.03 cm weighing 18.39 ± 0.89g (without *C. carpio*) and 8.4 ± 0.36 cm weighing 15.23 ± 0.36 g (with *C. carpio*) in 4 months and their survival rate was less than 70%. Prawns being benthic feeders utilized the leftover food (of the fishes) that settled at the bottom, therefore, saving the feed cost. It was observed that mean size of the fish attained in the polyculture practice was almost similar to that obtained in the monoculture. The ideal prawn polyculture should be practiced with fast growing compatible carps such as Rohu and grass carp. Bottom feeder carps such as Mrigal (*C. mrigala*) should be avoided in prawn polyculture practice as they compete with prawns in feeding.

Keywords: Indian Major Carps and Growth, Monoculture, *M. rosenbergii*, Polyculture

Abbreviations used: (**T_1**- Only *M. rosenbergii*), (**T_2**-*M. rosenbergii, C. mrigala* and *L. rohita*), and (**T_3**-*M. rosenbergii, C. mrigala, L. rohita* and *C. carpio*). **(MR-I)** Monoculture and **(MR-II)** in Polyculture with two carps and **(MR-III)** with three carps. **(MR)** *M. rosenbergii*, **(CM)** *C. mrigala*, **(LR)** *L. rohita* and **(CC)** *C. carpio*.

1. Introduction

Macrobrachium rosenbergii (de Man, 1879)[1] is a freshwater prawn, commonly known as 'Scampi' or 'giant freshwater prawn' commonly distributed in fresh as well as in brackish water and estuaries[2]. The production of freshwater prawn *M. rosenbergii* gained popularity since 1995 and China is the topmost producer followed by India, Thailand and Bangladesh[3]. India being the second largest contributor of freshwater prawns to the world market has undergone a phenomenal growth in the past two decades. Freshwater prawns are important in the capture and culture fisheries and are extensively distributed in freshwater and estuaries of the world mostly in tropical and subtropical areas. Freshwater prawn culture is an aquaculture business designed to raise and produce freshwater prawn for human consumption[4].

Out of 125 species of *Macrobrachium*, only a small number (*M. rosenbergii, M. malcolmsonii, M. birmanicum*, *M. choprai* etc.) have been exploited from the culture point of view. The giant freshwater prawn *M. rosenbergii* dominates the shell fish production currently because of its faster growth and adaptation to the environment and acceptance of artificial feed. The desire to culture *M. rosenbergii* has persisted since the first success at controlled production of juveniles of this prawn was achieved[5]. Minimizawa and Morizane (1970)[6] successfully cultured all larval stages using newly hatched nauplii of brine shrimp. Later, monoculture[7] and polyculture with a

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variety of fish species[8] have been successfully undertaken. The culture of freshwater prawn is very popular in South East Asian countries and South American countries. Moreover, the polyculture of *M. rosenbergii* with Chinese and Indian major carps have been reported from different parts of the world in recent years[9–11]. Ranjeet and Kurup (2002)[12]. reported that *M. rosenbergii* is one of the most desirable candidate species for freshwater aquaculture in different parts of the Indo-Pacific region.

Several investigators[13,14] also witness successful rearing of fish and prawn larvae using live feed as exclusive diet. The breakthrough in its seed production and larval rearing technology has led to a new wave of enthusiasm among the prawn farmers for its monoculture and polyculture along with fish species like catla (*Catlacatla*), rohu (*Labeo rohita*) and mrigal (*Cirrhinus cirrhosus*). Paddy fields, homestead ponds and coconut garden channels are used for the culture of *M. Rosenbergii*[15]. *M. rosenbergii* is cultured either alone (monoculture) or in combination with carps (polyculture).

After studies on *M. Dayanum*[16–20] and establishment of *M. rosenbergii* for the last 8 to 9 years in Jammu[21,22] first attempt has been made to study the growth of *M. rosenbergii* under mono and polyculture conditions in earthen ponds of Jammu region, the Northern part of India.

2. Materials and Methods

2.1 Rearing Units and Procedure

Experiment was conducted in the field ponds at village Rakh, near Sarore, located at a distance of about 12 kilometres from Jammu City. The experiment was carried out for a period of 4 months (August to November, 2009).

2.2 Experimental Ponds and Culturable Species

Three ponds comprised an area of 0.2 hectare and 0.1 hectare i.e., one pond of 0.2 hectare and two ponds 0.1 hectare each were used for the study. Before stocking, the ponds were prepared by following all the conventional pre-stocking procedures. The ponds were completely drained and elimination of unwanted/predatory fishes was removed by hand picking. After drying, the ponds were maintained at 1.5 metre during the study period, compensating the loss of water due to seepage and evaporation of water. The fertilization was carried out with application of cow dung at the rate of 10 tons/hectare/year; one fifth of which was applied two weeks prior to stocking of fish fries and prawn larvae as basal dose. The remaining amount was applied in equally divided doses at fortnightly intervals. Further inorganic fertilizers in the form of nitrogen and phosphates were applied fortnightly in split doses. Liming by $CaCO_3$ (Calcium Carbonate) was done at intermittent interval of one month at the rate of 80 kg/hect to maintain the desired pH of water and also for pond hygiene[23].

2.3 Stocking of Fish and Prawns

Larvae of *M. rosenbergii* (which were brought from CIFE sub centre Rothak in oxygen packed containers) were stocked in three different ponds with different densities of carps (*C. mrigala*, *L. rohita*, *C. carpio*) keeping the density of prawns (*M. rosenbergii*) constant and each density was treated as treatment. The experimental carps were brought from two different farms of the Jammu and Kashmir department of fisheries viz. National Fish seed farm Kathua and Gho-Manhasa Fish farm Jammu. Layout of the experiment designed is shown in the (Table A).

Table A. Layout of the experimental design for the mono and polyculture of *M. rosenbergii* with the Carps

Species	Stocking density/0.1 hectare		
	T_1 (MR-1)	T_2 (MR-2)	T_3 (MR-3)
M. rosenbergii	10000	10000	10000
C. mrigala	Nil	2000	2000
L. rohita	Nil	2000	2000
C. carpio	Nil	Nil	2000

Mean initial weight of prawns, *C. mrigala*, *L. rohita* and *C. carpio* were recorded and pieces of pipes were placed in the pond for shelter.

2.4 Feed and Feeding Rates

Prawns and fishes were fed commercial fish feed jalpari and godrej. Composition of the feed given in the (Table B) twice a day at 10:00 and 15:00 hrs. The feeding quantity was adjusted at monthly intervals as per the biomass increase, as could be determined through intermittent sampling.

Table B. Proximate composition of the formulated feed used for both mono and polyculture of *M. rosenbergii* with the Carps

S. No.	Ingredients	Percentage (%)
1.	Proteins	27.5
2.	Fats	3.5
3.	Moisture	10.0
4.	Calcium	1.0
5.	Phosphorous	0.5
6.	Lysine	1.3
7.	Energy	2650 K Cal.

2.5 Monitoring of Water Quality Parameters

Various water quality parameters such as temperature, DO, pH etc. were monitored at regular intervals during the experimental period.

2.6 Growth Parameters and Survival

Various growth parameters were estimated at weekly intervals in terms of Body Weight Gain (BWG), Percentage Weight Gain (%WG), Average Individual Body Length (AIBL), Total Length Gain (TLG), Average Individual Body Weight (AIBW), Specific Growth Rate (SGR), Feed Conversion Ratio (FCR), Feed Conversion Efficiency (FCE) and Survival by using the following formulae:

TLG (cm) = Average Final Length – Average Initial Length.

BWG (g) = Average Final Weight – Average Initial Weight.

%WG (%) = (Average Final Weight – Average Initial Weight) × 100/Average Initial Weight.

SGR (%) = 100 × ln (Final live weight)-ln (Initial live weight)/Experimental period.

FCR = weight of feed consumed/weight gain of fish.

FCE = 1/(FCR).

Survival rate (%) = 100 × No. of organisms found at the end of experiment/Total No. of organisms stocked

3. Statistical Analysis

The data was analysed to test the level of significance with the help of Microsoft Excel and SPSS (12.0 version, Chicago, USA). The level of significance was tested by one way analysis of variance (ANOVA), Post Multiple Comparisons[24].

4. Results and Discussions

Growth performance of prawns in mono and polyculture systems with respect to weight gain (g), Specific Growth Rate (SGR) and survival were calculated as depicted in (Tables 1, 2 and 3). The *M. rosenbergii* larvae were stocked in three different treatments. As is evident from (Tables 1-3), the initial mean length of prawn larvae was 3.40 ± 0.17 cm, 3.80 ± 0.0.45 cm and 3.80 ± 0.10 cm respectively for 1st, 2nd, 3rd (MR-1, MR-2, MR-3) treatment. The final mean length at the end of the trial period showed differences among different treatments and it decreased with the treatment from 1st (MR-1) to 3rd (MR-3). The *M. rosenbergii* larvae under treatment 1st (MR-1) Monoculture, showed the highest final mean length (10.40 ± 0.173 cm) followed by the 2nd treatment, MR-2 i.e., Polyculture with two carp species (10.10 ± 0.30 cm) and lowest in the third treatment, MR-3 i.e., polyculture with three carp species (8.4 ± 0.360 cm). Further, it was observed that the final mean length under the treatment 1st (MR-1) was significantly different ($p \leq 0.05$) from the MR-3 but did not show any significant difference ($p \geq 0.05$) from MR-2. Moreover, MR-2 also differed significantly from the MR-3.

Similarly, the perusal of (Tables 1-3) reveals that the initial mean weight of prawn larvae was 0.57 ± 0.01 g, 0.59 ± 0.02 g and 0.47 ± 0.12 g respectively for 1st, 2nd and 3rd (MR-1, MR-2, MR-3) treatment. The final mean weight at the end of the trial period also showed great differences among different treatments and it decreased with the treatment from 1st (MR-1) to 3rd (MR-3). The *M. rosenbergii* larvae under treatment 1st (MR-1) showed the highest final mean weight (23.84 ± 0.32 g) followed by the 2nd treatment, MR-2 (18.39 ± 0.89 g) and lowest in the third treatment, MR-3 (15.23 ± 0.36 g). It was observed that the final mean weight under the treatment 1st (MR-1) was significantly different ($p \leq 0.05$) from the MR-2 and MR-3. Moreover, MR-2 also differed significantly from the MR-3. The results of percentage mean weight gain was also found to be highest in treatment 1st (MR-1) and found to be significantly different from MR-2 and MR-3.

The results found were in agreement with the findings of Chowdhury et al., (1991)[25] and Tidwell et al., (2004)[26] who also opined that the lowest stocking density gave relatively high growth. A wide variation in size, as observed in the present study is an uncommon phenomenon in *M. rosenbergii* as Fujimura and Okamoto (1970)[27] have reported an average weight of 13.5 g after ten months as well as in seven and half months period. Tunsutapanich et al., (1980)[28] have reported the same to be 42.1 g while Popper and Davidson (1982)[29] have reported 26.0 g of average weight of *M. rosenbergii* after a cultivation period of eight months. Shirgur et al.(1988)[30] recorded a wide variation in mean growth from 13.28 g to 28.9 g within seven months of culture duration. Raje and Joshi (1992)[31] achieved average weight from 33.0 g to 160 g in 9 to 10 months of culture period. Similar results were also found by Indulkar et al., (2007)[32] where average final weight of *M. rosenbergii* ranged from 41.7 g to 78.2 g in monoculture and 36.5 g to 50.4 g in polyculture ponds over a period of 8 months.

Results also revealed that the Specific Growth Rate (SGR) of prawns was found to be 3.108 ± 0.084, 2.88 ± 0.14 and 2.85 ± 0.11 for the treatment 1st (MR-1), 2nd (MR-2) and 3rd (MR-3) wherein higher SGR of *M. rosenbergii* started to decrease from treatment 1st to 3rd. Statistical analysis also reveals SGR of MR-1 to be significantly different from rest of the two whereas SGR of MR-2 and MR-3 do not show any significant difference among each other. These results are in full agreement with the results of Tidwell et al., (2004)[26]. Similarly, El-Sherif and Ali-Mervat (2009)[33] found in their results that the SGR decreased with increase in density. Haque et al., (2003)[34] on the other hand found a significant increase from low density to high density and similar pattern was also witnessed by some authors[25,35].

Survival at the end of the culture period was found to be 75.5 ± 5.0%, 62.10 ± 5.0% and 52.70 ± 5.0% in MR-1, MR-2 and MR-3 respectively. The survival rates of all the treatments were found to be significantly different ($p \leq 0.05$) from each other. In other words, survival rate of *M. rosenbergii* in monoculture was found to be more than polyculture. Under comparable conditions, Shirgur et al., (1988)[30] got 60.5% to 68.3% survival rate after 7 months and Raje and Joshi (1992)[31] could get 33% to 50% survival after 9 to 10 months of culture period. Similarly, according to Haque et al., (2003)[34], the highest survival rate (85%) of *M. rosenbergii* was recorded in treatment T_1 (15 prawn, 15 catla, 15 rohu and 15 mrigal) and lowest in case of T6 (40 prawn, 15 catla, 15 rohu, 15 mrigal), which might be due to the increase of stocking density. Hoq et al., (1996) reported the survival rate of prawn to range from 32.22% to 75.5%, which supports the present finding as well. Our results were also comparable with the results found by Hossain and Kibria (2006)[36] that got 70.0–76.3% of prawn survival and also with the values reported by many workers[37–39].

Table 2 revealed that *C. mrigala* shows significantly high growth than the *L. rohita* in polyculture set up. Further, (Table 3) shows maximum growth in case *C. carpio*, followed by *C. mrigala* and finally *L. rohita*. Statistically, values differed significantly from each other ($p < 0.05$). Bottom feeders (*C. carpio* and *C. mrigala*) performed better growth rate against that of *L. rohita* probably due to the fact that being surface and column dweller, *L. rohita* is more sensitive to oxygen depletion, while being bottom dwellers, *C. carpio* and *C. mrigala* are more tolerant to fluctuation of oxygen concentration[40]. Among bottom feeders, growth performance of *C. carpio* appeared to be much better than *C. mrigala* probably due to their superior feed utilizing capability[41]. Mohanty (2003)[42] however, while carrying out experiments to evaluate feed intake pattern, growth and yield performance of fish and prawn found that irrespective of stocking density, faster growth rate could be recorded in *C. catla* followed by *C. carpio*, *C. mrigala*, *L. rohita* and *M. rosenbergii*.

A comparative growth performance of all the species of fishes (Tables 1, 2 and 3) in terms of mean growth rate decreased with an increase in stocking density. This is probably due to the competition for food and space that caused physiological stress and relatively degraded water quality due to increased density and biomass[43,44]. Sinha and Ramachandran (1985)[45] also reported that under crowded conditions at higher stocking density, fish suffers stress due to aggressive feeding interaction, eats less and grows slow.

Our results are also in accordance with the findings of workers who opined that growth of fish in a given pond may be expressed as a function of stocking density and stress caused by low oxygen levels at higher stocking densities[46,47]. The growth rate of carps like *catla, rohu* and *mrigal* were also found to be highest in polyculture[48].

Specific Growth Rate (SGR) recorded in three carp species (Table 3) showed values ranging from 2.560 ± 0.091 to 3.150 ± 0.067 in different experimental ponds and were not statistically and significantly different from each other. Some authors have reported specific growth rate of 1.52 and 1.4 respectively in rohu fry fed with 40% protein level in the feed[49,50]. Mohanty et al., (1990)[44] however, have reported optimum protein requirement

Table 1. Growth and survival of *M. rosenbergii* in monoculture (MR-I) and polyculture with two carps (MR-II) and with three carps (MR-III) for 120 days

Parameters	MR-I	MR-II	MR-III
Initial Mean Length, IML (cm)	3.40 ± 0.173[a]	3.80 ± 0.458[a]	3.80 ± 0.100[a]
Final Mean Length, FML (cm)	10.40 ± 0.173[a]	10.10 ± 0.30[a]	8.4 ± 0.360[b]
Initial Mean Weight, IMW (g)	0.572 ± 0.011[a]	0.598 ± 0.028[a]	0.478 ± 0.121[a]
Final Mean Weight, FMW (g)	23.842 ± 0.321[a]	18.390 ± 0.891[b]	15.236 ± 0.360[c]
Mean Weight Gain, MWG (g)	23.270 ± 0.267[a]	17.742 ± 0.917[b]	14.758 ± 2.246[b]
Percentage Mean Weight Gain %MWG (g)	4068.18 ± 304.14[a]	2966.89 ± 110.93[b]	3087.45 ± 76.62[b]
Specific Growth Rate,SGR (%W/day)	3.108 ± 0.084[a]	2.885 ± 0.142[b]	2.852 ± 0.114[b]
Survival (%)	75.5 ± 5.0[a]	62.10 ± 5.0[b]	52.70 ± 5.0[c]

Data presented above is the mean of three readings i.e. mean ±S.D.

The values (Mean ± S.D.) in a row having same superscript do not differ significantly (P > 0.05).

Table 2. Growth and survival of *Macrobrachium rosenbergii* (MR), *Cirrhinus mrigala* (CM) and *Labeo rohita* (LR) in polyculture for 120 days

Parameters	Species		
	MR	CM	LR
Initial Mean Length, IML (cm)	3.80 ± 0.458[a]	3.93 ± 0.351[a]	3.80 ± 0.173[a]
Final Mean Length, FML (cm)	10.10 ± 0.30[c]	12.40 ± 2.20[a]	11.80 ± 2.20[b]
Initial Mean Weight, IMW (g)	0.598 ± 0.028[a]	0.560 ± 0.064[a]	0.530 ± 0.020[a]
Final Mean Weight, FMW (g)	18.340 ± 0.891[c]	27.40 ± 0.662[a]	23.280 ± 2.180[b]
Mean Weight Gain, MWG (g)	17.742 ± 0.917[c]	26.840 ± 2.425[a]	22.750 ± 1.400[b]
Percentage Mean Weight Gain %MWG (g)	2966.89 ± 110.93[c]	4792.86 ± 123.84[a]	4292.45 ± 268.30[b]
Specific Growth Rate, SGR (%W/day)	2.885 ± 0.142[b]	3.243 ± 0.048[a]	3.153 ± 0.132[a]
Survival (%)	62.10 ± 5.0[c]	96.0 ± 1.0[a]	92.0 ± 1.0[b]

Data presented above is the mean of three readings i.e. mean ±S.D.

The values (Mean ± S.D.) in a row having same superscript do not differ significantly (P > 0.05).

Table 3. Growth and survival of *Macrobrachium rosenbergii* (MR), *Cirrhinus mrigala* (CM), *Labeo rohita* (LR) and *Cyprinus carpio* (CC) in polyculture for 120 days

Parameters	Species			
	MR	CM	LR	CC
Initial Mean Length, IML (cm)	3.80 ± 0.100[a]	3.8 ± 0.40[a]	3.7 ± 0.10[a]	3.6 ± 0.346[a]
Final Mean Length, FML (cm)	8.4 ± 0.360[b]	10.8 ± 0.529[a]	10.2 ± 0.854[a]	10.6 ± 0.400[a]
Initial Mean Weight, IMW (g)	0.478 ± 0.121[c]	0.552 ± 0.046[c]	0.838 ± 0.049[b]	1.210 ± 0.046[a]
Final Mean Weight, FMW (g)	15.236 ± 0.360[c]	24.183 ± 0.623[b]	23.105 ± 1.323[b]	26.140 ± 0.893[a]
Mean Weight Gain, MWG (g)	14.758 ± 2.246[b]	23.631 ± 0.599[a]	22.267 ± 1.277[a]	24.930 ± 1.861[a]
Percentage Mean Weight Gain, %MWG (g)	3087.45 ± 76.62[b]	4280.98 ± 307.76[a]	2657.160 ± 165.43[c]	2060.33 ± 116.04[d]
Specific Growth Rate, SGR (%W/day)	2.852 ± 0.114[a]	3.150 ± 0.067[a]	3.071 ± 0.069[a]	2.560 ± 0.091[a]
Survival (%)	52.70 ± 5.0[b]	94.0 ± 1.0[a]	90.0 ± 1.0[a]	95.0 ± 1.0[a]

Data presented above is the mean of three readings i.e. mean +S.D.

The values (Mean ± S.D.) in a row having same superscript do not differ significantly (P > 0.05).

in Indian major carp fry to be 40%. Thus, from ongoing discussions, comparatively low protein levels (27–30%) seem to be more ideal as compared to 40% levels; as is witnessed by higher SGR values obtained in former case. Present observations also get support from the observations made by Hossain and Kibria (2006)[36] who also could obtain SGR values of prawn between 2.08-2.19 when fed formulated diets containing 30% proteins. Also, the slower growth patterns of fishes and prawns as determined by Mohanty et al., (1990)[44] may be attributed to lower temperature and poor food intake of fishes.

Survival of carps as recorded after the completion of the experiment can be presented as *C. carpio* > *C. mrigala* > *L. rohita* (Table 3). Such a trend can be attributed to the species-specific capabilities to procure food and meet other stress conditions under polyculture set up[51]. Our results are also in accordance with Das and Krishnamurty, (1960) who found that the survival of carps, particularly during initial stages of life cycle is inversely related to the number of animals in the pond. Similarly, some workers recorded significant decrease in the survival rate of all the six cultivable carp species fry beyond the densities of 0.25 million/ha[52,53,54].

Prawns are suitable candidates for commercial polyculture. Experimental polyculture of *M. rosenbergii* with many species of fish is on record[11,12,23,34,55,56]. Polyculture of prawns with tilapia and grass carp or with *Colorsoma* and grass carp was shown to be profitable than monoculture[55]. Polyculture also improves the ecological balance of the pond water, preventing the formation of massive algal blooms[57] and allows the use of manures as substitute for supplemental feeds[58]. Rouse and Stickney (1982)[59] concluded that prawn-tilapia polyculture showed higher net profit than prawn monoculture.

The present study indicates that prawn and carps are suitable combination for the optimum growth. Prawns being benthic feeders utilized the leftover food (of the fishes) that settled at the bottom, therefore, saving the feed cost. It was observed that mean size of the fish attained in the polyculture practice was almost similar to that obtained in the monoculture. As in the presence of bottom feeders, prawns could not obtain sufficient share of feed, one may therefore, conclude that a comparative low growth and survival of prawn in polyculture condition is probably due to the competition stress posed particularly by two bottom feeder species (*Cyprinus carpio* and *Cirrhinus mrigala*).

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