

Reproductive Performance and Offspring Quality of Giant Freshwater Prawn, *Macrobrachium rosenbergii* Broodstock from Different Regions

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Abstract: The present study was conducted to compare the reproductive performance and offspring quality of adults of the giant freshwater prawn, *Macrobrachium rosenbergii* broodstock from four different sites (1) Krishna revarine wild breeders (KW) were captured in the Krishna River, Prakasham Barrage andhra Pradesh; (2) Krishna revarine pond-reared breeders (KP) were collected from grow out ponds which had been stocked with postlarvae originating from wild breeders from Krishna revarine hatcheries; (3) Godavari revarine pond-reared breeders (GP); and (4) Penna revarine pond-reared breeders (PP) were grown out in culture ponds in Nellore district andhra Pradesh and collected as broodstock at the end of grow-out culture period. *M. rosenbergii* females were individually stocked for 120 days in three 1500 L freshwater recirculation system tanks and fed a commercial diet. Ovarian development, moulting and spawning events were checked daily. In addition a number of egg and larval quality parameters were determined. The breeding frequency, fecundity, egg laying success rate, egg dimensions and egg hatchability were not significantly different between animals from the four different sources. However, there were significant differences in terms of offspring quality between the different broodstock sources. Individual dry weight, larval development rate, time to reach the postlarval stage, postlarval survival and tolerance to ammonia toxicity were all better in offspring originating from Krishna revarine wild. Krishna revarine wild, Krishna revarine pond-reared, Godavari revarine pond-reared and Penna revarine pond-reared did not significantly differ in terms of breeding frequency, fecundity and egg dimensions. However, larval quality of Krishna revarine wild and Penna revarine pond-reared breeders was markedly better than that of Krishna revarine pond reared stock and Godavari revarine pond-reared stock in terms of larval development, survival and post larval production. These results indicate that broodstock sourcing deserves proper attention in hatchery operations of *M. rosenbergii*. It furthermore proves that domesticated (pond-reared) animals are not necessarily inferior as breeders as compared to wild-sourced animals. The results may also point out the potential to selectively breed stocks with improved characteristics adapted to the local culture environment.

Key words: *Macrobrachium rosenbergii* % Reproduction % Larval Quality % Broodstock

INTRODUCTION

The giant freshwater prawn, *Macrobrachium rosenbergii* (de Man) is the largest species in the genus and is most favored species for culture. In India, the giant freshwater prawn is attractive important aquaculture freshwater species, as its culture, especially in rice fields is considered to have the potential to raise income to the farmers. New and Valenti, [1] reported that the farming of other species of *Macrobrachium*, notably *M. nipponense* (already very substantial in China), *M. malcolmsonii* and

M. amazonicum, is also expected to expand. The lack of a stable seed supply has been an important obstacle to the further expansion and development of *M. rosenbergii* culture was noticed by Phuong *et al.* [2]. According to Wilder *et al.* [3] farmers have traditionally depended on wild sources to obtain seed for aquaculture but are now faced with dwindling resources and a shortage of natural brooders. Thang, [4] stated that poor performance (in terms of survival and metamorphosis rate) of larvae from wild captured parent stock remains a bottleneck at present about all the hatcheries using cultured brood

stock only. According to Ling and Merican, [5] and New, [6] despite four decades of domestication little information is published concerning the effects of many generations of domestication on cultured stock (e.g. inbreeding level). There is still controversy whether it is better to use wild or pond-reared breeders and local or imported prawn breeders. Wild breeders are generally considered better, but quality may vary depending on capture techniques and transport conditions. Moreover, breeders from different origin might have different characteristics in terms of reproduction and offspring quality. A number of studies have been carried out comparing the reproductive performance and related variable of wild and pond reared broodstock of different species were reported by Rao [7], Palacios *et al.* [8], Peixoto *et al.* [9], Ragunathan, [10], Hoa *et al.* [11]. Evaluating reproductive characteristics and offspring quality of different prawn strains could also be considered as a first step in the development of selective breeding programs. To date, there are Hatchery output nevertheless is still insufficient to meet demands both in terms of both quantity and quality. Therefore, large numbers of *M. rosenbergii* post larvae (PL) are imported from other countries.

In the present study, an experiment was conducted to compare the reproductive performance and offspring quality of *M. rosenbergii* broodstock from four different sources: Krishna River wild; Krishna River pond-reared; Godavari River pond-reared and Penna River pond-reared with the objective to determine which broodstock source is most suited for seed production under conditions prevailing in South India. This knowledge may add to the development of improved hatchery seed quality of *M. rosenbergii* culture and serve as a starting point to set up a selective and better breeding program.

MATERIALS AND METHODS

Broodstock Sources: Adults giant freshwater prawn, *M. rosenbergii* were selected from four different sites: (1) Krishna revarine wild breeders (KW) were captured in the Krishna river, Prakasam Barrage andhra Pradesh; (2) Krishna revarine pond-reared breeders (KP) were collected from grow out ponds which had been stocked with postlarvae originating from wild breeders from Krishna revarine hatcheries; (3) Godavari revarine pond-reared breeders (GP); and (4) Penna revarine pond-reared breeders (PP) were grown out in culture ponds in Nellore district andhra Pradesh and collected as broodstock at the end of grow-out culture period. The individual weight and length of the animals were not

significantly different between the sources at the beginning of the experiment. Numbers of initial breeders for each source (n) were: KW (n = 60); KP (n = 80); GP (n = 50) and PP (n = 70).

Rearing Conditions and Set-Up

Brood Stock Management: Three separate brood stock tanks were set up for this operation and each one containing one 1000 L holding tank (1.4 x 2.4 x 0.3 m) and one 300 L overhead biological filter tank. The bio-filter was filled with coral stone. An aeration system provided aeration and aided the water to pass through the filter media. Water was continuously pumped to the brood stock holding tank into the bio-filter tank and then returned to the holding tank by the gravitation. The holding tank was divided into two rearing compartments and one central pump compartment, with each compartment containing female brooders.

Broodstock Backup System: The broodstock tank system, similar to the one described above was arranged to maintain extra animals from the four sources for replacing any mortalities that occurred during the initial phase of the experimental period. In this way, from each source an extra 50 females and 20 males were maintained separately.

Broodstock Rearing Methods: Cavalli *et al.* [12] reported that the broodstock rearing methods. In the present study similar techniques were followed. The prawns were randomly selected and stocked into the three experimental units. Freshwater was continuously pumped from the central compartment of the broodstock holding tank into the biological filter and flowed back to the holding tank by gravity. Exchange of water in the broodstock tanks is about 100% per day after removing waste and uneaten feed by siphoning. Ammonia and nitrate levels were maintained below 0.2 and 0.1 mg LG⁻¹ respectively. The intensity of light was maintained by 500 lux with fluorescent lamps above water surface. Temperature was maintained at 29±1°C. FAO, [13] reported that prawns were fed with *Artemia salina* along with a commercial formulated shrimp diet twice a day (7.00 AM and 18.00 PM). The formulated diet contained 400 g kgG⁻¹ crude protein, 77 g kgG⁻¹ total lipids and 108 g kgG⁻¹ ash.

Larval Rearing System: The set-up consisted of three separate recirculation systems. Each tank had 1000 L capacity and is connected to a recirculation system. Water from the biological filter tank flowed into a reservoir

tank from which it was pumped back to the larval rearing tanks. The water entered the larval tanks from the bottom at a flow rate of approximately 0.2-0.3 L/min. The total volume of the recirculation system was approximately 600 L. Water was exchanged at a rate of about 40% per day after removing wastes and uneaten feed by siphoning. Ammonia and nitrate levels were maintained less than 0.2 and 0.1 respectively. According to Mallasen and Valenti [14] general safe level of nitrite to *M. rosenbergii* hatchery may be difficult due to the great variability in larvae individual sensitivity. Water salinity was maintained 10 to 12 ppt and required salinity was prepared by mixing of sea water and freshwater. Vigorous aeration was supplied to all the rearing tanks. A fluorescent lamp system was maintained for providing around 1000-1200 lux at the water surface for 12 h.

On day from each spawner, groups of 800 newly-hatched (triplicate) larvae were collected and stocked in the rearing tanks. Larval stocking density was 75 larvae/L. Average water temperature was $30 \pm 1^\circ\text{C}$. Newly-hatched *Artemia salina* nauplii (the *Artemia* was supplied by OSI brand: Great Salt Lake, USA strain) were offered at a density of 10-15 ml LG¹ from day 1 to day 9. The feeding of *Artemia* offered at 6.00 AM and 17.00 PM. From day 10th to until metamorphosis of PL, the larvae were fed with prepared egg custard containing milk powder, soya been oil, mussel meat, prawn meat, mineral and essential vitamins along with *Artemia* feed. Along with these two a supplementary commercial diet, *Artemia* flakes (Brine Shrimp Flakes, O.S.I., USA) containing 530 g kgG¹ crude protein, 90 g kgG¹ total lipid, 110 g kgG¹ ash, 90 g kgG¹ moisture and 20 g kgG¹ fiber was also used twice (11.00 AM and 15.00 PM) in a day. The commercial diet was fed five times per day (8.00, 11.00, 13.00, 15.00 and 18.00h) while *Artemia* nauplii were fed twice in a day at 7.00 AM and 17.00 PM.

Parameters

Reproductive Parameters: Initially the mean weight and total length of females and males were recorded. Different stages of ovarian development were classified based on the color, size and outline of the ovary according to the description by Chang and Shih [15]. Duration of moulting and the inter-moult period of the females were also recorded. If the moulted female had developed ovaries it was allowed to mate with a hard-shelled male for 5 hours. Spawning events of the each female were recorded. Fecundity was estimated randomly from each group of broodstock is about 60% of the spawn, egg clusters were

removed 7 days after spawning from the brood. The eggs were then incubated *in vitro* in order to estimate egg hatchability. The remaining 40% of the eggs in the berried prawns were allowed to hatching. From these prawns the larvae were collected for further rearing purposes in order to assess larval quality.

To determine the total weight of the egg clutch, the females were first blotted dry with paper tissue. Then the eggs were removed and the egg mass and total (somatic) wet weight of the female was determined. With these values the egg clutch somatic index (ESI: egg clutch-weight somatic-weightG¹) was calculated. The ESI was determined on day 7 after spawning. Fecundity was determined as follows: Three egg sub-samples were weighed and the number of eggs in each sub-sample was then counted to determine the individual egg weight and the total number of eggs per clutch. Fecundity was both expressed as the number of eggs spawnG¹ and the number of eggs gG¹ female body weight. A number of females from each broodstock stock that were classified at phase-V of ovary development were sacrificed to determine the gonadosomatic index (GSI: gonad-weight somatic-weightG¹). Spawning frequency and survival (%) of the females over the four months rearing period was also calculated. Larval success rate (%) was calculated as the ratio of successful larval production (from eggs retained 7 days after spawning) and total number of spawning.

Egg and Larval Quality

Weight of Egg: Egg wet weight (μg) was determined by calculating the number of eggs per egg clutch. Dry weight (μg) of the egg was obtained by placing four samples for drying at 70°C for 36h. Moisture content of the egg was calculated based on the weight of the egg wet and dry weight estimates.

Hatchability of Egg: Hatching was estimated *in vitro*. From each egg clutch obtained in the first subgroup broodstock eggs was removed, three samples of eggs containing around 200-300 eggs were incubated in 300-ml fiber glass tank containing diluted seawater at a salinity of 8 ppt. Moderate aeration was provided in each tank. Hatching was calculated from the number of live larvae and dead eggs 24 hours after hatching. *In vivo* hatching (subgroup - 2) was also determined based on the average larval fecundity (larvae gG¹ female) in subgroup 2 and the average egg fecundity (egg gG¹ female) in subgroup 1. Where:

Fecundity (eggs gG⁻¹ of female) = Total eggs / body weight of the female.

Larval survival (larvae gG⁻¹ female) = Total larvae / body weight of the female

Larval Quality: Larval quality is defined by the active larval mobility in the rearing tanks and the feed consumption. The quality of the larvae was observed to be based on developmental rate and survival of the larvae. From each spawn, triplicate groups of several larvae (Zoea) were reared to the post larval stage (PL). The larval quality was observed and determined on the day 8 after hatching and at post larvae stage: Larval wet and dry weight was determined in the triplicate by weighting. For dry weight, larvae were dried at 70°C for 36 h. Survival of the larvae on day 8 was determined based on the metamorphosis to postlarvae.

Statistical Analyses: Duration of inter-moult periods, reproductive performance parameters and offspring quality parameters were analyzed by analysis of variance (one-way ANOVA) test.

RESULTS

Broodstock Reproductive Performance: For the present study four brood stocks from different sites were compared. Average values of water temperature, pH, dissolved oxygen and ammonia were 29±1°C, 7.5±0.4, 5.1±0.4 ppm and <0.1 ppm, respectively throughout the experimental period. The reproductive performance of *M. rosenbergii* females from the different stocks is presented in Table 1. The experimental design enabled to individually follow the reproductive cycle of *M. rosenbergii* females stock wise at least 5 moults and 3 consecutive spawns over the 120-days survey period. During that period some females of the Penna River source moulted 7 times; while this was 6 times for the Krishna River pond-reared and Godavari pond-reared sources; and 5 times for the Krishna wild source. The breeding frequency of the females reached up to 5 times for the Krishna River pond-reared and Penna River pond-reared sources; 4 times for the Godavari River source and only 4 times for the Krishna River wild source. Over the 120 days of the experiment, the Krishna revarine pond-reared broodstock had the lowest survival of the larvae (60%), which was significantly different ($p<0.05$) from the Krishna wild source (95%). The other two broodstock stocks estimated a similar value of 70%.

There was no significant ($p<0.05$) difference in the average inter moult period of 36 days, recorded in Godavari revarine brood and River Krishna wild stocks, other are ranged around 30-31 days. Egg laying success rate ranging from 70 to 90% was also not significant. Within each broodstock source, there was also no significant difference neither in inter-moult and inter-spawn period nor in larval success rate (Table 2). The fecundity expressed as number of eggs per gram female weight was approximately 1,100 eggs gG⁻¹ female for all four broodstock sources. However, this parameter was highly variable between individual females (SD- 64). The gonadosomatic index (GSI) of broodstock that was sampled at stage V of ovary development showed no differences between the broodstock sources and ranged from 6.9 to 8.1%. While, the egg clutch somatic index (ESI) ranged from 9.3 to 10.2%.

The individual wet weight and dry weight of the eggs were similar between the treatments, ranging from 84.2 to 90.3 µg eggG⁻¹ and 40.5 to 43.6 µg eggG⁻¹ respectively. Also the moisture content of the eggs was the same between the treatments, ranging from 54 to 56%. The (*in vitro*) egg incubation periods were also similarly between the broodstock sources. It took approximately 21 days at a water temperature of 30±1°C for the eggs to hatch. The egg *in vitro* hatching of the treatments ranged from 62 to 75%, which was higher than the *in vivo* hatching, which ranged from 49 to 54%. The present study shows there was no significant difference in the reproductive parameters between the different brood stocks, which are commonly utilized for post larval production in the Krishna, Godavari deltaic region. Also the characteristics of the eggs originating from the different broodstock sources were similar in terms of weight and hatching properties.

Larval Quality: Larval performance was observed in a remaining group of (second group) of breeders that was stocked to maintain until their entire egg clutch until hatching. Each female produced an average between 20,000 and 28,000 larvae during each hatching period (Table 3). The number of newly-hatched larvae per female body weight unit was around 600 to 700 larvae gG⁻¹ and was no difference between the different broodstock stocks. The dry weight of the newly-hatched larvae of the Krishna revarine wild and Penna revarine pond-reared sources was significantly higher than for the Godavari revarine pond-reared stock ($p<0.05$). When the larvae were grown, there was an also significant difference in the

Table 1: Reproductive performance (mean \pm SD) of *M. rosenbergii* females from different sources

Parameter	Broodstock			
	KW	KP	GP	PP
Weight (g)	42.5 \pm 2.5	38.5 \pm 3.8	40.5 \pm 3.5	43.5 \pm 1.8
Survival (%)	95 \pm 1	60 \pm 2	70 \pm 3	68 \pm 5
Inter moult period (days)	31 \pm 5	30 \pm 3	30 \pm 4	31 \pm 4
Inter spawn period (days)	51 \pm 3	50 \pm 4	45 \pm 4	48 \pm 6
Egg laying success rate (%)	94 \pm 6	82 \pm 3	81 \pm 5	80 \pm 2
Fecundity (eggG ¹ female)	1820 \pm 240	1245 \pm 365	1152 \pm 358	1124 \pm 457
Gonadosomatic index (%)	8.5 \pm 2.5	7.1 \pm 1.4	7.5 \pm 1.5	7.2 \pm 1.3
Egg clutch somatic index (%)	11.5 \pm 3	10.9 \pm 1.4	11.2 \pm 2.5	10.9 \pm 1.2

(KW = Krishna Revarine Wild, KP = Krishna revarine pond reared, GP = Godavari revarine pond reared PP = Penna revarine pond reared)

Table 2: Egg quality parameters (Mean \pm SD) of *M. rosenbergii* females from different sources

Parameter	Broodstock			
	KW n= 12	KP n=10	GP n=14	PP n=10
Egg wet weight (μ g)	85.2 \pm 5.4	90.3 \pm 1.6	89.2 \pm 2.6	89.6 \pm 4.2
Egg dry weight (μ g)	40.5 \pm 3.5	44.6 \pm 2.8	41.2 \pm 2.6	41.3 \pm 1.6
Egg in vitro hatching (%)	67.5 \pm 2.5	65.2 \pm 5.4	65.12 \pm 5.2	75.0 \pm 2.1
Egg in vivo hatching (%)	51	49	50	52

Table 3: Offspring quality (Mean \pm SD) of *M. rosenbergii* females from different sources

Parameter	Broodstock			
	KW	KP	GP	PP
Larvae per hatching event (n=16)	28,260 \pm 10,584	21,542 \pm 1,254	20,121 \pm 657	22,506 \pm 2,545
Larval fecundity (g /female)	702	624	602	658
Newly hatched larvae dry weight (μ g)	28 \pm 3	26 \pm 2	25 \pm 1	28 \pm 2
Larvae dry weight on day 10 (μ g)	90 \pm 12	106 \pm 16	70 \pm 19	138 \pm 12
Larval survival on day 10 (%)	90 \pm 3	75 \pm 5	63 \pm 4	80 \pm 2
First PL appearance (days)	16 \pm 1	22 \pm 2	27 \pm 3	19 \pm 3
Survival up to PL (%)	75 \pm 6	45 \pm 9	33 \pm 5	60 \pm 2

dry weight of eight-day-old larvae. Larvae from the Penna revarine pond-reared stock had the highest dry weight (138 μ g), followed by those originating from Krishna revarine pond-reared breeders (106 μ g) and Krishna revarine wild breeders (90 μ g); while the lowest weight was observed for larvae from the Godavari revarine source (70 μ g). A similar trend was observed for the survival on day 10 (Table 3). The larval stage index (LSI) on day 5 and 10 showed that the development of larvae from the Krishna revarine wild and Penna pond-reared sources was significantly faster than for larvae of the Krishna Pond reared and Godavari pond-reared sources (Table 3). On day 15, LSI was very different ($p < 0.05$) between the treatments, descending in the order Krishna revarine wild, Penna revarine pond-reared, Godavari revarine pond-reared and Krishna revarine pond reared.

The duration of larval rearing period beginning with zoea-1 stage to the post larval appearance varies from 16-19 days. In the wild brood stock collected from River

Krishna the larval rearing period (up to PL appearance) was 16 days, while in Krishna river based ponds the rearing period extended to 19 days. In the stocks collected from Godavari River deltaic ponds it was 22 days while in the pond reared brood stocks in the Krishna region it was 27 days. Based on the duration of the rearing period from the newly-hatched larvae to the first post larval appearance, two distinct groups could be identified. The group, larval development in the stock of Krishna wild and Penna revarine pond-reared broodstock in the rearing period significantly shorter rearing periods (16 and 19 days, respectively) in comparison with the group containing Godavari revarine delta pond reared stock and Krishna pond-reared stocks took 22 and 27 days, respectively ($p < 0.05$). The duration of larval metamorphosis from 10% up to 90% of the Godavari revarine pond-reared source was 10 days, which was significantly longer than for larvae from the three others sources. The survival up to post larval stage of the

Krishna wild (75%) and Penna revarine pond-reared (60%) sources was significantly higher than for the Krishna revarine pond reared (45%) and Godavari revarine pond-reared (33%) sources ($p < 0.05$). Overall, the larval development studies revealed that the larvae originating from Krishna wild and Penna revarine cultured ponds presented considerably better results than those from wild Krishna revarine pond-reared and Godavari revarine breeders.

DISCUSSION

The results of the present study showed that a comparison of reproductive performance of *M. rosenbergii* of different brood stocks from four different sources was largely the same in terms of egg laying capacity and reproductive capacity. This is the first study in this region on the reproductive capacities of the different brood stocks commonly utilized in this region to study the relative performance. The comparison of reproductive performance and offspring quality of pond reared and wild broodstock shrimps have attracted much attention, information available on the *Penaeus californiensis*, Moore *et al.* [16], the blue shrimp *Penaeus stylirostris*, Mendoza, [17], the black tiger prawn *Penaeus monodon*, Hoa *et al.* [11], the white shrimps *Penaeus schimitti*, Ramos *et al.* [18], the pink shrimp *Farfantepenaeus paulensis*, Peixoto *et al.* [9], the Indian white shrimp *Fenneropenaeus indicus*, Regunathan, [10], the Kuruma shrimp *Penaeus japonicus*, Presfon *et al.* [19] and the pacific white shrimp *Litopenaeus vannamei*, Palacios *et al.* [8]. Several studies on reproductive performance of wild and pond-reared penaeid shrimp broodstock was compared by Moore *et al.* [16], Menasveta *et al.* [20] and Treece, [21]. A lower fecundity has been commonly observed for pond-reared shrimp broodstock, but it has been indicated that this could be an effect of differences in shrimp size rather than source (Menasveta *et al.* [20], Cavalli *et al.* [12], Palacios *et al.* [8]). However, when comparing with a shrimp of similar size, according to Browdy *et al.* [22] lower fecundity was noticed in pond-reared *Penaeus semisulcatus*. Others obtained similar values for wild and pond-reared broodstock sources, e.g. for *Penaeus monodon*, Menasveta *et al.* [20] and for Kuruma shrimp, *Penaeus japonicus*, Preston *et al.* [19].

In the present study fecundity around 710 eggs gG^{-1} female and was not significantly different among treatments. In a series of nutritional experiments, Cavalli *et al.* [12] explained that the fecundity values

around 1,450 eggs gG^{-1} female for females with an average weight of 26.2 ± 5.1 g. Further, they stated that the efficiency of egg production tended to decrease with increasing female size. In the present study observed that the small sized females were produce higher fecundity than the larger females' or aged females. The larger size of the females used in the current study could thus account for the lower fecundity observed. Rao [7] reported similar results in wild *M. rosenbergii* populations in Sri Lanka and India; smaller females produced a higher number of eggs per unit body weight. These authors are also explained that egg size increased with increasing body size of the spawner, resulting in fewer eggs being produced. In addition, differences in feeding practices between different studies probably also affect reproductive performance. For example in the studies of Cavalli *et al.* [12] proved that the supplementation of the broodstock diet with fatty acid resulted in improved reproductive performance. In our study, a common commercial feed without any supplement was fed to the breeders.

According to Rao [7] the natural environment, *M. rosenbergii* may spawn up to 4 times or more per year and similar observations made by Ling [23]. In captive conditions Wickins and Beard [24] showed that one female spawned 4 times in 170 days. Cavalli *et al.* [12] reported that one female performed a capacity to breed up to 5 times over 180 days. In the present study, the breeding capacity reached up to 5 times in 120 days for the Penna revarine breeders. These results indicate that pond-reared prawns may be better than wild animals in terms of breeding frequency. Wild animals grew up under natural conditions which may differ from the captive conditions and therefore they may need some time to acclimate and adapt to the new conditions. Cavalli *et al.* [12] explained that optimal and stable environmental conditions and balanced and constant nutrition in culture conditions may also play a significant role in this contrast to reproductive parameters. In the current study, many indicators showed differences in terms of offspring quality between the different broodstock sources. In general, Krishna revarine wild, Penna revarine breeders resulted in better offspring quality than the broodstock of other source. Wild breeders are having rich amount of natural nutrition. This could have not undergone stress and may not have any abnormalities raised from nutritional condition. This may very likely be responsible for the higher breeding frequency and offspring performance observed for these wild breeders. The better performance of pond-reared animals may also

be the consequence of a rapid selection for animals that are adapted to grow in captivity. The pond-reared Godavari reared broodstock source on the other hand resulted in a lower survival and generally lowers offspring quality compared to the other domesticated sources. Because, they are less adapted to the conditions used in this experiment. These results seem to partly contradict the results of Thanh *et al.* [25] who found superior growth performance when comparing exactly the same Hawaiian *M. rosenbergii* strain with two different pond-reared strains from Vietnam origin. Differences in experimental conditions may of course account for this. Also, Thanh *et al.* [25] focused on grow out performance, while the present study focused on reproductive and larval rearing performance. Within the same broodstock source, the egg clutch somatic index values were higher than the gonadosomatic index values. This is logical, as the embryos are expected to behavior than the oocytes when still inside the body of the animal. The eggs increase in volume caused by uptake of water and by the development of the eggs after fertilization. The *in vitro* egg hatching in this study was not different between broodstock sources and ranged from 65 to 75%, which proved higher than the *in vivo* hatching, which ranged from 50 to 52%.

Cavalli *et al.* [12] explained that egg loss is considered to be partially due to consumption by the females, to the continual sloughing off of dying eggs due to epizootic infestations and to the loose nature of the larger grey eggs, which would render them more prone to physical losses. Wickins and Beard [24] reported that egg loss during *in vivo* incubation could amount to 31% of the eggs initially deposited in the brood chamber. In contrast, Damrongphol *et al.* [25] reported that removing the eggs from females increased their reproduction output through an increased breeding frequency. Wild brood stock of freshwater prawns *M. rosenbergii*, the levels of n-3 highly unsaturated fatty acid (HUFA) particularly 20: 5n-3 of ovary increase in the ovarian development process. The term 'larval quality' generally refers to the physiological condition of the larvae and is related to survival and growth rates during several larval developmental stages. According to Racotta *et al.* [26] reported that several variables at the broodstock management level are known or suspected to affect larval quality. In the present study, the weight of the newly-hatched larvae was different although the egg wet and dry weight was not different between the broodstock sources. When the larvae were raised to postlarvae, the

differences in larval rearing performance between larvae from the Penna revarine and Krishna revarine pond-reared sources and the Krishna wild and Godavari pond-reared sources became more and more pronounced. This study clearly demonstrated from the results of larval dry weight, larval stage index, time of appearance of post larvae and survival to post larval stage. It is confirmed the earlier findings that larval quality is difficult to assess and might only become apparent further down the rearing cycle.

CONCLUSIONS

The reproductive performance of four different sources of *M. rosenbergii* broodstock, Krishna revarine wild, Krishna revarine pond-reared, Godavari revarine pond-reared and Penna revarine pond-reared did not significantly differ in terms of breeding frequency, fecundity and egg dimensions. However, larval quality of Krishna revarine wild and Penna revarine pond-reared breeders was markedly better than that of Krishna revarine pond reared stock and Godavari revarine pond-reared stock in terms of larval development, survival and post larval production.

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