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Effect of salinity on survival and growth of giant freshwater prawn *Macrobrachium rosenbergii* (de Man)

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ABSTRACT

Two independent experiments were performed to determine the effects of salinity on survival and growth of juvenile *Macrobrachium rosenbergii*, first one was to determine the median lethal salinity (MLS-$50_{96\,h}$) and second one was to assess the survival and growth at different sub-lethal salinities under field condition. In MLS-$50_{96\,h}$ study 0, 5, 10, 15, 20, 25 and 30 ppt salinities were used to initially find out the salinity tolerance range. Accordingly, a definitive salinity tolerance test was done in next phase to find out exact median lethal salinity by directly transferring the test species to 21, 22, 23, 24, 25, 26 and 27 ppt salinity for 96 h. The median lethal salinity of *M. rosenbergii* was estimated at 24.6 ppt. In the second experiment, survival and growth performances of the prawn were recorded at different sub-lethal salinities viz., 5, 10, 15 and 20 ppt along with 0 ppt as control during 60 days culture period. The prawn exhibited lowest final average weight at 20 ppt salinity and significantly highest at 10 ppt salinity. Highest SGR and weight gain were obtained at 10 ppt followed by 5 ppt, 15 ppt and 0 ppt salinity but differences among treatment were not significant ($P > 0.05$). Survival rate of prawn varied between 91% (at 0 ppt) and 78% (at 20 ppt). The prawn grew and survived satisfactorily at 0–15 ppt salinities, implying that the species can be cultured commercially at wide salinity range. *M. rosenbergii* can be considered as an ideal species to promote, in view of current and future climate variables as more and more coastal areas of India are going to be vulnerable to saline water inundation.

1. Introduction

Salinity is one of the important environmental factors affecting survival, growth and distribution of many aquatic organisms (Kumlu and Jones, 1995; Kumlu et al., 1999, 2000). Although many crustaceans exhibit some degree of euryhalinity (Pequeux, 1995), optimal salinity levels for growth, survival and production competence are often species–specific (Parado-Estepa et al., 1987; Rouse and Kartamulia, 1992; Kumlu and Jones, 1995; Kumlu et al., 2001; Romano and Zeng, 2006; Ye et al., 2009). A variety of aquatic crustaceans have been reported to rear in inland saline water around the world (Ferraris et al., 1987; Saoud et al., 2003; Rahman et al., 2005). Thus, it is important to determine the optimum salinity level for each commercial prawn species in culture systems where the salinity can be altered to suit the species.

In tropics, fluctuations of salinity are very pronounced where the climate is characterized by wet and dry seasons (Suresh and Lin, 1992). But in recent years, climate variability manifested by sea level rise, increased incidence of coastal flood and tropical cyclones, which are responsible for salinity mediated water stress of freshwater fisheries in various parts of the world (Cruz et al., 2007; Badjeck et al., 2010). In West Bengal, India, many areas in Sundarban delta (UNESCO declared World Heritage Site) are vulnerable to saline water inundation and subjected to environmental hazard during extreme weather events like cyclones and storm surges. In 2009, the severe tropical cyclone '*Aila*' hit the Sundarban, inundating extensive areas with brackish water. It brought huge changes in environmental parameters, especially in water salinity increased from 13.64 ± 6.24 ppt to 17.08 ± 8.03 ppt with an increase of 25.2% (Mitra et al., 2011). Due to salinity intrusion in freshwater aquaculture areas, many freshwater species were subjected to severe salinity stress and some species perished due to their inability to cope up with such extreme conditions. Therefore, it is important to determine the salinity tolerance of freshwater aquaculture species

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and to ascertain whether some freshwater species can be cultured in brackish water areas.

The giant freshwater prawn *Macrobrachium rosenbergii* has a wide distribution throughout the Indo-Pacific region and most favoured for farming in tropical and subtropical areas of the world (New, 2002, 2005). Salinity plays a critical role on egg, embryo and larval development during life cycle of *M. rosenbergii*. In its natural setting, gravid females migrate across saline gradients to estuarine downstream to hatch their eggs and larval development takes place in brackish water (Ismael and New, 2000). This freshwater palaemonid prawn is popularly known as 'scampi' in Indian trade, farmed chiefly in small to medium-sized earthen ponds in West Bengal, Andhra Pradesh, Tamil Nadu and Kerala in India (Nair and Salin, 2012). Global production of this prawn has increased from 130,689 tons in 2000 to 203,211 tons in 2011 (FAO, 2013). The total scampi production from India in 2010–2011 was about 8778 metric tons and West Bengal was the leading producer. In 2011–12, India exported 2723 metric tons *M. rosenbergii* with an increase of 31.61% than the previous years (MPEDA, 2011).

Freshwater prawn *M. rosenbergii* has been studied in relation to the effects of different environmental factors (Brown et al., 1991; Chen and Kow, 1996; Manush et al., 2004). The effects of salinity on the growth and survival of several penaeid species have also been extensively studied (Dall et al., 1990). Salinities between 15 ppt and 25 ppt are considered optimal for *P. monodon* culture (Ferraris et al., 1986a; Chen et al., 1995). It was reported by New (1995) that adult *M. rosenbergii* can tolerate salinity ranging from 0 ppt to 25 ppt. Huong et al. (2010) studied the effects of salinities (15–25 ppt) on the osmoregulation, growth and moulting cycles of *M. rosenbergii* at Mekong delta. Yen and Bart (2008) studied negative effect of elevated salinity on the reproduction and growth female *M. rosenbergii*. But its lethal salinity level, growth and survival rate at different sub-lethal salinities, etc. are still uncertain. To address these issues, the present study was undertaken to determine median lethal salinity (MLS-$50_{96\,h}$), and to assess the survival and growth rates at different sub-lethal salinities.

2. Material and methods

2.1. Experimental species and acclimation

Juveniles of *M. rosenbergii* were obtained from the spawning of wild broodstock in a commercial hatchery located in Naihati, North 24 Parganas district of West Bengal, India and transported in oxygenated polythene bag (pH 7.5, alkalinity 100 ppm as $CaCO_3$, hardness 120 ppm as $CaCO_3$) to the laboratory. Before experimentation, healthy and active juveniles (transparent body and actively swimming) were segregated into 500 L FRP (fibreglass reinforced plastic) tanks filled with freshwater under constant aeration and acclimatized for three weeks at ambient temperature of 27–29.5 °C. About 30% of water was renewed daily. Prawn were fed ad libitum twice daily (9:00 h and 16:00 h) with commercial pelleted feed (35% crude protein). The leftover food and faecal matters were removed daily by siphoning.

2.2. Salinity tolerance ($MLS_{96\,h}$) test

In the first phase, a non-renewal static toxicity bioassay was done for salinity range finding as described by Peltier and Weber (1985). Juveniles of *M. rosenbergii* (length: 6.98 ± 0.67 cm; weight: 4.05 ± 0.84 g) were directly transferred to 0, 5, 10, 15, 20, 25 and 30 ppt saline water. Desired salinities were achieved by mixing freshwater with brine water collected from salt pan (>100 ppt salinity). The experimental system consisted of 10 L glass aquaria stocked with ten juveniles/aquarium for 96 h with three replicates. The pH and dissolved oxygen of the tanks ranged from 7.2 ppm to 7.6 ppm and 5.8 ppm to 7.6 ppm respectively. As 100% mortality was observed only at 30 ppt, a definitive salinity tolerance test was conducted in the second phase to determine the median lethal salinity concentration. Median lethal salinity (MLS_{96h}) is defined as the salinity at which survival of test species falls to 50% in 96 h following direct transfer from freshwater to various test salinities (Watanabe et al., 1990). The test species (length: 7.71 ± 0.61 cm; weight: 4.50 ± 0.81 g) were directly subjected to 21, 22, 23, 24, 25, 26 and 27 ppt salinities and observed for 96 h. As per APHA (2012), standard photoperiod of 16 h light: 8 h dark was followed. Each aquarium was covered with a fine meshed nylon net to prevent jumping out the test juveniles. The pH and dissolved oxygen of the aquaria were ranged from 7.0 ppm to 7.8 ppm and 5.5 ppm to 6.75 ppm respectively. Survival was recorded at 24, 48, 72 and 96 h of exposure to each salinity level. Lack of response to mechanical stimuli was the criteria to determine death of juveniles. Dead juveniles were removed during each observation. $MLS_{96\,h}$ was calculated by Probit method by pooling the mortality data from replicates within treatments and considered significantly different when the corresponding 95% confidence intervals did not overlap (Finney, 1971). The entire experiment was carried out in Mohanpur campus (Nadia district of West Bengal) of the University in India.

2.3. Field trials on survival and growth at different salinities

The field trial was conducted in 5 earthen ponds (0.02 ha each) located at Jharkhali fish farm complex (N 22°01.219′ and E 088°41.075′), a fringe area of Sundarban mangrove eco-region, West Bengal, India. Four different sub lethal salinities, viz., 5, 10, 15 and 20 ppt were chosen to assess the effects of salinity on survival and growth. Simultaneously freshwater (0 ppt salinity) was used as control. The different salinity gradients were created in experimental earthen pond by pumping saline water from the nearby tidal creek connected to river *Herobhanga* (average salinity 28–30 ppt). Three numbers of fine nylon net *happa* (12 × 8 × 4 ft) were placed in each earthen pond with support of bamboo frame. Fourty acclimatised *M. rosenbergii* were randomly sampled, stocked in each *happa* and allowed to grow for 60 days under ideal farm management. A water depth of 1.2 m was maintained throughout the experiment in each pond. Six numbers of hide outs (PVC pipes of 2″ diameter and 1′ long) were placed in each *happa* to act as shelter and avoid cannibalism. Prawn were fed twice a day (9:00 h and 16:00 h) ad libitum with commercial pelleted feed (Charoen Pokphand Group, Samut Sakron, Thailand; 32% crude protein, 4% lipid and 6% fibre).

Prawns were blot dried using a tissue paper and the body weight was measured fortnightly; while mortality (if any) was noted daily. The growth performances were calculated in terms of specific growth rate (SGR; %/day), body weight gain (BWG %), average daily growth (ADG; g/day) (Brown, 1957; Hopkins, 1992) by using the following formulae:

$$\mathrm{SGR}\left(\%/\mathrm{day}\right) = \frac{(LnWf - LnWf)}{t} \times 100$$

Where *Ln* represents the natural log of individual wet weight (g); *Wf* is the final wet weight, *Wi* the initial wet weight, *t* is the duration in day.

$$\mathrm{BWG}(\%) = \frac{(Wf - Wi)}{Wi} \times 100$$

Where *Wf* is the final wet weight and *Wi* the initial wet weight

$$\mathrm{ADG}(\mathrm{g/day}) = \frac{(Wf - Wi)}{t}$$