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NEWLY RECORDED FRESHWATER DIATIOMS (BACILLARIOPHYCEAE) FROM TWO WETLANDS OF DISTRICT SIRAJGANJ, BANGLADESH

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Abstract

A total 9 diatoms taxa newly reported from the sediments of Joysagar and Sitlai Beel has been reported. These are *Navicula cuspidata* var. *heribaudii* Peragallo, *N. grimmei* Krabke, *Navicula americana* Ehr, *Pinnulara major* (Kutz.) Cleve, *P. braunii* (Grun.) Cleve. *P. brevicosta* Cleve, *P. divergens*, *P. acrosphaeria* Brebisson, *P. stauroptera* (Grun.) Cleve and *P. hemiptera* (Kutz.) Cleve.

Key words: Epipelic diatoms, Wetlands, Northern Bangladesh, Joysagor, Sitlai Beel.

Introduction

Diatoms are good indicator of lake water pH (Batterbee *et al*. 1986). Since 1970's it has been apparent that diatom analysis of sediment cores for the purpose of re-constructing lake acidification relating to fallout of acidic pollutants from the atmosphere has considerable potential (Berge 1975, Davis and Berge 1980).

The ecology of epipelic diatoms are less well studied than their pelagic counterparts in various limnological studies in Bangladesh, except the work of Sultana *et al.* (2003). The seasonality and diversity of sediment diatoms and some of their taxonomic descriptions from two wetlands Joysagar and Sitlai Beel of Sirajganj, northern part of Bangladesh have been studied by Nahar and Khondker 2009 and Nahar *et al.* 2010. The present report on diatoms is a continuation of epipelons analysis of same areas i.e. Joysagar lake and Sitlai Beel.

Materials and Methods

The study sites Joysagar lake and Sitlai Beel are the part of Grameen Bank Fisherics Project, situated under Thana Rayganj and Tarash, repectively of Sirajganj district. Joysagar's geographical location is in between 24°28′40″ and 24°28′50″ E latitude and 89°25′24″ and 89°25′42″ N longitude. On the other hand the geographical location of Sitlai Beel is 24°28′10″ and E latitude and 89°26′30″ N longitude. The water area of

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Joysagar lake is 0.226 Km^2 having a length of 475.84 m and breadth 475.48 m. The water area of Sitlai Beel is 0.04 km^2 having a length of 243.84 m and breadth 170.68 m. The taxonomy of diatom is based on the structure of ciliceous cell wall of frustules. In order to see the structure clearly the organic parts of the diatom must be removed. To prepare clean frustules diatoms collected from surface sediment of two lakes were treated by the wet combustion method (Van der Werff 1958). Mud sample weighing 1 g was taken in a Pyrex test tube. Thirty per cent of hydrogen per oxide and a few crystals of potassium dichromate was used to start cleaning of the frustules. After combustion was completed 30 ml of distilled water was added to the suspension and kept at room temperature. Next day the water above the sediment was poured down. The suspension was rinsed in the same way for three times. After cleaning 0.2 ml of well mixed diatom suspension was smeared on acid cleaned cover glass (22 × 22) and air dried. The cover glass was finally mounted on acid cleaned slide with hyrax, a mounting medium of high refractive index (Tolonen *et al.* 1986 and Charles 1986). Both the percentage frequency of the constituent taxa and the concentration of valves (Battarbee and Kneen 1982) were calculated. One slide from each sampling point of the two lakes was counted for each sample date (De Nicola 1986).

The permanent slides were made under oil immersion at a magnification of 1000x via Nikon Optiphot, UFX-11WA microscope fitted with a Nikon FX-35WA camera, Japan. All the images of diatom samples were transferred to digital files and plates of photomicrographs were prepared keeping the scale attached to them. The species were identified with the help of Germain (1981), Hustedt (1930), Wuthrick (1975), Tolonen *et al.* (1986).

Results and Discussion

The following nine fresh water diatoms were recorded from Joysagar lake and Sitlai Beel, in Sirajganj district, These species of Bacillariophyceae have been identified as new records for Bangladesh.

Order: Naviculalis
Family: Naviculaceae

1. *Navicula cuspidata* Kutz. var. *heribaudii* Peragallo **(Pl. 1; Fig. 1)**

(Germain 1981, 172, Pl. 64, Fig. 3)
Cell length 65 - 110 µm, breadth 25.5 µm, striae 2 in 10 µm. Valve lanceolate with tappering ends. Axial area narrow with slightly broad central area. Striae punctate, thick, raphae central.

2. *Navicula grimmei* Krabke **(Pl. 1; Fig. 2a-c)**

(Germain 1981, 215. Pl. 80. Figs 15 - 18, Hustedt 1930, 273. Fig. 448)
Cell length 6.5-11mm, breadth 3.5-3.8 µm, striae 5-9 in 10 µm. Valve clliptical with captate ends, axial area linear, narrow, central area rounded, raphae straight, transapical striae radial, punetuate.

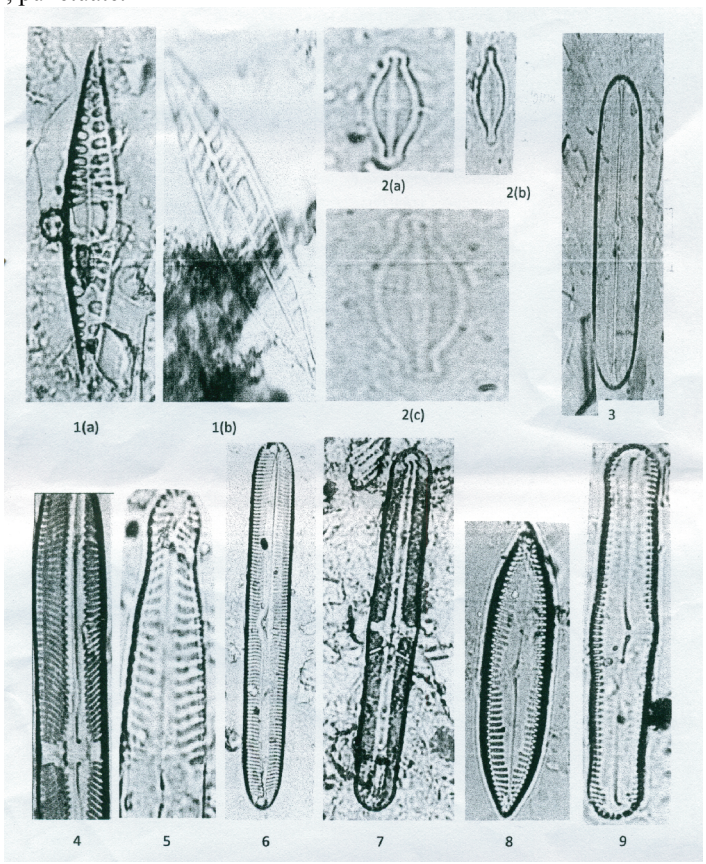

Plate 1. Fig : 1(a-b). *Navicula cuspidata* var. *heribaudii*, 2(a-c). *Navicula grimmei*, 3. *Navicula americanas,* 4. *Pinnularia divergens*, 5. *Pinnularia braunii*, 6. *Pinnularia major*, 7. *Pinnularia brevicosta*, 8. *Pinnularia hemiptera*. 9. *Pinnularia stauroptera*.

3. *Navicula americana* Ehr. **(Pl. 1; Fig. 3)**

(Germain 1981, 205. Pl. 77. Fig. 1, Hustedt 1930, 280. Fig. 464)
Cell length 68.4 - 147.2 µm, breadth 17.7 - 26.1 µm, striae 16 - 20 in 10 µm. Valve broadly linear with broadly rounded ends, axial area having narrow part with thin raphae

and with lateral expansion, linear, raphae more or less straight with central and polar nodules oppositely curved and thicker, striae punctate, transapical, radiate.

Genus: *Pinnularia* Ehrenberg

4. *Pinnularia divergens* W. Smith **(Pl. 1; Fig. 4)**

(Germain 1981, 253, Pl. 89, Fig. 20, Pl. 90, Fig. 1-7)
Cell length 84 µm, breadth 12 µm, 8 striae in 10 µm. Valve linear with rounded ends. Axial area linear widening towards the central end to form a transverse fascia up to each margin.

5. *Pinnularia braunii* (Grun.) Cleve **(Pl. 1; Fig. 5)**

(Germain 1981, 245, Pl. 88, Fig. 17; Hustedt 1930, 318, Fig. 578)
Cell length 40 - 100 µm, breadth 8.7 - 12 µm, 7 - 10 striae in 10 um. Valve linear with attenuated cuneate apices, axial area linear widening towards the centre which forms a broad transverse fascia, central ends of the raphac turned to one side, striae radiate at central area, convergent towards the centre and divergent towards the tips.

6. *Pinnularia major* (Kutz.) Cleve **(Pl. 1; Fig. 6)**

(Germain 1981, 259, Pl. 93, Fig. 3; Hustedt 1930, 333, Fig. 614; Nhyama 1971, 271, Pl. 5, Fig. 2)
Cell length 175.5 - 380.4 µm, 25 - 34 striae in 10 µm. Valve broadly linear with rounded ends, raphae complex with question marked terminal ends and central ends are turned to one side, axial area lincar with slightly tappering towards the ends and central area asymmetrically rounded, striae paralled crossed by a broad hand.

7. *Pinularia brevicosta* Cleve **(Pl. 1; Fig. 7)**

(Hustedt 1930, 330, Fig. 609)
Cell lenght 80 - 120 µm, breadth 10 - 15 µm, striae 7 - 10 in 10 µm. Valve linear, axial area linear, central area widening to form a fascia up to each margin. Raphe thread like, terminal ends question marked, turned to one side.

8. *Pinnularia hemiptera* (Kutz.) Cleve **(Pl. 1; Fig. 8)**

(Hustedt 1930, 330, Fig. 608)
Cell length 41. 7 - 50.7 µm, breadth 11.7 - 12.3 µm, striae 7 - 9 in 10 µm. Valve linear elliptical, outer line convex, axial area narrow, raphae thread like, both the central terminals curved to one side, transapical striae parallel.

9. *Pinnularia stauroptera* (Grun.) Cleve (Pl. 1; Fig. 9)

(Federovich 1980, 431, Fig. 3)

Cell length 30 - 133 µm, breadth 8 - 171.2 µm, striea 5 - 10 in µm. Valve linear slightly widened at the centre with broadly rounded ends, axial area linear about three fourth of the breadth of the valve, raphae straght with rounded central nodules turned to one sides, terminal ends turned to the same sides, striae parallel, short.

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Reference

Batterbee. R. W. and Kneen, M. J. 1982. The use of electronically counted microspheres in absolute diatom analysis. Limno. Oceanogr. **27**: 184-188.

Batterbee, R. W., Smol, J.P. and Merilainen, J. 1986. Diatom as indicator of pH. *In*: Diatom and lake acidity". Smol, J.P., Batterbee, R.W., Davis, R.B and Merilainen, J. (eds). Dr. Junk Publ. Dordrecht. 5-14.

Berge, F. 1975. pH- forandinger og sedimentasjon av diatomeer Langtjern Norges Technish-Natur viten-skapelige Ifedskningirod Inter. Rapport 11. 1-18.

Charles, D.F. 1986. A new diatom species, *Fragilaria acidobiontica,* from acidic lake in north eastern North America. *In*: *Diatoms and Lake Acidity* (Smol, J.P., Batterbee, R.W., Davis, R.B and Merilainen, J. (eds)). Dr. W. Junk. Publ. Dordrecht. pp. 35-43)

Davis, R.B. and Berge, F.1980. Atmospheric deposition in Norway during the last 300 years as recorded in SNSF lake sediments 11, Diatom stratigraphy and inferred pH. In *Ecological Impact of Acid precipitation Drablos,* D: and tollan, A (eds). Proc. Int, Conf, Ecol. Impact Acid Precp. SNSF project, Ose, Norway, 270-271.

De Nicola, D.M. 1986, The representation of living diatom communities in deep water sedimentary diatom assemblages in two (U.S.A.) lake. *In*. *Diatom and lake acidity.* Smol, J, P., Batterbee, R.W., Davis, R.B. and Merilainen, J. (eds). Dr. W. Junk Publ. Dordrecht. pp. 73-85.

Federovich S. L. 1980. Diatom Flora of Red Snow from Isbjorneo. Carey oer. Greenland. Nova Hedwigia. Band 33.. Braunchweig. J. Cramer. pp. 395-431.

Germain, H. 1981. Flora Des Diatomees. Diatomtphyceaes. Soc. Nouv. Des. Edin. Boubee. Paris. 444.

Hustedt, F. 1930. *Die Susswasser-Flora Mitteleuropas.* Heft. 10. Bacillariophyta (Diatomeae). Verlag Von GustavFischer, Jena. pp. 466.

Nahar, K. and Khondker, M. 2009. Addition to the list of freshwater diatoms (Bacillariophyceae) of Bangladesh. 1. Family: Coscinodiscaceae, Fragillariaceae and Eunoceaceae. Taxon Biodiv. Res. 9-12.

Nahar, K., Khondker, M. and Sultana, M. 2010. Seasonality and diversity of epipelic diatoms in two wetlands of Bangladesh. *Bangladesh J*. Bot**. 39**(1) 29-36.

Nhyama, Y.N. 1971. Phytoplankton in lake Abasiri. Environ. Soc. Hokkaido**.** **5**(2): 221-281.

Sultana, M., M. Khondker and Hoque. S. 2003. Status of epipelic algae and sediment composition of two urban ponds. *J. Asiat. Soc. Bangladesh, Sci.* **29**(1): 37-44.

Tolonen, K. M., Harjula, L. R. and Patila, A.S. 1986. Acidification of small lake in Finland documented by sedimentary diatom and chrysophycean remans. *In*: Diatom and lake acidity. Smol. J. P., Davis, R. B and Merilainen, J. (eds), Dr. Junk Publ. Dordrecht. 171-199.

Ven der Werff. 1958. A new method of concentrating and cleaning diatoms and other organisms. *Verhandl. In ter, verenin. Theoret Angewand.* Limonol., Stuttgard. Germany, **12** : 276 - 277.

Wuthrick, M. 1975. Less Diatomee. DruckLie DinAir. Leistal. 300-333.

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NEONATAL, INFANT AND UNDER-FIVE MORTALITY: AN APPLICATION OF COX PROPORTIONAL HAZARD MODEL TO BDHS DATA

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Abstract

This study utilizes data derived from the Bangladesh demographic and health survey (BDHS), 2014 to identify the determinants of neonatal, infant and under-five mortality in Bangladesh. Log-rank test has been used for bivariate analysis. Regression analysis has been performed by applying Cox proportional hazard model to the data. It has been found from the analysis that maternal education, region, exposure to NGO activities are significant determinants of under-five and infant mortality whereas region, gender of child, child's size at birth play significant role in reducing neonatal mortality in Bangladesh. The findings of the study suggest that policymakers should give priority on maternal education, region, and child's size at birth as well as exposure to NGO activities to reduce neonatal, infant and under-five mortality in Bangladesh.

Key words: Under-five mortality, Infant mortality, Neonatal mortality, Log-rank test, Cox Proportional Hazard model

Introduction

Child mortality is an important public health issue throughout the world since it is commonly used as one of the important measures of well-being and development of a country. Mortality of child is defined distinctly with respect to the age of a child as neonatal, infant and under-five mortality. By definition, neonatal mortality includes the deaths within first month of life, infant mortality includes the deaths within first year of life and under-five mortality includes the deaths between birth and fifth birthday (BDHS 2014). According to World Health Organization (WHO), around 5.6 million children died worldwide before reaching their fifth birthday in 2016. Globally remarkable progress has been made in child survival by reducing under-five mortality rate by 53 per cent from 91 deaths per 1000 live births in 1990 to 43 deaths per 1000 live births in 2015 (UNICEF 2015). Like other developing countries, Bangladesh has achieved Millennium Development Goal (MDG) 4 target of two-thirds reduction of under-five mortality rate from 133 deaths per 1000 live births in 1989 - 1993 to 46 deaths per 1000 live births in 2010 - 2014 (BDHS 2014). The infant mortality rate is 38 per 1000 live births in Bangladesh. Over the last two decades, infant mortality rate has been dropped by 56 per

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cent from 87 to 38 deaths per 1000 live births (BDHS 2014). Although infant mortality rate has been declined, it has been observed that infant mortality comprised of 65% of under-five deaths in 1989 - 1993 which raised to 83% in 2010 - 2014. Reducing under-five mortality to 37 or fewer deaths per 1000 live births by 2021 in Bangladesh is one of the targets of the health, nutrition and population sector program (MOHFW 2016). As the largest portion of under-five deaths took place during infancy, it becomes more important to identify the factors affecting infant mortality for reducing under-five mortality to achieve this target. The BDHS (2014) data reveal that neonatal mortality rate is 28 per 1000 live births indicating 46% fall in neonatal mortality compared to the period 1989 - 1993. Although under-five and infant mortality rates have declined, 61% of under-five deaths and 74% of infant deaths occurred in the neonatal period of life. It is expected to focus on neonatal mortality in order to decrease under-five and infant mortality rates. It is also notable that the pace of reduction in neonatal mortality (46%) from 1989 to 2014 is slowest compared with under-five (65%) and infant mortality (56%) (BDHS 2014). The pace of reduction in neonatal deaths should be accelerated to achieve the target of the health, nutrition and population sector program of 21 neonatal deaths per 1000 live births by 2021 (MOHFW 2016). The third sustainable development goal (SDG) is reducing neonatal mortality rate to at least as low as 12 deaths per 1,000 live births and under-five mortality to at least as low as 25 deaths per 1,000 live births. To achieve SDG 3 target, it is important to identify the factors influencing the under-five and neonatal mortality in Bangladesh. To ensure better development and well-being of the country, it is needed to improve child health by reducing neonatal, infant and under-five mortalities.

Globally social scientists and policymakers are greatly interested on the factors affecting child mortality as it is considered as an indicator of standard of living and socio-economic development of a nation. Worldwide various studies have been conducted to find the determinants of neonatal, infant and under-five mortality. Nisar and Dibley (2014) performed Cox regression analysis to determine the risk factors of neonatal mortality in Pakistan. In Nepal, Khadka *et al*. (2015) investigated the socio-economic determinants of infant mortality using logistic regression. A study was undertaken by Nasejje *et al*. (2015) to examine the determinants of under-five mortality in Uganda.

In Bangladesh, several studies have been conducted to identify the determinants of neonatal, infant and under-five mortality to promote socio-economic development and quality of life. Chowdhury (2013) performed Cox Proportional Hazard analysis to find the determinants of under-five mortality in Bangladesh. Place of residence, region and mother's age have been found significant factors affecting under-five mortality in his study. Mondal *et al*. (2009) investigated the factors having significant impact on infant and child mortality at Rajshahi district. The findings of the study revealed that the most

significant determinant of neonatal, post-neonatal and child mortality was mother's age at birth. Mother's education and treatment places were significant predictors of both neonatal and child mortality whereas residence, watching television, sex of child and birth order were found significant only for child mortality. Kamal *et al.* (2012) found maternal age, maternal education and birth order as potential risk factors of neonatal mortality in Bangladesh. Hossain and Islam (2008) studied the socio-economic variables affecting infants and children mortality. In this study, it was observed that mother's education, medical checkup during pregnancy and watches TV were significant factors influencing infant, child and under-five mortality. Another study on infant mortality by Fatima *et al.* (2016) used log-logistic parametric survival regression model and revealed that age of mother at birth, maternal education, gender of child, size of child at birth, place of delivery and membership of NGO significantly influence the infant mortality. Rahman (2008) conducted a study using Cox proportional hazard model to BDHS data and found that place of delivery, maternal education, source of drinking water, household electricity facility and household assets index had significant role in declining the child mortality rate.

In this paper an attempt has been made to determine the potential determinants affecting neonatal, infant and under-five mortality in Bangladesh.

Materials and Methods

The study uses secondary data extracted from nationally representative Bangladesh Demographic and Health Survey (BDHS) conducted in 2014 under the authority of the National Institute of Population Research and Training (NIPORT) of the Ministry of Health and Family Welfare. This survey interviewed 17,863 ever married women aged 15 - 49 and asked to provide information of their live births including the sex, month, year of each birth, survival status and age at the time of the survey or age at death and also asked about background characteristics (e.g., age, education, region, media exposure etc.).

Three outcome variables were considered in this study: the time to death within five years of a child; the time to death before reaching it's first birthday and the time to death within one month of life. A child is considered to be censored if it did not die within neonatal and infancy period and before reaching it's fifth birthday.

Based on previous studies (Chowdhury 2013, Mondal *et al*. 2009, Hossain and Islam 2008, Rahman 2008, Siddiqi *et al.* 2011, Kamal *et al.* 2012, Fatima *et al.* 2016) a set of explanatory variables are considered in this study which are mother's age at birth, maternal education, place of residence, region, wealth index, birth order number, gender of the child, place of delivery, child's size at birth, exposure to NGO (Non Government Organizations) activities and Access to media.

In order to identify the determinants affecting childhood mortality, information from 4723 children was used for our study purpose. Among these children, 170 died before fifth year of their birth, 163 died before first year of their birth and 125 died before first month of their birth which yields under-five mortality, infant mortality and neonatal mortality rates are 36, 35 and 26 deaths per 1000 live births, respectively. These rates underestimate the under-five mortality rate (46 per 1000 live births), infant mortality rate (38 per 1000 live births), and neonatal mortality rate (28 per 1000 live births) presented in BDHS (2014) report. This may occur because we deleted 3158 missing cases for child's size at birth and 3,162 missing cases for place of delivery and also excluded those children, who died before reaching their fifth birthday but they were born before preceding five years of the survey.

Log-rank test and Cox Proportional Hazard Model are used for bivariate and multivariate regression analysis, respectively.

Results and Discussion

Bivariate analysis: Table 1 presents the p values obtained from log-rank test for under-five, infant and neonatal mortality for selected explanatory variables. It has been found that maternal education, region, child's size at birth, exposure to NGO activities and access to media are significantly associated with under-five, infant and neonatal mortality. Besides those variables, wealth index shows significant relation with under-five mortality and gender of child is associated with neonatal mortality. The variables that are found significant are considered for Cox Proportional regression analysis.

Table 1. P values obtained from Log-rank test for under-five, infant and neonatal mortality for the selected explanatory variables.

Variables	Log rank test p values		
	Under-five mortality	Infant mortality	Neonatal mortality
Mother's age at birth	0.693	0.680	0.650
Maternal education	**0.006**	**0.010**	**0.060**
Place of residence	0.580	0.850	0.710
Region	**0.005**	**0.004**	**0.006**
Wealth index	**0.050**	0.140	0.380
Birth order number	0.410	0.260	0.400
Gender of child	0.300	0.330	**0.060**
Place of delivery	0.510	0.670	0.710
Child's size at birth	**0.050**	**0.040**	**0.030**
Exposure to NGO activities	**0.060**	**0.040**	**0.060**
Access to media	**0.010**	**0.040**	**0.060**

Survival regression analysis: The hazard ratios and p values obtained applying Cox proportional hazard model to under-five, infant and neonatal mortality data are reported in Table 2.

Under-five mortality: The study shows that the hazard rate of under-five mortality among children with higher educated mothers is 57% lower than that of children with illiterate mothers. The results reveal that maternal education is negatively associated with under-five mortality which found similar to the findings of the previous studies (Siddiqi *et al*. 2011, Islam *et al*. 2013). This may happen because education enhances mothers' awareness about child health, child nutrition and modern child health facilities. Table 2 depicts that the children of Sylhet experience the highest rate of mortality compared to the children of Dhaka. It is also observed that children who belong to Barisal experience the lowest rate of mortality compared to the children of Dhaka which conflicts with the results of the study of Chowdhury (2013). It is clear from Table 2, mother's exposure to NGO activities shows significant association with under-five mortality. A child whose mother is exposed to NGO activities experiences 33% more rate of under-five mortality compared to the child whose mother is not exposed to NGO. It may be due to the fact that the mothers who are engaged with an NGO do not get enough time to take proper care of their children. The variables wealth index, child's size at birth and access to media have been found insignificant factors determining the under-five mortality.

Infant mortality: The analysis reveals that children of higher educated mothers are more likely to survive during infancy compared to the infants of mothers who didn't attend school. Therefore, maternal education shows significant inverse relation with infant mortality which were similar to the study of Fatima *et al.* (2016). The study demonstrates that the rate of dying within first year of life is highest among children of Sylhet region. It has been found interesting that infants of Barisal have lower rate of mortality compared to that of Dhaka which contradicts with the results of the former study conducted in Bangladesh (Fatima *et al.* 2016). It is clear from Table 2 that children of mothers affiliated to NGO activities experience higher rate of dying during infancy than that of mothers who are not affiliated with NGO. Child's size at birth and access to media have no significant effects on infant mortality like under-five mortality.

Table 2. Hazard ratios and p values obtained from Cox Proportional Hazard analysis for under-five, infant and neonatal mortality for the selected explanatory variables.

Variables	Under-five mortality		Infant mortality		Neonatal mortality	
	HR	p-value	HR	p-value	HR	p-value
Maternal education						
No education(RC)	-	-	-	-	-	-
Primary	0.977	0.92	1.051	0.83	1.138	0.63
Secondary	0.867	0.54	0.895	0.64	1.007	0.97
Higher	**0.425**	**0.04**	**0.462**	**0.07**	0.490	0.14
Region						
Dhaka(RC)	-	-	-	-	-	-
Barisal	**0.404**	**0.02**	**0.367**	**0.02**	**0.404**	**0.07**
Chittagong	0.950	0.85	0.945	0.83	0.989	0.97
Khulna	1.276	0.38	1.190	0.55	1.514	0.22
Rajshahi	1.058	0.85	1.020	0.92	1.451	0.27
Rangpur	0.837	0.57	0.870	0.65	1.204	0.60
Sylhet	**1.522**	**0.09**	**1.569**	**0.07**	**1.884**	**0.03**
Wealth index						
Poor	1.243	0.36				
Middle (RC)	-	-				
Rich	1.219	0.41				
Gender of child						
Male (RC)					-	-
Female					**0.689**	**0.04**
Child's size at birth						
Large/Average (RC)	-	-	-	-	-	-
Small	1.267	0.19	1.301	0.15	**1.446**	**0.07**
Exposure to NGO activities						
Not NGO member(RC)	-	-	-	-	-	-
NGO member	**1.325**	**0.09**	**1.393**	**0.05**	1.364	0.11
Access to media						
Non-exposure(RC)	-	-	-	-	-	-
Exposure	0.794	0.24	0.832	0.29	0.814	0.29

RC : Reference category, HR : Hazard ratio.

Neonatal mortality: Although maternal education plays significant role in reducing infant and under-five mortality, the study shows that mother's education has no significant effect on neonatal mortality. Kamal *et al.* (2012) found maternal education as an important risk factor of neonatal mortality in his study using BDHS 2007 data and this findings is contradictory to our analysis. Like under-five mortality and infant mortality, the analysis reveals that the rate of survival during neonatal period is highest in Barisal whereas neonatal of Sylhet experience lowest rate of survival compared to that of Dhaka.

It has been observed that male children are more likely to die within 28 days of life compared to the female children. This may be due to the reason that naturally male children are more vulnerable than female children from the starting time of pregnancy (BDHS 2014). It is clear from the analysis that neonatal whose size at the time of birth was small experienced 45% more rate of mortality than those neonatal whose size at birth was large or average. Child's size at birth is significantly associated with neonatal mortality whether it has insignificant impact on both infant and under-five mortality. Although mother's exposure to NGO activities is significantly related with both infant and under-five mortality, it has been found as insignificant determinant of neonatal mortality. Access to media plays no important role in reducing neonatal deaths in Bangladesh.

From the study we observe that maternal education, region, mother's exposure to NGO activities are the potential determinants of infant and under-five mortality whereas region, gender of child, child's size at birth have significant effect on neonatal mortality in Bangladesh. The findings of the study suggest to improve female educational attainment as mother's education lowers the risk of dying of under-five children and infants. Policy makers should focus on the factors responsible for the highest mortality rate in Sylhet. Special health intervention programs should be taken in order to reduce mortality rates of children in Sylhet**.** Mothers' membership of NGO has been found to be significant determinant for under-five and infant mortality but shows no significant influence on neonatal mortality. NGOs should ensure maternity leave with salary and other facilities that could reduce the rates of mortality of children. Government should take necessary steps to enhance public awareness about maternal health care during pregnancy and child health care which may improve child survival in Bangladesh

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References

Bangladesh Demographic and Health Survey (BDHS), 2014. NIPORT, Dhaka, Bangladesh; Mitra and Associates, Dhaka, Bangladesh.

Chowdhury, A. H. 2013. Determinants of under-five mortality in Bangladesh. *Open Journal of Statistics* **3**: 213-219.

Fatima, T.Z. K.A. Mohammad and W. Bari. 2016. Log-Logistic Proportional Odds Model for Analyzing Infant Mortality in Bangladesh. *Asia Pacific Journal of Public Health* **29**(1): 60-69.

Hossain, M. and M. Islam 2008. Socio-economic variables affecting infants and children mortality in Bangladesh. *The Internet Journal of Health* **9**(2).

Islam, R., M. Hossain, M. Rahman and M. Hossain. 2013. Impact of socio-demographic Factors on child mortality in Bangladesh: An Multivariate Approach. *International Journal of Psychology and Behavioral Sciences* **3**(1): 34-39.

Kamal, S.M. M., M. Ashrafuzzaman and S. A. Nasreen. 2012. Risk factors of neonatal mortality. *Journal of Nepal Paediatric Society.***32**(1): 37-46.

Khadka, K. B. L. S. Lieberman, V. Giedraitis , L. Bhatta and G. Pande. 2015. The socio-economic determinants of infant mortality in Nepal: analysis of Nepal Demographic Health Survey, 2011. *BMC Pediatrics* .15:152

Ministry of Health and Family Welfare (MOHFW) [Bangladesh]. 2016. *Health, Nutrition and Population Strategic Investment Plan 2016-21.* Planning Wing, MOHFW,Government of the People's Republic of Bangladesh.

Mondal, N. I., K. Hossain and K. Ali, 2009. Factors influencing infant and child mortality: A case study of Rajshahi District, Bangladesh. *Journal of Human Ecology* **26**(1): 31-39.

Nasejje, J. B. , H.G. Mwambi, and T .N. O. Achia. 2015. Understanding the determinants of under-five child mortality in Uganda including the estimation of unobserved householdand community effects using both frequentist and Bayesian survival analysis approaches. *BMC Public Health* 15:1003.

Nisar, Y. B. and M. J. Dibley. 2014. Determinants of neonatal mortality in Pakistan: secondary analysis of Pakistan Demographic and Health Survey 2006-2007. *BMC Public Health* 14:663.

Rahman, M. 2008. Factors Affecting on Child Survival in Bangladesh: Cox Proportional Hazards Model Analysis.*The Internet Journal of Tropical Medicine* **6**(1).

Siddiqi, N. A., N. Haque and A. Goni. 2011. Differentials and determinants of under-five mortality in Bangladesh. *International Journal of Current Research* **3**(1): 142-148.

United Nations children's fund (UNICEF). 2015. Levels and trends in child mortality. Available at: http://www.unicef.org/media/files/IGME_Report_Final2pdf.

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RUSSELL'S VIPER (*DABOIA RUSSELII*) IN BANGLADESH: ITS BOOM AND THREAT TO HUMAN LIFE

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Abstract

The occurrence of Russell's viper (*Daboia russelii* Shaw and Nodder 1797) in Bangladesh is century old information and its rarity was known to the wildlife biologists till 2013 but its recent booming is also causing a major threat to human life in the area. Recently it has been reported from nine districts (Dinajpur, Chapai Nawabganj, Rajshahi, Naogaon, Natore, Pabna, Rajbari, Chuadanga and Patuakhali) and old records revealed 11 districts (Nilphamari, Dinajpur, Rangpur, Chapai Nawabganj, Rajshahi, Bogra, Jessore, Satkhira, Khulna, Bagerhat and Chittagong). Thus altogether 17 out of 64 districts in Bangladesh, of which Chapai Nawabganj and Rajshahi are most affected and 20 people died due to Russell's viper bite during 2013 to 2016. Its past and present distribution in Bangladesh and death toll of its bites have been discussed. Its booming causes have also been predicted and precautions have been recommended. Research on Russell's viper is deemed necessary due to reemergence in deadly manner.

Key words: Russell's viper, *Daboia russelii*, Distribution, Boom, Panic, Death toll

Introduction

Two species of Russell's viper are known to occur in this universe of which *Daboia russelii* (Shaw and Nodder 1797) is distributed in Pakistan, India, Nepal, Bhutan, Bangladesh and Sri Lanka (www.reptile.data-base.org); while *Daboia siamensis* (Smith 1917) occurs in China, Myanmar, Indonesia, Thailand, Taiwan and Cambodia (Wogan 2012). The former one occurs in Bangladesh (Khan 1982, 1992, 2015, Sarker and Sarker 1988, Ahsan 1997, Khan 2008, Islam 2009 and Hasan *et al*. 2014). Works on Russell's viper in Bangladesh have mostly been done for listing and distribution in the country except Islam (2009) and Hasan *et al*. (2014) who provided additional information on ecology mainly from literatures. So an attempt was made to collect some information on the species from the field. This paper includes the following aspects of Russell's viper: (1) past and present distribution of the species in Bangladesh, (2) its boom and panic to farmers, (3) bite and death occurrences, (4) awareness of the local people and (5) suggested recommendations.

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Materials and Methods

Published literatures were searched, newspaper reports were collected; physically searched some of the areas of Tanore, Godagari and Nachole Upazilas Rajshahi District and local farmers including some people staffs of Govt. and NGO were interviewed. Furthermore, the distribution of Russell's viper in Bangladesh was also compiled from the survey of the distribution of kraits in Bangladesh through verifying local collections of preserved snake specimens in the museums of 36 different institutes throughout the country (Ahsan and Rahman 2017). The institutes included important public universities, university colleges, colleges, medical college hospitals and museums in the country, which have collections of preserved snake specimens.

Results and Discussion

Recent records reveal that Russell's viper is found in nine districts but old records say 11 districts and altogether 17 out of 64 districts in Bangladesh (Table 1 and Fig. 1). It is apparent from the distribution (Fig. 1) that the occurrence of the species on record is mainly on lands along the Padma river belts and its connected other rivers and their tributaries (except Patuakhali and Bagherhat cases).

Table 1. Old and recent records of Russell's viper in Bangladesh.

Sl. No.	Districts (Upazila)	Old records	Recent records
1.	Nilphamari	Yes	-
2.	Dinajpur (Hili)	Yes	Yes
3.	Rangpur	Yes	-
4.	Bogra	Yes	?
5.	Chapai Nawabganj (Sadar, Shibganj, Gomatapur, Nachole)	Yes	Yes
6.	Rajshahi (Sadar, Poba, Godagari, Tanore)	Yes	Yes
7.	Jessore	Yes	-
8.	Satkhira (Assasuni, Kaliganj, Shyamnagar)	Yes	-
9.	Khulna (Koira, Paikgacha)	Yes	-
10.	Bagerhat (Sundarbans, not *upazila*)	Yes	-
11.	Chittagong (Patiya)	Yes	-
12.	Naogaon (Dhamoirhat)	-	Yes
13.	Natore (Boraigram, Singra)	-	Yes
14.	Pabna	-	Yes
15.	Rajbari (Pangsha)	-	Yes
16.	Chuadanga (Damurhuda)	-	Yes
17.	Patuakhali (Kalapara [Kuakata, not *upazila*])	-	Yes

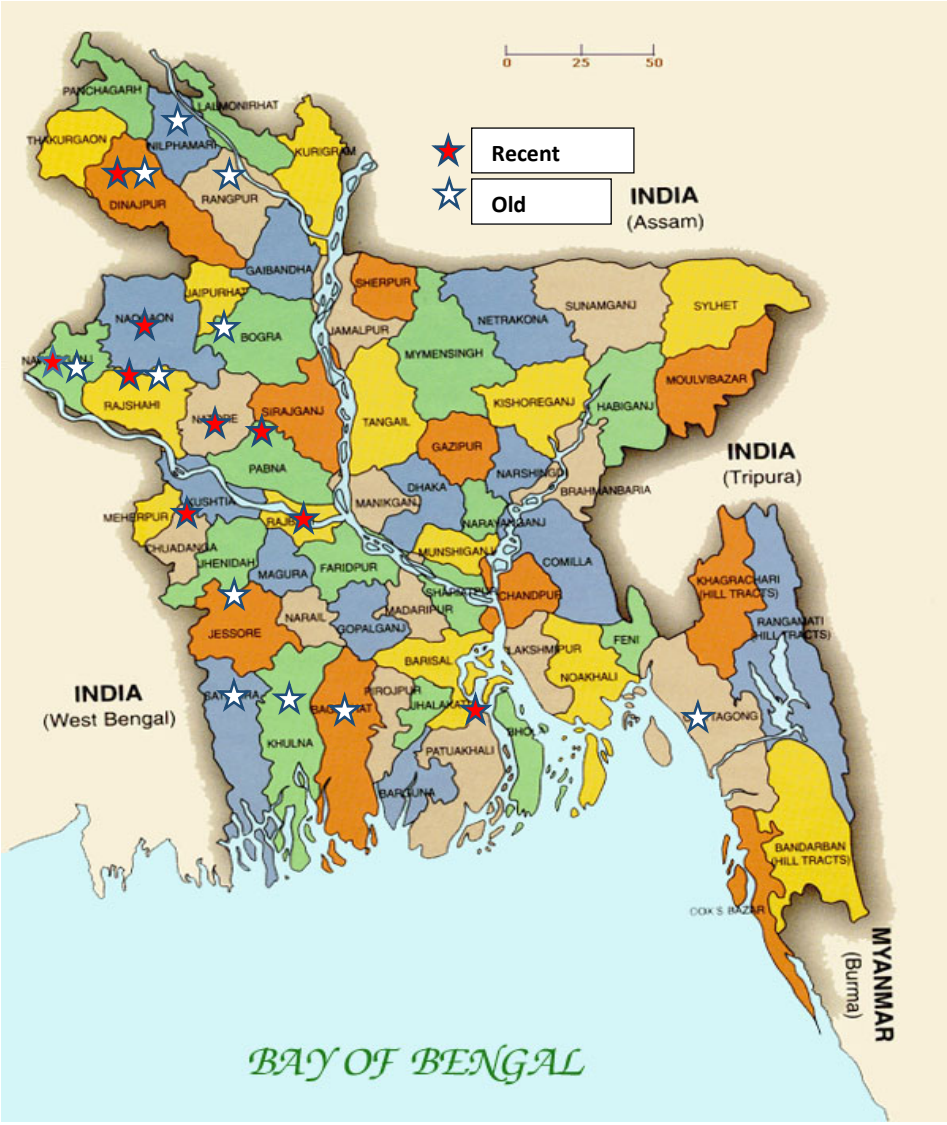

Fig. 1: Distribution of Russell's viper in Bangladesh

Russell's viper is mostly terrestrial but also found in water bodies and it is a good swimmer. It is crepuscular and nocturnal in habit during hot weather but becomes active during day time in the cool weather. It inhibits from plain up to the elevation of 2,100 m asl in south India (Daniel 2002) and found in open, grassy or bushy areas, scrub jungles, forested plantations, rocky hillocks, forest edges, mangroves and farmlands (Whitaker and Captain 2004). It tries to avoid dense forest. Its diets comprise rodents, crabs, frogs,

lizards and birds (Das 2002). Individuals become sexually mature within 2 to 3 years. Females give birth to 6 - 63 live young during May to November with a peak between June and July with a gestation period of more than 6 months (Daniel 2002, Whitaker and Captain 2004 and Das 2010). The species has recently been assessed as Near Threatened in Bangladesh according IUCN red list assessment categories (Rahman 2015) and it was assessed as Critically Endangered earlier (IUCN Bangladesh 2000).

After one death occurrence of person by Russell's viper bite in Rajshahi Medical College Hospital (RMCH) in 2013, medical doctors especially snakebite researchers came forward for remedies. In fact, one 18 years old school student was bitten in his right forearm by a Russell's viper in Nachole Upazila of Chapai Nawabganj district while he was trying to capture the snake with a misassumption of a non-venomous python. The victim was admitted to RMCH after failure of the traditional healers (i.e., Ozhas) locally. He died due to wide spread bleeding manifestations, rhabdomyolysis, renal failure and irreversible shock after nine days treatment in the RMCH with 50 vials of polyvalent anitivenom. After that accident there were several incidences of Russell's viper bites in different districts of Bangladesh that drew attention of the physicians and researchers of home and abroad. Medical reports on Russell's viper in Bangladesh reveal that its venom is neuro- myo-nephro- and haemotoxic type (Dr. Robed Amin, pers. comm.).

Table 2. Death case reported of Russell's viper bite in Bangladesh.

Sl. No.	Date	District	Upazila	Victim	Sex	Age	Treatment received*
1.	13 Mar 2013	Chapai Nawabganj	Nachole	Anwar Hossain	M	18	RMCH
2.	21 Nov 2013	Rajshahi	Tanore	Taijuddin	M	25	RMCH
3.	27 Nov 2013	Patuakhali	Kalapara	Amir Hossain	M	46	DMCH
4.	04 Apr 2014	Naogaon	Dhamoirhat	Jamaluddin	M	35	RMCH
5.	13 Nov 2014	Rajshahi	Tanore	Azimuddin	M	26	RMCH
6.	26 Nov 2015	Rajshahi	Tanore	Yasin Kalu	M	50	UHC
7.	26 Apr 2016	Rajshahi	Godagari	Naimul Islam	M	25	Ozha
8.	27 Apr 2016	Chapai Nawabganj	Gomastapur	Samsu Mia	M	26	RMCH
9.	29 Apr 2016	Rajshahi	Godagari	Mousumi	F	24	RMCH
10.	01 Jun 2016	Chapai Nawabganj	Shibganj	Abul Kalam	M	32	RMCH
11.	05 Jul 2016	Natore	Boraigram	Rashed	M	30	Ozha
12.	12 Jul 2016	Rajshahi	Godagari	Rofiqul Islam	M	41	Ozha
13.	17 Jul 2016	Rajshahi	Godagari	Ukhi Begum	F	38	Ozha
14.	20 Jul 2016	Rajshahi	Godagari	Abdul Hakim	M	36	Ozha
15.	22 Jul 2016	Rajshahi	Godagari	Kawser Ali	M	11	RMCH
16.	05 Aug 2016	Rajshahi	Godagari	Surjema Begum	F	26	Ozha
17.	11 Aug 2016	Rajshahi	Godagari	Mizan	M	29	Ozha
18.	25 Aug 2016	Rajshahi	Godagari	Shaheb Ali	M	45	UHC
19.	13 Sep 2016	Rajshahi	Godagari	Helaluddin	M	28	RMCH
20.	21 Oct 2016	Rajshahi	Tanore	Abdur Rahim	M	40	Ozha

Sources: Personal communication, News papers, NGO. * RMCH- Rajshahi Medical College Hospital, DMCH- Dhaka Medical College Hospital, UHC- Upazila Health Complex, Ozha- Traditional healers.

Although it came to limelight in 2013 but in 1995, there was one death record of an indigenous (*shawtal*) female due to Russell's viper bite in Shibrampur village under Tanore Upazila of Rajshahi district. The victim was treated by a local Ozha (traditional healer) and the local people killed the snake. The actual number of death case has not been maintained accurately by any organization or person but we have compiled it from different sources and found that at least 20 people died due to the bite of Russell's viper in Bangladesh between 2013 and 2016 (Table 2).

Farmers are the main victims of the snake bites because they work in the crop fields and 17 of the dead victims were males, and of which 14 died in 2016, one in 2015, two in 2014 and three in 2013 (Table 2). On the other hand, more than 100 snakes (Russell's vipers) have been killed by local people during that time period. Two of three specimens were rescued from Kulabona char of Poba Upazila under Rajshahi District (kept them in a private snake farm in Poba Upazila), and the other one rescued from the Padma River by fishermen's net in Pangsha Upazila of Rajbari District (kept in a private snake farm in Kalukhali Upazila of Rajbari District). Five individuals were rescued by the Wildlife and Nature Conservation Division, Rajshahi, of the Forest Department and they were released. These rescued and released individuals were: one from Dhamoirhat Upazila of Naogaon District and released on 14 September 2014 at Forhadabad char land afforested area (planted secondary forest) of Godagari Upazila of Rajshahi District; one from Hili Upazila of Dinajpur district and released at Belpukur of Rajshahi on 8 February 2015, two from Godagari Upazila and released at Forhadabad *char* land afforested area of Godagari and one from Gomastapur Upazila of Chapai Nawabganj District and released it at Belpukur of Rajshahi (M. M. Islam, pers. comm.).

Local people are very much scared of the bite of this species and using local technique like 3 - 4 m long light bamboo and gentle stir of paddy-plants (so that plants are not damaged) to run off snakes before harvesting crops. A few people are also using gumboots and jeans trouser as a safety measure advised by us. A day-long workshop was arranged with the help of local administration, Upazila Nirbahi (Administrative) Officer (Mr. M. M. Bhuiyan), one medical doctor (Dr. A. S. M. M. Rahman) of RMCH, one Professor (Dr. B. C. Das) of Zoology, University of Rajshahi and NGO member of Baroshik (Mr. Shahidul Islam) in Tanore Upazila of Rajshahi District on 30 November 2015 and one of us (MAS) conducted awareness discussion with local people for getting rid off of snake bite; where and how to do first-aid, prevention and get medical treatment.

Cause of booming Russell's viper in Bangladesh: It is very difficult to say the actual cause of booming of Russell's viper population in Bangladesh but the following may be the possible reasons:

1. Until 1990s usualy farmers used to cultivate one or two crops in a year and the land remained fallow for rest of the year due to the scarcity of water for cultivating crops;
2. Soon after 1990s farmers are cultivating two to three crops in a year due to the development of irrigation system and little land left fallow. As the crops are available more or less throughout the year and the main food of Russell's viper-the rats, are available in the crop fields, so Russell's viper gets opportunities for reproduction to increase its population;
3. As fallow lands and bushes are very limited so the snakes take shelter in the crop fields;
4. In charland (emerging land area) especially at Forhadpur, an afforestation program of Forest Department has helped to grow good vegetation there and few snakes from India have stranded through flood and got shelter there. Three individuals have been released at Forhadpur *char* land by the Forest Department. That has helped get mate of the snakes and reproduce in that safe place
5. Converted barren bush land areas (through fires) of Maldah district of West Bengal in India to agricultural land along the borders of Chapai Nawabganj district of Bangladesh may lead to migrate some individuals of Russell's viper to the affected areas in Bangladesh.

Cause of panic of Russell's viper bite: During 2013 to 2016, 20 people died due to the biting of Russell's viper in Rajshahi Division, so the people are panic about the snake and the possible causes of panic of the bites are:

1. People believe that there is no proper medical treatment of Russell's viper bite in Bangladesh;
2. People believe that if a person is bitten by Russell's viper then the death is a time factor;
3. Date of Govt. stocked polyvalent antivenom has expired on 16 August 2016;
4. Doctors and victims are not using the date-expired polyvalent antivenom;
5. Four to five doses are usually needed for treating a Russell's viper victim, which is costly (BDT 40-50 thousands, BDT 80 = 1 USD);
6. General mass victim cannot afford the antivenom cost; and

7. Russell's viper victim also needs dialysis which is costly and general mass people cannot afford it.

Recommendations

The following recommendations have been suggested for studying Russell's viper:

1. Survey of status and distribution of Russell's viper in Bangladesh be updated;
2. On emergency basis new polyvalent antivenom should be brought through the Govt. initiative;
3. Mono-valent antivenom for Russell's viper is produced in Myanmar and Thailand, so for trial basis it may be brought and be used like done for green pit viper victim in Chittagong Medical College Hospital (collected from Thailand);
4. Snake bite treatment management training program especially for Russell's viper should be initiated for Doctors and Nurses on emergency basis by the Govt. initiative;
5. Public awareness should be created in Russell's viper affected areas including in the schools and colleges;
6. Govt. should take initiative for producing its own antivenom using venom from locally relevant venomous snakes and
7. Incepta Pharmaceutical Ltd. is claiming of manufacturing snake venom antiserum for the first time in Bangladesh but in fact, the company is only marketing antivenom imported from Vins-Bio Products Ltd. of India resulting high cost of antivenom for the poor farmers, who are suffering from snake bites. So Govt. should either take initiative to manufacture the antivenom locally as suggested by WHO in 2009 or import it and supply to the Govt. Hospitals as done earlier for helping the victims.

The known and unknown distribution of Russell's viper (*Daboia russelii*) in Bangladesh has come in limelight. The probable causes of its boom and panic to farmers have also been pointed out. The awareness programs in the most affected areas have resulted conciseness of the farmers about the snake bite. It has also lessened fear and death toll of people due to snake bites and people have learned to work in the crop fields with cautions. The suggested recommendations may provide further help in policy making and to carry out future work on Russell's viper.

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References

Ahsan, M.F. 1997. Country report for Bangladesh- Herpetofauna of Bangladesh: Present Status, Distribution and Conservation. *In*: *Biology and Conservation of Amphibians, Reptiles and Their Habitats in South Asia*. (Proceedings on International Conference on the Biology and Conservation of the Amphibians and Reptiles of South Asia, Sri Lanka, August 1-5, 1996) (ed A. de Silva). pp. 9-17, Amphibians and Reptiles Research Organization of Sri Lanka, Kandy.

Ahsan, M.F. and M.M. Rahman. 2017. Status, distribution and threats of kraits (Squamata: Elapidae: *Bungarus*) in Bangladesh. *J. Threatened Taxa*. **9**(3): 9903-9910.

Das, I. 2002. *A Photographic Guide to Snakes and Other Reptiles of India*. New Holland Publishers (UK) Ltd., London. 144 pp.

Das, I. 2010. *A Field Guide to the Reptiles of South-East Asia*. New Holland Publishers (UK) Ltd., London. 376 pp.

Daniel, J.C. 2002. *The Book of Indian Reptiles and Amphibians.* Bombay Natural History Society, Oxford University Press, Delhi. 238 pp.

Hasan, M.K., M.M.H. Khan and M.M. Feeroz. 2014. *Amphibians and Reptiles of Bangladesh – A Field Guide*. Arannayk Foundation, Dhaka. 191 pp.

Islam, M.A. 2009. *Daboia russellii* (Shaw and Nodder, 1797). *In*: *Encyclopedia of Flora and Fauna of Bangladesh, Vol. 25. Amphibians and Reptiles* (eds. S.M.H. Kabir, M. Ahmad, A.T.A. Ahmed, A.K.A., Rahman, Z.U. Ahmed, Z.N.T. Begum, M.A. Hassan, and M. Khondker). Asiatic Society of Bangladesh, Dhaka. pp. 172-173.

IUCN Bangladesh. 2000. *Red Book of Threatened Amphibians and Reptiles of Bangladesh.* IUCN-The World Conservation Union, Bangladesh. 95 pp.

Khan, M.A.R. 1982. *Wildlife of Bangladesh: A Checklist*. The University of Dhaka, Dhaka. 174 pp.

Khan, M.A.R. 1992. *Bangladesher Shap* (*Snakes of Bangladesh*) (in Bengali), Bangla Academy, Dhaka. 227 pp.

Khan, M.A.R. 2015. *Wildlife of Bangladesh: Checklist and Guide*. M. J. Alam, Chayabithi, Dhaka. 568 pp.

Khan, M.M.H. 2008. *Protected Areas of Bangladesh: A Guide to Wildlife*. Nishorgo Program, Bangladesh Forest Department, Dhaka. 304 pp.

Rahman, M.M. 2015. *Daboia russelii*. In: IUCN Bangladesh. *Red List of Bangladesh Volume 4: Reptiles and Amphibians*. IUCN, International Union for Conservation of Nature, Bangladesh Country Office, Dhaka. p.103.

Sarker, M.S.U. and N.J. Sarker. 1988. *Wildlife of Bangladesh (A Systematic List with Status, Distribution and Habitat)*. The Rico Printers, Dhaka. 69 pp.

Whitaker, R. and A. Captain. 2004. *Snakes of India - The Field Guide.* Draco Books, Chennai. 479 pp.

Wogan, G. 2012. *Daboia siamensis*. The IUCN Red List of Threatened Species 2012: e.T201501A2707729. http://dx.doi.org/10.2305/IUCN.UK.2012-1.RLTS. T201501A2707729. en.Downloaded on 06 December 2016.

www.reptile-database.reptarium.cz/species?genus=Daboia&species=russelii. Downloaded on 06 December 2016.

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EVALUATION OF DIFFERENT MUTANTS AGAINST INSECT AND MITE PESTS WITH NATURAL ENEMIES IN COASTAL JUTE ECOSYSTEM

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Abstract

Jute is a rapid growing agricultural fiber crop and renewable source of biomass. The study was conducted to evaluate different jute mutants against insect and mite pests with associated natural enemies. Results revealed that 8 insect and mite pests and 8 natural enemies were recorded from coastal jute ecosystem. Jute hairy caterpillar and yellow mite were found to be the most damaging pests in jute field. Significantly the lowest per cent plant infestation per 5 rows was recorded in mutant BJC-214 (14.37) followed by BJC-7370 (14.81) and the highest per cent plant infestation (30.77) was found in mutant VM-1. Significantly the lowest per cent leaf infestation was in mutant HC-3 (25.40) followed by HC-95 (31.08) while the highest per cent leaf infestation per plant was recorded in mutant BJC-83 (46.30). In case of leaf area damage, the lowest per cent was observed in mutant HC-3 (9) followed by CVL-1 (10) and the highest was in mutant CVE-3 (45) followed by mutant 0-72 (30). Among different mutants, HC-3, CVL-1 and BJC-214 were found to be less infested by jute hairy caterpillar and these mutants could be used for multilocational trial for final recommendation as the tolerant mutants.

Key words: Jute mutants, Insect pests, Jute hairy caterpillar, Natural enemies

Introduction

Bangladesh is one of the major jute producing countries where about 90% of the world's jute is produced. Jute (*Corchorus* spp.; Malvales: Malvaceae) and mesta (*Hibiscus* spp.; Malvales: Malvaceae) are natural plant fibers of commercial importance after cotton. Two species of jute *viz*., *Corchorus capsularis* L. and *C. olitorius* L. are the most important fibre crops, and these are extensively grown in Bangladesh as a cash crop. In here about 6,72,615 hectares of land were under jute cultivation and the total production was about 75,01,011 bales in the year of 2014 - 2015 (BBS 2016). Several factors are responsible for the decrease of yield of jute, of which the loss due to insect pest is the major concern. Different harmful insects, mites and beneficial insects are found to occur in jute field from seedling stage to harvest. Forty species of insects and mites are considered to be the pests of jute in Bangladesh (Kabir 1975), of which jute hairy caterpillar (*Spilarctia obliqua* Wlk.), jute semilooper (*Anomis sabulifera* Guen), stem

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weevil (*Apion corchori* Marshall), grey weevil (*Myllocerus discolor* Bohemus) and yellow mite (*Polyphagotarsonemus latus* Banks) were recorded as the major pests of jute. About 12% yield loss is caused by insect pests alone (Anon. 1987). Jute suffers a great loss in yield and quality of fibres due to the severe attack by the jute hairy caterpillar, *Spilosoma obliqua* (Walker) in the field during the jute growing season (Kabir and Khan 1969). The young caterpillars remain in clusters up to 3rd instar and feed on the lower epidermis of leaves, but from the fourth instar they spread over the field, eat up whole leaf tissues leaving only ribs, and thus adversely affect the yield of jute fibre. Besides jute, this insect was also found to attack sunflower, pulse, groundnut, radish and soybean, cotton, brinjal, cabbage, cauliflower, linseed, peas and many leguminous plants (Mallik *et al*. 1996, Kabir 1966). The jute semilooper, a cosmopolitan pest, is reported from the entire jute growing region all over the world and has estimated to damage up to 90% of the leaves of jute plant in some cases (Tripathi and Ghose 1964). Damage to jute foliage results in poor plant growth and ultimately low fibre quantity (Tripathi and Ghose 1964, Sing and Das 1979, Das and Sing 1976, Das *et al*. 1995). In general the pest of second generation is comparatively more destructive to the fibre crop (Sing and Das 1979) and in 81% cases the 7 - 9 leaves of upper part of the standing crop are damaged (Dutta 1958). In some cases the extent of damage may extend up to 91% covering 9th position of the leaf of the tiller. Pre monsoon rains followed by drought condition are congenial for the outbreak of semilooper and may lead up to 50% loss of crop as reported by Dutta (1958). Yellow mite (*Polyphagotarsonemus latus* Banks) and red mite (*Oligonychus coffeae* Nietner) are considered as the other major pests (Das and Sing 1977) in India, are destructive pests and attack both the cultivated jute species (Martinez and Mendez 1994, Roe *et al*. 1996, Karmakar 1997, Chakravarthy *et al.* 1998). The damage of yellow mite is generally known as “Telenga” or Telchita”. The infestation usually appears on the apical leaves and a reduction of 10 - 17% fibre yield may be caused (Ahmed and Jalil 1993). Different methods *viz*., cultural, mechanical, biological and chemical are used to control jute pests but none of them provides effective and sound control. Farmers apply high doses of inorganic fertilizers and different types of toxic and hazardous type of newer insecticides in high quantum without any concern to the environment (Das and Sing 1986). In addition to that continuous and heavy use of synthetic insecticides creates several problems, including pesticide resistance (Rustanmani *et al*. 1985, Duguet and Wu 1986), and health hazards (Bhaduri *et al.* 1989). Primarily, chemicals of same group and in higher concentration affect other crop field and nearby crop ecosystem and it will make unquestionably more resistant pest in future because of the applied higher concentration. Secondly, several new chemicals with novel mode of action are available in market, but it may not be suitable unless their field efficiency and baseline data for toxicity is generated (RPMN 2007). Further, use of synthetic chemical insecticides

although successfully control the pest(s), it destroy predators, parasitoids and beneficial microbes causing imbalance in the ecosystem. The jute ecosystem supports large number of natural enemies of crop pests (Rahman and Khan 2009) and their importance in integrated approach for management of pests of jute has been developed (Rahman and Khan 2010). Therefore, it is urgent need to find out eco-friendly alternative approach for the management of jute pests. Considering the above facts the present research program was under taken to evaluate some jute mutants against jute hairy caterpillar and yellow mite and to know the incidence of insect pest and mite with associated natural enemies on these mutants in coastal jute ecosystem.

Materials and Methods

The experiment was conducted under natural field conditions at agricultural farm of Patuakhali Science and Technology University (PSTU), Dumki, Patuakhali during May to September, 2012. The experimental field was high land with sandy loam texture belonging to the Ganges Tidal Floodplain (AEZ 13). Twelve advanced mutants/lines *viz*., 0-9897, 0-72, 0-795, HC-2, HC-3, HC-95, BJC-83, BJC-214, BJC-7370, CVL-1, CVE-3 and VM-1 (715) were used as study materials to evaluate against jute hairy caterpillar and yellow mite and also to know the incidence pattern of insect pest with associated natural enemies. The experiment was laid out in randomized complete block design with three replications. The size of the individual plot was 4 m × 2.5 m and spacing between plot to plot and line to line was 0.5 m and 0.3 m, respectively. Seeds of 12 advanced mutants/lines of jute were collected from Bangladesh Jute Research Institute for conducting this experiment. The seeds were sown after final land preparation. All the agronomic practices including land preparation, sowing of seeds, fertilizer application and intercultural operations were done in raising the crop by the farm labours under constant supervision. Incidence of insect pests with associated natural enemies was recorded from seedling to harvesting. Infestations of jute plants under natural field condition were recorded at 60 days after sowing (DAS). Infested and uninfested plants and leaves were collected from five randomly selected rows of each plot to determine the level of infestation. The total number was counted and percentage of infested plants was calculated. The percentage of leaf infestation per plant was calculated again from five randomly selected plants. The percentage of leaf area damaged by jute hairy caterpillar was determined by eye estimation. The percentage of infestation was calculated by the following formula.

$$\text{Percentage of plants or leaves infested} = \frac{B}{A} \times 100$$

where, A = Number of total plants or leaves,

B = Number of infested plants or leaves

Data obtained from the experiment were statistically analyzed following ANOVA by using MSTAT-C programme and means were compared by DMRT.

Results and Discussion

Incidence of insect pests and natural enemies: As jute is grown during the summer season, a number of insect pests infest throughout the crop cycle. Insect pests *viz*., jute hairy caterpillar, jute semilooper, stink bug, hooded hopper, field cricket, sulphur butterfly, leaf eating caterpillar, red pumpkin beetle and ants were found to infest different mutants of jute after 60 DAS. Among them, jute hairy caterpillar was dominant and devastating. Beside these, jute yellow mite caused damage to the leaves of jute mutants. Similarly, the jute agro-ecosystem supports large number of natural enemies. Natural enemies *viz*., lady bird beetle, ground beetle, damsel fly, dragon fly, house fly, rove beetle, wasp and spider were observed on different mutants in jute ecosystem. Among them, lady bird beetle, spider and dragon flies were the most abundant (Ttable 1). In general 40 species of insects and mites attack on jute in Bangladesh as reported by Kabir (1966). Das and Sing (1986) and Rahman and Khan (2012) had enlisted a profile of insect pests in relation to the growth stage of the jute plant damaging jute crop. Rahman and Khan (2012) recorded 70 different species of pest belong to insects, mites and nematodes feeding on jute which appeared at different growth stages of jute in two consecutive years of observations.

Out of this, jute hairy caterpillar *Spilarctia* (= *Spilosoma*) *obliqua* (Walker) is of prime importance (Kabir and Khan 1968). Apart from jute hairy caterpillar, jute semilooper (*Anomis sabulifera* Guen.), Bihar hairy caterpillar (*Spilarctia obliqua* Wlk.), indigo caterpillar (*Spodoptera exigua* Hubner), stem girdler (*Nupserha bicolor* Dutt), stem weevil (*Apion corchori* Marshall), grey weevil (*Myllocerus discolor* Bohemus), yellow mite (*Polyphagotarsonemus latus* Banks) and red mite (*Oligonychus coffeae* Nietner) were recorded on *olitorius* jute var. JRO-54 from seedling to harvest stages of jute crop in India (Das and Sing 1977). Rahman and Khan (2012) observed Grey weevil (*Myllocerus discolor*) as a voracious feeder of tender leaves of jute seedlings during 2nd week of May and remained active throughout the crop season with peak infestation of 33.56% plant damage and 36% leaf damage in the first week of June in 2004. Rahman and Khan (2010) has been developed the importance of natural enemies in integrated approach for management of pests of jute.

Table 1. Incidence of insect pests and natural enemies on different mutants of Jute at Dumki, Patuakhali during May to September, 2012.

Sl. No.	Common name	Scientific name	Family	Order
	Insect and mite pests			
1	Jute hairy caterpillar	*Spilarctia obliqua* Walk.	Arctiidae	Lepidoptera
2	Jute semilooper	*Anomis sabulifera* Guen.	Noctuidae	lepidoptera
	Jute stem weevil	*Apion corchori* Marshall	Curculionidae	Coleoptera
	Jute grey weevil	*Myllocerus discolor* Bohemus	Curculionidae	Coleoptera
3	Hemipteran bug	Unidentified	Pentatomidae	Hemiptera
	Hooded hopper	*Otinotus elongates* Kif	Cercopidae	Hemiptera
4	Field cricket	*Brachytrypes portentosus*	Gryllidae	Orthoptera
5	Sulphur butterfly	Unidentified	Pieridae	Lepidoptera
6	Red pumpkin beetle	*Aulacophora* sp.	Chrysomelidae	Coleoptera
7	Ant	*Camponotus compressus*	Formicidae	Hymenoptera
8	Yellow mite	*Polyphagotarsonemus latus* Banks	Tarsonemidae	Acarina
Natural enemies				
1	Lady bird beetle	*Micraspis discolor*	Coccinellidae	Coleoptera
	Lady bird beetle	*Coccinella septempunctata*	Coccinellidae	Coleoptera
2	Ground beetle	*Ophionea nigrofasciata*	Carabidae	Coleoptera
3	Damselfly	Unidentified	Coenagrionidae	Odonata
4	Dragonfly	Unidentified	Ashnidae	Odonata
5	Wasp	Unidentified	Vespidae	Hymenoptera
6	Spiders	*Oxyopes* spp.	Lycosidae	Araneae
7	Assasin bug	*Zelus longipes* L.	Reduvidae	Hemiptera
8	Rove beetle	*Holobus kashmiricus*	Staphylinidae	Coleoptera

Percentage of jute plant infested by hairy caterpillar: The percentage of jute plants per 5 rows infested by jute hairy caterpillar on different mutants is presented in Table 2. Significantly the highest per cent plant infestation per 5 rows (30.77) was found in mutant VM-1 followed by 0 - 9897 (30.37) which was statistically similar to 0 - 72 (30.22) and HC-95 (29.91) followed by CVL-1 (22.32). Significantly the lowest per cent plant infestation was recorded in mutant BJC-214 (14.37%) followed by BJC-7370 (14.81) and HC-3 (14.86). However, no significant difference was observed on plant infestation among mutant HC-2 (17.71%), BJC-83 (16.09%) and 0-795 (15.65%). The rank order of plant infestation per 5 rows was VM-1 > 0-9897 > 0-72 > HC-95 > CVL-1 > CVE-3 > HC-2 > BJC-83 > 0-795 > HC-3 > BJC-7370 > BJC-214.

Table 2. Percentage of jute plants infested by jute hairy caterpillar on different mutants.

Mutants	Total number of plants checked/5 rows	Number of infested plants	Number of healthy plants	% infested plants/ 5 rows
0-9897	135	41	94	30.37ab
0-72	278	84	194	30.22ab
0-795	115	18	97	15.65d
HC-2	96	17	79	17.71d
HC-3	148	22	126	14.86de
HC-95	107	32	75	29.91ab
BJC-83	230	37	193	16.09d
BJC-214	174	25	149	14.37e
BJC-7370	135	20	115	14.81de
CVL-1	112	25	87	22.32bc
CVE-3	394	82	312	20.81cd
VM-1	169	52	117	30.77a
CV (%)				17.64
CD (5%)				6.403

Values are averages of three replications.

Percentage of infested leaves per plant: Percentage of jute leaves infested by jute hairy caterpillar on different mutants is presented in Table 3. Significantly the highest per cent leaf infestation per plant was recorded on mutant BJC-83 (46.30%). The lowest per cent leaf infestation was in mutant HC-3 (25.40) followed by HC-95 (31.08) which was statistically similar to BJC-214 (34.48), 0-795 (35.19). Statistically identical results were found in CVL-1 (36.54%) and BJC-7370 (36.54%). However, no significant differences were observed among mutants VM-1, CVE-3, HC-2, 0-72 and 0-9897 (Plate 1 and 2). The rank order of per cent leaf infestation per plant was BJC-83 > 0-9897 > 0-72 > HC-2 > CVE-3 > VM-1 > BJC-7370 ≥ CVL-1< 0-795 > BJC-214 > HC-95 > HC-3.

Table 3. Percentage of jute leaves infested by jute hairy caterpillar in different mutants.

Mutants	Total number of leaves/ plant	Number of infested leaves/plant	% infested leaves/plant
0-9897	10.6	4.6	43.40ab
0-72	10.2	4.2	41.18ab
0-795	10.8	3.8	35.19ab
HC-2	13.8	5.6	40.58ab
HC-3	12.6	3.2	25.40b
HC-95	14.8	4.6	31.08ab
BJC-83	10.8	5.0	46.30a
BJC-214	11.6	4.0	34.48ab
BJC-7370	10.4	3.8	36.54ab
CVL-1	10.4	3.8	36.54ab
CVE-3	12.0	4.8	40.00ab
VM-1 (715)	8.2	3.2	39.02ab
CV (%)			21.30
CD (5%)			5.501

Values are averages of 5 observations.

Percentage of leaf area damaged by hairy caterpillar: Fig. 1 revealed that the highest per cent leaf area damaged was observed in mutant CVE-3 (45) followed by mutant 0-72 (30) which was statistically identical to BJC-7370 (30) and the lowest was in mutant HC-3 (9) followed by CVL-1 (10), HC-95 (12) and BJC-83 (15). The intermediate higher level of leaf area damage was found in mutant 0-795 (17%) followed by BJC-214 (18%), HC-2 (22%) and 0-9897 (25%) which was statistically identical to VM-1 (715) (25%). The rank order of leaf area damage was CVE-3 > BJC-7370 ≥ 0-72 > 0-9897 ≥ VM-1(715) > HC-2 > BJC-214 > 0-795 > BJC-83 > HC-95 > CVL-1 > HC-3.

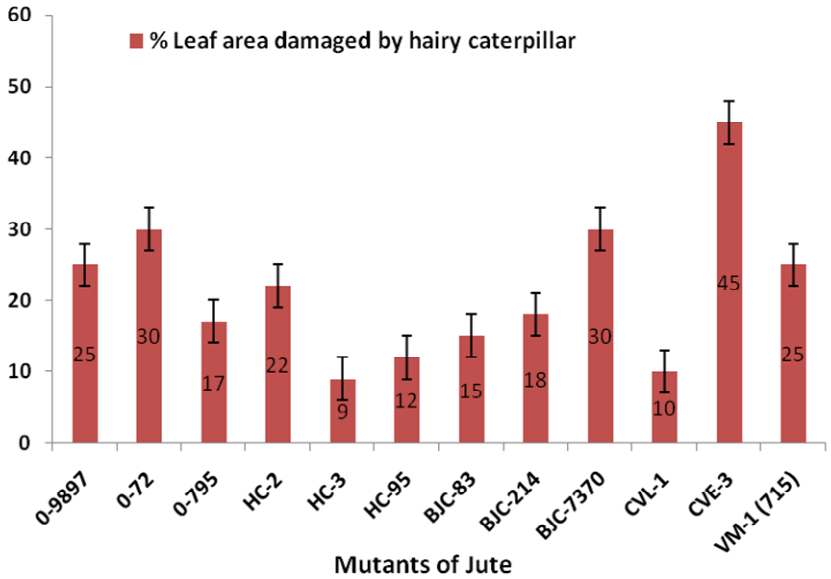

Fig. 1. Percentage of leaf area damaged by jute hairy caterpillar on jute mutants.

Fig. 2. Different immature stages of jute hairy caterpillar.

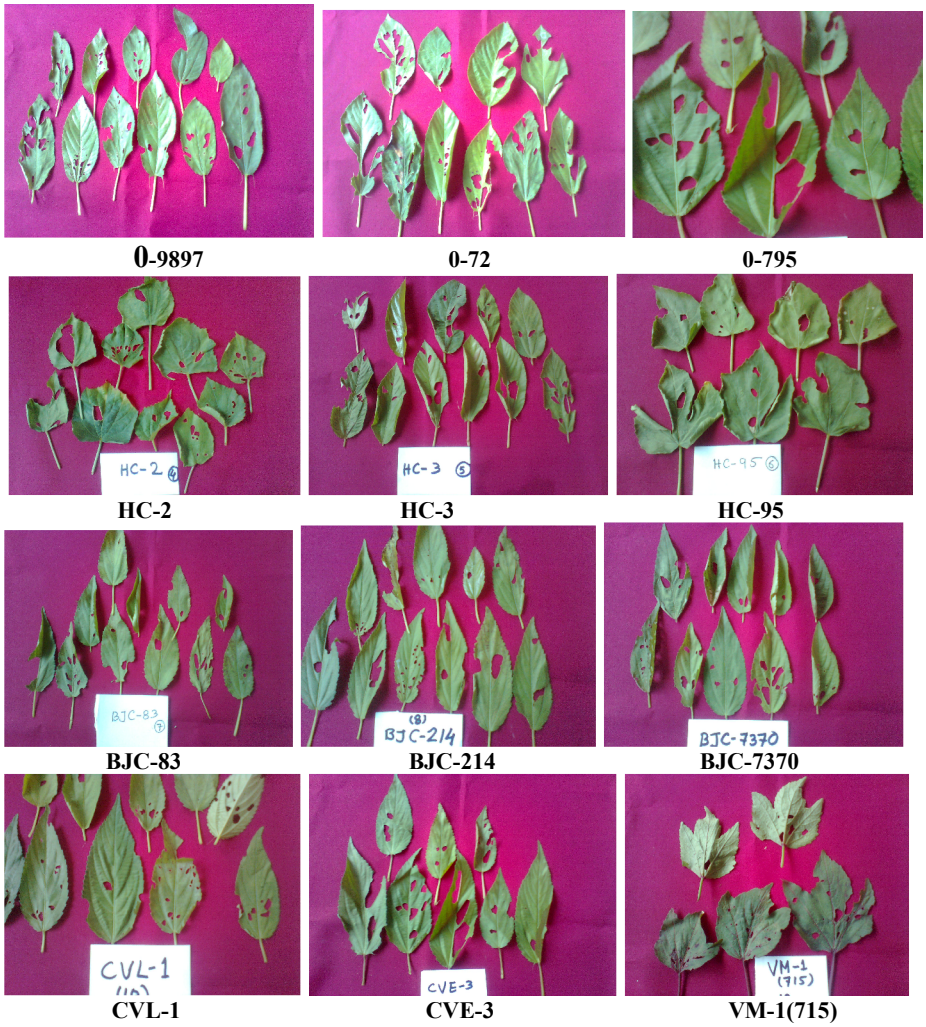

Fig. 3. Damaged leaves of different mutants caused by jute hairy caterpillar.

Damage symptoms of yellow mite (*Polyphagotarsonemus latus* Banks): The damage of yellow mite is generally known as "Telenga" or Telchita". The infestation usually appears on the apical leaves of jute plant (Fig. 4). Rahman and Khan (2012) observed that yellow mite incidence was started in the last week of May and attained its peak with 29.33% plant infestation and 35.87 mites/leaf in the last week of June, 2004 and 27.60% plant infestation with 18.66 mites/leaf in the 3rd week of June 2005.

Yellow mite, *Polyphagotarsonemus latus* is destructive for jute production (Das and Rouchaudhori 1979). They suck sap from younger leaves results in foliage discoloration; natural green colour of leaves turn into brown with change of shape due to curling (Das and Sing 1985). Loss of nutrition in young plant due to sucking, height of the plant becomes stunted and significant yield loss occurs (Nair 1986, Pradhan and Saha 1997).

Fig. 4. Damage symptoms due to yellow mite infestation in jute.

Rahman and Khan (2012) reported that *S. obliqua* infestation was noticed in the second week of June with 5.63% plant infestation and reached its peak infestation with 21.6% in the 2nd week of July and declined thereafter to cause 2.96% plant infestation in the last week of July in 2004. No hairy caterpillar larvae were found during harvest of the jute. Rahman and Khan (2010) reported from a pest complex of *olitorius* jute var. JRO-524 that incidence of *S. obliqua*, *A. sabulifera*, *M. discolor*, *A. corchori* and *P. latus* causing a minimum of 4.68, 6.10, 12.38, 5.09 and 10.47% plant infestation, respectively. Mahapatra (1996) found that yellow mite incidence started in the last week of May and continued up to July with 9.01 - 49.71% plant infestation and number of mites/leaf varied from 37.6 to 91.3. Das and Pathak (1999) reported a maximum of 77.39 yellow mites/leaf in *C. olitorius* jute and 16.00 mites/leaf in *C. capsularis* jute varieties.

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References

Ahmed, T.U. and A.F.M.A. Jalil 1993. Bangladesher Krishir Onistakari Pokamakar, Jibon Bittanta O Niyuntran (life history and control of insects harmful to Bangladesh Agriculture). 1st edition. Bangladesh Academy, Dhaka. pp. 131-201.

Anonymous. 1987. Technological advancement in jute cultivation. 1st edition. Bangladesh Jute research Institute (BJRI), Dhaka. 36 pp.

BBS, 2016. Bangladesh Bureau of Statistics, Yearbook of Agricultural Statistics-2015, 27th Series, Statistics and Information Division, Ministry of Planning, Government of the People's Republic of Bangladesh.

Bhaduri, N., D.P. Gupta and S. Ram 1989. Effect of vegetable oil on the ovipositional behavior of *Callosobruchus maculatus* (Fab.) Proc. 2nd Int. Symp. on Bruchids and legumes (ISBL-2) held at Okayama (japan), Sept 6-9, 1989, pp. 81-84.

Chakravarthy, A.K., S.V. Ravi and C. Somashekar 1998. Monitoring of insects and mites on potato (*Solanum tuberosum*). *Rev. Agril. Entomol*. **86**(12): 1503.

Das, L.K. and D.N. Roychaudhori 1979. *Physalis minima* - A new host plant of yellow mite, *Polyphagotar sonenus latus* (Banks). *Sci. & Cult*. **43**:169-170.

Das, L.K. and S. Pathak, 1999. Resistance behaviour of some jute varieties against their pests. *Environ. Ecol*. **17**(2): 456-457.

Das, L. K. and B. Sing, 1976. The effect of *Bacillus thuringiensis* Berliner on the gut of the jute semilooper, *Anomis sabulifera* Guen. *Sci. & Cult.* **42**: 567-569.

Das, L.K. and B. Sing, 1977. Economic control measures against the major pests of jute, *PANS,* **23:** 159–161.

Das, L.K. and B. Sing, 1985. Number of sprays suitable against yellow mite, *P. latus* (Bank) of jute, *Sci. & Cult*. **51**:376-377.

Das, L. K. and B. Sing, 1986. Effective control measures against the pest complex of capsularia jute Corchorus capsularis L. *Jute Development J.* 25-27.

Das, L. K., B. Sing and S. K. Pradhan 1995. Efficiency of different synthetic pyrethroids insecticides against pest complex of jute. *Sci. & Cult.* **61**: 203-204.

Duguet, J.S. and G.X. WU 1986. Assessment of activity of deltamethrin against *Callosobruchus chinensis* L. and *Callosobruchus maculatus* Fab. (Bruchidae). *Int. Pest Control*. **28**(2), 36-41.

Dutta, N. 1958. *Anomis sabulifera* Guen., Apion corchori Marsh-Insecticides and control. *Jute Bulletin*. 121-128.

Kabir, A.K.M.F. 1966. Phase variation in the jute hairy caterpillar, *Diacrisia obliqua* Walk. (Lepidoptera: Arctiidae). *Sindney Univ. Sci. J*. **11**: 1-3.

Kabir, A.K.M.F. and S.A. Khan 1968. Bioassay of some insecticides for the control of jute hairy caterpillar; *Diacrisia obliqua* Walker., *Indian J. Agric.* **6**(1-2): 131-138.

Kabir, A.K.M.F. and S.A. Khan 1969. Biology and life history of jute hairy caterpillar, *Diacrisia obliqua* Walker, in East Pakistan. *Pakistan J. Zool*. **1**(1): 45-48.

Kabir, A.K.M.F. 1975. Jute pest of Bangladesh. Bangladesh Jute research Institute. Dacca. 15. pp. 28-36.

Karmakar, K. 1997. Size, shape and behavior of *Polyphagotarsonemus latus* Banks (Acarina: Tarsonemidae). *Rev. Agril. Entomol*. **85**(12): 1494.

Mallik, M. U., M.S., Islam, S.A. Khan and M.A.I. Bhuiyan 1996. Studies on over wintering sites, laboratory rearing, mating behavior and population build up of *Spilosoma obliqua* Walker. Working materials, IAEA D4-RC-561.

Martinez, G. and G. Mendez, 1994. The white mite, *Polyphagotarsonemus latus* Banks (Acarina: Tarsonemidae) in tobacco cultivation in the province of villa Clara, *Rev. Agril. Entomol.* **84**(8): 939.

Mohapatra, L. N. 1996. Response of jute (Corchorus capsularis L.) germplasm against yellow mite, *Polyphagotarsonemus latus* Banks (Acarina: Tarsonemidae) in coastal region of Orissa. *Rev. Agril. Entomol*. **84**(11): 1307.

Nair, M.R.G.K. 1986. Insects & mites of crop in India. ICMR. New Delhi. 122 -126.

Pradhan, S.K. and M.N. Saha, 1997. Effect of yellow mite*, P. Latus* (Bank) infestation on the major nutrient contents of tossa jute (*Corchorus olitorius* L.*)* verities, *J. Entomol. Res*. **21**: 123-127.

Rahman, S. and M.R. Khan 2009. Natural enemies of insect and mite pests of jute ecosystem. *Ann. Plant Prot. Sci*. **17**(2): 466-467.

Rahman, S. and M.R. Khan 2010. Integrated management approach for control of the pest complex of Olitorius jute *corchorus olitorius*. *J. Plant Proct. Sci*. **50**(3): 340-346.

Rahman, S. and M.R. Khan 2012. Incidence of pests in jute (*Corchorus olitorius* L.) ecosystem and pest - weather relationships in West Bengal, *India. Archives of Phytopathology and Plant Protection.* **45**(5):591-607.

Roe, C.M., J.H. Yung, and D.K. Soon 1996. Host plant and damage of broad mite, *Polyphagotarsonemus latus* Banks on Horticultural crops in korea, *Rev. Agril. Entomol*. **85**(3): 333.

RPMN. 2007. Need for resistance risk assessment in major pest of jute to insecticides, Resistance Management Review, Resistance Pest Management Newsletter. **17**(1): 1-4.

Rustanmani, M.A., S.M.S.H. Naqvi and G.H. Abro 1985. Relative resistance/susceptibility of different pulses against pulse beetle, *Callosobruchus chinensis* L. *Pak. J. Zool*. **17**(1): 99-100.

Sing, B. and L. K. Das 1979. Semilooper, *Anomis sabulifera* Guen. escalating on jute pods. *Sci. & Cult*. 45: 121-123.

Tripathi, R. L. and S. K. Ghose 1964. Studies on prophylactic and curative measures against jute semilooper, *Anomis sabulifera* Guen. (Lepidoptera: Noctuidae). *Jute Bulletine*. 75-77.

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LAND SUITABILITY ASSESSMENT FOR MAIZE (*RABI*) CULTIVATION IN COX'S BAZAAR SADAR UPAZILA, COX'S BAZAAR, BANGLADESH

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Abstract

Based on the various agro-edaphic and agro-climatic characteristics, the suitability of maize cultivation during winter season has been determined in Cox's Bazaar Sadar Upazila. For this purpose, under the existing climate conditions, considered agro-edaphic factors of various geomorphic units are soil permeability, effective soil depth, available soil moisture, soil reaction (pH), soil salinity, slope etc. Long-term climate attributes of the study area were used to determine the overall climate suitability classes, and the combined land suitability classes for maize (*rabi*) cultivation have been determined through the adjustment of the agro-edaphic and agro-climatic suitability criteria. Thus, recognized combined land suitability classes for maize (*rabi*) cultivation in the present study area are 'highly suitable', 'suitable', and 'moderately suitable'. A total of 896 hectares land has been found as 'highly suitable' for maize cultivation in Cox's Bazaar Sadar Upazila while approximately 4403 and 11,000 hectares have been identified as 'suitable' and 'moderately suitable', respectively.

Key words: Land suitability, Agro-edaphic factors, Agro-climatic criteria, Maize, Cox's Bazaar

Introduction

Being one of the oldest and most important crops in the world maize (*Zea mays* L.) is the high yielding grain crop having multiple uses. It is widely cultivated throughout the world, and a greater amount of maize is produced each year than any other grain. Worldwide production of maize was 817 million tonnes in 2009 which is more than rice (678 million tonnes) or wheat (682 million tonnes), and in the year 2012 maize was cultivated in more than 159 million hectares of land worldwide, with a yield of over 5 t/ha (Mannaf 2012). The United States produce 40% of the world's maize harvest while other top producing countries are China, Brazil, Mexico, Indonesia, India, France, Argentina, South Africa and Ukraine (Unnayan Onneshan 2011).

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The expansion of maize cultivation was not successful in Bangladesh during 1960s due to the thrust of the government to promote a rice-based green revolution technology, though its production and yield have experienced an explosive growth in recent years (Rahman and Rahman 2014). For example, the total cropped area of maize has increased from only 2654 ha in 1972 to 197,082 ha in 2012; production from 2249 tonnes to 1,298,000 tonnes; and yield from 0.85 t/ha to 6.59 t/ha during the same period (Rahman and Rahman 2014, BBS 2012). At present, maize ranks 1st among the cereals in terms of yield rate (6.59 t/ha) as compared to Boro rice (3.90 t/ha) and wheat (2.78 t/ha) in Bangladesh (BBS 2012). This is because the Bangladesh Agricultural Research Institute (BARI) has developed seven open pollinated and 11 hybrid varieties of maize (Begum and Khatun 2006, BARI 2008) whose yield potentials are 5.5 - 7.0 t/ha and 7.4 - 12.0 t/ha, respectively, and are well above the world average of 3.19 t/ha (FAO 2011). Maize possesses a wide genetic variability, enabling it to grow successfully in any environment also in Bangladesh, it is grown both in winter and summer seasons, although the former is the dominant one (Rahman and Rahman 2014). This is because the present study attempts to determine the land suitability of maize cultivation during the winter or *rabi* season growing period in the Cox's Bazaar Sadar Upazila of Bangladesh.

Cox's Bazaar Sadar Upazila, is located within Cox's Bazaar district of the south-eastern region of Bangladesh. Occupying an area of 228.23 sq. km. Cox's Bazaar Sadar Upazila is located between 21°24' and 21º36' north latitudes, and 91°59' and 92º08' east longitudes (BBS 2012). It is bounded on the north by Chakaria Upazila, on the east by Ramu Upazila, on the south by Ramu Upazila and the Bay of Bengal, and on the west by Moheshkhali Upazila and the Bay of Bengal (SRDI 1996) (Fig. 1). Cox's Bazar Sadar Upazila is rich in natural resources, particularly is abundant with fish. Having a very large, elongated, straight and unbroken sandy beach with hills as the background, Cox's Bazaar attracts a large number of tourists all the year round. At present huge number of residential hotels, motels and cottages have been built to accommodate these tourists and the town is growing very fast. The total enumerated population in Cox's Bazaar Sadar Upazila was 4,59,082 in 2011 while it was counted 3,48,075 during the census conducted in 2001 (BBS 2012).

The overall aim of the present study is to assess the geo-environmental characteristics of the Cox's Bazaar coastal belt of Bangladesh with a view of determining the land suitability in Cox's Bazaar Sadar Upazila for maize (*rabi*) cultivation.

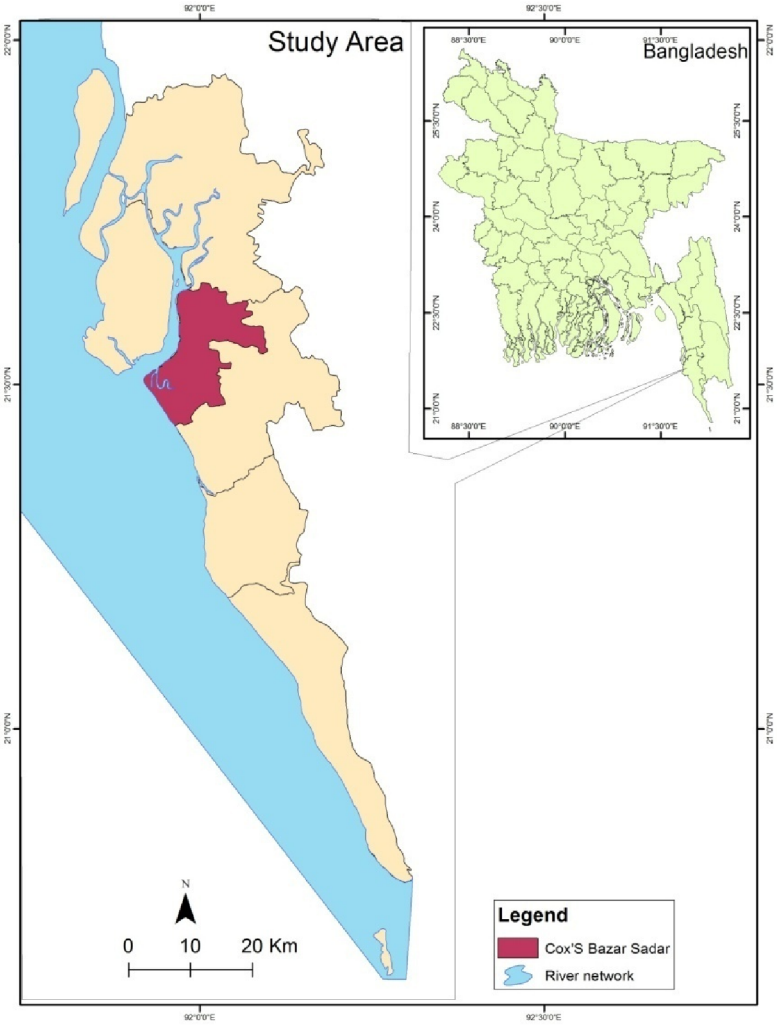

Fig. 1. Location of the study area (Source: Hoque 2017).

The specific objectives of the research for achieving the aim are: To determine the geomorphic unit wise agro-edaphic (e.g., soil permeability, available soil moisture, soil reaction , soil salinity etc.) and agro-climatic (e.g., duration of crop production seasons, standard deviations of their start dates, number of dry days, number of extreme hot and cool days, potential evapotranspiration etc.) criteria of the study area; and to assess the

land suitability of maize (*rabi*) cultivation, based on the determined agro-edaphic and agro-climatic criteria of different geomorphic units within the study area.

Materials and Methods

Identification of major geomorphic units in Cox's Bazaar Sadar upazila: Various geomorphic units of land in the Cox's Bazaar Sadar Upazila have been considered following the geomorphic classification of the Upazila made by (Hoque 2017) during the recent years. In that study, various geomorphic or landform units were initially been identified from 3D views of aerial photographs which have later been verified by the study of respective satellite imageries (e.g., Landsat TM and ETM+), topographic sheets and coastal area maps of Bangladesh. Ultimately, identified landform units were confirmed and finalized by a couple of detailed field surveys during the period from October, 2014 to April, 2015. Following the method, a total of 11 geomorphic units had been recognized (Hoque 2017) (Fig. 2) within the study area, out of which 8 units have been taken into consideration for detailed investigation under the present study. Finally, in-depth geo-environmental characteristics (e.g., agro-edaphic and agro-climatic criteria) of various geomorphic units have been determined through a number of detailed field surveys during the period between September, 2015 and May, 2016 for assessing the production suitability of maize (*rabi*), within the study area.

Determining land suitability : Generally crop production capacity of an area significantly depends on agro-edaphic and agro-climatic characteristics of the particular land unit, and therefore those characteristics of considered geomorphic units (Fig. 2) of Cox's Bazaar Sadar Upazila have been used in the present study for maize (*rabi*) cultivation suitability assessment. The process of assessing crop suitability is to some extent, similar to Hoque (2017) and consistent with the method followed by Bangladesh Agricultural Research Council (BARC 2013). The detailed procedure of determining agro-edaphic and agro-climatic characteristics of various geomorphic units of the study area along with the way of using them to determine agro-edaphic, agro-climatic, and combined maize (*rabi*) production suitability has been explained.

Table 1. Land factors with their codes, descriptions, and ratings for major crops in Bangladesh.

Factors	Codes	Land factor descriptions	Ratings
Soil permeability	p1	Slow (< 12 cm d^{-1})	1
	p2	Moderate (12-305 cm d^{-1})	2
	p3	Rapid (> 305 cm d^{-1})	3
Effective soil depth	d1	< 0.25 m	1
	d2	0.25 - 0.60 m	2
	d3	0.60 - 0.90 m	3
	d4	0.90 - 1.22 m	4
	d5	> 1.22 m	5
	d6	Very firm/hard plow pan	6
Available soil moisture	m1	< 100 mm	1
	m2	100-200 mm	2
	m3	200-300 mm	3
	m4	300-400 mm	4
	m5	> 400 mm	5
Nutrient satus	n1	Low	1
	n2	High	2
Soil reaction (pH)	a1	< 4.5	1
	a2	4.5-5.5	2
	a3	5.5-7.3	3
	a4	7.3-8.4	4
	a5	> 8.4	5
Soil salinity	s1	<2 dS m^{-1} or < 2 m Mohs cm^{-1}	1
	s2	2-4 dS m^{-1} or 2-4 m Mohs cm^{-1}	2
	s3	4-8 dS m^{-1} or 4-8 m Mohs cm^{-1}	3
	s4	8-15 dS m^{-1} or 8-15 m Mohs cm^{-1}	4
	s5	> 15 dS m^{-1} or > 15 m Mohs cm^{-1}	5
Soil consistency	t1	Not more than slightly firm, slightly sticky, slightly plastic, hard	1
	t2	Firm, very firm, sticky, plastic, hard, very hard	2
	t3	Extremely firm, very sticky, very plastic, extremely hard	3
	t4	Organic material to at least 25 cm below the surface	4
Drainage	w1	Well-drained	1
	w2	Moderately well-drained	2
	w3	Imperfectly drained	3
	w4	Poorly drained, surface drains < 15 Nov	4
	w5	Poorly drained, surface drains > 15 Nov	5
	w6	Very poorly drained	6
Depth of inundation	i1	No inundation	1
	i2	< 30 cm	2
	i3	30-90 cm	3
	i4	90-180 cm	4
	i5	180-300 cm	5
	i6	> 300 cm	6
Flood hazards	f1	None	1
	f2	Once in 10 years	2
	f3	Twice in 10 years	3
	f4	3-4 times in 10 years	4
	f5	5 times or more in 10 years	5
Slope	e1	< 3 per cent	1
	e2	3-8 per cent	2
	e3	8-16 per cent	3
	e4	16-30 per cent	4
	e5	30-45 per cent	5
	e6	> 45 per cent	6

Source: Modified after BARC 2012, on the basis of the field survey and expert judgments- 2016.

Agro-edaphic suitability: Involving the desired land and soil distinctiveness with major crops productions in Bangladesh, 11 agro-edaphic factors have been selected (Table 1) in this method. Based on the verification of individual crop productivity demand, the respective level of land and soil quality have been assessed using a 5 degree (0-4) limitations scale (Table 2) for different ranges of agro-edaphic factors. For this purpose, regarding respective crops production, the degrees of limitation with respect to crop requirements of individual land factors were assessed. Accordingly, within different geomorphic units (Fig. 2) of the study area the degrees of limitation of maize (*rabi*) cultivation for assorted land factors were imposed (Table 3) mainly based on the expert judgments from the National Agricultural Research System (NARS) scientists and other experts who have a wide knowledge base and field experience on crops cultivation. A wide range of literature published by BARC, BRRI, SRDI, UNDP, FAO etc. was also consulted for this purpose. After that, the degree of limitations assigned to land factors under each land face or geomorphic unit was counted. Afterwards, an overall suitability rating for each land face was derived based on the combined limitation ratings using the set of rules on the basis of Zijsvelt's soil-crop suitability model, revised by Brammer in 1985 and further modified by Hussain *et al*. in 2005 (quoted in BARC 2012). Ultimately, relationships between suitability ratings and number and degrees of limitations were determined to identify ranges of agro-edaphic suitability classes (e.g., S1- very suitable, S2- suitable, S3- moderately suitable, S4- less suitable and NS- not suitable) which were finally used to determine the combined land suitability classes (Table 8) for maize (*rabi*) cultivations in the study area.

Table 2. Five-degree limitations scale for different ranges of agro-edaphic factors to assess the suitability of various land units for major crops in Bangladesh.

Numbers	Degree of limitations
0	No limitation; the most favorable condition for cultivation
1	Slight limitation
2	Moderate limitation
3	Severe limitation
4	Very severe limitation; soil is unsuitable for the particular crop under consideration at the specified level of management

Source: BARC 2013; Field Survey and Expert Judgements- 2016.

Table 3. Degrees of limitations imposed on different land factors for maize (*rabi*) cultivation.

Code	Degree of limitations	Code	Degree of limitations	Code	Degree of limitations
p1	2	a3	0	i1	0
p2	0	a4	1	i2	0
p3	2	a5	2	i3	1
d1	3	s1	0	i4	3
d2	2	s2	2	i5	4
d3	0	s3	4	i6	4
d4	0	s4	4	f1	0
d5	0	s5	4	f2	0
d6	2	t1	0	f3	1
m1	2	t2	1	f4	2
m2	1	t3	3	f5	3
m3	0	t4	4	e1	0
m4	1	w1	0	e2	1
m5	3	w2	0	e3	3
n1	2	w3	0	e4	4
n2	0	w4	0	e5	4
a1	2	w5	3	e6	4
a2	1	w6	4		

Source: Based on BARC 2013; and Field Survey and Expert Judgements- 2016.

Agro-climatic suitability: A tropical monsoon climate with hot, wet summers and cool, dry winters prevails in Bangladesh, and only those crops that can be grown under these climatic conditions warrant the emphasis of being evaluated for our food security. For agro-climatic zoning, the area wise duration of crop production seasons, standard deviations of their start dates, number of dry days, excessive rainfalls, number of extreme hot and cool days, and potential evapotranspiration (PET) are generally considered in Bangladesh. Accordingly, considering respective climate constraints in a region, the following four precipitations and temperature related determinants are identified in different areas of the country with the view to ensure better planning strategy for various crops production (SRDI 1996):

(a) Duration of pre-*kharif* transition period, or time frame of uncertain and discontinuous rainfall.
(b) Average duration of rain-fed *kharif* and *rabi* crops production periods.
(c) Average number of days with minimum temperature < 15°C which is very much important for major *rabi* crops in particular.
(d) An average number of days with maximum temperature > 40°C, when the potential evapotranspiration (PET) rate reaches the detrimental level.

Finally, based on the critical analysis of the information related to precipitation, temperature, evapotranspiration, and exhaustion of soil moisture two main crops

production periods (*kharif* and *rabi*) are identified in Bangladesh which is highly adorned by three major climate seasons, *viz*. pre-monsoon, monsoon, and winter. Thus, three major crops growing periods (*viz*., pre-*kharif* transition period, kharif growing period, and rabi growing period) and two major thermal zones (*viz*., *rabi* or cool temperature zones, and extreme summer temperature zones) are recognized (BARC 2012) which play a significant role to determine crops agro-climatic suitability of a region.

Climate suitability determination of the study area: From the agro-climatic point of view, maize can be grown with a minimum temperature of 10ºC and a maximum 30ºC, though the most favorable temperatures for the pollination and quicker growth of maize range from 20 - 30ºC (Dewan *et al*. 1998). The average minimum and maximum temperatures of 12 and 29ºC, respectively, are ideal for successful maize production and it has the capacity to flourish under a wide range of moisture conditions (500 mm - 5000 mm of annual rainfall) (Dewan *et al*. 1998). However, 1000 - 1500 mm per year, and 300 - 600 mm rainfalls during the *rabi* growing period (October - November to February - March) are optimum for the maize (irrigated) cultivation in Bangladesh (BARC 2012).

Based on the verification of maize (*rabi*) productivity demand, the degrees of limitation with respect to requirements of individual climate conditions (e.g., temperature, rainfall) were assessed in different parts of the present study area. Alike agro-edaphic suitability determination, the degrees of limitation of maize (*rabi*) cultivation for respective climate attributes were also selected by the help of expert judgments from the National Agricultural Research System (NARS) scientists and other stakeholders who have a wide knowledge base and field experience on crops cultivation. A wide range of literature published by various organizations (e.g., BARC, BRRI, SRDI, UNDP, FAO etc.) was also consulted for this purpose. Finally, relationships were established among the ranges of prevailing climate attributes (e.g., temperature and rainfall) and respective maize (*rabi*) production suitability classes (Tables 4 and 5) with respect to the long-term average temperatures and rainfall data (Tables 6 and 7) of the study area. Thus, the overall climate suitability rating (*viz*. very suitable, suitable, moderately suitable, less suitable and not suitable) of various geomorphic units were determined which were later used for assessing the combined maize (*rabi*) production suitability classes (i.e., HS, S, MS, SS and NS) (Table 8) of the respective geomorphic units within the study area.

Table 4. Temperature categories (monthly), ranges and corresponding suitability classes of maize (*rabi*) production in Bangladesh.

Temperature types	Ranges	Corresponding suitability	Determined suitability class for the study area
Average	20 to <30	Very suitable	✓
Temperature (ºC)	16 to <20; or 30 to <34	Suitable	
	14 to <16; or 34 to <38	Moderately suitable	
	12 to <14; or 38 to <42	Less suitable	
	<12; or 42 and above	Not suitable	
Average minimum	11 to < 13	Very suitable	
Temperature (ºC)	9 to < 11; or 13 to < 16	Suitable	
	7 to < 9; or 16 to < 19	Moderately suitable	✓
	5 to < 7; or 19 to < 22	Less suitable	
	< 5; or 22 and above	Not suitable	
Average maximum	27 to < 31	Very suitable	✓
Temperature (ºC)	23 to < 27; or 31 to < 35	Suitable	
	19 to < 23; or 35 to < 39	Moderately suitable	
	15 to < 19; or 39 to < 43	Less suitable	
	< 15; or 43 and above	Not suitable	
Overall	-	Very suitable	✓

Source: Prepared on the basis of the expert judgments and literature review in 2016.

Table 5. Ranges of precipitation and corresponding suitability classes of maize (*rabi*) production in Bangladesh during *rabi* growing period.

Period of precipitation	Ranges (mm)	Corresponding suitability	Determined suitability class for the study area
Rabi growing	300 - 600	Very suitable	✓
Period (Oct. - Mar.)	250 to < 300; or 601 to 800	Suitable	
	200 to < 250; or 801 to 1000	Moderately suitable	
	150 to < 200; or 1001 to 1200	Less suitable	
	< 150; or > 1200	Not suitable	

Source: Prepared on the basis of the expert judgments and literature review in 2016.

Table 6. Averages of 30 years temperature data during *rabi* growing period (October - March) in Cox's Bazaar Sadar Upazila.

Temperatures	Name of the months covering *rabi* growing period						Average
	October	November	December	January	February	March	
Average (°C)	27.4	24.9	21.5	20.5	22.3	25.3	23.65
Average Minimum (°C)	24.0	20.5	16.2	14.6	16.4	20.2	18.65
Average Maximum (°C)	30.9	29.3	26.9	26.4	28.2	30.5	28.70

Source: https://en.climate-data.org/location/56253/Accessed on 01.07.2017

Table 7. Monthly averages of 30 years rainfall data during *rabi* growing period (October - March) in Cox's Bazaar Sadar Upazila.

October	November	December	January	February	March	Total
249 mm	73 mm	20 mm	7 mm	11 mm	22 mm	382 mm

Source: https://en.climate-data.org/location/56253/ Accessed on 01.07.2017

Combined suitability determination: At the last stage of the assessment process, in order to get the combined or overall land suitability classes of different geomorphic units for maize (*rabi*) cultivation, the agro-edaphic and agro-climatic suitability criteria were adjusted on the basis of the rules presented in Table 8. Finally, the overall or combined land suitability in Cox's Bazaar Sadar Upazila was determined and displayed in the map (Fig. 2) which show the potential areas under different land suitability classes, i.e. highly suitable, suitable, moderately suitable etc. for maize (*rabi*) cultivation.

Table 8. Relationship between agro-edaphic, agro-climatic and combined land suitability ratings.

Agro-climatic suitability rating	Agro-edaphic suitability rating	Combined land suitability rating
VS (Very suitable)	S1 (Very suitable)	HS (Highly suitable)
	S2 (Suitable)	S (Suitable)
	S3 (Moderately suitable)	MS (Moderately suitable)
	S4 (Less suitable)	SS (Slightly suitable)
	NS (Not suitable)	NS (Not suitable)
S (Suitable)	S1 (Very suitable)	S (Suitable)
	S2 (Suitable)	MS (Moderately suitable)
	S3 (Moderately suitable)	SS (Slightly suitable)
	S4 (Less suitable)	SS (Slightly suitable)
	NS (Not suitable)	NS (Not suitable)
MS (Moderately suitable)	S1 (Very suitable)	MS (Moderately suitable)
	S2 (Suitable)	SS (Slightly suitable)
	S3 (Moderately suitable)	SS (Slightly suitable)
	S4 (Less suitable)	NS (Not suitable)
	NS (Not suitable)	NS (Not suitable)
LS (Less suitable)	S1 (Very suitable)	SS (Slightly suitable)
	S2 (Suitable)	SS (Slightly suitable)
	S3 (Moderately suitable)	NS (Not suitable)
	S4 (Less suitable)	NS (Not suitable)
	NS (Not suitable)	NS (Not suitable)
NS (Not suitable)	S1 (Very suitable)	NS (Not suitable)
	S2 (Suitable)	NS (Not suitable)
	S3 (Moderately suitable)	NS (Not suitable)
	S4 (Less suitable)	NS (Not suitable)
	NS (Not suitable)	NS (Not suitable)

Source: Prepared on the basis of BARC 2012; expert judgments of NARS scientists; collated field experiences in 2016.

Results and Discussion

Various geomorphic units of land within the Cox's Bazaar Sadar Upazila have been adopted following the geomorphic classification of the area by Hoque (Hoque 2017). In that classification, a total of 11 geomorphic units (Fig. 2) were recognized out of which 8 units (e.g., medium high hilly areas, low hills and valley areas, piedmont plain with highland, foothill plain with medium highland, foothill floodplain with medium lowland, tidal floodplain with high and medium highland, tidal floodplain with medium highland, and tidal floodplain with medium high and medium lowland) have been taken into consideration for land suitability analysis under the present study. Considering agro-climatic (e.g., rainfall based crops growing periods, and thermal zones) and agro-edaphic characteristics (e.g., soil permeability, effective soil depth, soil moisture, nutrient status, soil pH, soil salinity etc.) of various landforms the unit wise land suitability of maize

(*rabi*) cultivation in the study area have been assessed which are discussed below in details.

Major geomorphic units of Cox's Bazaar Sadar Upazila: Among the identified major geomorphic units Medium High Hilly Area includes around 1,500 hectares areas maximum (900 ha) which are distributed over the eastern part of Eidgaon Union at seven locations. Rest of the areas are located in the southern most part of the Upazila under Jhilonga Union (525 ha) while a tiny piece of land is located in the Pukkhali Union at the north (Fig. 2). Low hills and valley area covers a total of 4,600 hectares land that enfolds approximately 23% of the Cox's Bazar Sadar Upazila. These lands are scattered over 6 major and a few minor segments of lands in Eidgaon, Patali Machuakhali, Jhilongja, Khuruskhul and Varuakhali Unions, and Cox's Bazaar Pourashava. Piedmont Plain with Highland includes a total of approximately 1900 hectares land covering about 10% area of the Cox's Bazaar Sadar Upazila and distributed over 10 isolated

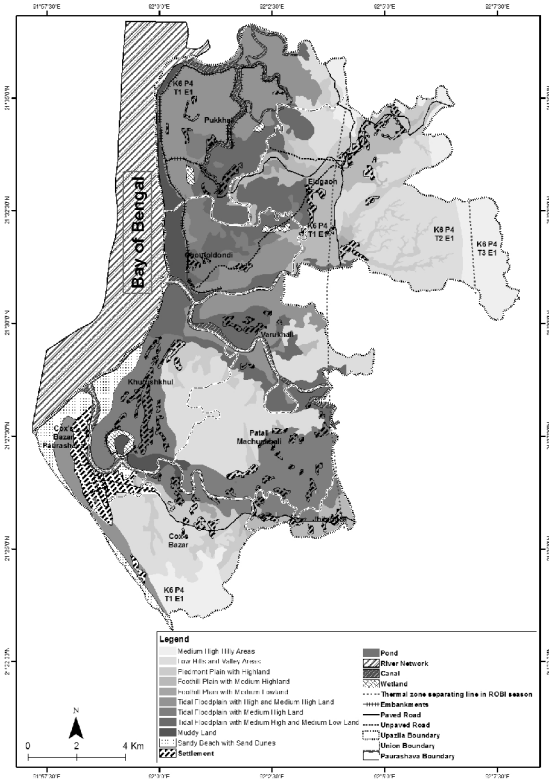

Fig. 2. Map showing various geomorphic units in Cox's Bazaar Sadar Upazila of Cox's Bazaar district (Source: Hoque 2017).

pieces of lands within Eidgaon, Jhilongja, Patali Machuakhali, Khuruskhul, Varuakhali, and Pukkhali Unions. Almost whole of this geomorphic unit includes agricultural lands containing 74% highland, 23% medium highland and a small amount of lowland. Foothill plain with medium highland covers 1180 hectares land which is only 6% of the total study area and distributed over 6 unions, namely Eidgaon, Jhilongja, Pukkhali, Chaufaldandi and Patali Machuakhali. Maximum of these lands are cultivable medium high land, while the rests are high land with settlements. Foothill plain with medium lowland occupiesonly 45 hectares area maximum of which are located in Jhilongja and Eidgaon Unions. On the other hand, Tidal floodplain with high and medium highland covers approximately 2800 hectares land which is nearly 14% of the whole study area. This geomorphic unit is separated into 7 segments and distributed over 8 unions of Cox's Bazar Sadar Upazila. More than half (1,545 ha) of these lands are located in the Pukkhali Union while the rests are located in Varuakhali, Choufoldondi, Jhilongja, Patali Machuakhali, Eidgaon, and Khuruskhul Unions (Fig. 2). Tidal floodplain with medium highland contains approximately 2,500 hectares of lands which are divided into 10 pieces and located in Eidgaon, Choufoldondi, Pukkhali, Varuakhali, Patali Machuakhali and Khurushkhul Unions. The whole area under this geomorphic unit contains medium highlands almost all of which are quite cultivable. Furthermore, Tidal floodplain with medium high and medium lowland occupies approximately 2180 hectares of lands which cover roughly 11% of the present study area. These lands are divided into 6 segments and located mainly in Patali Machuakhali, Khurushkhul, Jhilongja and Choufaldondi Unions (Fig. 2). Entire lands under this category are cultivable except a little area in Cox's Bazaar Pourashava and nearly 50 hectares of settlement areas located in the Choufaldondi Union.

Land suitability of maize (rabi) cultivation in Cox's Bazaar Sadar upazila: From the agro-edaphic point of view, maize can be grown all over the country under a wide range of soil conditions. It grows best on a fine sandy-loam to a heavy clay-loam soil, and from a moderately acidic (pH 5.0) to a moderately alkaline (pH 8.5) soil. Alike the present study area large areas of Bangladesh have mainly loamy soils with a pH range from 5.5 to 7.0, which is ideal for successful growth and development of maize (Hoque 2017). Moreover, maize has the capacity to thrive under a wide range of moisture conditions (500 - 5000 mm rainfall/year) which produces a good yield in favorable conditions and gives a reasonably good yield under moisture stress conditions. In fact, being a C4 cereal crop, maize is more efficient in converting solar energy to dry-matter than most other cereals and is also very efficient in using water (Dewan *et al.* 1998). However, based on the various agro-edaphic and agro-climatic characteristics, the suitability of maize cultivation during winter or *rabi* growing period has been determined in Cox's Bazaar Sadar Upazila area under the present study.

Based on the prevailing agro-climatic criteria and surveyed agro-edaphic factors of individual geomorphic units of the study area, land suitability classes for maize (*rabi*)

cultivation in Cox's Bazaar Sadar Upazila have been identified. Following the specific rules and adjustment processes (Table 8) to combine the agro-edaphic and agro-climatic suitability classes, the combined or overall land suitability classes of areas under the various geomorphic units of the study area were determined. Accordingly, recognized combined land suitability classes for maize (*rabi*) cultivation in the present study area are 'highly suitable', 'suitable' and 'moderately suitable', and calculated ranges of overall land suitability ratings for these classes are 1.00 - 1.25, 1.26 - 1.50 and 1.51 - 1.75, respectively. The study reveals that areas under the geomorphic unit of Foothill plain with medium highland are 'highly suitable' for maize (*rabi*) cultivation in Cox's Bazaar Sadar Upazila. A total of 896 hectares land has been found under this land suitability class, covering 4.6% of the study area, which is mainly distributed over Eidgaon (526 ha) and Jhilongja (286 ha) Unions (Fig. 3). The rests of the lands are located in Patali Machuakhali (30 ha), Pukkhali (30 ha) and Choufoldondi (23 ha) Unions, along with a little bit (01 ha) in Cox's Bazaar Pourashava. Approximately 34% lands (310 ha) under this suitability class are relatively high while the remaining 66% areas are medium highland. Beyond these, roughly 286 hectares lands under the geomorphic unit of Foothill plain with medium highland are not cultivable which are occupied by settlements and located mainly in the Eidgaon Union (Figs 2, 3). Identified soil classes within 'highly suitable' land suitability class for maize (*rabi*) cultivation in Cox's Bazaar SadarUpazila are Pahartali, Mirsharai, Ukhia, Muhuri and Bijipur, and maximum of these lands fall under Pahartali (556 ha), Mirsharai (233 ha) and Ukhia (62 ha) soil groups.

On the other hand, areas within the geomorphic units of Tidal flood plain with medium highland (2456 ha), Piedmont plain with highland (1887 ha) and Foothill plain with medium lowland (60 ha) of the study area (Fig. 2) have been identified as 'suitable' for the maize (*rabi*) cultivation. Covering more than 22% areas of Cox's Bazaar Sadar Upazila these lands are located in Eidgaon (1572 ha), Varuakhali (554 ha), Choufoldondi (548 ha), Pukkhali (530 ha), Patali Machuakhali (418 ha), Jhilongja (410 ha) and Khuruskul (369 ha).

Maximum of the lands (3321 ha) in this suitability class is medium-high, while 1022 and 60 hectares of lands are high and medium lowland, respectively. Nine distinct soil classes are identified within the areas under this maize (*rabi*) cultivation suitability class among which maximum of the lands fall under Pahartali (1491), Kutubdia (1105), Chakoria (860), Mirsharai (326) and Harbang (245) soil groups. The rests (376 ha) of the lands fall under the soil groups of Badarkhali, Chiringa, Bijipur, and Muhuri.

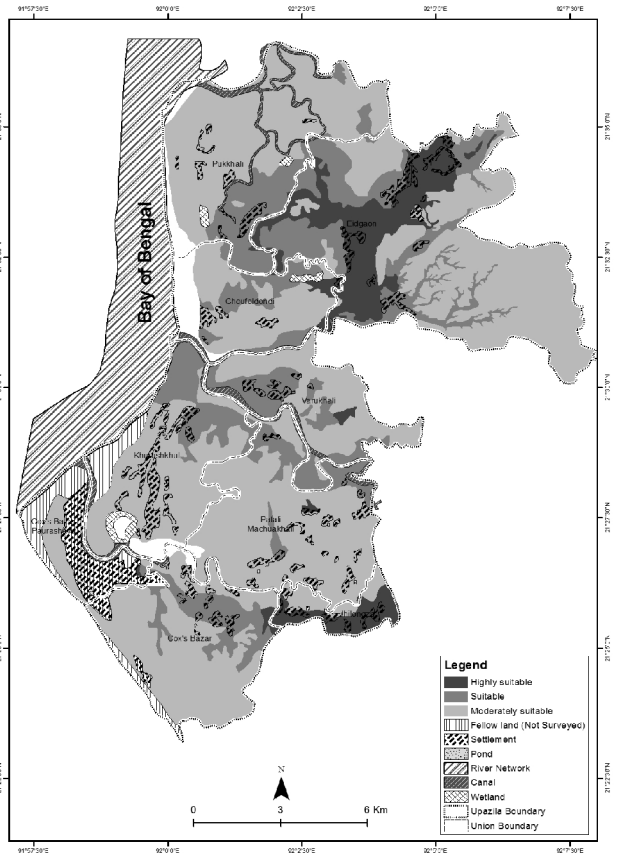

Fig. 3. Land suitability map of Cox's Bazaar Sadar Upazila for maize (*rabi*) cultivation.

In addition, having an overall land suitability range 1.51 - 1.75, areas within the geomorphic units of medium high hilly areas, low hills and valley areas, tidal flood plain with high and medium high land, and tidal flood plain with medium high and medium low land of the study area (Fig. 2) have been recognized as 'moderately suitable' (Fig. 3) for maize (*rabi*) cultivation. Covering approximately 55% of the study area a total of 11021 hectares lands have been found under this suitability class most of which are located in Eidgaon (2782 ha), Patali Machuakhali (2039 ha), Jhilongja (1783 ha), Pukkhali (1757 ha), Khuruskhul (1176), Varuakhali (787) and Choufoldondi (534 ha) Unions (Fig. 3). The rest (163 ha) of the lands are located in Cox's Bazaar Pourashava. The study reveals that approximately 55% (6022 ha) lands of this suitability class are highland while almost whole of the remaining lands is identified as medium highland (4947 ha). Moreover, more than 15 soil classes have been recognized within these land

masses out of which nearly 75% lands fall under Rangamati (2801 ha), Chiringa (1583 ha), Kutubdia (1474 ha), Chakoria (1076 ha), Pahartali (729 ha), Barkal (445 ha) and Subalong (445 ha) soil groups. Identified other soil groups within the areas of this land suitability class are Rangapani (382 ha), Lama (382 ha), Badarkhali (365 ha), Munakhali (332 ha), Mirsharai (310 ha), Dhum (297 ha), Shitakund (148 ha), Tamabil (148 ha) and Harbang (52 ha).

The widespread fertile alluvial soils and subtropical monsoonal climate make a huge area of Bangladesh suitable for maize cultivation. Before independence in 1971, maize was rarely cultivated across Bangladesh except in a few tribal areas of the south-eastern Chittagong Hill Tracts (Mannaf 2012). By the 2009-10 cropping season, it was planted on about 152,226 ha of land with national average grain yields of around 5.83 t/ha, producing well over a million tonnes of maize grain annually (BBS 2010). In fact, with the rapid expansion of poultry industry in the 1990s and 2000s, the demand for maize grain as poultry feed was increased very much in Bangladesh. From 2000 onwards, maize became a lucrative cash crop with a huge and expanding market demand, particularly to the farmers of northern and western Bangladesh (Mannaf 2012).

However, in order to achieve food security at the national level, it is important to encourage farmers of the country to cultivate appropriate crops in their land mainly considering the agro-ecological suitability. During the recent decades, along with the continuously changed climatic conditions of the world, the geo-environmental criteria of the coastal belt of Bangladesh have been changed significantly. This situation may also change the land suitability of various crops cultivations along the coastal areas of Bangladesh which justify the necessity to determine specific crop suitability of different land types at the micro level. In fact, the determination of exact production suitability of various crops in individual land units of coastal agricultural fields will enable to choose appropriate crops for cultivation within the study area which can also be practiced all over the country. This might fulfill the increasing demand for surplus food grains for the continuously growing population in future. Moreover, the appropriate knowledge base on the suitability levels of potential crops in a region can help develop technologies for adaptation of various crops to adverse conditions which may also change the suitability range of specific crops in specific regions. For example, technologies like introgression of flood and salt tolerant genes into different crop varieties might make them somewhat tolerant to flood and salinity in the flood-prone areas or in the saline coastal areas of the country. In addition, varietal development of crops, including management and agronomic manipulation, can offset the impact of hazards like high or low temperatures, floods, salinity, etc. on the yield.

Thus, the local level outcomes of the research work like the present study to determine crop suitability of lands for various crops, including maize varieties, will enable the country to develop a sustainable agriculture planning to ensure food security for the next generation.

References

BARC, 2012. *Land Suitability Assessment and Crop Zoning of Bangladesh*, Bangladesh Agricultural Research Council, Dhaka.

BARC, 2013. *Land Suitability based Crops Zones (Bhumir Upazugita Bhittik Fasal Anchal, in Bengali*), Bangladesh Agricultural Research Council, Dhaka.

BARI, 2008. *UdvabitaKrishiprojukti 2006-2007* (in Bengali). Bangladesh Agricultural Research Institute, Gazipur, Bangladesh.

BBS, 2010. *Statistical Pocket Book of Bangladesh.* Bangladesh Bureau of Statistics, Statistics Division, Ministry of Planning, Government of the People's Republic of Bangladesh, Dhaka.

BBS, 2012. *Yearbook of Agricultural Statistics of Bangladesh 2012*. Bangladesh Bureau of Statistics, Ministry of Planning, Government of Bangladesh, Dhaka.

Begum, M. and F. Khatun 2006. *Present Status and Future Prospect of Hybrid Maize in Bangladesh*. *Training on Hybrid Maize Seed Production Technology 20 - 21 September 2006 Training Manual.* Development of Hybrid Maize Research Project (GOB), Plant Breeding Division, Bangladesh Agricultural Research Institute, Gazipur, Bangladesh.

Climate-Data.Org. Climate: Cox's Bazar. https://en.climate-data.org/location/56253/ (Accessed July 1, 2017).

Dewan, S.F.K., M.A. Salam, and A.A. Mondal, 1998. *Prospects and Challenges of Expanding Maize Production in Bangladesh*. International Maize and Wheat Improvement Center (CIMMYT), Bangladesh.

FAO. 2011. *FAOSTAT.* Food and Agricultural Organization of the United Nations, Rome, Italy.

Hoque, A. 2017. Geo-Environmental Characteristics and Land Suitability Assessment for Aus Rice (*Rupa-Ufshi and Bona-Local*) Cultivation in Cox's Bazaar SadarUpazila of Bangladesh. *Oriental Geographer* **58**(1 & 2), in press.

Hussain, S.G., M.A.H. Chowdhury and M.A. Iqbal 2005. Report on Updating of Edaphic and Agroclimatic Suitability Rules for Selected Crops of Bangladesh. Submitted to CIMMYT/BARC Bangladesh Country Almanac Project.

Mannaf, M. 2012. *An Economic Study on Maize Production and its Impact on Food Security in Selected Areas of Bogra District.*Unpub. M. S. Thesis. Bangladesh Agricultural University, Mymensingh.

Rahman S. and M.S. Rahman 2014. Exploring the potential and performance of maize production in Bangladesh. *Int. J. Agric. Manag.* **3**: 99-106.

SRDI 1996. *Land and Soil Resource Utilization Guide(Bhumi O Mrittika Sampad Bebohar Nirdeshika, in Bengali), Cox's Bazaar Sadar Thana, Cox's Bazaar District.*series. 159, Soil Resource Development Institute, Dhaka, Bangladesh.

Unnayan Onneshan. 2011. Food prices, food security and the marginalized. *Bangladesh Economic Update* **2**(5): 2-19.

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BIOCHEMICAL COMPOSITION OF SOME SELECTED AQUATIC MACROPHYTES UNDER *EX-SITU* CONDITIONS

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Abstract

Ex-situ culture studies of five selected aquatic macrophytes, namely *Nymphaea nouchali* Burm. f., *Enhydra fluctuans* Lour., *Ipomoea aquatica* Forsk., *Hygroryza aristata* (Retz.) Nees *ex* Wight & Arn. and *Limnocharis flava* (L.) Buch. were carried out. Comparing the biochemical composition of the above mentioned five aquatic macrophytes, on an average, *Enhydra fluctuans* was found to contain highest amounts of proteins (18.20%) and *Ipomoea aquatica* contains highest amounts of carbohydrate (58.60%). Lowest amounts of proteins (14.35%) were recorded in *Hygroryza aristata* and *Limnocharis flava*. On the other hand lowest amounts of carbohydrates were obtained in *Nymphaea nouchali*. *Ipomoea aquatica* contained highest amounts of energy (321.23 kcal) and lowest amount was observed in *Limnocharis flava*. The five aquatic plants were low in fiber, fat and also in ash. Among all the five aquatic macrophytes, highest values of calcium and phosphorus were found to be present in *Limnocharis flava* and iron was highest in *Nymphaea nouchali*. Lowest values of calcium and phosphorus were present in *Ipomoea aquatica* and lowest amount of iron was present in *Limnochris flava*. The present study demonstrated that, these five aquatic macrophytes are the important sources of carbohydrate, protein and minerals, which are suitable for incorporation in human diet and feed also.

Key words: Biochemical composition, Aquatic macrophytes, *Ex- situ* culture

Introduction

Bangladesh, though very rich in wetland habitats with luxuriant growth of aquatic macrophytes, research work done in this field are not significant. Previous information of biochemical compositions of aquatic macrophytes are little. In Bangladesh, *exsitu* culture of different aquatic macrophytes were made by Alfasane *et al.* (2009, 2010 a,b,c,d and 2011) and biochemical composition of aquatic macrophytes, namely, *Euryale ferox* Salib., *Nelumbo nucifera* Gaertn. and *Trapa bispinosa* Roxb. were also studied by Alfasane *et al*. (2008, 2009 and 2011).

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Bangladesh is an over populated country and the people cannot satisfy their nutritional requirements. Although rice is the staple food in our country, exploration of other food source is very essential. Macrophytes of Bangladesh can be used as the source of vegetable nutrients and minerals. In rural area maximum population use these macrophytes as source of vegetable. Cattle largely depend on some common aquatic macrophytes. Study on the chemical composition and their adaptation in different habitats of macrophytes is very much essential.

People of Bangladesh traditionally eat or use these macrophytes without having any detailed knowledge on the biochemical composition of their products, because there is very little information on this aspect of aquatic plants of Bangladesh. The natural habitats of the plant have been decreasing at a high rate. Considering this decline an *ex situ* culture studies of the plants for their conservation and at the same time to know their food values, the biochemical composition of some selected aquatic macrophytes, namely *Nymphaea nouchali* Burm. f., *Enhydra fluctuants* Lour., *Ipomoea aquatica* Forsk., *Hygroryza aristata* (Retz.) Nees *ex* Wight & Arn., *Limnocharis flava* (L.) Buch. have been investigated.

Materials and Methods

The five species of aquatic macrophytes were selected and *ex situ* culture was made from June, 2011 to May, 2012 in the Botanical garden, Department of Botany, University of Dhaka (Figs. 1 - 5). Fresh leafy shoots of these species were collected for biochemical analyses. At first, these species were collected from the garden and then dried with the help of oven at 105°C for 5 hours. Then materials were crushed in a mortar with a pestle and the crushed materials were used to determine the amount of protein, carbohydrate, fat, moisture and ash contents according to the methods used by National Institute of Nutrition (1976). Moisture was determined with the help of a moisture meter (Chyo, Serial No.135252, 1B-30 CAPACITY) and protein was determined by Microkjeldhal method (National Institute of Nutrition 1976) . The ash content was determined in a Muffle furnace (CARBOLITE, Hope valley, S336RB, England, Serial No. 06/02/1539, Type-RHF 16/15). Digestion process of the ash was made for mineral contents. The ash after furnace is moistened with a small amount of glass-distilled water (0.5 - 1.0 ml) and 2 ml of conc. HNO_3 acid added to it. The mixture is evaporated to dryness in a muffle furnace and calcium, phosphorus and iron were determined with the help of a UV Spectrophotometer (Cintra 6, Serial No. V 3681, GBC, National Institute of Nutrition 1976). Biochemical composition of the selected aquatic macrophytes was determined by the method of National Institute of Nutrition (1976).

(a)

Fig.1a. *Ex situ* culture of *Enhydra fluctuans* in an earthen bin.

(b)

b. Many small cut pieces of *Enhydra fluctuans*.

(a)

Fig. 2a. *Ex situ* culture of *Ipomoea aquatica.*

(b)

b. *Ipomoea aquatica* was chopped into many small pieces.

(a)

Fig. 3a. *Ex situ* culture of *Limnocharis flava* in the culture pit.

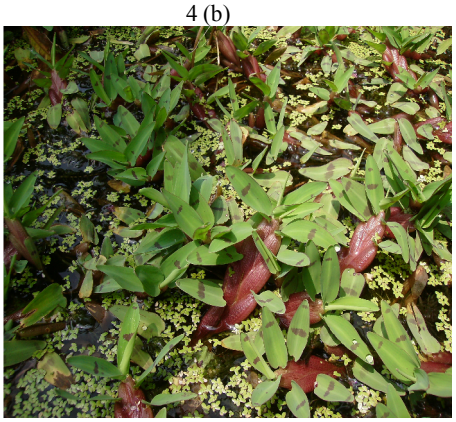
(b)

b. Leafy shoots of *Limnocharis flava* chopped into many pieces.

4(a)

4 (b)

4(c)



(5)

Figs 4a. *Ex situ* culture of *Nymphaea nouchali* in the culture pit. b. Red flower of *Nymphaea nouchali* with its long pedicel. c. Many small cut pieces of the pedicels of *Nymphaea nouchali*. 5. *Ex situ* culture of *Hygroryza aristata* in the culture pit.

Results and Discussion

Biochemical analyses of the biomass of *Enhydra fluctuants* showed that young shoots are extremely nutritious, containing 56.60% carbohydrate, 18.2% protein, 11.54% fibre, 14% ash and 1.14% fat. The mineral contents were 224.45 mg/100g calcium, 175.22 mg/100g phosphorus, 30.48 mg/100g iron of dry weight of sample (Table 1). *Enhydra fluctuans* contained a significant amount of P in their leafy shoots. Dried plant materials produced 317.28 kcal/100 g of energy. Similar observations were also made by Dewanji *et al*. (1993). The tissue chemistry of aquatic plants has been reported to show considerable variation in mineral composition which may be attributed to the age and type of plants sampled, and the fertility of the aqueous environment (Boyd 1968.). When plants are considered as a feed source calcium and phosphorous ratio constitutes an important parameter.

The biochemical analyses of *Ipomaea aquatica* showed that young shoots contained 58.60% carbohydrate, 16.8% protein, 10.30% moisture, 12.33% fibre, 13% ash and 1.30% fat. Dried plant materials were found to produce 321.2 kcal/100 g of energy. The mineral contents of this plant were as follows: calcium 128.26 mg/100 g, phosphorus 173.22 mg/100 g and iron 27.70 mg/100 g on dry weight basis. In the present material protein and ash contents were more or less to the value obtained by Yadav and Agarwala (2011). According to them submerged plants having higher amounts of ash may be due to extraneous mineral deposition from surrounding habitats.

The biochemical analyses of *Hygroriza aristata* showed that young plants contained 58.10% carbohydrate, 14.35% protein, 12.70% moisture, 25% fibre, 13.86% ash and 1.00% fat (Table 2). In 100 g dry plant parts produced 306.34 kcal of energy. The mineral content of *H. aristata* showed that they consist of 208.4 mg/100 g calcium, 228 mg/100 g phosphorus and iron 20.58 mg/100 g on dry weight basis. Previously similar observation on biochemical analyses of seeds of *Euryale ferox* showed that seeds consisted of 61.2% carbohydrate, 15.6% protein, 1.3% fat, 7.6% fibre, 1.8% ash and 12.5% moisture on dry weight basis (Alfasane *et al.* 2008).

Pedicels of *Nymphaea nouchali* were found to contain 55.50% carbohydrate , 17.15% protein, 12.30% moisture, 23% fibre, 14% ash and 1.50% fat (Table 2). Dry pedicels produced 307.33 kcal/100 g of energy. The mineral contents of this plant were 328.66 mg/100 g calcium, 250 mg/100 g phosphorus and 95.13 mg/100 g iron on dry weight basis. Another experiment on biochemical composition of seeds of another aquatic macrophyte namely, *Nelumbo nucifera* consisted of 63.8% carbohydrate, 16.4% protein, 1.6% fat, 4.5% fibre, 1.9% ash and 11.8% moisture on dry weight basis (Alfasane *et al.* 2009).

The proximate analyses of the species of *Limnocharis flava* showed that the leaves are nutritious, containing 57.3% carbohydrate , 14.35% protein, 13.10% moisture, 24% fibre, 14% ash and 1.25% fat (Table 1). Dry plants produced 305.39 kcal/100 g of energy. The amounts of calcium, phosphorus and iron were 493.18 mg/100 g, 262 mg/100 g, and 17.94 mg/100 g in dry weight of sample (Tables 1 and 2). Biochemical analysis of fruits of *Trapa bispinosa* was found to contain 71.55% carbohydrate and 10.80% protein on dry weight basis. The percentage of moisture, fibre, ash and fat were 7.30, 6.35, 8.50 and 1.85, respectively (Alfasane *et al.* 2011).

Comparing the biochemical composition of above mentioned five aquatic macrophytes, on an average, *E. fluctuants* was found to contain highest amounts of proteins (18.20%) and *I. aquatica* contained highest amounts of carbohydrate (58.60%). Lowest amounts of proteins (14.35%) were recorded in *H. aristata* and *L. flava*. On the other hand lowest

amounts of carbohydrates were obtained in *N. nouchali*. *I. aquatica* was found to contain highest amounts of energy (321.23 kcal/100 g) and lowest was observed in *L. flava*. The five aquatic plants are low in fiber, fat and also in ash (Table 1).

Table 1. Comparison of proximate composition of five different aquatic macrophytes.

Biochemical composition	Name of the aquatic macrophytes				
	Enhydra fluctuants	*Ipomoea aquatica*	*Hygroryza aristata*	*Nymphaea nouchali*	*Limnocharis flava*
Moisture (%)	10.06	10.30	12.70	12.30	13.10
Ash (%)	14.00	13.00	13.86	14.00	14.00
Protein (%)	18.20	16.80	14.35	17.15	14.35
Fat (%)	1.14	1.30	1.00	1.05	1.25
Fibre (%)	11.50	12.30	25.00	23.00	24.00
Carbohydrate (%)	56.60	58.60	58.10	55.50	57.30
Energy (Kcal/100 g)	317.28	321.23	306.34	307.33	305.39

Previously Alfasane *et al*. (2011) reported that the seeds of *T. bispinosa* contained 102.85 mg calcium, 3.8 mg iron and 325 mg phosphorus in 100 day mather. Dried seeds of *T. bispinosa* produced 354.85 kcal/100 g calories of energy.

Table 2. Comparison of mineral contents of different aquatic macrophytes.

Name of the aquatic macrophytes	Minerals (mg/ 100g)		
	Calcium	Phosphorus	Iron
Enhydra fluctuants	224.45	175.22	30.48
Ipomoea aquatica	128.26	173.22	27.7
Hygroryza aristata	208.4	228	20.58
Nymphaea nouchali	328.66	250	95.13
Limnocharis flava	493.18	262	17.94

Among all the five aquatic macrophytes, highest values of calcium and phosphorus were found to be present in *L. flava* and iron was highest in *N. nouchali*. Lowest values of calcium and phosphorus were recorded in *Ipomoea aquatica* and iron was present in *L. flava* (Table 2). One hundred g dried seeds of *Nelumbo nucifera* produced 343.70 calories of energy. The seeds are low in fiber, very low in fat and also in ash but high in carbohydrates and also protein. Dharmananda (2002) had also reported biochemical composition of *N. nucifera* and showed that in 100 g (yielding about 350 calories of energy), there were 63 - 68 g carbohydrate (mostly starch), 17 - 18 g of protein, and only 1.9-2.5 g fat; the remaining one is water (about 13%), and minerals (mainly sodium,

potassium, calcium, and phosphorus). Regarding the chemical composition the values obtained in the present investigation are close to the range reported by Dharmandra (2002) and Yadav and Agarwala (2011). Read (1946) had also reported biochemical composition of *Euryale ferox* and showed the chemical compositions as carbohydrate 75.7%, protein 9.9%, fat 0.3%, and ash 0.6%. Howard-Williams and Junk (1977) studied the nutritional values of 27 Amazonian macrophyte species and found 5.3 - 22.2% protein in the whole biomass on dry weight basis. The highest was found in *Azolla microphylla* Kaulf. and the lowest in *Scleria secans* (L.) Urb. and *Rhynchospora gigantea* Link.

Mineral nutrients are important aspects of nutritive quality. Execessive concentration of ash decreases the amount of organic constituents per unit weight and lowers food value. However, ash value below 15%, is of little value in evaluating the nutritive value of a feed since it is the individual element that is important in the metabolic processes. On the basis of an overall nutrient composition, the plants were found to contain sufficient quantities of nutrients and thus are safe enough to be considered as potential livestock feed. The amount of carbohydrate was also significant as a source of energy. The present study has demonstrated that, these five aquatic macrophytes may be the important source of carbohydrate, protein and minerals, which are suitable for incorporation in human diet and feed also.

References

Alfasane, M.A, M. Khondker and M.M. Rahman. 2011. Biochemical composition of the fruits of water chestnut (*Trapa bispinosa* Roxb.). *Dhaka Univ. J. Biol. Sci.* **20**(1): 95-98.

Alfasane, M.A., M. Khondker, Z.N.T. Begum, L.A. Banu, M.M. Rahman and U.F. Shahjadee. 2008. Fruit production and biochemical aspects of seeds of *Euryale ferox* Salisb. under *ex-situ* conditions. *Bangladesh J. Bot.* **37**(2): 179-181.

Alfasane, M.A., M. Khondker and Z.N.T. Begum. 2009. Biochemical composition of the seeds of *Nelumbo nucifera* Gaertn. *Dhaka Univ. J. Biol. Sci*. **18**(1): 83-85.

Alfasane, M.A., M. Khondker and Z.N.T. Begum. 2010a. Relationship between the growth of *Euryale ferox* Salisb. and some limnological parameters. *Dhaka Univ. J. Biol. Sci.* **19**(1): 41-46.

Alfasane, M.A., M. Khondker and Z.N.T. Begum. 2010b. Growth of water mimosa (*Neptunia natans* (L.f.) Druce) in relation to habitat limnology. *J. Asiat. Soc. Bangladesh, Sci,* **36**(1): 75-81.

Alfasane, M.A., M. Khondker and Z.N.T. Begum. 2010c. Growth and regeneration of *Cryptocoryne ciliata* (Roxb.) Fisch. ex Wydler under *ex-situ* conditions. *Bangladesh J. Bot.* **39**(1): 115-118.

Alfasane, M.A., M. Khondker and Z.N.T. Begum. 2010d. Effects of water depth on the growth of *Nelumbo nucifera* Gaertn. seedlings. *Dhaka Univ. J. Biol. Sci.* **19**(2): 111-118.

Boyd, G.E. 1968. Fresh water plants: a potential source of protein. *Economic Botany*. **22**:359-368.

Dewanji, A, S. Matai, L. Si and S. Barik. 1993. Chemical composition of two semi-aquatic plants for food use, *Plant Foods for Human Nutrition* **44**(1): 11-16.

Dharmananda, S. 2002. *Lotus seed, food and medicine*. March, 2002, [Online] as retrieved on 30 May 2008 15:05:19 GMT (Cited 2008 Jun 05). Available from: URL: http:// www.

itmonline.org/arts/lotus.htm.

Howard-Williams, C. and Junk, W. J. 1977. The chemical composition of central Amazonian aquatic macrophytes with special reference to their role in the ecosystem. *Arch. Hydrobiol*. **79**(4): 446-464.

National Institute of Nutrition. 1976. *A manual of laboratory techniques*, National Institute of Nutrition, Indian Council of Medical Research, Hyderabad- 500007, India. pp. 123.

Read, B. E. (ed.). 1946. *Famine foods listed in the Chiu huang pen ts'ao* [of Ting Wang Chou]: giving their identity, nutritional values and notes on their preparation. Shanghai, China: Henry Lester Insitute of Medical Research. 93 pp., Famine Foods, Compiled by Robert Freedman, NYMPHAEACEAE, [Online], Last update Thursday, March 5, 1998, (cited 2008 Jun 05). Available from: URL: http://www. hort.purdue.edu/newcrop/faminefoods/ff_families/ NYMPHAEACEAE.html

Yadav, R.N.S. and M. Agarwala, 2011. Phytochemical analysis of some medicinal plants, *J. Phytology,* **3**(12)*:* 39-47.

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LARVICIDAL IMPACT OF SOME LOCAL MEDICINAL PLANT EXTRACTS AGAINST *AEDES AEGYPTI* (L.)

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Abstract

The larvicidal potential of different solvent (hexane, chloroform, ethyl acetate, acetone and methanol) crude leaf extracts of five plants (*Blepharis maderaspatensis, Elaeagnus indica, Maesa indica, Phyllanthus wightianus* and *Memecylon edule*) were tested against the fourth-instar larvae of *Aedes aegypti*. All the tested extracts showed moderate to good larvicidal activities. However, the maximum larval mortality was detected in acetone extract of *E. indica* (LC_{50} 90.89, LC_{90} 217.21 and LC_{99} 441.88 ppm) followed by *M. indica* acetone extract (LC_{50} 173.21, LC_{90} 289.86 and LC_{99} 441.04 ppm). The results revealed that larvicidal properties of the four selected plants and encourages further investigation for the bioactive compounds that might possess good larvicidal properties in pure form.

Key words: Larvicidal, Plant extract, Bioactive compounds, *Aedes aegypti* vector

Introduction

Mosquitoes are vector for various diseases including malaria, yellow fever, filariasis Japanese encephalitis and chikungunya. Among these mosquito borne diseases dengue fever, dengue hemaorrhagic fever, yellow fever and chikungunya are prevalent in Southeast Asia and Africa (Maillard *et al*. 2013). It is transmitted by *Aedes aegypti* (Linn.). Synthetic insecticide is one of the methods available for controlling the mosquitoes. Mosquitoes develop resistance to synthetic insecticides (Wattal *et al*. 2011) and even to biopesticides (Tabashnik 2011). Synthetic insecticides adversely affect the environment also by contaminating air, water, and soil. There is an urgent need to find alternatives to the synthetic insecticides which are more potent and low-cost. Plants could be better rich source of alternative agents to control of mosquitoes, because they possess bioactive chemicals, which are specific to target-insects and are eco-friendly (Sukumar *et al*. 2012). Traditionally plant based products have been used in human communities for many centuries for managing insects. Several secondary metabolites present in plants serve as a defense mechanism against insect attacks and may act as insecticides, antifeedants, moulting hormones, oviposition deterrents, repellents, juvenile hormone mimics, growth inhibitors, antimoulting hormones as well as attractants. Plant based

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pesticides are less toxic, delay the development of resistance because of its new structure and easily biodegradable (Markouk *et al*. 2010). Several plant extracts and isolated compounds from different plant families have been evaluated for their promising larvicidal activities (Feinstein 2012). About 2000 species of terrestrial plants have been reported for their insecticidal properties (Wiseman and Chapagain 2011). Search for eco-safe, low cost and a highly potential insecticide for the control of mosquitoes needs the preliminary screening of plants to evaluate their insecticidal activities. Recent research has proved that effectiveness of plant derived compounds, such as saponine (Chowdhury *et al.* 2008), steroids, isoflavonoids, essential oils, alkaloids and tannins (Ghosh *et al.* 2011) have potential mosquito larvicides. Plant secondary metabolites and their synthetic derivatives provide alternative source in the control of mosquitos (Joseph *et al*. 2009). The present investigation was carried out to validate the larvicidal potential of different solvent extracts of five medicinal plants (*Blepharis maderaspatensis* (L.) B. Heyne ex Roth., *Elaeagnus indica* Servett., *Maesa indica* (Roxb.) DC, *Phyllanthus wightianus* Müll.Arg. and *Memecylon edule* Roxb.) against fourth instar *Ae. aegypti* larvae. All the plants were selected based on their ethno botanical importances and least explored.

Materials and Methods

Healthy leaves of *B. maderaspatensis* (Acanthaceae), *E. indica* (Elaeagnaceae), *M. indica* (Myrsinaceae) *P. wightianus* (Phyllanthaceae) and *M. edule* (Melastomataceae) were collected from Botanical garden Mirpur, Carzon Hall Campus, University of Dhaka and farm of Sher-e-Bangla Agricultural University, Dhaka. The plants were identified with the references of standard books and herbariums from the Agronomy and Crop Botany Department of Sher-e-Bangla Agricultural University, Dhaka. The plant materials were cleaned, air-dried at room temperature for two weeks and coarsely powdered.

Preparation of extracts: Powdered plant materials were extracted successively by using different solvents of increasing polarity (hexane, chloroform, ethyl acetate, acetone and methanol) in soxhlet apparatus for 18 hrs and the extractives were filtered through Whatman filter paper No. 4 then the extracts were concentrated at 40ºC in vacuum and stored at 4ºC for this investigations.

Test insects: Ae. aegypti, larvae were obtained from Sher-e-Bangla Agricultural University campus, Dhaka. Larvae were fed a diet of Brewer's yeast and powdered dog biscuits in the ratio of 3 : 1, kept at 27 ± 2º C and 75 - 85% relative humidity (RH), with a photoperiod of 14:10 LD for the larval growth. Late third instars to early fourth instars larvae were used for larval bioassay which obtained from the stock culture maintained at Department of Entomology, Sher-e-Bangla Agricultural University, Dhaka.

Larvicidal bioassay: The larvicidal activity of crude extracts of five selected plants were assessed by the protocol of WHO (2011) with some modifications and as per the method of Rahuman *et al*. (2010). Bioassay in a container where 25 fourth instar larvae were kept in 249 ml of distilled water with one ml of extracts (400 ppm) in DMSO. Tween-80 was used as an emulsifier at concentration of 0.02% (v/v). The chamber containing the control larvae received one ml of DMSO served as negative control. After 24 hur exposures the dead larvae were counted and corrected by using Abbott's (2007) formula and the percentage mortality was recorded from the average of six replicates.

Dose-response bioassay: Based on the preliminary screening, in which above 90% mortality of larvae occur alone, were subjected to dose-response larvicidal bioassay. The desired mortality percentage was observed in acetone and ethyl acetate extracts of *E. indica*, ethyl acetate extract of *B. maderaspatensis* and acetone extract of *M. indica* at 40 - 50 ppm were subjected to dose dependent bioassay. Different concentrations (50 - 400 ppm) of the above mentioned crude extracts were tested for larvicidal activity described by WHO (2011). The average mortality percentages of six replicates were recorded and corrected by using Abbott's formula.

Data were analyzed using one-way ANOVA. Significant differences between treatments were determined using Tukey's multiple range tests ($p \leq 0.05$). LC_{50}, LC_{90} and LC_{99} values were calculated using probit analysis.

Results and Discussion

The results of larvicidal efficacy of different solvent extracts of the selected plants was shown in Table 1. All the plant extracts showed good to moderate effect on fourth instar larvae of *Ae. aegypti* after 24 hrs of exposure at 400 ppm concentration. The highest mortality (100%) was observed in acetone extracts of *E. indica* and *M. indica.* Significant ($p > 0.05$) activity was detected in ethyl acetate extracts of *E. indica1* (97%) and *B. maderaspatensis* (90%) followed by *M. indica* chloroform extract (85%). Most of the extracts of *P. wightianus* exhibit considerable (42 - 82%) larvicidal activity and the remaining extracts of the selected plants showed least larvicidal activity. The least activity was detected in *M. edule* chloroform extract (1%).

Table 1. Larvicidal activity of different solvent leaf extracts of selected four plants against 4th instar larvae of *Ae. aegypti* at 400 ppm (0.04%).

Name of plants	% mortality*				
	Methanol	Acetone	Ethyl acetate	Chloroform	Hexane
Blepharis maderaspatensis	8.0±1.0[a]	48.0±6.0	90.6±0.5[a]	26.6±2.3	10.6±1.1[a]
Elaeagnus indica	22.6±2.0[b]	100±0.0b	97.3±0.5[ab]	21.3±0.5	34.6±1.1
Maesa indica	24.0±2.0[ab]	100±0.0ab	14.6±1.5[c]	85.3±1.5[c]	6.6±3.0[ab]
Memecylon edule	5.3±1.5[ab]	4.00±0.0	10.6±0.5[cd]	1.3±0.5	17.3±0.5
Phyllanthus wightianus	42.6±1.1	73.3±1.5	78.6±2.0	82.6±1.1[c]	70.6±2.0

Control = Nil mortality, total no. of larvae = 25, *Mean value of six replicates ± Sd. Significant at $p > 0.05$ level.

The toxicity of dose-response larvicidal bioassay is given in Table 2. On the basis of preliminary screening, four extracts were subjected to dose-response larvicidal bioassay where it was 90% larval mortality. Among them significant mortality rate was observed in acetone extract of *E. indica* with LC_{50}, LC_{90} and LC_{99} values of 90, 217 and 441 ppm, respectively followed by acetone extract of *M. indica* with LC_{50}, LC_{90} and LC_{99} values of 173, 289 and 441 ppm, respectively. The larvicidal activity of the different selected plant extract was found to be dose depended. *E. indica* ethyl acetate extract shows considerable mortality with LC_{50} LC_{90} and LC_{99} values of 151, 456 and 1121 ppm, respectively.

Table 2. Dose-response larvicidal bioassay of different solvent leaf extracts against 4th instar larvae of *A. aegypti.*

Name of plants	Extracts	Conc. (ppm)	% mortality*	LC_{50} ± SE (ppm) LCL-UCL	LC_{90}±SE(ppm) LCL-UCL	LC_{99} ± SE(ppm) LCL-UCL	$\chi^{2\,(df=4)}$
		100	18.6±0.5				
		150	30.6±0.5				
		200	42.6±2.0				
		250	62.6±1.5	197.6±0.2 (181.6-213.8)	438.0±0.3 (381.6-531.3)	838.3±0.8 (664.3-1174.3)	4.9
B.maderaspatensis	Ethyle acetate	300	77.3±1.5				
		400	90.6±2.5				
		50	24.0±1.0				
		100	50.6±0.5				
		150	70.6±1.1				
	Acetone	200	89.3±3.7	90.8±0.1 (80.1-101.1)	217.2±0.2 (191.5-254.8)	441.8±0.6 (358.7-587.5)	5.2
E. indica		300	97.3±1.1				
		400	100.0±0.0				
		50	18.6±1.5				
		100	26.6±1.1				
		150	41.3±3.5				
		200	52.0±3.6	151.2±0.4 (93.3-224.2)	456.1±0.5 (284.6-2005.6)	1121.7±1.2 (527.0-1644.2)	20.0
E. indica	Ethyle acetate	300	80.0±4.0				
		400	97.3±0.5				
		100	16.0±1.0				
		150	30.6±1.5				
		200	52.0±2.6	173.2±0.7 (135.9-206.9)	189.8±0.9 (237.2-448.8)	441.0±2.2 (325.6-968.0)	17.8
M. indica	Acetone	250	78.6±3.5				
		300	98.6±0.5				
		400	100.0±0.0				

Control - Nil mortality, significant at $p < 0.001$ level, *Mean value of six replicates ± Sd, LC= Lethal concentration, LCL = Lower confidence limit, UCL = Upper confidence limit, SE = Standard error, χ^2 = Chisquare and d*f* = Degree of freedom.

Nowadays, the control of mosquitoes at larval stage is focused with plant extracts. The advantage of targeting mosquito at the larval stage is they cannot escape from their breeding sites until the adult emergences and to reduce the overall pesticide use to control of adults by aerial application of adulticidal chemicals. Bioactive crude extracts or isolated phyto-constituents could be used as alternative to the currently used synthetic insecticides. The bioactivity of plant extracts might be due to various compounds *viz.* phenolics, terpenoids, and alkaloids present in plants (Sakthivadivel and Daniel 2011). Among 20 different leaf extracts of five plants, four extracts gave high larvicidal potency with low lethal concentrations (LC_{50} <197 ppm) against 4th instar larvae of *Ae. aegypti*. Cavalcanti *et al.* (2011) reported that the larvicidal activity of essential oils of Brazilian plants against *Ae. aegypti* and observed the LC_{50} to range from 60 - 533 ppm. Similarly, Rahuman *et al.* (2010) screened the petroleum ether extracts of *Citrullus colocynthis*; methanol extracts of *Cannabis sativus, Cannabis indica* and *Momordica charantia*; and acetone extract of *Trichosanthes anguina* against the larvae of *Ae. aegypti* the LC_{50} values are 74.57, 309.46, 492.73, 199.14, and 554.20 ppm, respectively which supports the present results that screened larvicidal activity of petroleum ether extracts of sixty three plants against *Cu. quinquefasciatus, An. stephensi* and *Ae. aegypti* larvae of which six were found to be potential larvicides. Similarly, Pavela (2012) reported the larvicidal activity methanolic extracts of thirty one Euro-Asiatic plants against *Cu. quinquefasciatus*. Likewise, Nazar *et al.* (2013) investigated 100 coastal plant extracts including *B. maderaspatensis* against the *Cu. quinquefasciatus* larvae of which seventeen plants possessed larvicidal properties and also the whole plant extract of *B. maderaspatensis* showed no activity but, the present investigation revealed that larvicidal properties of *B. maderaspatensis* against *Ae. aegypti*. The findings of present study are quite comparable with previous reports of Vinayaka *et al*. (2012) who have reported the larvicidal activities of different solvent leaf extracts of *Elaeagnus kologa* in which methanol, ethyl acetate and acetone extracts showed 100% in 15 and 20 mg/ml concentrations against *Ae. aegypti*. Suwanneepromsiri *et al.* (2010) reported that eight plants showed 100% mortality against *Ae. aegypti* larvae at a concentration of 100 µg/ml with LC_{90} values range between 13.9 and 56.2 µg/ml to 100 µg/ml that supports present results. The present result was supported by Nazar *et al.* (2013) that the larvicidal activity of *Ocimum canum* oil tested against *Ae. aegypti* and *Cu. quinquefasciatus* (LC50 301 ppm) and *An. stephensi* (234 ppm). Similarly, Ansari *et al* (2009) reported the larvicidal activity of *Pinus longifolia* oil against *An. stephensi* (LC_{50} 112.6 ppm), *Ae. aegypti* (82.1 ppm) and *Cu. quinquefasciatus* (85.7 ppm). The results of our study was found to be comparable with the findings of Nazar *et al.* (2013) who have reported that the effect of water extract of citrus seed extract showed LC_{50} values of 135, 319, 127 and 411 ppm against the larvae of *Ae. aegypti* and *Cu. quinquefasciatus,* respectively.

Conclusion

All the tested plants possessed different range of larvicidal property which may be used as a traditional mosquito control agent. On the basis of the present investigation results we could conclude that acetone, ethyl acetate extract of *E. indica*, acetone extract *M. indica* and ethyl acetate extract of *B. maderaspatensis* contains potent larvicidal bioactive principles which might be needed further purifications for their synthetic analogue.

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References

Abbott, W. S. 2007. A method of computing the effectiveness of an insecticide. *J. Econ. Entomol*. **18**: 265-266.

Ansari, M. A, Mittal, P. K, Razdan, R. K and Sreehari, U. 2009. Larvicidal and mosquito repellent activities of pine (*Pinus longifolia*, Family: Pinaceae) oil. *J. Vector Borne Dis*. **42**: 95-99.

Cavalcanti, E. S. B, Morais, S. M. Lima, M. A. A. 2011. Santana EWP, Larvicidal activity of essential oils from Brazilian plants against *Aedes aegypti* L. *Mem. Inst. Oswaldo Cruz*. **99**: 541-544.

Chowdhury, N., Ghosh, A. and Chandra, G. 2008. Mosquito larvicidal activities of *Solanum villosum* berry extract against the dengue vector *Stegomyia aegypti*. BMC *complement Altern Med*. **8**: 10.

Feinstein, L. 2012. Insecticides from plants. *In*: Insects: The year book of agriculture, USA, Washington, 222-229.

Ghosh, A., Chowdhury, N. and Chandra, G. 2011. Laboratory evaluation of a phytosteroid compound of mature leaves of day jasmine (Solanaceae: Solanales) against larvae of *Culex quinquefasciatus* (Diptera: Culicidae) and non-target organisms. *Parasitol Res*, **103**: 221-277.

Joseph, C. C., Ndoile, M. M., Malima, R. C., Nkunya and M. H. 2009. Larvicidal and mosquitocidal extracts, a coumarin, isoflavonoids and pterocarpans from *Neorautanenia mitis*. *Trans R. Soc Trop. Med. Hyg*. **98 (8)**: 451-455.

Maillard, M., Marston, A. and Hostettmann, K. 2013. Search for molluscicidal and larvicidal agents from plants in Baladrin M: Human medicinal agents from plants. *American Chemical Society*. Washington DC **534**: 256-273.

Markouk, M., Bekkouche, K., Larhsini, M., Bousaid, M., Lazrek, H. B. and Jana, M. 2010. Evaluation of some Moroccan medicinal plant extracts for larvicidal activity. *J. Ethnopharmacol*. **73**: 93-297.

Nazer, S., Ravikumar, S., Williams, P. G., Syed Ali, M. and Suganthi, P. 2013. Investigated a hundred coastal plant extracts against the *Culex quinquefasciatus* larvae of which seventeen coastal plants were posses larvicidal potential. *Indian J. Sci. Technol*. **2 (3)**: 2427.

Pavela, R. 2012. Larvicidal activites of some Euro-Asiatic plants against *Culex quinquefasciatus* Say (Diptera: Culicidae), *J. Biopesticides* **1**: 81-85.

Rahuman, A. A., Gopalakrishnan, G., Ghouse, B. S., Arumugam, S. and Himalayan, B. 2010. Effect of *Feronia limonia* on mosquito larvae. *Fitoterapia* **71**: 553-555.

Sakthivadivel, M. and Daniel, T. 2011. Evaluation of certain insecticidal plants for the control of vector mosquitoes *viz*, *Culex quinquefasciatus*, *Anopheles stephensi* and *Aedes aegypti*. *Applied Entomol. Zool*. **43 (1)**: 57-63.

Sukumar, K., Perich, M. J. and Boobar, L. R. 2012. Botanical derivatives in mosquito control: A review. *J. Amer. Mosquito Control Association* **7**: 210-237.

Suwanneepromsiri, Amaranaksathit, Maleeya, Kruatrachue Usavadee Thavara 2010. Evaluations of larvicidal activity of medicinal plant extracts to *Aedes aegypti* (Diptera: Culicidae) and other effects on a non-target fish. *Insect Sci.* **13**: 179-188.

Tabashnik, B. E. 2011. Evolution of resistance to *Bacillus thuringiensis*. *Annual Review of Entomol*. **39**: 47-79.

Vinayaka, K. S., Prashith Kekuda, T. R, Nethravathi, H. R., Thippeswamy, N. B, Sudharshan and S. J. 2012. Free radical scavenging and insecticidal activity of *Elaeagnus kologa* Schldl. *Drug Invention Today* **1 (1)**: 74-77.

Wattal, B. L., Joshi, G. C. and Das, M. 2011. Role of agriculture insecticides in precipitating vector resistance. *J. Communicable Diseases* **13**: 71-73.

Wiseman, Z and Chapagain, B. P. 2011. Larvicidal effects of aqueous extracts of *Balanites aegyptiaca* (desert date) against the larvae of *Culex pipiens* mosquitoes. *Afr. J. Biotechnol.* **4** (11): 1351- 1354.

World Health Organization. 2011. Guidelines for laboratory and field testing of mosquito larvicides. WHO/CDS/WHOPES/GCDPP/ 2005.13. Geneva: WHO, 9.

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EFFECTS OF PROBIOTICS ON GROWTH AND PRODUCTION OF MONOSEX TILAPIA (*OREOCHROMIS NILOTICUS*) IN NYLON NET CAGES AT DEKAR *HAOR*, SUNAMGANJ, BANGLADESH

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Abstract

To assess the effect of probiotics on growth, survival rate and production performance of all monosex tilapia (*Oreochromis niloticus*) for a period of 120 days in 2016 in nylon net cages placed in Dekar *haor* of Sunamganj district. The study was categorized into four treatments as T_1 (brand a), T_2 (brand b), T_3 (brand c) and T_4 (control) based on probiotics and each having three replicates. Cages were stocked with nursed male tilapia fry at a density of 35 nos./m^3 with average size of 14.33 ± 6.41 - 16.33 ± 3.15 g. Tilapia of all the cages were fed with commercial mega floating feed at a decreasing rate of 10 - 5% of total biomass thrice daily. Feed was supplemented with probiotics at a rate of 0.5 g/kg. Comparatively higher growth (307.33 ± 33.92 g), survival rate (97.6 ± 4.90%), yield (10.5 ± 1.15 kg/m^3), net profit (Tk.798.96 ± 90.85/m^3) and lower food conversion ratio (1.16) were secured in T_3 than that of other treatments, which were manifolds higher than the earthen freshwater and brackish waterbodies. Therefore, results of the study reveal that probiotics may be used in aquaculture for increasing fish production.

Key words: Probiotics**,** Cage farming, Growth performance, Survival rate, Production

Introduction

Fisheries sector plays a key role in the agro-based economy of Bangladesh. There are many *haors* (bowl shaped floodplains depression connected into canals and rivers with unique hydro-ecological characteristics) in Bangladesh. These are located in north-eastern region of the country covering an area of 19,998 sq. km and accommodating 19.37 million people (MPHA 2012). These are also known as freshwater seas and act as a home of indigenous fishes and other aquatic biodiversity. *Haor* has a great contribution to national fisheries sector. It is a vital supplier of inland freshwater fisheries with a fishing area of 1,14,793 ha. About 10% of the total population is directly or indirectly employed in fisheries sector. Fisheries of Bangladesh have enormous prospects and scope of

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progression (DoF 2017). Tilapia (*O. niloticus*) are widely distributed in many countries of the world. Now it can be found in more than 100 countries (Ballarin and Hallar 1982).

Among different species of tilapia, Nile tilapia (*O. niloticus*) of monosex type are more suitable fish for cage culture. They do not breed/multiply, which make it easy for fish farmers to avoid uncontrolled breeding in their growing water-bodies. They grow fast and attain large size within a short period in pond, cage and pen than other tilapia species. Monosex tilapia become marketable size of 100 - 150 g within 2 - 3 months. Male tilapia grow significantly faster, larger and are more even in size than females (Ponzoni *et al*. 2005). This species is currently considered to be the most important and commonly cultured species around the world and constitutes over 70% of cultured tilapia (Fitzsimmons 2004) which represent approximately 6% of total farmed fish production (FAO 2004). Size of tilapia is entirely dependent on the size of pond/cage/pen, natural productivity of water, feed quality, frequency of feeding, stocking density, size of fry/fingerlings and management.

Cage aquaculture is a rising technology to accelerate fish production. A widespread and profitable culture of fish and prawns in cages has already been developed successfully in Asia, Europe and America (Beveridge 1987). This practice in South-East Asia first started from late 1800s, since then, many countries are practicing cage culture in freshwater and marine environments including ponds, rivers, *haors*, *beels*, open sea, estuaries, lakes, reservoirs, etc. (Balcazar *et al*. 2006). Cage culture in open waterbodies like *haor* area could provide a prospect for increasing fish production, uplift of livelihood of rural fish farmers and mitigating protein demand in the nation.

Probiotics are feed additives defined as live beneficial bacteria that are found in nature and may serve as dietary supplements to improve the host intestinal microbial balance and growth performance (Gatesoupe 1999). Today, probiotics are quite common place in health promoting "functional foods" for human as well as therapeutic, prophylactic and growth supplements in animal production and human health (Geovanny *et al*. 2007).

Though probiotics of several brand names (Aqua photo, Aqua mazic, Ammonil, Safegut, Probio-Aqua, Super biotic, Super PS) in powder or liquid forms are found in the markets, most of the farmers do not know the techniques of use and impact of these probiotics. A few works have been done on probiotics in freshwater aquaculture and shrimp culture in brackishwater to determine the mode of application of *Bacillus* probiotics (Islam *et al.* 2008). But work related to use of probiotics in *haor* cage farming are not available in Bangladesh. Therefore, there is a need to understand the effect of probiotics in artificial diet used for tilapia cage culture in *haor* area. Keeping these in mind, the present research was undertaken aimed to evaluate the effect of probiotics on the production of monosex

tilapia (*O. niloticus*) in cages and to develop farming system technique of tilapia cage culture in open waterbody.

Materials and Methods

The study was conducted in the Dekar *haor* (naturally depressed seasonal-perennial open waterbody), one of the most important and largest *haor* of Bangladesh. The *haor* is surrounded by four Upazilas as Dakshin Sunamganj, Sunamganj sadar, Dowarabazar and Chhatak of Sunamganj district. It is situated by the side of Sylhet-Sunamganj high way and closed to Sunamganj district town. The study was conducted for a period of four months from 10 August to 8 December, 2016.

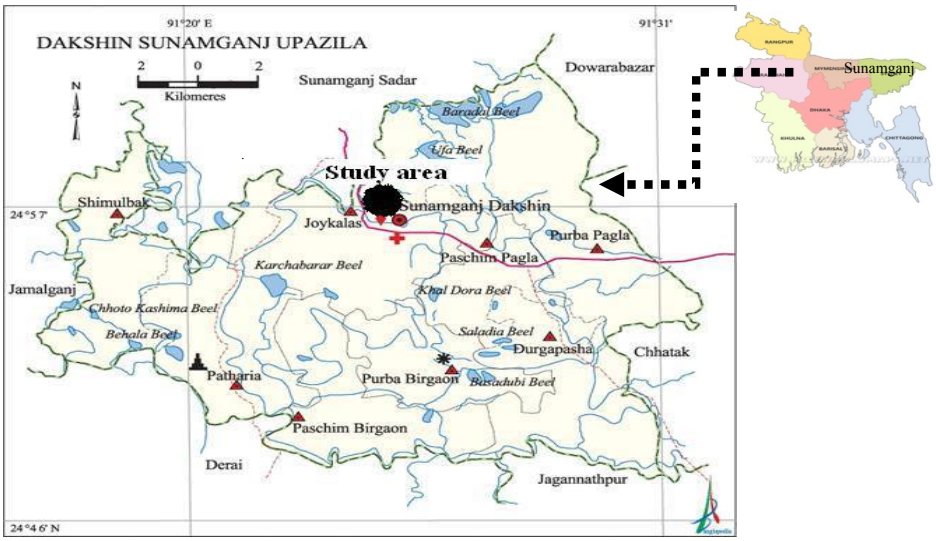

Fig. 1. A map showing the study area (Large black mark) in Dakshin Sunamganj Upazila.

Nine newly constructed floating nylon net cages (3 × 3 × 1.5 m) were set in the periphery of the *haor*. Frames of cages made by GI pipes and aluminium drums (250 litre) were used to float the cages in water. Wet cages were made of knot-less polyethylene net (mesh 1.0 cm). Cages were hanged with cage frame. Bamboo made platform was set up over the cages and all cages were fixed with poles of the platform. Cages were installed at both sides of the platform for easily feed supply and intensive supervision. Open part of each cage was covered with another piece of nylon net (mesh 7 - 7.5 cm) to avoid escaping of fish and predation by bird.

This study was a one factorial in which probiotics were the only experimental variable as T_1 (brand a-biozyme), T_2 (brand b-rapid grow), T_3 (brand c-miracure) and T_4 (control) having three replicates. The place selected for setting the cages was cleaned manually and

limed with CaO at a rate of 0.025 kg/m^2. After five days of liming, all cages were stocked with required quantity of fry of male tilapia (*O. niloticus*) at a density of 35 no./m^3. Monosex tilapia fry were purchased from a private hatchery and was transported in oxygenated polythene bags from hatchery to experimental area. Before stocking, fry were acclimatized to the cage water for one hour period. Initial weight and length of 30 fishes were recorded before stocking in cages.

Stocked fry of tilapia were fed with commercial mega floating feed at a decreasing rate of 10 - 5% of body weight thrice daily until the previous day of harvest. Proximate compositions as moisture, crude protein, crude lipid, ash, crude fiber, carbohydrate of supplemented feed were 11, 30, 7, 15, 8 and 29%, respectively. The total daily feed ration was divided into three equal portions and was applied in the morning between 8.00 - 9.00 a.m. in noon 12.00 - 1.00 p.m. and in evening 5.0 - 6.00 p.m. Feeding rates were adjusted every 15 days intervals depending on the body weight of stocked tilapia. Net of the cages were cleaned and checked every 15 days intervals. Behavior of tilapia was regularly observed specially after providing feed in the morning and in the evening to determine their conditions as movement and diseases.

Water quality parameters like surface temperature, transparency, dissolved oxygen (DO) concentration, pH, total alkalinity and ammonia were determined at fortnightly intervals between 9 and 10 a.m. at the time of fingerlings sampling. Surface water temperature was measured on the spot using a standard centigrade thermometer. Transparency was recorded using Secchi disc. Dissolved oxygen was determined using a portable DO meter (YSI digital DO meter, Model 58, HANNA Company, America). pH of cage water was recorded using pH meter (HANNA Company, America). Total alkalinity was measured by titrimetric method (APHA 2000). Ammonia nitrogen was measured using ammonia test kit (Biosol, A.A. Biotech PVT LTD., Fishtech BD LTD).

Fortnightly sampling was done to determine growth of tilapia fry and to adjust the feed rations. Growth was measured regarding weight (g) with digital balance and length by measuring scale.

Tilapias were totally harvested after 120 days of culture. They were caught using hand scoop net and lifting all cages from water on the same day. After harvest, all tilapia of cages were counted and weighed individually to determine survival rate, growth and yield. Specific growth rates (SGR), food conversion ratio (FCR), protein efficiency ratio (PER) and survival rate (%) were calculated following the equation as cited by Pechsiri and Yakupitiyage (2005). The equations are as follows:

Weight gain = Mean final weight – mean initial weight

Survival rate (%) = (Number of fish harvested ÷ total number of fish stocked) × 100

SGR (% /day) = {Ln (final body weight) – Ln (initial body weight) × 100}/cultured period.

Protein efficiency ratio (PER) = Weight gain (g)/protein consumed (g)

Feed conversion ratio (FCR) = Feed consumed (g dry weight)/live weight gain (g wet weight) of fish

Yield of fish = No. of fish caught × (average final weight of fish – average initial weight fish)

Economic analyses of the different treatments was reckoned on the basis of purchasing prices of tilapia fry, feed, fertilizer, lime, transport cost and revenue from the sale of harvested tilapia. At the end of the study, all fish were sold at local market. Tilapia was sold at a rate of Tk. 120.0/kg. Net profit and cost-benefit ratio (BCR) were calculated using the following formula:

Net profit = Total return – total cost

BCR = Total return/total cost

Survival rate, growth and yield variables were analyzed using one way analysis of variance (ANOVA) to compare the treatments means. If the main effect showed significant, the ANOVA was followed by Duncan's Multiple Range Test (DMRT) (Zar 1984). All ANOVA were tested at 5% level of significance using SPSS (Statistical Package for Social Science) version 20.

Results and Discussion

Final weight of tilapia was the highest in T_3 (307.33 g) followed by T_2 (238.5 g), T_1 (216.33 g) and T_4 (175.07 g), respectively (Table 1 and Fig. 2). These results of the present study are consistent with the findings of Ahmed *et al*. (2014), who found final weight of tilapia as 207.90 - 271.48 g at 50/m^3 densities over 120 days rearing in suspended cages fed commercial diet supplemented with probiotics at Dakatia river, Chandpur, Bangladesh. Begum *et al.* (2017) also demonstrated final weight of tilapia attained from 202.45 - 275.88 g for 120 days reared in net cages supplied floating feed with probiotics at a pond of Sylhet Agricultural University (SAU), Bangladesh, which is comparatively lower than the findings of the present study.

Daily weight gain of monosex tilapia in the present study was recorded from 1.34 - 2.42 g by rearing for 120 days at 35 no./m^3 density and supplemented with floating feed. Ahmed *et al*. (2014) calculated daily weight gain of 1.45 - 1.98 g using commercial floated feed with probiotics in cages at Dakatia river and Begum *et al.* (2017) reported daily weight gain of monosex tilapia attained from 1.69 - 2.30 g for 120 days reared in net cages

supplied floating feed with probiotics at a pond of SAU. So daily weight gain of tilapia in the present study is similar with the findings of above mentioned researchers.

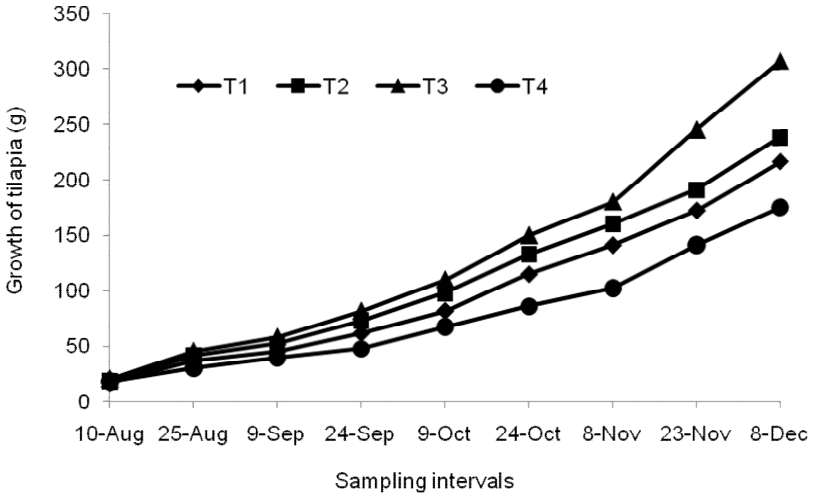

Fig. 2. Growth rate of tilapia (*O. niloticus*) under four treatments in *haor* environment.

In the present investigation, food conversion ratio (FCR) of tilapia ranged between 1.16 and 1.63 (Table 1). During the study period the FCR in four treatments were 1.31, 1.20, 1.16 and 1.63 in T_1, T_2, T_3 and T_4, respectively. The findings of the present study are coincided with the findings of Dev (2015), Ahmed *et al*. (2014) and Begum *et al.* (2017), who recorded FCR of tilapia in cage culture as 1.18 to 1.25, 1.11 to 1.41 and 1.01 to 1.38, respectively. Significantly higher protein efficiency ratio (PER) of tilapia was found in T_3 (2.87) compared to T_4 (2.05), T_1 (2.55) and T_2 (2.78), respectively. The observed PER values are in agreement with the findings of Begum *et al*. (2017), who recorded PER 2.26-3.10 in cage culture.

Specific growth rate (SGR) of tilapia varied from 2.09 - 2.43%. SGR was comparatively higher in T_3 (2.43%) than those of T_2 (2.29%), T_1 (2.15%) and T_4 (2.09%), respectively (Table 1). The observed SGR values are higher than the findings of Ahmed *et al*. (2014), who recorded 1.52 - 1.74% in Dakatia river. In earthen pond, Diana *et al*. (1996) recorded SGR of *O. niloticus* as 3.10% using feed and fertilizer in Thailand and Ahmed *et al.* (2013) reported SGR of monosex tilapia as 3.09% using prepared feed (55.24% protein). These findings are higher than that of the present study.

Table 1. Growth, survival rate and yield (mean±SD) of *Oreochromis niloticus* (monosex) in different treatments with probiotics.

Parameters	Treatments			
	T_1 (Brand a)	T_2 (Brand b)	T_3 (Brand c)	T_4 (Control)
Stocking density (nos./m^3)	35	35	35	35
Average initial weight (g)	16.33±3.15	15.33±2.75	16.66±3.48	14.33±6.41
Average final weight (g)	216.33^{c} ± 7.52	238.5^{b} ± 11.19	307.33^{a} ± 33.92	175.07^{d} ± 18.66
Daily weight gain (g)	1.67	1.86	2.42	1.34
FCR	1.3^{b}	1.20^{bc}	1.16^{c}	1.63^{a}
PER	2.55	2.78	2.87	2.05
Survival rate (%)	91.9^{b}±3.72	97.1^{a}±5.57	97.6^{a}±4.90	91.4^{b}±2.95
Specific growth rate (%/day)	2.15^{c}	2.29^{b}	2.43^{a}	2.09^{d}
Yield (kg/m^3)	6.95^{c}±0.88	8.10^{b}±1.08	10.5^{a}±1.15	5.60^{d}±0.71

Mean values in the same row with same superscript letters are not significantly different ($p > 0.05$).

Survival rate of male tilapia in this study was 91.4 - 97.6% (Table 1). Higher survival of tilapia was found in T_3 (97.60%) followed by T_2 (97.10%), T_1 (91.90%) and T_4 (91.40%). Survival rate of caged tilapia ranged from 95.76 - 97.54% (Ahmed *et al*. 2014) and from 95.39 - 95.87% (Dev 2015), which are comparable to that of present study. Begum *et al.* (2017) obtained the survival rate of tilapia in cage culture as 89.52 - 91.43%, which is slightly lower than the present findings.

Yield of tilapia obtained from all treatments ranged from 5.60 - 10.5 kg/m^3 with the highest yield (10.5 kg/m^3) in T_3 and the lowest yield (5.60 kg/m^3) in T_4 (Table 1). The observed yield was higher than the findings of Begum *et al.* (2017), who recorded 6.35 - 8.82 kg/m^3 in a freshwater pond. But the finding of the present study is slightly lower than the finding of Moniruzzaman *et al*. (2015), who obtained 12.4 kg/m^3 tilapia production from cages at 50/m^3 densities at Kaptai lake.

Profit of tilapia farming in the present study was the highest (TK.798.96 ± 90.85/m^3) in T_3 followed by T_2 (TK.565.63 ± 94.0/m^3), T_1 (TK.433.26 ± 39.9/m^3) and T_4 (TK. 298.22 ± 80.7/m^3). The lowest profit (TK.298.22 ± 80.7/m^3) was found in controlled treatment (without probiotics, T_4) (Fig. 3). Benefit cost ratio (BCR) was also highest in T_3 (2.90) followed by T_2 (2.39), T_1 (2.08) and T_4 (1.79) indicating that highest benefit was obtained from the treatment of brand c probiotics (T_3) since it contains three beneficial bacteria and utilize supplied feed very efficiently. So it may be concluded that brand c probiotics (T_3) is better among four treatments in respect of survival rate, growth and fish yield.

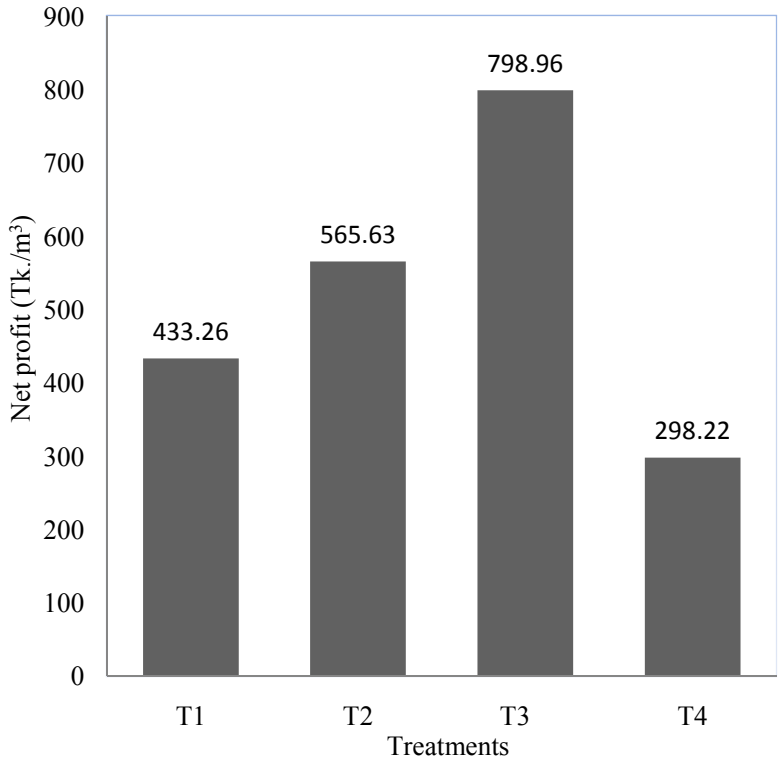

Fig. 3. Net profit of tilapia farming under four treatments in Dekar *haor*.

Table 2. Water quality parameters (mean±SD) recorded from cages under different treatments during the study period of August- December 2016.

Parameters	Treatments			
	T_1 (Brand a)	T_2 (Brand b)	T_3 (Brand c)	T_4 (Control)
Temperature (^oC)	29±1.8	29.1±1.9	28.9±1.8	28.7±1.9
Transparency (cm)	35.23±1.48	34.17±1.25	33.34±1.52	36.24±1.31
Dissolved Oxygen (mg/l)	6.49±0.81	6.68±0.79	6.88±0.80	6.11±0.75
pH	6.85 (7.0-7.5)	6.73 (7.0-7.4)	6.50 (7.0-7.4)	7.02 (7.0-7.4)
Total alkalinity (mg/l)	118.10±5.62	122.11 ± 4.70	127.20 ± 6.60	121.12 ± 5.40
NH_3-N (mg/l)	0.09±0.002	0.05±0.001	0.01±0.002	0.10±0.005

Environmental parameters (water temperature, transparency, dissolved oxygen, pH, alkalinity and ammonia) of the study are presented in Table 2. Values of water temperature in the present study were 28.7 - 29.1^{o}C. Begum *et al*. (2017) and Dev (2015)

recorded the temperature of a pond in SAU campus as 26.8 - 30.9 and 28.5°C, respectively. These findings are similar to the findings of the present study. Water transparency in the study ranged from 33.34 - 36.24 cm. The finding of present study is similar with the findings of Begum *et al.* (2017) and Dev (2015), who recorded transparency of 30.0 - 40.9 cm and 30-40 cm, respectively. Concentrations of dissolved oxygen of the study were 6.11 to 6.88 mg/l, which is similar to the findings of Begum *et al.* (2017) and Dev (2015), who recorded dissolved oxygen as 4.5 - 6.1 mg/l and 5.25 mg/l, respectively at SAU ponds. Water pH of this study varied from 6.5 - 7.02. The findings of the present study are in agreement with the pH values of 7.0 - 7.5 obtained by Begum *et al.* (2017). Values of total alkalinity were in the range of 118.10 - 127.20 mg/l in all cages. Begum *et al.* (2017) recorded total alkalinity were ranging from 80.0-85.7 mg/l in cages in SAU pond. Mairs (1966) stated that waterbodies having alkalinity 40 ppm or more are considered more productive than waterbodies of lower alkalinity. So the findings of the present study are within suitable ranges. Concentrations of ammonia nitrogen in all treatments varied between 0.01 and 0.10 mg/l. Begum *et al.* (2017) recorded 0.018 mg/l ammonia concentration in the SAU research pond. Meade (1985) stated that the permissible level is higher than the value of 0.012 mg/l commonly accepted by fish culturists. Ammonia values of the present study were within the accepted level (> 0.012 mg/l).

Open waterbodies are directly/indirectly connected with one another. There is a great scope to introduce tilapia cage farming in the open waterbodies without disturbing the water environment. Introduction of tilapia cage culture system in the open waterbodies can enhance the fish yield to a significant level. Results of the study imply that brand c probiotics (T_3) is better among four treatments from the viewpoint of survival rate, growth, yield and economic benefit. Therefore, it may be suggested to apply probiotics in tilapia cage farming in open/perennial waterbodies for increasing fish production with high profit.

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References

Ahmed, G.U., N. Sultana, M. Shamsuddin and M.B. Hossain. 2013. Growth and production performance of monosex tilapia (*Oreochromis niloticus*) fed with homemade feed in earthen mini ponds. *Pakistan Journal of Biological Science*. **16**(23): 1781-1785.

Ahmed, T., S.J. Hasan, M.R.A. Hossain, I. Haidar, A.K.M.S.A. Rubel and M.H. Pramanik. 2014. Assessment on impact of dietary probiotic supplementation on growth indices of monosex

tilapia (*Oreochromis niloticus*) cage culture at Dhakatia river, Chandpur, Bangladesh. *World Journal of Fish and Marine Sciences* **6**(5): 441-446.

APHA (American Public Health Association). 2000. Standard methods for the examination of water and waste water. 18th ed., APHA, Washington, D. C.

Balcazar, J., A. Aguirre, G. Gomez and W. Paredes. 2006. Culture of hybrid Red tilapia (*Oreochromis mossambicus* × *Oreochromis niloticus*) in marine cages: Effects of stocking density on survival and growth. University of Zaragoza, Zaragoza, Spain.

Ballarin, J.D. and R.D. Hallar. 1982. The intensive culture of tilapia in tanks, raceway & cages. Recent advanced in aquaculture, West view press, Boulder, Colorado, USA. pp. 265-355.

Begum, N., M.S. Islam, A.K.M.F. Haque and I.N. Suravi. 2017. Growth and yield of monosex tilapia (*Oreochromis niloticus*) in floating cages fed commercial diet supplemented with probiotics in freshwater pond, Sylhet. *Bangladesh Journal of Zoology* **45**(1): 27-36.

Beveridge, M.C.M. 1987. Cage aquaculture. Fishing News Books Ltd. Farnhan, Surrey, England.

Dev, A.R. 2015. Comparison of production performance and economics between mono-sex and mixed-sex tilapia (*Oreochromis niloticus*), MS Thesis, Department of Aquatic Resource Management, Faculty of Fisheries, SAU, Sylhet. pp. 48-51.

Diana, J.S., C.K. Lin and Y. Yi. 1996. Timing of supplemental feeding for tilapia production. *Journal of the World Aquaculture Society* **27**: 410-419.

DoF (Department of Fisheries). 2017. National Fish Week Compendium (in Bengali). Ministry of Fisheries and Livestock, Dhaka, Bangladesh. 160pp.

FAO (Food and Agriculture Organization). 2004. Fish Stat Plus. Aquaculture Production 1950-2002.

Fitzsimmons, K. 2004. Development of new products and markets for the global tilapia trade. *In:* Bolivar, R., G.Mair and K. Fitzsimmonas (Editors), Proceeding of the 6th International Symposium on Tilapia in Aquaculture, Manila, Philippines. pp. 624-633.

Gatesoupe, F.J. 1999. The use of probiotics in aquaculture. *Aquaculture* **180**: 147-165.

Geovanny, G.R., B.J. Luis and M. Shen. 2007. Probiotics as control agents in aquaculture. *Journal of Ocean University of China* **6**(1): 76-79.

Hussain, M.G. 2004. Farming of tilapia: Breeding plans, mass seed production and aquaculture techniques. 149pp.

Islam, M.L., H.K. Pal and M.J. Alam. 2008. Effectiveness of commercial probiotics as a biotechnological tool for shrimp (*Penaeus monodon*) health management. Project Completion Report, Bangladesh Fisheries Research Institute, Brackishwater Station, Paikgacha, Khulna, Bangladesh. 15pp.

Mairs, D.F. 1966. A total alkalinity atlas for marine lake waters. *Limnological Oceanography* **11**: 68-72.

Meade, J.W. 1985. Allowable ammonia for fish culture. *Prog. Fish Cult*. **47**: 135-145.

Moniruzzaman, M., K.B. Uddin, S. Basak, Y. Mahmud, M. Zaher and S.C. Bai. 2015. Effects of stocking density on growth, body composition, yield and economic returns of monosex tilapia (*Oreochromis niloticus*) under cage culture system in Kaptai lake of Bangladesh. *Journal of Aquaculture Research and Development* **6**: 4-7.

MPHA (Master Plan of *Haor* Areas). 2012. Ministry of Water Resources. Government of Peoples Republic of Bangladesh. Volume 1, Summary Report, April 2012.

Ponzoni, R.W., A. Hamzah, T. Saadiah and N. Kamaruzzaman. 2005. Genetic parameters and response to selection for live weight in the GIFT strain of Nile tilapia (*Oreochromis niloticus*). *Aquaculture* **247**: 203-210.

Pechsiri, J., A. Yakupitiyage. 2005. A comparative study of growth and feed utilization efficiency of sex-reversed diploid and triploid Nile tilapia (*Orechromis niloticus* L.). *Aquaculture Research* **36**: 45-51.

Zar, H. 1984. Biostatistical Analysis. Printice Hall Inc, Englewood Clifts. New Jersey, 592. pp.

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PREVALENCE OF FUNGI WITH SEEDS OF TWENTY BRRI RELEASED RICE VARIETIES AND SEED QUALITY ANALYSIS*

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Abstract

A total of 20 rice varieties of BRRI dhan 56 to BRRI dhan 75 were collected from Bangladesh Rice Research Institute (BRRI) for seed quality analysis, detection and identification of fungi associated with seeds of selected rice varieties. Dry inspection indicated that the percentage of pure seeds ranged from 90 - 100. The highest percentage of pure seed was found in BRRI dhan 66 and BRRI dhan 70 (100) and lowest in BRRI dhan 68 (90). A total of 21 fungal species were isolated from the selected rice varieties following "Blotter and Tissue Planting" methods. They were *Alternaria padwickii, A. tenuissima, Aspergillus flavus, A. fumigatus, A. niger, A. ochraceus, A. clavatus, A. terreus, Bipolaris sorokiniana, B. spicifera, Chaetomium globosum, Curvularia lunata, Drechslera oryzae, Fusarium* sp.1*, Fusarium* sp. 2*, Nigrospora* sp.*, Penicillium* sp.*, Pestalotiopsis guepinii, Rhizopus stolonifer, Syncephalastrum racemosum* and *Trichoderma viride*. Among them *Penicillium* sp., *Drechslera oryzae, Aspergillus ochraceus, A. flavus*, *A. fumigatus*, *A. niger* and *Fusarium* sp.1 were predominant in most of the rice varieties. In Tissue Planting method *Drechslera oryzae* showed the highest mean per cent frequency (6.69) and lowest was in the *Bipolaris sorokiniana* (0.41). Maximum total fungal association was recorded in variety BRRI dhan 61 (156.79%) and minimum in BRRI dhan 66 (24.69%). In Blotter method *Penicillium* sp. showed the highest mean per cent frequency (7.56) and lowest was in *Rhizopus stolonifer* (1.71). Maximum total fungal association was recorded in BRRI dhan 63 (147.37%) and minimum in BRRI dhan 65 (19.21%). Germination percentage of seeds was highest in BRRI dhan 66 (88) followed by BRRI dhan 67 (82), BRRI dhan 74 (80) and lowest in BRRI dhan69 (24). The percentage of seedling mortality was highest in BRRI dhan 63 (42) and lowest in BRRI dhan 74 (8.0) followed by BRRI dhan 67 (10). Correlation coefficient and regression analysis indicated that prevalence of fungi has significant effect on seed germination and seedling mortality. The present research work suggests that out of 20 BRRI rice varieties, BRRI dhan 65, BRRI dhan 66, BRRI dhan 67 and BRRI dhan 74 showed better performances on the basis of percentage of pure seed, fungal association, seed germination and seedling mortality.

Key words: Prevalence, Fungi, BRRI rice, Seed quality, Germination percentage

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Introduction

Rice (*Oryza sativa* L.) is one of the most important food crops mostly grown in tropical and sub-tropical climates. It is the main staple food of Bangladeshi people which covers 92% of food grain production and 75% of the total cultivable land (Ahmed *et al.* 2013). Among the rice growing countries, Bangladesh rank fourth to China, India and Indonesia both in acreage and production (Anon. 2003). The average per hectare production of rice in Bangladesh is extremely low as compared to other rice growing countries of the world (BBS 2012). Rice provides 76% of calorie and 66% of total protein requirement of daily food intake (Bhuiyan *et al*. 2002). In Bangladesh, more than 78 hybrid rice varieties are grown (Bhandari *et al.* 2011).

Rice suffers from more than 60 different diseases. In Bangladesh, 43 diseases are known to occur on the rice crop. Among them 27 are seed borne of which 14 are of major importance. Rice seed plays an important role to carry pathogen in quarantine. Fungi are the principal organisms associated with seed in storage. Of the seed borne diseases of rice, 22 are caused by fungi (Fakir *et al*. 2002). The destructive seed-borne fungal diseases of rice are brown spot (*Drechslera oryzae* and *Bipolaris sorokiniana*), bakanae (*Fusarium moniliforme*), blast (*Pyricularia oryzae*), sheath blight (*Rizoctonia solani*), sheath rot (*Sarocladium oryzae*) and stem rot (*Sclerotium oryzae)* cause yield reduction, quality deterioration and germination failure (Haque *et al.* 2007). To avoid the infection of foreign pathogen and to develop better rice variety, Bangladesh Rice Research Institute (BRRI) has been trying since last few decades. As a result 75 rice varieties have been released from BRRI since 2015 but information about the seed quality status of these rice varieties is inadequate. The storage fungi grow vigorously and initiate grain spoilage. These also bring about several undesirable changes making them unfit for consumption and sowing. So far no pathological investigation has been done on 20 (BRRI dhan 56 BRRI dhan 75) released rice varieties. Therefore, the present investigation was undertaken to find out seed borne mycoflora of the 20 BRRI released rice varieties and their seed quality status.

Materials and Methods

Seeds of 20 BRRI released rice varieties (BRRI dhan 56 to BRRI dhan 75) were collected from Genetic Resources and Seed Division of Bangladesh Rice Research Institute during January 2015 to July, 2016, were kept in brown paper bag and stored immediately in a dry safe place in the laboratory until used for the experiments. One hundred gm seeds of each sample were visually inspected to analyze the seed quality. In a clean laboratory table, the seeds of each working sample were separated and the seeds were separated then graded into different categories (Table 1).

Per cent purity of seeds was determined according to the following formula (Khatun and Shamsi 2016):

$$\text{Per cent purity of seed} = \frac{\text{Weight of pure seed}}{\text{Total weight of seed}} \times 100$$

The fungi associated with rice seeds were isolated following "Tissue planting method" (Anon. 1968) and "Blotter method" (Anon. 1996).

Identification of the fungal isolates was determined based on morphological characteristics observed under a compound microscope following the standard literatures (Benoit and Mathur 1970, Booth 1971, Ellis 1971, 1976 and Barnett and Hunter 2000). Per cent frequency of the occurrence of the fungal isolates was calculated by adopting the formula of Spurr and Wetly (1972). Seedling mortality was determined after ten days of incubation by the formula of Anon. (2014).

Interrelationships among storage mycoflora, seed germination, purity and seedling mortality of different varieties of rice seeds were measured through correlation and regression analysis (Steel and Torrie 1960, Khatun and Shamsi 2016).

Results and Discussion

To analysis of seed quality, the percentage of normal and abnormal rice seeds is presented in Table 1. According to Seed Certification Agency (SCA) the accepted range of pure seed of rice is 96 to 99% in Bangladesh. Dry inspection indicated that the percentage of pure seeds ranged from 90 to 100. The highest percentage of pure seed was found in the varieties of BRRI dhan 66 and BRRI dhan 70 (100) and lowest was recorded in BRRI dhan 68 (90). The highest percentage of spotted seed was recorded in the variety of BRRI dhan 62 (2.50) and lowest in BRRI dhan 68 (0.10). The highest percentage of discolored seeds was found in the variety of BRRI dhan 64 (6.25) and lowest in BRRI dhan 73 (0.20). The highest percentage of weed seeds was found in the variety of BRRI dhan 72 (0.70) and lowest in BRRI dhan 64 (0.05). The highest percentage of inert materials was found in the variety of BRRI dhan 61 (1.30) and lowest in BRRI dhan 69 (0.10).

Table 1. Per cent incidence of different types of rice seeds in dry seed inspection.

Name of varieties	Pure seed	Spotted seed	Discolored seed	Weed seeds	Inert materials
BRRI dhan 56	98.00	0.40	1.00	-	0.60
” ” 57	99.00	-	1.00	-	-
” ” 58	97.00	0.60	1.50	0.50	0.40
” ” 59	99.00	-	1.00	-	-
” ” 60	92.00	2.00	5.00	0.10	0.90
” ” 61	94.00	1.70	3.00	-	1.30
” ” 62	92.00	2.50	4.50	0.50	1.50
” ” 63	98.00	-	1.90	-	0.10
” ” 64	92.00	0.50	6.25	0.05	1.20
” ” 65	92.00	0.40	1.20	0.30	0.20
” ” 66	100	-	-	-	-
” ” 67	99.00	-	1.00	-	-
” ” 68	90.00	0.10	9.40	-	0.50
” ” 69	96.00	0.20	1.30	0.20	0.10
” ” 70	100	-	-	-	-
” ” 71	99.00	-	1.00	-	-
” ” 72	99.00	-	0.30	0.70	-
” ” 73	99.00	-	0.20	-	0.80
” ” 74	99.00	-	1.00	-	-
” ” 75	98.00	0.20	1.10	-	0.70

Naher *et al.* (2016) made dry seed inspection on BR11, BRRI dhan 30 and BRRI dhan 33 rice varieties. They reported that out of three varieties the highest percentage (83.35) of pure seed was in BRRI dhan 30. They also reported that the lowest percentage of spotted (2.75) and discolored seed (2.16) was in BRRI dhan 30 and BR11, respectively.

A total of 21 seed borne fungi were isolated from the selected BRRI rice varieties following tissue planting method (Table 2). The highest frequency percentage of *A. padwickii* and *P. guepenii* was noticed in BRRI dhan 60; *A. tenuissima, A.flavus, A. terreus* and *S. racemosum* on BRRI dhan 74, *A. fumigatus, B. spicifera, Fusarium* sp.1 on BRRI dhan 73, *A. niger* and *Fusarium* sp. 2 in BRRI dhan 65, *D. oryzae* and *Penicillium* sp. in BRRI dhan 61, *A.clavatus* on BRRI dhan 75, *C.globosum* in BRRI dhan 56*, C. lunata* and *Nigrospora* sp. in BRRI dhan 63*, R. stolonifer* in BRRI dhan 67 and *T. viride* in BRRI dhan 63. Among these fungi *D. oryzae, A. ochraceus*, *A. flavus, Penicillium* sp. and *A. fumigatus* were predominant in most of the rice varieties (Table 2).

More than ten species of fungi were found to be associated with BRRI dhan 57, BRRI dhan 61 and BRRI dhan 63 varieties (Table 2). Maximum total fungal association was recorded in BRRI dhan 61 (156.79%), BRRI dhan63 (136.5%), BRRI dhan 60 (130.5) BRRI dhan 57 (108.52%) and BRRI dhan 74 (104.49%) whereas minimum was

Table 2. Per cent frequency of fungi with different varieties of BRRI rice seeds in tissue planting method.

Name of fungi	Name of rice varieties																				
	BRRI dhan 56	BRRI dhan 57	BRRI dhan 58	BRRI dhan 59	BRRI dhan 60	BRRI dhan 61	BRRI dhan 62	BRRI dhan 63	BRRI dhan 64	BRRI dhan 65	BRRI dhan 66	BRRI dhan 67	BRRI dhan 6 68	BRRI dhan 69	BRRI dhan 70	BRRI dhan 71	BRRI dhan 72	BRRI dhan 73	BRRI dhan 74	BRRI dhan 75	Mean
Alternaria padwickii	-	9.61	6.45	-	13.84	-	-	8.8	-	-	-	6.45	12.35	-	-	6.67	-	-	3.22	-	3.38
A. tenuissima	10.71	-	-	14.28	-	-	-	18.42	-	-	-	-	-	-	7.14	-	-	-	21.42	-	3.59
Aspergillus niger	-	-	-	-	-	5.12	-	-	19.04	-	-	-	-	-	-	-	-	-	-	20.5	2.23
A. flavus	13.43	12.9	5.97	-	-	15.9	5.22	1.4	2.98	4.47	-	1.49	-	5.22	8.95	2.98	2.98	-	23.07	6	5.64
A. fumigatus	10.68	-	9.16	4.58	8.1	3.05	-	-	4.58	7.63	8.1	-	2.29	-	8.39	3.05	4.58	22.2	7.63	5.34	5.27
A. niger	- -	11.02	5.76	7.6	6.7	10.38	3.84	-	-	16.42	7.6	-	-	3.84	-	-	-	5.76	10.5	7.6	4.83
A. ochraceus	2.72	8.16	-	14.96	16.92	28.2	10.2	8.16	4.08	-	6.8	-	2.72	5.22	-	5.76	6.73	6.8	-	-	6.37	
A. terreus	-	7.4	-	-	-	11.45	3.7	11.11	-	-	-	3.7	-	-	-	7.4	14.81	-	21.42	-	4.04
Bipolaris oryzae	-	-	-	-	3.30	2.10	-	-	-	-	-	-	-	-	-	-	-	3.00	-	-	0.41
B. sorokiana	-	-	-	-	12.08	13.57	-	-	-	-	-	-	-	-	-	-	-	20.02	-	-	2.23
Curvularia geniculata	18.66	17.85	9.41	-	13.28	7.14	-	4.58	-	10.71	-	-	-	-	-	-	-	-	-	-	4.08
Curvularia lunata	-	11.76	-	-	17.64	6.52	-	18.51	-	-	-	-	-	-	5.88	-	-	-	-	-	3.01
Curvularia oryzae	5.59	2.79	6.29	7.69	-	23.52	-	13.28	11.18	5.59	4.19	5.22	5.22	-	-	16.78	12.58	7.6	-	6.2	6.69
Curvularia sp. 1	-	5.84	2.56	-	-	-	-	7.05	-	8.33	-	5.76	-	4.48	5.12	14.1	15.38	21.42	-	5.76	4.69
Curvularia sp. 2	-	-	-	-	22.1	5.56	-	-	-	22.3	-	-	-	-	-	-	5.55	-	-	-	1.78
Nigrospora sp.	-	-	-	8.14	-	-	-	12.85	-	-	-	-	-	-	-	-	-	-	-	-	1.04
Curvularia sp.	8.96	10.69	6.34	2.58	-	24.28	5.17	10.14	4.76	-	-	-	5.17	-	4.76	2.52	6.34	6.94	5.18	8.74	5.52
Curvularia species	-	-	-	-	18.57	-	-	9.52	-	12.8	-	-	-	-	-	-	-	-	-	-	2.04
Curvularia velosiella	5.78	-	-	-	-	-	-	-	-	-	-	10.57	4.1	-	-	-	-	-	-	6.52	1.34
Curvularia verruculosa	-	-	6.52	-	-	-	-	-	-	-	-	-	-	-	8.04	8.88	10.39	6.6	12.05	5.2	2.91
Drechslerella spp.	6.25	12.5	-	6.25	-	-	-	12.75	-	-	-	-	10.25	12.08	-	-	-	-	-	-	3.02
Total % frequency	82.78	108.5	58.46	66.08	130.5	156.7	26.1	136.5	46.62	88.25	24.69	33.19	42.1	30.84	48.28	68.14	79.34	99.74	104.49	71.86	

- Represents no growth of fungi.

in BRRI dhan 69 (30.84%), BRRI dhan 62 (26.13%) and BRRI dhan 66 (24.69%). In tissue planting method, Ora *et al.* (2011) found ten seed borne pathogens *viz., Alternaria tenuissima, Aspergillus flavus, A. niger, Bipolaris oryzae, Curvularia lunata, Fusarium moniliforme, Penicillium* sp., *Nigrospora oryzae, Rhizopus stolonifer* and *Xanthomonas* spp. associated with rice seeds. The highest incidence of *Xanthomonas* spp. was noticed on Tinpata whereas *Bipolaris oryzae* on Aloron, *Fusarium moniliforme* on ACI-1, *Rhizopus stolonifer* on Tia, *Alternaria tenuissima* on Hira-1, *Curvularia lunata* on Aloron, *Penicillium* sp. and *Aspergillus flavus* on BRRI hybrid dhan-1, *Aspergillus niger* on Taj-1 were observed. *Nigrospora* sp. was recorded only on Hira-1. Of all the pathogens *Xanthomonas* spp*., Bipolaris oryzae, Aspergillus* sp*., Fusarium moniliforme* and *Rhizopus stolonifer* were predominant.

In blotter method a total of 17 seed borne fungi were isolated from the selected BRRI rice varieties (Table 3). The highest frequency percentage of *A. padwickii* and *T. viride* was noticed in BRRI dhan 67; *Aspergillus niger* in BRRI dhan 56*, A. flavus* on BRRI dhan 68, *A. fumigatus* in BRRI dhan 64, *A. terreus, A. ochraceus* and *C. globosum* in BRRI dhan 61*, B. sorokiniana* and *P. guepenii* in BRRI dhan 71*, C. lunata* and *Fusarium* sp. 2 in BRRI dhan 63*, D. oryzae* and *R. stolonifer* in BRRI dhan 72*, Fusarium* sp.1 and *S. racemosum* in BRRI dhan 74 and *Penicillium* sp. in BRRI dhan 60 varieties (Table 3). *Penicillium* sp. showed the highest mean frequency percentage (7.56) of infection in 20 rice varieties which was followed by *A. fumigatus* (6.79), *A. flavus* (5.86), *D. oryzae* (5.24), *A. ochraceus* (4.99). Maximum total fungal association was recorded in BRRI dhan 63 (147.3%) whereas minimum was in BRRI dhan 65 (19.21%) variety.

Rahman *et al*. (2000) identified *Bipolaris oryzae, Trichoconis padwickii, Curvularia lunata, Nigrospora oryzae, Alternaria tenuis, Aspergillus* spp. and *Penicillium* spp. in BR 11 variety. Gopalakrishnan *et al*. (2010) conducted an experiment in India to identify the seed borne pathogen associated with rice seed and they recorded eight genera of fungi *viz*., *Alternaria, Aspergillus, Bipolaris, Chaetomium, Curvularia, Fusarium, Sarocladium* and *Trichoderma* comprising 12 species. Among them, the most predominant one was *Bipolaris oryzae* which was associated with 58.89% seed samples followed by *Alternaria padwickii* (52.96). In blotter method, Naher *et al.* (2016) detected six fungal species *viz., Alternaria padwickii, Aspergillus* spp*., Bipolaris oryzae, Curvularia lunata Fusarium moniliforme* and *Fusarium oxysporum* from the 3 rice varieties such as BR11, BRRI dhan 30 and BRRI dhan 33. In blotter method, Ora *et al.* (2011) found 12 seed borne pathogens *viz.*, *Alternaria tenuissima, Aspergillus* spp, *Bipolaris oryzae, Chaetomium globosum, Curvularia lunata, Fusarium moniliforme, Penicillium* sp*., Phoma* sp*., Nigrospora oryzae, Rhizopus stolonifer, Tilletia barclyana* and *Xanthomonas oryzae*. Of all the pathogens *Xanthomonas* spp, *Rhizopus stolonifer, Aspergillus* spp. *Bipolaris oryzae and Fusarium moniliforme* were predominant.

Table 3. Per cent frequency of fungi with different varieties of BRRI rice seeds in blotter method.

Name of fungi	Name of BRRI rice varieties																				
	BRRI dhan 56	BRRI dhan 57	BRRI dhan 58	BRRI dhan 59	BRRI dhan 60	BRRI dhan 61	BRRI dhan 62	BRRI dhan 63	BRRI dhan 64	BRRI dhan 65	BRRI dhan 66	BRRI dhan 67	BRRI dhan 68	BRRI dhan 69	BRRI dhan 70	BRRI dhan 71	BRRI dhan 72	BRRI dhan 73	BRRI dhan 74	BRRI dhan 75	Mean
Alternaria pedicelli	-	-	-	-	12.5	-	-	-	-	-	-	18.75	-	-	-	-	-	14.5	-	-	2.26
Aspergillus flavus	-	-	17.39	10	-	-	10	16.66	13.33	-	-	-	20	-	-	13.33	-	16.66	-	-	5.36
A. fumigatus	-	-	10.71	9.52	-	7.14	-	20	21.42	-	-	20.5	-	14.5	17.85	-	-	14.28	-	-	6.79
A. niger	30.78	14.04	-	-	-	-	-	-	-	8.69	-	19.39	-	-	-	8.69	-	-	-	-	4.07
A. ochraceus	5.71	20	-	-	-	17.14	-	8.57	-	-	5.71	-	-	11.42	-	-	17.14	-	14.28	-	4.99
A. terreus	-	-	-	-	-	30.33	-	17.14	9.52	-	-	-	-	-	-	-	-	-	-	-	2.84
Bipolaris sorokiniana	-	-	-	-	-	-	-	-	16.32	-	-	-	-	-	-	18.32	-	16	22	-	3.65
Chaetomium globosum	5.5	-	-	-	12.5	15.85	7.5	12.5	5.5	-	-	20	5	-	-	-	7.5	-	-	-	4.59
Curvularia lunata	-	12.18	-	-	-	-	-	16.36	-	-	-	-	-	-	-	10.27	-	-	-	-	1.94
Drechslera oryzae	10.52	-	12.5	-	7.14	11.9	-	2.38	4.76	10.52	-	-	-	-	-	11.9	14.28	4.76	-	14.28	5.24
Fusarium sp. 1	-	8.82	-	-	-	17.64	-	-	5.88	-	11.76	-		8.82	-	14.7	-	5.88	20.58	5.88	4.99
Fusarium sp. 2	-	-	-	-	10.9	-	17.64	23.52	-	-	-	-	-	11.76	11.76	-	-	-	-	-	3.77
Penicillium sp.	8.27	5.45	-	18.18	29.41	14.54	3.63	24.36	-	-	9.9	-	5.45	5.45	3.63	-	10.9	-	-	12.09	7.56
Pyricularia grisea	12.5	-	-	-	-	-	-	5.88	-	-	-	-	-	-	-	22.5	-	-	-	-	2.04
Rhizopus stolonifer	-	-	-	-	-	-	-	-	-	-	12.85	-	-	-	-	-	21.42	-	-	-	1.71
Sporophalas trunacemosum	-	20	-	-	6.66	-	-	-	-	-	-	-	-	-	-	13.33	-	18.90	26.66	-	4.27
Trichoderma viride	-	-	-	-	-	-	-	-	-	-	-	21.05	-	-	-	-	5.26	-	10.52	-	1.84
Total % frequency	73.28	86.49	40.6	37.7	79.1	114.5	38.77	147.3	76.73	19.21	40.22	99.69	30.4	51.95	33.24	113.0	76.5	90.98	94.04	32.25	

- Represents no growth of fungi.

The fungal association with rice seeds also effects germination, seedling mortality as well as seedling height (Table 4). Among twenty varieties, in BRRI dhan 74, the germination percentage was highest (98%) and in BRRI dhan 62 this was lowest (25%). The highest mortality percentage value of rice seedling was found in BRRI dhan 62 (16%) and the lowest value was found in BRRI dhan 74 (2.04%). The length of root was highest in BRRI dhan 72 (5.37cm) and lowest in BRRI dhan 62 (2.20cm), whereas shoot length was highest in BRRI dhan 73 (8.97 cm) and lowest in BRRI dhan 67 (4.56 cm).

Table 4. Per cent germination, seedling mortality and seedling height of rice seeds after ten days of incubation.

Name of varieties	Germination (%)	Mortality (%)	Seedling height (cm)	
			Root	Shoot
BRRI dhan 56	82	7.30	4.26	5.50
” ” 57	60	13.34	4.33	5.37
” ” 58	78	5.12	4.00	5.40
” ” 59	72	4.16	4.92	7.58
” ” 60	64	9.37	3.25	7.30
” ” 61	46	15.22	3.33	6.66
” ” 62	25	16.00	2.20	7.82
” ” 63	35	8.58	3.30	6.62
” ” 64	72	10.77	2.33	6.60
” ” 65	65	6.06	3.39	5.55
” ” 66	94	3.19	5.00	5.90
” ” 67	80	6.25	2.49	4.56
” ” 68	74	5.40	2.21	5.00
” ” 69	46	10.86	3.27	5.69
” ” 70	96	5.20	4.39	7.22
” ” 71	78	3.84	5.22	8.83
” ” 72	88	4.54	5.37	8.29
” ” 73	78	6.41	5.19	8.97
” ” 74	98	2.04	4.82	8.31
” ” 75	76	7.90	4.48	8.00

In case of Tissue Planting method Fig. IA shows the relationship between percentage of germination rate and occurrence of fungi and negative correlation between the two variables. Here regression line gives a downward sloping curve which means that germination of seeds decreases when the percentage of fungi increases or the germination of seed increases when the percentage of fungi decreases. In the present study, the correlation co-efficient value between percentage of fungi and percentage of germination was +0.216. Fig. 1B shows the relationship between occurrence of fungi and seedling mortality and positive correlation between the two variables. Here regression line gives an upward sloping curve which means that both the variable change in the same direction i.e. the mortality of seeds increases when the percentage of fungi increases. The correlation coefficient value between percentage of fungi and seedling mortality was +0.212.

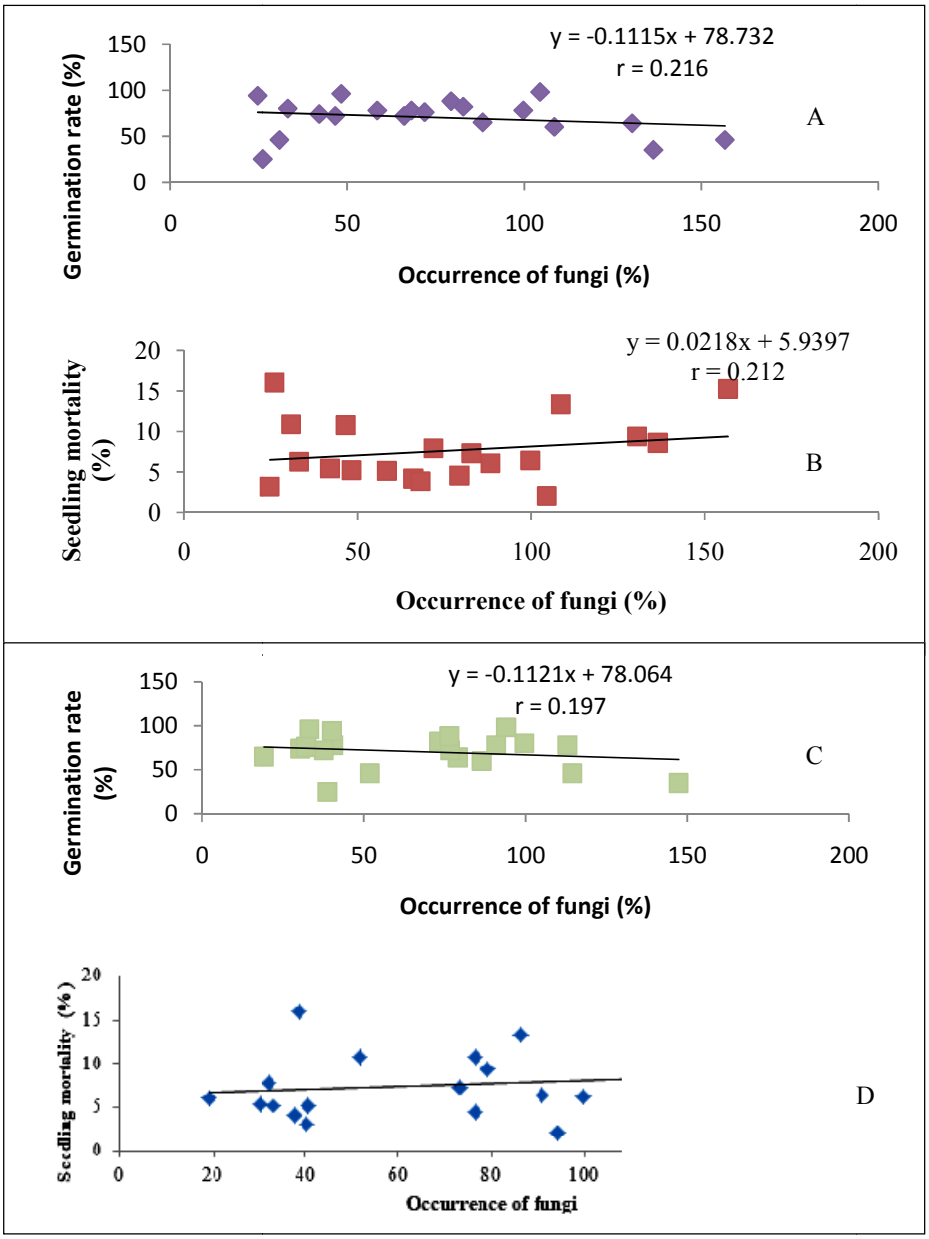

Fig. 1. For tissue planting method (A - B) correlation coefficient and regression equation between A = Germination rate (%) and occurrence of fungi (%), B = Seedling mortality (%) and occurrence of fungi (%); For blotter method (C - D) correlation coefficient and regression equation between C = Germination rate (%) and occurrence of fungi (%), D = Seedling mortality (%) and occurrence of fungi (%).

Similarly, for blotter method Fig. IC shows the relationship between percentage of germination rate and occurrence of fungi and negative correlation between the two variables. Here regression line gives a downward sloping curve which means that germination of seeds decreases when the percentage of fungi increase or the germination of seeds increases when the percentage of fungi decrease. In the present study, the correlation co-efficient value between percentage of fungi and percentage of germination was +0.197. Fig. 1D shows the relationship between occurrence of fungi and seedling mortality and positive correlation between the two variables. Here regression line gives an upward sloping curve which means that both the variable change in the same direction i.e. the mortality of seeds increases when the percentage of fungi increases. The correlation coefficient value between percentage of fungi and seedling mortality was +0.153.

In the present work a total of 21 fungal species were isolated from the seeds of selected twenty BRRI released rice varieties. Among these fungi *Penicillium* sp., *Drechslera oryzae, Aspergillus ochraceus, A. flavus*, *A. fumigatus*, *A. niger* and *Fusarium* sp.1 were predominant in most of the rice varieties. The present work also showed that occurrence of fungi had significant effect on the seed germination and seedling mortality. On the basis of percentage of purity, fungal association, seed germination and seedling mortality BRRI dhan 65, BRRI dhan 66, BRRI dhan 67 and BRRI dhan 74 showed better results out of 20 BRRI released rice varieties.

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References

Ahmed, M., M. Hossain, K. Hassan and C.K. Dash. 2013. Efficacy of different plant extract on reducing seed borne infection and increasing germination of collected rice seed sample. *Universal Journal of Plant Science* **1**(3): 66-73.

Anonymous. (Commonwealth Agricultural Bureau), 1968. *Plant pathologist's pocket book.*1st edition. The Commonwealth Mycological Institute, England. pp. 267.

Anonymous. 1996. International rules of seed testing assoc. *In*: *Proc. Int. Seed Test. Assoc.* pp. 19-41.

Anonymous. 2003. Production Yearbook, Food and Agriculture Organization, Rome, Italy, Vol. **56.**

Anonymous. 2014. International Rules for Seed Testing. International Seed Testing Association, Switzerland. pp. 10.

BBS 2012. *The Statistical Yearbook of Bangladesh* (BBS). Ministry of Planning. The People's Republic of Bangladesh. pp. 468.

Barnett, H.L. and B.B. Hunter. 2000. *Illustrated Genera of Imperfect Fungi.* 4th edn., Burges Pub., Co. Minneapolis. pp. 185.

Benoit, M.A. and S.B. Mathur.1970. Identification of species *Curvularia* on rice seed. *Proc. Inst. Seed Test. Assoc.* **35**(1): 1-23.

Bhandari, H., S. Mohanty and M. Mossain. 2011. Hybrid Rice in Bangladesh: Current Status and Future Project. *In: Proceedings of the 7th ASAE Conference 2011*, Hanoi, Vietnam. pp. 13-15.

Bhuiyan, N.I., D.N.R. Paul and M.A. Jabber. 2002. Feeding the extra millions by 2025 - challenges for rice research and extension in Bangladesh. A key note paper presented in the National Workshop on Rice Research and Extension-2002 held at BRRI, Gazipur, Bangladesh.

Booth, C. 1971. The genus *Fusarium.* The Commonwealth Mycological Institute, England. pp. 267.

Ellis, M.B. 1971. *Dematiaceous hyphomycetes.* The Commonwealth Mycological Institute, England. pp. 608.

Ellis, M.B. 1976. *More Dematiaceous hyphomycetes*. The Commonwealth Mycological Institute, England, 507. pp.

Fakir, G.A., I. Hossain, M.U. Ahmad, M. Asad-ud-Doullah and M. Alam. 2002. Quality of farmer's Boro and T. Aman rice seeds collected before sowing from Bogra, Rajshahi and Rangpur Districts of Bangladesh. A paper presented in the review and planning meeting of the rice seed health improvement (PETRRA) project, held on 21-22 April at BRRI, Gazipur, Bangladesh.

Gopalakrishnan, C., A. Kamalakannan and V.Valluvaparidasan. 2010. Survey of seed-borne fungi associated with rice seeds in Tamil Nadu, India. Libyan Agric. *Res. Cen. J. Intl.***1**(5): 307-309.

Haque, A.H.M.M., M.A.H. Akhon, M.A. Islam, K.M. Khalequzzaman and M.A. Ali. 2007. Study on seed health, germination and seedling vigor of farmers produced rice seeds. *Intl. J. Sustain. Crop Prod.* **2**(5): 34-39.

Khatun, A. and S. Shamsi. 2016. Estimation of interrelationship among seed germination, purity, seedling mortality and association of fungi with seeds of chickpea. *Bangladesh J. Bot.***45**(3): 693-698.

Naher, L., M.A. Aliand S. Sheheli. 2016. Effect of seed treatment on seed borne fungi of rice. *Progressive Agriculture* **27**: 48-56.

Ora N., A.N. Faruq, M.T. Islam, N. Akhtar and M.M. Rahman. 2011. Detection and identification of seed borne pathogens from some cultivated hybrid rice varieties in Bangladesh. *Middle-East Journal of Scientific Research* **10** (4): 482-488.

Rahman, A.J.M.K., M.M. Islam and M.A.T. Mia. 2000. Evaluation of cleaning methods to improve the quality of farmer's saved rice seed. *Bangladesh J. Plant Pathol.***16** (1& 2): 39- 42.

Spurr, H.W.J. and R.E. Wetly. 1972. Incidence of tobacco leaf microflora in relation to brown spot disease and fungicidal treatment. *Phytopathol.* **62**: 916-920.

Steel, R.G.D. and J.H. Torrie 1960. *Principles and Procedures of Statistics*. McGraw-Hill Book Co., New York, pp. xvi + 481.

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SOME ASPECTS OF REPRODUCTIVE BIOLOGY OF THE MUDSKIPPER *APOCRYPTES BATO* FROM THE COAST OF CHITAGONG

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Abstract

Some aspects of reproductive biology of the mudskipper *Apocryptes bato* (Hamilton 1822) from the coastal waters of Chittagong, Bangladesh was conducted. Disproportionate occurrence of male and female (1.20 : 1) was observed in the number of two sexes. A prolonged spawning season was found from June to early October with a single peak. The aspects in the ovary indicate one complete spawning of females in a single spawning season. The fecundity was found to vary from 7453 - 31195 with an average of 17590 ± 6867. Significant coefficient of correlation between the diameters of the eggs of corresponding anterior, middle and posterior regions of the right and left ovaries indicated the simultaneous release of eggs from both the ovaries. A much closer relationship of fecundity and the significant 't' values indicated fecundity increases with the increase of total length, standard length, body weight and gonad weight.

Key words: Sex ratio, Maturation, Spawning, Fecundity

Introduction

Apocryptes bato (Hamilton 1822) is a member of amphibious gobies of the family Gobiidae locally called 'Chiring' or 'Dali Chewa' in Bangladesh (Rahman *et al.* 2016). The species is widely distributed from the eastern coast of India to south-east Asia and Australia. It is found in shallow and exposed inter tidal mudflats of estuaries and mangrove swamps with other sympatric species is amphibious in nature (Daniel 2002, Shukla *et al.* 2014). Reproduction in most mudskippers follows a nuptial parade and elaborate courtship routine where the male leads the female to his burrow for mating after which eggs are deposited on the wall of the burrow (Chukwu *et al.* 2010, Brillet 1970). Studies of the reproductive biology are a prerequisite for sustainable management of a fisheries (Parvez and Nabi 2015). Hence the present study is designed to reveal the aspects of reproductive biology like sex ratio, maturity, spawning and fecundity of *A. bato* from the coast of Chittagong, Bangladesh.

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Materials and Methods

A total of 132 specimens were collected from *Fisheries Ghat* landing center and three local markets of Chittagong, Bangladesh during June, 2009 to February, 2010. Gravid individuals were sorted out for fecundity. The body length-weight and the gonad and liver weight were recorded. The eggs were taken at random from the anterior, middle and posterior region of both lobes of the ovaries. All the ovaries were preserved in 5% formalin and then the diameter of eggs were measured by ocular micrometer.

Sex ratio, period of maturity and spawning were determined from the Gonadosomatic Index (GSI), Hepatosomatic Index (HSI) and Condition factor (K) of both sexes. Fecundity was studied to assess the productive potential of the fish stock and relationship established with the body length, body weight and gonad weight of the fish. The ratio of sexes were tested by "F" test to distinguish the difference, if any, from the hypothetical ratio 1 : 1. The value of "F" was calculated by the formula:

$F = \frac{\mathrm{Sx}^2 . \delta \mathrm{x}^2}{\mathrm{Sy}^2 . \delta \mathrm{y}^2}$. where, $\mathrm{Sx}^2 = \frac{Nx}{Nx-1}.\mathrm{Sx}^2$ and

$\mathrm{Sy}^2 = \frac{Ny}{Ny-1}.\mathrm{Sy}^2$.

Here, Sx^2 = Sample variance, $\delta \mathrm{x}^2$ = Population variance,

Nx = Sample size for male and Sy^2 = Sample variance,

$\delta \mathrm{y}^2$ = Population variance, Ny = Sample size for female.

The GSI of the gonads of each fish were calculated using the formula,

$GSI = \frac{\text{Gonadal weight}}{\text{Total weight}} \times 100$, (King 1995). HSI was calculated by the formula, $HSI = \frac{\text{Weight of liver}}{\text{Gutted weight of body}} \times 100$, (El-Boray 2004) and K was calculated by the formula, $K = \frac{\text{Body weight - Gonad weight}}{(\text{Length})^3} \times 100$ (Nabi 1994).

The pre-spawning, spawning and post spawning periods were determined critically after assessing the month-wise values GSI, HSI and K. Stages of maturity were determined from the weight, colour, shape, and transparency of the gonad, GSI, ova diameter and consistency of the ovary. For estimation of fecundity the gravimetric method was followed after McGregor (1922) and value of fecundities presented as the total number of eggs in both the ovaries followed by Healy and Nicol (1975). Total number of eggs for fish was calculated from the sample mean and the total weight of the ovary. Arithmetic relationships were, fecundity (F) – total length (TL) : F = a + b TL, fecundity (F) – standard length (SL) : F = a + b SL, fecundity (F) – body weight (BW) : F = a + b BW, fecundity (F) – gonad weight (GW) : F = a + b GW, the coefficient of correlations (r)

were calculated and the regression lines were derived following the method of least square (LeCren 1951, Hartman and Conkle 1960). The significance of r was tested at 5% level of significance. Value of 't' was calculated with (n – 2) degrees of freedom from the formula: $t = \frac{r\sqrt{n-2}}{\sqrt{(1-r^2)}}$.

Results and Discussion

The sex ratio of male to female was found as 1.20: 1, showing dominance of male over female. The monthly occurrence and different standard length group wise distribution of male and female is represented in Fig. 1. The monthly distribution and different standard length group wise distribution of male and female *A. bato* were tested by 'F' test and the calculated value of 'F' was found 16.50 and 6.66, respectively for both distributions which were highly significant at 5% level of significance.

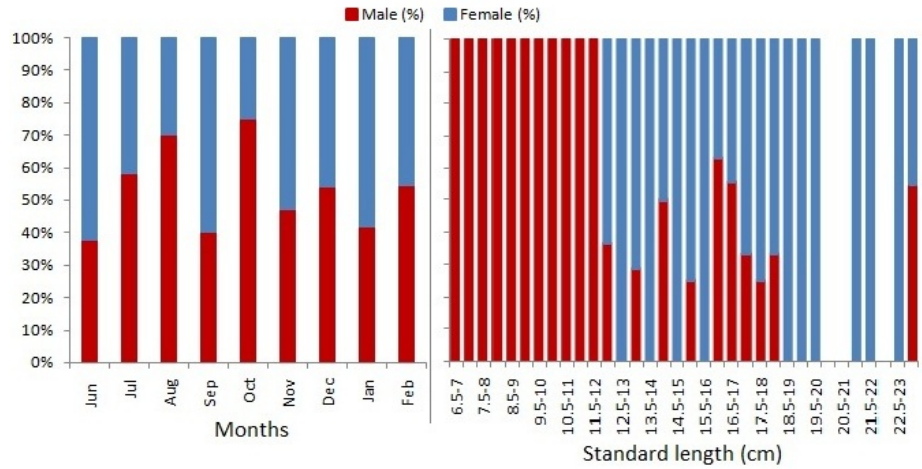

Fig. 1. Monthly and standard length group wise distribution of male and female *A. bato*.

Difference in the number of males and females of *A. bato* disagrees with the universal hypothesis that the number of individual of two sexes of a species in an ecosystem should be 1.0 : 1.0. This hypothesis is not found for all organisms as the dominance in number of male over female or *vice versa* of a population depends on the surrounding ecological environment (Parvez and Nabi 2015). Disproportionate occurrence in the number of two sexes of *A. bato* agrees with Chukwu *et al.* (2010) for *Preophthalmus barbarus* and Hoda and Akhtar (1982) in the case of *Boleophthalmus dentatus* but disagrees slightly with the report of Murdy (1989) on the same species and on the *P. papilio* where females were found significantly more than the males with a ratio of 1 male to 1.42 females in Lagos lagoon, Nigeria (Lawson 2010). Dominance of the males over the females during the spawning period (except the months August and September) may be due to the requirement of higher number of males for successful mating.

Monthly changes were found to occur in the GSI, HSI and K both for male and female (Fig. 2, Table -1). The gradual changes in the weight of the testes and ovary were uniform and more or less parallel.

Table 1. Average value of GSI, HSI and K (percentages with mean and standard error of mean are given) of male and female *A. bato*.

	Male			Female		
	GSI ± S.E.	HSI ± S.E.	K ± S.E.	GSI ± S.E.	HSI ± S.E.	K ± S.E.
Jun.	0.94 ± 0.49	0.30 ± 0.06	0.41 ± 0.24	11.55 ± 0.98	1.55 ± 0.13	0.47 ± 0.05
Jul.	0.60 ± 0.27	0.39 ± 0.07	0.41 ± 0.17	4.48 ± 0.76	0.62 ± 0.19	0.45 ± 0.07
Aug.	0.79 ± 0.28	0.24 ± 0.13	0.54 ± 0.17	3.25 ± 0.26	0.36 ± 0.27	0.30 ± 0.07
Sep.	1.21 ± 0.60	0.13 ± 0.05	1.07 ± 0.22	3.55 ± 0.97	0.46 ± 0.19	0.53 ± 0.11
Oct.	1.62 ± 0.41	0.58 ± 0.24	1.00 ± 0.09	7.89 ± 0.96	1.12 ± 0.15	0.45 ± 0.17
Nov.	1.24 ± 0.50	0.24 ± 0.04	0.78 ± 0.17	7.15 ± 0.89	0.91 ± 0.19	0.37 ± 0.06
Dec.	0.17 ± 0.06	0.23 ± 0.03	0.89 ± 0.07	3.05 ± 0.61	0.67 ± 0.21	0.49 ± 0.08
Jan.	0.08 ± 0.02	0.40 ± 0.06	0.84 ± 0.10	4.63 ± 0.82	0.61 ± 0.23	0.38 ± 0.08
Feb.	0.12 ± 0.04	0.60 ± 0.21	0.86 ± 0.21	3.40 ± 0.38	0.40 ± 0.14	0.42 ± 0.06

The mean GSI value of male increases gradually from July and reached peak in October and then it decreased. In the case of female it fluctuated with two peaks in June and October-November. The mean HSI value of male has two peaks in October and February (Fig. 2). There were also two peaks in female during June and October after that it decreased up to February. The mean value of K for male was comparatively low from June to August and high from September to February with little fluctuation (Fig. 2). In female, it was found almost similar with fluctuating in a zig zag manner.

From the morphological study two stages of the testis was ascertained as, Stage-I (Immature): The testis of this stage was thread like in structure, whitish in color and GSI ranged from 0.02 (February) to 0.06 (End of February). Stage-IV (Ripe): The testes of this stage were milky white and if stripped by fingered creamy milt comes out of them. GSI ranged from 0.06 (June) to 0.16 (July).

The five maturity stages of the gonads of the female *A. bato* were observed in different spawning periods which were determined from the morphological study of ovaries, from GSI values and from ova diameters. The stages were, Stage-I (Immature): The tiny transparent immature ova vary from 0.29 mm to 0.93 mm in diameter and their GSI ranged from 0.13 to 0.87. Stage-II (Maturing or rebuilding): Ovaries are whitish to yellowish in colour and somewhat longer than the immature ovaries. The diameter of maturing ova varies generally from 0.33 mm to 0.84 mm and their GSI ranged from 0.13 to 2.99. Stage-III (Mature): Ovaries are yellowish to yellow white in color and large in shape. Ova are firmly attached to the ovarian tissue and themselves. Ova diameter ranged from 0.84 mm to 0.98 mm and their GSI vary from 1.23 to 4.84. Stage-IV (Ripe):

Ovaries are yellowish to dark yellowish and ova are not firmly attached with ovarian tissue. Ova diameter ranged from 0.73 mm to 0.95 mm and their GSI vary from 4.84 to 7.70. Stage-V (Spent): Empty ovarian bags with very small white eggs (Granule like) present. Ova diameter varies from 0.64 mm to 0.87 mm and their GSI vary from 0.17 to 2.25.

The HSI value remained relatively high and nearly constant for both male and female throughout the maturation period until the beginning of the spawning indicating the reserves in the liver are not seriously depleted during the process of yolk formation. It is probably because of *A. bato* is a carnivorous fish (Rahman *et al.* 2016) and it was found to continue feeding during the period of maturation. The condition factor remained relatively high and nearly constant for both male and female during the pre-spawning period agrees with the report of Day (1871) for *A. cantories*.

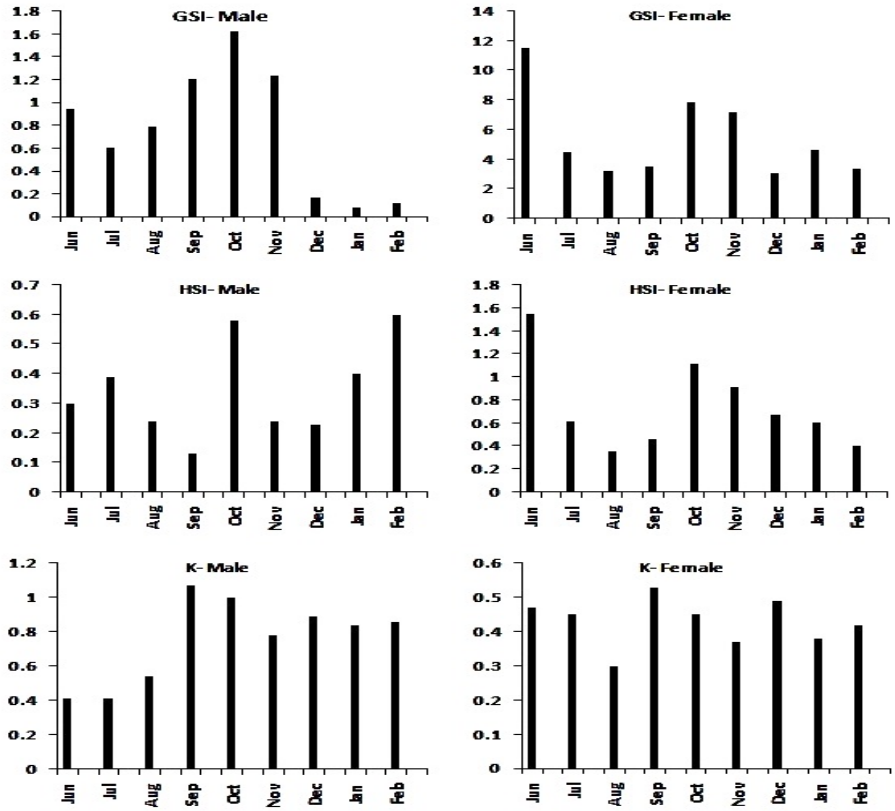

Fig. 2. Monthly variation in GSI, HSI and K of male and female *A bato*.

Spawning: A prolonged spawning period (June to early October) with a peak in June to July was found for *A. bato* in the present study. Rahman (1989) observed one major

spawning period from December to February for *A. bato* and *A. cuvieri*. *Boleophthalmus pectinirostris* was found to spawn from May to July with intensive spawning in June (Prefecture *et al.* 1993). Late January to early February are the pre-spawning months of the male *A. bato* while late January to late February are the pre-spawning months of female. In the present investigation mature and immature ova were not found simultaneously with residual ripe ova and post-ovulatory follicles in the spent ovarian bags. These aspects in the ovary indicate that the females spawn ripe ova completely once in a single spawning season.

Fecundity: The fecundity of *A. bato* varied from 7453 to 31195 (Table 2). The average number of eggs was 17590 ± 6867 indicate the high fecundity for its size. High fecundity of *A. bato* for its size agrees with the result of Murdy (1989) in the same species from the Hooghly estuary. But Chukwu *et al.* (2010) reported low fecundity for *P. barbarous* with a mean of 4400 ± 545. The difference in fecundity follows a pattern to be expected from a series of intergrading population (Nagasaki 1958).

Table 2. Characteristics of fish having the maximum and minimum fecundity value.

Fecundity	TL (cm)	BW (g)	GW (g)
31,195	20.60	34.40	4.46
7,453	19.20	26.9	1.3

The weight of the ovaries varied from 0.16 g to 0.97 g and the mean weight was calculated to be 2.38 ± 1.14. The eggs were spherical in shape. The diameter of eggs varied from 0.16 mm to 1.01 mm and the mean diameter was found to be 0.52 ± 0.25 mm. Coefficient of correlation between the diameters of the eggs of the corresponding anterior (r_a = 0.96, t = 13.73, middle (r_m = 0.95, t = 13.33) and posterior (r_p = 0.98, t = 13.57) regions of the right and left ovaries at 5% level of significance indicates simultaneous release of eggs from both the ovaries.

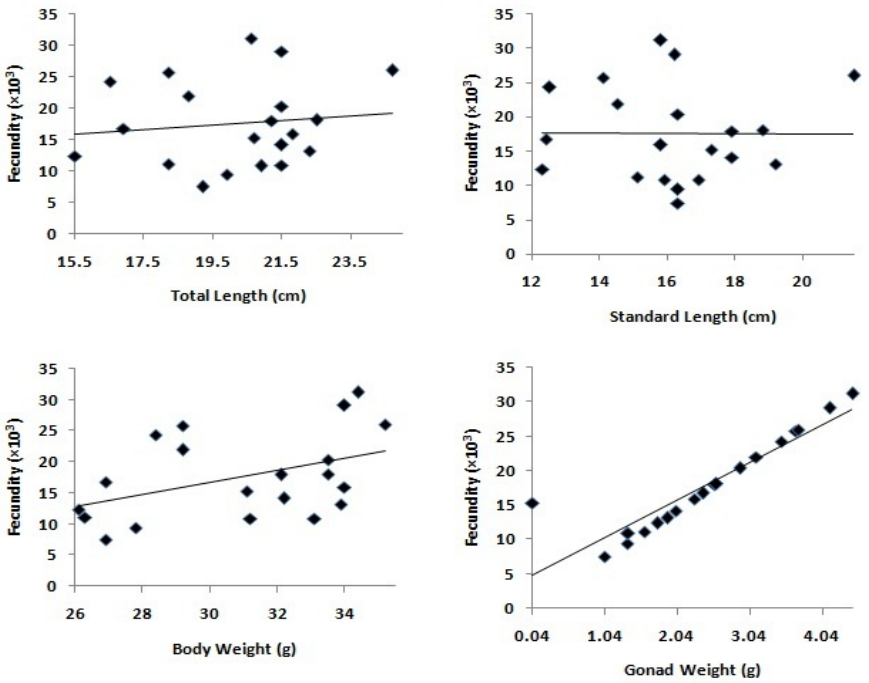

Fig. 3. Relationship of fecundity with total length, standard length, body weight and gonad weight.

The relationships of fecundity with total length were found, F = –24132 + 623 TL (r = 0.98, t = 5.20); for standard length, F = –17523 + 864 SL (r = 0.98, t = 5.45); for body weight, F = –12579.25 + 974.78 BW (r = 0.99, t = 9.38) and F = 4556 + 5462 GW (r = 0.82, t = 5.46) for gonad weight. The regression lines were linear and positive (Fig. 3) and the resulting correlations were found to be highly significant ($t_{0.05}$ = 2.09) at 5% level of significance. Linear and positive relationship between the fecundity and other factors agrees with the result of Murdy (1989) for the same species from the Hooghly estuary.

Significant correlations between the diameters of the eggs of corresponding anterior, middle and posterior regions of the right and left ovaries indicates the simultaneous release of eggs from both the ovaries and same rates of maturation. This agrees with the report of Murdy (1989) on the same species from Hooghly estuary. The aspects in the ovary indicate that the females do not spawn several times in a single spawning season. The *Apocryptes bato* has high fecundity and fecundity increases with the increase of length, body weight and gonad weight of the fish.

A disproportionate occurrence in the number of two sexes and dominance of male over female was found in the fishery of *A. bato* in the coast of Chittagong. A long spawning season with a peak in June to July was found in the present study. The fish has a comparatively high fecundity for its body size. The findings of aspects of reproductive

biology obtained in the present study could be used in taking appropriate measures for the sustainable management of the *Apocryptes bato* fishery. The information will increase the life history database of the fish and will provide a baseline data for further studies of the species.

References

Brillet, C. 1970. Relations entire territoiret compartment afresivite chez les Periophthalmes. *C.R. Aead. Sci. Poris Serv. D.* **270**: 1507-1510.

Chukwu, K.O., S.N. Deekae. and U.U. Gabriel. 2010. Reproductive biology of *Periopthalmus barbarus* (Linneaus 1766) in new Calabar River, Nigeria. *Agric. Biol. N. Am.* **1**(6): 1158-1161. doi:10.5251/abjna.2010.1.6.1158.1161.

Daniel, R.J.R. 2002. *Freshwater Fishes of Peninsular India*. University press. 288 pp.

Day, F. 1871. On the fishes of the Andaman Islands. Proceedings of the General Meetings for Scientific Business of the Zoological Society of London 1870 (pt 3): 677 - 705.

El-Boray, K.F. 2004. Reproductive biology and histological characters of male rhabdosargus haffara (teleostei; sparidae) from Suez bay, Red sea. *Egyptian Journal of Aquatic Research* **30**(B): 226-233.

Hartman, W.L. and C.Y. Conkle. 1960. Fecundity of red salmon at Brooks and Karkuk lakes, Alaska. Fishery. *Bull. Fish Wilds. Serv. U.S.* **180**: 53-60.

Healy, M.C. and C.W. Nicol. 1975. Fecundity comparisons for varius stocks of lake white fish, *Coregonus chupeaformes. J. Fish. Res. Board, Can.* **32**(3): 404-407.

Hoda, S.M.S. and Y. Akhtar. 1982. Maturation and Fecundity of Mudskipper *Boleophthalmus Dentatus* in the Northern Arabian Sea. *Centre of Excellence in Marine Biology, University of Karachi, Karachi* 32, *Pakistan* 64-73 pp.

King, M. 1995. Fisheries biology, assessment and management,1st ed. Fishing News Books, London. 341 pp.

Lawson, E.O. 2010. Aspects of Reproductive Biology in Mudskipper, *Periophthalmus apilio* from Mangrove Swamps of Lagos Lagoon, Lagos, Nigeria. *Journal of Fisheries International* **5**(2): 36-43. DOI: 10.3923/jfish.2010.36.43

LeCren, E.D. 1951. The length-weight relationship and seasonal cycle in gonadal weight and condition in the perch (*Perca fluviatilis*). *J. Anim. Ecol.* **20**: 271-279.

McGregor, E.A. 1922. Observations on the egg yield of Klamath River King Salmon, Calif. *Fish Game* **8**: 160-164.

Murdy, E.O. 1989. A Taxonomic Revision and Cladistic Analysis of the Oxudercine Gobies (Gobiidae: Oxudercinae) Records of the Australian Museum Supplement **11**: 1-93.

Nabi, M.R.U. 1994. On the study of the thread fin *Polinemous paradiscus* from the landing centers and local market of Chittagong, M. Sc. Thesis, Institute of Marine Sciences, University of Chittagong.

Nagasaki, F., 1958. The fecundity of Pacific herring *(Clupea pallasi*) in British Columbia coastal waters. *J. Fish. Res. Bd. Can.* **15**: 313-330.

Parvez, M.S. and M.R.U. Nabi. 2015. Reproductive Biology of Tapper Tail Anchovy *Coilia ramcarati* along the Coast of Chittagong. *Suranaree Journal of Science and Technology* **22**(4): 397-408.

Prefecture, K., M. Washio, S. Komiya. and T. Takita. 1993. Maturation of the Mudskipper *Boleophthalmus pectinirostris* distributed in the mud flats of the Midori river. *Nippon Suisan Gakkaishi* **59**(4): 575-580.

Rahman, A. 1989. Freshwater Fishes of Bangladesh, *In:* Kabir, S.M.H. (Ed.). Zoological Society of Bangladesh, Department of Zoology, University of Dhaka. Bangladesh.

Rahman, M.S., M.M. Rahman, M.S. Parvez. and M.R.U. Nabi. 2016. Feeding habit and Length-Weight Relationship of a Mudskipper *Apocryptes bato* from the coast of Chittagong. *Journal of Bangladesh Academy of Sciences* **40**(1): 57-64.

Shukla, M.L., J.N. Trivedi, G.M. Soni, B.K. Patel, and K.D. Vachhrajani. 2014. Mudskipper (Gobiidae: Oxudercinae) fauna of Northern Gulf of Khambhat with two new record of the species from Gujarat, India. *European Journal of Zoological Research* **3**(3): 67-74.

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