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EFFECTS OF TEMPERATURE AND SALINITY ON GROWTH, HATCHING RATE AND SURVIVAL OF THE GIANT FRESHWATER PRAWN, *MACROBRACHIUM ROSENBERGII* (DE MAN) UNDER CAPTIVE CONDITIONS

Shailender M*[1], Suresh Babu Ch[2], Sarmal K P[1], Kishor B[1]
[1]Rajiv Gandhi Centre for Aquaculture, Kodiyaghat, South Andaman, India
[2]Department of Biotechnology, Krishna University, Andhra Pradesh, India

Corresponding Author: Dr. M. Shailender, Rajiv Gandhi Centre for Aquaculture, Kodiyaghat, South Andaman, India.

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Abstract: The present study was conducted to know the effect of different levels of temperature (26°C, 30°C and 34°C) and salinity (0, 6, 8, 12, 16ppt) on growth, hatching rate and survival of female *Macrobrachium rosenbergii* under captive conditions. Juvenile prawns of 0.32± 0.031g and 2.9±0.508 cm were reared for 12 months. The results exposed that growth of the prawn was increased as temperature increased from 26to 30°C then the growth declined at the highest temperature (34°C). Also as salinity increased from 0 to 16ppt, growth of females decreased at all temperatures tested. The highest total length (15.6cm) and total weight (42.1g) were obtained at a 30°C temperature and 6ppt salinity. Under the above conditions, the weight of eggs increased significantly up to 4.56g, while the lowest weight (0.10g) was obtained at 34°C-0 ppt. The incubation period was significantly affected by temperature. The longest mean period (26 days) was recorded at the lowest tested temperature (26°C) with all salinities, while the shortest one (18 days) was reported at 30°C at 6 ppt and at 34 °C at 6 ppt. The hatching rate was increased (ranging from 27 to 75%) as salinity increased at all treatments. The highest hatching rate (75%) was observed at (30°C- 6ppt), while the lowest rate was found at 0 ppt with all temperatures tested. The number of accumulative berried females maximum (Jan to March) during winter to early summer session and it was decreased as salinity increased from freshwater to 16 ppt. While the highest number was observed at 30 °C temperature and 0 ppt salinity and the lowest number was one 34°C-16 ppt. It was clearly found that optimum level of both temperature and salinity for growth, reproduction and hatching success of *M. rosenbergii* was 30°C temperature and 6 ppt salinity.

Keywords: *M. rosenbergii,* Temperature, Salinity, Growth, Hatching Rate

INTRODUCTION

Macrobrachium rosenbergii is commonly called as 'scampi' in India and it is known to be the largest freshwater prawn, since it is commonly familiar as the giant river prawn. It migrates from a region of lower to higher salinity during its breeding season. *Macrobrachium* species has many favorable characters for simulation prawn culture (John, 2009). It can tolerate wide ranges of temperature (14-35°C) and salinity (0-25ppt) (New, 1995). Gravid female's crossways saline gradients to estuaries, where eggs hatch and larvae develop (Ismael and New, 2000). In an earlier study, Singh (1980) demonstrated that prawns were able to grow in salinity up to 17 gL^{-1} with highest growth achieved at salinity between 0 and 2 gL^{-1}. On the other hand, Smith *et al.* (1982) studied the growth of *M. rosenbergii* and found little difference in growth rate up to 10 gL^{-1}. In prawn hatcheries, berried females are commonly transferred from freshwater ponds or brackish water areas to improve their eggs hatching rates. Law *et al.* (2002) reported that the egg hatching rate improved when the females were held in 12gL^{-1}. New (2005) similarly suggested that hatchability could increase if the females were held at low level salinity (5gL^{-1}).

A recent study carried out by Yen and Bart (2008) demonstrated that females of *M. rosenbergii* reared at lower salinity of 0 and 6 gL^{-1} produced larger number of larvae compared to 12 and 18 gL^{-1}, and the number of larvae produced was inversely related to the salinity levels. The successful organization of a species in a given habitat depends on its capability to adapt to the suitable environment (Charmantier, 1998). Salinity and temperature are the most important abiotic factors touching growth and survival of many aquatic organisms (Kinne, 1963; 1964). They strongly affect the hatching rate of eggs and the survival of the resulting larvae of *Penaeus* shrimp (Preston, 1985). The influence of temperature on Crustacea depends on the thermal range of the species, geographical distribution, acclimatization response and physiological and behavioral adaptations (Espina *et al.* 1993 and Gutierrez- Yurrita, 2000). The effect of temperature on gonadal development and spawning of freshwater crayfish at different temperatures was studied by Osalde *et al.* (2004) who found that the gonado-somatic and maturation index were significantly different between 16°C and 21 and 26°C. The effect of temperature on reproduction and spawning was

studied on some crustacean species such as *Penaeus merguiensis* (Hoang *et al.*, 2002), the Japanese spiny lobster *Panulirus japonicus* (Matsuda *et al.* 2002), and the crayfish *Procambarus llamasi* (Osald *et al.* 2004). Meanwhile, numerous studies were focused on the effect of a single environmental variable on growth, survival and reproduction of crustaceans such as Jayalakshmy and Natarajan (1996) who investigated the effect of salinity on *M. idella*; Soundrapandian (2008)studied the effect of salinity on *M. malcolmsonii*; Law *et al.* (2002) and Chen and Chen (2003) studied the influence of pH on *M. rosenbergii*; Yen and Bart, (2008) examined the effect of salinity on *M. rosenbergii* but relatively few workers studied the interrelationship of two or more factors that influence aquatic organism. Hill (1974); Lee and Fielder (1982); Vljayan and Diwan (1995); Ponce-Palafox *et al.* (1997) and Zacharia and Kakati (2004) examined the effect of temperature and salinity on *Scylla serrata*, *M. australiense*, *Penaeus indicus, Litopenaeus vannamei* and *Penaeus merguiensis*. The effect of temperature, salinity and hatching rate of fresh water prawn *M. rosenbergii* has important factor for increasing its seed production. Therefore, the present study conducted the performance of *M. rosenbergii* females in response to different combinations of salinity and temperatures under captive conditions.

MATERIALS AND METHODS

The present study was conducted at fresh water prawn hatchery (Kakati Aqua Tech Pvt Ltd) located at Vijayawada, India. Freshwater prawn *M. rosenbergii* Juveniles of belonging to the same brood (total weight 0.21 ±0.021g and total length 3.1±0.208cm) were purchased from Priya prawn Farming Company at Repalle. In this experiment all the animals were divided into three groups, each was held at one of the constant temperatures 26, 30, 34 °C. Each of the three groups was divided into three sub groups treated with different salinity levels 0 ppt (de-chlorinated river water), 8 ppt, 12 ppt and 16 ‰. Prawns were permissible to acclimatize to the selected treatments of temperature and salinity for one week earlier to the experiment start. Animals were fed twice a day (9:00 and 18:00 h.) on a pelletized shrimp feed (40% protein) based on visual observation of leftover feed and fecal matter to be removed daily from each tank (Fiber tanks with a diameter of 1 m). Observation took place over 12 months (from July 2011 to July 2012). Water temperature was adjusted daily by using 300-W thermostat controlled immersion heater. Salinity was obtained by mixing de-chlorinated tap water and raw salt and adjusted to the desired levels salinity by using a salinity conductivity- temperature Meter (YSI Model 33). Maturing females were counted and observed daily for the presence of eggs and change in egg color. Five females from each treatment with gray black eggs (24-48 before hatch) were selected and individually transferred into small fiber tank (500 l) with continuous aeration and having the same temperature and salinity conditions. Total length of females was measured from the rostrum to the end of telson using a scale and the weight was recorded before and after egg hatching by electronic digital balance (Model MR-220), the difference in weight at before and after weight indicate or it was equal to the weight of eggs. Hatching rate was calculated from the number of eggs in a brood and the number of larvae hatched out (Soundarapandian**,** 2008). Egg numbers were determined by taking a sample of eggs using a forceps and were weighed after the eggs were wiped by using a paper towel and counted then the total number of eggs was calculated (Das *et al.,* 1996). The egg incubation period was determined as the number of days from spawning to hatching time. Newly hatched larvae were scooped out with 100 micron nylon net and stocked into a plastic bucket. Aeration was applied to uniformly distribute the larvae in the water column. The number of live ones was estimated volumetrically by taking 50 ml samples (Yen and Bart, 2008). Data were analyzed by using a two-way ANOVA (F test, $P<0.05$) to estimate the effect of temperature (26, 30 and 34 °C) and salinity (0, 6, 8, 12 and 16 ppt) on the growth, survival and hatching rate of the experimental animal. If significant difference was indicated at the 0.05 level, then Scheffer's test was used to compare treatments (Scheffer's, 1943).

RESULTS AND DISCUSSION

Temperature and salinity are extremely important parameters affecting growth and survial of the freshwater prawn, *Macrobrachium rosenbergii***.** The total length, weight and reproduction performance of *M. rosenbergii* were shown in Table (1). All specimens that were held at freshwater (dechlorinated river water) and 26 – 30 °C did not show any significant difference in total length, carapace length and weight of females except at 34 °C where they decreased significantly. The highest total length (15.6cm) and total weight (42.1 g,) were observed at combination of 30°C- 6 ppt, followed by combination of 30°C-8 ppt. The lowest values (9.1 cm total length and 8.5 g total weight) were found at 34°C -0 ppt. The growth rate was significantly affected ($P<0.05$) due to temperature and salinity interaction. Our results showed that growth of the present prawn increased as temperature increased from 26 to 30°C, while at 34°C, growth declined to its lowest value at all salinity levels. This may be due to the increased calorific intake at higher temperature. Firkins and Holdich (1993) reported similar results and stated that growth of crayfish decline at 34°C might result from increased metabolic demands approaching the calorific intake, leaving little energy for growth, despite animals being fed to excess. This fact confirms the suggestion that high temperature to a certain point increases the molting

frequency and growth of the penaeid shrimp (Staples and Heales, 1991; O Brien, 1994 and Parado-Estepa, 1998).

Table 1: Growth and hatching rate of *M. rosenbergii* at different salinities and temperatures

Temp (°C)	Salinity (ppt)	Final total length (cm)	Final total weight (g)	Weight of eggs (g)	No of eggs	Incubation period	No of hatched larvae	Hatching rate
26	**0**	12.6± 1.096	22.6 ±0.98	2.5 ±0.6	22400 ±251	26 ±1.5	6048	27
	6	12.0 ±1.065	20.4± 0.78	1.1 ±0.5	14200± 741	23± 1.5	3834	27
	8	14.2 ±1.001	30.1± 3.2	4.12± 0.5	32000± 254	25 ±1.5	9600	30
	12	13.2 ±1.23	26.5± 1.2	3.25 ±0.6	28850± 957	25± 1.5	8078	28
	16	13.2 ±1.23	26.5± 1.2	3.25± 0.6	28850± 957	25± 1.5	8078	28
30	**0**	11.7± 1.87	16.5± 2.5	1.4 ±1.4	16700± 266	22 ±1.5	8350	50
	6	15.6± 1.85	42.1± 2.8	5.64± 1.3	125200± 126	18 ±1.5	93900	75
	8	14.2± 1.5	32.5 ± 2.1	4.56 ±1.2	76540± 864	20 ±1.5	53578	70
	12	13.7 ±1.98	32.6± 1.5	3.21± 2.6	56240± 234	21± 1.5	37118.4	66
	16	12.2± 1.34	18.4± 1.32	2.1 ±1.2	32480 ±198	21± 1.5	21112	65
34	**0**	9.1 ± 1.65	8.5 ±2.5	0.10± 0.24	3547 ±240	22± 1.5	1205.98	34
	6	12.2 ±1.98	26.6± 1.5	2.21± 0.98	16540 ±128	18 ±1.5	6946.8	42
	8	11.4 ±1.47	24.2± 3.4	1.01± 0.79	10364 ±874	20± 1.5	4249.24	41
	12	10.5± 2.1	18.6± 1.8	0.98± 0.06	8547± 358	21± 1.5	3247.86	38
	16	9.5 ±1.28	12.6± 3.4	0.55± 0.14	4850 ±110	22± 1.5	1746	36

The present study revealed that growth of females decreased as salinity increased from 0 ppt to 16 ppt which agrees with Goodwin and Hanson (1975) who indicated that juvenile *M. rosenbergii* grows more rapidly in fresh water or slightly brackish water (<5 ‰) when compared to more brackish water of up to 15 ‰. Additionally, Vljayan and Diwan (1995) reported that the optimal levels of temperature and salinity which gave the fast molt with highest growth increment of *Penaeis indicus* were 31 °C and 15 ‰. Furthermore, Jane and Goldman (1978) reported that growth of juvenile freshwater crayfish, *Pacifastacus leniusculus* decreased with increasing salinity while daily food consumption decreases sharply with salinity. Higher final weight of *M. rosenbergii* females at lower salinity may be due to the fact that prawns takes in more water at ecdysis than in higher salinities and this results in size increase (Yen and Bart, 2008). The weight of eggs of female was influenced significantly (P<0.05) where the highest weight was 5.64 g at a combination of 30 °C- 6 ppt, and the lowest value (0.1 g) was obtained at (34 °C-0 ppt). Consequently, the highest number of eggs (125200 eggs) achieved at 30 °C-6 ppt and the lowest numbers of eggs (4850) were obtained at 34 °C-16 ppt. This change was highly significant (P<0.05). In this respect, Dube and Portelance (1992) recorded that warm temperature is an effective mean and a preponderant factor in accelerating ovarian maturation and promoting egg lying among the crayfish, *Orconectes limosus.* The incubation period of the female eggs was significantly affected by temperature (P<0.05). According to Wear (1974); Heasman and Fielder (1983); Choy (1991); Zeng *et al*. (1991) and Arshad *et al* (2006) temperature is one of the most important factors regulating egg development for several crustacean species. The longest mean incubation periods (23, 22 and 20.33 days) were recorded at 24 °C with different salinity levels, while the highest temperature (34°C) resulted in the shortest incubation period (17, 17.33, 18 days) at all salinity levels (P<0.05) and this may be due to the fact that lower temperature merely slow down the rate of egg development, while as temperature increases ovarian maturation and egg laying increase (Dube and Porlelance, 1992). This finding is in agreement with the results obtained by Arshad *et al.* (2006) who stated that the egg incubation period of blue swimming crab, *Portunus pelagicus* decreased exponentially from 8.33 to 6.67 days with increasing temperature from 28 °C to 32 °C.

On the other hand, Soundarapandian (2008) reported that the incubation period of *M. malcolmsonii* was 14 days in freshwater but it decreased to 11 days with the addition of brackish water of 7 ‰ salinity. In the present study, the highest hatching rates (75.0, 70.0%) were recorded at both 6 ppt and 8 ppt salinity levels under 30 °C, respectively, while the lowest one (36%) was obtained at 34 °C -16 ppt. Therefore, salinity at a certain limit increases the hatching rate due to the absorption of salts, which results in more internal pressure that enhances rupture of the egg membrane. Soundarapandian (2008) obtained a similar result where he reported that hatching percentage of *M. malcolmsonii* increases when the berried females were reared in 7 ‰ salinity than in freshwater. Ling (1969) found that the presence of lower small amount of brackish water (4- 6 ‰) provides a better media for hatching of *M. rosenbergii* eggs. Katre and Pandian (1972) reported that the egg of *M. idea* is able to pick up salts from brackish water than from freshwater. The number of accumulative berried females decreased as salinity increased from freshwater to saline water at 16 ppt, it was shown in Table 2. It is evident that higher salinity delays maturation for about two months, while

higher temperature accelerates maturation. The highest number of berried females (77 females) was observed at 30°C- 0 ppt, while the lowest number (5 females) was obtained at 34 °C-16 ppt. This confirms the observation of Yen and Bart (2008) that salinity delays maturation of *M. rosenbergii*, while the number of berried females (with gray eggs) decreased with increasing salinity from 143 at 0gL^{-1} to 59 at 18gL^{-1}. Moreover, Jayalakshmy and Natarajan (1996) held *Macrobrachium idella* at 15 gL^{-1} salinity and observed that any post molt attempt to mate was largely unsuccessful and fertilization of eggs did not take place.

Table 2: Availability of mature females in different salinities (seasons) during 2011-2012

Temp (oC)	Salinity (ppt)	2011		2012		Total
		July-Sep	Oct-Dec	Jan-March	April-June	
26	0	0	0	20	25	45
	6	0	0	18	14	32
	8	0	0	10	10	20
	12	0	0	5	6	11
	16	0	0	2	4	6
30	0	0	0	45	32	77
	6	0	0	37	24	61
	8	0	0	26	16	42
	12	0	0	20	10	30
	16	0	0	10	5	15
34	0	0	0	30	24	54
	6	0	0	15	21	36
	8	0	0	14	10	24
	12	0	0	5	5	10
	16	0	0	3	2	5

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