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ABUNDANCE OF MACROZOOBENTHOS IN RELATION TO BOTTOM SOIL TEXTURAL TYPES AND WATER DEPTH IN AQUACULTURE PONDS

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Abstract

The present experiment was conducted to evaluate the effects of bottom soil textural classes and different water depths on abundance of macrozoobenthos in aquaculture ponds. Three treatments, i.e., ponds bottom with sandy loam (T1), with loam (T2) and with clay loam (T3) were considered in this experiment. Samples were collected from three different depths (60.96 cm, 106.68 cm and 152.40 cm) with three replications. The ranges of water quality parameters were suitable for the growth of macrozoobenthos during the experimental period. Similarly, chemical properties of soil were also within suitable ranges and every parameter showed comparatively higher ranges in T2. Eight genera were recorded belonging to major groups of Chironomidae, Oligochaeta, Mollusca and Ceratoponogonidae. The highest population densities of Oligochaeta (1200±4.25 per m^2), Chironomidae (1422±4.88 per m^2), Ceratopogonidae (399±1.56 per m^2) and Mollusca (977±2.24 per m^2) were found in T2. The population densities of macrozoobenthos showed fortnightly variations in all the treatments. Among the three depths, significantly highest densities of macrozoobenthos were recorded in 106.68 cm in every treatment. The mean abundance of macrozoobenthos was significantly highest in T2. The present study indicates that loamy soil pond bottom along with water depth 106.68 cm is suitable for the growth and production of macrozoobenthos in aquaculture ponds.

Keywords: Benthos, Aquaculture, Soil Textural Class, Pond, Water Quality

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Introduction

The benthos is defined as that assemblage of animal living in or on the sediments and dependent upon the decomposition cycle of organic matters that are the basic food supply in any aquatic ecosystem (Brinkhurst, 1974). Different kinds of macrobenthos are very important food organisms for bottom-feeding fishes; they are important in sediment-water interactions; the presence and abundance of benthos indicates normal limnological conditions of the water bodies; and they are also occasionally used as food by fishes of upper water and mid-water and column water. The growth of fish depends largely upon the availability of food organisms namely plankton and benthos. Benthos is one of the very important food items of fishes especially the bottom feeders. About 60% of total food items of bottom-feeder fishes come from insect larvae (Habib *et al*., 1984; Ali *et al*., 1987). Moreover, the benthic fauna, through their burrowing and feeding activities play a significant role in the exchange of nutrients, dissolved gases and other materials between sediments and overlying water. The productivity of a water body largely depends upon the plankton and benthos (Habib *et al*., 1984).

The nutrients status of both soil and water plays a significant role in the growth and abundance of aquatic organisms, especially plankton and benthos. The chemical properties (nutrients status) have some growth promoting effect on the various species of benthos fauna (Habib *et al*., 1984). On the other hand, nutrient status of soil depends on the type of soil texture. In soil science, the USDA (Donahue *et al*., 1990) defines twelve major soil textural classes. Loam soils generally contain more nutrients and humus than sandy soils. However, there is no study on the effects of bottom soil textural types on growth and abundance of benthic fauna so far. Productivity of benthos as well as productivity of water body depends on the kind of textural types of pond bottom-soil along with limnological and ecological conditions. On the other hand, water depth is another important factor that control light intensity, dissolved oxygen, benthic fauna etc. in a water body. In the present study, it was evaluated the effects of bottom soil textural types and water depth on abundance of macrozoobenthos in aquaculture pond.

Materials and Methods

Experimental design

The experiment was conducted in the ponds situated at the campus of Bangladesh Agricultural University, Mymensingh during August to November 2011. The experiment had three treatments with three replications, i.e., ponds bottom with sandy loam (T1), with loam (T2) and with clay loam (T3). Samples were collected from three different depths (D1= 60.96 cm, D2= 106.68 cm and D3= 152.40 cm) with three replications.

Water quality parameters

Various physical and chemical water quality parameters of the ponds such as water temperature (°C), transparency (cm), dissolved oxygen (mg L^{-1}), free CO_2 (mg L^{-1}), total alkalinity (mg L^{-1}), PO_4-P (mg L^{-1}) and NO_3-N (mg L^{-1}) were estimated fortnightly following standard methods.

Chemical parameters of pond bottom-soil (sediment)

Chemical properties of pond bottom-soil (sediment) such as pH, available phosphorus (ppm), total nitrogen (%), organic carbon (%) and organic matter (%) were estimated fortnightly using the standard method (Sattar and Rahman, 1987).

Study of macrozoobenthos

The samples were collected fortnightly randomly from 3 depths of water of each of the ponds by lowering an open Ekman dredge on bottom mud. Then collected benthos with mud was put on a fine mesh-screen net fixed with a small steel frame and mud was washed in the pond water and the bottom materials were passed through a 0.2 mm mesh of screen net for a preliminary separation of benthos and large particles from mud and water. The benthic organisms remained on the screen-net were collected by means of fine forceps and kept into small plastic bottles containing 5% formalin for preservation.

Macrozoobenthos population density (no. per m^2) = no. found in bottom-mud collected by Ekman dredge × 44.44 = no. per 225 cm^2 × 44.44. Where, area of open mouth of Ekman dredge = 225 cm^2

The preserved organisms were then transferred to a petri dish and washed with tap water to remove the remaining washable detritus and mud. Then the samples were cleaned by means of distilled water and the organisms were separated from each other with the help of sorting needless and fine forceps, which were again sorted into major taxonomic groups by means of hand lens (magnifying glass, 65 mm, Optical Instrument Co. China) and low power microscope (magnification:10×2.5) wherever necessary. Then the organisms were counted and identified according to different taxonomic groups according to Needham and Needham (1963), Maitland and Heedspith (1974), Wetzel and Lickens (1979).

Statistical analysis

Values are expressed as means ± standard error of the mean (SEM). Data were analyzed by one-way analysis of variance (ANOVA) followed by Tukey's post hoc test to assess statistically significant differences among the different sampling days, different depths and different treatments. Statistical significance was set at $p<0.05$. Statistical analyses were performed using SPSS Version 14.0 for Windows (SPSS Inc., Chicago, IL).

Results

Water quality parameters

The results of water quality parameters are shown in Table 1. Throughout the study period, water temperature (°C), transparency (cm), dissolved oxygen (mg L^{-1}), free CO_2 (mg L^{-1}), total alkalinity (mg L^{-1}), PO_4-P (mg L^{-1}) and NO_3-N (mg L^{-1}) were within the productive ranges and showed no abrupt changes during the experimental period in all the treatments.

Table 1. Water quality parameters (Means ± SEM; n = 3) of the ponds during the experimental periods

Parameters	Treatments		
	Treatment 1	Treatment 2	Treatment 3
Water temperature (°C)	27.32 ± 3.13	27.00 ± 3.07	27.20 ± 3.20
Air temperature (°C)	27.50 ± 2.88	27.50 ± 2.88	27.50 ± 2.88
Transparency (cm)	32.30 ± 0.91*	16.00 ± 1.15	15.30 ± 1.11
Dissolved oxygen (mgL^{-1})	7.86 ± 0.24	7.21 ± 0.70	5.86 ± 0.48
Free CO2 (mgL^{-1})	3.86 ± 0.90	3.43 ± 1.62	4.00 ± 0.82
Total alkalinity (mgL^{-1})	82.72 ± 8.28	149.14 ± 9.05*	51.00 ± 6.86
Phosphate-phosphorous (mgL^{-1})	2.20 ± 0.58	2.68 ± 0.23	1.73 ± 0.46
Nitrate-nitrogen (mgL^{-1})	3.11 ± 0.55	3.58 ± 0.19	2.78 ± 0.33

* Indicates the significant difference among the treatments

Chemical parameters of pond bottom-soil (sediment)

In the present study, the ranges of pH, organic carbon (%), organic matter (%), available phosphorus (ppm) and total nitrogen (%) of pond bottom-soil in the aquaculture ponds varied from 6.8 ± 0.26 to 7.47 ± 0.21, 0.75 ± 0.10 to 0.98 ± 0.06, 1.34 ± 0.16 to 1.66 ± 0.14, 13.36 ± 1.58 to 25.87 ± 0.88 and 0.07 ± 0.01 to 0.09 ± 0.01, respectively (Table 2). All the parameters were within the suitable ranges and showed no abrupt changes during the experimental period in all treatments.

Table 2. Chemical parameters of pond bottom-soil (means ± SEM; n = 3) during the experimental periods

Parameters	Treatments		
	Treatment 1	Treatment 2	Treatment 3
pH	7.03 ± 0.14	7.13 ± 0.16	7.32 ± 0.13
Organic carbon (%)	0.78 ± 0.07	0.94 ± 0.08	0.84 ± 0.13
Organic matter (%)	1.34 ± 0.13	1.64 ± 0.12	1.41 ± 0.20
Available phosphorus (ppm)	13.86 ± 1.25	25.76 ± 0.89	16.10 ± 1.12
Total nitrogen (%)	0.07 ± 0.01	0.07 ± 0.01	0.08 ± 0.02

Abundance of macrozoobenthic fauna

During the study period, 8 genera of macrozoobenthos were recorded belonging to the major groups of Chironomidae, Oligochaeta, Ceratoponogonidae and Mollusca (Table 3). The individual groups of macrozoobenthic fauna (means ± SEM; n = 3) in the aquaculture ponds during the experimental periods are shown in Table 4.

Table 3. Species composition of macrozoobenthos found in the aquaculture ponds during the experimental periods

Oligochaeta	Chironomidae	Ceratoponogonidae	Mollusca
Brachiura sowerbyi	*Chironomus* sp.	*Culiciodes* sp.	*Viviparous bengalensis*
Peloscolex ferox	*Pentaneura* sp.	*Amphizoa* sp.	
Aelosoma sp.			

Table 4. Individual groups of macrozoobenthos (means ± SEM; n = 3) in the aquaculture ponds during the experimental period

Fortnightly sampling day	Treatments	Macrobenthos (number per m^2)			
		Oligochaeta	Chironomidae	Ceratopogonidae	Mollusca
1	T1	533 ± 2.05[b]	756 ± 2.35	-	311 ± 1.25
	T2	1111 ± 3.25[a]	1022 ± 3.85	222 ± 1.31	533 ± 1.34
	T3	755 ± 2.25[ab]	799 ± 2.33	177 ± 1.28	-
2	T1	311 ± 1.25[b]	1111 ± 3.11	133 ± 1.74	178 ± 1.22[b]
	T2	711 ± 2.22[a]	1155 ± 4.75	355 ± 1.85	888 ± 2.21[a]
	T3	844 ± 2.35[a]	888 ± 2.95	177 ± 1.65	-
3	T1	489 ± 1.85[b]	1111 ± 3.88	-	311± 1.26[b]
	T2	799 ± 2.56[a]	1288 ± 4.95	399 ± 1.56[a]	888 ± 2.25[a]
	T3	711 ± 2.33[a]	1111 ± 4.12	44 ± 0.25[b]	-
4	T1	178 ± 1.44[b]	578 ± 2.21	-	133 ± 1.23[b]
	T2	755 ± 2.24[a]	977 ± 2.23	266 ± 1.25	755 ± 2.12[a]
	T3	266 ± 1.56[b]	844 ± 2.35	311 ± 1.66	-
5	T1	267 ± 1.65[b]	333 ± 1.66[b]	133 ± 1.22	444 ± 1.27
	T2	1200 ± 4.25[a]	1199 ± 3.44[a]	266 ± 1.23	622 ± 1.95
	T3	711 ± 3.32[a]	933 ± 2.77[ab]	133 ± 1.20	-
6	T1	356 ± 1.52[b]	667 ± 2.22[b]	44 ± 0.25[b]	222 ± 1.21[b]
	T2	888 ± 2.26[a]	1244 ± 4.21[a]	399 ± 1.28[a]	888 ± 2.26[a]
	T3	533 ± 1.88[b]	933 ± 2.24[ab]	311 ± 1.26[a]	-
7	T1	444 ± 1.55[b]	1067 ± 3.28	-	267 ± 1.75[b]
	T2	1022 ± 4.22[a]	1422 ± 4.88	222 ± 1.21	977 ± 2.24[a]
	T3	799 ± 2.23[b]	1022 ± 4.22	222 ± 1.21	-

Values with different superscripts are significantly different among treatments ($p<0.05$)

The highest number of Oligochaeta (1200 ± 4.25 per m^2) was found in T2 and the lowest number (178 ± 1.44 per m^2) in T1. The highest number of Chironomidae (1422 ± 4.88 per m^2) was found in T2 and the lowest number (333 ± 1.66 per m^2) was found in T1. The highest number of Ceratoponogonidae (399 ± 1.28 per m^2) was found in T2 and the lowest number (0 per m^2) was found in T1 and T3. The highest number of Mollusca (977 ± 2.24 per m^2) was found in T2 and the lowest number of Mollusca (0 per m^2) was found in T1 and T3. On the other hand, the total number of macrozoobenthos (means ± SEM; n = 3) ranged from 888 ± 2.24 to 1783 ± 3.54, 2655 ± 4.24 to 3644 ± 5.23 and 1322 ± 2.89 to 2044 ± 3.63 per m^2 in the ponds of T1, T2 and T3, respectively (Fig. 1).

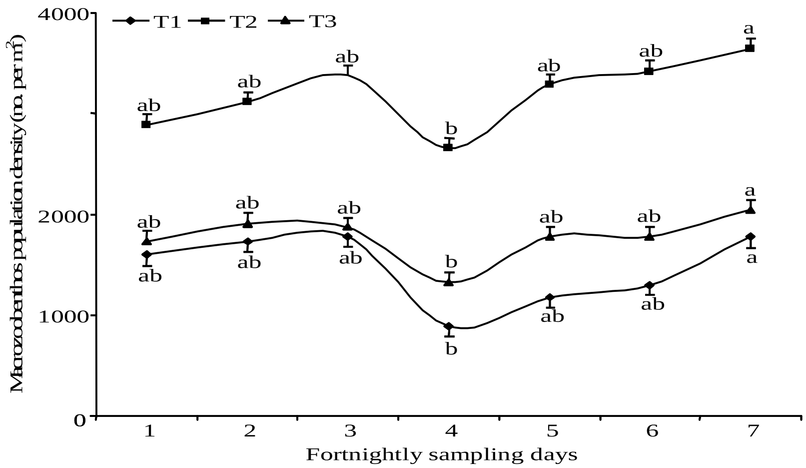

Fig. 1. Fortnightly variations in abundance (means ± SEM; n = 3) of total macrozoobenthos in the experimental ponds under three treatments during the study period. Values accompanied by different letters are statistically significantly different ($p<0.05$).

The macrozoobenthos densities showed fortnightly variations. Among different depths, significantly highest densities of macrozoobenthos were recorded in 106.68 cm in every treatment (Fig. 2). Based on mean value (Fig. 3), it was observed that macrozoobenthos showed its highest density in T2 (3211 ± 9.97 per m^2) followed by T3 (1775 ± 7.20 per m^2) and T1 (1464 ± 7.35 per m^2).

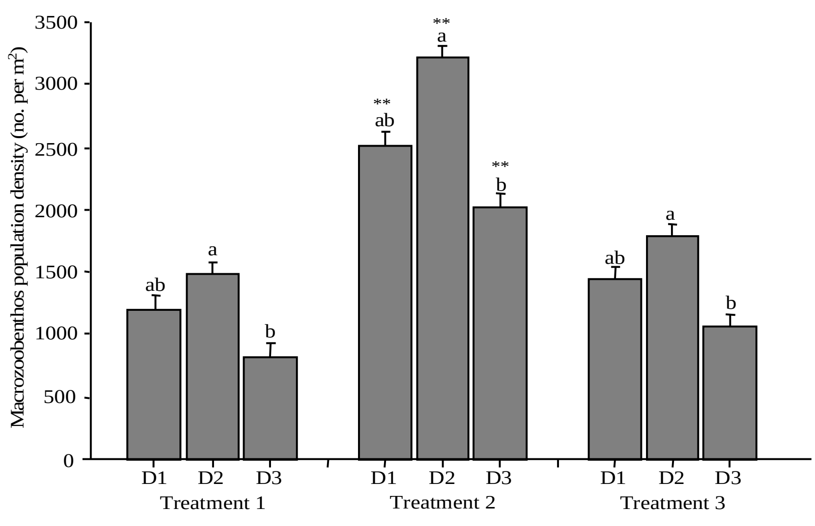

Fig. 2. Macrozoobenthos population densities (means ± SEM; n = 3) in three treatments at different depths during the study period. Values accompanied by different letters are statistically significantly different ($p<0.05$). Asterisks denote significant differences among treatments (**$p<0.05$). D1 = 60.96 cm depth, D2 = 106.68 cm depth, D3 = 152.40 cm depth.

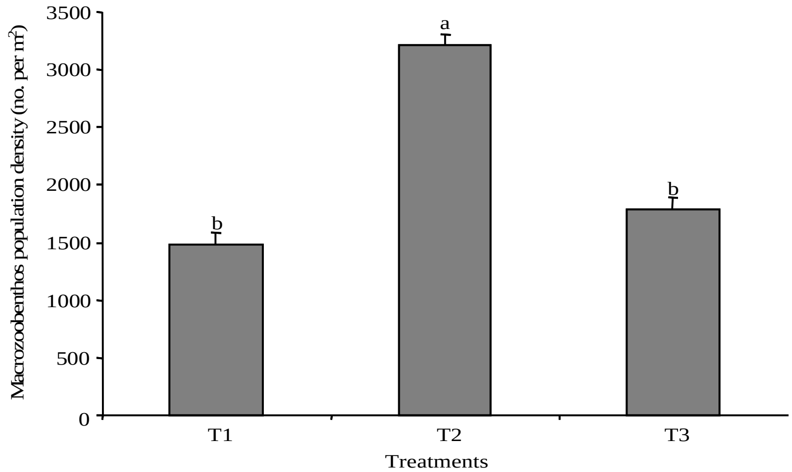

Fig. 3. Macrozoobenthos population densities (means ± SEM; n = 3) in different treatments during the study period. Values accompanied by different letters are statistically significantly different ($p<0.05$).

Discussion

The present study was conducted to evaluate the effects of bottom soil textural conditions and water depth on the abundance of macrozoobenthos in aquaculture pond. The highest abundance of macrozoobenthos found in the ponds bottom with loam and water depth 106.68 cm indicates that loamy bottom soil along with water depth 106.68 cm is suitable for the growth and production of macrozoobenthos in aquaculture pond.

The water quality parameters of the experimental ponds were within the productive ranges for the growth of macrozoobenthos during the experimental period. Within limit productive ranges of such water quality parameters have been observed by several authors (Uddin *et al.,* 2007; Chowdhury *et al.,* 2008; Rahman *et al.,* 2012; Talukdar *et al.,* 2012) in the aquaculture ponds of BAU area. Similarly, the ranges of pH, organic carbon (%), organic matter (%), available phosphorus (ppm) and total nitrogen (%) of pond bottom-soil in the experimental ponds were within the suitable ranges for the growth and production of macro-benthos (Table 2). Hossain (2000), Kohinoor (2002), Akter (2006) and Siddika *et al.* (2012) have observed more or less similar results.

A total number of 8 genera of macrozoobenthos belonging to Chironomidae (3), Oligocheta (2), Ceratopogonidae (2) and Mollusca (1) were recorded in the present study (Table 3). Other studies recorded were 23 genera belonging to 14 families in a marsh (Saha *et al.*, 2006), 29 genera under arthropods, annelids and mollusks in Vajiralongkom and Srinakarin Reservoir (Sonsupap *et al.*, 2007), 13 genera in lagoon of Nigeria (Edokpayi *et al.*, 2010), and 18 genera in two Phyla, Mollusca and Arthropods in Majidun river, Nigeria (Esenowo and Ugwumba, 2010).

In the present study, significantly highest number of Oligochaeta (1200±4.25 per m²), Chironomidae (1422±4.88 per m²), Ceratopogonidae (399±1.56 per m²) and Mollusca (977±2.24 per m²) were found in T2 (Table 4). Bais *et al.* (1992) and Hossain (2000) have observed more or less similar results. The densities of macrozoobenthos showed fortnightly variations (Fig. 1) but in every sampling day highest number were observed in T2. Interestingly, among three depths of 60.96 cm, 106.68 cm and 152.40 cm, significantly highest densities of macrozoobenthos were recorded in 106.68 cm depths in every treatment and it might be due to favourable light intensity in this depth. On the other hand, the mean abundance of macrozoobenthos was significantly highest in T2 (Fig. 3). The occurrence of these dominant groups of macrozoobenthos in T2 might be due to the suitable ecological conditions of the ponds that favoured the growth of these groups. Chemical properties of soil were comparatively higher in T2 may be an important cause to the higher abundance of macrozoobenthos population in the present study. This argument also supported by several authors (Ali *et al.,* 1987; Verneaux *et al.,* 2004; Kailasam and Sivakami, 2004) who found the significant effect of chemical properties on the macrozoobenthos growth and production. Moreover, loamy soils generally contain more nutrients and humus. Humus is a temporary intermediate product left after considerable decomposition of dead plants and animals, which might be support food for macrozoobenthos. This result indicated that pond bottom with loamy soil is more suitable for growth and production of macrozoobenthos in aquaculture ponds.

In conclusion, suitability of bottom soil textural types and water depth on macrozoobenthos population density were analyzed in aquaculture pond. Most of the water quality parameters of the ponds were more or less similar and within productive limit and chemical properties of soil were within suitable ranges. The mean abundance of macrozoobenthos density was significantly highest in T2. Significantly, highest densities of macrozoobenthos were recorded in 106.68 cm depths in every treatment. This findings of the study indicates that loamy soil bottom along with water depth 106.68 cm is suitable for the growth and production of macrozoobenthos in aquaculture ponds.

References

Akter, N. 2006. Effect of bottom soil properties on the abundance of benthic fauna in nursery ponds. MS Thesis. Department of Aquaculture, Bangladesh Agricultural University, Mymensingh, Bangladesh. 74 p.

Ali, M.M., Rahmatullah, S.M. and Habib, M.A.B. 1987. Abundance of benthic fauna in relation to metrological and physical-chemical factors of water. *Bangladesh J. Agril. Sci.* 12: 239-247.

Bais, V.S., Yatheesh, S. and Agrawal, N.C. 1992. Benthic macro-invertebrates in relation to water and sediment chemistry. *J. Freshwater Biol.* 4: 183-191.

Brinkhurst, R.O. 1974. A guide for the Identification of British Aquatic Oligochaeta, Freshwater Biological Association, Scientific Publication no. 22 & 55. 65 p.

Chowdhury, M.M.R., Shahjahan, M., Rahman, M.S. and Sadiqul Islam, M. 2008. Duckweed (*Lemna minor*) as supplementary feed in monoculture of Nile tilapia, *Oreochromis niloticus*. *J. Fish. & Aqua. Sci.* 3: 54-59.

Donahue, R.L., Miller, R.W. and Shickluna, J.C. 1990. Soils: An Introduction to Soils and Plant Growth. Prentice-Hall of India Private Ltd, New Delhi. 110001. 667 p.

Edokpayi, C.A., Olowoporoku, A.O. and Uwadiae, R.E. 2010. The hydrochemistry and macrobenthic fauna characteristics of an urban draining creek. *Int. J. Biodiver. & Conser.* 2: 196-203.

Esenowo, I.K. and Ugwumba, A.A. 2010. Composition and abundance of macrobenthos in Majidun River, Ikorodu Lagos state, Nigeria. *Res. J. Biol. Sci.* 5: 556-560.

Habib, M.A.B., Haque, A.K.M. and Islam, M.A. 1984. Status of macro-benthos in two ponds in Bangladesh Agricultural University Campus, Mymensingh. *Bangladesh J. Agril. Sci.* 11: 39-46.

Hossain, M.Y. 2000. Effects of biophosphorus in organic and inorganic fertilizers on water quality parameters and biological production. MS Thesis. Department of Fisheries Management, BAU, Mymensingh. 24 p.

Kailasam, M. and Sivakami, S. 2004. Effect of thermal effluent discharge on benthic fauna of Tuticorin Bay, South East coast of India. *Indian J. Marine Sci.* 33: 194-201.

Kohinoor, A.H.M. 2002. Development of culture technology of three small indigenous fishes mola (*Amblypharyngodon mola*), punti (*Puntius gonionotus*) and chela (*Chela cachius*) with notes on some aspects of their biology. PhD Thesis. Department of Fisheries Management, Bangladesh Agricultural University, Mymensingh. 363 p.

Maitland, P.S. and Heedspith, P.M.G. 1974. The zoobenthos of lake levan, kinross and estimates of its production in the sub-littoral area during 1970 and 1971. pp. 219-239. *In:* Proceeedings of Royal Society, Edinburgh.

Needham, J.G. and Needham, P.R. 1963. A Guide to the study of Freshwater Biology. 5th edition, Liolden-day Inc., San Francisco, 106 p.

Rahman, M.S., Shahjahan, M., Haque, M.M. and Khan, S. 2012. Control of euglenophyte bloom and fish production enhancement using duckweed and lime. *Iranian J. Fish. Sci.* 11: 358-371.

Saha, G.N., Sehag, K.L., Mitra, E. and Nandy, A.C. 2006. Studies on the seasonal and diurnal variations in physico-chemical and biological conditions of a perennial freshwater pond. *J. Inland Fish. Soc. India.* 3: 79-102.

Sattar, M.A. and Rahman, M.M. 1987. Techniques of Soil Analysis, Published by M.A. Sattar, BAU, Mymensingh. 54 p.

Siddika, F., Shahjahan, M. and Rahman, M.S. 2012. Abundance of plankton population densities in relation to bottom soil textural types in aquaculture ponds. *Int. J. Agril. Res. Innov. & Tech.* 2 (1): 56-62.

Sonsupap, N., Meksumpun, C. and Meksumpun, S. 2007. Comparative study on species composition, density and distribution of benthic fauna for assessment of aquatic enrichment status in Vajiralongkom and Srinakarin Reservoir, Kanchanaburi Province. pp. 310-317. *In:* Proceedings of the 45th Kasetart University Annual Conference, Kasetart, 30 January-2 February, 2007.

Talukdar, M.Z.H., Shahjahan, M. and Rahman, M.S. 2012. Suitability of duckweed (*Lemna minor*) as feed for fish in polyculture system. *Int. J. Agril. Res. Innov. & Tech.* 2 (1): 42-46.

Uddin, M.N., Rahman, M.S. and Shahjahan, M. 2007. Effects of duckweed (*Lemna minor*) as supplementary feed on monoculture of GIFT strain of tilapia (*Oreochromis niloticus*). *Prog. Agric.* 18: 183-188.

Verneaux, V., Verneaux, J., Schmitt, A. and Lambert, J.C. 2004. Relationships of macrobenthos with dissolved oxygen and organic matter at the sediment-water interface in ten French lakes. *Archiv-fur-Hydrobiologie.* 160: 247-259.

Wetzel, R.G. and Lickens, E.E. 1979. Limnological Analysis. W.B. Saunder, 175 p.