

Innovative pond-based seed production technique of giant freshwater prawn *Macrobrachium rosenbergii* (De Man, 1879) in Odisha, India: A case study

D. Panda*, B. R. Pillai, S. Sahu and B. Mishra

ICAR-Central Institute of Freshwater Aquaculture, Kausalyaganga, Bhubaneswar-751 002, Odisha, India



Abstract

An innovative method of seed production of giant freshwater prawn *Macrobrachium rosenbergii* (De Man, 1879) in brackishwater ponds, in place of sophisticated indoor hatcheries is in practice in the Balasore District of Odisha, India. A survey was conducted in the Balasore District to collect data on various aspects of pond-based seed production of *M. rosenbergii* (scampi) using a structured interview schedule during September to November 2021. The present paper provides a detailed account of this farmer-led innovative and low-cost technology of pond-based scampi seed production. The study revealed that, younger farmers, with lower educational attainment but extensive experience in scampi and shrimp farming are primarily involved in pond-based seed production as a secondary activity. The seed production season begins in December and continues until July of the following year. The duration of each seed production (crop) cycle ranges from 45-60 days. The ponds used for scampi seed production are connected to a canal that supplies brackishwater with a salinity of 12-20 ppt from the nearby sea. Berried prawns are collected locally and stocked in well-prepared plankton-rich ponds @ 1952 ± 831 nos. ha^{-1} . The hatched scampi larvae in the ponds are fed on a variety of feed items until they reach the post-larvae (PL) stage, which takes approximately 18-25 days. About a week after the appearance of post-larvae, the PLs are harvested and sold. In 2021, the selling price per piece of scampi PL ranged from ₹0.30 to 0.65. Although the survival from zoeal to PL10 ranges from 0.4 to 8%, with an average of only 1.50%, the cost of seed production using this technique (₹0.21 seed⁻¹) is much lower than that of standard hatchery-based seed production. On an average, each farmer produces 10.5 lakh seeds per hectare per crop, with an investment of ₹2.24 lakh seeds per hectare per crop, contributing a net income of ₹2.7 lakhs over a span of 2 months. This innovative and low-cost pond-based seed production technology offers a viable alternative to wild collection or hatchery production of scampi seeds, helping to meet the growing demand for scampi seed in the country. Despite these advantages, the seed growers face several challenges. The major constraints include the lack of seed acclimation facilities to freshwater, the unavailability of good quality berried prawns and the absence of an effective seed marketing strategy. Addressing these challenges through policy intervention, is urgently needed for sustainable development in the long run.

*Correspondence e-mail:

debapnd@yahoo.co.in

Keywords:

Macrobrachium rosenbergii, Pond-based seed production, Post-larvae, Prawn farming, Scampi

Received : 06.06.2023

Accepted : 17.04.2024

Introduction

Giant freshwater prawn *Macrobrachium rosenbergii* (De Man 1879) widely known as scampi in trade circle is the most important cultivable species among all freshwater prawns. The superior cultivable attributes such as fast growth rate, large size, hardiness, euryhaline nature, compatibility with carps and good consumer preference

lure farmers to adopt this species as a viable option for enhancing farm income. This species is indigenous to India and is distributed in lakes, rivers, swamps, irrigation canals and ponds, as well as estuarine areas on both the east and west coasts (Davassi, 2011). The larvae of this species require brackishwater for growth and survival. Therefore, it is found in waters that are directly or indirectly connected

with natural brackishwater sources. The advantage of freshwater prawn culture in promoting rural livelihood and food security is well known. This species can be cultured in freshwater and low saline brackishwater areas (salinity <7 ppt) in both monoculture and polyculture systems with carp and other compatible species. In low stocking densities farming operations with lower costs of production compared to marine shrimps enable this species to be a good choice for sustaining rural populations (Kutty *et al.*, 2009).

Despite all these advantages, the first commercial freshwater prawn hatchery in India was established at Bhimavaram, Andhra Pradesh, only in 1990. Freshwater prawn farming assumed national significance only in the late 1990s as the demand for prawns was increasingly felt as an alternative to the tiger shrimp *Penaeus monodon* (Nair and Salin, 2012). The farmed production of *M. rosenbergii* in India has shown a phenomenal increase since the mid-nineties until 2005. The production increased from less than 178 t in 1996 to 42,870 t in 2005 (FAQ, 2008). Freshwater prawn production in the country has been in a declining phase for the last two decades. The total production of farmed scampi in India during 2020-21 was 8,303 t (MPEDA, 2022a), which is nearly 80% less than the highest production reported in 2005. The recurrence of several episodes of diseases due to poor quality seed together with deteriorated water quality and marketing problems adversely affected the sector (New *et al.*, 2008). The major reasons cited by farmers for moving away from this species were poor growth rate and low survival during culture, resulting in unsatisfactory economic returns. Inbreeding depression was thought to be one of the causes for low productivity of this species (Pillai *et al.*, 2020).

Although there is ample scope and potential for expansion of freshwater prawn farming in India, there are only five Indian states that mainly contributed to the country's scampi production *i.e.*, Andhra Pradesh, West Bengal, Gujarat, Maharashtra and Odisha. The production reported from Maharashtra and Gujarat is from reservoirs and village ponds (MPEDA, 2022a). Most of the production now comes from village ponds and reservoirs or small-scale polyculture practiced by marginal and small farmers in these states. India has vast freshwater resources, including 2.38 million ha of ponds and tanks, 0.798 million ha of *Bheels* and oxbow lakes that can be used for freshwater prawn culture. Besides, part of the 1.44 million ha of available brackishwater area in the country can also be made available for freshwater prawn culture. With little concerted effort, freshwater prawns can be easily incorporated into the existing carp-based aquaculture system, as prawns are compatible with major carps. Scampi is also being cultured in coastal brackishwater ponds along with white leg shrimp, *Penaeus vannamei* in Odisha and West Bengal. Recently, the production and area under scampi culture is again slowly increasing and reached 21,317 t in 2021-22, registering a 2.5 fold increase compared to the previous year's production (MPEDA, 2022b).

Although there is good demand for scampi seed across the country, there are only a few hatcheries involved in seed production at present and most of these hatcheries are located in coastal areas. Although there were 71 scampi hatcheries in India during the last decade including 43 in Andhra Pradesh with an installed production capacity of about 8 billion post-larvae annually, currently only a few are operating due to several technical and marketing issues (Ayyappan, 2022). At present about 17 hatcheries are engaged in scampi seed production with a production capacity of about 500 million.

The higher investment required to establish hatcheries, seasonal shortages of quality broodstock, the necessity of brackishwater for larval rearing, longer larval rearing durations as well as shorter breeding and seed production seasons all impact the availability of freshwater prawn seed to meet the prevailing demand in India. Due to these constraints in seed production, the collection of wild seeds from estuaries and rivers continues to be a major source of seeds for farming. However, naturally collected seeds lack uniform size and quality due to the presence of other non-performing prawn species. This inconsistency has compelled farmers to explore alternative methods of scampi seed production in addition to existing hatchery production.

The brackishwater (BW) pond-based scampi seed production technology has evolved in eastern Indian states like Odisha and West Bengal during the last two decades. However, this technology gained popularity only in the last decade. At present in India, pond-based seed production of scampi is limited to the coastal areas of the East Medinipur District of West Bengal and Balasore District of Odisha. The mass scale pond-based scampi seed production is a common practice for the last seven years in the Contai area of East Medinipur District, West Bengal (Maity *et al.*, 2018). Subsequently, the technology was adopted by the farmers of neighbouring state of Odisha. In Odisha, the pond-based seed production of scampi was started nearly a decade ago. The present study was carried out to analyse this farmer-led, innovative, low-cost technology of pond-based scampi seed production in the Balasore District of Odisha.

Materials and methods

Survey and data collection

A survey was conducted in coastal areas of the Balasore District, Odisha to collect data on various aspects of pond-based scampi seed production. The data were gathered by interviewing farmers (seed growers) using a structured interview schedule during September to November, 2021. The survey schedule comprised the following modules: (1) Demographic profile of farmer; (2) Household information; (3) Asset ownership and land use pattern; (4) Information on production system and its management and (5) Seed harvesting and marketing activities.

Data analysis

The survey captured detailed data about the pond-based scampi seed production in BW ponds in Balasore Sadar Block, Balasore, Odisha. In this farmer-led innovative technique of pond-based scampi seed production, information on major input costs such as pond lease value, procurement of berried prawns, feed, fertiliser, lime, bleaching powder, hiring of labour, as well as fuel and electricity expenses were collected and analysed. A matching pond lease value was added as an opportunity cost for the ponds that were not on lease but owned by the respondents. The total cost of feed for brooder and larvae was calculated as the sum of the product of the total quantity of feed used and the unit cost of each feed/ingredient used. The cost of organic manure and inorganic fertiliser (single super phosphate, diammonium phosphate and urea) were summed up to get the total fertiliser expenses. Similarly, hiring of labour for feeding, cleaning pond periphery, aeration and

harvesting were added together to get total man-days involvement during a crop cycle. Mainly three types of labour were being used i.e. family, hired part-time and hired full-time labour. The cost for hired labour was obtained by multiplying the total number of man-days by the daily wage. The cost for family labour was computed as an opportunity cost assuming a daily wage equal to 75% of the wage for hired full-time labour. The sum of all these components was computed as total production cost (₹) ha⁻¹ crop⁻¹. Total revenue was computed as the product of the yield of scampi seeds in numbers ha⁻¹ crop⁻¹ multiplied by the unit selling price (₹). The net profit was calculated as total revenue less total production cost. The benefit-cost ratio (BCR) was computed as total revenue divided by total production cost.

Results and discussion

The pond-based seed production of scampi is restricted to five Gram Panchayats (GP) of Balasore Sadar Block i.e. Gudu Pahi, Padmapur Jayadev Kasab Pahi, Tundra and Inchudi (Fig. 1). In the present study, data were collected from a total of 22 respondents (N=22) covering 121 ponds with total area of 29.23 ha. The inability of some of the farmers to provide the seed production information resulted in a reduction in the sample size. About 5 survey schedules had to be excluded due to inconsistencies and incompleteness in the data set.

The survey revealed that farmers engaged in shrimp (*P. vannamei*) or scampi farming were mostly practicing pond-based scampi seed production as a secondary activity during December-July in the above five coastal GPs. These GPs are thinly populated, mainly inhabited by the fishermen communities. Shrimp farming is one of the major activities in these areas followed by scampi farming in brackishwater ponds. These areas are well connected with water supply channels for drawing water for culture from the Bay of Bengal near the estuarine region of river Budhabalanga. The number of crops (cycles) of seed production undertaken by the farmers varies from one to three depending upon the availability of pond and interest of the farmers. Pond-based seed production of scampi was undertaken in brackishwater ponds used for scampi or *P. vannamei* culture. The total number of farmers practicing seed

production of scampi in earthen ponds are about 350 (Table 1). The villages under these five GPs practicing pond-based seed production include Gudu Pahi, Hidigaon, Jayadev Kasapa Pahi, Badakia, Huda Pahi, 8 miles, 9 miles, 12 miles, 17 miles, Bhimpur Pahi, Bardhanpur Pahi, Kalamatia, Thakur Pahi, Khandia Khapara, Kalamatia, Khadu Pahi, Inchudi and Thakur Pahi. This activity is gradually spreading to nearby areas.

One of the major rivers of the state i.e. Budhabalanga is draining into the Bay of Bengal in the north of this area. The Budhabalanga delta region was known for its mangrove forests with very rich estuarine fish biodiversity. Although, the estuary harbours only the degraded mangrove forests at present (Panda *et al.*, 2013), it still serves as a breeding ground for many fish species including *M. rosenbergii* as witnessed by the occurrence of berried prawns and juveniles in the estuarine region. The prime requirements for scampi seed production include the availability of good quality brackishwater with salinity 12-14 ppt, temperature 28-31°C, pH 8.0-8.5 and dissolved oxygen levels above 5 ppm (New, 2002; Soundarapandian, 2009). The suitability of these environmental parameters, including desired salinity, nutrients and plankton biomass, is likely restricting the seed production activity to these five GPs at present. The ponds of this area receive good quality brackishwater from the nearest sea through feeder canals for larval rearing.

Demographic profile

Data analysis of the demographic profile of the respondents revealed that more than one-third of the respondents were in the

Table 1. Name of the Gram Panchayat and number of farmers engaged in scampi seed production in earthen ponds

Name of the Gram Panchayat	Nos. of farmers practicing pond seed production of scampi
Gudu	100
Padmapur	50
Jayadev Kasapa	50
Tundra	50
Inchudi	100
Total	350

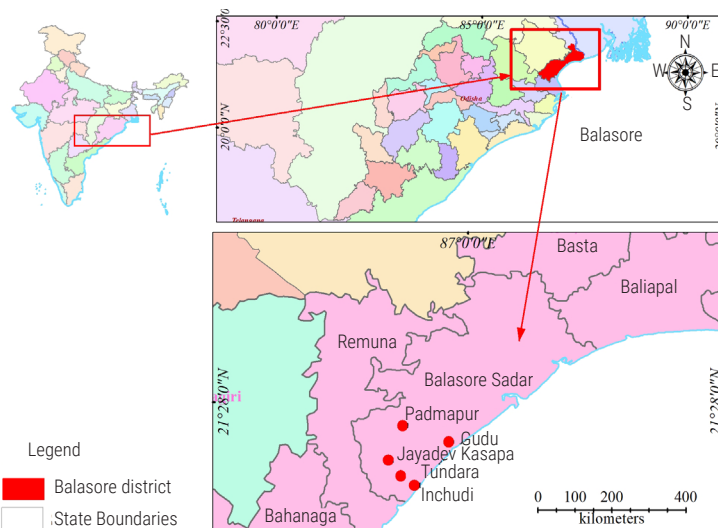


Fig. 1. Map showing pond-based scampi seed production sites in Balasore Sadar Block of Balasore District, Odisha, India

35-45 age groups. Additionally, about 27% of the respondents were above 55 years of age. Younger generation between age group 25-35 years accounted for 23% of respondents involved in the study (Fig. 2). In West Bengal, Maity *et al.* (2018) reported that, approximately 48% of the farmers were aged 31-45 years, 32% were in the 15-30 age group, while only 20% were from the age group of 46-60 years. Given the labour-intensive nature of this activity, the younger age group's involvement may be more pronounced compared to the older age groups, especially since it is a relatively new endeavour in the locality.

The primary occupation of majority of the respondents (above 72%) was fish farming (mainly scampi and shrimp). Most of the farmers (32%) engaged in scampi seed production had education below matriculation. About 23, 18 and 13% of farmers had educational qualifications of matriculation, intermediate and graduation respectively, while about 14% did not provide information on educational qualification (Fig. 3). Similar findings regarding lower educational attainment among farmers engaged in pond seed production were also reported earlier in east Medinipur, West Bengal, where 51% of farmers completed education from 4th to 8th standard, 47% completed 9th to 12th standard and only 1% of the farmers were graduates (Maity *et al.*, 2018).

Pond preparation

The basic concept of the pond-based scampi seed production technique is mainly based on the green water technique developed

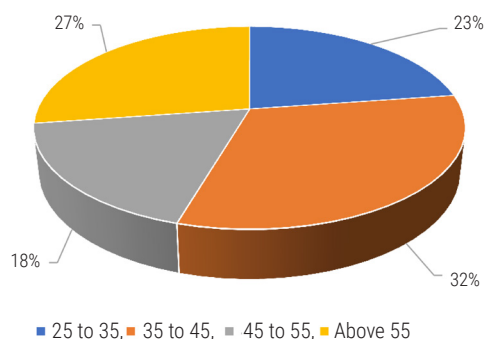


Fig. 2. Age of farmers involved in scampi seed production in BW ponds

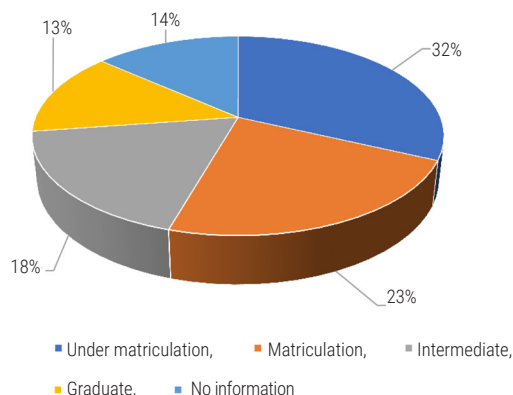


Fig. 3. Educational attainment of respondents involved in scampi seed production in BW ponds

by Fujimura in the early seventies. In this technique, the rearing of larvae is carried out in a medium of mixed plankton predominated by green algae. This algal population helps in removing the toxic by-products and wastes such as ammonia and nitrite. The mixed phytoplankton do not provide any nutrition to the larvae, but helps to provide an optimum environment for growth and survival. However, the green water technique has shown limited success in the hatchery system due to its challenging management and the additional complications it introduces to the hatchery process. For this reason, most commercial freshwater prawn hatcheries now use the clear water systems of management (New, 2002). Although the seed output is less as compared to clear water larval rearing technique, green water technique has many advantages in outdoor seed production especially in pond conditions. The modified version of this green water technology has been applied in outdoor BW pond-based system by the farmers innovatively. A similar method of seed production combined with nursery rearing in earthen ponds was previously experimented in Thailand (Tunsutapanich, 1994). In this method, larvae were initially fed with natural zooplankton and later supplemented with *Artemia* nauplii and artificial feed in 10 ppt salinity earthen pond provided with aeration. However, the extent to which this technology has been further applied or adopted is not well documented. Over the years, farmers in Odisha have successfully adopted this innovative technology for scampi seed production in BW ponds.

The production cycle starts with pond drying and pond preparation during December every year. The duration of each seed production cycle (one crop) range from 45 to 60 days. Hence, maximum of three cycles of seed production are possible during one season from December to July. After harvesting vannamei/scampi during November, the ponds are drained, bottom soil removed and sun dried during December to January. The brackishwater for the ponds is sourced from the nearby Bay of Bengal Sea through canals. Ponds selected for this purpose typically range in size from 0.12 to 0.50 ha and are connected to the brackishwater supply canal. After ploughing and drying the pond bottom, the ponds are filled with brackishwater of 12-20 ppt from the nearby channel. The water depth in the pond is maintained at 1.0-1.5 m. During summer season, water salinity is adjusted to normally 12-14 ppt using freshwater. Bleaching powder is applied at 250-312 kg ha⁻¹ to disinfect pond water. About seven days after the application of bleaching powder, the pond water is de-chlorinated by vigorous aeration, either by using pumps or manually by employing labourers to disturb the water column. Following this, lime is applied in the water at 100-350 kg ha⁻¹ to adjust the pH and alkalinity. Fertilisers and manures like urea, di-ammonium phosphate (DAP), single super phosphate (SSP), mustard oil cake (MOC) and ground nut oil cake (GNOC) are applied in the pond either alone or in different combinations to initiate plankton growth in the pond. The dose of fertilisation varied from farm to farm. The most prevalent doses of fertilisers are urea 10.0 kg, SSP 15.0 kg mixed with 50-75 kg ha⁻¹ of soaked GNOC or MOC. Fermented yeast and probiotics are also sometimes applied for luxurious growth of plankton. With these applications and daily aeration in the morning and evening, the ponds are made ready within 15-20 days for stocking. The zooplankton produced through fertilisation thus serve as natural feed for the scampi larvae. Once the pond water turns brownish-green with a luxurious growth of phyto and zooplankton, the berried prawns are stocked in the pond.

Collection of berried prawns and stocking

Egg bearing females (berried prawns) are the primary source of larvae for pond-based scampi seed production. These are collected either from nearby culture ponds, rivers or local vendors. Berried females are released into well-prepared ponds with plankton-rich, slightly brownish-green water for hatching and larval rearing. The size of berried prawn ranges from 25-100 g with prices varying from ₹35 to 75 per individual depending on size. The stocking density of berried prawns ranged from 500 to 3750 nos. ha⁻¹ depending on the availability. Healthy berried females with intact appendages are selected based on egg colour and quantity of eggs. Generally grey berried prawns are preferred by the farmers as they release the larvae within 24-48 h. Efforts are made to stock berried females having similar egg colour. The berried females are disinfected using 20 ppm formalin dip treatment before stocking. The berried prawns are fed with chopped mussel meat, minced fish or with scampi/vannamei feed at 2-3% of total biomass twice daily during initial 3-4 days after stocking.

Larval rearing

The eggs generally hatch into zoea I within 24-48 h after stocking of grey berried prawns. To facilitate this process, the pond water column is regularly disturbed from the bottom by stirring or churning, carried out 4-5 times daily, for 1-2 h by labourers from morning till evening. In some farms, pond water is aerated using a pump fitted with a fine mesh net at the suction head or a paddle wheel aerator especially at night. However, some farmers opt not to use pumps or paddle wheel aerators to avoid larval mortality caused by excessive aeration. Three to four days after stocking berried prawns, the presence of larvae is checked using a scoop net. The larval density is estimated by visual inspection.

In addition to the natural feed available in the pond, the larvae are fed twice a day with a mixture of wheat flour, milk powder, biscuits, broken coarse wheat, pulses, glucose, vitamins and minerals. Different farmers utilise various types of feeds for feeding larvae; but, milk powder, biscuits and refined wheat flour (Maida) are commonly used. These feed items are soaked overnight and, in the morning, only the soluble portion is spread over the pond for feeding larvae. However, about 40% of the farmers also used commercially available shrimp starter feed in dough form added with probiotics in addition to the above food items as larval feed. Utmost care is taken to maintain dissolved oxygen above 5 ppm. About 10-12 labourers ha⁻¹ are employed for churning/disturbing water from early morning to evening at regular time intervals to maintain the dissolved oxygen level in the pond. The farmers believed that the higher the churning effect, the better the oxygen level in the pond. Sometimes farmers use commercially available zeolite to prevent the formation of toxic gases. During this process, generally the spent females are not fed. Most of the spent females die due to high salinity and the few surviving individuals are harvested along with the seed and sold.

Harvest of post-larvae (PL)

After 15-20 days of rearing, the larvae are collected daily using a scoop net to check the transformation from larvae to PL stage. Larvae generally metamorphose to PL in 18-25 days. After 10 days of observing PLs, the harvesting of PL10 (8-10 mm size) begins,

which is done using a scoop net or by placing bundles of date palm leaves in the pond. These bundles are hung in the water column using longitudinally driven ropes across the pond surface. Post-larvae resting on the submerged date palm leaves are harvested at night using scoop nets and then kept in hapas for sale.

The salinity of the pond water doesn't remain constant throughout the season in different cycles. It remains high in pre-monsoon *i.e.* 15-18 ppt during March-May, while it decreases to 7-8 ppt towards the end of the season *i.e.* June-July due to the arrival of the south-west monsoon. The farmers generally harvest and sell PLs at salinity ranging from 7 to 18 ppt during different crops. As most of the farmers do not have any facility to acclimatise the harvested PLs from higher salinity pond water to freshwater, PLs are sold immediately after harvest from BW ponds. It generally takes about 3-7 days to harvest all the PLs from the pond. After complete harvesting, the pond is completely drained, dried and prepared for the next cycle.

Seed output and productivity

The seed production showed an increasing trend from 167.7 lakhs in 2019 to 231.6 lakhs 2021. The average productivity varied from 7.98±6.5 lakhs crop⁻¹ ha⁻¹ in 2019 to 10.5±5.4 lakhs in 2021 (Fig. 4). There were wide variations in the seed output per unit area. This method of pond-based scampi seed production is relatively new and still evolving, relying on individual farmers who may lack technical knowledge of scampi seed production techniques. Hence, such wide variations in results are expected and reflect the ongoing learning and adaptation process among farmers. The stocking density and the size of berried prawns vary from farm to farm and range from 500-3750 nos. ha⁻¹ and 25-100 g respectively. The biomass of berried prawns range from 25-187.5 kg crop⁻¹ ha⁻¹. By considering 1000 nos. zoea-I per gram body weight of berried prawn, total number of zoea-I is calculated for each farm. The seed output (%) was back-calculated from total seed production and found to vary between 0.4 to 8% with an average of 1.50%, which is much less than the seed output from any scampi hatchery. The seed output is largely dependent on season, quality of berried females and experience of the farmer. Higher seed output (20-150 lakh ha⁻¹ crop⁻¹) was reported from West Bengal (Maity *et al.*, 2018) which might be due to the longer experience of the farmers engaged in

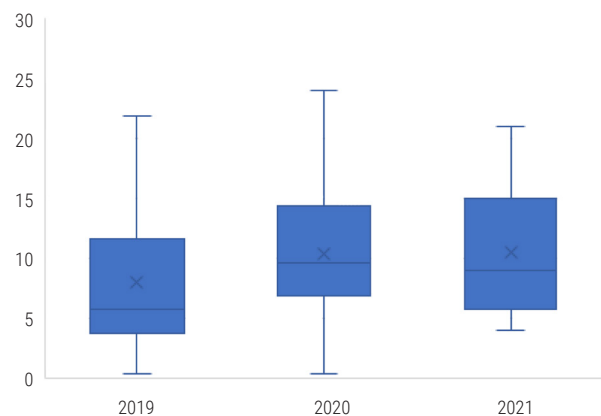


Fig. 4. Scampi seed productivity (lakhs crop⁻¹ ha⁻¹) in BW ponds from 2019 to 2021 in Balasore Sadar Block of Balasore District, Odisha

pond-based scampi seed production in West Bengal. From Thailand, Tunsutapanich (1994) reported an average production of 17 to 25 million ha⁻¹ juvenile prawns (29-35 days old) from brackishwater ponds stocked with 25 to 37 million larvae ha⁻¹ with an average survival rate of 67.50 to 68.75%, which is significantly higher than that reported in the present study as well by Maity *et al.* (2018).

Economics of pond-based scampi seed production

The price of berried prawns range from ₹35-75 individual⁻¹ based on the body weight. On an average about ₹1.0 lakh was spent by the farmers towards purchase of berried prawns (Table 2). For the farmers who collected berried prawns from their ponds, a matching value of berried prawns were added. The expenditure towards the purchase of berried prawns accounted for 47% of the total expenditure. The cost of feed for berried and larvae accounted for ₹0.13 lakh. Another major expenditure (22%) was towards hiring of manpower for pond preparation, feeding, aeration and harvesting which was about ₹0.51 lakh ha⁻¹. The mean lease value of one ha pond was estimated as ₹0.35 lakh. The expenses towards bleaching and liming was about ₹0.11 lakh (Table 2). The expenditure towards manuring and fertilisation of pond was ₹0.05 lakh. The cost of electricity and fuel was considered as miscellaneous expenditure and estimated as ₹0.03 lakh. The total expenditure was estimated as ₹2.24 lakh crop⁻¹ ha⁻¹. The selling price per piece of PL (scampi seed) ranged from ₹0.30 to 0.65 during 2021. The total revenue generated through sale of PL was estimated as ₹4.9 lakh crop⁻¹ ha⁻¹, giving rise to a net income of ₹2.7 lakh crop⁻¹ ha⁻¹ in a span of 2 months. In West Bengal, the net income varied from ₹1.48 to 10.30 lakh from 0.1 ha pond (Maity *et al.*, 2018), which appears to be over-estimated. At present, with 10.5 lakh crop⁻¹ ha⁻¹ seed output and ₹2.24 lakh crop⁻¹ ha⁻¹ investment, the cost of seed production per seed is estimated as about ₹0.21, which is much lower than the standard hatchery-based seed production (>₹0.60). The benefit to cost ratio was estimated as 2.14 (Table 2), indicating the pond seed production technology as a low-cost profitable activity. Hence, it is observed that the present innovative pond-based mass scampi seed production technology in BW ponds with low input is highly suitable for small-scale farmers and can be an alternative to natural collection of seeds and hatchery production to meet the growing demand of seed in the country.

Seed marketing

The farmers were selling the harvested seeds at a price ranging from ₹0.30 to 0.65 per piece. The price of seeds at the beginning of season remained high at ₹0.65 per piece and decreased to ₹0.30 towards the end of the season. Bigger size seeds acclimatised to lower salinity fetches better price, however, the proportion of which was very negligible due to the lack of facility for seed acclimatisation at the farmers' field. The average price per piece remained as ₹0.48±0.11 during 2021. The farmers informed that most of the seeds produced here were sold through middlemen to West Bengal and Bangladesh. Remaining seeds were sent to scampi farmers in Andhra Pradesh and Odisha. The farmers are mostly dependent on the middlemen for seed marketing including packing and transportation as they do not have these facilities. There is less preference for scampi seeds which are directly harvested from BW ponds due to lower survival in freshwater ponds. On the other hand, although there is huge demand of freshwater acclimatised scampi

seeds for stocking in freshwater ponds, the farmers are unable to supply them due to lack of acclimatisation facilities.

Most of the farmers are depending on the local vendors for supply of berried prawns. These berried prawns are being collected from the nearby culture ponds. This cycle is repeated several years without any genetic management of stock. Some of the scampi farmers are having reservation about the quality of pond produced seeds due to its poor growth in culture ponds. Inbreeding depression was thought to be one of the causes for low productivity of this species. It has been observed that domesticated stocks of prawns sourced as broodstock in commercial farms worldwide experience a decline in productivity due to inbreeding depression, as hatchery-produced siblings are 'recycled' as broodstock over multiple generations (New, 2002; Weimin, 2007). Farm-reared females appear to attain sexual maturity much earlier than their wild counterparts; the size at first maturity is also smaller; and they are characterised by relatively poor fecundity and larval viability, resulting in a reduction in the mean size of cultured prawns in subsequent generations (Wilder *et al.*, 1999). Further, the availability of broodstock from the wild is seasonal and their quality is often inconsistent. Besides, indiscriminate exploitation of egg-carrying females from nature also raises several issues concerning the biodiversity of freshwater prawns, as it might impact their recruitment to the wild population. Hence, it is suggested to replace about 10-20% of existing brooders annually, with brooders from wild or from isolated farms or with CIFA-GI Scampi®, a genetically improved strain of scampi developed by ICAR-Central Institute of Freshwater Aquaculture, Bhubaneswar (Panda *et al.*, 2022) to improve the quality of seeds.

Constraints faced by farmers

Almost all the farmers identified seed marketing as one of the major problems faced by them. At present, there is very little demand for pond-based scampi seed probably due to the lack of awareness about this method. Although farmers are producing lakhs of seeds annually, most of the seeds are marketed through the middlemen to Bangladesh. Most of the farmers do not have seed packing facilities and they depend on middleman for seed packing and transportation.

Pond-produced seeds are generally at stages less than PL10 and are directly harvested from ponds with salinities above 10 ppt and sold. The lack of infrastructure facilities for acclimatising the seeds to freshwater compels farmers to sell them immediately

Table 2. Mean and standard deviation (SD) of different variables of production and economic characteristics of pond-based scampi seed production in the Balasore District of Odisha

Parameters	Mean±SD (₹)
Lease value	35795.5±5844.5
Berried prawn	107528.4±51179.0
Bleaching powder and lime	11332.5±553.7
Manure and Fertiliser	4965.9±2807.6
Feed	13326.7±5762.5
Hiring of manpower	51366.4±13064.0
Miscellaneous (Electricity, fuel etc.)	3431.8±1275.2
Total expenditure crop ⁻¹ ha ⁻¹	227747.2±52327.9
Total revenue crop ⁻¹ ha ⁻¹	488055.5±222129.7
Net Profit crop ⁻¹ ha ⁻¹	260308.3±215357.5
B:C	2.14

after harvest from higher salinity ponds at lower prices. This lack of access to good quality freshwater for salinity reduction and seed acclimatisation is therefore, one of the most pressing challenges faced by farmers.

The lack of timely availability of good quality berried prawns in sufficient numbers is another major constraint faced by farmers. Farmers have observed that berried prawns supplied by the vendors are progressively decreasing in size each year, with fewer fertilised eggs in the brood pouch. This decline may be attributed to inbreeding, as local farmers have been using the same breeding stock year after year. To address this issue, it is recommended to annually replace about 10-20% of existing brooders with specimens sourced from wild populations, from isolated farms or CIFA-GI Scampi® to introduce genetic diversity and improve breeding success.

The pond-based mass seed production of giant freshwater prawn is comparatively a new innovative technique practiced by farmers of the Balasore District in Odisha. Although this technique requires sound knowledge of its management, it has emerged as a low-cost profitable venture for the coastal scampi farmers bringing a net income of ₹2.7 lakh in a span of 2 months. The cost of seed production in this technique is much lower than the standard hatchery-based seed production. However, this technique has its limitations as it is highly site specific and successfully practised in few suitable pockets in the country. As this technique depends on natural brackishwater, it is vulnerable to pollution loads in nearby sea. Further, as the area is situated very close to the coast it is also vulnerable to natural disasters like cyclones which are very common in the east coast. For sustainability of this technology, awareness on broodstock management should be created among the farmers for production of good quality seeds. Hence, it is suggested to replace 10-20% of existing brooders annually with brooders from wild or isolated farms or CIFA-GI Scampi® to avoid inbreeding related problems. Moreover, establishment of infrastructure for acclimatisation of seed to freshwater, seed packing and transportation facilities as well as developing marketing linkage will encourage the seed growers to upscale this technology.

Acknowledgements

The authors are thankful to the Director, ICAR-CIFA, Bhubaneswar and District Fishery Officer, Department of Fisheries, Balasore, Odisha for extending the facilities to carry out this study under PMMSY CS Scheme on Scampi.

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