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ABUNDANCE OF PLANKTON POPULATION DENSITIES IN RELATION TO BOTTOM SOIL TEXTURAL TYPES IN AQUACULTURE PONDS

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Abstract

Plankton is an important food item of fishes and indicator for the productivity of a water body. The present study was conducted to evaluate the effects of bottom soil textural conditions on abundance of plankton in aquaculture pond. The experiment was carried out using three treatments, i.e., ponds bottom with sandy loam (T1), with loam (T2) and with clay loam (T3). The ranges of water quality parameters analyzed were suitable for the growth of plankton during the experimental period. Similarly, chemical properties of soil were also within suitable ranges and every parameter showed higher ranges in T2. A total 20 genera of phytoplankton were recorded belonged to Chlorophyceae (7), Cyanophyceae (5), Bacillariophyceae (5), Euglenophyceae (2) and Dinophyceae (1). On the other hand, total 13 genera of zooplankton were recorded belonged to Crustacea (7) and Rotifera (6). The highest ranges of phytoplankton and zooplankton densities were found in T2 where low to medium-type bloom was observed during the study period. Consequently, the mean abundance of plankton (phytoplankton and zooplankton) density was significantly highest in T2. The highest abundance of plankton in the T2 indicated that pond bottom with loamy soil is suitable for the growth and production of plankton in aquaculture ponds.

Keywords: Phytoplankton, zooplankton, aquaculture, soil textural classes, water quality

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Introduction

Live organisms of the water consists of three major groups namely plankton, nekton and benthos. Among these, plankton is of fundamental importance to fisheries. Plankton is also a vital factor influencing the fish production. Phytoplankton is the basic primary producers of all types of water bodies and is used as food by fish directly or indirectly. The qualitative and quantitative abundance of phytoplankton indicate the productive status of a water body, whether it is an oligotrophic or a eutrophic one. Therefore, a thorough knowledge of abundance of phytoplankton and its quality in time and space in relation to environmental conditions has become a prerequisite for fish production. Existence of zooplankton production primarily depends on the primary production. Zooplankton is a link in food chain between the primary producers and nektonic and benthonic animals in higher trophic levels. Their functions decrease phytoplankton populations through grazing (Raymont, 1963); accelerate phytoplankton growth excreting nutrient substances which are finally metabolized (Ketchum, 1962); and supply themselves as food to predators.

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. Soil textures are classified by the fractions of each soil separate (sand, silt, and clay) present in a soil. Classifications are typically named for the primary constituent particle size or a combination of the most abundant particles sizes, e.g. sandy clay or silty clay. A fourth term, loam, is used to describe a roughly equal concentration of sand, silt, and clay, and lends to the naming of even more classifications, e.g. clay loam or silty loam or sandy loam. Loam soils generally contain more nutrients and humus than sandy soils. However, so far there is no study on the effects of bottom soil textural conditions on growth and abundance of benthic fauna. Productivity of plankton and productivity of water body depends on the kind of textural class of pond bottom-soil. In the present study, an experiment was conducted to evaluate the effects of bottom soil textural conditions on abundance of plankton in aquaculture ponds.

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). The average depth of the experimental ponds was 106.68 cm.

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}), pH, 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 the standard method.

Chemical parameters of pond bottom-soil (sediment)

Various chemical parameters of the ponds bottom soil (sediment) such as pH, available phosphorus (ppm), total nitrogen (%), organic carbon (%) and organic matter (%) were estimated fortnightly using standard method (Sattar and Rahman, 1987).

Study of plankton

Plankton population of ponds water such as phytoplankton density (cells L^{-1}) and zooplankton density (cells L^{-1}) were estimated fortnightly. The counting of plankton (both phytoplankton and zooplankton) was done with the help of Sedgwick-Rafter Counting Cell (S-R cell) under a compound binocular microscope. The plankton population was determined by using the formula of Rahman, (1992). Identification of plankton (phytoplankton and zooplankton) up to generic level were made according to Prescott (1964), Needham and Needham (1963) and Belcher and Swale (1978).

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 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 and Discussion

The present study was conducted to evaluate the effects of bottom soil textural conditions on the abundance of plankton in aquaculture ponds. The highest abundance of plankton found in the ponds bottom with loam indicated that loamy bottom soil is suitable for the growth and production of plankton in aquaculture ponds.

Water quality and bottom-soil (sediment) parameters of ponds

The water quality parameters of the experimental ponds were within the productive ranges for the growth of plankton and benthos and showed no abrupt changes during the tenure of experiment (Table 1). Within limit productive ranges of such water quality parameters have also observed by a number of other authors (Wahab *et al.,* 1995; Kohinoor *et al.,* 1998; Haque *et al.,* 1998; Uddin *et al.,* 2007; Chowdhury *et al.,* 2008). Similarly, the ranges of pH, organic carbon (%), organic matter (%), available phosphorus (ppm) and total nitrogen (%) of pond bottom-soil in the aquaculture ponds were within the suitable ranges and showed no abrupt changes during the experimental period in all the treatments (Table 2). These results is in agreement with Akter (2006), who observed more or less similar results during his study on effect of bottom soil properties on the abundance of benthic fauna in nursery ponds.

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 (^{0}C)	27.20 ± 3.13	27.00 ± 3.07	27.20 ± 3.20
Air temperature (^{o}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 CO_2 (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 treatment

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 ± 0.13	7.13 ± 0.16	7.32 ± 0.13
Organic carbon (%)	0.78 ± 0.03	0.94 ± 0.02	0.84 ± 0.03
Organic matter (%)	1.36 ± 0.01	1.64 ± 0.01	1.41 ± 0.01
Available phosphorus (ppm)	13.86 ± 0.51	25.76 ± 0.13	16.99 ± 0.38
Total nitrogen (%)	0.073 ± 0.005	0.076 ± 0.005	0.08± 0.01

Abundance of plankton

A total 20 genera of phytoplankton (Table 3) were recorded belonged to Chlorophyceae (7), Cyanophyceae (5), Bacillariophyceae (5), Euglenophyceae (2) and Dinophyceae (1) were recorded in the present study, which is more or less similar to the findings with Kohinoor, (2000) who recorded 24 genera of phytoplankton belonging to Euglenophyceae, Cyanophyceae, Bacillariophyceae and Chlorophyceae. More or less similar numbers of genera were recorded in the plankton population by a number of authors in the ponds of Bangladesh Agricultural University campus (Dewan *et al.*, 1991; Wahab *et al.*, 1995; Kohinoor *et al.*, 1998; Uddin *et al.*, 2007 and Chowdhury *et al.*, 2008).

Table 3. Generic status of phytoplankton under different major groups found in the aquaculture ponds during the experimental periods

Major groups	Generic names		
	T1	T2	T3
Chlorophyceae	*Chlorella*	*Chlorella*	*Chlorella*
	Oocystis	*Pediastrum*	*Oocystis*
	Pediastrum.	*Scenedesmus*	*Pediastrum*
	Scenedesmus	*Closterium*	*Scenedesmus*
	Ulothrix	*Actinastrum*	*Closterium*
		Oocystis	
Cyanophyceae	*Anabaena*	*Microcystis*	*Microcystis.*
	Gomphospaeria	*Anabaena*	*Anabaena*
	Microcystis	*Gomphospaeria.*	*Gomphospaeria*
		Aphanocapsa	*Oscillatoria*
		Oscillatoria	
Bacillariophyceae	*Cyclotella*	*Asterionella*	*Asterionella*
	Diatoma	*Cyclotella*	*Cyclotella*
	Asterionella	*Diatoma*	*Diatoma*
		Fragillaria	*Fragillaria*
		Tabellaria.	*Tabellaria.*
Euglenophyceae	*Euglena*	*Euglena*	*Euglena*
	Phacus	*Phacus*	*Phacus*
Dinophyceae	*Ceratium*	*Ceratium*	*Ceratium*

Table 4. Fortnightly variations in mean abundance of total phytoplankton (x10^5 cells L^{-1}) in the experimental ponds under three treatments during the study period.

Treatments	Sampling days						
	1	2	3	4	5	6	7
T1	9.07	9.16	8.30	7.85	8.00	9.40	10.24
T2	30.05	32.90	29.70	29.39	29.70	32.72	32.30
T3	19.00	16.90	15.80	19.50	15.80	21.10	19.10

The densities of phytoplankton (means ± SEM; n = 3) were ranged from 7.85 to 10.24, 29.39 to 32.90 and 15.80 to 21.10 (x 10^5) cells L^{-1} in the ponds of T1, T2 and T3, respectively (Table 4). Phytoplankton abundance in aquaculture ponds were recorded in some other studies ranged from 2.0 - 8.0 x 10^5 cells L^{-1} (Dewan *et al.*, 1991), 9.26 - 16.03 x 10^4 cells L^{-1} (Wahab *et al.*, 1991) and 10.70 - 50.65 x 10^4 cells L^{-1} (Haque *et al.*, 1998). The mean abundance of total phytoplankton (Fig. 1) was significantly higher in T2 followed by T3 and T1 where light to medium-type bloom was observed during the study period. Similar observations were noted by Mathias (1991), Chowdhury and Sultana (1989) in various habitats.

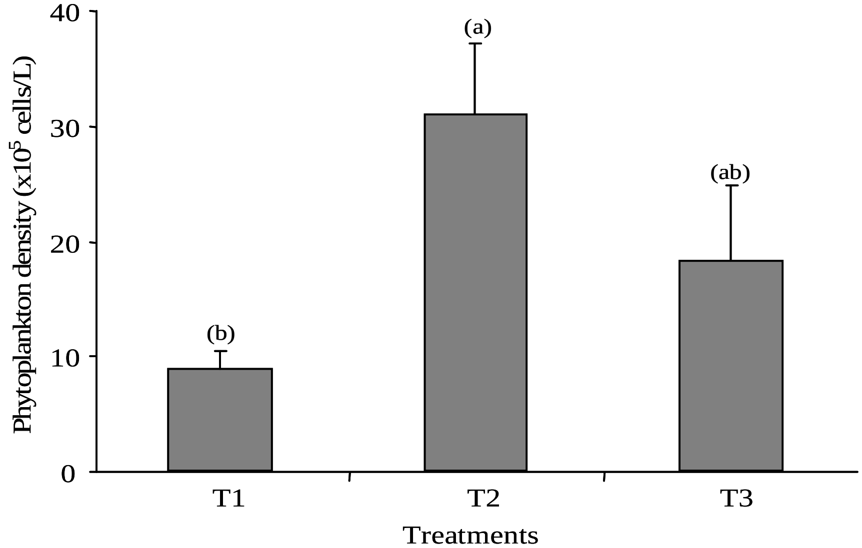

Fig. 1. Cell densities (means ± SEM; n = 3) of total phytoplankton in different treatments during the study period. Values accompanied by different letters are statistically significantly different ($p < 0.01$).

Total 13 genera of zooplankton (Table 5) were recorded belongs to Crustacea (7) and Rotifera (6). Kiran *et al.* (2007) found in their study that the population of zooplankton consisted of cladocerans (4), copepods (2) and rotifers (7), which are more or less similar to the present study. Masud *et al.* (1996) recorded 11 genera of zooplankton belonging to crustacean (7) and rotifera (4) which are lower than those of the present study.

Table 5. Generic status of zooplankton under different major groups found in the aquaculture ponds during the experimental periods

Major groups		Generic names		
		T1	T2	T3
Crustacea	Cladocera	*Daphnia* *Diaphanosoma* *Ceriodaphnia*	*Daphnia* *Diaphanosoma* *Ceriodaphnia* *Moina*	*Daphnia* *Diaphanosoma* *Ceriodaphnia* *Moina*
	Copepoda	*Cyclops* *Diaptomus*	*Cyclops* *Diaptomus*	*Cyclops* *Diaptomus*
	Crustacean larva	Nauplius	Nauplius	Nauplius
Rotifera		*Brachionus* *Filinia* *Keratella* *Hexarthra* *Polyarthra.*	*Asplanchna* *Brachionus* *Filinia* *Keratella* *Hexarthra* *Polyarthra*	*Asplanchna* *Brachionus* *Filinia* *Keratella* *Hexarthra* *Polyarthra*

Table 6. Fortnightly variations in mean abundance of total zooplankton (x10^3 cells L^{-1}) in the experimental ponds under three treatments during the study period.

Treatments	Sampling days						
	1	2	3	4	5	6	7
T1	25.00	25.40	25.50	24.10	22.70	22.70	26.50
T2	78.50	81.30	84.10	86.30	74.40	83.40	93.80
T3	66.90	61.00	67.00	67.90	60.40	55.90	76.00

The densities of zooplankton (means ± SEM; n = 3) were ranged from 22.7 ± 2.32 to 26.50 ± 3.32, 74.40 ± 3.50 to 93.8 ± 4.56 and 55.90 ± 3.65 to 76.00 ± 3.85 (x 10^3) cells L^{-1} in the ponds of T1, T2 and T3, respectively (Table 6). The mean abundance of total zooplankton (Fig. 2) was significantly higher in T2 followed by T3 and T1. Dewan *et al.* (1991) found zooplankton density ranged between 2.0 ×10^5 cells L^{-1} and 2.0 ×10^5 cells L^{-1} which are more or less similar to that of the present study.

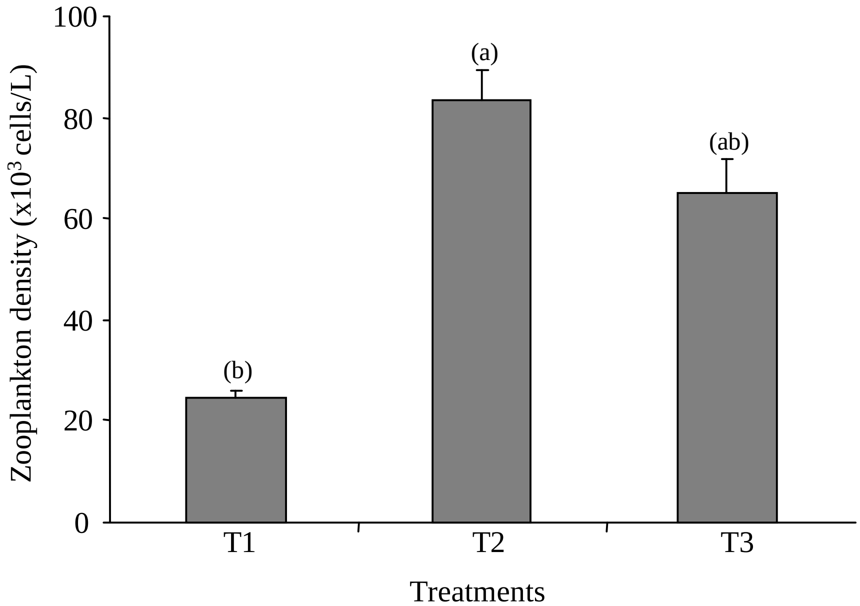

Fig. 2. Cell densities (means ± SEM; n = 3) of total zooplankton in different treatments during the study period. Values accompanied by different letters are statistically significantly different ($p < 0.01$).

However, in the present study, significantly highest mean abundance of phytoplankton and zooplankton were recorded in T2 (Fig. 1 & 2). The occurrence of these groups of plankton might be due to the suitable ecological conditions of the ponds that favoured the growth of these groups. Hulyal and Kaliwal (2008) found in an experiment that the distribution and population density of zooplankton depends upon the physico-chemical factors of the environment. On the other hand, chemical properties of soil were comparatively higher in T2 (Table 2) may be an important cause to the higher abundance of macro-benthos population in the present study. This argument also supported by Ali *et al.* (1987), Verneax *et al.* (2004) and Kailasam and Sivakami (2004) who found the significant effect of chemical properties on the plankton growth and production. Moreover, loam 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 macro-benthos. This result indicated that pond bottom with loamy soil is suitable for growth and production of macro-benthos in aquaculture ponds.

In conclusion, suitability of bottom soil textural conditions on abundance of plankton population density was analyzed in aquaculture ponds. Most of the water quality parameters of the ponds were more or less similar and within productive limit, and chemical properties of soil were also within suitable ranges. The mean abundance of plankton density was significantly highest in T2 indicated that loamy soil bottom is suitable for the growth and production of plankton 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. p. 74.

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.

Belcher, H. and Swale E. 1978. A Beginner's Guide to Freshwater Algae. HMSO, London. p. 47.

Chowdhury, A.N.B. and Sutltana, N. 1989. Occurrence and seasonal variation of zooplankton in a fish pond in relation to some physicochemical factors. *Bangladesh J. Zool.,* 17: 101-106.

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. and Aquatic Sci.,* 3: 54-59.

Dewan, S., Wahab, M.A., Beveridge, M.C.M., Rahman, M.H. and Sarker, B.K. 1991. Food selection, electivity and dietary overlap among planktivorous Chinese and Indian Major Carps fingerlings grown in extensively managed, rain-fed ponds in Bangladesh. *J. Aqua. and Fish. Manag.,* 22: 277-294.

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.

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.

Haque, M.S., Wahab, M.A., Wahid, M.I. and Haq, M.S. 1998. Impacts of Thai silver barb (*Puntius gonionotus* Bleeker) inclusion in the polyculture of carps. *Bangladesh J. Fish. Res.,* 2: 15-22.

Hulyal, S.B. and Kaliwal, B.B. 2008. Water quality assessment of Almatti Reservoir of Bijapur (Karnataka State, India) with special reference to zooplankton. *Environment Monitoring Assessment,* 139 (1): 299-306.

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.

Ketchum, C. 1962. On the study of primary produce in the sea by soviet scientist. *Int. Rev. Gel. Hydrobiol,* 45: 107-111.

Kiran, B.R., Puttaia, E.T. and Devidas-Kamath. 2007. Diversity and seasonal fluctuation of zooplankton in fish pond of Bhadra fish farm, Karnataka. *Zoos Print Journal,* 22(12): 2935-2936.

Kohinoor, A.H.M. 2000. Development of culture technology of three small indigenous fish mola (*Amblypharyngodon mola*), punti (*Puntius sophare*) and chela (*Chela cucius*) with notes on some aspects of their biology. Ph.D. Thesis, Department of Fisheries Management, BAU, Mymensingh. 263 p.

Kohinoor, A.H.M., Islam, M.L., Wahab, M.A. and Thilsted, S.H. 1998. Effect of mola (*Amblypharyngodon mola* Ham.) on the growth and production of carps in polyculture. *Bangldesh J. Fish. Res.,* 2: 119-126.

Masud, A.K.M.S., Chowdhury, H.A., Rahmatullah, S.M., Salam, M.A. and Islam, A.K.M.S. 1996. Comparative study on the zooplankton population of Derelict, Extensive and Semi-intensive Fish Ponds. *Bangladesh J. Aquaculture,* 18: 33-37.

Mathias, P.M. 1991. Seasonal trends in the fluctuation of phytoplankton and physico-chemical factors in a tropical lake (Govindgarh lake, Maddhya Pradesh, India) and their interrelationship. *Indian J. Inland Fish. Soc.,* 17 (1-2): 11-24.

Needham, J.G. and Needham, P.R. 1963. A Guide to Study of Freshwater Biology. 5th Edn., Holden-Day, Inc., San Francisco. 106 p.

Prescott, G.W. 1964. Algae of Western Great Lakes area. Wm. C. Brown Co. Dubuque, IOWA, 946 p.

Rahman, M.S. 1992. Water Quality Management: Aquaculture. BRAC Prokashana, Mohakhali, Dhaka, Bangladesh. 84p.

Raymont, J.E.G. 1963. Plankton and productivity in the oceans. Macmillan, New York, USA. 60 p.

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

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*). *Progres. 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(2): 247-259.

Wahab, M.A., Ahmed, Z.F., Islam, M.A. and Rahmatullah, S.M. 1995. Effect of introduction of common carp, *Cyprinus carpio* (L.) on the pond ecology and growth of fish in polyculture. *Aquaculture Research,* 26: 619-628.

Wahab, M.A., Begum, M.A. and Ahmed, Z.F. 1991. The effects of silver carp introduction in the polyculture of major Indian carps. *BAURes Progrssive,* 5: 429-437.