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A study examining the viability of farming green mussels (*Perna viridis*) on the southeast coast of India's Bay of Bengal

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Abstract: Coastal green mussel farming is at the forefront of aquaculture developments due to its widespread acceptance as an affordable protein source and ultimate delicacy. Because of its tropical warmth, abundant rainfall, and nutrient-rich water from the extensive India's coastal waters boast some of the richest ecosystems on the planet, with highly productive fisheries. With a focus on coastal landlocked channels and estuaries, this study attempts to evaluate the viability of green mussel (*Perna viridis*) culture in the southeast coast of the Bay of Bengal. A system for grading site capacity was implemented, considering both natural food requirements and biophysical factors. This allowed for a quick and efficient assessment of possible locations for green mussel farming, on the other hand, have medium to good suitability ratings, meaning that commercial green mussel aquaculture is best. Furthermore, high levels of plankton and chlorophyll-α provide sufficient natural food supply for green mussel aquaculture.

Key words: environmental factors food accessibility, *Perna viridis*, plankton composition, site suitability, and site capability grading system.

INTRODUCTION

A tropical Indo-Pacific clam species, *Perna viridis* is distributed along the shores of Southeast Asia and India (Sallih, 2005; Rajagopal et al., 2006; McGuire and Stevely, 2009). It is regarded as a profound delicacy globally and is an inexpensive source of protein with great nutritional benefits (Rajagopal et al., 1998; Taib et al., 2016). The history of using green mussels for commercial purposes goes all the way back to the thirteenth century (Appukuttan, 1988; Appukuttan et al., 2003). Around the coast of southeast Asia, its farming has flourished recently (Appukuttan, 1977; Nair and Appukuttan, 2003). High primary productivity in coastal locations, clean water, and readily available seeds are favorable variables that promote green mussel farming in the Indian subcontinent (Hickman, 1992; Laxmilatha, 2013). However, because of their heavy reliance on the diminishing capture fisheries and lack of alternative sources of income, most small-scale coastal fishing communities are facing economic challenges and risk of falling into poverty. It is crucial to build the coastal farming system to counteract these downward conditions by converting overfished fishing practices into marine culture-based fisheries production in coastal areas.

With an emphasis on the blue economy, the Indian government has recently given the development of coastal farming, top priority to generate revenue for these destitute coastal fishermen and farmers. Green mussel culture in inshore coastal waters can be self-regulating, requiring little maintenance and no additional feed supplement when the right environmental conditions and natural primary production are met (Kripa and Mohamed, 2008; Soon and Ransangan, 2015). Furthermore, high fecundity, year-round reproduction, high population density, and a mobile free living phase are some of the beneficial characteristics of mussels (Rajagopal et al., 1998; Spencer, 2002) have contributed to their success in aquaculture in numerous nations. Strong winds and large waves (Aypa, 1990), a minimum water depth of 1.5 m (Aypa, 1990), current speeds between 0.1 and 0.3 m s-1 (Aypa, 1990), stable high salinity between 21 and 33 ppt (Rajagopal et al., 1998; Apukuttan et al., 2003; FAO, 2021), an alkalinity range between 50 and 200 ppm (Nayak et al., 2014), a temperature between 25 and 35°C (Rajagopal et al., 1998; FAO, 2021), and primary production with chlorophyll-α of 0.7–17 µg L-1 (Rajagopal et al., 1998; Saxby, 2002) have all been shown to be more beneficial for the commercial success of green mussel farming.

Considering these requirements, the study's application of the site capability rating system is meant to identify possible farming sites quickly and efficiently along southeast coast by considering environmental factors and food availability. The results of this study could be used to design green mussel farming more successfully and as a tool to assess the possibilities of farming other species of mollusks.

RESEARCH METHODOLOGY

Site of sampling

Natural resources of green mussel from vellar estuary, Parangipettai was a remarkable side for sample collection and some nearby small culture areas have also played significant role for collecting green mussels. Year-round samples were taken in triplicates once a month between 9:00 and 10:00 during high tide.

Evaluation of environmental parameters

Every month, in-situ measurements of the water temperature, salinity, pH and dissolved oxygen were made for each location. The water's depth was manually noted. A vertical water sampler was used to gather water samples. Using a digital turbidity meter, the turbidity of the samples that were collected was determined.

The titrimetric approach was used to assess total alkalinity (APHA, 1992). Using a vacuum pressure air pump, the collected water samples were filtered through microfibre glass filter paper (Whatman GF/C) for analysis.

Evaluation of the availability of food

Every month, at every site, three duplicates of plankton samples were obtained by filtering the 10 liters of subsurface water through a 45 µm mesh plankton net after the water was collected using a Kemmerer water sampler (1200-E Kemmerer, WildCo, FL, USA). 10% neutral buffered formalin was used to preserve the concentrated samples (50 ml) in little plastic vials. Plankton estimates, both qualitative and quantitative, were performed with a Sedgewick-Rafter Cell (S-R cell) that held 1000 1 mm3 cells. To give planktons time to settle, a 1 mL preserved sample was placed in the S-R cell and left undisturbed for 15 minutes.

The plankton individuals in ten randomly chosen cells were then counted using an Optika B-190TB binocular microscope (Ponteranica, Italy) and McGaraghan (2018) used as model to identify planktons up to the genus level, and Al-Kandari et al. (2009) divided them into various groupings.

Evaluation of the site's appropriateness for P. viridis cultivation

A site capacity rating system was established to evaluate the potentials of the chosen sites for green mussel farming. The system is based on the assessment of multiple biophysical characteristics. Based on their biological significance and impact on the development and survival of green mussels, the nine most crucial water quality parameters—temperature, depth, salinity, turbidity, dissolved oxygen, pH, current speed, alkalinity, and chlorophyll-α contents—were given a weighted value (0.05, 0.1, and 0.15) for this purpose. The cumulative weighted value of all the parameters under study added up to 1.00 (Table 1). Ultimately, the weighted value of each water quality criterion was multiplied by its rated value to determine the overall weighted value of the chosen site. Next, based on Table 2, the site's eligibility for green mussel farming was categorized using the station's total weighted value.

Examining data statistically

The Microsoft Office Excel application and the SPSS Windows Statistical Package (version 21) were used for all the descriptive statistical analyses.

RESULT & DISCUSSION

Known as a self-regulating culture species, green mussel larvae are mostly dependent on the environmental factors of the surrounding water for their survival, growth, and productivity. It is possible to infer from the illustration of environmental fluctuation that the chosen places had certain circumstances with somewhat similar fluctuations. Because of the favorable climate and water quality factors, the Bay of Bengal coast has a large deal of potential for green mussel culture (Shahabuddin et al., 2010).

The optimal locations for green mussel culture should have appropriate shelter, be free of turbid convulsions, and satisfy all physical and chemical specifications. The green mussel has a high degree of environmental tolerance, and every parameter evaluated at the chosen sites somewhat falls into the tolerance range. The temperature ranged from 24.0°C to 34.1°C at the several locations, with no discernible difference between them.The ideal temperature ranges for green mussel culture include 11°C–32°C, 25.3°C–34.6°C (Rajagopal et al., 1998).

Parameters	S- 1	S- 2	S- 3	S- 4	S- 5
Temperature (°C)	25-33	23-35	22-36	24-34	26-32
Depth (m)	7.1-8.0	>8.0	6.1-8.0	4.1-7.0	5.1-8.0
Turbidity (NTU)	12-120	15-100	20-80	20-60	20-40
Current speed (ms^{-1})	0.3-0.7	0.25-0.6	0.2-0.5	0.15-0.4	0.1-0.3
pH	7.1-8.5	7.0-8.6	7.3-8.4	7.5-8.3	7.7-8.2
DO (mg L^{-1})	4.1-5	5.1-6	6.1-7	7.1-8.0	>8.0
Salinity (ppt)	18-36	21-35	23-34	25-33	27-32
Alkalinity (mg L^{-1})	45-210	50-200	70-180	90-160	110-140
Chlorophyll-α (μgL^{-1})	1.5-9.0	2.0-8.5	2.5-8.5	3.0-8.0	3.5-8.0

Table 1. Physicochemical parameters data from each site

S= Site; like S- 1: First site.

Weighted category	Site assessment
7.1-8.5	Good; suitable for farming
8.6-10.0	Excellent; incredibly suitable for farming
7.3- 8.7	Good; suitable for farming
8.2- 9.6	Excellent; incredibly suitable for farming
8.5- 9.8	Excellent; incredibly suitable for farming

Table 2. Site evaluation according to weighted categories

The temperature range observed is suitable for sustaining the appropriate growth and condition index of green mussels, with none of the chosen sites registering winter temperatures below 23°C or summer temperatures above 34.1°C (Rajagopal et al., 1998). In green mussel culture, water depth plays a critical role in preventing issues with ground predators, seabed turbidity, and bottom friction. A minimum of 1.5 meters of mean depth (Aypa, 1990) is necessary for healthy mussel cultivation, successful spat settling, and predator survival.

The chosen sites have a mean depth of more over two meters, suggesting that they would meet the water depth requirements for green mussel production. High turbidity has an adverse effect on green mussels because they are a filter feeder species. According to Soon and Ransangan (2014), the suspended particles cause turbidity, which obstructs and harms the fragile gills and reduces the amount of green mussel produced. Furthermore, the increased turbidity may hasten the emergence of rival and predator species. Most of the examined months at the chosen sites displayed a tolerable range of turbidity, except for the monsoon season.

However, slow water velocity typically encourages organic and inorganic particle matter to settle on the cultured organisms, which slows down the growth of the mussels. Current speeds between 0.17 and 0.35 m s-1 are ideal for green mussel culture. With the help of convulsions and tidal surges, a higher current speed of up to 0.72 m s-1 was reported in the stations during the monsoon. Sany et al. (2014) state that the primary cause of the pH value decrease in marine habitats is thought to be effluents from land runoff. All sites recorded pH ranges fell within the permitted range for the cultivation of green mussels, however. Although the DO level might not directly affect the green mussel's capacity for culture, high oxygen levels are necessary for the energy-intensive selective feeding processes (Bayne, 1998).

The DO levels were found to be within the acceptable range for mussel farming in all the chosen sites and were significantly higher (>5.7 ppm) (Sallih, 2005). Green mussels thrive best in environments that are rather stable and salinity-rich (Saxby, 2002). According to reports, the ideal salinity range for green mussels varies between 27 and 35 ppt (Aypa, 1990), 24 and 30 ppt (Rajagopal et al., 1998), and 18 and 33 ppt (FAO, 2021). Green mussels' capacity for filtration is improved at their ideal salinity of 24–30 ppt (Rajagopal et al., 1998). The growth and survival of bivalves may be adversely affected by low salinity (Saxby, 2002). According to Rajagopal et al. (1998), the ideal range for chlorophyll-α distribution is between 0.7 and 17 µg L-1.

According to a recent study, the plankton community from study area, comprised around 81 taxa, of which 14 were zooplanktons and 58 were phytoplankton (Fig-1). These findings suggest that there is enough food available to support green mussel farming on Bangladesh's southeast coast. On the other hand, because of their inadequate nutrition, Chlorophyceae and Cyanophyceae are low-quality food for *P. viridis* (Jónasdóttir, 2019). More than 20–60% of all the plankton that was consumed was quantitatively composed of coscinodiscus alone (Soon and Ransangan, 2017; Asaduzzaman et al., 2020). Thus, more preferred plankton further increases the viability of green mussel farming on southeast coast. It is known that chaetoceros entangle at the gills of shellfish (Ogongo et al., 2015). A lesser abundance of Chaetoceros (1.8%) has been found in our study.The basic biophysical aspects of growing green mussels were considered when implementing the grading points (Sidik et al., 2008; Soon and Ransangan, 2017). The most important variables for self-regulating green mussel culture are temperature, turbidity, salinity, current speed, and food availability (Lovatelli, 1988). Even though green mussels are a resilient species that can withstand abrupt changes in these factors, optimal conditions are necessary for healthy byssus development, spat settling, abundant feeding, growth, and reproduction.

These sites are considered ideal and suggested for green mussel farming, considering all the biophysical variables, food composition, and food availability (Fig- 1).

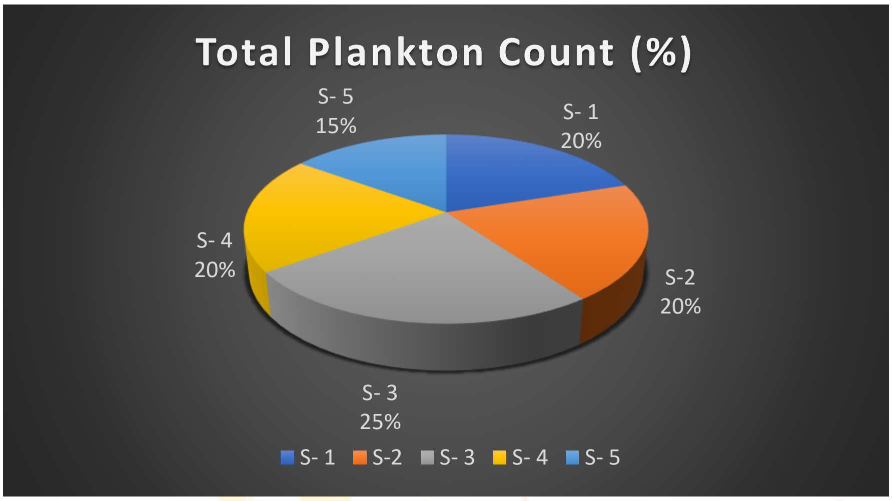

Fig- 1: Pie chart record of plankton collection from different study sites

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