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The Pharma Innovation

ISSN (E): 2277- 7695
ISSN (P): 2349-8242
NAAS Rating: 5.23
TPI 2021; SP-10(11): 932-937

www.thepharmajournal.com
Received: 10-09-2021
Accepted: 19-10-2021

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Mud crabs farming: An alternative sustainable livelihood approach in Sundarban, West Bengal, India

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Abstract
One study was conducted mainly in 4 zones of Sundarban namely Sagar-Namkhana, Matla, Saptamukhani and Bidya-Raimongol zone, to assess the prospects of crab culture as an alternative livelihood from sustainable development perspective in Sundarban, West Bengal, India from September 2018 to February 2020. Mainly farming of orange mud crabs (*Scylla olivacea*) were observed in the survey sites. Data were collected from the farmers through a semi-structured questionnaire and analyzed. According to the zones and coordinates average weight of the mud crabs varied; in Matla zone average weight of mud crabs was observed the highest (300gm). The survey indicated that mainly male villagers are engaged in mud crabs rearing or collection process and most of them prefer traditional process for rearing mud crabs. Most of the respondents have their fisheries and rear crabs, collecting crablets from the riverside as a partial livelihood option. Profitability Index (PI) and Benefit-Cost ratio (BCR) reveal that mud crab farming can be a profitable alternative livelihood for the disaster-prone people of Sundarban exploiting its unutilized and under-utilized brackish water resources by developing appropriate management practice through participatory planning, and capacitating the community for implementing the same.

Keywords: Sundarban, crab farming, brackish water, sustainable livelihood, profitability index, cost benefit ratio

1. Introduction
Coastal ecosystem are complex and dynamic areas that are constantly affected by biophysical changes, development plans, tourism pressure, population growth, pollution, and many other factors (Campbell *et al*., 2006; Roy, 2020) [2, 13]. Being at the interface of land and water, the coastal ecosystem provides essential livelihoods for agricultural and fisher communities. The Sundarban (the name derived from the abundance of local Sundari tree (*Heritiera fomes*) is a mangrove dominated deltaic ecosystem formed at the confluence of the Ganges, the Brahmaputra, and Meghna Rivers that originate from the Himalayan mountains in the north and readily transcend into the Bay of Bengal in South. Sundarban region is one of the richest biodiversity zones of India and mangroves serve as a biological buffer between land and sea. Mangroves also provide natural barriers by absorbing storm surge impacts during extreme weather events such as hurricanes, cyclones, and very severe storms (Sambadnam and Kathiresan, 2015) [14]. The two key adaptations are their ability to survive in waterlogged and anoxic (no oxygen) soil, and the ability to tolerate brackish waters. Mangroves can also remove salt by ultra-filtration through their roots (Krishnamurti *et al*, 2014). Mangroves prevent erosion and stabilize the coastal ecosystem. Mangrove litter contain valuable bioactive substances which when falls into the river water forms an energy-rich detritus that support the growth and survival of the aquatic life (Viswanathan and Raffi, 2015; Kathiresan and Qasim 2005) [3, 8].
Mangroves provide a favorable habitat for the proliferation of zooplankton, fishes, shrimps, crabs, etc. This unique ecosystem found in the intricate mesh of mangrove roots offers a nursery habitat for juvenile organisms. The local thriving coastal community utilize these local bio-resources as their livelihood option mainly due to the remoteness and inaccessibility of Sundarbans. Crab collection is a major livelihood of the people of Sundarban. Mud crab farming has the potential to support vulnerable coastal population thereby strengthening its resilience, flexibility, and adaptability in the dynamical coastal climate of Sundarban (Rahman *et. al.*, 2017, Ahmed, 1992; Kamal, 2002; Zafar, 2004; Zafar and Hossain, 2008) [12, 1, 7, 17, 18]. *Scylla spp.* (often called mud crab or mangrove crab) is an ecologically important species of crab found in the estuaries and mangroves of Africa, Australia, and Asia.

These crabs are known for their robust size and dense meat content and have been greatly sought after over the years and largely fished from the mangrove creeks (Keenan *et al*., 1998, Shelly and Lovatelli, 2011) [9, 15]. However, little effort has been done so far to understand the biology and fishery of mud crabs of Sundarban and their influence on socio-economic development of this region. Keeping the above points in mind, a study was carried out to explore the existing mud crab culture and its economic viability. The aim of this study was to find out the potential of mud crab farming as a sustainable livelihood option in Sundarban, India. The study also dealt with the identification of the vulnerability context of native crab farmers, aspects obstructing sustainable crab fisheries development to identify the needed technological refinements that would facilitate to enhance production, profitability, and thus enabling sustainability of coastal crab culture practices in Indian Sundarban.

2. Materials and Methods

2.1 Study area

Sundarban is the world's largest coastal wetland (latitude 21°27'30"N and 22°30'00" N and longitude 89°02'00"E and 90°00'00" E) with a total area of 10,000 km2, 40% of the mangrove forests lie in India and the rest in Bangladesh. The land zone, containing exposed sand bars, occupies 414,259 ha (70%) and water bodies cover around 187,413 ha (30%) (UNESCO). The rivers have branched into several distributaries named, Matla, Raimangal, Saptamukhani, *etc*., which again are crisscrossed with tidal creeks and channels to form this dynamic hydrological river system. The area experiences a high tide and a low tide, twice every day. During high tide, saline water from the ocean enters into the freshwater river system thus making it a vibrant brackish water ecosystem; the salinity variation in various sectors of Sundarban is noticeable. The area experiences annual rainfall of 1600 mm to 1800 mm and subtropical monsoonal climate with severe cyclonic storms. A huge amount of sediments carried by the rivers contribute to its expansion and dynamicity. Salinity gradients change over a wide range of spatial and temporal scales and pH level varies from 6-8; the maximum and minimum temperature varies between 12 °C to 40 °C from winter to summer season respectively.

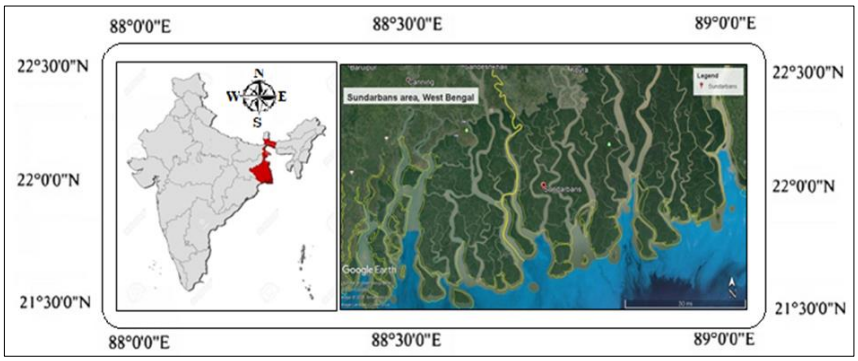

Fig 1: The study area map showing the location of survey area

2.2 Socio-economic survey

Many of the crab collectors along with their entire family members are involved in different activities in crab rearing like feeding, stocking, and other pre-stocking and post stocking management. Thus the crab collectors in Sundarban can be categorized as: 1) crab collectors 2) crab collectors and rearers 3) crab rearers. A structured questionnaire was designed to obtain qualitative and quantitative data on fishing activities, in particular mud crab collection as well as social, economic, and environmental factors influencing fishers and their daily activity. The survey was conducted in four zones *viz*, Matla, Saptamukhi, Sagar, and Raimangal. Matla zone includes villages *viz*, Jharkhali bazaar, Parbatipur, Joyramkhali, Balakhali, Dabu, and Katamari. The survey included age, experience, and training (if, obtained); techniques used (culture period, stocking season, male to female ratio, survival rates, production, farming cost, income, feed types and feeding strategy, harvesting methods, and marketing information); management practices and other relevant issues (such as satisfaction level and income) to ascertain the feasibility and sustainability of crab rearing and culture.

2.3 Analytical Techniques

In this study, both socioeconomic evaluation and data analysis techniques were used. The data were arranged into an MS Excel 2007-based database, following the objectives of the study and average data were calculated to obtain the comprehensive result. The profitability analysis (PI) and Benefit-cost Ratio (BCR) was obtained to evaluate the economic sustainability of this alternative suggested livelihood option.

2.4 Profitability Analysis (PI)

To determine the profitability of crab farming, costs items were divided into two components: fixed costs (tools and equipment cost, interest on operating capital, etc.) and variable costs (tax, labor cost, transportation cost, etc.). Net profit was derived by deducting all costs (variable and fixed costs) from gross return. In determining the net return or profit of the crab farmers, the Profitability Index (PI) and benefit-cost ratio (BCR) was used with the below-mentioned equation to determine the profitability of the crab farmers (Jahan and Islam, 2016).Net return/profit of farmers:

$$PI=P_m.Q_m(TVC+TFC) \ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (1)$$

Where

PI=Profit of crab collector/crab whole seller/ crab rearers

P_m = Per unit price (price per kg) of crab

Q_m = Total quantity of crab (kg)

TVC = Total variable costs of crab collector/crab whole seller/crab rearers

TFC = Total fixed costs of crab collector/crab whole seller/crab rearers

The benefit-cost ratio (BCR) was computed by the following

equation.

BCR= Gross return/Total cost…… (2)

3. Results and Discussions

A total of 164 crab collectors, 52 crab rearers and 12 crab wholesalers participated in the survey. From the study, it was found that most of the people were involved in crab collection rather than selling and rearing. Information collected through structured questionnaire from the mud crab collectors and crab rearers were documented. Details regarding age, sex, educational qualification, yearly income, techniques of collecting crabs, best time (season) for collecting crabs, problems faced during crab collection and their solutions were collected. Other details such as the wholesale price of crabs according to their gender variation, the previous system of buying and selling crabs, transportation used during crabs selling, the price difference between local and international markets including their demography was also documented. The summary of the details has been furnished in Table 1. From the random respondents that we had surveyed, 86% population villagers are male and 14% populations are female. From this observation, it can also be concluded that generally male villagers are attached to the crab collection process.

Table 1: Summary of the key demographic details in study sites based on the survey questionnaire results

Variables	Percentage of Respondents
Male	86
Female	14
Age of respondents below 40	60
Age of respondents between 41 to 60	30
Age of respondents above 60	10

Table 2 represents the percentage of respondents surveyed from the selected sites. From the survey, it was found out that 40% respondents were from Matla zone, 32% from Saptamukhani zone 16% from Sagar and 12%, Raimangal respectively.

Table 2: Percentage of respondents from each surveyed location

Zone	Percentage
Matla	40
Saptamukhi	32
Sagar	16
Raimangal	12

In the study, mainly green mud crabs were observed at the selected sites. The average weight of mud crabs along with their respective sites and coordinates have been presented in Table 3. The result shows that the maximum average crab weight was recorded at Jharkhali Bazar of Malta zone (300gm) whereas the minimum weight was recorded from Joygopalpur (50 gm) of Raimangal zone. The respondents also added that the width and weight of the crabs was directly related to water salinity. With increase in water salinity, the weight and width of the mud crabs (both male and female) are increased.

Table 3: Site specific average weight of mud crabs

Zone	Area	Co-ordinates	Weight
Matla	Jharkhali Bazar	22.0497° N, 88.6687° E	300gm
Matla	Parbotipur	22.6548° N, 88.2291° E	150gm
Matla	Joyramkhali	22.3055° N, 88.7059° E	100gm
Matla	Balakhali	22.3596° N, 88.3397° E	100gm
Matla	Dabu	22.2537° N, 88.6458° E	100gm
Matla	Katamari	22.0253° N, 88.5964° E	250gm
Matla	Mundapara	22.5153° N, 88.4198° E	125gm
Saptamukhani	Brajaballavpur	21.9624° N, 87.6507° E	75gm
Raimangal	Sandeshkhali	22.3627° N, 88.8767° E	70gm
Raimangal	Joygopalpur	22.1468° N, 88.7037° E	50gm
Sagar	Bankimnagar	23.2064° N, 88.5928° E	75gm
Sagar	South Durgapur	22.4141° N, 88.5928° E	75gm

Figure 2 depicts the mode of crab rearing process practiced by the farmers of Indian Sundarbans. Findings of the survey-based study revealed that the farmers generally prefer the traditional process (95%), but some farmers use the crab cage process (5%) for rearing mud crabs.

Due to the increase in demand for orange mud crabs; farmers now harvest mud crabs of smaller size and generally rear crabs in their fisheries. Some rear in riverside small fish ponds. Some farmers don't have any specific regions for rearing mud crabs and hence sell it to 'byaparis' (middlemen in crab business) (Figure 3 a). The random respondents are engaged in different professions. Of the respondents 38% are engaged only in crab rearing, 44% are engaged in crab rearing along with another profession, 18% are engaged in other professions (Figure 3 b). From the survey, it is found that most of the respondents are engaged in crab rearing and only a few of them are attached to other professions.

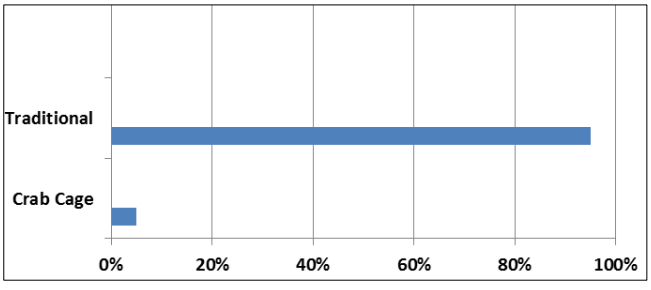

Fig 2: Crab rearing process

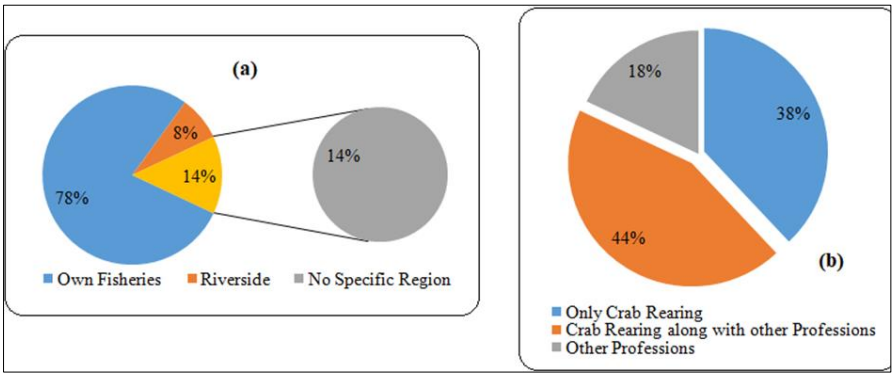

Fig 3: (a) Rearing areas of Mud crabs (b) Professions of the respondents

Monoculture of mud crabs can be done extensively and intensively in cages/closed nets or pens. They can also be easily reared in polyculture mode successfully along with other species including grass shrimp, tiger shrimp, and other marine species thus ensuring the proper utilization of the ecological niches of an aquatic ecosystem. Some of the common fish species reared along with mud crabs in polycultures are Tilapia (*Oreochromis niloticus*), Bhetki (*Lates calcarifer*), Vangan (*Liza tade*), and Parse (*Chelon parsia*) which have good commercial value and enable the farmers to earn more profit.

Table 4: Initial and Final weight of mud crabs

Initial weight (gm)	Time taken (months)	Final weight (gm)
20-100	3	250-500
100-250	1.5	250-500
250-500	2	500-750

The harvested mud crabs are reared in specific areas for a specific period to attain proper weight. The mud crabs mostly take 1.5 to 3 months to reach optimum weight. According to most of the respondents, the best season for mud crab rearing is Monsoon i.e., mid-June to mid-August, while some others also prefer winter (mid-December to mid-February) and summer (mid-April to May) rearing (Table 5).

The selling process of the mud crab is also included in the survey to calculate the share of profit of the farmers. The farmers sell to various outlet points of which 72% are middle man, 26% sell to whole sellers, 2% sell in direct market (Figure 4).

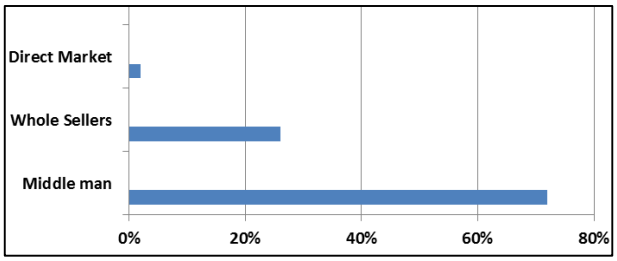

Fig 4: Selling process of the Crabs by the farmers

The local people of that region are generally dependent upon crab rearing process. As a result, their livelihood is completely dependent on them. There are 62% who are satisfied about the price, but 34% people mentioned that they are not happy and satisfied with the prices and 4% people are did not want to disclose the matter (Fig 5). From this socioeconomic survey, it is evident that good earning and a profit of around 3000 to 4000 rupees every month is assured from crab collection alone.

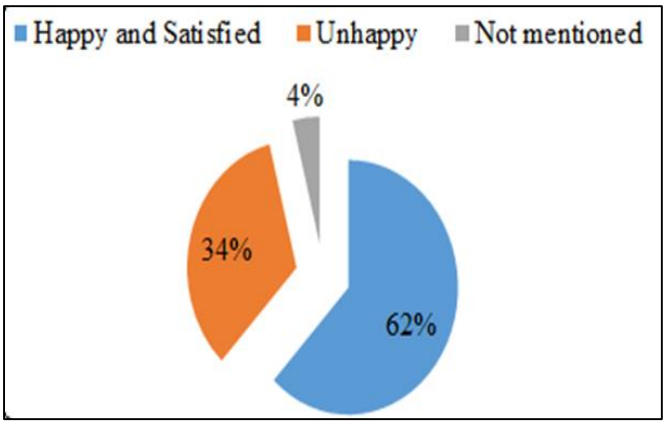

Fig 5: Feedback of the respondents with the market value of crabs

The Profitability Index (PI) was also calculated to evaluate the economic benefit of the farmers from mud crab farming as a source of sustainable income. To calculate the PI, the average values of crab weight, total price and other recurring prices were used. The PI of Crab whole sellers, Crab rearers, and crab collectors were separately calculated to understand the maximum revenue earned by the mode of occupation. The results revealed that the maximum profit was realized by the crab rearers (18078.75 /-), followed by the crab wholesalers (13345.2 /-). The crab collectors also earned a considerable profit of around 4303.6 /- (Table 6). Hence, overall it can be predicted that mud crab framing is an overall profitable occupation for the aquafarmers of Sundarban. The benefit-cost ratio of crab farming was found to be 3.58 implying that the crab production is profitable for farmers.

Table 5(a): Profitability Index of Crab Wholesalers (International Market)

Crab Wholesalers (International Market)			
Male Crab		**Female Crab**	
Total Average weight (kg)	**Total average price (per kg)**	**Total Average weight (kg)**	**Total average price (per kg)**
25.200	739	20.700	678
Pm*Qm	18622.8	Pm*Qm	14034.6
Boat Cost (TVC)	1008	Boat Cost (TVC)	828
Packing Cost (TFC)	504	Packing Cost (TFC)	414

Tata 407 Cost (TVC)	1764	Tata 407 Cost (TVC)	1449
TVC + TFC	3276	TVC + TFC	2691
PI	15346.8	PI	11343.6

Table 5(b): Profitability Index of Crab rearers

Crab Rearer			
Male Crab		**Female Crab**	
Total Average weight (kg)	**Total average price (per kg)**	**Total Average weight (kg)**	**Total average price (per kg)**
27.000	690	42.500	625
P*Q	18630	P*Q	26562.5
Boat Cost (TVC)	1080	Boat Cost (TVC)	1700
Packing Cost (TFC)	540	Packing Cost (TFC)	850
Tata 407 Cost (TVC)	1890	Tata 407 Cost (TVC)	2975
TVC + TFC	3510	TVC + TFC	5525
PI	15120	PI	21037.5

Table 5(c): PI of Crab Collectors

Crab Collectors	
Total Average weight (kg)	**Total average price (per kg)**
21200	333
P*Q	7059.6
Boat Cost (TVC)	848
Packing Cost (TFC)	424
Tata 407 Cost (TVC)	1484
TVC + TFC	2756
PI	4303.6
Average	4303.6

Table 6: Cost Benefit ratio for the Crab Farming

BCR (Gross Return/Total Cost)		
Types	Average PI	Average TC
Crab Wholesalers	13345.2	2983.5
Crab rearers	18078.75	4517.5
Crab Collectors	4303.6	2756
Average	11909.18	3419
BCR	3.48	

4. Conclusion

Mud crabs fetch a good market value in both domestic and also serve as an ideal species for live export to other countries too. The market value can range from 8 to 25 USD depending on size and season (Lalramchhani *et al*, 2019) [11]. Crab harvesting is the main important livelihood of the people who live in Sundarban. As crabs usually take a very short time (2-2.5 months) from a medium size (weight 500gm) to achieve optimum (weight 1-1.2kg), local coastal community take part in either crab harvesting, crab whole selling or retailing. *Scylla olivacea* is a very common species in Sundarban commonly known as orange crabs (Mosera, Rearing of *Scylla olivacea* from small sizes (20-100 gm) to marketable size (500 gm to 750 kg) is very common in Indian Sundarban. Through the present study, it was found out that crab collection and farming is a profitable business. Hence, crab rearing/farming can be an alternative option for sustainable livelihood management. This alternative sustainable livelihood options would be beneficial for the villagers in Sundarban. Besides, the existing lucrative market potential is an added advantage for this alternative option to register a significant and sustained socio-economic development for the marginal communities in Sundarban. Semi-intensive crab culture, especially during the spare period of agricultural activity, will facilitate them and boost their economy.

However, there are certain constraints associated with mud crab farming. Being a natural disaster prone zone, Sundarban region is a cyclonic prone zone, being very close to the Bay of Bengal frequented by prominent depressions and severe storms which makes it very difficult for the local community to survive and engage successfully in their occupation. Apart from the natural disaster, crab sellers also don't get the adequate price of their products as they directly sell the harvest to the local aggregators directly. Loss of harvest due to robbery and improper post-harvest measures leading to mortality of crabs and improper management are also some of the challenges faced by the farmers. The lack of professional knowledge of farmers regarding improved crab aquaculture methods, scientific and organized fishing, and sparse marketing networks are some of the critical challenges that hinder the production and profitability of crab aquaculture for the small farmers. Appropriate steps should be taken by the government, private sectors, NGOs, and most importantly, the stakeholders to accelerate the growth potential of crab aquaculture as a viable and sustainable economic option for building resilience and well-being of disadvantaged people in the climate-vulnerable terrain of Sundarban. To conclude, adequately developed crab aquaculture may serve as a prosperous and promising occupation for securing long term livelihood security of the coastal communities.

5. Acknowledgements

This study was undertaken as a part of the project under Centre for Environmental Studies, Vidyasagar University, W.B. The authors are grateful to Directorate of Distance Education, Vidyasagar University, W.B for providing the necessary financial support for the study. The authors are thankful to Nature Environment & Wildlife Society (NEWS)for conducting the whole work and for providing necessary information and support. The authors are also thankful to crab farmers of Sundarban who participated and provided valuable information for this study.

6. References

1. Ahmed MK. Mud Crab - A Potential aqua-resource of Bangladesh. In: The mud crab: Report of the seminar on the mud crab culture and trade held at Surat Thani, Thailand. Angell, C., 1992, 95-102.
2. Campbell J, Whittingham E, Townsley P. Responding to coastal poverty: should we be doing things differently or doing different things? CAB International Environment and Livelihoods in Tropical Coastal Zones, (Eds C.T. Hoanh TP, Tuong Gowing JW, Hardy B) 2006, 274-292
3. Viswanathan, C, Raffi SM The natural diet of the mud crab *Scylla olivacea* (Herbst, 1896) in Pichavaram mangroves, India. Saudi Journal of Biological Sciences

2015;22(6):698-705.
4. Gopal B, Chauhan M. Biodiversity and its conservation in the Sundarban Mangrove Ecosystem. Aquatic Sciences 2006;68(3):338-354. https://whc.unesco.org/en/list/798/#:~:text=Lying%20between%20latitude%2021%C2%B0,covering%20187%2C413%20ha%20(30%25).
5. Jahan H, Islam MS. Economic performance of live crab (*Scylla serrata*) business in the southwest coastal region of Bangladesh. International Journal of Fisheries and Aquatic Studies 2016;4(1):453-457
6. Joel DR, Ray PJS. Ecological distribution of some edible portunid crabs of the Pulicat Lake (Abstract). In: Symposium on coastal aquaculture, Cochin, India, 1980.
7. Kamal D. Development of fattening technology for the mud crab (Scylla serrata) in small ponds with special reference to biology, nutrition, microbial quality, marketing and transportation from the South-Western region of Bangladesh. Final report, Action research for poverty alleviation project, Grameen Trust, Dhaka, Bangladesh, 2002.
8. Kathiresan K, Qasim SZ. Biodiversity of mangrove ecosystems. Hindustan, New Delhi, 2005, 51.
9. Keenan CP, Davie PJF, Mann DL A revision of the genus Scylla deHaan, 1833 (Crustacea: Decapoda: Brachyura: Portunidae). The Raffles Bulletin of Zoology 1998;46(1):217-245.
10. Krishnamurthy P, Jyothiprakash PA, Qin LIN, He JIE, Lin Q, Loh CS *et al*. Role of root hydrophobic barriers in salt exclusion of a mangrove plant *Avicennia officinalis*. Plant, Cell & Environment 2014;37(7):1656-1671.
11. Lalramchhani C, Balasubramanian CP, Shyne Anand PS, Ghoshal TK, Prem Kumar, Vijayan KK *et al*. Mud crab farming: An alternative livelihood in the Indian Sundarban. Aquaculture 2019;23(3):20-29.
12. Rahman MM, Islam MA, Haque SM, Wahab A Mud crab aquaculture and fisheries in coastal Bangladesh. World Aquaculture 2017;48(2):47-52.
13. Roy M. Coastal Tourism and Environment Issues of Concern and Sustainability: A Case Study in Digha, WB, India. Journal of Water Pollution & Purification Research 2020;7(3):6-12.
14. Sambadnam S, Kathiresan K. Mangroves as bioshield: An undisputable fact. Ocean and Coastal Management 2015;103:94-96 DOI:10.1016/j.ocecoaman.2014.11.011
15. Shelley C, Lovatelli A. Mud crab aquaculture, a practical manual. FAO, Fisheries and aquaculture technical paper, Rome, Italy 2011, 567.
16. Mosera S, Donald Mc, Laoprasertb S, Tongdeec, N Population ecology of the mud crab Scylla olivacea: a study in the Ranong mangrove ecosystem, Thailand, with emphasis on juvenile recruitment and mortality. Fisheries Research 2005;71;27-41.
17. Zafar M. Mud crab Scylla serrata fattening in bamboo cages in Bangladesh coastal waters. In: The book of abstracts. 7th Fisheries Forum, Penang, Malaysia. Gupta, M.V., Editor. 30 November- 4 December, Asian Fisheries Society, Manila, Philippines, 2004, 79.
18. Zafar M, Hossain MI. Community-based pen culture of mud crab, Scylla serrata in the mangrove swamp of Cox's Bazar. In: Abstracts book of 3rd fisheries conference and research fair 2008, Bangladesh Fisheries Research Forum (BFRF), Bangladesh Agricultural Research Council, Dhaka, Bangladesh, 2008, 170.