Growth performance of *Catenella nipae* on bamboo poles in the inter-tidal mangrove swamps of Chittagong coast

### Abstract

Macro-benthic algae *Catenella nipae* was cultured from November ’06 to August ’07 at the Salimpur planted mangrove area of Chittagong Coast. Growth of the cultured *C. nipae* on bamboo poles was measured during the investigation period. Average growth of *C. nipae* on bamboo poles was recorded 0.19cm/day. Physico-chemical parameters of water and soil were recorded during culture period in the tidal swamp of Salimpur mangrove area. Water temperature ranges from 24.0 to 31.5°C, salinity from 6.0 to 21.0‰, dissolved oxygen (DO) from 3.8 to 5.8ml/l, water pH from 7.2 to 8.4, total dissolved solids (TDS) from 410 to 598mg/l, total suspended solids (TSS) from 50 to 118mg/l, Total alkalinity from 95 to 1118ppm, NO$_3$-N from 0.18 to 0.47mg/l, NO$_2$-N from 0.56 to 0.69mg/l, PO$_4$-P from 0.90 to 1.10mg/l, HCO$_3$ from 69.88 to 93.80mg/l, were recorded during culture period. Soil organic carbon, organic matter, soil PO$_4$-P, soil pH were ranges from 2.22-2.37%, 4.22-4.51%, 1.10-1.39mg/100g and 5.9-6.7, respectively in the culture area. Growth of *C. nipae* showed a significant positive relation with water and soil parameters such as dissolved oxygen (DF=17, P=0.006, t=3), NO$_3$-N concentration (DF=17, P=0.055, t=2) and a negative correlation with HCO$_3$ concentration (DF=17, P=0.004, t=3). Physico-chemical parameters of both water and soil revealed that the coastal area of Salimpur could be a significant place for commercial culture of seaweeds *C. nipae* in Bangladesh.

### Introduction

Seaweeds are sedentary organisms, growing on the rocky or hard substratum of intertidal water of World Ocean. They belong to the group of plants known as algae containing some of the most primitive members of the plant kingdom. Okazaki stated, “Seaweeds as the name implies covers the macroscopic plant life of the sea except for the flowering plants”. It has immense importance both for human and faunal communities. Prehistorically, people have been consuming seaweed either raw or cooked condition. Novaczek reported that seaweeds have large amount of protein, amino acids, lipids, vitamins and minerals, polysaccharides and dietary fibers. Some compounds of seaweeds control high blood pressure, level of cholesterol, and prevent strokes. These can also be used as remedy for rheumatism, diarrhea, and for controlling the growth of tumors.

The culture of seaweed for human consumption is a relatively new enterprise. The concept of seaweed and its cultivation is limited to the scientific community, people hardly known about its importance and culture technique in developing countries. The status of seaweed cultivation in Bangladesh is still at the nascent stage.

The study is first experiment of *Catenella nipae* culture on bamboo poles in the intertidal waters of Salimpur coast in Bangladesh where plenty of *C. nipae* grows naturally remains unutilized for long time. In addition, now-a-days utilization of algae as human food has been increasing in many countries like China, Japan, Philippines and Myanmar. Whereas the mass people of Bangladesh do not know that the algae can be used as human food.

### Materials and methods

The investigation was carried out from November 2006 to August 2007 at Salimpur mangrove area. Bamboo poles were used for culture of *Catenella nipae*. A total area of 5mx5m was selected. To culture *C. nipae* on bamboo poles, at first bamboo poles were collected and cut into 0.5m size length each. Within the culture area bamboo poles were installed maintaining 0.5m distance between two consecutive poles. Then body segments of *C. nipae* from the nature were collected and were attached in the bamboo poles with the help of thread. Routine checked of the culture system was done. After each three months interval culture experimental algal species was collected carefully with the help of a sharp knife and taken in to plastic bag. Water and soil sample were collected from the intertidal mangrove areas of Salimpur coast during study period and analyzed using standard methods APHA.

### Results

#### Measurement of growth

The average daily growth was observed as 0.19± 0.11cm during the culture period. Maximum daily average growth was 0.29cm in August 2007 and minimum value was recorded 0.11cm on July 2007 (Table 1). There is no major trend of fluctuation for the growth of *C. nipae* in the culture period. Growth of *Catenella nipae* shows a positive correlation with DO (DF=17, P=0.006, t=3) and NO$_3$-N (DF=17, P=0.055, t=2) concentration. A negative correlation was found between growth of *Catenella nipae* & HCO$_3$ concentration (DF=17, P=0.004, t=3).
Growth performance of *Catenella nipae* on bamboo poles in the inter-tidal mangrove swamps of Chittagong coast

Abundance of pneumatophores and natural biomass

In the present study the in parallel with culture performance growth of *C. nipae* was measured in the natural environment. The average number of pneumatophores found as 79.1±7.73 and average natural biomass content was found 159.10±41.14 g/m$^2$ (Table 2) whereas the maximum values in per pneumatophore was recorded on November (2.90) and minimum value was on March (1.52). A Significant relationship was found between number of Pneumatophores and biomass of *Catenella nipae* of the Salimpur mangrove area ($t=3, P=0.0106, DF=29$) and it was observed that biomass is proportionally related with the availability of water.

### Table 1 Growth of the colony of *Catenella nipae* after attachment

| Bamboo No. | Initial length (cm) | Measurement on Feb, 2007 | Measurement on May, 2007 | Measurement on August, 2007 |
|------------|---------------------|--------------------------|--------------------------|-----------------------------|
|            | Length (cm) | Growth (cm) | Daily Growth (cm) | Length (cm) | Growth (cm) | Daily Growth (cm) | Length (cm) | Growth (cm) | Daily Growth (cm) |
| 1          | 2.5        | 5.08       | 2.58             | 0.08           | 8.47        | 3.39             | 0.11           | 22.86        | 14.39             | 0.46             |
| 2          | 4.96       | 10.16      | 5.2              | 0.17           | 12.7        | 2.54             | 0.08           | 21.59        | 8.89              | 0.29             |
| 3          | 3.01       | 6.35       | 3.34             | 0.11           | 11.85       | 5.5              | 0.18           | 22.86        | 11.01             | 0.36             |
| 4          | 5.07       | 11.43      | 6.36             | 0.21           | 12.7        | 1.27             | 0.04           | 20.32        | 7.62              | 0.25             |
| 5          | 2.54       | 5.08       | 2.54             | 0.08           | 11.01       | 5.93             | 0.2            | 19.05        | 8.04              | 0.26             |
| 6          | 10.98      | 20.32      | 9.34             | 0.3            | 22.31       | 1.99             | 0.07           | 25.32        | 3.01              | 0.1              |
| Mean       |             |             |                  | 0.16           |             |                  | 0.11           |             | 0.29              |                  |
| Total Mean |             |             |                  | 0.19 cm        |             |                  |                |             |                   |                  |

### Table 2 Abundance of Pneumatophores along with natural biomass (g/m$^2$) of *Catenella nipae* in the vicinity of culture area

| Month     | Sample                | Quadrate 1 | Quadrate 2 | Quadrate 3 | Mean  |
|-----------|-----------------------|------------|------------|------------|-------|
| November  | Pneumatophores        | 75         | 82         | 98         | 85    |
|           | Biomass (g)           | 250        | 240        | 250        | 246.67|
| December  | Pneumatophores        | 80         | 78         | 75         | 78    |
|           | Biomass (g)           | 160        | 150        | 140        | 150   |
| January   | Pneumatophores        | 80         | 76         | 84         | 80    |
|           | Biomass (g)           | 195        | 210        | 185        | 196.66|
| February  | Pneumatophores        | 76         | 81         | 72         | 77    |
|           | Biomass (g)           | 120        | 150        | 160        | 143.33|
| March     | Pneumatophores        | 73         | 60         | 70         | 68    |
|           | Biomass (g)           | 115        | 100        | 95         | 103.33|
| April     | Pneumatophores        | 84         | 80         | 75         | 80    |
|           | Biomass (g)           | 150        | 140        | 155        | 148.33|
| May       | Pneumatophores        | 81         | 90         | 75         | 82    |
|           | Biomass (g)           | 150        | 180        | 195        | 175   |
| June      | Pneumatophores        | 72         | 83         | 95         | 84    |
|           | Biomass (g)           | 120        | 135        | 150        | 135   |
| July      | Pneumatophores        | 75         | 80         | 70         | 75    |
|           | Biomass (g)           | 110        | 118        | 125        | 117.67|
| August    | Pneumatophores        | 92         | 85         | 76         | 85    |
|           | Biomass (g)           | 150        | 180        | 195        | 175   |

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Harvesting

After the culture period of three months, *Catenella nipae* colony weight on average was found as 176±4.97g on the bamboo poles.

Water and soil parameters

The average water temperature was recorded as 29.05±2.45°C whereas highest value (31.5°C) was recorded on June 2007 and the lowest 24°C in February 2007, average salinity was 14.30±5.35%, highest salinity was recorded 21% on March 2007 and lowest 6% in August 2007, average D.O was (4.95±0.62ml/l) where highest 5.80ml/l on July and lowest value 3.80ml/l on December 2007, average pH was (7.78±0.37) where maximum was 8.4 on February 2007 and minimum was 7.2 in August 2007, average TDS was (541.10±59.35mg/l) where highest value 598.00mg/l was recorded on July 2007 and the lowest value 410.00mg/l on February 2007, average TSS was (76.30±22.01mg/l) where the highest value 118.00mg/l was recorded on August 2007 and the lowest value 50.00mg/l was recorded on January 2007. Alkalinity was maximum 118.00ppm on February 2007 and the lowest value 95ppm on August 2007, average NO3-N as 0.34±0.09mg/l where highest NO2-N value was found 0.47mg/l on June 2007 and lowest value 0.18mg/l was recorded on February 2007 average NO3-N was 0.65±0.05mg/l where highest NO3-N value was found 0.69mg/l on May 2007 and lowest value 0.56mg/l was recorded on January 2007, average PO4-P was recorded as 0.99±0.06mg/l where, highest PO4-P value was found 1.10mg/l on January 2007 and lowest value 0.90mg/l was recorded on June 2007, average HCO3 was observed as 81.33±4.50mg/l where highest HCO3 value was found 93.80mg/l on June 2007 and lowest value 69.88mg/l was recorded on February 2007 and average BOD was recorded 1.86±0.17ml/l where highest value was 2.16ml/l on November 2006 and lowest value 1.56ml/l on June 2007 respectively in the study area (Table 3).

The average soil organic matter was recorded as 4.39±0.10%, the highest value was 4.51% on recorded on January 2007 and the lowest value 4.22% in July 2007. The mean organic carbon was recorded as 2.31±0.05%, the highest value was 2.37% was recorded on November 2006 and January 2007 respectively and the lowest value 2.22% on July 2007. Average PO4-P was observed as 1.28±0.1mg/l/100g. Highest PO4-P value was found 1.39mg/l/100g on August 2007 and lowest value 1.10mg/100g was recorded on March 2007. The average soil pH was 6.30±0.28. Maximum soil pH was 6.7 on January 2007 and minimum value was recorded 5.9 on August 2007. The soil texture of the study area was sandy clay loam. Sand ranges from 67.00% to 72.68%, Clay ranges from 23.69% to 29.60%, Silt ranges from 2.50% to 5.11% during the whole study period (Table 4) (Table 5).

Table 3 Physico-chemical parameters of tidal water in the culture site of *C. nipae* (November 06 to August 07)

| Month | Water Temp. °C | Salinity ppt | D.O ml/l | Water pH | T.D.S mg/l | T.S.S mg/l | T.A | NO2-N mg/l | NO3-N mg/l | P04-p mg/l | HCO3 ppm | BOD ml/l |
|-------|----------------|-------------|---------|----------|------------|------------|-----|-------------|-------------|------------|----------|---------|
|       | November       | 26          | 10      | 4.5      | 7.5        | 585        | 78  | 0.38        | 0.69        | 1.01       | 70.8     | 2.16    |
|       | December       | 28          | 18      | 3.8      | 7.7        | 547        | 65  | 0.36        | 0.66        | 1.09       | 75.33    | 2.05    |
|       | January        | 30          | 20      | 4.2      | 7.9        | 498        | 69  | 0.25        | 0.56        | 1.1        | 73.25    | 2       |
|       | February       | 24          | 16      | 5.3      | 8.4        | 410        | 58  | 0.18        | 0.65        | 0.99       | 69.88    | 1.98    |
|       | March          | 31          | 21      | 5.8      | 8.2        | 467        | 57  | 0.22        | 0.61        | 0.96       | 71.8     | 1.92    |
|       | April          | 30          | 20      | 5.2      | 7.9        | 563        | 50  | 0.37        | 0.58        | 0.97       | 85.05    | 1.88    |
|       | May            | 30          | 15      | 4.8      | 8.1        | 578        | 67  | 0.35        | 0.69        | 0.99       | 92.98    | 1.78    |
|       | June           | 31.5        | 10      | 4.9      | 7.4        | 593        | 89  | 0.47        | 0.68        | 0.9        | 93.8     | 1.56    |
|       | July           | 30.27       | 7       | 5.8      | 7.5        | 598        | 112 | 0.42        | 0.69        | 0.93       | 91.87    | 1.63    |
|       | August         | 29.75       | 6       | 5.2      | 7.2        | 572        | 118 | 0.4         | 0.69        | 0.95       | 88.86    | 1.67    |

DO, dissolved oxygen; TDS, total dissolved solid; TSS, total suspended solid; TA, total alkalinity; BOD, biological oxygen demand; COD, chemical oxygen demand

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### Table 4 The physico-chemical parameters of soil in the culture site of *C. nipae* (November 06 to August 07)

| Month   | % of Organic carbon | % of Organic Matter | PO4-P mg/100g | Soil pH | Soil Texture | % of Sand | % of Clay | % of Silt |
|---------|---------------------|---------------------|---------------|---------|--------------|-----------|-----------|-----------|
| November| 2.37                | 4.5                 | 1.16          | 6.1     | 67.58        | 27.85     | 4.57      |
| December| 2.35                | 4.48                | 1.27          | 6       | 68           | 29.12     | 2.88      |
| January | 2.37                | 4.51                | 1.38          | 6.7     | 67.95        | 28.86     | 3.19      |
| February| 2.34                | 4.46                | 1.26          | 6.5     | 67           | 29.6      | 3.4       |
| March   | 2.31                | 4.4                 | 1.1           | 6.6     | 69.55        | 26.9      | 3.55      |
| April   | 2.27                | 4.33                | 1.15          | 6.5     | 70           | 24.88     | 5.11      |
| May     | 2.24                | 4.26                | 1.33          | 6.5     | 72.68        | 23.69     | 3.63      |
| June    | 2.26                | 4.3                 | 1.36          | 6.2     | 71.9         | 25.6      | 2.5       |
| July    | 2.22                | 4.22                | 1.35          | 6       | 70.55        | 26.53     | 2.92      |
| August  | 2.34                | 4.45                | 1.39          | 5.9     | 69.88        | 26.95     | 3.17      |

### Table 5 Correlation Matrix between the Biomass of *Cattenella nipae* with different water parameters

|              | Biomass (g) | D,O (ml/L) | NO2-N (ml/L) | NO3-N (ml/L) | PO4-P (ml/L) | HCO3 (ml/L) | BOD (ml/L) |
|--------------|-------------|------------|--------------|--------------|--------------|-------------|------------|
| Biomass (g)  | 1           | -1         | 1            |              |              |             |            |
| D,O (ml/L)   | -1          | 1          |              |              |              |             |            |
| NO2-N (ml/L) | 1.00E-01    | -9.00E-02  | 1            |              |              |             |            |
| NO3-N (ml/L) | 1.00E-01    | 8.00E-02   | 1            | 1            |              |             |            |
| PO4-P (ml/L) | 5.00E-01    | -1         | -4.00E-01    | -4.00E-01    | 1            |             |            |
| HCO3 (ml/L)  | -3.00E-01   | 3.00E-01   | 1            |              | 4.00E-01     | -1          | 1          |
| BOD (ml/L)   | 1           | -5.00E-01  | -1           | -4.00E-01    | 1            | -1          | 1          |

### Discussion

**Growth performance of *C. nipae***

In the present study the daily growth was observed 0.19 cm/day on the bamboo poles in an average which suggest a suitable rate for culture of this alga in this area. And growth of the cultured algae showed a significant positive relation with dissolved oxygen (DF=17, P=0.006, t=3) (Figure 1), NO3-N concentration (DF=17, P=0.055, t=2) (Figure 2), and a negative correlation with HCO3 concentration (DF=17, P=0.004, t=3) (Figure 3).

Soe-Htun et al. 7 reported luxuriant growth of *Catenella* on the bamboo stakes in an experimental culture in Myanmar. These were harvested using a spoon. The yield of *Catenella* was about 40-50 g (wet wt.) per bamboo stake (Figure 4).

There are the components in sea water in concentrations of mg-atoms/m³ that are of fundamental importance to the growth of marine algae, the base of the food chain in the sea. These components are soluble inorganic phosphate (0.1-3.5 mg-atoms/m³), nitrate (0.1-43 mg-atoms/m³), nitrite (0.1-3.5 mg-atoms/m³), ammonium (0.35-3.5 mg-atoms/m³), and hydrated silicate ions (0.1-170 mg-atoms/m³). These marine fertilizers are consumed only in the upper layers of the ocean where light conditions permit photosynthesis and are often limiting to growth. 8
Growth performance of Catenella nipae on bamboo poles in the inter-tidal mangrove swamps of Chittagong coast

Physico-chemical parameter

The growth of seaweeds is governed by various factors like temperature, salinity, pH, dissolved oxygen, water transparency; nutrients Lunnings. His studies found that for the growth of tropical seaweeds the optimum water temperature ranges between 15-30°C. The findings of the present investigation is exclusively agreed with the above mentioned report.

Meade recommended standard water quality for aquaculture as water pH 6.5-8, DO 5mg/l, and alkalinity 10-400ppm. The mean D.O value was found (4.95+0.62)ml/l in the present investigation which is quite satisfactory for normal growth and functioning of aquatic organisms. While the standard values of D.O of the coastal water of Bangladesh is 6ml/l. So the present findings are exclusively agreed with the above information.

The environmental quality standard value of pH of coastal water of Bangladesh is 6-9. Zafar found the water temperature, salinity, pH, DO ranged from (30-33°C), (6-16ppt), (6.9-7), (2.95-5.77ml/l) at the Fauzdarhat planted mangrove area. The present study also showed a similar trend of results.

Hossain recorded water temperature, salinity, water pH, DO ranged from (20-29°C), (6.5-10ppt), (6.8-7.4), (3.77-5.50ml/l) at the Fauzdarhat mangrove area. In the present investigation recorded water temperature, salinity, DO, water and soil pH were more or less similar to the above mentioned report.

Talukder recorded water temperature ranged between 11.65-31.40°C, water pH 6.27-7.75, dissolved oxygen 2.34-5.71ml/l, salinity ranges from 6.51-16.30 ppt, total suspended solids ranges between 112.03mg/l to 343.34mg/l, total dissolved solids 377.16mg/l to 573.32mg/l, PO4-P ranges from 1.01-4.68ml/l, NO3-N varied from 1.15-3.34ml/l, BOD 2.95-6.63ml/l, soil pH 5.30-7.70 in a study on macrobenthic algae of the Fauzdarhat mangrove, chittagong. The findings of the present investigation is apparently similar to the above mentioned report.

Chowdhury reported the micronutrients of the coastal water of Cox’s Bazar and recorded maximum (NO3-N=1.520µg at/l, PO4-P=1.804µg at/l and SiO2-Si=46.62µg at/l) during July to August and minimum (NO3-N=0.084µg at/l, PO4-P=0.224µg at/l and SiO2-Si=3.28µg at/l) during November to December respectively. Noori (1999) reported the micronutrients concentration of the coastal water of southeast coast of Bangladesh and recorded maximum (NO3-N=1.195µg at/l, PO4-P=2.330µg at/l and SiO2-Si=63.31µg at/l) during May to August and minimum (NO3-N=0.020µg at/l, PO4-P=0.075µg at/l and SiO2-Si=0.673µg at/l) during September to December respectively. The findings of the present investigation are apparently similar to the above mentioned report.

Grant recorded the inter-tidal soil pH ranged from 7.6 to 8.1 from the inter-tidal sand flat of North Inlet, South Carolina, U.S.A. Islam recorded pH values ranged from 6.35 to 6.85 in bottom sediment collected from lower Meghna river estuary during premonsoon. Present findings are more or less similar to these above mentioned report.

Within the marine sediments there is generally a decrease in organic content with depth in the deposit. Correns, Reveille and Shepard have all reported this characteristics distribution. Connell, obtained a linear relationship between organic matter and calcium carbonate and concluded that calcareous material contained about 0.2% organic matter and having no calcareous material contained a constant proportion of organic matter. Kundalarao and Murty reported that organic matter of intertidal zone of the Kinda bay,
Growth performance of Catenella nipae on bamboo poles in the inter-tidal mangrove swamps of Chittagong coast

east coast of India was 0.70% to 2.17% which is closely similar to the present observation where organic matter varied from 4.22% to 4.51%.

Vizakat et al.22 expressed that the texture of sediment as silty clay/sand silts; silty sand of the subtidal soft sediment of the west coast of India. Alam23 recorded the seasonal variation of sediment percentage in the Halishahar coast; Chittagong and he found maximum sand percentage in monsoon and minimum in winter, which is similar to the present investigation.

Growth of Catenella nipae shows positive relation with physico-chemical parameter of water viz. with T.S.S (r=0.43355), NO3-N(r=0.2485), NO2-N(r=0.963417), PO4-P(r=0.612974), BOD (r=0.579897) and negative relation with DO (r=0.44623), Temperature (r=-0.51815), HCO3 (r=-0.79903), pH (r=-0.99814), T.D.S (r=-0.99593), Total alkalinity (r=-0.79447) in the present investigation. Soil parameter viz. organic matter (r=0.997018), organic carbon (r=0.9998137), PO4-P (r=0.999554) shows positive relation and soil pH (-0.55191) shows negative relation with growth.

Conclusion
If the proper steps are taken for seaweed culture and management, it may open a new avenue for the local farmers, creating an alternative livelihood option. Thus, phyco-aqua industry will come as an indicative tool for national economic emancipation, poverty alleviation, livelihood option. Thus, phyco-aqua industry will come as an indicative tool for national economic emancipation, poverty alleviation, livelihood option. Therefore, the present study can be the path-finder on the relation and soil pH (-0.55191) shows negative relation with growth.

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Conflicts of interest
The authors declare there are no conflicts of interest.

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