Development of Culture of Seaweeds in Bangladesh Coast

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Objectives

- To make a detailed inventory of available seaweed species in Bangladesh coast
- To develop culture technique of seaweed in St. Martin and other suitable areas
- To investigate the nutrient and medicinal properties of seaweeds.

Achievements

Inventory of available seaweed

Survey was conducted in and around Cox's Bazar (St. Martin Island, Inani, Bakkhali, Teknaf and Moheshkhali) during November 2015 to April 2016. Different species of seaweed i.e. *Actinotrichia fragilis, Asparagopsis taxiformis, Caulerpa* sp., *Colpomenia* sp., *Enteromorpha* sp., *Gracilaria* sp., *Hypnea* sp., *Jania* sp., *Padina* sp., *Porphyra* sp., *Sargassum* sp., *Ulva* sp. etc. were collected by hand-picking from the inter-tidal zone of study are during low-tide. Fresh samples were taken into plastic jars and then kept into icebox for laboratory work. In the laboratory, samples were gently brushed under running seawater, rinsed with distilled water, dried with paper tissue and finally preserve by open air drying.

Table 1. Status of seaweed resources in Bangladesh

Seaweed species abundance in different months							
Scientific name	Type	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Actinotrichia fragilis	RSW		+	++	+	+	
Asparagopsis taxiformis	RSW			+	++	++	+
Caulerpa (3 sp.)	GSW				+	++	++
Chrysymenia sp.	RSW				+	+	
Colpomenia (2 sp.)	BSW		+	++	+		
Dictyota (2 sp.)	BSW		+	+	+		+
Enteromorpha (3 sp.)	GSW	+	+	+	+		
Galauxara sp.	RSW		+	+			+
Gracilaria sp.	RSW			+	+	+	
Helimeda (2 sp.)	GSW		+	+	+		
Hydroclathrus sp.	BSW		+	++	+++	+	
Hypnea (4 sp.)	RSW	+	+++	+++	+++	+++	+
Jania sp.	RSW			+	+		
Padina (2 sp.)	BSW		+	+++	+++	+	
Peyssonellia sp.	RSW			+	+	+	
Porphyra sp.	RSW		+	+	+		
Sargassum (3 sp.)	BSW			++	+++	+++	+
Ulva sp.	GSW		+	++	+		

RSW = Red seaweeds
BSW = Brown seaweeds
GSW = Green seaweeds

+ Normally available
++ Moderately available
+++ Largely available

Seaweed culture

Experimental culture sites of seaweeds were sheltered intertidal zones of Saint Martin (N20°37.043, E092°19.715), Bakkhali river estuary (N21°28.500, E091°57.941) and Inani beach (N21°13.941, E092°02.596). Culture experiment was started on 05, 07 and 09 December 2015, respectively. Coir rope was used as net material for substrate with horizontal square of 4m×4m. Four corners of the nets were tied with rocks or bamboo with plastics floats placed 25 cm above from the bottom. Micronutrients enriched seaweed species *Hypnea* sp. was selected for culture experiment. Seeding was done by inserting the young fragments of *Hypnea* sp. with an average of 4±0.5kg fw (fresh weight) and average 5cm length in the twists of the coir ropes with short length of string at a density of 35-40 seed/m^2. Partial harvesting was done every 15 days interval of total 60 days culture period. Seaweed mean biomass was recorded at the end of 60 days of experiment and expressed as wet weight of seaweed per unit culture area (Kg/m^2) and computed with the following formula:

$$Y = (W_t - W_0)/A$$

Where: Y = biomass production;
W_t = wet weight at day t; W_0 = initial wet weight; A = area of 4 m^2 net.

Daily growth rate (DGR) % was calculated every 15 days of culture period using formula of Hung *et al.* (2009).

$$DGR = [(W_t/W_0)^{1/t} - 1] \times 100 \text{ \%/day}$$

Where: W_0 is the initial wet weight, W_t is the final wet weight, and t is days of culture

Three replications were conducted in each culture area. The physio-chemical parameter and culture results are shown in Table 2 and Figs. 1-3.

Table 2. Phusio-chemical parameters of the culture sites

Experimental sites	Mean values of physio-chemical parameters							
	Temperature (°C)	Salinity (‰)	DO (mg/l)	pH	NO_3-N (mg/l)	PO_4-P (mg/l)	Transparency (cm)	Depth (cm) at max. high tide
St. Martin	24.62	31.72	5.88	7.22	0.34	0.17	71.4	98
Bakkhali	22.92	28.82	4.5	5.7	0.89	0.28	52	92
Inani	23.86	29.94	5.58	6.4	0.43	0.23	62.8	90

During December 2015 to January 2016, a total of 12 partial harvests were made in three sites (Saint Martin, Bakkhali and Inani), 4 partial harvests in each sites. In Saint Martin, the maximum partial harvesting was recorded as 19.31±0.27 kg fresh wt at 60th day; the minimum 5.90±0.10 kg fresh wt. occurred at 15th day. In Bakkhali, a maximum 17.39±0.38 kg fresh wt. was partially harvested at 60th day; the minimum was 5.10±0.07 kg fresh wt. at 15th day. In Inani, the partial harvesting peaked at 14.82±0.16 kg fresh wt. at 60th day and the lowest was 4.24±0.07 kg fresh wt. at 15th day (Fig. 1)

Maximum daily growth rate of 3.21±0.01 %/day at 60th day and minimum daily growth rate 2.71±0.16 %/day was observed at 15th day in Saint Martin. In Bakkhali, the DGR value peaked at 2.97±0.04 %/day at 60th day and the lowest was 1.71 ±0.10%/day at 15th day. In Inani, the DGR was at a maximum 2.65±0.02 %/day at 60th day and minimum daily growth rate 0.41±0.11 %/day was observed at 15th day harvest (Fig. 2).

Harvest at the end of 60 days duration of culture period in three sites resulted in the absolute maximum biomass yield of 11.05± 0.10 kg fresh wt./m^2) in Saint Martin and the lowest biomass of 7.82±0.04 kg fresh wt./m^2) in Inani (Fig. 3).

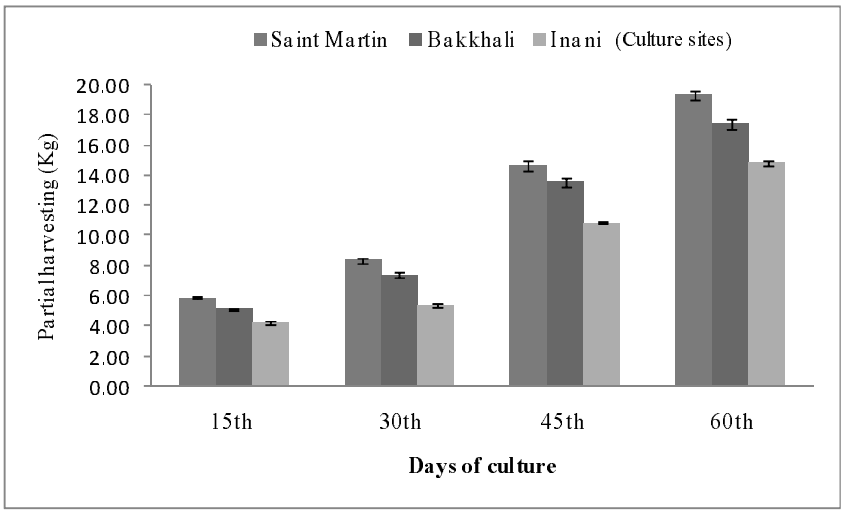

Fig. 1. Partial harvest (Kg) of *Hypnea* sp. on 60 days of culture period in three sites.

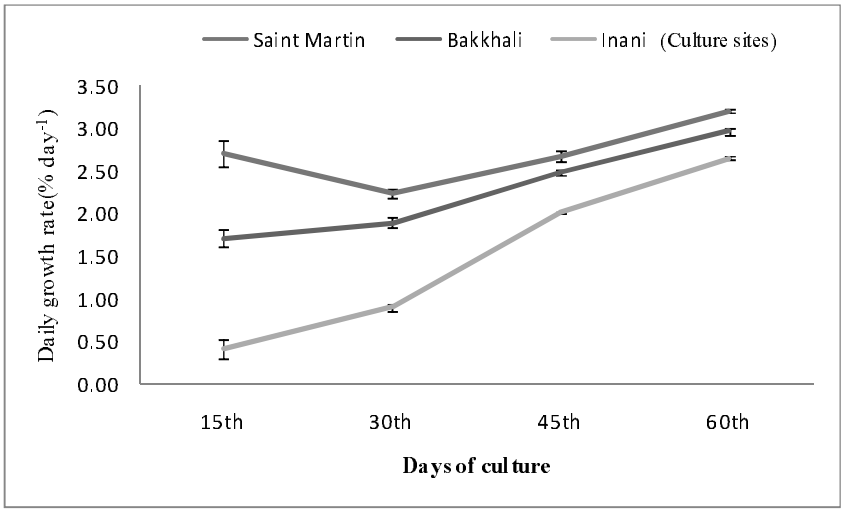

Fig. 2. Daily growth rate %/day of *Hypnea* sp. on 60 days of culture period in three sites.

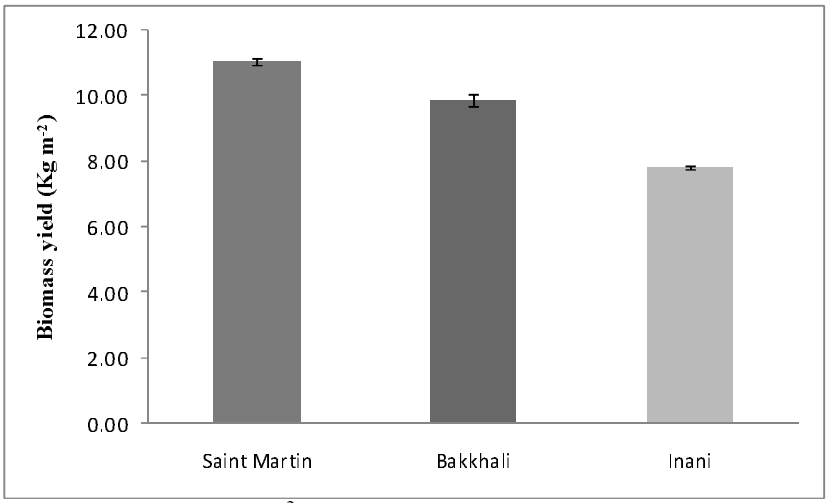

Fig. 3. Biomass production (Kg/m^2) of *Hypnea* sp. on 60 days of culture period in three sites.

Fig. 5. Seaweed culture net set-up, production and processing.

Fine Tuning of Mud Crab (*Scylla* sp.) Fattening Practices in Cox's Bazar Region

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Objectives

- To demonstrate and standardize mud crab fattening (in pen and cage) in Cox's Bazar region
- To develop crab nursing technique for culture practice
- To build-up awareness and knowledge back-up of crab fatteners on improved crab fattening practices.

Achievements

During crab fattening practice from December 2015 to March 2016, concurrently in pen and cages at Chaufoldondi, Cox's Bazar, the water temperature was fluctuated between 23.4^0 to 29.3^{0}C. The salinity was ranged between 26‰ to 30‰. Dissolved oxygen content varied from 6.2 to 7.4 mg/l. The alkalinity was between 68 to 96 mg/l and the pH values were between 6.8 to 7.8. The mean values of temperature, salinity, dissolved oxygen, alkalinity and pH was 26.9±1.46^{0}C, 27±2.01‰, 6.9±1.17 mg/l, 86±2.7 mg/l and 7.1±0.98, respectively. Gonad development performance and survival of crabs in the 3 different trials are shown in Table 1.

Table 1. Crab fattening practice concurrently in pen and cages at Chaufoldondi, Cox's Bazar

Trial no.	Treatments	Gonad development (%) in days								Survival (%)
		7	14	21	28	35	42	49	56	
01	T_1 (2crab/m^2)	--	--	--	--	--	--	30	52	36
	T_2 (1crab/cage)	--	--	--	--	--	--	30	50	18
02	T_1 (2crab/m^2)	--	--	40	80	100				56
	T_2 (1crab/cage)	--	--	40	80	100				48
03	T_1 (2crab/m^2)	45	78	100						88
	T_2 (1crab/cage)	45	75	100						82

Nursing of wild crablets was conducted from December 2015 to January 2016 at Nuniyarchara, Cox's Bazar, where highest temperature was recorded as 25.9 ^{0}C and the lowest temperature was 23.7 ^{0}C. The salinity was varied between 27‰ to 30‰. Dissolved oxygen content was 6.2 to 6.9 mg/l. The alkalinity was from 83 to 84 mg/l and the pH value was ranged between7.2 to 7.6. The mean values of temperature, salinity, dissolved oxygen, alkalinity and pH was 25.13±0.81^{0}C, 28.86±1.21‰, 6.69±0.23mg/l, 83.29±0.49mg/l and 7.40±0.23respectively.

The initial mean weight of crablet was 0.15 g. After feeding with crab pellet feed, shrimp crumble feed and trash fish in different trial (T_1, T_2 & T_3) the weight after 44 days was 0.87 g, 0.79 g and 1.02 g and survival rate was 33%, 55% and 58%, respectively.

Second time crablet nursing trial was conducted during the May to June 2016 at Nuniyarchara, where, highest temperature was recorded as 34 ^{0}C and the lowest temperature was 29 ^{0}C. The salinity was varied between 25‰ to 28‰. Dissolved oxygen content was 5.6 to 6.3 mg/l. The alkalinity was varied from 96 to 105 mg/l and the pH value was ranged between7.2 to 7.8. The mean values of temperature, salinity, dissolved oxygen, alkalinity and pH was 33.34±0.49^{0}C, 26.44±0.29‰, 5.09±0.51mg/l, 103.61±0.36mg/l and 7.60±0.19 respectively.

The initial mean weight of crablet was 0.17 g. After feeding the soul fish at different density (05, 10 and 15 ind/m^2) the weight of crablet after 44 days was 16.31g, 10.65g and 4.91g and survival rate was 46.66%, 26.66% and 26.66%, respectively (Table 2).

Table 2. Crablet nursing trial in hapa at Nuniyarchara, Cox's Bazar

Trial nos.	Treatments	Initial weight (g)	Final weight (g)	Mean values of water quality parameters				
				Water temp. (°C)	Salinity (‰)	DO (mg/l)	Alkalinity (mg/l)	pH
T_A (with different feedings) 12nos./hapa	T_1 (Crab feed)	0.15	0.87	24.2±0.93	27±0.56	6.8±0.97	83±0.38	7.1±0.36
	T_2 (Shrimp feed)	0.15	0.79					
	T_3 (Trash fish)	0.15	1.02					
T_B (with different stocking density)	T_1 (05 Crablet)	0.17	16.31	33.34 ±0.49^0	26.44 ±0.29	5.09 ±0.51	103.61 ±0.36	7.60 ±0.19
	T_2 (10 crablet)	0.17	10.65					
	T_3 (15 crablet)	0.17	4.91					

Proximate composition of two types of pellet feeds i.e. crab pellet and shrimp crumble, the % moisture, crude protein and crude lipid level was almost same (10.00 & 10.08)%, (44.10 & 43.05)% and (10.69 & 10.57)%, respectively. The % ash, crude fiber and carbohydrate were (13.43 & 10.49)%, (4.10 & 3.65)% and (17.68 & 22.16)%, respectively (Table 3).

Table 3. Proximate compositions of Thai origin crab pellet feed and shrimp crumble feed.

Feed	Moisture (%)	Ash (%)	Crude protein (%)	Crude lipid (%)	Crude fiber (%)	Carbohydrate (%)
Crab pellet feed (Thai)	10.00	13.43	44.10	10.69	4.10	17.68
Shrimp crumble feed (Thai)	10.08	10.49	43.05	10.57	3.65	22.16

However, the protein content of two types of feeds were same (44.10 and 43.05 %, respectively) and the growth rate are almost similar (DGR & BWG, Table 4), the survival rate was batter with crablet fed shrimp crumble feed than crab pellet feed (33.33% and 55.56%). At the end of the trial, feeding with shrimp crumble feed and trash fish (T_1 & T_2), survival rate (55.56 & 58.33)% and FCR (1.39 & 1.32) were almost same, although DGR and BWG of crablets were better in feeding trash fish than pellet feeds (Table 4). On the other hand, in different stocking density, T_1 (05 crablets/m^2) showed the highest growth (16.31 g) and better survival rate (46.66%), DGR and BWG than T_2 and T_3 (10 and 15 crablets/m^2) fed soul fish (Table 4).

Table 4.Survival and growth rate of crablets for 44 days in different feeding and different stocking density (mean ± SD)

Trial nos.	Treatments	Initial weight (g)	Final weight (g)	DGR (%)	SR (%)	BWG (%)	FCR
T_A (with different feedings) 12nos./hapa	T_1 (Crab feed)	0.15	0.87	1.71±0.6	33.33.±5.9	480±24.8	0.80±0.03
	T_2 (Shrimp feed)	0.15	0.79	1.52±0.8	55.56±6.4	426.67±18.9	1.39±0.02
	T_3 (Trash fish)	0.15	1.02	2.07±0.4	58.33±7.4	580±34.5	1.32±0.04
T_B (with different stocking density)	T_1 (05 Crablet)	0.17	16.31	36.68±3.46	46.66±3.20	9494±59.63	
	T_2 (10 crablet)	0.17	10.65	23.81±2.91	26.66±1.55	6165±46.82	
	T_3 (15 crablet)	0.17	4.91	10.77±2.93	26.66±2.75	2788±39.32	

The crab fattening practice with the farmer in pen at Bodorkhali, Cox's Bazar, the water temperature was fluctuated between 25.6^0 to 30.2^{0}C. The salinity was ranged between 26‰ to 30‰. Dissolved oxygen

content varied from 6.5 to 7.2 mg/l. The alkalinity was ranged between 96 to 109 mg/l and the pH values were between 5.8 to 7.2 during February 2016 to May 2016. Gonad development performance survival of crabs is shown in Table 5.

Table 5. Crab fattening practice in pen at Badorkhali, Chakariya, Cox's Bazar

Trial no.	Treatment	Gonad development (%)		Survival (%)
		7 days	14 days	
01	T1(2 crab/m^2, BFRI)	68	100	86
	T2 (traditional method)	46	82	43
02	T1(2 crab/m^2, BFRI)	62	100	93
	T2 (traditional method)	48	88	47
03	T1(2 crab/m^2, BFRI)	67	100	90
	T2 (improved traditional)	56	86	62

Factors Causing Emerging Shrimp Diseases and Development of their Health Management Strategies

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Objectives

- To investigate major disease outbreak in relation to farm structure, water quality, shrimp stocking and management of shrimp farm and possible prevention measures in Cox's Bazar area
- To assess the present status of WSSV infection in wild brood of *P. monodon* and cultured farms using Nested PCR technique
- To study on pathogenic bacteria associated with *P. monodon* disease in shrimp hatchery and farms.

Achievements

Studies revealed that uncontrolled and improper farming practices have led to serious environmental and health related problems in most of the shrimp farms and hatcheries in Cox's Bazar. Overall temperature, pH, DO, transparency, EC, alkalinity, chloride, salinity, nitrate, nitrite and phosphate in shrimp farms were found to be at optimal range; however, ammonia content was found high in traditional farms under study areas. Level of un-ionized ammonia that exceed 0.1 ppm might adversely affected shrimp in ponds. The level of unionized ammonia (0.0-0.9 ppm) might be the causes of black gill, tail rot and white guts diseases in the shrimps. On the other hand, the ammonia level and total bacterial counts of water samples were influenced probably due to shrimp excreta, dead plankton and other organic and inorganic matter on the pond bottom, and also by salinity because, shrimp grow-out ponds with high salinity at Moheshkhali had higher counts of total bacterial counts of 2.96×10^9/ml.

The presence of viral DNA was observed in all of the traditional farms and also in adjacent canals/river. Of 401 shrimp samples tested 197 (49.12%) were found to be positive for WSSV by PCR assay and out of 62 post larvae (PL) collected, 21(34%) were infected with WSSV. All the shrimp hatcheries showed

persistent occurrence of WSSV infection and 39 (42%) nauplii out of 93 were positive for WSSV by PCR assay. Out of 70 juvenile shrimp collected, 45 (64%) samples were positive for WSSV infection. On the other hand, 92 (52%) out of 176 *P. monodon* broods were positive for WSSV by PCR assay. The average WSSV infection in brood tiger shrimp were 32%, 32% and 68% for the years 2014, 2015 and 2016, respectively, and the three years data revealed an increasing trend i.e. prevalence of WSSV increasing from 2014 than 2016. Among broods collected from the deep sea zone, WSSV prevalence was (57%) in May, falling to 0% during the month of November. Many of the brooders and juveniles did not exhibit any external symptoms of WSSV infection. However, following PCR amplification with WSSV detection primers clear products were revealed, indicating the presence of latent infection. Thus, effective prevention and control methods are urgently needed to control the spread of the WSSV disease. Diagnostic PCR can be applied to screen for carrier brood stock and shrimp larvae used for shrimp culture. This may assist prevention of WSSV in shrimp culture systems.

The presence of bacteria in the water sample of both shrimp hatcheries and farm alerts the hatchery and farm manager to be more careful with the maintenance and cleanliness of the hatchery and the premises of the farms. Some level of bacterial growth was found in the samples collected from different stages after UV treatment and the presence of microbes in these filtrated waters with a variations among the hatcheries that could possibly mean that the quality of filtration unit were not same in different hatcheries though, there is supposed to be no or little microbes in water sample. After filtration, less bacteria were found in other stages compared to the outlet. This showed that cleanliness was not properly managed in the hatcheries. Although the level of bacteria was less in outlet compared to inlet, it was higher than other stages in the hatchery, which might not have any adverse side effect on the surrounding environment. However, the management of the hatchery contributed to the increase amount of microbes. The average total colony and Vibrios counts in nursery ($1.15x10^5$ to $2x10^2$) and *Artemia* tank ($3.7x10^4$ to $2.65x10^4$) was more in compared to sea water ($3x10^4$ to $4x10^2$) which indicates the horizontal contamination of these hatcheries. And also the amount of bacteria found in other than sea water, further indicates that the cleanliness was not properly managed in these hatcheries. The number of bacterial growth in the inlet of the water was fluctuating in different time frame: CFU of $3.2x10^7$ in 30th Jan; $1.1x10^7$ in 17th Feb; 1.14 $x10^8$ in 18th March; $7x10^6$ in 8th April and $1.26x10^8$ in May. In addition, the bacterial growth in the outlet was also decreasing.

Hence, seasonal environmental factors play an important role in determining the presence of bacteria in water bodies. So, the sources of nitrogenous compounds should be examined carefully to protect our pristine aquatic lives and environment. Excretions, feed amount and left over feeds should be well maintained with other organic fertilizers applications in the semi-intensive farm as it can lead to increase in ammonia concentration. The dissolve oxygen and salinity concentration from the hatchery's outlet should be monitored to allow optimal dissolved oxygen or above for aquatic metabolic activities and to safe salinity sensitive freshwater aquatic organisms in the vicinity. Water renewable of semi-intensive and extensive farms for PL rearing were controlled by few factors: dilution of semi-intensive and extensive farms in April by the rain, decomposition of micro-organisms in dry stagnant farms in February, high organic nutrient loads in the farm in the form of ammonia and phosphate and low alkalinity due to high temperature and rainfall in March and April.

Brood Development and Seed Production of Commercial Important Marine Fishes

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Objectives

- To develop broods through rearing of wild fish and reproductive biology study of mullet (*Mugil cephalus*)
- To develop induced breeding techniques of mullets using different hormonal doses
- To refine live feed culture technique for larval rearing of mullet.

Achievements

Wild brood rearing and reproductive biology study of striped mullet (Mugil cephalus)

Management of brood rearing ponds

Wild broods of striped mullet were collected during August to December 2015 in Niribili Fish Farm, Rejukhal, Cox's Bazar. Two (55 and 40 decimal sized) brood rearing ponds-equal in depth, configuration and pattern including water supply facilities and also well organized inlet (connected to coastal areas) and outlet system to maintain saline water level were used. The water depth was maintained at a maximum of 1.4 m.

Brood development (Mugil cephalus)

Previously remained and also newly collected some of adult/sub-adults of mullets (*M. cephalus*) were re-stocked in the two saline ponds of Niribili Fish Farm in the month of August. The fish were fed with commercially available floating feed twice daily @ 3% of their body weight for their rearing stage and added Vit-E (Selvitdex) in the month of October-December for their gonadal maturation. The salinity maintained between of 25 ppt in all stages of brood development which was the required range for satisfactory gonadal development of mullets.

Table 1. Status of mullet stocking in Rejukhal under different treatments

Description	Treatment 1	Treatment 2	Remarks
Total area	55 decimal	40 decimal	GPS : Longitude-91.8^{0}E & Latitude-21.26^{0}N
Depth	1.5 meter	1.3 meter	
Size (L X W)	190 x 58	163 x 46	
Stocked nos. of mullets	50 nos.	36 nos.	About 30 nos. previously reared which were two years & the rest wild collection
Average weight.	1,290 g	1,325 g	
Total Biomass	61.5 kg	47.7 kg	
Length (min - max)	30 – 48cm	31 – 49cm	
Feeding schedule	2.5 kg/day	2 kg/day	3% of the body weight
Feeding frequency	2 times/day	2 times/day	

Physico-chemical parameters of pond water

The physicochemical parameters of the pond water in the breeding sections were measured daily following standard methods (APHA 1995) and the average values are given in Table 2.

Table 2. Weekly average water quality data of the ponds in Rejukhal under different treatments

Date	Salinity (ppt)	Temp. (^{0}C)	Depth (cm)	Trans. (cm)	P^H	DO (mg/l)	NH_3 (mg/l)	Alkalinity (mg/l)	Hardness (mg/l)
12/11/15	28-29	25.6-29.7	138.4	34.2-37.1	8.1	6.9-7.2	0.25-0.31	91.3-96.8	72.8-81.5
19/11/15	29-30	24.9-28.2	143.7	33.7-37.6	7.9	6.4-6.9	0.24-0.31	89.3-95.6	69.8-78.4
26/11/15	29-30	23.7-27.1	144.1	34.8-38.1	7.8	6.8-7.4	0.21-0.29	87.4-94.7	69.3-78.1
04/12/15	28-29	24.2-27.6	145.6	35.4-37.1	7.9	6.4-7.1	0.18-0.21	88.6-95.3	70.2-77.5
12/12/15	29-30	23.9-27.8	145.4	36.1-38.5	7.7	6.6-7.2	0.19-0.23	87.8-94.6	70.9-78.4
21/12/15	28-30	23.4-27.7	143.6	35.2-37.4	7.8	6.2-6.5	0.11-0.16	88.9-96.7	72.4-79.1
30/12/15	28-30	23.1-27.2	134.5	35.8-37.3	7.7	6.3-6.6	0.12-0.19	86.4-93.6	71.8-77.6
07/01/16	26-28	22.8-26.6	137.9	34.8-35.8	7.6	6.0-6.2	0.12-0.22	88.1-94.2	70.8-76.2
15/01/16	28-29	21.1-26.5	138.4	35.1-37.2	7.8	6.0-6.3	0.13-0.23	86.8-96.8	70.6-77.5
23/01/16	27-29	24.3-27.7	138.8	35.7-37.1	7.9	6.1-6.4	0.13-0.22	87.8-97.1	72.3-79.2
31/01/16	26-28	24.6-28.1	139.4	35.5-36.8	7.8	6.2-6.5	0.11-0.21	87.9-93.6	72.9-79.6

Reproductive biology study

Sampling was conducted at 15 Dec, 2015 to 30 Jan, 2016. Fishes were captured by seine net and transported to the holding tanks by plastic drums with anesthesia dose named 2-Phenoxy Ethanol (2ml/10 l water). Each tank has been provided with continuous water circulation and aeration. After transportation of broods, they were treated with Furacin (50 ppm) and females and males were separated and oocytes were sampled by following Live Ovarian Biopsy (LOB) method (Table 3).

Table 3. Observation of gonadal maturation

Indicators	Observations
Brood developed	86 nos. (F:M = 75:25)
Av. weight (g)	1,307
Condition of fish	Healthy
Intestinal fat	Not so much
Ovary	Developed in 60-70% of stocked fishes in Jan, 2016
Eggs	Exist
Sperm	Exist in more than 30% fishes in Jan, 2016

Histological criteria used to determine reproductive and their sexual differentiation stage in female mullets is given below (Tables 4).

Table 4. GSI value of domesticated striped mullets (*M. cephalus*)

Month	Total wt	Total L	Gonad wt	GSI Value	Maturity (%) & Stages
Dec,15	1.55 Kg	51 cm	85 g	8.43	Close to running ripe stage (60%)
Jan, 16	1.61 Kg	52 cm	87 g	8.77	Close to mature yolk stage (70%)

Gonado-Somatic Index (GSI) of fecund fishes found ranges from 3.56 to 8.23 and average size of vitellogenetic oocytes (520µm) was corresponding to GSI between 8.5-10 (McDonough *et. al* 2003).

Hatchery facility development

Hatchery facilities such as brood stock conditioning tank and subsequent spawning, incubation, larval rearing and plankton mass culture unit were re-established temporarily for induced breeding trials in the Niribili Fish Farm, Reju Khal. The breeding trials were done in the last week of the month of January, 2016 and continued to till last week of the month February, 2016.

Induced breeding trials of striped mullet

Experiments on induced breeding have been conducted at the last week of January to the end of February, 2016. Maximum fishes were captured by seine net and transported to the holding tanks by plastic drums with anesthesia dose (2ml/10 l water). Each tank has been provided with continuous water circulation and aeration.

After transportation of broods, they were treated with Furacin (50ppm) and females and males were separated and oocytes were sampled by following Live Ovarian Biopsy (LOB) method. Injections were initiated within 48 hrs after transportation and acclimatization. Interval between injections varied from 24 to 36 hrs. Dry carp pituitaries (FAO) for 1st dose and LRH A_2 (2nd dose) with the combinations of Domperidone and Calcium injections were injected in varied total dose and also used HCG for the 1st dose of male and both male/female in the second trial. In case of both female and male, hormone was injected in deep muscle at base of the dorsal fin. Spawning behavior was closely observed visually. Eight pairs kept in eight tanks but not found any positive response.

In case of fecundity study, the females were dissected and eggs retaining in the abdomen were counted for the measurement of fecundity volumetrically. Eggs were continuously monitored by using ocular and stage micrometer to estimate eggs diameter and also checked oil globules diameter. The following results were found from the three trials which described in Table 5.

Table 5. Hypophyzation results of *Mugil cephalus* (last week of Jan, 15 to the end of Feb,16)

Weight of fish	Length of fish	Initial diameter of oocytes	Total dose of hormones per fish				Number of injections	Responded results
			PG	LRH	Domperidone	HCG		
Kg	cm	µm	mg	µg	µg	IU	nos	(-)
1.30	41	565	40	100	0.3		3	(-)
1.64	46	560	50	150	0.3		3	(-)
1.80	53	587	60	300	0.3		3	(-)
1.65	49	563	55	-	-	30000	2	(-)
1.40	44	570	45	-	-	25000	2	(-)
1.54	51	570	55	250	0.3		3	(-)
1.41	45	575	45	150	0.3		3	(-)
1.13	38	570	40	-	-	30000	2	(-)

++ spawned with fertilized eggs, + spawned, -/(-) did not spawned and atresia checked

Live feed culture technique for marine fish larval rearing

Phytoplankton culture (*Nannocloropsis oculata*): The culture period of *Nannocloropsis oculata* was 7 days. Here we maintained indoor culture system.

First step: After oven test tube filled with 9 ml enriched sea water and inoculation with 1 ml of stock cultured and incubated in light with aeration.
Second step: To prepare 50 ml culture, we used 40 ml working solution and 10 ml test tube culture which was first step.
Third step: To prepare 250 ml conical flask we need 200 ml working solution and 50 ml previous culture. This 50 ml culture was used for inoculating 250 ml conical flask.
In this way to prepare 1 liter, 2 liter and finally 20 liter jar culture we used 250 ml, 500 ml and 2 liter culture media for inoculation. Every step we maintained for 7 days.

Availability of Marine Pearl Producing Bivalves in South-eastern Coast of Bangladesh and Development of Pearl Culture Technology

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Jakia Hasan, Scientific Officer

Objectives

- To investigate the major pearl producing bivalves in the south-east coast of Bangladesh
- To identify the appropriate species for pearl culture by rearing in pond/cistern
- To develop culture technology of *Placuna placenta* (Kortal) by rearing on-station pond as well as coastal channel.
- To develop pearl products for commercial purpose.

Achievements

Investigation of major pearl producing bivalves in the coast
Specimens were collected from Ghotivanga khal under Moheshkhali and Chera dip in St. Martin under Teknaf Upazilas. At Ghotivanga khal the bottom structure was muddy and salinity, pH and water depth were 26 ppt, 7.3 and 0.1-2.0 m, respectively. At Chera dip the bottom structure was rocky and salinity, pH and water depth were 34 ppt, 7.5, 0.1-0.5 m, respectively (Table 1). During the study periods a total 2 species of marine bivalves were collected from 2 sampling sites of the Moheshkhali and St. Martin Island. Among collected two species, one species (*Crassostrea* sp.) was newly discovered at Chera dip (Table 2).

Table 1. Water quality parameters of the study area

Sampling site	Location	Salinity (ppt)	pH	Bottom structure	Water depth (m)
Ghotivanga khal	Moheshkhali	26	7.3	Muddy	0.1-2.0
Chera dip	St. Martin	34	7.5	Rocky	0.1-.5

Table 2. Collection of pearl oyster species from different areas

Place/ Location	Species	Status	Max L (cm)	Min L (cm)	Max. wt (g)	Min wt (g)	Number
Ghotivanga khal	*Placuna placenta*	live	16.00	8.7	280	60	625
Chera dip	*Crassostrea* sp.	live	8.2	4.3	150	70	4

Culture of windowpane oyster, Placuna placenta

Placuna placenta (kortal) were collected from the coastal river of Moheshkhali and stocked in three fiber glass tanks (500 L) marked as T_1, T_2, T_3 with sand substratum at MFTS, Cox's Bazar. The stocking density was 100, 125, 150 individuals for T_1, T_2, T_3 respectively with maintaining 35 cm water depth. Average stocking size and weight of kortal were 15.5-11.5 cm and 200-120 g, 13.5-8.7 cm and 150-60 g, 15.6-9.3 cm and 270-90 g, respectively for 3 treatments (Table 3).

Table 3. Rearing of Kortal in FRP tanks with sand substratum

Rearing of kortals in tanks with sand substratum	Stocking density/ 35 cm water depth	Stocking size of oyster (cm & gm)
T_1	100	15.5-11.5 cm, 200-120 gm
T_2	125	13.5-8.7 cm, 150-60 gm
T_3	150	15.6-9.3 cm, 270-90 gm

P. placenta (kortal) were also stocked in plastic tanks (300 L) marked as G_1, G_2, G_3 with sand substratum. Stocking density were 30, 40, 50 number of individuals respectively maintaining 35 cm water depth. Average stocking size and weight of kortal were 14.8-9.5 cm and 250-130 g, 16.00-9.4 cm and 280-150 g, 14.5-8.8 cm and 210-80 g, respectively (Table 4).

Table 4. Rearing of Kortal in plastic tanks

Rearing in plastic tanks (300 L)	Stocking density/ 35 cm water depth	Stocking size of oyster (cm & gm)
G_1	30	14.8-9.5cm, 250-130 gm
G_2	40	16.00-9.4 cm, 280-150 gm
G_3	50	14.5-8.8 cm, 210-80 gm

Culture of Placuna placenta in saline pond

Most abundant bivalve species in our coast, *Placuna placenta* (kortal) were collected from the coastal river of Moheshkhali and stocked in a pond adjacent to Kreju khal, Ukhia, Cox's Bazar. Total 108 nos. kortal were hanged in pond water with the help of three ropes denoted by Rope 1, Rope 2 and Rope 3. Net bags were constructed by round shaped iron ring (8 mm diameter) and net. Stocking density of Rope 1, Rope 2 and Rope 3 were 5, 4 and 3 number of individuals, respectively. Average stocking size and weight of Rope 1, Rope 2 and Rope 3 were 14.5-12.5 cm, and 120-250 gm, 11.3-14.6 cm and 90-200 gm, 9-15.5 cm and 80-280 gm (Table 5). Plastic small cages were also used.

Table 5. Rearing of Kortal with hanging net bag in pond

Rearing in pond	Stocking/net beg	Total number	Stocking size (cm & gm)
Rope 1	5	45	14.5-12.5 cm, 120-250 gm
Rope 2	4	36	11.3-14.6 cm, 90-200 gm
Rope 3	3	27	9-15.5 cm, 80-280 gm

Water quality parameter in rearing tanks and pond: *P. placenta* (kortal) were reared during July'15 to April'16 in three different environment and water quality parameter were measured fortnightly. The FRP and plastic tank were regularly fed with sea water and salinity was varied from 27-31 ppt. The pH value observed between 7.4-.7.8. Dissolve oxygen was maintained between 7.1 to 8.1 ml/L, although regular aeration was provided in the FRP and plastic tanks. During the period of investigation the average temperature ranged from 24.8^{0}C to 25.5^{0}C in tanks and 26.6 in saline pond. Average mortality rate observed was 9-14% in tanks and 4% in pond (Table 6).

Table 6. Water quality parameter during experiment period

Sl no	Tank/pond	Salinity (ppt)	pH	DO (ml/L)	Temp ^{0}C	Water depth (m)	Mortality %
1	FRP Tank	27	7.8	8.1	25.5	0.40	14.0
2	Plas. Tank	25	7.4	7.1	24.8	0.40	9.0
3	Pond	31	7.4	6.8	26.6	1.30	3.0

Growth performance of *Placuna placenta*l) in pond: The growth performance of *P. placenta* (kortal) was observed in each three month interval. About 30% of sample was randomly selected to show the growth performance. The initial mean length was 12.25±1.04 cm in July. In the month of October to January the mean length were 12.71±1.06 cm to 13.36±1.05 cm. Final mean length was 13.50±1.14 cm in the month of April. During the culture period average length was increased in 1.23 cm. *P. placenta* show highest length performance from October to January that was 0.65 cm and lowest length performance from January to April was 0.14 cm.

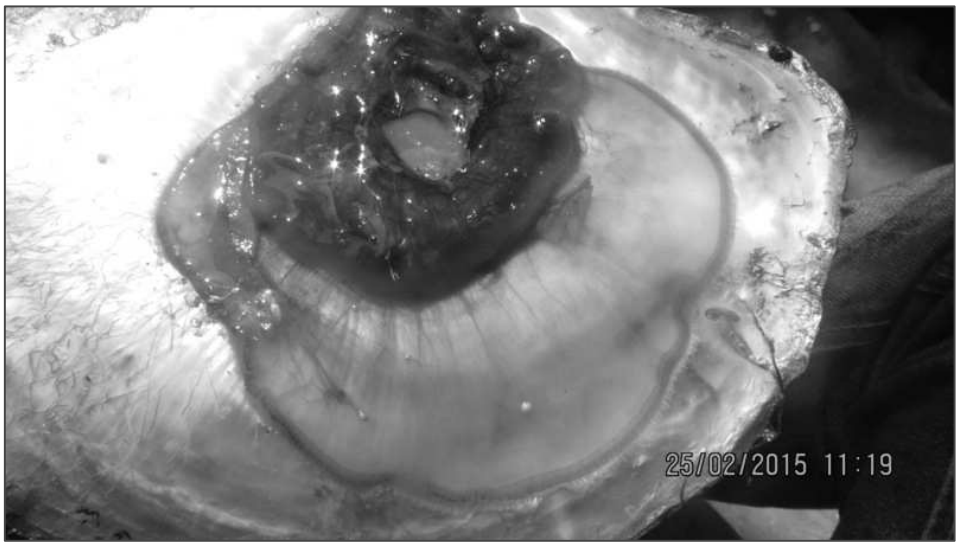
Table 7. Growth performance of *Placuna placenta* (kortal) in pond

Month	Rope	Mean length (cm)	Total mean length with SD (cm)
July	R1	11.15	12.27±1.02
	R2	12.51	
	R3	13.15	
October	R1	11.51	12.71±1.06
	R2	13.12	
	R3	13.52	
January	R1	12.15	13.36±1.05
	R2	13.76	
	R3	14.16	
April	R1	12.21	
	R2	13.90	13.50±1.14
	R3	14.40	

Collection of pearl from kortal in pond: During the culture period of kortal in pond, the pearl development in kortal was observed on three month interval. About 10% of sample was randomly selected to observe the pearl formation. A total 40 number of reared kortal were sampled among them 25 pieces (62.5%) were found pearl inside their body. Maximum number of pearl was found in July that was 26 pieces and lowest amount of pearl found in October was 17 pieces. Maximum pearl size was found in the month of April was 4.2 mm and lowest size of pearl was observed in the month of July was 2.6 mm (Table 8).

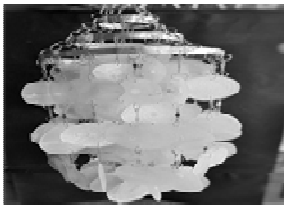
Table 8. Collection of pearl from *Placuna placenta* (kortal) reared in pond

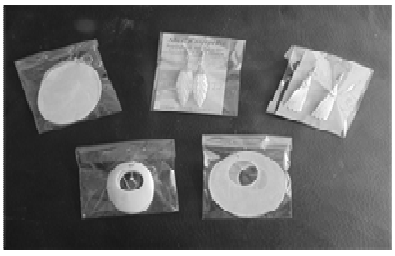
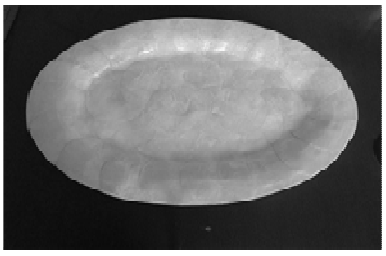
Month	Sampling nos. of reared oysters	Pearl bearing oyster	Number of pearl obtained	Maximum Pearl size (mm)
July'15	10	7	26	2.6
October'15	10	6	17	3.4
January'16	10	8	22	3.3
April'16	10	4	14	4.2



Development of pearl products

The kortal shells were used to make simple jewellery and decorative items. Firstly the kortal shells were treated with HCL to obtain polished and thin pearly shells were grinded by grinding machine to get desirable shape. Then the polished shells were used to make different types of wall mate, simple jewelers and handicrafts.



Improvement of Dried Fish Production System Suitable for Small Entrepreneurs and Marginal Producers

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Objectives

- To refine and extension of hygienic fish drying production technology for small to large scale producers
- To assess and standardize better quality shelf-life of dried fish in storage condition of large scale producers
- To develop preventive measure to reduce infestation and weight loss in storage condition by using recommended/approved insecticides.

Achievements

Refinement and expansion of large scale hygienic fish drying production techniques

Marine Fisheries and Technology (MFTS), Cox's Bazar come forward to take an initiatives for medium and large scale entrepreneurs to produce hygienic dry fish through a well organized and newly developed dry fish production technology named **"BFRI Mechanical Fish Dryer"** which obviously play a potential role to fulfill the local, regional and national as well as international demands.

Construction technique of the BFRI Mechanical Fish Dryer Model

The main body of dryer is constructed using SS (box type) bar and floor contained black colored steel sheet for air-heating collector, a heat controlling box or section having thermostat, a 12 inch fan for air flow and small exhaust fan to control the required airflow over the product to be dried. These are connected in series of electric wiring. Both the collector and the drying unit are covered with transparent celluloid (1.2mm) polyethylene. Black paint is used as an absorber in the floor which acts as collector. The products to be dried are placed in Vertical and horizontal in the dryer. The whole system is placed horizontally (North-south) on a cleaned platform. Air at required flow rate is supplied by a fan. The power requirement to drive the fan is low. The cover is fixed like a sloping roof to prevent the dryer unit from rain. Compared to the typical feature of greenhouse solar-energy dryers, in this dryer solar radiation passes through the transparent cover of the collector and heats the whole system. The heated air from collector while passing over the fish absorbs moisture from the fish. Solar radiation also passes through the transparent cover of the dryer and heats the fishes. In case of bad weather condition, the system contained induction heater (1000 watt) incorporated with a heat controlling box was found very effective to keep the temperature within the desirable range (40-55^{0}C). However, the maximum-minimum thermometer was found very useful to monitor and control the temperature.

The horizontal SS bars that were set in parallel position along the top of the width of the dryer to hang the fish by dual hooks were found very suitable like other models. The dryer was found useful both in rainy or sunny days, throughout the day and year. Generally, the drying time for the 400-600 kg raw fish was found to be about three days, but depends on size, condition of fish and weather.

The costs of electric energy to operate the dryer in absence of the sunlight would be much higher than that of sunny days. Therefore, it is wise to operate the dryer during the sunny day and use the heater only at night. Nevertheless, in case of emergency due to sudden bad weather, the heater would be very useful for

saving the fish. As the availability of electricity is a prerequisite to operate this type of dryer, it cannot be set in some remote places where sufficient electric supply may not be ensured.

Fish drying trial with this model

Three species, Silver pomfret (*Pampus argenteus*), Ribbon fish (*Lepturacanthus savala*) and Bombay duck (*Harpodon nehereus*) were dried using the newly developed BFRI Mechanical Fish Dryer. All the factors of fish drying were found favorable for commercial operation of Bombay duck, Silver pomfret, Ribbon fish etc. After getting satisfactory operational and economic output, the final version with two-layered transparent celluloid, has been finalized as 'BFRI Mechanical Fish Dryer' for demonstration. Finally, four units of the dryer have already been constructed and demonstrated in four places, one in on-campus (MFTS, BFRI) and four off-campuses (Majher Ghat, Cox's Bazar) in Cox's Bazar, Bangladesh. This technology is highly recommended for both Small & Medium Entrepreneurship (SME) as well as large producers in the high quality export oriented fish drying sector.

Efficiency of the BFRI Mechanical Fish Dryer

The drying performances of the three models of dryers are summarized in Table 1 in terms of drying time, temperature, capacity, durability, energy efficiency and incidence of blowfly infestation.

Table 1. Comparative drying performance between traditional method with Mechanical fish dryer using method

Performance indicators	Traditional fish dryer model (wooden)	BFRI Mechanized Fish Dryer	Comments
Drying capacity (Raw fish in single unit)	50 kg	400-650 kg (depends on spp.)	The "BFRI Mechanical Fish Dryer" model is the most energy efficient and cost effective, so, this model was selected for further study
Drying time (12% moisture)	4-5 days	3 days (max)	
Temperature maintenance	35-40 ^{0}C (natural mainly)	45-55 ^{0}C	
Efficiency to use solar energy	Efficient	Very efficient	
Durability	2/3 years with major maintenance	At least 10 -15 years with minor maintenance	
Capital costs	Tk.20,000/-	Tk.75,000/-	
Operational costs (per 50 kg)	Tk.1000/-	Tk.1000/-	
Incidence of fly infestation	None	None	
Overall product quality	Up to the mark	Excellent	

Proximate composition analysis

The nutritional contents were found better of the products produced by the BFRI Mechanical Fish Dryer in relation with the standard drying procedures, mainly due to the removal of moisture in higher percentage. The percentage of actual protein content based on nitrogen was also found to be higher due to the lower degree of spoilage in the product produced by the BFRI Mechanical Fish Dryer.

Table 2. Proximate composition of dried fish (1st trial lot) produced by BFRI Mechanical Fish dryer and a demonstration of BFRI Mechanical Fish Dryer

Name of Processor	Fish species	Moisture (%)	Lipid (%)	Crude protein (%)	Ash (%)	CHO (%)
MFTS, BFRI	Lotiya	18.2	11.50	61.57	7.73	1.13
	Churi	16.78	6.70	60.74	9.93	0.86
Update Agro Industries Ltd	Lotiya	17.6	12.13	62.51	7.34	1.02
	Churi	16.62	4.70	64.44	15.06	0.18