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QUALITATIVE AND QUANTITATIVE VARIATION IN PLANKTON COMMUNITIES BETWEEN MONO AND POLYCULTURE SYSTEMS IN KHULNA, BANGLADESH

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Abstract: Plankton population of shrimp and shrimp-GIFT (Genetically Improved Farmed Tilapia) culture ponds were studied. The present study was carried out to estimate phytoplankton and zooplankton abundance and diversity in mono and polyculture systems. A total of 13 phytoplankton genera of cyanophyceae, chlorophyceae, bacillariophyceae, euglenophyceae, rhodophyceae and dinophyceae were recorded from the monoculture ponds while 12 phytoplankton genera were measured from shrimp-tilapia mixed culture ponds. Six genera of zooplankton under copepod, rotifer, cladocera, ostracoda were identified in monoculture system and 7 genera were found from polyculture ponds. The numbers of phytoplankton and zooplankton species were recorded to be significantly ($p<0.05$) higher in monoculture, compared to the polyculture system. In both culture systems, cyanophyceae of phytoplankton and copepod of zooplankton were the dominant groups.

Key words: Phytoplankton, zooplankton, shrimp culture, shrimp-tilapia mixed culture, Bangladesh.

Introduction

Fish production in aquaculture is associated with pond management including culture species combination and their densities, feeding, and the quality and quantity of other nutrients input. In monoculture, a single species of fish is stocked in a pond while in polyculture, a variety of fish from different niches are stocked. Tang (1970) described polyculture as a harmonious system where available fish food and stocked fish are balanced. The likelihood of success or failure in aquaculture production is a function of water quality involving physico-chemical variables i.e. temperature, dissolved oxygen, pH, and biological variables i.e. phyto and zooplankton biomass. The qualitative and quantitative values of phytoplankton in a body of water form the basic link in the food chain of fishes (Rahmatullah *et al.*, 1983). The practical knowledge in the abundance of planktonic population and its quality in time and space in relation to environmental conditions might be a pre-requisite for scientific fish culture and management. Any changes of physicochemical and biological parameters may affect the growth, development and maturity of fish (Nikolsky, 1963; Jhingran, 1985). Phytoplankton communities undergo a continual succession of dominant species due to changes in growth factors, such as light, temperature and nutrient concentrations in an aquatic environment (Chan, 1980). Nutrients are taken up by phytoplankton,

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and planktivorous fish and shrimp keep water quality better by consuming phyto and zooplanktons. The total population of planktons and their seasonal abundance are directly related with water qualities (Miah *et al.*, 1983). Most of the studies concentrated on the distribution and seasonal variation of plankton population. Islam and Aziz (1975) and Ganapati (1943) studied seasonal variation of plankton; Martínez-Córdova and Peña-Messina (2005) studied the abundance of zooplankton in semi-intensive mono and polyculture systems, and Chowdhury and Mamun (2006) studied the abundance and diversity of plankton in fish pond. But the information about plankton abundance and diversity in relation to fish culture systems and management is poor. Therefore, the present study was conducted to know the qualitative and quantitative abundance of phyto and zooplankton populations in shrimp monoculture and shrimp-GIFT mixed culture ponds.

Materials and Methods

Four ponds of 0.2 hectare (ha.) with 2-2.5 m depth were selected from Bangladesh Fisheries Research Institute at Paikgacha thana in Khulna, Bangladesh. The ponds were connected with a river allowing entrance to coastal water into the pond. For monoculture of shrimp Pond 1 (P_1) and Pond 2 (P_2), and for polyculture with shrimp and GIFT tilapia (a Nile tilapia strain belongs to the genus, *Oreochromis*), Pond 3 (P_3) and Pond 4 (P_4) were selected. Sampling was carried out during the month of June, 2007. Plankton samples were collected from each pond by conical shaped monofilament nylon net of 10µm mesh size. Collected plankton samples with water were kept in plastic containers, and carried to the Water Quality Laboratory of Fisheries and Marine Resource Technology Discipline, Khulna University for further analyses. Plankton net of 200 µm was used to get zooplankton separated from the plankton samples. About 250 ml samples of zooplankton were preserved with 1.5 ml Borax buffered formalin (5%) and phytoplankton samples with 1.5 ml Lugol's solution. Planktons were enumerated under a light microscope by using Sedgwick-Rafter counting cell (Welch, 1948). Identification was done by following the literatures of Moniruzzaman (1997); Zheng (1984) and Davis (1956). Water temperature, pH, salinity, and transparency were measured by mercury thermometer, pH meter, refractomete and secchi disc, respectively. Dissolved oxygen content in water was measured by titrimetric method (Welch, 1948). Data were analysed using Microsoft Excel and SPSS.

Results

***Qualitative Abundance of Phyto and zooplankton**:* In the present investigation, six classes of phytoplankton population and four orders of zooplankton communities were identified. The species compositions of phyto and zooplankton of monoculture and polyculture ponds are summarized in Table 1 and Table 2, respectively. The diversity of phytoplankton species was found to be higher in monoculture system with 13 phytoplankton genera, compared to polyculture with 12 genera. The species under the class cyanophyceae were found to be qualitatively

Table 1. Phytoplankton species composition in monoculture and polyculture systems.

Class	Monoculture	Polyculture
	Microcystis sp.	*Microcystis* sp.
Cyanophyceae	*Spirulina maior*	*Sp.irulina maior*
	Oscillatoria tenuis	-
	Nostoc sp.	-
	-	*Aphanothece elabans*
	-	*Anabaenopsis* sp.
Chlorophyceae	*Chlorella* sp.	*Chlorella* sp.
	Oocystis sp	*Oocystis* sp.
	-	*Desmodium swartzii*
Bacillariophyceae	*Biddulphia sinensis*	-
	Nitzschia punges	Nitzschia punges
	-	*Navicula futilis*
	Coscinodiscus radiatus	*Coscinodiscus radiatus*
	Chateceros atlantum	-
Euglenophyceae	*Euglena viridis*	*Euglena viridis*
Rhodophyceae	*Chroothece mobilis*	*Chroothece mobilis*
Dinophyceae	*Peridinium* sp.	-

- = not detected

Table 2. Zooplankton species composition in monoculture and polyculture systems.

Order	Monoculture	Polyculture
Rotifer	*Brachionous* sp.	*Brachionous* sp.
	Filinia longiseta	*Filinia longiseta*
Copepod	*Cyclops* sp.	*Cyclops* sp.
	Mesocyclops sp.	*Mesocyclops* sp.
	Diaptomus sp.	-
Cladocera	*Daphnia* sp.	*Daphnia* sp.
	-	*Sida* sp.
Ostracoda	-	*Cypris* sp.

- = not detected

abundant in both culture conditions while the class bacillariophyceae was observed to diversify the monoculture only. No species belonging to the class dinophyceae was found in polyculture system. It was also observed that there was variation in species belonging to the same class between mono and polyculture system. The order copepod was observed to be dominant in monoculture system while the polyculture was rich with the order cladocera. The polyculture system was found to be more diversified in zooplankton communities, compared to monoculture. In polyculture, 7 genera under 4 orders of zooplankton were identified while 6 genera were observed in monoculture. The order ostracoda was found to be fully absent in monoculture system.

Quantitative Abundance of Phyto and zooplankton

During the period of studying phytoplankton the average number of cyanophyceae, chlorophyceae, bacillariophyceae, euglenophyceae, rhodophyceae and dinophyceae in monoculture ponds were 7933, 500, 3900, 3133, 1900 and 33 units l^{-1}, respectively while the average number of cyanophyceae, chlorophyceae, bacillariophyceae, euglenophyceae and rhodophyceae in polyculture ponds were 6400, 700, 3033, 2266 and 2333 units l^{-1}, respectively (Fig. 1). Among the phytoplankton population, the class cyanophyceae, bacillariophyceae, euglenophyceae, dinophyceae were found to be more abundant in monoculture while the polyculture system had greater abundance of chlorophyceae and rhodophyceae over the groups.

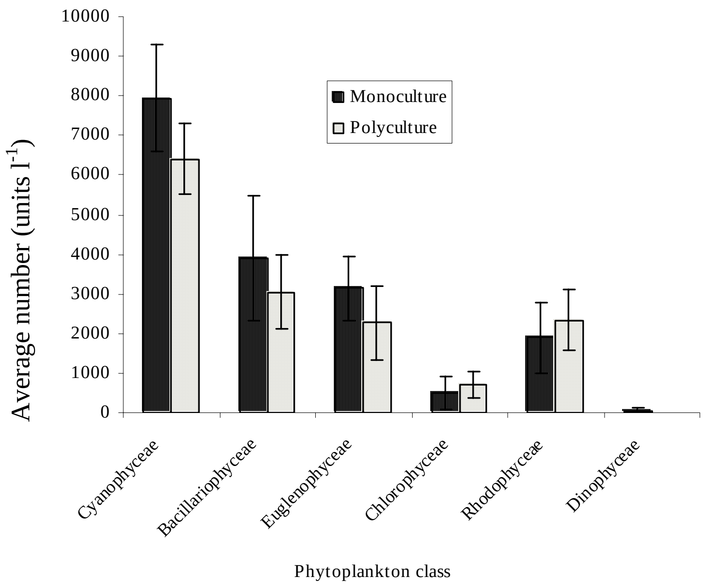

Fig. 1. Average number of phytoplankton of different classes in monoculture and polyculture systems.

The average number of copepod, rotifer and cladocera monoculture system were 1133, 633 and 100 units l^{-1}, respectively while the numbers of copepod, rotifera, cladocera and ostracoda in polyculture system were 833, 467, 133 and 100 units l^{-1}, respectively (Fig. 2). The comparison between monoculture and polyculture system indicates that there had been greater abundance of copepod and rotifer in monoculture whereas the order cladocera and ostracoda were abundant in polyculture system. Significant mean differences ($p<0.05$) were observed between monoculture and polyculture systems for both phytoplankton and zooplankton abundance.

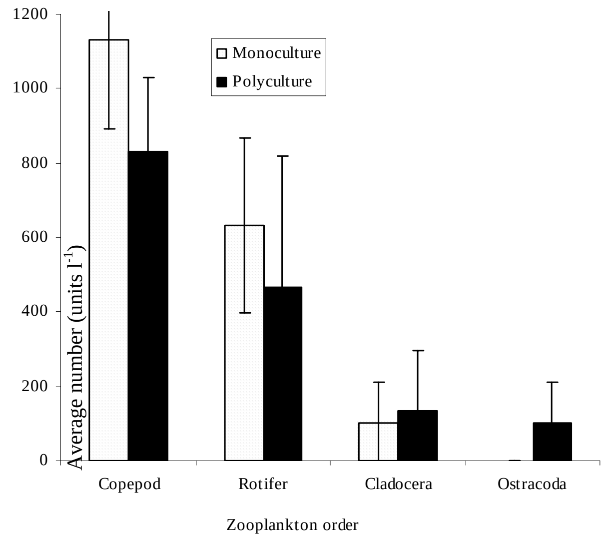

Fig. 2. Average number of zooplankton of different orders in monoculture and polyculture systems.

Physico-chemical parameters of water in cultural ponds: The mean values of water quality parameters i.e. temperature, DO, pH, salinity and transparency are summarized in Table 3. There was no significant mean difference ($p>0.05$) in values of water parameters between monoculture and polyculture, except for transparency and DO.

Table 3. Physico-chemical conditions of water in monoculture and polyculture systems.

Parameters	Monoculture		Polyculture	
	Range	Mean ±SD	Range	Mean ±SD
Water temperature (°C)	28-32	30±1.8	28-32	29.9±1.7
Transparency (cm)	23-44	31.2±6.9	16-31	22.3±5.4
pH	7.1-8.0	7.7±0.4	7.1-7.9	7.6±0.3
DO (mg l^{-1})	5.6-7.0	6.4±0.5	5.2-6.0	5.6±0.3
Salinity (ppt)	15-17.5	16.2±0.9	15-17.5	16.2± 1.0

Discussion

The abundance of phyto and zooplankton of this study reveals that there were qualitative and quantitative variations of plankton communities between the monoculture and polyculture systems. It is well documented that the occurrence of plankton population is determined by the physico-chemical factors of a water body. Islam (2007) reported a significant correlation between the physicochemical condition and the occurrence of zooplankton; Jhingran (1985) and Nikolosky (1963) described the relationship between the plankton production and physicochemical parameters of pond water; and Roy (1955) observed a strong correlation between the abundance of plankton population and the physico-chemical parameters of water body. However, the plankton variability between the two culture systems of the present study was not related to the water quality as the physicochemical parameters between the two culture conditions were recorded to be almost same, except DO values and transparency.

The variation in plankton population between the two culture systems might be associated with the species composition. In a polyculture setting, tilapia and shrimp can utilize different niches in the culture system. Fitzsimmons (2001) stated that tilapia in polycuture farm, can filter phyto and zooplankton in the upper water column while shrimp spend most of the time in the pond bottom grazing on a wide variety of plankton, bacteria and detritus. But in a shrimp monoculture system, shrimp is the only consumer of plankton population. So, with considering the feeding habit and different niches of the stocked species, there is likelihood of variation in plankton population for different culture systems.

Gliwicz and Rowan (1984) reported on oligotrophic alpine lakes where fish controlled the *Daphnia* population so effectively that *Cyclops* released from the competitive interaction, became dominant. Reid *et al.* (2000) reported that there was strong interaction between different fish species and the plankton. Seda and Duncan (1994) studied relationship between fish stock and zooplankton community structure. They found that when fish stock reduced, large-bodied cladocerans made an increased contribution to zooplankton biomass, and *D. Magna* was dominant. Moreover, Yang *et al*. (2005) reported that large changes in zooplankton community structure coincided with markedly changes in concentration of chlorophyll *a* and transparency. Similarly, the significant variations observed in transparency and DO level might indicate the existence of variation in plankton communities between monoculture and polyculture systems of the present study.

The Study results indicate that in monoculture, phytoplankton groups except chlorophyceae and rhodophyceae had a numerical superiority over the other groups of polyculture system. In case of monoculture, zooplankton abundance of copepod and rotifer except cladocera was also dominant over polyculture system. Qualitatively, there was variation in plankton composition between monoculture and polyculture. Among phytoplankton population, the group dinophyceae was found to be unique for monoculture system while the polyculture system was characterized by zooplankton group, ostracoda. The reasons behind this diversification in plankton groups between monoculture and polyculture systems might be associated with the food habit of cultured species, their composition, vertical and horizontal distribution of plankton population, nutrient accumulation and variation in water quality parameters. The present work suggests further investigation for disclosing these facts.

Conclusion

The present study reveals that the quantitative and qualitative abundance of plankton population could vary with culture systems. The abundance of phyto and zooplankton was higher in shrimp monoculture ponds than in shrimp-tilapia polyculture ponds. The findings of the present work might provide baseline information for further research on species selection, and food and feeding strategies for fish culture systems.

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References

Chan, A.T. 1980. Comparative physiological study of marine diatom and dinflagellates in relation to irradiance and cell size. II. Relationship between photosynthesis, growth, and carbon/chlorophyll a ratio. *Journal of Phycology*, 16: 428-432.

Chowdhury, A. H. and Mamun, A. A. 2006. Physio-chemical conditions and plankton population of two fishponds in Khulna. *University journal of zoology of Rajshahi University*, 25: 41-44.

Davis, C.C. 1956. *Marine and freshwater plankton*. University Press, Michigan.

Fitzsimmons, K. 2001. Polyculture of tilapia and penaeid shrimp. *Global Aquaculture Advocate*, 4(3): 43-44.

Ganapati, S.V. 1943. An ecological study of a garden pond containing abundant zooplankton. *Indian Academy of Science (Botany)*, 17(2): 41-58.

Gliwicz, Z. and Rowan, M. 1984. Survival of Cyclops *Abyssorum tatricus* (Copepoda, Crustacea) in alpine lakes stocked with planktivorous fish. Oceanology and Limnology, 29: 1290–1299.

Islam, A.K.M.N. and Aziz, Z. 1975. A preliminary study on the zooplankton of the north-eastern bay of Bengal, Bangladesh. *Bangladesh Journal of Botany*, 4(1-2): 1-32.

Islam, S.N. 2007. Physicochemical condition and occurrence of some zooplankton in a pond of Rajshahi University. *Research Journal of Fisheries and Hydrobiology*, 2(2): 21-25.

Jhingran, V.G. 1985. *Fish and Fisheries of India*. Hindustan Publishing Corporation, Delhi.

Martínez-Córdova, L.R and Peña-Messina, E. 2005. Biotic communities and feeding habits of *Litopenaeus vannamei* and *Litopenaeus stylirostris* in monoculture and polyculture semi-intensive ponds. *Aquaculture Research*, 36 (11): 1075–1084.

Miah, M.I.; Islam, B.N. and Dewan, S. 1983. Studies on the ecology of two ponds in Bangladesh Agriculture University Campus, Mymensingh. *Bangladesh Journal of Aquaculture*, 2-5 (1): 33-41.

Moniruzzaman, K. 1997. *Practical limnology and systematics of freshwater hydrophytes*. Dhaka University, Dhaka, Bangladesh.

Nikolsky, G.V. 1963. *The ecology of fishes*. Academic Press. London.

Rahmatullah, S.M.; Islam, M.A. and Ali, M.M. 1983. The qualitative and quantitative studies of phytoplankton of a pond within the Bangladesh Agricultural University campus, Mymensing. *Bangladesh Journal of Aquaculture*, 2-5 (1): 43-50.

Reid, P.C.; Battle E.J.V.; Batten S.D. and Brander, K.M. 2000. Impact of fisheries on plankton community structure. *ICES Journal of Marine Science*, 57: 495–502.

Roy, H.K. 1955. Plankton ecology of the river Hoogly at Palta, West Bengal. *Ecology*, 36: 169-175.

Seda J. and Duncan A. 1994. Low fish predation pressure in London reservoirs: II. Consequences to zooplankton community structure. *Hydrobiologia*, 291:179–191.

Tang, Y.A. 1970. Evaluation of balance between fishes and available fish foods in multispecies fish culture ponds in Taiwan. *Transactions of the American Fisheries Society*, 4: 708-718.

Welch, P.S. 1948. *Limnological Methods*. McGraw Hill, New York.

Yang, Y.F.; Huang, X.F.; Liu, J.K. and Jiao, N.Z. 2005. Effects of fish stocking on the zooplankton community structure in a shallow lake in China. *Fisheries Management and Ecology*, 12: 81–89.

Zheng, Z. 1984. *Marine Planktology*. China Ocean Press, Beijing.