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STUDY ON THE DIVERSITY AND SEASONAL VARIATION OF ZOOPLANKTON IN A BROOD POND, BANGLADESH

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ABSTRACT

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The present study was designed to estimate zooplankton abundance qualitatively and quantitatively in carp brood fish culture systems. Plankton samples were collected from Gallamari fisheries extension & training centre farm, Batiaghata, Khulna, one time in a month. A total 6 groups of zooplankton were found from the study ponds. The identified zooplanktons were under six orders namely copepoda, rotifera, cladocera, ostracoda, crustacean larvae and bryozoa. Numbers of zooplankton groups were recorded to be the highest in December. In the brood pond copepod was the dominant order. Among various orders of zooplankton, the percentages of copepoda, rotifera, cladocera, ostracoda and crustacean larvae brysozoa in brood fish culture system were 55%, 8%, 25%, 9%, 2% and 1% respectively. Copepoda was dominant in May, June, July, August, October, November and December but cladocera was dominant in September. Insect larvae were dominant in all month of study period. Bryozoa was found only in December. Five physico-chemical parameters were also studied during study period namely, water temperature, salinity, transparency, dissolve oxygen and pH. The relationship of zooplankton with physico-chemical parameters were also measured to observed variation of zooplankton monthly. The findings of the present study will help to improve the management strategies of the brood culture pond.

Key words: Zooplankton, brood pond, seasonal variation

INTRODUCTION

The word ‘plankton’ is originated from the Greek ‘planktos’ which means ‘drifting’. Plankton is microscopic organisms that formulate the base of food chains and food webs in all aquatic ecosystems. It is an enormous group of aquatic organism drifting about in water under the action of water movement. They are mostly small, many of them are minute, and their structure can only be seen clearly with the aid of a binocular or compound microscope, with the exception of some large animals, such as certain medusae (Chynea, Physalia, etc), heteropods (Pterotrachea) and tunicates (Pyrosoma). Although they belong to different taxa, they have one thing in common, i.e. owing to the lack of strong locomotory organs (like fish fins), they are weak in locomotion and can only drift about in water at mercy of waves and currents, being incapable of mobbing anywhere as fish do (Zheng Zhong *et al.,* 1984).

Zooplankton is microscopic organisms that formulate the base of food chains and food webs in all aquatic ecosystems. All the secondary production in aquatic ecosystems directly or indirectly relies on plankton. They also play a major role in recycling nutrients as well as cycling energy within their respective environments. They are located in the pelagic zone of ponds, lakes, rivers and oceans where light penetrates. Plankton excretes large quantities of organic matter, which dissolves and integrates into the biomass of different bacteria.

Zooplankton plays an important food item of omnivorous and carnivorous fishes (Alam *et al.,* 1987). The larvae of carps feed mostly on zooplankton (Bardach *et al.,* 1972), because zooplankton provide the necessary amount of protein requires for the rapid growth and development of different organs specially the ground of fishes. Brood fishes productivity depend on zooplankton as an ideal food source of them.

Very little is known about the plank tonic flora and fauna of brood farm pond in Khulna, although the study of plankton began in other parts of the world over a century. In temparate and polar waters considerable work has been done (Costlow, 1971). Khulna is situated in the southern-west part of the Bangladesh and besides the river Bhairab. Geographically Khulna is situated between 22˚49″ north latitude and 89˚34″ east longitudes with its elevation of 2.13 meters above mean sea level.

Gallamari fisheries extension & training centre farm, Batiaghata, Khulna, the aquatic brood pond is heavily abundant with phytoplankton and zooplankton. The physico-chemical factors and nutrient status of water play the most important role in governing the production of planktonic biomass. A very few researcher worked on the percentage, composition, seasonal variation and occurrence of zooplankton of in brood fish farm in Khulna. George (1966), Krishnamurthy (1966), Sreenivasan (1967) and Michael (1968a) worked in detail on the ecology and zooplankton population from different waters of India. Some of the works which have been done in Bangladesh include those of Das & Bhuiyan (1974), Islam and Mendes (1976), Khan et al. (1978), Ali et al. (1980), Patra and Azadi (1987), Bhuiyan et al. (1997), Bhuiyan and Nesa (1998a, 1998b).

But little information is available on the seasonal variation of zooplankton and their relationship with the physico-chemical parameters of water in brood fish pond. The physico-chemical parameters are water temperature, turbidity, pH, dissolve oxygen (DO), free carbon dioxide, alkalinity, bicarbonate alkalinity.

Zooplankton constitutes important food item of many omnivorous and carnivorous fishes. The larvae of white fish (Mullet) feed mostly on zooplankton (Dewan et al., 1977) because zooplankton provides the necessary amount of protein for the rapid growth and especially that of the gonad. Zooplankton contributes about 82% of the food item of Anabas testudineus (Shofi and Mustafa, 1976), 32% of Notoptrus notoptrus (Mustafa and Ahmed, 1979).The main food item of Xenentodon cancila and the zooplankton contributes about 23% of the food item of Macrobrachium rosenbergii, 47% of the Catla catla (Ali and Islam, 1981), 6.37% of the Labeo rohita (Ali and Islam, 1981), 24.19% of the Oreochromis nilotica (Islam et. al., 1984), 38.5% of the Rohtee cotio (Ali et al,. 1985) and 30% of the Mystus vittatus (Bhuiyan and Haque, 1984). Bhuyan (1988) observed that the food of Cirrhina reba constitute mainly of zooplankton.

Zooplankton plays a very important role in the food chain as they are in the second trophic level as primary consumer and as contributors to the next tropic level. Planktonic biomass available in an ecosystem is of fundamental importance for fish production.

In order to fisheries development and to increase the present production level, proper and scientific management is essential in which the knowledge of water quality and natural productivity plays an important role. The main objectives of the study was to determine physico- chemical parameters of the fish brood pond and to observe zooplankton abundance of the fish brood pond in different seasons and also to know the relationship between physico-chemical parameters and zooplankton abundance.

MATERIALS AND METHODS

Area of sampling*:* The pond under study has been selected from Gallamari fisheries extension & training centre farm, Batiaghata, Khulna. It is near Khulna University, beside Khulna-Satkhira high way road. The fish farm brood pond has an area of 75 decimals. The average depth of the fish culture pond was 1.5 meter. During the study period there were no aquatic plants in this spot and it receives direct sunlight. There are silver, rui, mrigal, catla, and grass carp in the brood pond. Various artificial feed are used for 172 piece of silver carp, 220 pieces of rui, 200 pieces of mrigal, 55 pieces of catla and 12 pieces of grass carp.

Sampling period: Once in 2nd week of every month around 9.00 a.m. Sampling was started May to December.

Sample size*:* Zooplankton samples were collected from three parts of a brood pond using by simple conical tow-net oblique or horizontal tows which mesh size is 90µm and the diameter of the net at mouth was 30 cm. Sample size was varied with water depth because the net was dragged vertically. By using depth of water and conical tow-net diameter, the sample size was calculated.

Sample collection: Sampling of zooplankton has been conducted by zooplankton net mesh size 90µ considering triangular points of varsity lake. The samples were kept in the plastic container and carried out to the Water Quality Laboratory and Biology Laboratory of FMRT Discipline for further analyses.

Identification and calculation: Sample water has been mixed with 1.5 ml Lucas reagent and kept in 100ml in a biker. Then it is poured on S-R (sedgwick rafter) cell. Then it has been set up with microscope to identify different species of zooplankton. Thus, a series of pencil and ink drawing on postcards of the species of the observed were prepared to identify the organisms. Identification was done following Davis (1945), Moniruzzaman (1997), Zheng Zhong et. al. (1984).

Counting

For plankton counting, the Sedgwick-Rafter (S-R) cell was used which is 50 mm long, 20 mm wide and 1 mm deep. Before filling the S-R cell with sample, the cover glasses were diagonally placed across the cell and then samples were transferred with a large bore pipette so that no air bubbles in the cell covers were formed. The S-R cell was let standard for at least 15 minute to settle plankton. Then plankton on the bottom of the S-R cell was counted enumerated by compound microscope. By moving the mechanical stage, the entire bottom of the slide area was examined carefully. Organisms lying between two parallel cross hairs were counted as they passed a vertical line.

Number of plankton (Phyto and Zooplankton) in the S-R cell was derived from the following formula APHA (1976).

$$No\ speies/l = \frac{C \times 1000 mm^3}{L \times D \times W \times S}$$

Here,

C= No of organisms counted
L= Length of each stripe (mm)
D= Depth of each stripe (mm)
W= Width of each stripe (mm)
S= No. of stripes

Physico-chemical parameters

At first sample is taken from the selected pond and measured various types of physico-chemical such as temperature, turbidity and pH, DO, hardness etc. Water temperature was measured at each station using a mercury thermometer of 0 to 50 degree centigrade range. Surface water was taken in a plastic container and recorded its temperature immediately by dipping the thermometer for about one minute. Water P^H was measured by a bench top electrometric pH meter. Transparency of water was measured by using secchi disc. The sample was taken from three different corners of the pond. For DO measurement sample was fixed up by using alkaline iodide and manganous sulfate then after few times concentrated H_2SO_4 was added into the BOD bottle. For another measurement (hardness, alkalinity, free CO_2) different plastic bottle was used to collect the sample. The parameters (DO, hardness, free CO_2, alkalinity) was measured by using relevant equipments and chemicals in the laboratory. Different titrimatric method was applied to experiment those parameters. For alkalinity, 2 drops methyl orange indicator was added into 10 ml of the sample and H_2SO_4 solution was taken in the burette. In the titration of alkalinity, light pink color was observed at the end point. 0.1N NaOH was taken in the burette and phenolphthalein indicator (5 drops) was added to the solution. Permanent pink color was observed at the end point. Two drops starch solution was added to the fixed up sample (20 ml) and $Na_2S_2O_3$ was taken in burette. The titration was continued to first disappearance of blue color. In hardness measurement standard EDTA solution was taken into burette and 1 ml buffer solution and 2 drops black-T solution was added into 50ml of the sample. At the end point of titration the solution was observed normally blue color. Three times experiment was done for each parameter to determine the average result.

RESULTS AND DISCUSSION

Water body is an ecosystem with a complicated network of various physical-chemical parameters and its biota. Zooplankton was examined both qualitatively and quantitatively with regard to standard methods for the examination of water and waste water by Clesceri *et.al*. Correlation amount of various groups zooplankton abundance and water quality parameter, for example water temperature pH, salinity, DO, total alkalinity and free CO_2 were also well marked. Water body of the brood carp fish pond is an ecosystem with a network of various physico-chemical parameters and its biota. The physico-chemical parameters and plankton communities together form a comprehensive ecosystem and as in any ecosystem, there are interactions between the plankton and also between the plankton and the physico-chemical parameters. These interactions are directly or indirectly subjected to the complex influences, some of which results in quantitative changes e.g. increases or decreases of size of the population. Such variation in population is occurred for the variation in nutrients and other favorable conditions of water (eg. water temperature, pH, salinity, DO, alkalinity, free CO_2 etc.) during the plankton production. (Welch, P. S.1952). Zooplankton showed inverse relationship with water temperature, pH and free carbon dioxide (Patra and Azadi, 1987) and positive correlation with the dissolve oxygen, carbonate and bicarbonate, alkalinity (Alam *et al.*, 1989).

In carp brood pond six group of Zooplankton were identified. Dominant species was Copepod (55%) of which four genera are-. *Merocyclops* sp., *diaptomus* sp.,*Cyclops* sp., *Mesocyclops* sp. And second dominant species were Cladoceron (25%) eg. *Bosmina* sp., *Praunus* sp.

During this study a distinct fluctuation of zooplankton population in carp brood pond from May to December, 2008 was observed. This fluctuation was the impact of different physico-chemical parameters on zooplankton population. Similar observations were noted by Krisnomoorthi and Visvesvara (1966), Michel (1968b), Mathew (1975), Islam *et al*., (1975), Ali *et al*., (1980), Chowdhury *et al*., (1987), Jana *et al*., (1990), Islam *et al*., (2000) in different working areas. The study of Patra and Azadi (1997) in Halda River in Bangladesh showed similar plankton composition. A total of 11 genera of different group of zooplankton were identified from the study area. C.D. Todd and M.S. Laverrack reported six genera, C.D Charles reported four genera and A.K.M. Nurul Islam *et al*., (1987) reported single genera of different zooplankton from different water bodies.

Temperature is one of the most outstanding and biologically significant phenomena of aquatic environment; it has the relationship on zooplankton variation. In pond the range of water temperature was found 33^{o}C to 27^{o}C. The maximum temperature was 33^{o}C in May and minimum in November (27^{o}C). The highest temperature during summer months was reported by Das and Bhuiyan (1974), Islam *et al*., (1974) in Bangladesh. The low temperature was found in winter is supported by Das and Bhuiyan (1974). The rainfall and air temperature has the direct influences on the variation of water temperature (Michael, 1968).

Zooplankton abundance showed inverse relationship with water temperature in carp brood pond system.

In the pond Rotifera (r = -.130), Copepoda (r = -.401), Cladocera (r = -.024), Ostracoda (r = -.819), Crustacen (r = -.641) and bryozoa s(r = -.482). Such finding resembles the works of Chowdhury *et al.,* 1987, Patra and Azadi (1987) and Islam N. *et al.,* 2000. Ostracoda, crustacean larvae shows highly significant with water temperature.

Turbidity is a very general term that describes the “cloudiness” or “muddiness” of water. Turbidity can be caused by many substances, including microscopic algae (phytoplankton), bacteria, dissolved organic substances that stain water, suspended clay particles, and colloidal solids. Although turbidity can be a problem in many different types of water, turbidity caused by suspended clay tends to occur most often in soft, poorly-buffered (low alkalinity) waters. Some of the substances that cause turbidity are more desirable in fish culture or recreational farm ponds than others. In moderate amounts, phytoplankton is a desirable form of turbidity because it provides food for microscopic animals (zooplankton) and filter-feeding fish, and improves water quality by producing dissolved oxygen and removing potentially toxic compounds such as ammonia.

Fluctuation of the limit of visibility is inversely related with turbidity. Transparency depends on zooplankton abundance of zooplankton, organic particles etc. The range of transparency was 5cm to 20cm.

In the brood pond the lowest transparency was found in September due to blooming. The highest transparency was in July and December. In the study time without cladocera all of zooplankton (Rotifera, Copepoda, Ostracoda, Crustacen and bryozoa) showed inverse relations. In the pond the correlation of Rotifera($r = .390$), Copepoda($r= .820$) Cladocera($r = -.395$), Ostracoda($r = .284$), Crustacen($r = .412$) and bryozoa($r = .268$). Copepoda was highly significant and crustacean significant, too.

The pH of water used in aquaculture can affect fish health directly. For most species, a pH between 6.5 and 9 is ideal. The pH value of pond water showed to be alkaline in nature with small variation. The pH range of the pond was 7.2 to 7.55. In the study pond the highest pH value was recorded in September and December and lowest pH was recorded in November. The correlation of zooplankton with pH was at the experiment, [Rotifera (-.33), Copepod (-.476), Cladocera (.020), Ostracoda (-.774), Crustacen (.168) and Bryozoa(.506). Zooplankton abundance also showed inverse relationship and direct relation with pH in the carp brood pond. Highly significant correlation with Ostracod showed inversely, Copepod and Rotifer too. But, Bryozoa showed positive significant relation.

Zooplankton showed inverse relationship with pH in monocultures which support the works of Patra and Azadi (1987) in Halda River and Alam *et al*., (1987).

At lower pH, the species ability to maintain its salt balance is affected and reproduction ceases. Most species die at approximately pH 4 or below and pH 11 or above. Also at low pH, metals toxic to fish, zooplankton and shellfish can be leached out of the soil. In addition phosphate, which is commonly added as a fertilizer, can rapidly precipitate at high pH. Low pH waters are often treated using lime. Alum can be used to treat high pH waters. In cases where the high pH problem is due to excess phytoplankton photosynthesis in waters with high alkalinity and low calcium hardness, gypsum can be added as a source of calcium. The pH value in alkaline condition in the pond water was supposed to be helpful for proper growth and developments of fishes and aquatics organism Nikolsky (1963) and Hut (1972).

Free carbon dioxide refers to carbon dioxide gas dissolved in water. The term is used to distinguish a solution of the gas from the combined carbon dioxide present in bicarbonate and carbonate ions. We get free CO_2 from Carbon dioxide which is produced during the respiration cycle of animals, plants and bacteria. All animals and many bacteria use oxygen and release carbon dioxide. The general formula for plant respiration is summarized below.

Respiration:

$$C_6H_{12}O_6 + O_2 \rightarrow CO_2 + H_2O$$

Carbon-rich foods + Oxygen → Carbon Dioxide + Water

Free CO_2 is of interest in aquaculture because (1) it can be a stressor of aquatic animals, (2) it influences the pH of waters and (3) it is a nutrient required for plant growth and its availability may limit primary productivity of some aquatic system. It also used to neutralize the alkalinity of water.

In the carp brood pond, the carbon dioxide content of water showed seasonal change. The range of carbon dioxide was 2.2mg/L to 20mg/L. The highest value was found in October and lowest in July. But zooplankton abundance showed direct relationship with free CO_2 in the pond. The correlation value for various species were Rotifera ($r = .407$), Copepoda ($r = .283$), Cladocera ($r = .181$), Ostracoda ($r = .739$), Crustacean larvae($r = .340$), and Bryozoa ($r = .438$). The all species showed directly relation but Ostracoda significant. This result does not support the result of Alam *et al.,* 1987, Patra and Azadi 1987 and Islam N. *et al.,* 2000.

It’s lucky for fish that "free" carbon dioxide (by "free" we mean it is not combined with anything) levels rarely exceed 20 mg/L (milligrams per liter), because most fish are able to tolerate this carbon dioxide level without bad effects. Higher level (60-80 mg/L) of free CO_2 has narcotic effect on aquatic animals and even causes death.

Alkalinity is a measure of the buffering capacity of a solution, or the capacity of bases to neutralize acids without an increase in pH. The alkalinity of a solution is usually made up of carbonate (CO_3^{2-}), bicarbonate (HCO_3^-), and hydroxides (OH^-). Total alkalinity is the sum of the carbonate and bicarbonate alkalinities.

Most aquatic organisms can live in a broad range of alkalinity concentrations. The desired total alkalinity level for most aquaculture species lies between 50-150 mg/L CaCO3, but no less than 20 mg/L.

The range of alkalinity was 259mg/L to 398mg/L (20). The highest value was found in December and lowest in September. But zooplankton abundance showed direct relationship with free CO_2 in the pond. The correlation value for various species were

Rotifera (r =.477), Copepoda (r =.545), Cladocera (r =-.010), Ostracoda (r =-.137), Crustacean larvae (r =.520), and Bryozoa (r =.767). Cladocera, Ostacoda showed native relation but Rotifer, Copepod, crustacean larvae and Bryozoa had direct relation with pH. As increasing amounts of acid are added to a water body, the pH of the water decreases, and the buffering capacity of the water is consumed. At that time to increase the alkalinity limestone is used. Liming with agricultural limestone increases total alkalinity, augmenting the availability of phosphorus for phytoplankton growth. Pond fertility is improved and primary productivity increases which, in turn, can lower toxic, nitrogen wastes and elevate day time dissolved oxygen concentrations.

But if the water become more alkaline than the carbonic acid is used to reduce the total alkalinity. But carbonic is toxic to aquatic organisms. If we can control the aquatic habitat, than we wish to get high production of organisms.

The term "hardness" is one of the oldest terms used to describe characteristics of water. In fact, Hippocrates (450-354 B.C.) used the "hard" and "soft" terms in a discourse on water quality. He states "Consider the waters which the inhabitants use, whether they are marshy and soft, or hard and running from elevated and rocky situations ". Water hardness is similar to alkalinity but represents different measurements. Hardness is chiefly a measure of calcium and magnesium, but other ions such as aluminum, iron, manganese, strontium, zinc, and hydrogen ions are also included. When the hardness level is equal to the combined carbonate and bicarbonate alkalinity, it is referred to as carbonate hardness. Hardness values greater than the sum of the carbonate and bicarbonate alkalinity are referred to as non-carbonated hardness. Most aquatic organisms can tolerate a broad range of calcium hardness concentrations, but a desirable range is 75mg/L to 250 mg/L with a minimum concentration of 20 mg/L.

In the study period the range of the hardness was 150mg/L to 250mg/L.The highest value was found in July and lowest value was found in October and November. The correlation value for various species were Rotifera (r=-.299), Copepoda (r=-.045), Cladocera (r=-.566), Ostracoda (r=-.653), Crustacean larvae (r =-.159), and Bryozoa (r =-.259). The zooplankton had showed inverse relation with various physico-chemical parameters, Cladocera, Ostracoda showed significant inversely with parameters.

Low- hardness levels can be increased with the addition of ground agriculture lime.

Dissolved oxygen (DO) is the most important chemical parameter in aquaculture. Low-dissolved oxygen levels are responsible for more organisms' kills, either directly or indirectly, than all other problems combined. Like humans, aquatic organisms require oxygen for respiration. The amount of oxygen consumed by the fish is a function of its size, feeding rate, activity level, and temperature. Small fish consume more oxygen than do large fish because of their higher metabolic rate. The amount of oxygen that could be dissolved in water decreases at higher temperatures and decreased with increasing in altitudes and salinities.

The range of dissolve oxygen was 3mg/L to 8mg/L. The highest value was found in July and lowest in June. But, most of the zooplankton abundance showed inverse relationship with dissolve oxygen in the pond. The correlation value for various species were

Rotifera (r=-.655) Copepoda (r=-.400) Cladocera (r=-.090), Ostracoda (r=-.225), Crustacean larvae (r=.291), and Bryozoa (r=.234). Rotifer, copepod had highly significant inversely with dissolve oxygen. Crustacean larvae, Bryozoa had less significant directly related with dissolve oxygen. Such finding resembles the works of Alam *et al.,* 1987.

Oxygen enters the water primarily through direct diffusion at the air-water interface and through plant photosynthesis. Direct diffusion is relatively insignificant unless there is considerable wind and wave action.

During this study a comprehensive discussion on the physico-chemical parameters and the zooplankton abundance of carp brood fish pond has been made. The physico-chemical parameters and the zooplankton abundance showed some interrelationships. These relationships are helpful to understand the seasonal and spatial variation of zooplankton population.

During this study period there are various groups of zooplankton species have been found such as copepods, cladocerans, cyclops, daphnia, decapoda, crustacean etc. Copepods and daphnia are the most dominant zooplankton species.

From the above observation it is found that the zooplankton abundance has been varied from place to place and it showed direct or indirect relationships with the physico-chemical parameters. These finding will be helpful for the future observation and field work on zooplankton population.

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