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Helyar, K.R. and W.M. Porter. 1989. Soil acidification, its measurement and processes involved. *In:* Robson, A.D. (ed.) 'Soil Acidity and Plant Growth', Academic press, pp. 61-101.

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GROWTH PERFORMANCES AND NUTRIENT COMPOSITIONS OF PABDA *OMPOK BIMACULATUS* (BLOCH, 1797) GROWN IN RECIRCULATING AND CLOSED AQUACULTURE SYSTEMS

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Abstract

This study evaluated the growth performances and nutrient compositions of pabda *Ompok bimaculatus* (Bloch, 1797) in a recirculating aquaculture system (RAS) and a closed aquaculture system (CAS). The average daily weight gain (ADG) and specific growth rate (SGR) of pabda in RAS (ADG: 0.18 g/d; SGR: 3.40 %/d) was 3.61- and 1.41-folds higher than that of the CAS (ADG: 0.05 g/d; SGR: 2.40 %/d). Fish had significantly higher level of PUFA (Poly-unsaturated fatty acid) in CAS (41%) than in RAS (33%). The ratio between omega-3 and omega-6 fatty acids in RAS and CAS were 0.73 and 0.69, respectively. This study's results have demonstrated that the culture of pabda in RAS is more suitable than CAS in terms of growth.

Key words: Pabda, Growth, Nutrient compositions, RAS, CAS

Introduction

The inland aquaculture of Bangladesh accounted for 56.24% of the total fish yield during 2017-18 (DoF 2019). Although pond aquaculture accounting the highest percentage of fish production, average pond production is still low (lower than 5 tons/ha) (DoF 2019). Pond production can be increased many folds by adopting intensive cultural techniques such as recirculating aquaculture system (RAS). RAS and closed aquaculture system (CAS) are both closed systems of aquaculture. The closed aquaculture system refers to the land-based rearing of aquatic species in raceways, tanks, and ponds. Recirculation of water is held in RAS, while wastewater is removed periodically in CAS. The advantages of RAS include improved waste water management opportunities and recycling of nutrient (Piedrahita 2003), control of biological pollution (Zohar *et al.* 2005),

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consumption of reduced water (Verdegem *et al.* 2006), improving fish welfare (Martins *et al.* 2010), maintenance of better hygiene and management of disease (Summerfelt *et al.* 2009, Tal *et al.* 2009), improvement of production efficiency and reduction in work intensity (McKenzie *et al.* 2012, Suhr and Pedersen 2010).

Pabda *Ompok bimaculatus* is a high value cultured fish having good taste and flavor with great demand and price. This fish is listed in the IUCN Red book as the threatened fish of Bangladesh as an endangered species (IUCN 2015). Pabda has been farming in the ponds except for RAS and CAS that can be adopted as the solutions to increase production as well as improvement of growth performance and nutritional quality.

Luo *et al.* (2014) have observed the growth, welfare, digestive activity, and partial cost-effectiveness of genetically improved farmed tilapia (*Oreochromis niloticus*), cultured in a recirculating aquaculture system and an indoor bio-floc system. The growth and welfare of rainbow trout (*Oncorhynchus mykiss*) have been reported in recirculating and flow-through rearing systems by d'Orbcastel *et al.* (2009). The nutritional status of the wild *O. bimaculatus* has been investigated by Alam *et al.* (2016). Although the culture of pabda in the RAS system has started in the last five years, its performances, for example, pabda growth and nutritional qualities, have not been reported. Therefore, there is a need to compare the growth performances and nutritional qualities of pabda in RAS and CAS.

The objectives of this study were to determine the growth performances of cultured pabda in RAS and CAS systems; analyze proximate composition; detect amino acid and fatty acid profiles.

Materials and Methods

Experimental fish and procedures: Pabda were used as a study fish because of its high value and farming in Bangladesh in recirculating aquaculture system (RAS) for the last 5 years. Fry of the fish was collected from Sharnalata Matshya Hatchery, Trishal, Mymensingh, Bangladesh. The experiment was undertaken from July to October 2017 in RAS and closed aquaculture system (CAS) for four months.

Culture systems: Three tanks of RAS (10,000 L capacity) were used by filling with 10,000 liters tap water, while three concrete tanks were used for CAS as the experimental systems. In CAS, each small tank was 10 × 6 × 21/4 ft, filled with 650 liters of tap water.

Culture station: The fish was reared in RAS in the Agro 3 Fish Hatchery and Culture Farm, Mymensingh. However, the CAS experiment was undertaken in the wet laboratory

of Zoology Section, Biological Research Division, Bangladesh Council of Scientific and Industrial Research (BCSIR), Dhaka.

Experimental design: This was a 2 × 4 factorial study in triplicate. The fixed factors were RAS and CAS and four culture months. Growth performances were measured by ADG (average daily weight gain), SGR (specific growth rate), FCR (feed conversion ratio) and well-being or condition factor (*K*).

Stocking density: Each RAS tank and CAS tank was stocked with a fish fry at the rate of 1 fish/L, i.e., 10,000 and 650 fries, respectively. The initial average weight and length of a fish were 0.35 g and 1.25 cm, respectively. Before stocking, the fry was acclimatized for 6 hours in a flow-through tank system in clean water. After that, they were slowly released into the tanks. No feed was given on the first day of stocking.

Feeding of fish: In both systems, fish were fed the same commercial diet (Tongwei, China). Fish were fed with powdered feed at 10% of body weight (BW) in the 1st month and pellet feed at 4% BW in the 2nd & 3rd months and 2% BW in the 4th month.

Sampling design: Fish samples (10 fish/tank) were drawn every month with a fine meshed net. Individual length (cm) was measured by using a measuring scale and weight (g) by an electronic balance. At the end of the experiment, the final length (cm) and weight (g) of the individual fish were also recorded.

Water quality variables: Water quality variables of CAS were monitored at every 7 days interval. The dissolved oxygen (DO) concentration and water temperature (°C) of each tank were measured by using a portable DO meter. The level of pH was measured by a digital pH meter. Light intensity was measured by using a light intensity meter.

Fish growth performances: Final body weight and length of 10 fish were recorded from each tank after harvest. The observed body weight and food intake data were used to calculate the following growth indices:

1. Average Daily Weight Gain (ADG) = $W_2 - W_1 / T_2 - T_1$
2. Specific Growth Rate (SGR) = $(\ln W_2 - \ln W_1 / T_2 - T_1) \times 100\%$
3. Feed Conversion Ratio (FCR) = Feed (g) consumed by fish/ Weight (g) gain of fish
4. Condition factor (*K*) = $(W / L^3) \times 100$

Where, W_2 = Final body weight (g) of fish at time T_2 (day), W_1 = Initial body weight (g) of fish at time T_1 (day), W= Body weight in gram (g), L= Body length in centimeter (cm).

Biochemical composition of the fish muscle: The studies fish (Pabda) of our experiment was a small indigenous species (SIS), so we collected the whole muscle to make a pull sample for analysis. Moisture and ash were measured following the methods described by AOAC (2000). The crude protein content was assayed by measuring nitrogen (N, 6.25) using the Kjeldahl method (Kjeldahl 1883), and the crude lipid content was measured by the Floch method using chloroform: methanol (2:1) (Folch *et al.* 1957). The amino acid profiles were determined using an automatic amino acid analyzer following the protocol established by SYKAM S4300, The Czech Republic. Fat was extracted into the ether and then methylated to fatty acid methyl esters (FAMEs). Gas chromatography (GC) was used to measure FAMEs quantitatively (Dodds 2005).

Statistical analysis: Percent data were transformed into the square root before statistical analysis. Means between systems were compared by t-test, while among months by ANOVA followed by Tukey's HSD post hoc for multiple comparisons. The Statistical Package for the Social Sciences (SPSS) v. 20.0 software package (SPSS, SAS Institute Inc. Gary, USA) and Microsoft office excel 2007 were used for statistical analysis. The level of significance was at 5%.

Results and Discussion

Average daily gain (ADG, g/day): The average daily weight gain (ADG) of pabda reared in the RAS system, which was more than 3.61 times higher than those cultured in the CAS regardless of the culture duration (Table 1). The fish grew better in the first month of stocking and had no significant difference to the fourth month regardless of the system. ADG of the fish sampled in the second and third months showed no significant difference (Table 1).

In RAS, the sample's ADG observed in the first and fourth months was similar but significantly higher than did the third month (Table 1). However, ADG found in the second month was not significantly different from the first and fourth months.

In CAS, the highest ADG was observed in the first month of stocking, while the lowest ADG was found in the third month (Table 1). The level of ADG detected in the second and fourth months was not significantly different from the level of ADG measured in the third and the first months.

The observed high ADG in the RAS could have resulted from maintaining of water quality parameters at optimum level. Fish reared in the RAS might not have suffered from any potential stress resulting from water quality parameters. Optimum culture

condition might have played a vital role in the digestion, absorption, and assimilation of the ingested feed stuffs. A better environmental condition might also have facilitated in regular eating feed stuffs. In contrast, CAS had a low DO level sometimes, particularly in the morning that could have exerted pressure. Besides, in CAS, the concentration of NH_3 has been found to rise above tolerance level. This increased NH_3 might have played a negative role in eating feed stuffs. In CAS, water was washed out partially for 15 days. This kind of use of the cultural environment might have stressed the fish not eating at their satiation level, which was not in the case of RAS circumstance.

Table 1. Average daily weight gain (ADG, g/day) of pabda *Ompok bimaculatus* sampled one-month intervals in two culture systems, RAS and CAS, respectively.

Culture duration (Months)	Culture systems		Overall
	RAS	CAS	
1	0.22 ± 0.029^{a}	0.07 ± 0.003^{a}	0.15 ± 0.036^{a}
2	0.15 ± 0.014^{ab}	0.05 ± 0.009^{ab}	0.10 ± 0.022^{bc}
3	0.11 ± 0.012^{b}	0.03 ± 0.009^{b}	0.07 ± 0.020^{c}
4	0.22 ± 0.022^{a}	0.04 ± 0.003^{ab}	0.13 ± 0.041^{ab}
Overall	$0.18 \pm 0.017_{a}$	$0.05 \pm 0.056_{b}$	0.11 ± 0.016

Values (mean ± SEM) with different subscripts letters in the row and superscripts letters in the column are significantly different (t-test, ANOVA, HSD; $p < 0.05$).

Over culture duration, the average daily weight gain (ADG) has been found to drop until the third month of culture duration but again rose at the last month. The observed highest ADG (0.15 ± 0.036 g/d) in the first month of stocking represents the exponential growth pattern of fish established by Dutta (1994).

Specific growth rate (SGR, %/day): The specific growth rate (SGR, %/day) of pabdareared in RAS (3.39 ± 1.12 %/d) was 1.41 times higher than those reared in CAS (2.40 ± 0.75 %/d) across the culture duration (Table 2). SGR of the fish in the first month was significantly higher than the other three months regardless of the system (Table 2). The level of SGR of the fish sampled in the second month was similar to that of the fourth month but significantly higher than in the third month.

In RAS, the SGR of the fish sampled in the first month of stocking was 5.85-, 11.17-, and 7.86-folds higher than did the second, third and fourth months, respectively (Table 2). However, the level of SGR observed in the following three months was not significantly different.

In CAS, the level of SGR measured in the first month of stocking was 4.15-, 16.34- and 12.10-times higher than in the second, third and fourth months (Table 2). However, the level of SGR detected in the third and fourth months was similar.

Table 2. Specific growth rate (SGR, %/day) of pabda *Ompok bimaculatus* sampled one-month intervals in two culture systems, RAS and CAS, respectively.

Culture duration (Months)	Culture systems		Overall
	RAS	CAS	
1	9.79 ± 0.410^{a}	6.61 ± 0.115^{a}	8.20 ± 0.736^{a}
2	1.67 ± 0.280^{b}	1.60 ± 0.258^{b}	1.63 ± 0.171^{b}
3	0.88 ± 0.109^{b}	0.60 ± 0.169^{c}	0.74 ± 0.109^{c}
4	1.25 ± 0.109^{b}	0.81 ± 0.081^{c}	1.03 ± 0.115^{bc}
Overall	$3.40 \pm 1.122_{a}$	$2.40 \pm 0.745_{a}$	2.90 ± 0.667

Values (mean ± SEM) with different subscripts letters in the row and superscripts letters in the column are significantly different (t-test, ANOVA, HSD; $p<0.05$).

Growth of fish across both systems has been found to maintain similar trends over culture duration in which fish grew fast in the first month of stocking that could be due to the exponential growth pattern. Dropped ADG in the later months of our study follows the growth trends of fish growth patterns reported by Rounsefell and Everhart (1953).

SGR in both RAS and CAS systems has been found to be similar, which denotes identical growth performance in both systems. As observed in this studied fish, SGR has a declining trend over the duration except for a slight increase in the last month. This declining trend of SGR with time indicates typical fish growth trends. The highest performance of fish in SGR in the first month could be due to powdered feed, which small fish have easily ingested. Powdered feed might be digested and absorbed well and finally assimilated to build the body tissue. The application of pellets from the second month of culture might have reduced SGR by reducing the later months' utilization efficiencies. GIFT (Genetically Improved Farmed Tilapia) tilapia *Oreochromis niloticus* had a 1.90% specific growth rate when reared in the RAS at 8.06 kg/t initial stocking density (Luo *et al.* 2014). Pabda, in the RAS of the present study, performed better in SGR (3.4% %/d) compared to tilapia. In a previous study, d'Orbcastel *et al.* (2009) demonstrated that rainbow trout *Oncorhynchus mykiss* had an overall SGR of 0.85% over a culture duration of 77 days, much lower than the present study.

Feed conversion ratio (FCR): FCR did not differ between culture systems across culture durations (Table 3).

Among months, the third month had the highest FCR (5.61±1.053) than those observed in the other three culture months (Table 3) across culture systems.

In RAS, the highest FCR (4.16±0.67) was observed in the third month, while the lowest level (0.87 ± 0.05) was measured in the first month of stocking (Table 3). However, levels of FCR found in the other two months were similar but significantly lower than the value of the third month.

Table 3. The feed conversion ratio of pabda *Ompok bimaculatus* sampled one-month interval in two culture systems, RAS and CAS, respectively.

Culture duration (Months)	Culture systems		Overall
	RAS	CAS	
1	0.87 ± 0.0513^{b}	0.98 ± 0.059^{b}	0.93 ± 0.290^{b}
2	1.99 ± 0.4625^{b}	2.11 ± 0.491^{b}	2.06 ± 0.303^{b}
3	4.16 ± 0.6657^{a}	7.06 ± 1.729^{a}	5.61 ± 1.053^{a}
4	1.35 ± 0.1339^{b}	2.24 ± 0.279^{b}	1.79 ± 0.243^{b}
Overall	$2.09 \pm 0.4707_{a}$	$3.10 \pm 0.837_{a}$	2.60 ± 0.482

Values (mean ± SEM) with different subscripts letters in the row and superscripts letters in the column are significantly different (t-test, ANOVA, HSD; $p<0.05$).

Like RAS, CAS had the highest FCR in the third month of culture duration (Table 3). Levels of FCR detected in the other three culture months were significantly lower than that of the third month but similar.

Fish performed better in converting feed into flesh in RAS than in CAS, although the difference was not significant. This better performance in RAS might have resulted from better water quality indices in the RAS than in the CAS. Slightly higher FCR, as observed in the CAS, indicates loss of feed due to uneaten by the fish. In RAS, tilapia had an FCR of 1.47, which was nearly 14% lower than the FCR found in the RAS of the present study (Luo *et al.* 2014).

Excess FCR in the third month of culture, as has been found in this study, could have resulted from excessive feed use. Due to weaning, fish were not eating the required quantity of feed after the first month when pellet feed was started to give. Moreover, fish were given feed at 4% of their body weight (BW) in the second and third months but 2% in the fourth month. So, in the fourth month, the fish has been eaten enough feed and thus lost was lower than the previous month. Therefore, loss of most feed in the third month of culture might be responsible for higher FCR.

Water quality parameters: In RAS, temperature, DO concentration, pH, NH_3 were always maintained 28-30ºC, 7-8 mg/l, 7-8 and <0.05 mg/l, respectively. In CAS, the observed range of temperature, DO conc., pH and light intensity were 28.57 ± 0.24°C to 32.27 ± 0.13ºC, 2.64 ± 0.08 to 7.36 ± 0.77 mg/l, 6.93 ± 0.19 to 8.54 ± 0.12 and 7.67 ± 1.20 to 24.00 ± 1.00 Lux; respectively.

Proximate compositions of fish muscle: The proximate compositions of the fish muscle are given in Table 4. Ash and crude lipid content in fish muscle were significantly higher in RAS than that of CAS. However, the proximate composition such as moisture content, ash content, crude protein content and crude lipid content of pabda followed the typical range as expected (DoF 2002).

Table 4. Proximate compositions (% wet basis) of the muscle of pabda *Ompok bimaculatus* sampled from two culture systems, RAS and CAS, respectively.

Proximate composition (% wet basis)	Culture system	
	RAS	CAS
Moisture	$78.68 \pm 1.23_a$	$79.78 \pm 0.37_a$
Protein	$16.41 \pm 1.35_a$	$15.47 \pm 0.47_a$
Ash	$6.85 \pm 0.59_a$	$3.74 \pm 0.57_b$
Lipid	$3.77 \pm 0.75_a$	$1.55 \pm 0.10_b$

Values (mean ± SEM) with different subscripts letters in the row are significantly different (t-test, $p<0.05$).

Amino acids: Of 8 essential amino acids, lysine, leucine and arginine were the major essential amino acids (EAAs) in the fish in both systems (Table 5).

Of non-essential amino acids (NEAAs), glutamic acid was found in the highest percentage in both systems (RAS: 18.38 ± 0.18**;** CAS**:** 16.31 ± 0.21) followed by aspartic acid (RAS: 11.26 ± 0.21; CAS: 11.93 ± 0.39) (Table 5).

Alam *et al.* (2016) have found similar levels EAAs in the same wild fish. Of the NEAAs, glutamic acid (15.28%) has been reported in the same wild fish, which is close to the present study's findings. Zhao *et al.* (2010) have found lysine (6.24%), leucine (5.78%) and arginine (4.20%) in the promfret *Pampus punctatissimus* that follows the trend of the findings of the present study.

Fatty acids: Of five monounsaturated fatty acids (MUFA), oleic acid was highest in both systems but did not differ significantly. CAS had 4.60- and 1.93-times higher palmitoleic acid and eicosenoic acid than RAS (Table 6).

Table 5. Amino acids (%) of the muscle of pabda *Ompok bimaculatus* sampled from two culture systems RAS and CAS, respectively.

Amino acids (%)	Culture systems	
	RAS	CAS
EAA		
Valine	5.89 ± 0.05	5.79 ± 0.31
Threonine	4.85 ± 0.12	4.82 ± 0.06
Histidine	2.95 ± 0.30	3.39 ± 0.59
Arginine	6.36 ± 0.19	6.06 ± 0.32
Phenylalanine	4.12 ± 0.13	4.44 ± 0.22
Lysine	10.70 ± 0.35	10.84 ± 0.31
Leucine	10.34 ± 0.43	9.59 ± 0.23
Isoleucine	6.22 ± 0.18	6.31 ± 0.14
NEAA		
Glutamic acid	$18.38 \pm 0.18_a$	$16.31 \pm 0.21_b$
Glycine	5.23 ± 0.13	5.00 ± 0.33
Proline	4.39 ± 0.16	4.57 ± 0.11
Alanine	6.56 ± 0.13	6.17 ± 0.07
Aspartic acid	11.26 ± 0.21	11.93 ± 0.39
Serine	3.88 ± 0.14	4.13 ± 0.15

Values (mean ± SEM) with different subscripts letters in the row are significantly different (t-test, $p<0.05$).

Among nine polyunsaturated fatty acids (PUFA), RAS had a significantly higher eicosatrienoic acid level than the CAS. However, CAS had significantly higher levels of α-linolenic acid and eicosadienoic acid. EPA and DHA between systems did not differ (Table 6).

The total percentage of PUFA in pabda was nearly 33% in RAS, which was significantly lower than that of CAS (41%). Similarly, MUFA was found to be significantly higher in CAS (32%) than did the RAS (20%). In RAS, saturated fatty acid (SFA) was 1.71-folds higher than in the CAS.

The difference in the fatty acid composition of pabda between two systems could be due to the difference in water quality, particularly water temperature (Zhao *et al.* 2010). Therefore, controlled water temperature in the RAS might have played a positive role in gaining a higher quantity of fatty acids in the fish than that of CAS.

Table 6. Fatty acids (%) of the muscle of pabda *Ompok bimaculatus* sampled from two culture systems, RAS and CAS, respectively.

Fatty acids (%)	Culture systems	
	RAS	CAS
SFA		
C14: 0 Myristic acid	$10.54 \pm 0.75_a$	$4.66 \pm 0.43_b$
C16: 0 Palmitic acid	$29.81 \pm 0.68_a$	$14.76 \pm 0.56_b$
C18: 0 Stearic acid	3.97 ± 0.06	3.57 ± 0.66
C20: 0 Arachidic acid	1.20 ± 0.07	2.22 ± 0.29
C23: 0 Tricosanoic acid	$0.72 \pm 0.21_b$	$1.82 \pm 0.11_a$
MUFA		
C14: 1 Myristoleic acid	0.82 ± 0.09	1.47 ± 0.45
C16: 1 Palmitoleic acid	$0.89 \pm 0.10_b$	$4.09 \pm 0.19_a$
C18: 1 Oleic acid	13.36 ± 1.85	17.99 ± 1.49
C20: 1 Eicosenoic acid	$2.55 \pm 0.36_b$	$4.92 \pm 0.21_a$
C22: 1 Erucic acid	2.81 ± 0.51	3.95 ± 1.02
PUFA		
C18: 2 Linoleic acid	3.12 ± 0.91	3.44 ± 0.79
C18: 3 γ-Linolenic acid	3.72 ± 0.40	4.56 ± 0.71
C18: 3 α-Linolenic acid	$3.26 \pm 0.06_b$	$7.01 \pm 0.31_a$
C20: 2 cis-11, 14 Eicosadienoic acid	$0.91 \pm 0.19_b$	$1.93 \pm 0.03_a$
C20:3 Eicosatrienoic acid	$8.11 \pm 0.17_a$	$6.98 \pm 0.08_b$
C20: 4 Arachidonic acid	5.71 ± 1.62	6.20 ± 1.09
C22: 2 cis-13, 16 Docosadienoic acid	1.57 ± 0.55	2.15 ± 0.95
C20: 5 Eicosapentaenoic (EPA)	3.09 ± 0.72	2.83 ± 0.71
C22: 6 Docosahexaenoic (DHA)	3.86 ± 1.05	5.48 ± 0.56
ω-3/ ω-6	0.73	0.69

Values (mean ± SEM) with different subscripts letters in the row are significantly different (t-test, $p<0.05$).

The presence of oleic acid is the highest percentage among the MUFA in pabda agrees with the findings of Alam *et al.* (2016) in wild pabda. Jabeen and Chaudhry (2011) have found 21-25% oleic acid in *Cyprinus carpio*, 10-18% in *Labeo rohita* and 11- 16% in *Oreochromis mossambicus*. The observed 41% PUFA in the experimental fish in CAS could have resulted from natural food such as phytoplankton

and zooplankton that is similar to the finding of Alam *et al*. (2016) in the wild pabda. The presence of a lower level of PUFA in the fish raised in RAS could be due to the application of commercial feed only. In CAS, natural food organisms might have supplied additional PUFA.

The ratio between omega-3 and omega-6 fatty acids in RAS and CAS were 0.73 and 0.69, respectively (Table 6). The observed ratio between omega-3 and omega-6 fatty acids in RAS and CAS in the present study has been found to be higher than *Cyprinus carpio* (0.27), *Labeo rohita* (0.23) and *Oreochromis mossambicus* (0.23) (Jabeen and Chaudhry 2011). However, these levels (0.73 and 0.69) have been to be lower compared to wild (2.72) and farmed (5.10) yellow perch *Perca flavescents* (Gonzalez *et al.* 2006) that is due to the marine environment. Further, Usydus *et al.* (2012) reported that the ratio between omega-3 and omega-6 fatty acids must be above 0.25 for proper prophylactic properties of the fatty acids that have been ensured in the present study.

The culture of pabda in RAS could be beneficial in terms of the growth of fish compared to CAS. RAS may require lower culture duration to get the marketable fish, thus having three consecutive cycles of fish production in the same system over a year. Having three harvests will therefore reduce the production cost and make the system profitable. The culture of pabda in RAS may also reduce the feed cost by reducing FCR. Although the percentage composition of amino acids remains similar between RAS and CAS systems, a higher percentage of fatty acids was observed in RAS produced pabda.

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COMPARATIVE STUDY ON PROXIMATE AND MINERAL COMPOSITION OF NATIVE AND HYBRID PANGAS (*PANGASIUS PANGASIUS*, *P. HYPOPHTHALMUS*) AT RAW AND FRIED STAGES

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Abstract

A study was conducted on the proximate and mineral composition of native and hybrid pangas, namely *Pangasius pangasius* and *Pangasius hypophthalmus* at raw and fried stages between January and December 2017. At the raw stage higher amount of average protein (23%) found in native pangas compared to hybrid (19.7%) and hybrid pangas contain higher fat (15.95%) compared to native (12.75%), although the moisture content was the same in both. Protein and fat were higher in both fishes at 26.8% and 20.95% in natives and 24.05% and 24.2% in hybrids at the fried stage. At the raw stage, mineral contents were higher in natives and the highest content was sodium (185.38 mg/100 g) followed by phosphorus (166.90 mg/100 g) and calcium (116.35 mg/100 g) and slightly decreased those minerals at the fried stage of the same fish. In the fried stage, mineral contents were found almost the same, although calcium, magnesium, iron was slightly varied and phosphorus, sodium found high in amount. But energy level was higher (328 Kcal) in hybrids compare to native. Thus, the study of raw and fried stages indicates that native pangas are better in proximate and mineral composition than the hybrids, but the energy was high in hybrids.

Key words: Native and hybrid pangas, Proximate composition, Minerals, Raw stage, Fried stage.

Introduction

Bangladesh is an agro-based country blessed with vast inland water in the form of ponds, canals, ditches, flat plains, haors, baors, rivers, and estuaries covering 43.10 million hectares which is an excellent ecological condition for the propagation of fish (BBS 1994). Inland fish and fisheries play important roles in ensuring global food security.

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They provide a crucial source of animal protein and essential micronutrients for local communities, especially in the developing world (Youn 2014). The Food and Agriculture Organization (FAO) estimates that about one billion people world-wide rely on fish as their primary source of animal protein whether eaten raw or cooked, salted, smoked or preserved or any other way, the popularity of fish is worldwide (FAO 2008). Over 75% of the global fish production is used for direct human consumption and the consumption of fresh fish is growing at the expense of other forms of fish products. The remaining fishes destine for non-food products, in particular the manufacture of fishmeal and fish oil (FAO 2008). The proportion of global fish production used for direct human consumption is now over 77%, a significant rise of the last decades, with consumption of fresh fish outstripping other fish products such as canned fish (FAO 2016). However, wild fish is not sufficient for the current demand of the consumers and that's why fish culture is introduced to balance the demand and supply. Nowadays, to meet up the scarcity of fish protein, hybrid pangas are cultured everywhere in Bangladesh along with native pangas for nutritional values and many economic advantages. Wild and farmed fish vary in nutrients (Netteton and Exler 1992) as well as sensorial, chemical and physical properties (Love 1980).

The biochemical composition of fish varies from species to species and with the same species from one individual to another, individual variation usually is due to some factors such as size, age, season, sex and geographical location (Stansby 1962). The proximate composition generally comprises the estimation of moisture, protein, fat and ash contents of the fresh fish body. The percentage composition of these constituents accounts for about 96-98% of the total tissue constituents in fish (Nowsad 2007). The assessment of the fish's proximate composition is important to know its nutritive value, and its better processing and preservation (Mridha *et al*. 2005). In addition, estimation of the proximate profile of a fish is often necessary to ensure that they meet the requirements of food regulations and commercial specifications.

Fish is a high protein food consumed by a large percentage of the populace because of its high palatability, low cholesterol and tender flesh (Eyo 2001). It comprises all ten essential amino acids in desirable quantity for human consumption. Fish protein is very rich in such amino acids as methionine, lysine and low in tryptophan compared to mammalian protein (Nowsad 2007). Fish normally has more polyunsaturated fatty acids (PUFA) than animal fats. An increasing amount of evidence suggests that high content of PUFA in the fish flesh and fish oil are beneficial in reducing the serum cholesterol (Huynh *et al*. 2007). The latter, fish, is also a good source of vitamins and minerals *viz*., calcium, phosphorus, sodium, potassium, iron, manganese, zinc, copper, etc. They absorb

minerals not only from their diets but also from the surrounding water via their gills and skin (Lall 2002). Generally, fresh fish contain a considerable amount of minerals, but processed fish such as dried fish have higher values (Kinsella 1986). The measurement of these micro-nutrients in fish will reveal their availability to fish consumers and thus give a room to prevent the resultant effects of their deficiencies. Consumption of fish and their products helps in preventing cardiovascular and other diseases (Cahu *et al.* 2004). Fish are a rich source of essential nutrients required for supplementing both infant and adult diets (Botta *et al.* 1978). Monalisa *et al.* (2013) worked on a comparative study of nutrient contents of native and hybrid Koi (*Anabas testudineus*) and Pangas (*Pangasius pangasius*, *P. hypophthalmus*) fish in Bangladesh. Zaman *et al.* (2015) determined nutrient contents of some popular freshwater and marine fish species of Bangladesh. Das *et al.* (2015) worked on microbiological and nutritional assessment of some selected cultured species. Hasan *et al.* (2018) worked on quality assessment of salt-cured spotted snakehead. The present study was conducted to elucidate the proximate and mineral composition of native and hybrid pangas at both raw and fried stages.

Material and Methods

The native fish samples of pangas (*Pangasius pangasius*) were collected from the Meghna River of Chadpur point (Site 1) and Meghna River of Bhairab Point (Site 2). On the other hand, the hybrid pangas (*Pangasius hypophthalmus*) were collected from a culture pond at Gazipur (Site 3) and a culture pond at Narsingdi (Site 4). After collection, fresh fish samples were taken to the Institute of Food Science and Technology Laboratory, BCSIR, Dhaka, for further laboratory analysis. The nutrient contents were estimated in two stages of the selected species, at raw and fried stages. The fishes were washed properly to avoid any germs, dirt, or infectious agents. Then fishes were degutted and washed again and chopped fish muscles on a hard-chopping board. The chopped muscles of fish were used for the analysis at the raw stage. At the fried stage, the fishes were washed and cleaned properly and degutted. The same fish muscles were fried with soybean oil for 3-4 minutes at 70-80°C and then other procedures were followed one by one as like that of raw stage.

Chemical analysis for moisture, protein, fat and ash were done following the standard method described in the AOAC manual (AOAC 2005). The loss of weight was calculated as percent moisture content using this formula:

$$\text{Moisture (\%)} = \frac{\text{Loss in weight of sample (g)}}{\text{Weight of sample (g)}} \times 100$$

Ash content was determined by wigniting sample about 4-5 g, in a Muffle Furnace burned at 400-500°C and calculated using following formula:

$$\text{Ash (\%)} = \frac{\text{Weight of ash (g)}}{\text{Weight of sample (g)}} \times 100$$

The Kjeldahl method was used to determine the protein content of the fish samples. The data were taken by doing duplicate analyses for protein. The following formulas were used:

$$\text{\% of Nitrogen} = \frac{\text{Millieuivalent of nitrogen (0.014)} \times \text{Titrant value (ml)} \times \text{Strength of HCl}}{\text{Weight of sample (g)}}$$

Crude Protein (%) = 6.25 × % of Nitrogen

Lipid content was determined by Soxhlet apparatus using acetone as solvent. The percentage of total lipid was calculated by using the following formula:

$$\text{Total lipid (\%)} = \frac{\text{Weight of lipid (g)}}{\text{Weight of sample (g)}} \text{ x } 100$$

The carbohydrate content of samples was calculated using the following formula:

Carbohydrate = 100 – (% of moisture + % of protein + % of ash + % of fat)

The energy of the fish sample was calculated by the following formula:

Energy = (% of carbohydrate × 4.1) + (% of protein × 4.1) + (% of fat × 9.1)

Calcium, magnesium are being determined by the titration method. The atomic absorption spectrophotometric method was used for the determination of iron (Fe) phosphorous (P), zinc (Zn) and copper (Cu). Sodium (Na) was estimated with the flame photometer.

Results and Discussion

Proximate composition: In the raw stage, native pangas were enriched with moisture (61.92±1.22), protein (23.00±1.00) and ash (1.30±0.10) than hybrid, which contained 61.74±0.44, 19.70±0.80 and 1.185±0.08 on average, respectively. Hybrid pangas

contained more fat (15.95±0.25) and carbohydrate (1.42±0.02) than native species (Table 1). This may occur as the different feeding habits and metabolism systems. Hybrid pangas contain more energy (231±1.00) than the native species as it contains more fat value. The result is more or less similar to the findings of Monalisa *et al.* (2013). Begum *et al.* (2012) found very close moisture and fat value in domesticated stock of *Pangasius hypophthalmus* in laboratory condition.

Table 1. Proximate composition of native and hybrid pangas at a raw stage.

Proximate composition	Native pangas			Hybrid pangas		
	Site 1	Site 2	Average ± SE	Site 3	Site 4	Average ± SE
Moisture (%)	60.70	63.15	61.92±1.22	61.30	62.19	61.74±0.44
Protein (%)	24.00	22.00	23.00±1.00	20.50	18.90	19.70±0.80
Fat (%)	13.00	12.50	12.75±0.25	15.70	16.20	15.95±0.25
Ash (%)	1.20	1.40	1.30±0.10	1.10	1.27	1.185±0.08
Carbohydrate (%)	1.10	0.95	1.02±0.07	1.40	1.44	1.42±0.02
Energy (Kcal)	221.00	207.00	214.00±7.00	232.00	230.00	231±1.00

The proximate composition of native and hybrid pangas (Table 2) indicates that moisture content was significantly decreased in the fried stage, compared to the raw stage. It was observed that there is a great change in fat and protein contents between the raw and fried stage. In the fried stage, the values were high in both native and hybrid pangas from the raw stage. Sainani and Kapute (2017) found a decreased amount of moisture and a high amount of protein and fat content in the fried stage than the raw stage in Malawi tilapia (*Oreochromis karongae*), which are closely similar to the present finding.

At the raw stage, the higher moisture and ash content of native pangas (*Pangasius pangasius*) collected from site 2 was 63.15%, 1.4%, respectively. The higher protein, fat, and carbohydrate estimated for native pangas from site 1 were 24%, 13% and 1.1%, respectively (Fig. 1). On the other hand, the highest amount of moisture, fat and ash of hybrid pangas collected from site 4 was 62.19%, 16.2% and 1.27%, respectively, but the highest protein content, 20.5%, was found in the sample from site 3 (Fig. 2)

In the fried stage, the higher moisture, ash and carbohydrate contents of native pangas from site 2 were 50.3%, 1.6% and 1.39, respectively (Fig. 1). The higher protein and fat contents were estimated at 28.4% and 21.5% in the native sample from site 1 (Fig. 1). For hybrid pangas, the higher moisture (49.02%), fat (25.1%), ash (1.51%) and carbohydrate (1.87%) were found in the sample collected from site 4 (Fig. 2) and the highest protein 25.6% was estimated in the sample from site 3 (Fig. 2).

Table 2. Proximate composition of native and hybrid pangas at the fried stage.

Proximate composition	Native pangas			Hybrid pangas		
	Site 1	Site 2	Average ± SE	Site 3	Site 4	Average ± SE
Moisture (%)	47.20	50.30	48.75±1.55	48.07	49.02	48.55±0.47
Protein (%)	28.40	25.20	26.80±1.60	25.60	22.50	24.05±1.55
Fat (%)	21.50	20.40	20.95±0.55	23.30	25.10	24.20±0.9
Ash (%)	1.57	1.60	1.58±0.01	1.43	1.51	1.47±0.04
Carbohydrate (%)	1.30	1.39	1.34±0.04	1.60	1.87	1.74±0.13
Energy (Kcal)	316.00	304.00	310.00±6.00	323.00	328.00	325.50±2.50

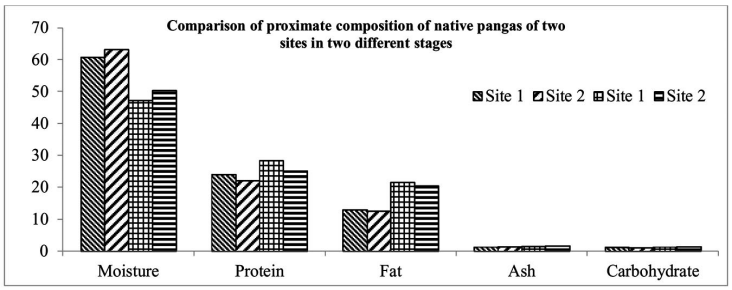

Fig. 1. Comparison of proximate composition of native pangas of two sites in two different stages.

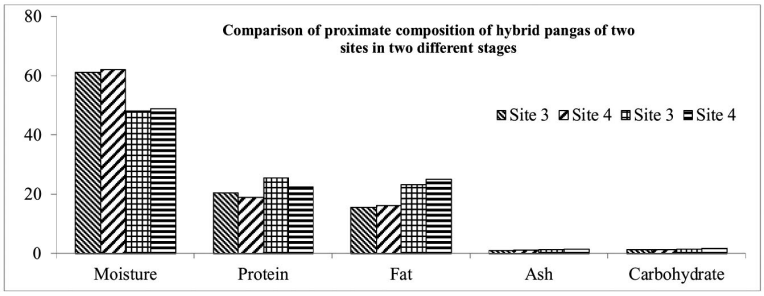

Fig. 2. Comparison of proximate composition of hybrid pangas of two sites in two different stages.

The highest protein content was 24% which has similar to the finding of Islam *et al.* 2012. They found 26% protein in native pangas. Begum *et al*. (2012) found 78.29% moisture in domesticated stock of *Pangasius hypophthalmus* in laboratory conditions. Islam *et al.* (2012) recorded 62.71 % moisture, 11.1 % fat and 23.18% protein value of hybrid pangas which are closely similar to the present finding. Hasan *et al.* (2018) recorded 74.14% moisture, 17.75% protein, 2.8% fat, 2.89% ash and 0.73% carbohydrate

for *Channa puncatus* at the raw stage. There is a great change in fat and protein contents between the raw and fried stage due to heat. The amount other than moisture became a higher proportion because of water loss in the fried stage. (Tables 1-2). Mahaboob *et al.* (2018) had found a decreased amount of moisture and a high amount of protein and fat content in the fried stage than the raw stage, closely similar to the present findings.

Energy estimation: Higher energy was found in hybrid species 231±1.00 as its fat content was higher in the raw stage and the freid stage, which was 316 Kcal in native and 328 Kcal in hybrid species (Tables 1 and 2). Gopalan *et al.* (1971) reported 161 Kcal for pangas fish which is quite different from the present finding. Hasan *et al.* (2018) found 101 kcal for *Channa punctatus* in the raw stage.

The mineral content of native and hybrid pangas: At raw and fried stages, native pangas contained higher amount of sodium (Na), calcium (Ca), magnesium (Mg), phosphorus (P) and iron (Fe), zinc (Zn) and copper (Cu) than the hybrid species (Tables 3 and 4). But in the case of the fried stage, it was observed that Fe was decreased in a very low concentration from the raw stages in both native and hybrid pangas (Tables 3 and 4). At both the raw and fried stage, the higher amount of sodium, magnesium, phosphorus, iron, zinc, copper for native pangas collected from site 1 was 190.5 mg/100 g, 48.5 mg/100 g, 170.3 mg/100 g, 4.74 mg/100 g, 0.90 mg/100 g, 0.43 mg/100 g and 198.2 mg/100 g, 44.2 mg/100 g, 185.2 mg/100 g, 4.13 mg/100 g, 0.81 mg/100 g, 0.37 mg/100 g, respectively in the samples from site 2 (Fig. 3). The highest amount of calcium (122.5 mg/100 g at raw and 110.2 mg/100 g at fried stage) was estimated in native species from site 2 (Fig. 3). For hybrid pangas, the highest amount of sodium (105.3 mg/100 g and 116.6 mg/100 g), calcium (88.7 mg/100 g and 72.4 mg/100 g), magnesium (27.3 mg/100 g and 25.3 mg/100 g) and phosphorus (133.2 mg/100 g and 142.4 mg/100 g) were found in the sample from site 4 at both raw and fried stages, respectively (Fig. 4) but higher amount of iron (1.61 mg/100 g and 1.3 mg/100 g), zinc (0.76 mg/100 g and 0.69 mg/100 g) and copper (0.27 mg/100 g and 0.25 mg/100 g) were estimated in samples of site 3 at both raw and fried stages respectively (Fig. 4).

Islam *et al.* (2012) reported the calcium content of native and hybrid Pangas 110 mg/100 g. Native pangas contain a high amount of calcium content than the hybrid. This finding is quite similar to the investigation of Islam *et al.* (2012). The values of other minerals such as sodium, zinc, iron, and copper were more or less similar to the study of Monalisa *et al.* (2013). Hasan *et al.* (2018) found 381.2 mg/100 g Ca, 105 mg/100 g Mg, 68.6 mg/100 g P and 11.4 mg/100 g Fe in *Channa punctatus* in the raw stage.

Table 3. Mineral content of native and hybrid pangas at a raw stage.

Minerals mg/100 g	Native pangas			Hybrid pangas		
	Site 1	Site 2	Average ± SE	Site 3	Site 4	Average ± SE
Sodium (Na)	190.50	180.25	185.38±5.12	95.70	105.30	100.50±4.80
Calcium (Ca)	110.20	122.50	116.35±6.15	75.36	88.70	82.03±6.67
Magnesium (Mg)	48.50	42.31	45.40±3.09	23.05	27.30	25.17±2.12
Phosphorus (P)	170.30	163.50	166.90±3.40	122.50	133.20	127.85±5.35
Iron (Fe)	4.74	4.50	4.62±0.12	1.61	1.52	1.56±0.04
Zinc (Zn)	0.90	0.81	0.85±0.04	0.76	0.72	0.74±0.02
Copper (Cu)	0.43	0.37	0.40±0.03	0.27	0.24	0.25±0.01

Table 4. Mineral content of native and hybrid pangas at the fried stage.

Minerals mg/100 g	Native pangas			Hybrid pangas		
	Site 1	Site 2	Average ± SE	Site 3	Site 4	Average ± SE
Sodium (Na)	198.20	192.40	195.30±2.90	104.60	116.60	110.60±6.00
Calcium (Ca)	96.50	110.20	103.35±6.85	67.30	72.40	69.85±2.55
Magnesium (Mg)	44.20	39.70	41.95±2.25	20.40	25.30	22.85±2.45
Phosphorus (P)	185.20	177.02	181.11±4.09	131.07	142.40	136.73±5.66
Iron (Fe)	4.13	4.03	4.08±0.05	1.30	1.27	1.28±0.01
Zinc (Zn)	0.81	0.74	0.77±0.03	0.69	0.67	0.68±0.01
Copper (Cu)	0.37	0.32	0.34±0.02	0.25	0.20	0.22±0.02

The study indicated that native pangas are a good source of minerals than hybrid pangas. (Tables 3-4). This study may be useful in developing nutrient-balanced and cost-effective diets for consumers.

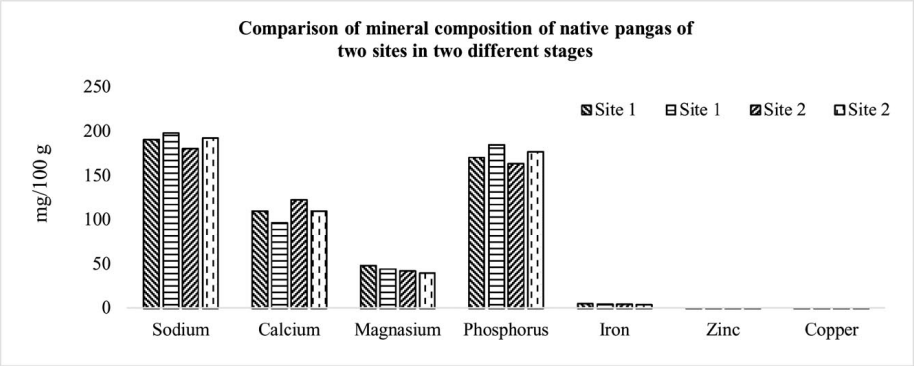

Fig. 3. Comparison of mineral content of native pangas of two sites in two different stages.

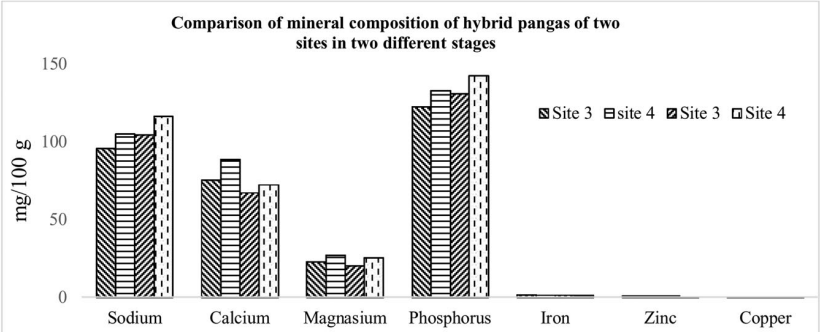

Fig. 4. Comparison of mineral content of hybrid pangas of two sites in two different stages.

The present study has elucidated the importance of native and hybrid species by estimating proximate and mineral composition. Since hybrid fishes are now very popular in rural and urban areas, there are still some confusions to the consumers about the nutrition of hybrid ones. The hybrid species contain more fat content than the native. Native pangas contain a significant amount of protein compared to the hybrid. The examined native fishes had appreciable Na, Ca, Mg, Fe, P, Zn and Cu than hybrid fishes. There is no significant effect on mineral composition after frying compared to the raw fish. This study may be helpful in developing nutrient-balanced and cost-effective diets for consumers.

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BREEDING BIOLOGY OF COMMON KINGFISHER (*ALCEDO ATTHIS*, LINNAEUS 1758)

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Abstract

The breeding biology of the common kingfisher (*Alcedo atthis*) was studied from 2008 to 2011 in Dhaka North City Corporation and Savar Upazilla. The breeding season was April to September. It laid 3 to 7 glossy white, almost round eggs with a size of 2.5±0.3 cm length, 2.2±0.3 cm breadth, and 5.3±0.7g weight. It incubated for 16 to 21 days. During hatching, the hatchlings' weight ranged from 8.5 to 10.5 g and total body length from 43.2 to 58.6 mm whereas, it was 30.1 to 32.7 g and 151 to 155.5 mm, respectively, during fledging. Hatching success was 83.3%. Stolen by people (13.9%) and infertility (2.8%) were the causes of egg loss. The young birds fledged out after 21 to 27 days of hatching. A total of 56.7% of nestlings were unable to fly due to stolen (43.3%), deaths due to unknown reasons (6.7%) and deaths due to natural disaster (6.7%). The breeding success was 36.1% in relation to eggs laid and 43.3% in relation to eggs hatched.

Key words: Egg, Hatchling, Fledgling, Breeding success, Common kingfisher, *Alcedo atthis*

Introduction

The common kingfisher, *Alcedo atthis* (Linnaeus 1758) (order Coraciiformes; Family Alcedinidae), nests in holes in sandy or loamy embankments considering the soil particle composition of nesting banks and some other related factors like compactness, porosity, etc. (Heneberg 2004). It avoids sites with sparse or very dense vegetation, prefers rivers with the availability of fish, about 54-60 mm shallow waters and of course, demands sandy or loamy banks for nesting (Morgan and Glue 1977, Iribarren and Nevado 1982, Raven 1986, Peris and Rodriguez 1996, 1997, Campos *et al.* 2000). Thus, habitat is one of the most important factors determining the distribution and settlement of species (Partridge 1981). An appropriate nesting site must offer food, shelter from predators and

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unfavorable weather conditions (Li and Martin 1991, Martin and Roper 1988). Wetland degradation, water pollution, climate change and disturbances caused by fish farmers create threats to them. Although they may get benefit from human dams and fish farming, they are at risk of poisoning through bioaccumulation of pollution and toxins in their fish prey (Rayner *et al*. 1991). Several studies have been done on ccommon kingfishers globally, (Raven 1986, Reynolds and Hinge 1996, Peris and Rodriguez 1997, Sayako *et al*. 2002, Heneberg 2004, Kasahara and Katoh 2008) and in Bangladesh (Naher and Sarker 2015, 2016, 2018). However, information on the breeding biology of common kingfishers is restricted in Bangladesh and even in the world. To take conservation initiative of this species, one should know their detailed breeding biology. Hence, the present study investigated the breeding biology of common kingfishers (*Alcedo atthis*). The objectives of this study were to determine reproductive success, mortality rates and the causes of eggs and fledgling loss. With this knowledge, we will be able to make a conservation plan to sustain the species by protecting nest and nestlings by reducing the challenges.

Materials and Methods

The fieldwork was performed twice a week during the breeding season, from 7:00 am to 7:00 pm, following focal animal sampling at 5 minutes intervals (Altmann 1974). Pair formation and courtship behavior were noted under several headings: (i) Advertising display: One bird squatting on a tree branch, calling and jerking its head right and left and flying from one branch to another around the other bird, (ii) Head bobbing: Squatting on a tree branch, head jerking up and down while neck and nape drew back and almost or actually touched the back, (iii) Mutual display: While one bird displayed, the other bird joined with and did the same. During this time, both birds sat side by side on the same or different branches (0.05 to 2 m, median=1.5 m, n = 42), (iv) Courtship flight: While the pair chased each other by flying up and down in a zig-zag fashion and calling, (v) Mounting: While one bird mount over another with or without cloaca contact.

The eggs were marked as I, II, III and so on with permanent ink and measured with slide calipers and weighed with a spring balance and care was taken to avoid excessive disturbance when first seen. The breeding success was calculated by using the following formulae:

Hatching success (%) = (No. of eggs hatched / total no. of eggs laid) × 100

Fledging success (%) = (No. of nestlings fledged / total no. of nestlings hatched) × 100

Breeding success (%) = (No. of eggs laid / No. of nestlings fledged) × 100

Study area: The study was done at Nikunja 1 in Dhaka North City Corporation Area and three villages (Sinduria, Boro-Walia, and Kashipur) under Savar Upazilla. Nikunja-1 (23.82500^0 N 90.42002^0E) is located on the west side of the Dhaka Airport highway. There are two Lakes, one at the east (668.5 X 17.07 m) and another one at the west side (218.13 X 75.05 m) of the Nikunja 1 residential area. The northern and southern side of Nikunja 1 is bounded by Nikunja 2 residential area and Dhaka Cantonment Gulf field, respectively. One nest was built at the bank of the eastern lake of Nikunja-1 in 2009, which was reused in 2010. On the other hand, Savar Upazila is located in the Dhaka district and covers 280.13 sq. km. Sinduria (23.88137^0 N and 90.23320^0E), Boro-Walia (23.88627^0 N and 90.25197^0E) and Kashipur (23.88483^0N and 90.24294^0E) villages were located under Boro-walia Union in Savar Upazila of Dhaka district. One nest was found at Bara Walia, which was reused in 2010 and 2011. One nest was built at Sinduria in 2010 which was reused in 2011. One nest was found at Kashipur in 2011. These villages are located at the Jahangirnagar University Campus.

Results and Discussion

Breeding season: The breeding season started from April and continued up to September. Most of the observers around the world, including the Indian subcontinent, found that the breeding season covered more or less the same months as found in the present study in Bangladesh (Whistler 1986, Ali and Ripley 1987, Singer 1996). But a quite different finding was observed by Grimmett *et al.* (1998), who found the breeding season from November to June in India.

Pair formation: Pair formation occurred through a course of displaying behavior. Advertising display was recorded for one to seven days (mean 4.8 ± 1.2, n=9 pairs). The advertiser started its display by squatting on the branch of densely covered trees (*Dalbergia sisoo*, *Albizia procera*, or *Morus indica*) hanging over the water. This behavior was followed by head bobbing which occurred 14 to 49 times per minute (mean 21.9± 4.9, n=42 of 3 birds). Ali and Ripley (1983), Anderton and Rassmussen (2005) also reported the advertising display of white-throated kingfishers.

Mutual display: Head bobbing was followed by courtship flight which was recorded for 1 to 3 days (mean 1.8 ± 1, n=6), through which the pair formation occurred permanently. After pair formation, one partner offered food to the other, sometimes the other bird received it or not. This behavior is known as ‘engagement fish’. Courtship involved chasing each other with calling and usually culminates in the male catching and offering the female an ‘engagement fish’.

Sexual behavior: Mounting took place within 1 to 2 days of pair formation, lasting for 1 to 3 seconds while cloaca contact did not occur, but it increased to 3 to 7 sec (4.5 ± 1, n=12) while cloaca contact occurred. During mounting, both partners flapped their wings with calling. After mating, both partners flew away towards the nearby branches and preened their feathers for 1 to 5 minutes (median 4.2, n=12).

Nest site selection and territory establishment: After pair formation, both the partners selected abandoned and isolated nest sites, near or away from human habitation (Figs. 1-2). They chose a vertical, sandy-loam area where they could dig holes comfortably. The pair searched for newly cut down slopes or eroded hills/heaps at the bank of the lake, pond, river, or near the paddy field and ditch (Naher and Sarker 2016).

Figs. 1-2: 1. Nest of common kingfisher. 2. Nest of common kingfisher beside a water body.

Nest: The nest was a 36.5 cm long horizontal tunnel with an oval-shaped entrance, the vertical diameter was 8.25 cm and the horizontal diameter was 4.25 cm. The widened oval shaped egg chamber with 11.6 cm ×12.7 cm size was built at the end of the nest. Only one nest was built in the nest site. The same observation was reported by Naher and Sarker (2016).

Clutch size: In May and June, it laid eggs. The clutch size varied from 2 to 7 eggs (mean 4.5 ± 1.5, n = 8). Clutch of 5 was common (50%). Clutch sizes of 4 to 8 eggs were reported in different areas of the world (Jerdon 1982, Flegg 1984, Whistler 1986, Ali and Ripley 1987). Various factors are responsible for the variability of clutch sizes such as the condition of the breeding female, availability of resources necessary to produce eggs, time of laying in the season and anticipated future availability of food for feeding nestlings (Klomp 1970, O'Connor 1984, Lessels and Krebs 1989).

Color and shape of the egg: The color of the egg was glossy white (Fig. 3). It may be pinky white, white or pure unmarked China-white of hard texture with a high gloss (Finn 1978, Jerdon 1982, Flegg 1984, Singer 1996, Whistler 1986, Ali and Ripley 1987).

The egg was almost round (Fig. 3). Flegg (1984) and Jerdon (1982) reported such a shape. Whistler (1986) and Ali and Ripley (1987) described the spherical-shaped eggs.

Fig. 3. Eggs of common kingfisher.

Morphometry of eggs: The length, width and weight of the eggs varied from 2.01 to 2.91 cm (2.5±0.3, n=36), 1.8 to 2.5 cm (2.2±0.3, n=36), 4.9 to 7.5 g (5.3±0.7, n=36), respectively (Table 1). The length is significantly correlated with width ($r=0.81$, $df=34$, $p < 0.05$) and weight ($r=0.55$, $df=34$, $p < 0.05$), even width is also significantly correlated with weight ($r=0.38$, $df=34$, $p < 0.05$).

Incubation period: The incubation period ranged from 16 to 21 days (18.5 days ± 1.1, n =8). Different clutches of different nests had different incubation period and the test was statistically significant ($r = 0.264$, $df = 6$, $p < 0.05$). Almost same observation was made by different workers (Ali and Ripley 1987, Singer 1996).

Table 1. Clutch size of common kingfisher in different locations.

Year	SA	Clutch size	Egg measurement																							
			1st			2nd			3rd			4th			5th			6th			7th			avg ± SD		
			L	B	W	L	B	W	L	B	W	L	B	W	L	B	W	L	B	W	L	B	W	L	B	W
			2.11	2.03	6.7	2.72	2.46	6.7	2.53	2.32	5.9	2.47	2.17	6.7	2.06	1.92	4.9	2.38	2.13	5.4	2.15	2.01	5.7	2.5 ± 0.3	2.2 ± 0.2	6.4± 0.7
	B	05	2.47	2.12	6.9	2.01	1.82	5.2	2.45	2.15	5.1	2.34	2.13	6.3	2.71	2.53	6.8									
2010	N	05	2.8	2.41	7.2	2.75	2.35	6.8	2.28	2.06	5.3	2.53	2.25	6.6	2.23	2.11	5.6									
	B	04	2.18	1.8	5.8	2.77	2.46	5.6	2.31	2.14	5.7	2.66	2.37	7.0												
	S	05	2.25	1.97	6.2	2.74	2.37	6.5	2.79	2.48	6.4	2.80	2.5	7.3	2.17	2.05	7.1									
2011	B	03	2.87	2.3	7.5	2.8	2.2	7.1	2.13	2.14	6.8															
	K	02	2.53	1.9	6.8	2.04	1.91	6.5																		
	S	05	2.91	2.1	7.1	2.9	2.4	6.8	2.11	1.94	5.1	2.62	2.11	7.2	2.1	1.8	6.8									

Note: L = Length, B = Breadth, W = Weight, N= Nikunjo, B=Bara Walia, S=Shinduria, K=Kashipur, SA=Study area.

Hatching and hatching success: One (79.2%, n= 24) to three (4.2%, n=24) eggs were hatched in one day. As soon as the first egg hatched out, the parents started collecting and providing food to the hatchling alternatively. For example, one partner took 3 min to 40 min (19.5 ± 12, n=35) to feed the nestlings at a time and repeatedly did the same.

The hatching success was 83.3 % (n=36). The mean brood per nest was 3. However, the eggs were lost due to stealing by people (13.9%) or remained unhatched due to infertility (2.8%) (Table 2).

Physical feature of the hatchling: The newly hatched hatchling was naked with transparent body skin and flesh colored. The beak and claws were black. Eyes were closed. Eyelids appeared large and dark gray. Egg tooth was present which were disappeared at the 7th to 9th days of hatching. The claw, wing, and tail feathers were absent (Figs. 4 and 5). The measurement of hatchlings and fledglings is represented in Table 3.

Figs. 4-5: 4. Physical feature of the hatchlings of common kingfisher. 5. Physical feature of the nestlings of common kingfisher.

Opening of the eyes: The eyes started to open after the 7th to 8th days of hatching, which were completely opened at the age of 10th to 12th days. Cramp *et al.* (1988) recorded pied kingfisher opened its eyes after the 9th day of hatching.

Fledging period: After 20 to 22 days of hatching, the nestlings started to practice flying. They first tried to glide from the nest to nearby branches of the trees, paddy fields, or any support where they could perch easily. The eldest nestlings' seen comparatively took more time (25-27 days) to fledge than others (21-24 days). The average fledging periods ranged from 21 to 27 days (24.8 days ± 1.1, n = 16).

Table 2. Nesting detail of common kingfisher in different sites.

NS	Year	Egg laying dates							Egg hatching dates							Fledging dates/comments
		1	2	3	4	5	6	7	1	2	3	4	5	6	7	
N	2009	7/8	8/8	9/8	10/8	11/8	12/8	14/8	25/8	27/8	29/8	28/8	29/8	30/8	1/9	5 Stolen by people and 2 died naturally
B	2009	24/6	25/6	26/6	27/6	28/6			12/7	15/7	13/7	14/7	15/7			Stolen by people
N	2010	15/7	16/7	17/7	18/7	19/7			5/8	6/8	7/8	6/8	8/8			30/8
B	2010	12/6	13/6	14/6	16/6				29/6	UH	30/6	3/7				23/7
S	2010	5/8	6/8	7/8	8/8	9/8			23/8	23/8	26/8	26/8	26/8			18/9
B	2011	10/7	11/7	12/7					26/7	27/7	26/7					Stolen by people
K	2011	22/7	25/7						8/8	10/8						Flooded
S	2011	7/8	8/8	9/8	9/8	11/8			-	-	-	-	-	-	-	Stolen by people

Note: N = Nikunjo, B = BaraWalia, S = Shinduria, K = Kashipur, UH = Unhatched.

Table 3. Measurement of different body parts of the hatchling and fledgling of common kingfisher.

Variables	Hatchling at the hatching time (n=25)		Fledgling at the fledging time (n=13)		Adult (from literature)	
	Range	Mean ± sd	Range	Mean ± sd	Range	Mean ± sd
Body weight (g)	8.5-10.5	9.7±0.6	30.1-32.7	31.1±0.9	34-46g (Animal corner 2020)	34 g (ADW 2020)
Body length (mm)	43.2-58.6	50.0±3.6	151-155.5	153.3±2.0	17- 19 cm, (Animal corner 2020)	19 cm (Beautybirds 2020)
Wing length (mm)	16.7-21.2	18.9±0.9	65.2-71.3	68.8±1.8	7.5cm (Beauty of birds 2020)	26 cm
Head length (mm)	9.7-12.8	10.9±0.8	24.2 ±26.8	25.6±0.6	-	-
Beak length (mm)	6.1-8.2	7±0.5	36-40.5	38.5 ±1.5	-	4 cm (Animal corner 2020)
Feet length (mm)	10.5-13.7	11.9±0.8	10.5-13.7	11.9 ±0.8	-	-
Tarsus length (mm)	4.7-8.4	5.7±0.9	11.3-12.8	11.8±0.4	-	-
Primaries length (mm)	0	0	32.3-38.7	35.5±2.1	-	25 cm (Animal corner 2020)
Rectrices length (mm)	0	0	23.0-26.1	24.4±1.1	-	-
Claws length (mm)	0	0	4.1-4.3	4.2±0.1	-	-

Fledging success: The fledging success was 43.3% (n=30). The hatchlings were failed to fledge due to different reasons (Fig. 6), of which stolen by people was the leading cause (76%). Mean fledgling per nest was 2.0 ± 2.3 (nest no =8). One nest was built in July in Kashipur in 2011, which was flooded in August with two hatchlings due to heavy rainfall. Nestlings also die from flooding of the nest (ADW 2020). Also, bioaccumulation of pollution and toxins in fish affects the mortality rates of Kingfishers (ADW 2020).

The fledglings were almost similar to the adult in size (Table 3, but with duller and greener upperparts and paler underparts. It was also reported in Animal Corner (2020). Its bill was black, and initially, the legs have also remained black.

Breeding success: The breeding success was 36.1% in relation to eggs laid and 43.3% in relation to young fledged, whereas the mortality rate was 63.9 % and 56.7%, respectively. Kingfishers have relatively high reproductive rates, compensating for increased mortality in some areas (Fioratti 1992, Rayner *et al.* 1991).

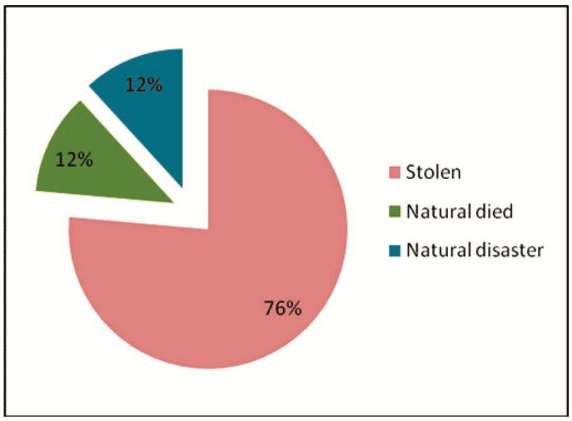

Fig. 6. Causes of loss of nestlings during the nesting period.

The common kingfishers build their nests near wetlands. As our country's wetlands are declining at an alarming rate, their nesting sites are under threat. Moreover, sudden fill-up of wetlands by the owners without concerning their nests decreases reproductive success. Regular cleaning activities of the owners at the bank of water bodies also destroy their nests. Besides, nests are also flooded by rising water levels caused by sudden heavy rainfall. In accordance with this, local boys steal the eggs and nestlings, and enhance the mortality rates. Additionally, cutting trees like, Sisoo (*Dalbergia sissoo*), Koroi (*Albizia*

procera), Gagan siris (*Albizia richardiana*), Tunt (*Morus indica*), Shimul (*Bombax ceiba*), Jhau (*Casuarina littorea*), Jiga (*Lannea coromandalica*) around the water bodies is another cause which was used for preying, resting, bathing and diving. They preferred to use 3 to 10.2 m (7.4 ± 2.3, n=14) height trees or brunches. As they live on fishes and insects, fish farmers trap them and kill them in Nikunjo 1. More than sixty percent of nests were destroyed due to anthropogenic reasons. If it were possible to check, the breeding success would increase. However, people should be aware to conserving the nest sites and habitat around the wetlands to conserve this species in nature.

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DAMAGE POTENTIAL AND CONTROL OF THE COMMON MORMON BUTTERFLY, *PAPILIO POLYTES* CRAMER ON CITRUS

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Abstract

Studies were conducted to know the damage potential and effect of insecticides on leaf area feeding and larval mortality of the common Mormon butterfly, *Papilio polytes* Cramer in the homestead garden and germplasm center of the Patuakhali Science and Technology University (PSTU) campus and in the laboratory, Department of Entomology, PSTU, Patuakhali, Bangladesh during October to December 2016. Ten *Citrus* host plants such as Kagoji lime-BAU-1, BAU-2, BAU-3, BAU-4, BARI kagoji, elachi lime, sweet orange, orange, jamir and pumelo were used as study materials. To determine the effects of insecticides on leaf area feeding and larval mortality, five treatments viz., T_1 = Voliam flexi 300SC @ 0.5 ml/l of water, T_2 = Voliam flexi 300SC @ 1.0 ml/l of water T_3 = Bioneem Plus @ 0.5 ml/l of water, T_4 = Bioneem Plus @ 1.0 ml/l of water T_5 = control were applied. Under natural field conditions, the highest percentage of leaf infestation was recorded in orange, followed by BAU-3, BAU-4, malta and elachi lime, while the lowest percentage was in BARI kagoji on 23 and 30 November, 2016. At the top canopy, the highest percentage of leaf infestation was recorded in orange and elachi (56%), while the lowest was in BAU-4 (8%). At the middle canopy, the highest percentage of leaf infestation was recorded in orange (56%), while the lowest was in jambura (12%). At the lower canopy, the highest percentage of leaf infestation was recorded in BAU-3 (40%), while the lowest was in elachi (8%). At the top canopy, significantly the highest percentage of infested leaves per branch was observed in orange (51.39%) and the lowest percentage of infested leaves per branch was in BAU-4 kagoji lime (10.86%). At middle and lower canopies, no significant difference was observed in the percentage of infested leaves per branch among different citrus varieties. The lowest percentage (6%) of leaf area consumed by 4th instar larva was recorded in T_2 (Voliam flexi 300SC @ 1.0 ml/l of water) treated leaf, while the highest percentage of leaf area consumption was found in T_5 (control) at 3 HAT. The highest percent mortality (100%) of larvae was found in T_2 treated citrus plant, while the lowest percent mortality was in the T_3 (70%) treated plant. No mortality was recorded in the untreated control (T_5) plant.

Key words: Citrus, Damage potential, Control, *Papilio polytes*

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Introduction

The genus *Citrus* is unique in its diversity of forms, and no other fruit crop can parallel it. *Citrus* spp. is the most cherished and highly priced fruit throughout the tropical and subtropical regions of the world (Butani 1979). The citrus industry is the third largest, in the world after mango and banana. In Bangladesh the citrus crop covering an area of about 5786 acres with an annual production of 68721 M. tons (BBS 2016). The yield of citrus in Bangladesh is very low compared to other countries due to attacks by a large number of insect pests, which cause a decline in yield (Chadha 1970). About 823 species of insects and mites attack citrus trees in the world (Ebeling 1959), around 165 species of economically important insect pests in India causing up to 30 per cent yield loss (Pruthi and Mani 1945), and 120 to 250 insect species were also reported from India (Nayar *et al*. 1976). The common mormon, *Papilio polytes* Cramer occurs throughout tropical and subtropical regions of the Old World, wide spread from the Middle East across southern Asia to Japan and Taiwan, and southward through Malaysia, Philippines, Indonesia, and New Guinea into Australia (Zakharov *et al.* 2004, Eastwood *et al.* 2006, Smith and Vane-Wright 2008, Mérit *et al.* 2009, Morgun and Wiemers 2012, IUCN Bangladesh 2015). These are described as the most destructive pests in the citrus nurseries in Bangladesh (Wehling *et al.* 2006, Shihan 2018). The New World arrival of this vagile lepidopteron pest is a potential threat to the citrus industries in these regions. The subspecies *P. polytes* is found mainly in Southeast Asia (Smith and Vane-Wright 2008) and can usually be sighted visiting flowers in the gardens of Singapore residential areas. The name of this butterfly is often derived from its food plant on which its caterpillar feeds on *Citrus* spp. named Key lime, *Citrus aurantifolia* (Tan and Khew 2012). Due to the import of kumquats (*Citrus japonica*) during the Chinese New Year season in Singapore, there is more food for their caterpillars to feed on (Khew 2010). The *P. polytes* is an economically important pest whose larval forms cause severe damage to the citrus family by devouring the foliage heavily during the later stages of their development. The larvae are a serious pest of citrus nursery stock (trees 1-2 ft. in height) and other young citrus trees and are capable of defoliating entire nursery groves. Larvae may utilize young foliage on more mature trees (Singh 1993, Matsumoto 1996, Narayanamma *et al*. 2001). The larval food plants of *P. polytes* in Asia are from the family Rutaceae, while in Australia and Papua New Guinea, the butterfly also feeds on host plants of the family the Fabaceae (Lewis 2010). The caterpillars feed voraciously and cause extensive damage to nurseries and young seedlings leaving behind midribs only. The caterpillars can completely defoliate young citrus trees (below 2 feet) by feeding only on fresh leaves and terminal shoots, the entire plant and devastate citrus

nurseries, while in mature trees, caterpillars may prefer young leaves and leaf flush (Lewis, 2010; Butani 1979, Bhutani and Jotwani 1975). Severe infestation leads to retards plant growth and decreases fruit yield (Pruthi 1969). Many pesticides were tested against this pest and found effective (Shivankar 1999). Hand-picking of caterpillars and spraying with endosulfan 35 EC (2 ml/10 litres of water) were the recommended means of pest control by Indian government agencies and agricultural colleges (Unattributed 2008); however, endosulfan has since been banned by the Supreme Court of India (Economic Times 2012, Times of India 2012). Sharma and Shrivastava (1970) stated that *Papilio demoleus* L. is an important pest of Citrus leaves in India. In 1968 at Rewa in Madhya Pradesh, trees of *C. reticulata* were sprayed three times at intervals of 15 days with six insecticides, and treated foliage was brought into the laboratory after each application for artificial infestation with larvae of *P. demoleus*. Mortality was assessed 48, 72, and 96 h after infestation. The results show that a 0.2% wettable-powder spray of carbaryl was the most effective treatment, although it was not significantly superior to 0.1% gamma BHC (lindane), 0.02% endrin or 0.05% malathion; 0.03% dimethoate or phosphamidon gave comparatively poor results. So far, I know the published research report on damage potential and control strategies against the common mormon butterfly is not available in Bangladesh. Considering above facts, the research work was undertaken to know the damage potential and effect of insecticides on leaf area feeding and larval mortality of the common mormon butterfly, *P. polytes* Cramer on citrus.

Materials and Methods

Studies were conducted in the homestead garden, germplasm center, and entomology laboratory of the Patuakhali Science and Technology University (PSTU), Dumki, Patuakhali, Bangladesh, from October to December 2016.

Determination of extent of damage on citrus host plants by larvae: Data on the extent of damage were taken from 10 plants of different citrus varieties viz., Kagoji lime-BAU-1, BAU-2, BAU-3, BAU-4, BARI kagoji, elachi lime, malta, orange, jamir and Jumbura grown in the germplasm center, Department of Horticulture, PSTU. The age of the plant was 5 years. Each plant was considered one treatment replication. Five branches were selected randomly from each plant and each branch was categorized into three viz., top, middle and lower categories. The number of infested and healthy leaves was counted from each of the three categories. Then the percentage of infested leaves was estimated.

Effect of insecticides on leaf area consumption and larval mortality: For this purpose, five treatments viz., T_1 = Voliam flexi 300SC @ 0.5 ml/l of water, T_2 = Voliam flexi

300SC @ 1.0 ml/l of water T_3 = Bioneem Plus @ 0.5 ml/l of water, T_4 = Bioneem Plus @ 1.0 ml/l of water T_5 = control were used. At first, 15 lemon leaves were collected and then dipped into the solution of above mention 5 treatments. In control, treatment leaves were treated with distilled water. Each treatment replicated 3 times. Five beakers were used for preparing the solution of each treatment to avoid any admixture of the insecticides. Then the leaves were sun dried and were placed in 15 petridishes. Later on, the 4th instar larva was individually placed in each petridish. The percent area of leaf consumed by the 4th instar larva was determined by eye estimation at 3 HAT. The larval condition was recorded at 3 HAT due to feeding or no feeding on treated leaves. The mortality of larvae was counted at 12 HAT by applying different treatments on the citrus plant.

Statistical analysis: Data were analyzed following ANOVA using WASP (Web-based Agricultural Statistical Package) software. CD (Critical difference) means were separated by values.

Results and Discussion

Damage potential under natural field condition: The percentage of leaf infestation/plant by larvae of common mormon butterfly on different varieties of citrus on 16, 23 and 30 November, 2016 is shown in Fig. 1. On 16 November, the highest percentage of leaf infestation was recorded in elachi lime (33.91%), followed by BAU-1 (23.08%), orange (22.82%), sweet orange (22.66%), BAU-4 (21.79%), and BAU-3 (21.79%) while the lowest percentage was in BARI kagoji (10.64%) followed by pumelo (12.38%), BAU-2 (17.54%) and jamir (18.27%).

On 23 November, the highest percentage of leaf infestation was recorded in orange (44.00%), followed by BAU-3 (37.33%), sweet orange (36.00%), elachi lime (33.33%) and BAU-1 (29.33%). However, the lowest percentage was in pumelo 18.67%) followed by BAU-4 (24.00%), BAU-2 (25.33%), BARI kagoji (25.33%) and jamir (26.67%).

On 30 November, the highest percentage of leaf infestation was recorded in orange (40.00%), followed by BAU-3 (36.00%), BAU-4 (33.33%), sweet orange (30.67%) and elachi lime (30.67%) while the lowest percentage was in BARI kagoji (17.33%) followed by BAU-2 (20.00%), pumelo (21.33%), jamir (28.00%) and. BAU-1 (29.33%).

Percentage of leaf infestation per branch at various canopy: Fig. 2 revealed the percentage of leaf infestation per branch at a different canopy of citrus varieties. At the top canopy, the highest percentage of leaf infestation was recorded in orange and elachi

(56%), while the lowest was in BAU-4 (8%). The rank order of leaf infestation from highest to lowest was orange≥elachi>BAU-3≥sweet orange>BARIkagoji≥jamir>BAU-1>pumelo>BAU-2>BAU-4. Likewise, at the middle canopy, the highest percentage of leaf infestation was recorded in orange (56%) while the lowest was in pumelo (12%). The rank order was orange>sweet orange > elachi > BAU-2 ≥ BAU-4 > BAU-1≥ Jamir > BARIkagoji > BAU-3 > pumelo. At the lower canopy, the highest percentage of leaf infestation was recorded in BAU-3 (40%), while the lowest was in elachi (8%). The rank order from highest to lowest was BAU-3 > BAU-4 ≥ BAU-2 > BAU-1 > orange > sweetorange ≥pumelo > BARI kagoji ≥ jamir > elachi.

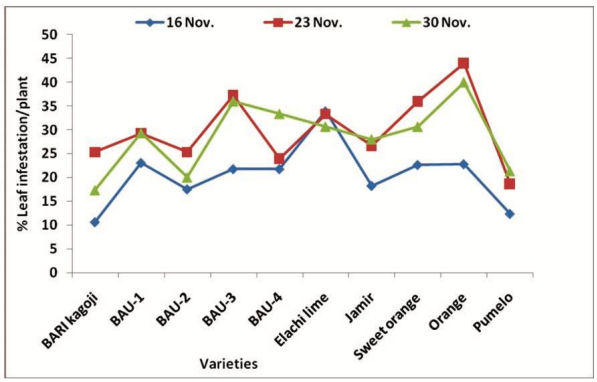

Fig. 1. Percentage of leaf infestation per plant by larvae of a common mormon butterfly on different citrus varieties on 16, 23, and 30 November, 2016.

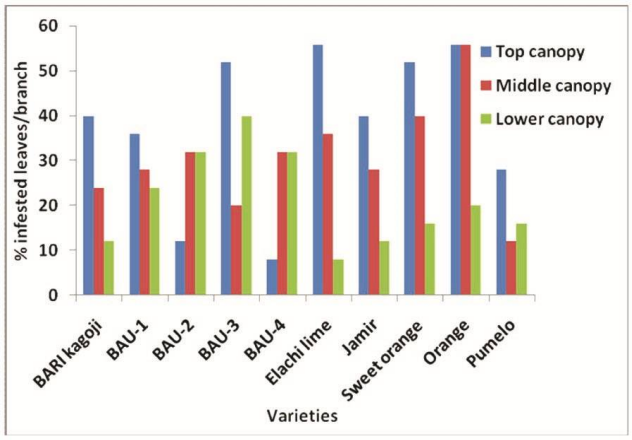

Fig. 2. Percentage of leaf infestation per branch at various canopy levels of different citurs varieties in November 2016.

Number of infested leaves per branch per plant: At the top canopy, significantly the highest number of infested leaves/branch was recorded in elachi lime (1.79), which was statistically similar to orange (1.75), sweet orange (1.70) and BAU-3 kagoji lime followed by BARI Kagoji (1.50). However, the lowest number of infested leaves/branch was recorded in BAU-4 kagoji lime (0.91) followed by BAU-2 kagoji (0.98), Pumelo (1.33) and BAU-1 kagoji (1.46) (Table 1).

At the middle canopy, no significant difference was observed in the number of infested leaves/branches among different varieties of citrus. The range of infested leaves was 1.02 to 1.72, while the highest number of infested leaves was on orange (1.72), and the lowest was in pumelo (1.02) (Table 1).

At the lower canopy, no significant difference was observed in the number of infested leaves/branches among different citrus varieties. The range of infested leaves was 0.91 to 1.50 while the highest number of infested leaves was recorded in BAU-3 Kagoji (1.50) followed by BAU-2 kagoji (1.38), BAU-4 (1.34) and BAU-1 kagoji (1.20) while the lowest was in Elachi lime (0.91) (Table 1, Plate 1).

Table 1. Number of infested leaves per branch per plant at different canopy level of citrus varieties

Varieties of citrus	Number of infested leaves/branch/plant at		
	Top canopy	Middle canopy	Lower canopy
BARI Kagoji	1.50[ab]	1.27	0.98
BAU-1 Kagoji	1.46[abc]	1.36	1.29
BAU-2 Kagoji	0.98[bc]	1.40	1.38
BAU-3 Kagoji	1.66[a]	1.19	1.50
BAU-4 Kagoji	0.91[c]	1.44	1.34
Elachi lime	1.79[a]	1.37	0.91
Jamir	1.51[ab]	1.36	0.98
Sweet orange	1.70[a]	1.55	1.09
Orange	1.75[a]	1.72	1.12
Pumelo	1.33[abc]	1.02	1.09
CV (%)	**30.16**	**29.90**	**38.85**
CD value	**0.568**	**NS**	**NS**
F value	**2.404**	**1.107**	**0.924**
Prob.	**0.029**	**0.388**	**0.518**

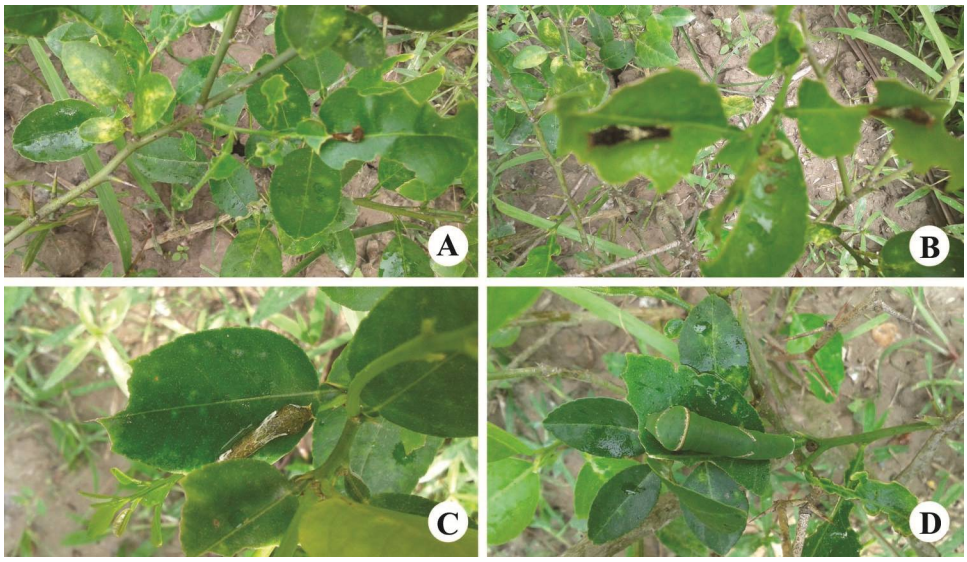

Plate 1. Damage symptom by larvae (A-1st, B-2nd & 3rd, C-4th and D-5th instar) of common mormon butterfly.

Percentage of infested leaves per branch per plant: The percentage of infested leaves per branch per plant of different citrus varieties at different canopy levels, is presented in Table 2. At the top canopy, significantly the highest percentage of infested leaves/branches was recorded in orange (51.39%), which was statistically similar to sweet orange (48.85%), elachi lime (48.69%) and BAU-3 kagoji (42.64%), followed by jamir (36.31%), BARI kagoji (36.08%), BAU-1 kagoji (33.78%) and pumelo (28.70%). However, the lowest percentage of infested leaves/branch was recorded in BAU-4 kagoji lime (10.86%) followed by BAU-2 kagoji lime (13.40%).

At the middle canopy, no significant difference was observed in the percentage of infested leaves/branches among different citrus varieties, but it ranged from 16.10% to 48.69%. The highest percent leaf infestation was recorded in orange (48.69%), followed by BAU-4 kagoji (34.17%), BAU-1 kagoji (31.64%), Jamir (31.41%), BAU-2 kagoji (31.24%) and elachi lime (30.84%). However, the lowest percent leaf infestation was recorded in pumelo (16.10%) followed by BAU-3 (23.86%) and BARI kagoji (26.40%) (Table 2).

At the lower canopy, the percentage of leaf infestation/branch ranged from 10.86% to 36.08%, while the highest percent leaf infestation was recorded in BAU-3 kagoji

(36.08%), followed by BAU-2 Kagoji (31.24%), BAU-1 kagoji (29.09%) and BAU-4 kagoji (28.55%). However, the lowest percentage of leaf infestation/branch was in elachi lime (10.86%), followed by jamir (13.40%), BARI kagoji (13.40%), orange (18.24%), sweet orange (18.63%) and pumelo (18.63%) (Table 2).

Table 2. Percentage of infested leaves per branch per plant at the different canopy levels of citrus varieties.

Varieties of citrus	Percentage (%) of infested leaves/branch/plant at		
	Top canopy	Middle canopy	Lower canopy
BARI Kagoji	36.08[ab]	26.40	13.40
BAU-1 Kagoji	33.78[ab]	31.64	29.09
BAU-2 Kagoji	13.40[b]	31.24	31.24
BAU-3 Kagoji	42.64[a]	23.86	36.08
BAU-4 Kagoji	10.86[b]	34.17	28.55
Elachi lime	48.69[a]	30.84	10.86
Jamir	36.31[ab]	31.41	13.40
Sweet orange	48.85[a]	38.78	18.63
Orange	51.39[a]	48.69	18.24
Pumelo	28.70[ab]	16.10	18.63
CV (%)	**60.58**	**59.19**	**92.70**
CD value	**27.25**	**NS**	**NS**
F value	**2.212**	**1.093**	**0.934**
Prob.	**0.041**	**0.394**	**0.510**

Management of common mormon butterfly

Effect of insecticides on leaf area feeding by larvae under laboratory condition: Fig. 3 revealed that the lowest percentage (6%) of leaf area consumed by 4th instar larva was recorded in T_2 (Voliam flexi 300SC @ 1.0 ml/l of water) treated leaf followed by T_4 (Bioneem Plus @ 1.0 ml/l of water), T_1 (Voliam flexi 300SC @ 0.5 ml/l of water), and T_3 (Bioneem Plus @ 0.5 ml/l of water) while the highest percentage of leaf area consumption was found in T_5 (control) at 3 HAT. After 3 hours, all the larvae were found dead.

Effect of different treatment on the larval mortality of common mormon butterfly on a treated citrus plant: It was evident from figure 4 that the highest percent mortality

(100%) of larvae was found in T_2 treated citrus plant followed by T_4 (90%) and T_1 (80%). In comparisons, the lowest percent mortality was in T_3 (70%) treated plant. No mortality was recorded in the untreated control (T_1) plant.

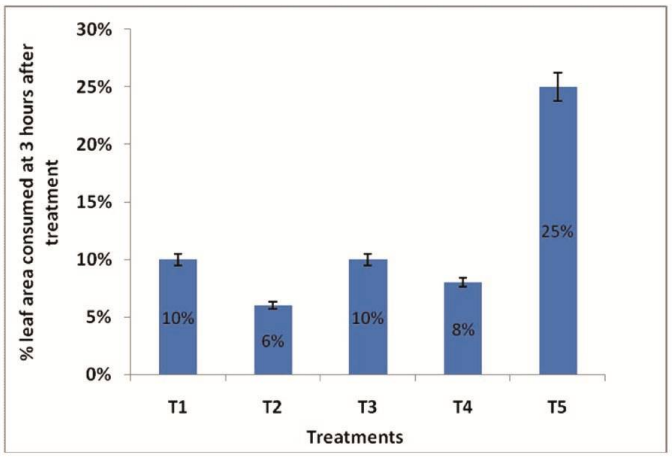

Fig. 3. Effectiveness of different treatments on leaf area consumed by 4th instar larva at 3 HAT. T_1 = Voliam flexi 300 SC @ 0.5 ml/l of water, T_2 = Voliam flexi 300 SC @ 1.0 ml/l of water, T_3 = Bioneem Plus 1% EC @ 0.5 ml/l of water, T_4 = Bioneem Plus 1% EC @ 1.0 ml/l of water, T_5 = Control.

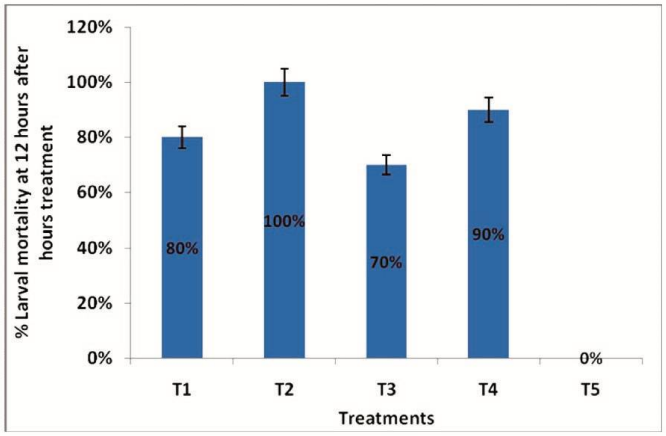

Fig. 4. Effectiveness of different treatments on the larval mortality of common mormon butterfly at 12 HAT on citrus plant. T_1 = Voliam flexi 300 SC @ 0.5 ml/l of water, T_2 = Voliam flexi 300 SC @ 1.0 ml/l of water, T_3 = Bioneem Plus 1% EC @ 0.5 ml/l of water, T_4 = Bioneem Plus 1% EC @ 1.0 ml/l of water, T_5 = Control.

This finding shows that the percentage of leaf infestation varied among three canopies of citrus varieties. The highest and lowest percentage of leaf infestation for various citrus varieties differed from one canopy to another. It was also observed that the larval stage of the pest caused damage by feeding voraciously on tender leaves and terminal shoots. As a habit, they feed on the margin reaching the midrib. The grown-up larvae even fed on mature leaves and completely defoliated the nurseries. The damage was more predominant in the nursery than in orchard trees. The habit of the larva and nature of damage found in the present study conformed with observations of Atwal (1964), Butani (1973). Sarada *et al*. (2014) stated that the larval population density was high during October to December months and July to December was the most favorable period of its activity in general. Severe infestation results in defoliation of the tree due to feeding of pedicels, heavily infested plants bear no fruit (Bhutani and Jotwani 1975) and leads to retards plant growth and decreases fruit yield (Pruthi 1969). The phytophagous larvae generally eat younger leaves and can denude growing shoots. During major infestations, the entire plant may be defoliated (Zacher 1914). The lemon butterfly larvae feeding on young leaves throughout the larval period and the population of lemon butterflies was higher in August and lowest in May. The extent of damage was also found higher in August (Shikdar *et al*. 2008). Narayanamma and Savithri (2002) found leaf infestation ranged from 14.71% to 59.98% by *P. demoleus*. In this study, the insecticide voliam flexi 300 SC @ 1.0 ml/l of water was found effective on larval mortality of the common mormon butterfly. This result is supported by Shivankar (1999), who stated that many pesticides were tested against this pest and found effective. Spraying with aqueous extract of neem seed kernal @ 0.5% twice at 8 days interval is effectively checked the pest population as it has strong antifeedant and repellant activity (Singh *et al*. 1996, Chauke *et al*. 1999) who stated azadirachtin (0.3%) as effective one against citrus butterfly among the various neem products. The efficacy of different concentrations of the biopesticides *Bacillus thuringiensis* and *Beauveria bassiana*, as well as of neem seed kernel extract, neem oil and azadirachtin were tested by Narayanamma and Savithri (2002) against *P. demoleus* in Andhra Pradesh, India.

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CITY DWELLERS' PERCEPTION OF ENVIRONMENTAL HAZARDS AND RISKS IN DHAKA CITY

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Abstract

This paper examines the social perceptions against the existing overall environmental hazards and pollutions of different residential areas of Dhaka Metropolitan area. The empirical data have been collected through a semi-structured questionnaire from 180 households. The findings reveal that more than 60% of people in residential areas are at high risk for environmental hazards due to the vast population density and unplanned high-rise buildings. Furthermore, on average, more than 53% of respondents have uttered various pollutions emphatically air, dust and noise pollution which are now common environmental phenomena of residential areas for unruly behaviors of dwellers and mismanagement of respective authorities. Moreover, the lack of open space is a burning question for the city dwellers, which causes a ventilation crisis through accelerating indoor pollution claimed by 95% of slum dwellers. After all, slum dwellers are more deprived of overall urban facilities, and abiding in unhygienic conditions made them more prone to fire hazards and severe health disorders. So, the study suggests that policymakers and city corporation authorities should be more concerned and taken proper initiatives to eradicate multifaceted issues to fabricate a sustainable environment for city dwellers.

Key words: Environmental hazard, Risk/ Pollution, Social perception, Slum, Dhaka city.

Introduction

In most urban cities of developing countries, the ever-growing population and its evolving nature have resulted in dramatic shifts in the current pattern of land use in and around those cities, thereby impacting the environment of the city (Rout and Bhagat 2012). Because urbanization has now become one of the world's major environmental challenges (Dewan *et al.* 2012). The world's urban population has risen rapidly from 751 million to 4.2 billion within 1950-2018, where 54% live in Asia (United Nations 2019). As a result, the cities are increasingly overcrowded and spoiled worldwide (Blanco *et al.* 2009, McDonald *et al*. 2010, Wolch *et al.* 2014). Due to the absence of sustainable

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urban environment maintenance strategies, the cities are facing difficulties related to environment pollution, transport system, housing issues, health infrastructure and other civic amenities and services (Rout and Bhagat 2012). Notwithstanding, the urban areas particularly have the high potentiality of losses from natural hazards (Dewan *et al.* 2012, Brecht *et al.* 2013) owing to uncontrollable growth of population and mismanagement of urban services (Bhattarai and Conway 2010, Islam *et al.* 2014).

Dhaka, as capital and the fastest-growing megacity of Bangladesh, has higher inbound traffic on roads, increasing energy consumptions, vast waste generations, and scarcity of proper performance of environmental rules and regulations rising the emission of pollutants into the air[1], water, and soil (Hosamane and Desai 2007, Alam 2009, Parvin *et al.* 2013, Ahmed 2014). According to World Health Organisation (WHO) 2018, Dhaka is the worst air polluted city among the top 20 cities in the world. The air quality and urban environment have weakened over the last decade for radical change in emissions from vehicle exhaust[2], growing congestion, the vast emerging of industrial activities, construction activities and brick kilns, road dust, residential and commercial biomass burning, waste burning, and diesel generators (Habib and Alam 2003, Guttikunda *et al.* 2013, World Health Organization 2014, Balakrishnan *et al.* 2019). Dhaka is also marked for a tremendous scarcity of outdoor facilities due to unplanned growth and has the lowest per capita number of open spaces[3] although the city's lungs are open spaces (Hossain 2006, Khan 2014). According to Dewan *et al.* (2012) and Islam *et al.* (2014), severe environmental pollution issues result from urbanization in terms of changes in land usage, the inadequacy of settlements, lack of water and sanitation services, and degradation of the community's ambient environment. Such studies concentrate mainly on the problems of land use change and its environmental effects in the city.

Research has also considered the perceptions of urban residents regarding the community environment and quality of life. An emphasis was given to define what variables ultimately differentiate or affect how people perceive their quality of life (Islam *et al.* 2014). A dynamic combination of variables including intellect and emotion is responsible for people's perception of environmental risks and hazards. Understanding perceptions

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1 Air pollutants, such as carbon monoxide (CO), CO_2, NO_2, nitrogen oxides (NOx), sulfur dioxide (SO2), ozone (O3), Lead (pb) heavy metals, volatile organic compounds (VOCs), and irrespirable particulate matter (PM2.5 and PM10) (Begum *et al.* 2010, Kampa and Castanas 2008, Salam *et al.* 2008, Hosamane and Desai 2007, Goyal *et al.* 2006, Akimoto 2003).

2 Vehicle exhaust- motorcycles, Private cars, aged busses, passenger cars, three-wheeler passenger vehicles, commercial vans, and freight trucks (Guttikunda *et al.* 2013, Habib and Alam 2003).

3 "P*laygrounds, stadiums, parks, woods, swimming pools, public libraries, theatres, art galleries, exhibition halls, museums and so on"* (Hossain 2006).

means exploring individuals' knowledge, thoughts, and attitudes about their environment (Olowoporoku 2018). On the other hand, different residents have distinct perceptions over the various environmental issues through human actions that are primarily responsible for the worse environment directly or indirectly. According to Rahman *et al.* (2010), in higher-income neighborhoods, families are typically well placed not only in terms of coping with issues of family size, but also with issues of community level. The contrary is true for the urban poor living in low-income areas, where conditions at the community level will exacerbate issues seen at the level of the home. Local issues are further exacerbated, where the vulnerable homes, most especially but not solely in informal communities, are poorly provided with basic facilities and services. Furthermore, the unsuitable spatial planning and control of the scarce resources is accused of further impeding Dhaka's socio-environmental parameters (Dewan *et al.* 2012).

Several research studies of urban dwellers' perceptions on environmental hazards and risks in Dhaka City or its particular area have already been carried out by Maniruzzaman and Haque 2007, Paul and Bhuiyan 2010, Rahman *et al.* 2010 (Chattogram), Dewan *et al.* 2012, Islam *et al.* 2014, Khan *et al.* 2018, Khatun and Islam, 2015, Rahman *et al.* 2018. However, this is the first attempt to study urban resident perceptions by addressing high-income, middle-income, and slum dwellers of the Dhaka Metropolitan Area (DMA). So, this paper's main thrust is to identify and assess the social perceptions/ behaviors against the existing overall environmental hazards and risks/ pollutions of urban residential areas in DMA. In addition, the study will also try to determine the influencing factors responsible for creating urban residential problems within the study areas.

Materials and Methods

Selection of the study area: Dhaka Metropolitan Area (DMA) was chosen as the study area for aggregation of the vast population in residential zones. There are various types of residential areas such as high-income, upper middle-income, middle-income, lower middle-income and also some sorts of mixed-up residential areas. That's why to extract the attitudes towards environmental hazards and risks (earthquake, fire, waterlogging, pollution) through different perspectives (Khatun and Islam 2015), three distinct residential areas were selected purposively which are situated nearly each other (Fig. 1). Dhanmondi (10, 11, and 12) have been selected for high-income residential areas, which is also recognized as the first planned residential area in Dhaka city developed by the Public Works Department in the 1960s. The area is the nearly central part of the city, and

a total of 2.179 km^2 is designed with a grid pattern plan with the road (Haque & Asami, 2011). Another area is Mirpur Pallabi 11½, selected as a middle-income residential area near the Rupnagar and Eastern Pallabi and under Dhaka North City Corporation (DNCC). Our study area occupies about 2 km^2 area. The other is the Kallayanpur slum area known as *Kallayanpur Pora Bastee* and a low-income residential area situated at Kallayanpur mahalla under the Kallayanpur ward of Mirpur Thana. Furthermore, slum dwellers are the most affected victims for the hazards and risks. To fulfill the objectives of the study, the following activities were undertaken.

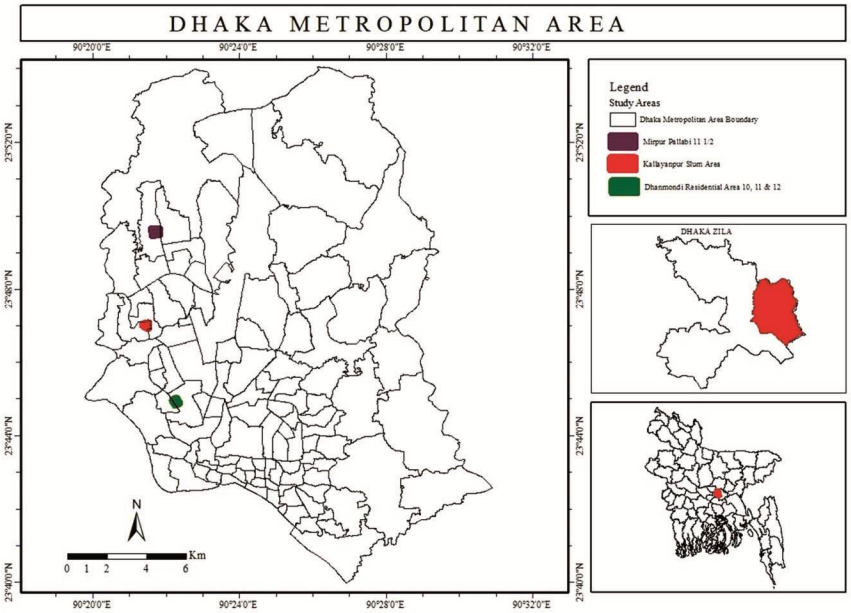

Fig. 1. Location of the study areas in the Dhaka Metropolitan Area.
Source: Field Study, 2018

Primary data collection: Data were collected in 2018 from the selected residential areas through maintaining various processes. A quantitative approach was used to collect data for this study. A detailed semi-structured questionnaire survey was carried out within those areas to collect primary data. The questionnaire was developed based on residents' experiences. In addition, discussions with various researchers were added and also negotiated with experts on this field. Hence, to demonstrate any mistakes or contradictions, it was essential to pre-test our new questionnaire and determined whether it would produce valuable results that would lead to the study's objectives. The pilot survey was carried out with residents before to the main study. Some minor difficulties

with the text and sequencing of two issues were found, which were well addressed before the key research.

Each questionnaire was translated in Bengali from English so that the residents can understand and respond fruitfully. A face-to-face questionnaire survey was conducted, which is the most effective method for data collection (Bird *et al.* 2009). For the selection of the participants, a purposive, systematic sampling technique was used due to some difficulties that occurred during data collection. Because most residents of high- and middle-income residential areas were unwilling to interview and share their views and perceptions with researchers on account of their tight schedule of businesses, jobs and also for feeling insecurity with unknown persons. In some apartment buildings, it was strongly prohibited for outsiders to enter the gate. As a consequence, the normal sampling interval varies in study areas. For example, each 4th household was selected in certain residential areas, while every 10th household was selected in another area. But such kinds of problems did not take place in slum areas. However, each participant was told of the purpose and the potential use of the dataset before to the interview. They were also told that, at any given time, they were entitled to withdraw from the survey without repercussions. Households' heads over 20 years old and living here more than 5 years were targeted, and anonymity was ensured for all participants. In the absence of the household head, an adult member of the household was interviewed. A total of 180 households (60 households from each area) were studied to assess their perceptions/ behaviors against environmental risks, pollutions, and other scarcities. An in-depth study was conducted to know their assistance from city corporations, NGOs, and health care facilities.

Secondary data collection: The secondary data were collected from government and non-government official documents and statistics, yearly reports, various published books, research papers, journals, articles, daily newspapers, and web-based documents to know the background and existing knowledge.

Data processing and analysis: All types of data were collected carefully. All the questions were asked to know the perceptions of the dwellers. Their responses on various hazards and risks were assessed using a 1-5 Likert scale, where 1 means the lowest probability or no risk and 5 signifies very risk or the highest. Apart from that, associated questions were also analyzed to explore the related intensities. Furthermore, the collected data were analyzed by computer-based specific statistical software MS excel 2016. The map of the study areas on different aspects is prepared using Arc GIS 10.4. The analysis has been presented using descriptive statistics.

Results and Discussion

Environmental hazards: Most urban areas are highly vulnerable to earthquakes, fire, and waterlogging/ flash floods because of unorganized settlements and large aggregation of the population (Karim 1995). The study found that about 64% of Dhanmondi respondents and 70% of the Mirpur area claimed very risky for earthquakes due to the vast density of both population and buildings, causing a significant loss of properties and lives. On the contrary, more than 85% of slum dwellers uttered low risk in the Kallayanpur slum (Fig. 2) due to the absence of high-rise buildings except for compact shanty settlements. But all the slum dwellers (also known as *Pora Bastee*) claimed that fire is the most significant hazard and life-threatening issue because they recently faced a destructive fire in January 2016 (The Daily Star 2016b) a day ago suspended eviction from High court. Several slum-dwellers alleged that the ruling party men set the shanties on fire to complete their eviction for benefitting from different projects within the land if thrown off (The Daily Star 2016a). Slums are unplanned and lack of emergency response in fire (Claret *et al.* 2012, Thomas 2007). Contrarily, 70% of people Dhanmondi R/A (Fig. 2) have voiced very risky for crowded settlements and descript electric wiring, which can be devastated within no time by fire. But, Mirpur Pallabi uttered moderately hazardous areas (Alam and Baroi 2004) due to maintaining zonal policies and regulations.

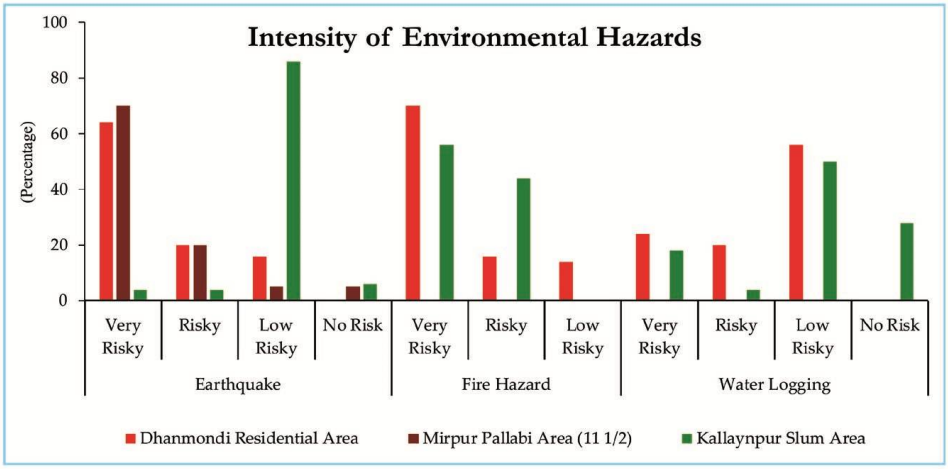

Fig. 2. A comparative scenario of the intensity of environmental risks.
Source: Field Study, 2018

Waterlogging problems have become more and more severe in urban areas for excessive rainfall (Alam and Rabbani, 2007, Mark *et al.* 2018, Zhang *et al.* 2012). Besides, the blockage of drainage and sewerage systems for solid waste dumping creates a massive

waterlogging problem, which is the main reason for mosquito growth and associated diseases (Rasid 1996, Ahmed *et al.* 2007, Islam *et al.* 2010). Moreover, waterlogging is the combination of physical, social, environmental problems and economic burden which directly affects poor dwellers (Mowla and Islam 2013) and also communication sector, schools, garment factories, etc. (Alam and Rabbani 2007). The study explored that waterlogging is not a very big problem, but in the rainy season, it becomes terrible in Dhanmondi, Mirpur, and Kallayanpur slum area responded by overall 20% people (Fig.1). Moreover, Slum areas of Bangladesh where dwellers have to confront water stagnation by excessive rainfall for narrow and unpaved roads (Kamruzzaman and Hakim 2016). Only 10% of slums had a good drainage system to avoid waterlogging, but Dhaka and Chattogram had the worst drainage conditions (Islam *et al.* 2006, Mohit 2012).

Uneven sewerage system: The sewerage system is the crucial element of amenities encompasses various components such as receiving drains, utility holes, pumping stations, storm overflows, and screening chambers of the combined sewer or sanitary sewer (Hassan *et al.* 2017). The study revealed that the sewerage system is well organized in Dhanmondi R/A, where a hundred percent of dwellers use a septic tank. The quality of the sewerage system in Pallabi is also well enough where more than 85 percent of residents use a septic tank for their houses which is an excellent sign for an ideal sewerage system (Fig. 3). Apart from 6% of people use integrate sewerage system. But in the Kallayanpur slum, the situation has been developed recently. At present, about 42% of households use the septic tank, and 48% use integrated sewerage systems (Fig. 3). The rest of the sewerage lines are connected to the drainage line of the Kallayanpur slum, which creates a severe problem for all the slum dwellers. Because of narrow roads and inadequate drainage systems, waterlogging and flash floods occur around their houses during the rainy season (Ahmed 2014, Braun and Aßheuer 2011, Farah *et al.* 2015, Islam *et al.* 2006, Kamruzzaman and Hakim 2016). Furthermore, for waterlogging, the sanitation system got affected. Water supplied line become polluted and unavailable for use and flares various water-borne diseases like diarrhoea, typhoid, cholera, skin diseases, fever, asthma, jaundice which affected Kallayanpur slum dwellers seasonally (Ahmed 2014, Dana 2011, Farah *et al.* 2015, Gulis *et al.* 2004, Kamruzzaman and Hakim 2016, Latif *et al.* 2016).

Menace problem: According to Islam *et al.* (2010), 38.4% of inhabitants claimed that waterlogging is the main reason for mosquitos' growth. Without that, cemented tanks, bathtubs, septic tanks, unused wells, derelict ponds, polluted canals, and open water containers serve as real heaven for mosquito breeding (Bashar *et al.* 2006, Chepesiuk 2003, Khan *et al.* 2014, Snehalatha *et al.* 2003). Furthermore, the study revealed that 60%

of households claimed mosquito as a very severe problem (Fig. 4a) which was not so severe before ten years.

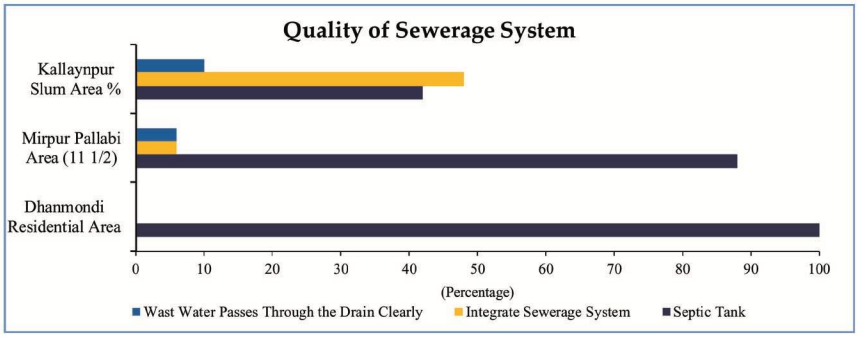

Fig. 3. Comparative study of quality of sewerage system
Source: Field Study, 2018

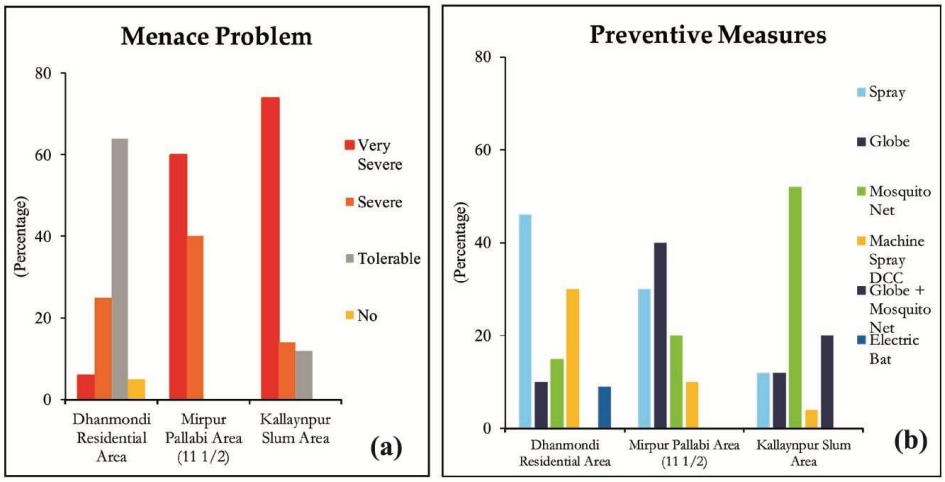

Figure 4. Comparative scenario of a mosquito problem and alternative measures.
Source: Field Study, 2018.

But in the Kallayanpur slum, the mosquito problem is more severe than in other residential areas, which is urged by 74% of slum dwellers, wherein Dhanmondi R/A only 6% (Fig. 4a). Now various mosquito-borne diseases have become a leading health problem in Bangladesh (Bashar *et al.* 2006, Snehalatha *et al.* 2003). Dengue fever, chikungunya fever, yellow fever, hemorrhagic fever, malaria are the prime mosquito-borne diseases (Bashar 2006, Bashar *et al.* 2006, 2012, Chowdhury *et al.* 2012, Gautam *et al.* 2017, Halstead 1966, Hassan *et al.* 2014, Khan *et al.* 2014). The study also found

that 62% uttered Chikungunya[4] as a devastating epidemic in Kallayanpur slum where only 26% claimed dengue fever is caused by Aedes aegypti and Aedes albopictus mosquitoes (Bashar *et al.* 2014, Hassan *et al*. 2014).

Figure 4b shows that more than 50% of slum dwellers use mosquito nets and 20% use globe/coil as preventive measures for protection from the menace. This behavior is also similar in the Pallabi area, where 60% use both globe and mosquito net. But in Dhanmondi R/A, more than 45% of households use Aerosol spray and also get the facility of Machine spray from DCC (Fig. 4b). According to Dhar-Chowdhury *et al.* (2016), the DCC authority has periodic programs of spraying larvicides (e.g., DDT) and insecticide pesticides (e.g., fenthion, Malathion) where this facility is very rare in slum areas but emerging in Mirpur Pallabi.

Major environmental risks: As the fastest-growing megacity of the world, Dhaka city contains more than 20 million people (United Nations 2019), and every year millions of people are added from the different parts of Bangladesh. These enormous populations have an extra burden on the residential areas of the Dhaka Metropolitan area and accelerating the pollution day by day. The study explored that Dhanmondi R/A (after being planned and agglomeration of high-income people), the intensity of air pollution, noise pollution, and dust pollution are very severe claimed by 44%, 56% and 60% of households, respectively (Fig. 5) due to congestion of commercial, residential and institutional buildings; motorized vehicles, construction works and indiscriminate use of loudspeaker (Alam 2009). Respondents also added that pollution level is magnifying because of the maintenance disorder in public facilities and proper implementation of law enforcement. In the Mirpur Pallabi area, these problems are significantly serious because of the ongoing construction activities where 58% of households urged dust pollution, and 32% encouraged air pollution. But 48% of people claimed noise pollution is moderately high because of this common problem. Contrarily in the Kallayanpur slum, the study revealed that more than 55% of households are fronting very severe dust pollution and air and noise pollution, respectively (Fig. 5) due to congestion, burning solid fuels for cooking which are wood, papers, and elastic and plastic wastes and noisy behaviorof the dwellers. These pollutions (basically air pollution) lead to fatalities and severe health diseases like acute lower respiratory infections, cardiovascular disease, lung cancer, and diabetes (Alam 2009, Guttikunda and Goel 2013, Hosamane and Desai 2007).

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[4] *"Chikungunya is characterized by fever, nausea, fatigue, myalgia, headache, rashes, prolonged joint pain, and arthralgia"* (Gautam *et al.* 2017).

On the other hand, water quality issues are a significant challenge that humanity faces every day in this century (Schwarzenbach *et al.* 2010) where surface water is more prone to contamination due to the availability of sewage and wastewater particularly in Dhaka city (Islam *et al.* 2015b). The study revealed different scenarios from the study areas.

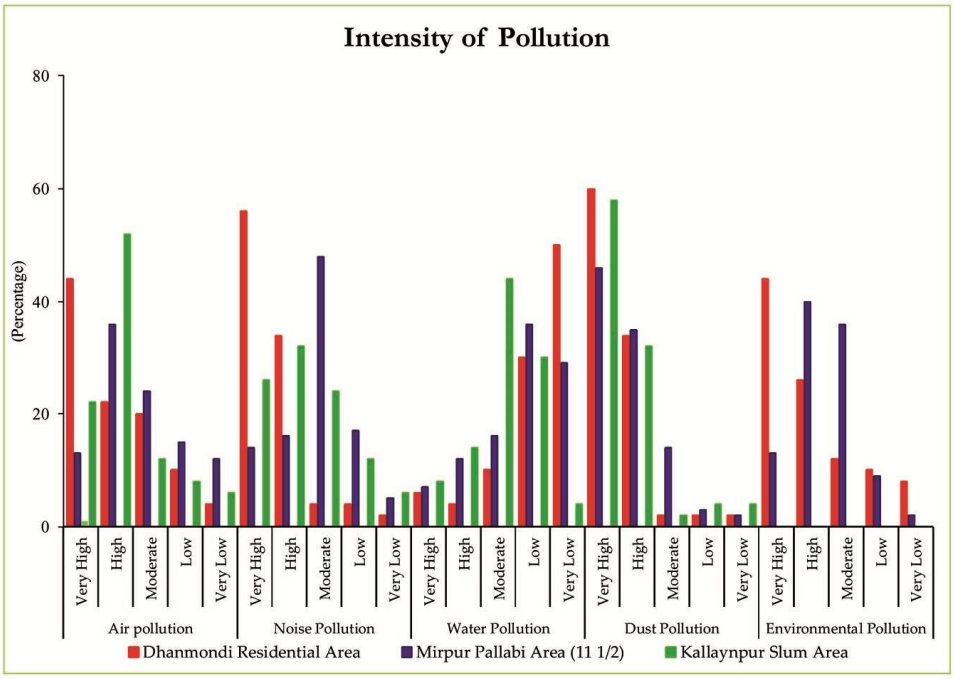

Fig. 5. The comparative scenario of pollutions as perceived by the respondents.
Source: Field Study, 2018

For being high to middle-income group residential area, about 80% and 56% of Dhanmondi R/A and Mirpur Pallabi area ′ s household respondents claimed that they have very few issues on water pollution (Fig. 5). This is because they are well supplied by WASA and for existing developed sewerage system. But in the Kallayanpur slum, despite existing contaminated pond by waste disposal, unplanned utility services, and sanitation infrastructure (Akanda and Hossain 2012), maximum respondents (about 75%) said that they have moderate water pollution because they are habituated to use polluted water and to wait on a queue for a long time due to collect drinking water supplied by WASA vehicle only in the morning. Using contaminated water causes various health diseases, including skin, diarrhea, malaria, cholera, dysentery, bacterial origin typhoid

fever, and yellow fever (Akanda and Hossain 2012, Halder and Islam 2015, Islam *et al.* 2010; Talukdar *et al.* 2013).

Indoor pollution: In residential areas, along with other pollutions, indoor pollution is boosting up day by day due to lack of ventilation facilities. Becasue the high density of settlements affects the accessibility of natural agents (natural lighting, views, ventilation, etc.) for domestic services (Chen *et al.* 2008). The lack of ventilation, low lighting and barrier loaded kitchens and bathroom facilities are hamper residential satisfaction in Dhaka Metropolitan Area (Boadi *et al.* 2005, Phillips *et al.* 2004, Sheuya 2008). The research revealed a significant absence of ventilation facilities in Kallayanpur Slum, where 95% of residents claimed no sufficient ventilation (Fig. 6). The situation is extremely vulnerable because of overcrowding and congestion, low-quality building structure (materials like wood, bamboo, straw, thatch or tins, and scraps, etc.), no separate place for cooking (creates high levels of indoor air pollution), lack of ventilation, lighting, sanitation facilities (Agarwal and Taneja 2005, Sheuya 2008, Alamgir *et al.* 2009, Jahan 2012) which are pernicious to safety, health and morals (Marimuthu *et al.* 2016, Sundari 2003). On the contrary, Dhanmondi and Mirpur Pallabi get incredible sufficient ventilation claimed by 70-76% of residents (Fig. 6). Most apartment holders gave the highest priority to water facilities and adequate ventilation (Kamal and Pramanik 2015).

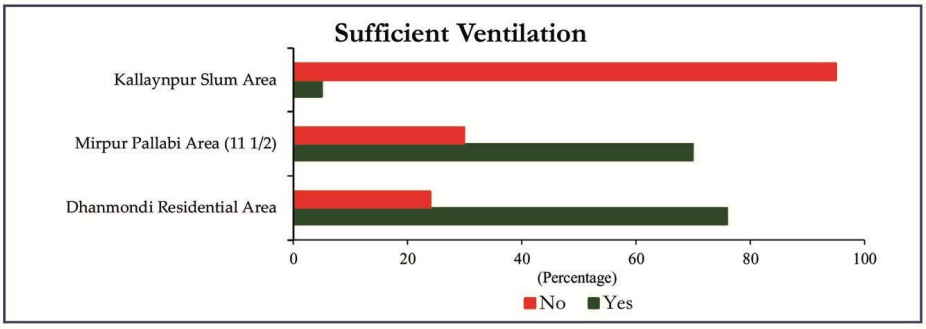

Fig. 6. The comparative scenario of ventilation facility.
Source: Field Study, 2018

Open space: Ventilation facilities are primarily dependent on the availability of open space, which is diminishing at an alarming rate. At present, Dhaka's urban infrastructure is highly vulnerable due to overpopulation. Dhaka city has 21.57% open space, of which city parks involve 0.89%, urban ranger service 0.02%, gardens 0.90%, and 12.12% has a place with agriculture (Islam *et al.* 2015a, Rahman and Siddiquee 2012). For these

reasons, the city dwellers are not well privileged with urban open space everywhere in the city. Therefore, open space which exists represents highly unequal distribution.

The study has been conducted to know the satisfactory level of city dwellers in those particular study areas. Figure 7 shows that 78 percent of dwellers of Dhanmondi R/A are moderately satisfied and only 8% are satisfied with the existence of Dhanmondi lake (as a recreational place) and some playgrounds (especially for children). *Abahani Playground* is located in that area which is recognized as an open space for recreation but for a limited time. At the same time, in Mirpur area, more than 70% of people are satisfied, and about 25 percent of dwellers are more satisfied because of close to the National Zoo, Botanical garden & National Stadium and adjacent of playgrounds to their buildings and locality. But in the Kallayanpur slum area, there are no open spaces, recreational sites and playgrounds for high density of population and settlements. More than 75% of slum dwellers are unsatisfied with not existing any open space because these kinds of people have no facilities to pace, even after expanding the highest amount of money per square feet among all dwellers of the city (Fig. 7).

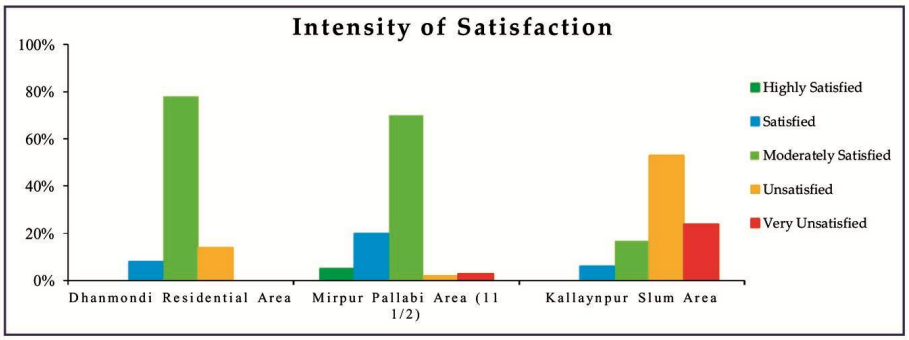

Fig. 7. Comparative study of satisfaction about open space.
Source: Field Study, 2018

Only 23% of dwellers of this area express their middling satisfaction because of the remaining small school playground along with the south-east corner of the slum. And the slum children get access to play in the playground only after school breaks up in the afternoon and on holiday. Otherwise, children use mosque premises as their recreation place and playground. There is also a water body, called ‘Jhil’ by local people, full of wastage and garbage. Hence the dream for open space is just a joke for them. But all the slum dwellers demand a recreational site and a playground for their children’s mental refreshment.

Conclusions and Recommendations

This research investigates social perceptions of environmental hazards and risks and their causal interaction to other challenges in the study areas of Dhaka Metropolitan Area, Bangladesh. The findings expose that the intensity of environmental threats and challenges varies mainly according to their residential location, income, and administrative services. The study demonstrated that existing social and infrastructural conditions are primarily responsible for aggravating of people's vulnerability in the study areas to earthquake disasters and other associated risks. A large number of residents of high and middle-income residential areas (more than 65%) in our study live in planned but disorganized multistoried buildings, which are more prone to earthquakes, fire, waterlogging, and pollutions. On the contrary, slum dwellers are highly exhausted and frightened owing to fire hazards than any other challenges. These dwellers are also highly vulnerable to air, water, and noise pollution, which directly affecting their health. Furthermore, the severity of environmental triggers has crossed a threshold that citizens cannot simply disregard. The findings indicated that the crucial stressors accompanied by noise, air, dust, and water pollution results from unplanned consumption of environmental resources.

Although this research has sought to examine environmental issues on multiple scales, environmental problems in households and neighborhoods are often indistinguishable. Indeed, they are also mutually inclusive; for example, neighborhood drainage congestion affects the mosquito threat. There is a two-way mechanism at work here, as household waste that is not properly disposed of that could be stored in the drains of the area, affecting sewage congestion and, in turn, raising the risk of infestation by insects, particularly mosquitoes. However, the main issue is not so much the attitude of householders as the fact that inadequate service provision and limited maintenance leave them with few alternatives. In addition, a particular issue for lower-income communities in DMA is poorly built environmental infrastructure, with the absence of structured infrastructure coverage for underprivileged communities and households impeding the resolving of health-related problems. This condition reflects the isolation and inequality of the urban poor, who, as a result of the under-supply of infrastructure at the household level, suffer from the most pervasive environmental health issues. It can also be emphasized that there are certain facets of a sustainable residential or community environment that Nongovernmental Organizations or Aid Agencies cannot solve without government intervention, such as the electricity shortage, low quality housing and, above all, the scarcity of citywide infrastructure (roads, piped water supplies, drainage and sewerage systems).

From the observation, the study also found that the vast majority of survey respondents were not completely ready for a potential earthquake and fire hazards that are likely to occur in or around Dhaka Metropolitan Area in the foreseeable future. This implies that they do not perceive environmental hazards and risks as a threat to their lives. On the opposite, a good environmental condition often influences the thoughts and decisions of individuals, which typically determines human perceptions. Furthermore, it is crucial to consider the socio-spatial differences in people's attitudes that ultimately influence and dictate people's behaviors as well as environmental activism. Therefore, it is recommended that responsible and relevant stakeholders (such as the Ministry of Disaster Management and Relief, the Ministry of Forests, Environment and Climate Change, the Dhaka City Corporation, civil society, etc.) should immediately take effective steps to improve the resilience and capability of citizens in order to deter large-scale damage caused by earthquakes and other risks. In addition, these stakeholders should synergize efforts to develop enlightenment initiatives and introduce policies that could increase awareness among residents about environmental threats and risks resulting from their living conditions. Particularly, vulnerability has four dimensions, such as human, social, economic, and environmental dimensions. So, we assume that any analysis that looks at the problem in depth must, in any sense, consider a multidimensional research approach to the problem.

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GROWTH PERFORMANCE AND COST-BENEFIT ANALYSIS OF BRACKISHWATER FIN FISHES (*MUGIL CEPHALUS* AND *RHINOMUGIL CORSULA*) WITH PRAWN (*MACROBRACHIUM ROSENBERGII*) IN POLYCULTURE AT COASTAL PONDS

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Abstract

The study was carried out to observe growth, production and profit of prawn, stripped mullet (*Mugil cephalus*) and corsula mullet (*Rhinomugil corsula*) at different stocking ratio under polyculture in the Bagerhat district for four months. The experiment was designed as a randomized block design and had three treatments based on stocking ratio with three replicates in each treatment. Juveniles of prawn (*Macrobrachium rosenbergii*) and fingerlings of fin fishes (stripped mullet and corsula mullet) were stocked at a stocking ratio of 3:1:1, 4:1:1 and 5:1:1/m^2 in T_1, T_2 and T_3, respectively. Prawn and fin fishes were fed with a commercial diet and farm made formulated feed on a daily basis. Recorded water quality parameters were within suitable ranges of prawn and fish culture. Higher growth (43.0 g) of the prawn was achieved in T_1 followed by T_2 (41.0 g) and T_3 (38.0 g), but prawn growth was not significantly different between T_1 and T_2. The growth and survival rate of prawn, stripped mullet and corsula mullet were lower in T_3, where the stocking ratio was higher. Higher production of the prawn was obtained in T_2 (1148.0 kg/ha) than those of T_1 (954.6 kg/ha) and T_3 (1083.0 kg/ha). But significantly ($p<0.05$), higher production of stripped mullet was found in T_1 (650.0 kg/ha) and T_2 (579.5 kg/ha) than T_3 (500.5 kg/ha). Similarly, higher production of corsula mullet was found in T_1 (850.0 kg/ha) and T_2 (834.9 kg/ha) than T_3 (719.8 kg/ha). However, combined production and net profit of prawn and fin fish farming were significantly ($p<0.05$) higher in T_2 (2562.4 kg/ha, BDT 277,384.51/ha) followed by T_3 (2303.3 kg/ha, BDT 229,693.95/ha) and T_1 (2454.6 kg/ha, BDT 179,393.31/ha). So from a production and economic point of view, polyculture of prawn and fin fish at a stocking ratio of 4:1:1/m^2 is more profitable compared to other stocking ratios and this system may be suggested to disseminate at coastal farmers' level.

Key words: Prawn and fin fish farming, Stocking ratio, Production, Profit

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Introduction

Giant freshwater prawn (*Macrobrachium rosenbergii*) is one of the most desirable candidate species for freshwater aquaculture in different parts of the Indo-Pacific region (Ranjeet and Kurup 2002). It is popularly known as 'golda' in Bangladesh. Its rapid growth rate, distinctive taste, high disease resistance and high demand in both domestic and international markets have made it valuable species. Bangladesh is also considered one of the most suitable countries in the world for prawn farming due to its fertile land and environment friendly conditions. Golda farming in ponds has been increased quite rapidly in recent years in Bangladesh. The practice of integrated farming of golda with rice, fish and vegetables is spreading, particularly among small-scale farmers, providing a year round supply of crops for family subsistence supplemented by a cash crop (golda) (Fleming 2004). *M. rosenbergii*, being a benthophagic omnivore, is an excellent candidate for polyculture. Its culture with fish also improves the ecological balance of the pond water, preventing the formation of massive algal blooms and proper utilization of supplemented feed (Cohen and Ra'anan 1983). According to Zimmermann and New (2000), freshwater prawns are good candidates for polyculture systems. They allow fish farmers to increase productivity and profits with a small additional cost and no environmental impact. It may culture with suitable fin fish species, which can directly help to enhance production and income as a whole with an environment friendly situation.

Mullets are important culturable fish species due to their excellent growth performance, high resistance to water qualities and low mortality rates. As these three animals are having three different feeding habits (*M. cephalus*-bottom and column feeder, *R. corsula*-surface feeder and prawn-benthic feeder), they can be cultured economically under a polyculture system. In many countries, mullets are cultured in association with other fishes and prawn/shrimp (Uddin *et al*. 2006, Islam *et al*. 2008). Jhingran (1984) denoted some culturable brackishwater fin fishes in India, many of which apply to Bangladesh. Fin fish species like *M. cephalus* and *R. corsula* are non-carnivorous and bears high demand and market prices (Shofiquzzoha *et al*. 2001). These species are locally called 'bhangan' and 'khorsula'. A polyculture system may also contribute to reduce the disease risk in the pond and could offer a higher rate of production of prawn and fish than the present production from the same area with higher economic benefit.

Polyculture can increase the yield of fish and prawn/shrimp by reducing inter-specific resource competition. Another benefit of polyculture is the ability to reduce the pollution resulting from farming activity (Midlen and Redding 1998, Lutz 2003). In Bangladesh,

despite having its great potentiality of polyculture in brackishwater, very few works have been done to date regarding this aspect. Most of the time, prawn farmers of this country could not properly harvest prawns due to miss management. So economic loss owing to suddenly prawn crop failure might be partially minimized by fin fish crop. Production and profitability of prawn and fin fish farming depend on several factors. Stocking density, feed, feeding intensity and stocking size of prawn/fish are the most imperative factors among them. Considering these facts, the present study was undertaken to assess the growth, production and economic return based on different stocking ratio of freshwater prawn, flathead grey mullet/stripped mullet (bhangan) and corsula mullet (khorsula) under a polyculture system in brackishwater ponds of the southwestern part of the country.

Materials and Methods

Study area and design: The experiment was performed in nine brackishwater earthen ponds situated at Sadar Upazila of Bagerhat district in Bangladesh from 1st April to 30th July 2019. The study area lies between latitude 22°35' N to 22°50' N and longitude 89°38' E to 89°53' E. Average area of the pond was 400 m^2 and the depth of water was 0.8-1.7 m each. The experiment was conducted following randomized block design (RBD) with three treatments, namely T_1, T_2 and T_3, and each having three replicates. Prawn juvenile, bhangan (stripped mullet) and khorsula (corsula mullet) fingerlings were stocked at a ratio of 3:1:1, 4:1:1 and 5:1:1 nos/m^2 in T_1, T_2 and T_3, respectively.

Earthen pond preparation and management: Before starting the experiment, ponds were treated with agricultural lime ($CaCO_3$) at a rate of 250 kg/ha based on soil pH. Ponds were then filled with tidal water gradually up to a depth of 0.9 m from the nearby tidal canal through a screen net. All unwanted organisms were eliminated using rotenone at a rate of 3 ppm and then lime ($CaCO_3$) was applied at a rate of 125 kg/ha for neutralizing its action. After 5 days of cleaning, ponds were fertilized with urea and TSP at a rate of 50 and 100 kg/ha, respectively. After 4-5 days of fertilization, the color of the water turned green. Fine mesh sized nylon net was used as a fence on the dikes around the ponds to prohibit the potential disease carriers fauna as a snail, crab, snake and others from outside.

Stocking of prawn and fin fishes: Hatchery produced prawn juveniles were collected from the local market. Fin fish fingerlings were collected from a private hatchery of Bagerhat. After buying, fingerlings were acclimatized for two days in a hapa. Prawn juveniles were stocked 25 days ahead of fin fish fingerlings. Before releasing the juveniles of prawn in

ponds, polythene bags were kept in the experimental ponds for about 30 minutes and water was exchanged between bags and ponds to acclimatize with pond water temperature. After that, juveniles were released in ponds. Prawn juveniles were stocked in all ponds at a density of 3, 4 and 5 nos/m^2 but the stocking density of bhangan and khorsula was 1:1 in all treatments. Average initial weight and length of 30% of each were recorded individually before releasing them in ponds with the help of a portable digital balance (CAMRY digital electrical balance, EK 3052, Bangladesh) and a measuring scale, respectively.

Post stocking management: During the culture period, prawn were fed with commercial supplementary feed (32.0% protein, 11.0% moisture, 4.0% crude lipid and 8.0% crude fiber-written on the feed bag) procured from the local market was applied 6 days in a week to the ponds at a rate of 10% of total prawn biomass for the first month, 6% for 2nd month and gradually decreased up to 3% until the end of the study. Fin fishes were fed with farm made feed (40% rice bran, 20% wheat flour, 15% corn flour, 20% fish meal and 5% mustard oil cake) thrice a day at a rate of 10% of the total biomass for the first two months and 5-3% of body weight at the end of the culture period. The total feed of a day was divided into three equal parts and was applied in the morning between 8.00-9.00 am, in the noon 12.00-1.00 pm, and in the evening between 5.00-6.00 pm. Fin fish feed was used before 30-45 minutes of prawn feed applying due to proper utilization of feed and to minimize the feed competition among the cultured species. The same schedule was followed for both shrimp and fin fishes from beginning to last. Lime was applied to all ponds at monthly intervals at a rate of 50.0-75.0 kg/ha based on water depth for keeping the water quality of ponds in good condition. Dried coconut leaves, palm leaves, jute bags and bamboo's *kanchi* (branches of bamboo) were placed on the pond bottom to create shelter for prawn as well as other fish and to keep the water cool.

Water quality monitoring: At ten-day intervals, water quality parameters of ponds like temperature, salinity, transparency, dissolved oxygen (DO) concentration, pH, total alkalinity and ammonia were measured between 9.00 and 10.00 am. The salinity of water was measured using a portable refractometer (ATAGO, Hand Refractometer). Surface water temperature was determined *in situ* using a standard centigrade thermometer. Transparency was recorded using Secchi disc. Dissolved oxygen was determined using a portable DO meter (YSI 58 digital DO meter, HANNA, Yellow Springs, Ohio 45387 USA). The pH of the water was recorded using a pH meter (HANNA, USA). Total alkalinity was measured by the titrimetric method (APHA, 2000). Ammonia nitrogen was measured using an ammonia test kit (Biotech PVT Ltd., Fishtech BD Ltd).

Sampling, harvesting and production parameters: Fortnightly sampling of 20-25% of stocked prawn and fin fish was done to estimate the biomass and to adjust the feeding rations and also to observe the physical conditions of the stocked species. Prawn and fin fish were sampled using a cast net. The weight and length of 40 individuals of each species were recorded for growth assessment. Weight (g) was measured using a portable balance and length (cm) by measuring scale. Sampling was continued until harvest.

After 120 days of culture, bamboo poles and leaves were removed, water was drained out of the ponds and all prawn and fin fish were harvested by repeated netting (cast net and surrounding net). All prawns and fish harvested from each pond were counted, measured and weighted individually to determine survival rate, growth and yield. Specific growth rate (SGR), feed conversion ratio (FCR) and survival rate (%) were calculated following the equation as cited by Pechsiri and Yakupitiyage (2005). The equations are as follows:

Weight gain (g) = Mean final weight (g) − mean initial weight (g).

Specific growth rate (SGR) (%/day) = {Ln (final body weight) − Ln (initial body weight) × 100}/cultured period (days).

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

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

Yield of fish/prawn= No. of prawn/fish caught× (average final weight of prawn/fish− average initial weight of prawn/fish).

Economic analysis: A simple algebraic economic analysis was carried out to determine the net return and benefit-cost ratio of prawn and fin fish culture in different treatments. The following equation was used to quantify the profitability of prawn and brackishwater fin fish culture in pond systems: $NR = TR - (FC + VC + Ii)$.

Where NR = net return, TR = total revenue from prawn and fin fish sales, FC = fixed/common costs, VC = variable costs and Ii = interest on inputs. Benefit-cost ratio (BCR) was determined as total net return/total input cost.

The prices of different kinds of inputs, prawn and fin fishes (bhangan and khorsula) correspond to the Bagerhat wholesale market prices in 2019. Prawn and fishes were sold at a rate of BDT 500.00-550.00/kg and BDT 100.00-120.00/kg, respectively.

Statistical analysis: Growth, production, net returns and benefit cost ratio were analyzed using one way ANOVA to compare the treatment means. If the main effect was found significant, the ANOVA was followed by DMRT (Duncan's Multiple Range Test). All ANOVA was tested at a 5% significance level using SPSS (Statistical Package for Social Science) version 20.

Results and Discussion

Water quality variables of culture ponds: Water quality variables of experimental ponds like temperature, transparency, dissolved oxygen, salinity, pH, alkalinity and ammonia were measured in ten-day intervals. Water temperatures varied from 27.61 to 33.2°C in all treatments and was found in agreement with recorded temperature: 27.0-32.3°C and 28.0-35.5°C by Islam *et al.* (2016) and Islam and Mahmud (2012), respectively. Salinity in all treatments fluctuated from 3.47 to 6.44 ppt, which resembles the findings of Islam *et al.* (2016), who recorded the water salinity as 1.5 to 6.5 ppt in shrimp ponds. Water transparency was ranged from 28.78 to 36.97 cm, which was similar to the findings of Islam *et al.* (2016), who recorded water transparency ranges from 28.0 to 44.0 cm and it was lower than the transparency (35.0 to 60.5 cm) reported by Islam and Mahmud (2011). Dissolved oxygen (DO) recorded to range from 4.15–5.28 mg/l, which supports the findings of Islam *et al.* (2016), who found the DO ranges from 4.0 to 5.1 mg/l in shrimp ponds. Whereas, pH values varied from 6.55 to 7.36, which is almost similar to the findings of Islam *et al.* (2016), who found water pH ranges from 7.1 to 7.7 in shrimp ponds. Total alkalinity varied from 92.33 to 101.15 mg/l, which is very close to the findings of Islam *et al.* (2016), who found it ranges from 90.0 to 106.5 mg/l in shrimp ponds. Concentrations of ammonia nitrogen in this study ranged between 0.008 to 0.097 mg/l, which is within the acceptable level (>0.012 mg/l) of prawn/shrimp aquaculture made by Meade (1985) and Islam *et al.* (2016).

Growth, FCR and survival of prawn and fin fish: Almost similar sized prawn juveniles stocked in all treatment ponds, but the final weight of prawn was the highest in T_1 (43.0 g) followed by T_2 (41.0 g) and T_3 (38.0 g), respectively. In the case of fin fishes, the highest final weight of bhangan was recorded in T_1 (100.0 g) than that of T_2 (95.0 g) and T_3 (91.0 g) and the highest final weight of khorsula was found in T_1 (125.0 g) than that of T_2 (121.0 g) and T_3 (118.0 g) (Table 1). Islam *et al.* (2016) recorded the mean final weight of prawn and tilapia as 58−63 and 149−199 g, respectively, in prawn and tilapia mixed culture for 150 days in farmers' shrimp ponds of Bagerhat. Islam and Mahmud (2012) recorded the final weight of prawn and tilapia as 63-73 and 163.5-168.5 g,

respectively, for 180 days in mixed culture at different stocking density in Shrimp Research Station (SRS) pond complex, Bagerhat. Islam and Mahmud (2011) also demonstrated that final weight of prawn and tilapia as 74 to 85 and 99 to 149 g, respectively, in brackishwater ponds at different stocking densities for 180 days in SRS

Table 1. Growth, survival rate and production (mean ± Sd) of *Macrobrachium rosenbergii, Mugil cephalus* and *Rhinomugil corsula* in different treatments.

Species and production parameters	Treatments		
	T_1 (3:1:1/m^2)	T_2 (4:1:1/m^2)	T_3 (5:1:1/m^2)
Macrobrachium rosenbergii			
Average initial weight (g)	3.0 ± 0.13	3.0 ± 0.16	3.0 ± 0.11
Average final weight (g)	43.0^a ± 3.27	41.0^a ± 3.63	38.0^b ± 4.11
Daily weight gain (g)	0.33^a ± 0.03	0.32^a ± 0.03	0.29^b ± 0.04
Survival rate (%)	74.0^a ± 2.33	70.0^a ± 2.00	57.0^b ± 1.6
Specific growth rate (%/day)	2.22 ± 0.10	2.18 ± 0.12	2.12 ± 0.12
Production (kg/ha)	954.6^c ± 30.10	1148.0^a ± 32.8	1083.0^b ± 30.4
Mugil cephalus			
Average initial weight (g)	3.5 ± 0.19	3.5 ± 0.23	3.5 ± 0.20
Average final weight (g)	100.0^a ± 3.16	95.0^b ± 3.08	91.0^c ± 2.89
Daily weight gain (g)	0.81^a ± 0.03	0.76^b ± 0.03	0.73^c ± 0.03
Survival rate (%)	65.0^a ± 2.0	61.0^b ± 1.75	55.0^c ± 1.5
Specific growth rate (%/day)	2.79 ± 0.08	2.75 ± 0.08	2.72 ± 0.08
Production (kg/ha)	650.0^a ± 20.0	579.5^b ± 16.63	500.5^c ± 13.65
Rhinomugil corsula			
Average initial weight (g)	4.0 ± 0.27	4.0 ± 0.25	4.0 ± 0.22
Average final weight (g)	125.0^a ± 4.25	121.0^b ± 3.92	118.0^c ± 3.67
Daily weight gain (g)	1.01 ± 0.02	0.98 ± 0.04	0.95 ± 0.03
Survival rate (%)	68.0^a ± 3.0	69.0^a ± 1.75	61.0^b ± 2.0
Specific growth rate (%/day)	2.87 ± 0.08	2.84 ± 0.08	2.82 ± 0.07
Production (kg/ha)	850.0^a ± 37.5	834.9^b ± 21.2	719.8^c ± 23.6
Combined production (kg/ha)	2454.6^b ± 54.7	2562.4^a ± 82.6	2303.3^c ± 97.4

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

pond complex, which are slightly higher than the findings of the present study. Shofiquzzoha and Alam (2008) mentioned that the final weight of shrimp and silver barb was 23.77 and 69.75 g, respectively, in concurrent culture for 120 days at Brackishwater Station (BS) pond complex, Khulna, which is lower than the present findings. They also recorded the final weight of shrimp and tilapia as 24.93 and 161.83 g, respectively, for 120 days in the same pond complex, which is also lower than the present findings except for tilapia.

Daily weight gain recorded for prawn, bhangan and khorsula as 0.29−0.33, 0.73−0.81 and 0.95-1.01 g, respectively, for 120 days (Table 1). It is mentioned here that the daily weight gain of prawn was not significantly different between T_1 and T_2. Islam *et al.* (2016) calculated the daily weight of prawn and tilapia as 0.39−0.42 and 0.99−1.33 g, respectively, in shrimp ponds. Islam and Mahmud (2012) reported the daily weight of prawn and tilapia as 0.35−0.41 and 0.91−0.94 g, respectively, at different stockings. Islam and Mahmud (2011) also demonstrated the daily weight of prawn and tilapia as 0.41−0.47 and 0.55−0.83 g, respectively, in brackishwater ponds. Shofiquzzoha and Alam (2008) stated that the daily weight of shrimp and silver carb in contemporary culture was 0.20 and 0.55 g, respectively, for 120 days, which is lower than the present findings. They also recorded the daily the weight of shrimp and tilapia as 0.21 and 1.34 g, respectively, for 120 days in the same pond complex, corresponding with the present findings.

The specific growth rate (SGR) of prawn (2.12-2.22) was not significantly different among treatments. On the other side, the highest SGR of bhangan was found in T_1 (2.79) and lowest in T_3 (2.72). SGR of khorsula was higher in T_1 (2.87) and lower in T_3 (2.82). Islam *et al.* (2016) recorded SGR of prawn and tilapia as 1.52-1.65 and 3.98-4.13%, respectively, in shrimp ponds. SGR of prawn and tilapia ranged between 1.71−1.80 and 3.13-3.15%, respectively reported by Islam and Mahmud (2012). Thus, the findings of prawn of the above mentioned studies are lower, but tilapia findings are higher than this study. However, Shofiquzzoha and Alam (2008) observed SGR of shrimp and tilapia as 6.94 and 4.26%, respectively, for 120 days, higher than the present findings.

Feed conversion ratio (FCR) of prawn and fin fishes was significantly lower in T_1 (2.56) than that of T_2 (2.90) and T_3 (3.20). These findings coincide with Islam *et al.* (2016), who recorded FCR of prawn and tilapia as 2.70-3.60. Chanratchakool *et al.* (1995) stated that FCR varies with the stocking density, quality of feed and the size at which the shrimps were harvested and also depended on the production cycle and between populations. Hasan (2001) reported FCR increased/decreased with the quality of supplemented feed

and with the mean weight of prawn/shrimp/fish as they grew. In this study, the lowest FCR was recorded in $T_{1,}$ which seems to be due to efficient utilization of maximum ratio by prawn and fin fishes.

The survival rate of the prawn was significantly ($p<0.05$) higher in both T_1 (74.00±2.33%) and T_2 (70.00±2.00%) than T_3 (57.00±1.60%), but there was no significant difference between T_1 and T_2. On the contrary, survival of bhangan was highest in T_1 (65.0±2.00%) and was lowest in T_3 (55.00±1.50%). Besides, survival of khorsula was highest in T_2 (69.0±1.75%) and lowest in T_3 (61.00±2.00%). Significant difference in survival of bhangan and khorsula under three treatments was observed (Table 1). Similar, survival of prawn and tilapia as 66−72 and 56.2-65.5%, respectively for 150 days was demonstrated by Islam *et al.* (2016), and Islam and Mahmud (2012) recorded survival of prawn and tilapia as 62-70 and 68-71.5%, respectively for 180 days. Islam and Mahmud (2011) obtained the survival of these species as 58−65 and 66−73%, respectively. It was observed that growth rate and survival of prawn decreases with the increase of stocking density of fin fishes. Survival rate and growth were also associated with water depth and space in ponds. The present study observed significantly lower SGR and survival of prawn in T_3, it could be due to intra and inter-specific competition among the animals stocked. Garcia-Perez *et al.* (2000) stated that there are many factors that affect the survival of prawn/shrimp as environmental stress, water level, the required amount of feed, stocking ratio, cannibalism, bird predation, predator fish, etc. Cannibalism during moulting period is a common phenomenon and may be responsible for monthly mortality of 4% (AQUACOP, 1990).

Production of prawn and fin fishes (bhangan and khorsula): Daily weight gain and survival rate of prawn under T_1 and T_2 was not significantly different. But the number of prawn counted more in T_2 at harvest than T_1 due to higher stocking density in T_2. So prawn production (1148.0 kg/ha) obtained highest in T_2, which was significantly different ($p<0.05$) than T_1 (954.6 kg/ha) but not significantly different from T_3 (1083.0 kg/ha). It also enhanced the combined production and economic profit of the polyculture system of prawn and fin fishes. As opposed to, higher production (650.0 kg/ha) of bhangan was found in T_1, which was significantly different ($p<0.05$) than that of T_3 (500.5 kg/ha) but not significantly different from T_2 (579.5 kg/ha). Higher production (850.0 kg/ha) of khorsula was obtained in T_1, which was significantly different ($p<0.05$) than that of T_3 (719.8 kg/ha), but there was no significant difference between T_1 (850 kg/ha) and T_2 (834.9 kg/ha). The combined production of prawn and fin fishes was 2454.6, 2562.4 and 2303.3 kg/ha in T_1, T_2 and T_3, respectively. Significantly ($p<0.05$) higher combined production (2562.4 kg/ha) was achieved in T_2 followed by T_1 (2454.6 kg/ha) and T_3

(2303.3 kg/ha) (Table 1). Observed production was almost similar with the findings of Islam *et al.* (2016) and Islam and Mahmud (2012), who recorded combined production of prawn and tilapia as 2491.80-2510.60 kg/ha/150 days and 2191.39-2441.47 kg/ha/150-180 days, respectively. But the findings of the present study are higher than the findings (1105.0-2133.4 kg/ha/180 days) of Islam and Mahmud (2011). In contrast, the production of shrimp reported by Islam and Mahmud (2010) and Shofiquzzoha and Alam (2008) was 416.9-641.7 kg/ha and 402.73 kg/ha, respectively, which are lower than the production found in the present study. Total production of the present study was higher than Islam and Mahmud (2010) due to might be associated with thrice species stocked, higher protein percentage of supplied feed, better size of prawn and fin fish juvenile/fry as well as good management of water quality. The combined yield of prawn and tilapia reported by Asaduzzaman *et al.* (2009) was 1,763.0 kg/ha/120 days, which is lower than the present findings. The highest combined production obtained by Uddin *et al.* (2006) in ponds stocked with 75% tilapia and 25% prawn was 1,691 kg/ha, which is also less than the present study.

Profit of prawn and fin fish (bhangan and khorsula) farming: Total net profit of prawn and fin fish (bhangan and khorsula) farming was significantly higher in T_2 (BDT 2,77,384.51/ha) followed by T_3 (BDT 2,29,693.95/ha) and T_1 (BDT 1,79,393.31/ha). The benefit-cost ratio (BCR) was also higher in T_2 (1.57) compared to T_3 (1.48) and T_1 (1.41), respectively (Table 2). The observed profit was slightly higher than the findings of Islam *et al.* (2016), who achieved the profit from prawn and tilapia farming as BDT 147,819.00-238,923.00/ha in brackishwater ponds. Islam and Mahmud (2011) recorded

Table 2. Cost-Benefit analysis of prawn (*Macrobrachium rosenbergii*), bhangan (*Mugil cephalus*) and khorsula (*Rhinomugil corsula*) production in different treatments.

Particulars	Treatments		
	T_1 (3:1:1/m^2)	T_2 (4:1:1/m^2)	T_3 (5:1:1/m^2)
Total gross return (BDT/ha)	6,16,938.00±2837.45	7,64,024.00±3418.62	7,08,223.00±3592.48
Total cost (BDT/ha)	4,37,544.68±3591.30	4,86,639.49±3618.85	4,78,529.05±4116.87
Net profit (BDT/ha)	1,79,393.31^c±3729.18	2,77,384.51^a±6513.52	2,29,693.95^b±3642.30
Benefit cost ratio (BCR)	1.41^c: 1	1.57^a: 1	1.48^b: 1

Mean values in the same row with different superscript letters indicate significantly different ($p<0.05$).

the profit of prawn and tilapia culture ranges from BDT 137,021.00 to 236,797.00/ha, which is also lower than the present study's findings. Islam and Mahmud (2010) found the net profit of shrimp farming as BDT 45,086.33-181,182.35, which is much lower than

the present findings. Results of the study indicated that the stocking ratio of fin fish affected the economic return positively. There was no adverse change in water quality due to the different densities of fin fishes. Further, the inclusion of fin fish did not hamper the growth and production of prawn. Presently, the polyculture system has been getting more popular over monoculture due to its contribution to boosting total fish production worldwide. From the viewpoint of growth, production and economic return, the farming of prawn, bhangan and khorsula at a stocking ratio of 4:1:1/m^2 is a profitable aquaculture system in coastal areas. So based on production and economic performance, it may conclude from the study's results that the polyculture of prawn and fin fishes (bhangan and khorsula) at a ratio of 4:1:1/m^2 could be advised to adopt at farmers' level for getting high production and significant economic profit.

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SCREENING OF FUNGICIDES AND PLANT EXTRACTS FOR CONTROLLING BLIGHT DISEASE OF *TAGETES* SPP.

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Abstract

A field experiment was conducted in the Botanical research garden, Department of Botany, University of Dhaka during 2015, 2016 and 2017 to evaluate the efficacy of two fungicides and two plant extracts against blight disease of *Tagetes erecta* L. and *T. patula* L. Both the fungicides Bavistin 50 WP and Tilt 250 EC and leaf extracts of *Azadirachta indica* A. Juss. and *Citrus medica* L. showed effective management of the disease over the untreated check. However, among the treatments, Bavistin 50 WP and Tilt 250 EC at 100 ppm concentration and *A. indica* and *C. medica* L. at 10% concentration were found significantly superior in controlling percent disease index and increasing number of healthy flowers. The number of healthy flowers was highest per plant, 17.13 in *T. erecta* in 2017 and 25.00 in *T. patula* in the year 2016.

Key words: Screening, Fungicides, Plant extracts, Blight, *Tagetes* spp.

Introduction

Tagetes erecta and *Tagetes patula* belong to Asteraceae (Compositae) family, and it is native to North and South America, but some species now become naturalized worldwide. *Tagetes erecta* are sometimes known as American or African marigolds, and *Tagetes patula*s is French marigold. French Marigolds are commonly planted in butterfly gardens as a nectar source. The florets of *Tagetes* spp. are rich in orange, yellow carotenoid, lutein and are used as a food color. The essential oil of the flower contains antioxidants (Politi *et al.* 2016). Seeds of *T. erecta* is a natural pesticide. Leaves are used as blood clotting agents in Ayurbedhic treatment. Plants has antifungal properties also. The plant is also used against fever, dysenteries, indigestions, ulcers, and eczemas (Ahmed *et al.* 2008, Ghani 2003 and Yusuf *et al*. 2009). It is most effective against the nematode species *Pratylenchus penetrans* (Olabiyi and Oyedunmade 2000 and Politi *et al*. 2012). The plant also has mosquitocidal potentiality (Rajasekaran *et al*. 2004). In Bangladesh, flowers are very popular for decorative purposes. Marigold is now a profitable cultivated crop to the farmers, but socioeconomic data and information of this

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flower is very scarce in Bangladesh. Diseases were major problems for marigold cultivation. Fungal or bacterial to the diseases are the main obstacles to the rapid expansion of commercial marigold cultivation in Bangladesh. In many cases, disease occurrence is an important threat for commercial cultivation of marigold, blight and leaf spot are two common diseases of *Tagetes* spp. Mukerji and Bhasin (1986) reported blight inflorescence leaf spot, gray mould, powdery mildew, flower and bud rot diseases of *Tagetes* spp. from India. Powdery mildew, gray mold, white mold (Bakr *et al*. 2010, Sultana and Shamsi 2011 and Rahman *et al*. 2015), and blight disease of marigold have been reported from Bangladesh (Aktar and Shamsi 2014, 2015, 2016, 2018a).

However, reports on the management of blight disease of *Tagetes* spp. are inadequate in Bangladesh (Rahman *et al*. 2015). Therefore, the present study was undertaken to evaluate the efficacy of selected fungicides and plant extracts against blight disease of *T. erecta* and *T. patula*. Though, as control measures, chemical fungicides and leaf extracts are reported to control blight diseases of various plant spp (Yasmin and Shamsi 2019). So, it is necessary to find out the effective and sustainable control measure of blight disease of *Tagetes* spp. in our country.

Materials and Methods

The field experiments were conducted in the field plots of Botanical research Garden, Dhaka University, during 2015, 2016, and 2017. Efficacy of selected fungicides and plant extract were studied on *T. erecta* and *T. patula*. The pathogenic potentiality of *Alternaria alternata*, the causal agent of blight symptom, was determined by the methods of Aktar and Shamsi (2014). The concentration of fungicides and plant extract was prepared following Aktar and Shamsi (2018b). Particulars of the fungicides and plant extracts are presented in Tables 1 and 2. The experimental design was followed by Islam *et al*. (2015-16).

The field plots were prepared in November of each experimental year. Biofertilizer was used during field preparation. Three weeks old, fifteen seedlings were transplanted in each sub-plot measuring 1.5 × 1 m. Spacing between sub-plots was 1 m. The plants were spaced 25 cm by 25 cm. Ten plants were randomly selected to record disease severity and production of healthy flowers.

The experimental design was random block design (RBD), having three replications. Data were recorded after 15 days of each spray. Final data were recorded after 15 days of the last spray. The percent disease index (PDI) was calculated by the formula of Rahman

and Rashid (2008). The disease severity was recorded by using 0-9 scale. For visual estimation of severity, a 0-9 point DS scale was used for rating of all foliar diseases studied (PDI=McKinney's Index, Ghos *et al.* 2009).

No infection = 0, 0-10% leaf area infected = 1, 10-20% leaf area infected = 2, 20-30% leaf area infected = 3, 30 – 40% leaf area infected = 4, 40 – 50% leaf area infected = 5, 50-60% leaf area infected = 6, 60-70% leaf area infected = 7, 70-80% leaf area infected = 8, 80-90% or more leaf area infected = 9.

The incidence and severity of blight of *T. erecta* and *T. patula* were recorded from the plants grown in gardens of Curzon Hall Campus, Dhaka University. Each plot was visited and data were recorded twice a month. Data were expressed in percentage. Similarly percent disease incidence (PDI) was recorded using the following formula:

$$\text{Disease incidence (\%)} = \frac{\text{Total no. of infected plants}}{\text{Total no. of plants}} \times 100$$

Two fungicides, Bavistin 50 WP and Tilt 250 EC at 100 ppm concentration and leaf extracts of *A. indica* and *C. medica* at 10% concentration, were applied on *T. erecta* and *T. patula* (Tables 1 and 2). Control plants were treated with water. A total of four sprays were done at 15 days intervals.

Table 1. Particulars of the fungicides used in the experiment.

Sl. No.	Trade name	Formulation	Recommended dose (ppm)	Ten times lesser of recommended dose (ppm)	Manufacturers
1.	Bavistin	50 WP	500	100	BASF Bangladesh Ltd.
2.	Tilt	250 EC.	1000	50	Syngenta (BD) Ltd.

Table 2. Particulars of the plant extracts used in the experiment.

Sl. No.	Plant species	Used part	Family
1.	*Azadirachta indica* A. Juss	leaves	Meliaceae
2.	*Citrus medica* L.	leaves	Rutaceae

Analysis of data: Data on different parameters were analyzed following computer package MSTAT-C and means were compared using DMRT. The data were collected and evaluated by analysis of variance (ANOVA) by using STAR statistical program.

Results and Discussion

In 2015-2017, out of four treatments, Tilt 250 EC showed promising results in controlling blight of *T. erecta.* Percent disease (PDI) value was lowest 3.27 in 2015, 3.27 in 2016 and 3.41 in 2017. The number of infected flowers/plant was lowest 1.57 in 2015, 2.93 in 2016, and 5.50 in 2017, respectively. The number of healthy flowers/plant was a maximum 10.13 in 2015, 14.93 in 2016, and 17.13 in 2017 (Table 3)

Bavistin 50 WP showed 6.08 in 2015, 5.65 in 2016, and 6.04 in 2017 PDI in blight infected plants. Infected flowers per plant were 4.13 in 2015, 4.53 in 2016, and 7.23 in 2017. Healthy flowers per plant were 9.17 in 2015, 9.40 in 2016, and 10.10 in 2017 (Table 3).

Table 3. Screening of fungicides and leaf extracts for controlling blight disease of *T. erecta.*

Experiment year	Treatment	PDI	No. of infected flower/plant	No. healthy flower per plant
2015	Bavistin 50 WP	6.08 b*	4.13 ^{ab}	9.17 ^{ab}
	Tilt 250 EC	3.27 ^{d}	1.57 ^{d}	10.13 ^{a}
	Azadirachta indica	4.76 ^{c}	3.17 ^{c}	8.40 ^{b}
	Citrus medica	6.04 ^{b}	3.30 ^{bc}	6.30 ^{c}
	Control	7.54 ^{a}	4.53 ^{a}	5.23 ^{c}
	CV (%)	10.18	13.27	8.96
2016	Bavistin 50 WP	5.65 ^{ab}	4.53 ^{ab}	9.40 ^{d}
	Tilt 250 EC	3.27 ^{d}	2.93 ^{c}	14.93 ^{a}
	Azadirachta indica	4.77 ^{c}	3.33 ^{c}	12.67 ^{b}
	Citrus medica	5.03 ^{bc}	4.07 ^{b}	11.07 ^{c}
	Control	6.37 ^{a}	4.83 ^{a}	7.80 ^{e}
	CV (%)	7.58	7.30	4.72
2017	Bavistin 50 WP	6.04 ^{a}	7.23 ^{ab}	10.10 ^{c}
	Tilt2 50 EC	3.41 ^{d}	5.50 ^{d}	17.13 ^{a}
	Azadirachta indica	4.58 ^{c}	6.57 ^{bc}	16.53 ^{a}
	Citrus medica	5.18 ^{b}	6.13 ^{cd}	13.67 ^{b}
	Control	6.27 ^{a}	7.83 ^{a}	8.60 ^{d}
	CV (%)	3.17	8.06	5.89

*Means followed by the same letter within a column did not differ significantly at the 5% level by DMRT.

Leaf extract of *Azadirachta indica* showed 4.76 in 2015, 4.77 in 2016, and 4.58 in 2017 PDI in blight infected plants. Infected flowers per plant were 3.17 in 2015, 3.33 in 2016 and 6.57 in 2017. Healthy flowers per plant were 8.40 in 2015, 12.67 in 2016, and 16.53 in 2017 (Table 3).

Citrus medica showed 6.04 in 2015, 5.03 in 2016 and 5.18 in 2017 PDI in blight infected plants. Infected flowers per plant were 3.30 in 2015, 4.03 in 2016, and 6.13 in 2017. Healthy flowers per plant were 6.30 in 2015, 11.07 in 2016, and 13.67 in 2017 (Table 3).

Whereas the control plant showed 7.54 in 2015, 6.37 in 2016, and 6.27 in 2017 PDI in blight infected plants. Infected flowers per plant were 4.53 in 2015, 4.83 in 2016, and 7.83 in 2017. Healthy flowers per plant were 5.23 in 2015, 7.80 in 2016, and 8.60 in 2017 (Table 3 and Plate 1, A-E).

In 2015-2017, out of four treatments, Tilt showed the promising result in controlling blight of *T. patula,* Percent disease index (PDI) value was lowest at 2.91 in 2015, 4.27 in 2016, and 3.23 in 2017, respectively. The number of infected flowers/plant was lowest at 3.30 in 2015, 1.70 in 2016, and 2.80 in 2017, respectively. The number of healthy flowers/plant, was maximum 15.30 in 2015, 25.00 in 2016, and 23.17 in 2017, respectively. Whereas Bavistin showed 5.28 in 2015, 5.31 in 2016, and 5.29 in 2017, respectively PDI in blight infected plants (Table 4).

Infected flowers per plant were 4.40 in 2015, 3.67 in 2016, and 3.63 in 2017, respectively. Healthy flowers per plant were 12.97 in 2015, 11.07 in 2016, and 15.73 in 2017, respectively (Table 4).

In 2015, plants treated with leaf extracts of *A indica* showed 3.48 PDI, number of infected flowers per plant 4.10, and number of healthy flower per plant 15.17 respectively. In 2016, plants treated with extracts of *A. indica s*howed PDI 4.96, number of infected flowers per plant 6.33, and number of healthy flower per plant 23.47, respectively. Moreover, in the 2017 experimental year, PDI 4.36, the number of infected flowers per plant 2.90, and the number of healthy flower per plant 21.43 were recorded (Table 4).

Whereas, in the experimental year 2015, plants treated with showed leaf extract of *C. medica* showed PDI 4.45, the number of infected flowers per plant 4.57, and the number of healthy flower per plant 12.17, respectively. In the 2017 experimental year, PDI 5.03, the number of infected flowers per plant 3.30, and the number of healthy flowers per plant 15.53 were recorded (Table 4).

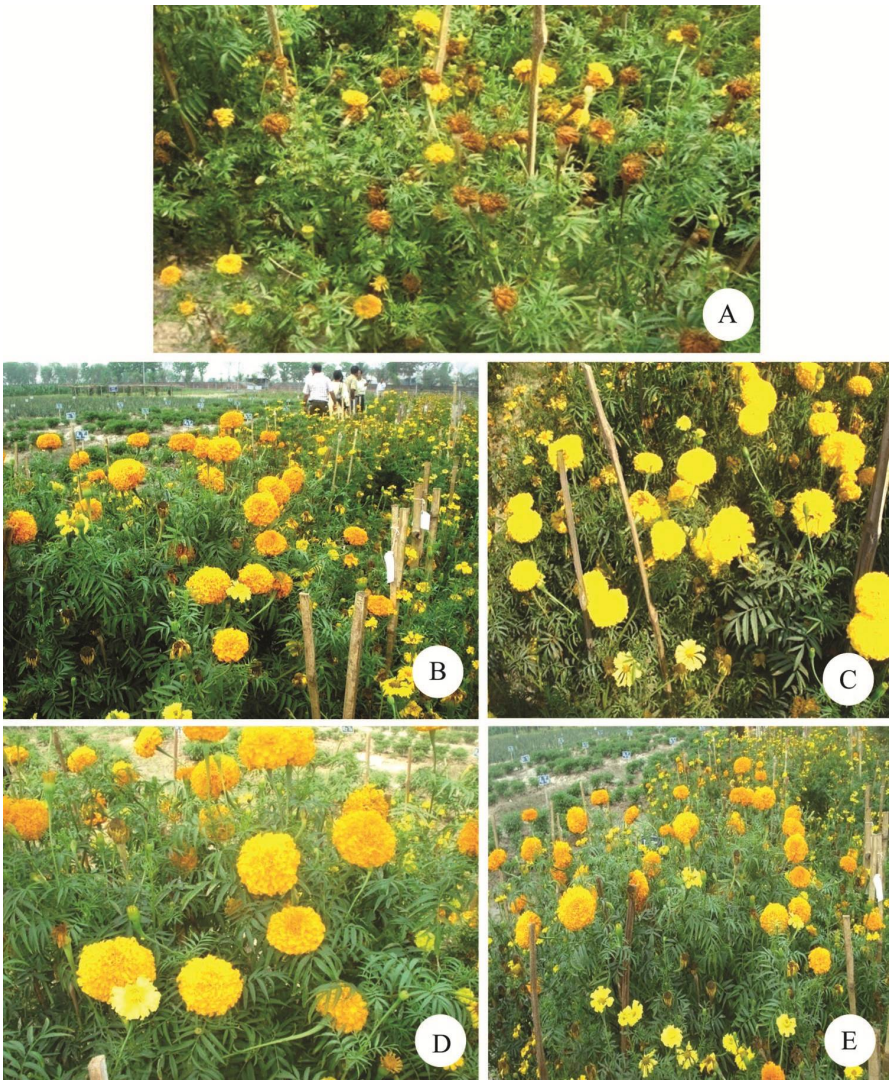

Plate 1. Effects of fungicides and leaf extracts on the yield of flowering of *T. erecta*: A. Control, B. Bavistin, C. Tilt, D. *A. indica* and E. *C .medica.*

Subsequently, Control plants treated with water showed 5.44 in 2015, 6.20 in 2016, and 5.80 in 2017 PDI in blight infected plants. Infected flowers per plant were 6.17 in 2015, 6.80 in 2016, and 4.63 in 2017. Healthy flowers per plant were 9.53 in 2015, 8.33 in 2016, and 7.77 in 2017 (Table 4 and Plate 2, A.E).

Table 4. Screening of fungicides and leaf extracts for controlling light disease of *T. patula.*

Experiment year	Treatment	PDI	No. of infected flower/plant	No. healthy flower per plant
2015	Bavistin 50 WP	5.28 [a*]	4.40 [b]	12.97 [b]
	Tilt 250 EC	2.91 [d]	3.30 [c]	15.30 [a]
	Azadirachta indica	3.48 [c]	4.10 [b]	15.17 [a]
	Citrus medica	4.45 [b]	4.57 [b]	12.17 [b]
	Control	5.44 [a]	6.17 [a]	9.53 [c]
	CV (%)	6.02	21.62	3.87
2016	Bavistin 50 WP	5.31 [b]	3.67 [b]	11.07 [b]
	Tilt 250 EC	4.27 [c]	1.70 [c]	25.00 [a]
	Azadirachta indica	4.96 [b]	6.33 [a]	23.47 [a]
	Citrus medica	5.08 [b]	6.50 [a]	20.10 [a]
	Control	6.20 [a]	6.80 [a]	8.33 [b]
	CV (%)	6.39	10.67	20.89
2017	Bavistin 50 WP	5.29 [ab]	3.63 [b]	15.73 [b]
	Tilt250 EC	3.23 [d]	2.80 [c]	23.17 [a]
	Azadirachta indica	4.36 [c]	2.90 [c]	21.43 [a]
	Citrus medica	5.03 [b]	3.30 [bc]	15.53 [b]
	Control	5.80 [a]	4.63 [a]	7.77 [c]
	CV (%)	6.68	10.50	8.46

*Means followed by the same letter within a column did not differ significantly at the 5% level by DMRT.

Various workers in different countries of the world evaluated the efficacy of other fungicides against *Colletotrichum* spp., *Phomopsis vexans*, *Macrophomina phaseolina*, *Rhizopus nodosus*, *Fusarium* spp., *Phoma* spp., *Botryodiplodia theobromae*, *Colletotrichum gloeosporioides*, *Sclerotium rolfsii* and *Alternaria* spp., under laboratory and field conditions (Stirling *et al.* 2004,Chowdhury *et al*. 2015, Mamun *et al*. 2016 and Hosen *et al*. 2016). But fungicide's toxicity is not always restricted to the target pest organism, also observed in mammals, including humans (Belpoggi *et al.* 2002). Most fungicides can cause acute toxicity, and some cause chronic toxicity as well (Goldman 2008). The World Health Organization (WHO) and the United Nations Environment Program (UNEP) estimates that each year, three million workers in agriculture in the developing world experience severe poisoning from pesticides, about 18,000 of whom die (Panday *et al.* 1983). However, care should be taken during the use of the fungicides.

Some pest management researchers have focused on developing alternative inputs to synthetic chemicals for controlling diseases (Pal and Gardener 2006 and Baker 1987). One of them is the use of biological antagonists and plant extracts. Biological control presents a better alternative with relatively low cost, no side effects, and reduced resistance development in the pathogen (Okigbo and Nmeka 2005).

Plate 2. Effects of fungicides and leaf extracts on the yield of flowering of *T. patula*: A. Control, B. Bavistin, C. Tilt, D. *A. indica* and E. *C. medica.*

Islam *et al.* (2015-2016) observed that in field trial Tilt 200 EC (Propiconazole, Dose 0.1 ml/l) and Secure 600 WG (Mancozeb + Fenamidone, Dose 2 g/l) were significantly reduced the severity of *Botrytis* blight of marigold. Autostin and Tilt at 100 ppm concentration and *Azadiractaindica* and *Citrus limon* at 10% concentration were found significantly superior in controlling the disease severity, PDI (Percent disease index), and increasing number of healthy leaves.

As control measures, chemical fungicides, leaf extracts are successfully reported to control leaf spot and anthracnose diseases (Yasmin and Shamsi 2019).

The present study also reported that the fungicides Bavistin 50 WP and Tilt 250 EC and leaf extracts showed effectively manage the disease over control. However, among the treatments Bavistin 50 WP and Tilt 250 EC at 100 ppm concentration and *Azadirachta indica* A. Juss. and *Citrus medica* L. at 10% concentration was found significantly superior in controlling PDI and increasing number of healthy flowers.

Conclusion

Blight disease drastically damaged the plants of *Tagetes*. Considering the importance of the plant, it is necessary to save the plaat immediately. The present investigation is the first approach to controlling the blight disease of the plants mentioned above in Bangladesh. The findings of this research work will be helpful for designing a proper management of blight disease. Application of Bavistin and Tilt at 100 ppm concentration may be commercially used for managing blight disease of *T. erecta* and *T. patula*. For more confirmation, the above mentioned fungicides also need to 2-3 years trial in field condition. In small-scale gardening or those persons who want to maintain the plants in the yard for medicinal or recreation purposes, *A. indica* and *C. medica* at 10% concentrations can be useful for controlling blight disease.

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- **Short communication**

A STUDY ON WATER QUALITY OF *HAIL HAOR* ECOSYSTEM OF BANGLADESH

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During the last few decades, agricultural activities have been expanded in the wetland areas of *Hail haor*, which affected the wetland ecosystem adversely. There are some common natures of pollutions with domestic sewage, pesticides, insecticides, fertilizers, and industrial pollutants discharged from the upper catchment tea gardens and forest sites. The other threats are flood control dams, conversion of wetlands for agriculture or brickfields, human settlements, deforestation, extraction of sands or peats, algal blooms, etc. Therefore, water quality control is a top-priority agenda in many parts of the world (WHO 2011) and of course in Bangladesh. It becomes very important to assess the water quality of the *haor* basin ecosystem. For this reason, a study was conducted to analyze some important physicochemical parameters of water resources of the *Hail haor* ecosystem. Water samples were collected in four seasons viz monsoon (June-August), summer (September-November), winter (December-February) and post winter (March-May) from some selected spots. The bottles used for sampling were rinsed with deionized water and dried. At each sampling station, the sampling bottles were rinsed at least three times before samples were collected by immersing about 10 cm below the surface water. Water samples were collected in clean and opaque screw capped plastic bottles, wrapped up with aluminum foil, preserved in the refrigerator. The samples were filtered through 0.45 µm micro-pore Whitman filter paper and were kept at freeze to avoid further contamination. The parameters pH, EC (Electrical Conductivity), TDS (Total Dissolved Solids) and DO (Dissolved Oxygen) were measured by digital pH, EC, TDS, and DO meters, respectively. A digital thermometer determined the temperature of the water. The BOD_5 was determined by measuring initial DO_1 and DO_5 after 5 days incubation in the dark condition at 20°C (Klein and Gibbs 1979). Alkalinity was measured as $CaCO_3$ by

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titration of the water samples to an endpoint pH of 4.5 corresponding to the endpoint of the bromocresol green-methyl red indicator (APHA 2012). Ammonia-N contents of water were analyzed by micro Kjeldahl's distillation method (Jackson 1967). Nitrate-N contents were determined by the colorimetric method using a fixed absorbance in a UV-VIS spectrophotometer (Armstrong 1963). COD, chloride, and sulfate were determined by the USEPA Reactor Micro-digestion method, Titrimetrically, and Turbidimetrically, respectively (Jirka and Carter 1975, APHA 2012). The results of all the water quality parameters for *Hail haor* is presented in Table 1.

The highest temperature of *Hail haor* water was 29.78^{o}C in June, and the lowest was 22.45^{o}C in February, whereas the mean temperature was 25.90^{o}C. In the winter season, the water temperature varies from 22.45 to 24.75^{o}C and 26.20 to 27.0^{o}C during the dry season, which was found within the standard limits (EQS 1997 and DoE 2017). In River water temperature, the DoE standard for sustaining aquatic life is 20 to 30°C both in dry and wet seasons. The highest pH of *Hail haor* water was recorded at 7.67 in February, and the lowest was 6.88 in June, with the mean pH value of 7.12. The standard limits of pH range were 6.5 to 8.5 (ADB 1994, EQS 1997, De 2005, WHO 2011 and DoE 2017), and the study showed that all of the values were within the standard limits. The pH in both wet and dry seasons was favorable for fisheries and other aquatic organisms. The highest EC of the water was found 186.75 ds/m in February and the lowest was 53.81 in June, and the mean EC was 115.63 ds/m and the standard limit of EC in water is 700 ds/m (EQS 1997, DoE 2017) and the study showed that all the observed EC were within the standard limits. The acceptable range of EC for irrigation water is 750 ds/m and aquaculture water are 800 to 1000 ds/m (ADB 1994). The measured EC of all samples was lower than acceptable limits. In the monsoon season, the flow of the water increases, which may cause the dilution of the salinity of the water, while in the dry season, the flow of the surface water decreases which increases EC. In the winter season, the EC ranged from 93.43 to186.75 ds/m and in the dry season, the EC varies from 53.81 to 128.53 ds/m, which might be due to the seasonal variations. The highest DO of water was found 6.01 mg/l in June, and the lowest was 2.06 mg/l in April. The mean DO content was 4.40 mg/l. The standard limit of DO is 5.0 mg/l (EQS 1997, WHO 2011, De 2005, DoE 2017), and the study showed that DO contents were satisfactory level and suitable for fisheries and aquatic resources except in the summer. DO contents varied from 5.01 to 6.25 mg/l during the monsoon and winter season and 1.79 to 5.08 mg/l during the dry and late winter season. According to environmental quality standards (EQS), the following requirements for DO are prescribed: 6.0 mg/l for drinking water, 4.0 to 6.0 mg/l for fish and livestock, and 5.0 mg/l for industrial application. In summer, DO contents were much

lower than the desired limits, indicating that water quality is not satisfactory for aquatic organisms, which might be due to the presence of a higher level of organic waste pollutants. The highest TDS of the *haor* water was 125.73 mg/l in February, and the lowest was 45.85 mg/l in November, and the mean TDS contents were 73.36 mg/l. Seasonal variation revealed that TDS ranged from 45.85 to 125.73 mg/l in the winter and 35.91 to 85.96 mg/l in the dry season. The USPH (United States Public Health) acceptable TDS is 500 mg/l (De 2005), 1000 mg/l, 1500 mg/l, and 2000 mg/l for domestic water, drinking water, industrial water and for irrigation, respectively (ADB 1994). According to another report and the standard limit of TDS in water is 600 mg/l (EQS 1997 and WHO 2011). The TDS values were found within the standard limits.

The highest BOD_5 content of the water samples was found at 2.19 mg/l in June, and the lowest was 1.02 mg/l in February, and the mean BOD_5 was 1.50 mg/l. The BOD_5 status didn't show any significant variation among four distinct seasons because *Hail haor* water might not be contaminated to a large extent. The standard limit of BOD_5 in water is 5 mg/l (DoE 2017). Generally, unpolluted waters typically have BOD_5 values of 2 mg/l or less (Agbaire and Oyibo 2009, Garg *et al.* 2010, Utang and Akpan 2012). The permissible limit for BOD for drinking water is 2 mg/l, fish culture is 6 mg/l, and irrigation purpose is 10 mg/l in Bangladesh standard (EQS 1997). BOD_5 contents ranged from 1.02 to 1.5 mg/l in the winter season and 1.3 to 2.19 mg/l in the dry season revealed that the BOD_5 concentrations are within the desirable limits for aquaculture. In the present study, COD ranged from 54.71 to 75.83 mg/l in the winter and 27.33 to 52.91 mg/l in the dry season, demonstrating the highest COD as 75.83 mg/l in February and the lowest as 27.33 mg/l in June, and the mean COD was 52.70 mg/l. COD in the unpolluted surface water is 20 mg/l or less (Agbaire and Oyibo 2009, Garg *et al.* 2010, Utang and Akpan 2012). A higher COD indicates a higher level of pollution (Varunprasath and Daniel 2010). It can be assumed that the study site receives a higher amount of non-biodegradable chemical substances from surrounding sources. As a result, the water quality is not suitable for fish and other aquatic resources. It is found that the calculated ratio of mean BOD and COD matches well with the findings of Lee and Nikraz (2014). In the winter season, the alkalinity ranged from 25.85 to 28.67 mg/l, and in the dry season, it varied from 24.83 to 31.67 mg/l due to the seasonal variations. The highest alkalinity was 31.67 mg/l in April, and the lowest was 24.83 in June, and the mean alkalinity was 27.75 mg/l. The standard limit of alkalinity in water is 150 mg/l (DoE 2017). The studies showed that all the observed alkalinities were within the normal limit, and favorable for aquatic habitats.

Table 1. Water quality parameters of *Hail haor* in different seasons.

Samples	pH	**EC** (ds/m)	**TDS** (mg/l)	**DO** (mg/l)	**BOD_5** (mg/l)	**COD** (mg/l)	Alkalinity (mg/l)	Nitrate (NO_3^-)	NH_3 (mg/l)	Temperature (°C)	Sulfate (mg/l)	Chloride (mg/l)
						Monsoon Season						
S1	7.2	56.5	32.6	5.56	2.71	29	24.6	6.62	0.72	30.3	24	25.1
S2	7.1	76.5	40.3	5.86	2.97	20	28.1	6.16	0.95	30.3	32	29.5
S3	6.86	46.1	22.1	6.25	2.06	19	21.2	6.82	0.79	29.9	28	14.3
S4	6.82	53.1	41.3	6.1	2.27	26	23.1	6.98	0.47	29.6	22	21.6
S5	7.15	44.6	30.2	6.17	2.34	11	21.5	7.19	1.12	29.3	31	14.7
S6	6.58	46.7	38.4	6	2.58	30	28.1	8.70	1.32	30.2	28	19.6
S7	7.02	61.2	47.4	6.04	1.87	37	27.2	5.78	0.71	29.6	21	31.4
S8	6.74	32.8	16.7	6.02	1.81	29	25.4	4.62	0.31	30.5	31	13.5
S9	6.91	51.5	35.6	6.1	1.87	41	21.3	7.81	0.82	29.7	30	30.9
S10	6.81	57.5	46.3	6.03	1.95	27	24.8	5.95	0.58	29.5	20	26.8
S11	6.89	61.6	51	5.89	1.96	33	26.3	6.59	0.88	29.1	26	32.5
S12	6.56	57.7	29	6.12	1.98	26	26.6	7.1	0.93	29.4	19	35.7
						Winter Season						
S1	6.98	85.9	42.2	5.23	1.22	76	28.1	4.31	0.61	24.8	31	34.2
S2	7.04	88.2	44.3	5.21	1.25	57	32.3	3.95	0.65	24.7	35	41.5
S3	7.08	101.2	46.7	5.01	1.51	53	28.4	4.13	0.79	24.9	22	23.9
S4	6.91	85.3	36.1	5.65	1.53	44	27.6	3.70	0.77	24.8	26	32.4
S5	7.12	74.5	40.7	5.28	1.58	36	33.1	3.21	0.82	24.7	36	19
S6	7.15	178.6	106.3	5.65	1.62	42	30.4	4.06	0.78	25.1	37	20.6
S7	7.01	93.1	36.7	5.45	1.68	48	32.5	3.02	0.41	25	25	25.8
S8	7.1	103.7	53.8	5.25	1.64	47	24.2	3.08	0.52	24.6	19	42.1
S9	7.3	79.3	40.44	5.62	1.53	58	25.8	4.27	0.42	24.2	28	37.3
S10	7.35	87.8	36.9	5.06	1.58	69	31.4	2.23	0.63	24.7	28	31.5
S11	7.46	59.6	29.4	5.32	1.69	75	20.5	3.50	0.41	24.8	23	39.7
S12	7.25	75.4	30.01	5.03	1.72	42	29.4	1.36	0.86	25	32	24.3
S13	7.2	91.4	55.5	5.22	1.65	38	28.6	2.02	0.79	24.9	21	39.1
S14	7.1	104.8	42.9	5.8	0.91	81	29.1	1.12	0.32	24.3	18	9.2

EC = Electrical Conductivity, TDS = Total Dissolved Solids, DO = Dissolved Oxygen, BOD = Biological Oxygen Demand, COD = Chemical Oxygen Demand.

(Contd.)

Table 1 contd.

Samples	pH	**EC** (ds/m)	**TDS** (mg/l)	**DO** (mg/l)	**BOD_5** (mg/l)	**COD** (mg/l)	Alkalinity (mg/l)	Nitrate (NO_3^-)	NH_3 (mg/l)	Temperature (°C)	Sulfate (mg/l)	Chloride (mg/l)
						Late Winter Season						
S1	8.11	194	119.8	2.87	0.98	106	25.4	3.05	0.7	22.8	53	55.1
S2	8.76	204.5	118.6	3.39	0.96	82	28.3	3.02	0.82	22.7	48	59.5
S3	7.74	169.5	97	2.4	1.12	61	31.2	2.98	0.5	22.5	51	41.3
S4	7.56	203.4	156.8	3.85	1.09	66	28.9	1.84	0.92	22.4	41	78.9
S5	7.33	181.5	98.7	4.43	1.13	51	29.4	2.45	1.02	22.6	59	24.7
S6	7.44	238.5	188.4	5.02	1.2	69	23.4	2.76	1	22.1	51	59.6
S7	7.26	139.2	99.5	4.56	0.92	83	26.8	1.78	0.63	22	32	29.6
S8	7.55	169.5	116.2	4.86	0.86	48	19.3	2.31	0.88	21.9	39	32.7
S9	7.31	164.5	102.3	4.34	1.02	91	22.8	2.15	0.93	22.5	38	47.9
S10	7.65	182.2	109.6	5.02	0.92	54	25.4	1.05	1.05	22.8	35	46.8
S11	7.53	193.6	142.3	5.08	0.81	101	21.8	0.98	0.52	22.2	48	63.5
S12	7.81	200.8	159.6	4.28	1.04	98	27.5	0.95	1.1	23	42	61.4
						Summer Season						
S1	7.18	113.5	93.7	2.87	1.57	53	27.6	8.94	0.92	26.8	41	52.9
S2	6.96	130.2	72.6	2.92	1.49	62	28.1	9.15	1.21	26.5	56	48.6
S3	6.72	127.4	87.3	1.91	1.46	71	33.3	8.58	0.89	26.4	35	32.3
S4	7.02	127.8	86.2	1.94	1.5	41	31.4	8.57	1.69	26.6	37	40.5
S5	7.21	105.3	82.4	1.95	1.31	40	29.6	7.73	1.52	26.5	40	44.5
S6	6.79	185.5	113.5	1.9	1.13	58	31.4	5.56	1.02	27	36	72.1
S7	6.65	108.6	102.4	1.91	1.18	42	32.5	6.62	1.32	26.5	29	38.6
S8	6.63	129.9	64.1	1.87	1.27	35	34.9	9.25	1.92	26.9	33	36.5
S9	6.68	119.8	68.6	1.79	1.22	41	34.2	7.8	1.54	27	31	68.4
S10	6.84	142.6	78.8	1.92	1.19	56	34.1	8.98	1.85	26.8	37	50.6
S11	6.68	130.4	83.6	1.95	1.14	67	31.5	5.8	0.92	26.2	35	62.4
S12	6.21	121.3	98.4	1.83	1.18	69	31.6	7.33	1.36	26.4	30	77.9

EC = Electrical Conductivity, TDS = Total Dissolved Solids, DO = Dissolved Oxygen, BOD = Biological Oxygen Demand, COD = Chemical Oxygen Demand.

Nitrate contents were 2.21 to 3.14 mg/l during the winter and 6.69 to 7.86 mg/l during the dry season. The highest nitrate content was 7.86 mg/l in April, and the lowest was 2.21 mg/l in February, and the mean nitrate content was 5.03 mg/l. The standard limit of nitrate is 10 mg/l (WHO 2011) and according to the surface water regulation of EU 1989 (EPA 2001) the recommended limit values of nitrate were 50 mg/l. The study showed that nitrate contents were at a satisfactory level for fisheries and other aquatic organisms. Ammonia content ranged from 0.63 to 0.84 mg/l in the winter season and 0.81 to 1.35 mg/l in the dry season, reaching the highest level at 1.35 mg/l in April and the lowest at 0.63 mg/l in November, and the mean ammonia content was 0.89 mg/l. According to the surface water regulation of EU 1989 report (EPA 2001), the recommended limit of ammonia ranged from 0.2 to 4.0 mg/l, where, in another report suggested the limit of ammonia in water as 1.2 mg/l (ADB 1994). The study revealed that ammonia concentration in *haor* water was much lower compared to the recommended limits; similar observation was reported for ammonia contents for *Tanguar haor* water (Islam 2011). Sulfate contents were 27.21 to 44.75 mg/l during the winter season and 26 to 36.67 mg/l during the dry season, touching the highest value of 44.75 mg/l in February, the minimum value of 26 mg/l in June, and the mean sulfate content was 33.65 mg/l. The standard limit of sulfate is 250 mg/l (WHO 2011), and the regulation of EU 1989 (EPA 2001) recommended the limit as 200 mg/l. The study revealed that the sulfate contents were at a satisfactory level. Chloride contents were 30.04 to 50.07 mg/l during the winter and 24.26 to 52.1 mg/l during the dry season The highest chloride content was 52.1 mg/l in April and the lowest was 24.26 mg/l in June and the mean chloride content was 39.11 mg/l. The standard limit of chloride is 250 mg/l (EQS 1997, EPA 2001), and the study showed that chloride contents were satisfactory and suitable for aquaculture and other aquatic resources.

Concerning all measured parameters, it could be settled that the only COD level was much higher than the standard level in the study site. The reason behind this is that along its course *Mono* River receives many types of point, and non-point sources of pollutants from industries, agricultural fertilizer residues, and municipal wastes, rural market discharges, agrochemicals, and pesticides used in upstream tea gardens. So, it is suggested to control point and non-point sources of pollutants immediately to restore the water quality of the *Hail haor* ecosystem.

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