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Research Article

STUDIES ON PRIMARY PRODUCTIVITY AND PLANKTONS DIVERSITY IN SANSOLAV POND OF BIKANER DISTRICT

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ABSTRACT

The relationship between biodiversity and ecosystem functioning is a central issue in ecology. The insurance hypothesis suggests that biodiversity could improve community productivity and reduce the temporal variability of main ecosystem processes. In the present study, we used a plankton community that was investigated from September 2012 to November 2013 in Sansolav pond of Bikaner District to test this hypothesis and explore the mechanisms involved. As a result, 17 zooplankton and 15 phytoplankton are showed apparent monthly variations. The average temporal stability index of zooplankton taxa lower significantly higher than that of phytoplankton. Complex relationships were observed between the species richness and temporal stability of different phytoplankton taxa: a unimodal relationship for both Cyanophyceae and Bacillariophyceae, Chlorophyceae and total phytoplankton. These relationships were primarily controlled by the portfolio effect; while the effects of over yielding and species asynchrony were relatively weak. Phytoplankton species richness had a significant positive influence on the temporal stability indices of protozoa, Rotifera and total zooplankton, while its influence on Cladocera and copepods was not significant. The dominant mechanisms were found to be 'trophic over yielding' these results demonstrated that the effects of diversity on community stability can be complex in natural ecosystems. In addition, the diversity of phytoplankton not only influenced its own temporal stability, but also affected the stability of zooplankton through trophic interactions.

INTRODUCTION

Earth is blessed with great biodiversity, including both flora and fauna. Life first appeared in warm shallow water, this fact is widely accepted. Water acts as a universal solvent for various biochemical reactions and also acts as a life source for green planet by supporting different ecosystems. According to Biennial Report on Fresh Water resources[17]. Water spread is 1.4 billion cubic kilometers in a wide variety of forms and conditions. Although present in such large amount, still usable water is a scare commodity. 97% of water is marine water, only 35 million cubic kilometer as fresh but maximum amount is locked up in glaciers or other forms and not easily accessible. Ponds, reservoirs are very large natural and artificial water bodies that provide habitat and food for many organisms like species of fish and wildlife[10]. They are constructed for domestic use where large natural lakes are sparse and unsuitable for human exploitation, enhancement of fisheries and improvement of water transport.

The nature and abundance of phytoplanktons, its quality and seasonal distribution are mainly determined by physical and chemical features. Their sensitivity and large variations in species composition are often a reflection of significant alteration in ambient condition within and ecosystem. The phytoplankton serves as the producers in the food chain in the aquatic ecosystem and the productivity depends upon the quality of water. The relative abundance of chlorophyll is indicative of productive water. Diatomic species such as *Nitzschia, Gyrosigma and Epithemia* are known to avoid acid water and very low concentration of calcium and magnesium[21]. Phytoplanktons are likely to play a key role in solving some environmental problems, in studying photosynthesis, in understanding aquatic ecosystems and in the production of useful substances[20].

Zooplankton feed on Phytoplankton and directly related with the growth of fish especially prawn and shrimp. Most forms of zooplankton are motile, and thus their distribution both vertically and horizontally may be quite variable. Zooplankton

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plays an role of important food item of omnivorous and carnivorous fishes[2]. The larvae of carps feed mostly on zooplankton[7], because zooplankton provide the necessary amount of protein requires for the rapid growth and development. The zooplankton depends upon the availability of phytoplanktons and forms the second tropic level in the aquatic food chain. Zooplanktons act as mediate as for the transfer of energy from lower to higher tropic levels.

The primary productivity of an ecological system, community or any part thereof, is defined at the rate at which radiant energy is stored by photosynthetic and chemosynthetic activities of the producer organisms in the form of organic substances which can be used as food materials. Primary productivity thus denotes the rate of primary production, i.e. the primary production per unit of time and area. Primary production which refers to the quantity of new organic matter produced by photosynthesis. Photosynthetic fixation of carbon in the inland aquatic system occurs in various plant communities such as phytoplankton, periphytic algae, benthic algae, and macrophytes. Production by the phytoplankton, the primary synthesis, is the most important phenomenon and reflects the nature and the degree of productivity in the aquatic ecosystem. This has received much attention in limnological studies during the past few decades and it has been measured by several workers in various aquatic ecosystem of the world. [30]Discovered the C^{14} method for regular analysis of photosynthetic rates of planktonic algae and this has been elucidated by[31]. Some modifications of this technique were done by[5]. The impact of solar radiation on the aquatic system and primary productivity has been discussed and worked out by many authors. In order to identify the causative agent for the increase or decrease in photosynthesis, works on isolated chloroplasts and the importance of pigments and algae were done by[13].

MATERIALS AND METHOD

Phytoplankton

The quality and quantity of plankton depends upon many factors including type of water body, sampling depth, time of day or night, season of year nutrient content of water other biota in water body and presence of toxic materials. For surface water sampling, known volume of water can be directly taken and filtered through bolting silk. Direct water samples were collected in 500 ml polythene bottles from both water bodies. I.e., Sansolav pond for the analysis of phytoplankton population Collected samples were immediately preserved and stained by adding 4% formaldehyde and lugol's iodine solution on the spot then brought to laboratory for investigation after one week of sedimentation of samples the supernatant was removed and known volume of from the water sample was examined under microscope using Sedgwick rafter slide. The identification and quantitative estimation of phytoplankton were made by[4, 8, 11&26] the results were expressed in units x 10^3/l.

It would be batter to store the preserved samples in well ventilated room at temperature less then 28°C the sample should kept in wide mouth glass bottle. A good quality preprinted labels, on which collector's name fixative and preservative used and other field information are written should be put on the bottle for the ready references at the time of sample analysis.

Zooplankton

Zooplankton samples were collected by filtering 50 l water through plankton net No.25, 0.3 mm mesh size. Collected samples were transferred in 100 ml polythene bottle and immediately fixed and preserved in 4% formalin solution at the spot. The preserved zooplankton samples was withdrawn and placed in Sedgwick rafter counting chamber using a pipette or dropper and observed under the microscope. Key provided by[11, 24, 26&34] were used for identification and quantitative estimation of the zooplankton. Results were expressed in No./l.

Primary productivity

Light and dark bottle method of [16]was employed for the estimation of primary productivity. Two BOD bottles were suspended in the water body in such a manner that their stopper of the mouth was just below the water surface bottles were incubated for a period of 8 hours to illustrate oxygen change for all measurement. Dissolved oxygen concentration was determined in the beginning i.e; initial DO was measured by modified Winkler's method[4], productivity is calculated on assuming that one atom of carbon is assimilated for each molecule of oxygen released.

$$CO_2 + H_2O \rightarrow (CH_2O)_X + O_2\uparrow$$

The increase in oxygen concentration in light bottle during incubation period is a measure of net production which is because of concurrence use of oxygen in respiration. It is somewhat less than the total (or gross) production. The loss of oxygen in dark bottle is used as an estimate of respiration.

Net primary productivity and gross primary productivity were estimated by

NPP (net primary productivity) = [(DO in light bottle - initial DO) x0.375] / T
GPP (gross primary productivity) = [(DO in light bottle - DO in dark bottle) x0.375]/T

Where 0.375 is a factor (i.e.; 12/32 = 0.375) used to convert oxygen to carbon. Under ideal condition. 1 mole of O_2 (32 g) is released for each mole of C (12g) fixed and T is time period of incubation. Net primary productivity and gross primary productivity values were expressed in $gC/m^2/h$.

RESULTS

In the present study primary productivity of Sansolav pond has been calculated. Total fifteen months reading recorded of primary productivity as Gross primary productivity, Net primary productivity, during September 2012 to November 2013 is depicted in Table 1

Net Primary Productivity ($gC/m^3/h$) record at water body maximum 0.3548 in month September 2013 and minimum 0.1014 at the months November 2012, March, April and June 2013. The total average of net primary productivity of the fifteen months is 0.2085 recorded. Gross primary productivity ($gC/m^3/h$) record at water body maximum 0.6081 in month October 2013 and minimum 0.2034 at the month November 2012 and April 2013.

Table 1 Primary Productivity (gC/m^3/h) at Sansolav pond of Bikaner (from September 2012 to November 2013) (pond was dry in month of May)

	Monsoon			Winter				Summer				Monsoon		winter	
Months→ / Primary Productivity↓	**SEP**	**OCT**	**NOV**	**DEC**	**JAN**	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**AVE.**
NET Primary Producrivity	0.3041	0.2338	0.1014	0.1520	0.2534	0.1520	0.1014	0.1014	-	0.1014	0.2534	0.3040	0.3548	0.3040	0.2027	0.2085
Gross Primary Productiviy	0.4561	0.5068	0.2034	0.2534	0.4054	0.2534	0.2534	0.2034	-	0.2534	0.4054	0.4561	0.5068	0.6081	0.3548	0.3657

The total average of gross primary productivity of fifteen months is 0.3657 recorded (Table 1) a checklist of zooplankton occurred in semi-intensive culture system is shown in Table 2.

Maximum amount of phytoplanktons (4850) were observed in month of August 2013. All class of algae were observed only.

Table 2 Zooplankton population (No./l) at Sansolav pond of Bikaner (from September 2012 to November 2013) (pond was dry in month of May)

	Monsoon			Winter				Summer				Monsoon		Winter	
Months / Zooplankton	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Ave.**
Protozoa																
Paramecium caudatum	60	45	30	20	30	35	40	20	-	10	20	45	40	45	50	38.33
Euglina sociobilis	20	30	-	20	10	-	-	10	-	-	-	30	20	15	-	12.08
Euglina acus	20	-	40	40	30	25	45	15	-	20	-	25	20	30	45	26.66
Amoeba proteus	40	50	45	10	-	30	35	25	-	20	10	40	60	40	25	32.08
Total protozoans	140	125	115	90	70	90	120	70	-	50	30	140	140	130	120	109.17
Rotifera																
Keratella cochlearis	30	40	25	15	35	10	40	20	-	10	20	30	35	20	30	27.5
Keratella quadrata	40	30	15	-	20	20	30	10	-	20	10	20	40	15	10	20.83
Brachionus bidentata	20	-	10	35	-	20	25	-	-	-	15	25	20	25	15	17.5
Trychocera longiseta	10	-	20	15	20	10	-	-	-	-	-	15	20	20	25	12.92
Total rotifers	100	70	70	65	75	60	95	30	-	30	45	90	115	80	80	78.75
Crustacea: Cladocera																
Daphnia carinata	80	60	50	60	30	50	60	30	-	20	20	70	45	40	50	51.25
Moina brachiata	40	-	30	20	20	-	10	10	-	10	10	30	40	-	20	18.33
Total cladocerans	120	60	80	80	50	50	70	40	-	30	30	100	85	40	70	69.58
Crustacea: Copepoda																
Mesocyclops leukarti	-	30	45	-	25	20	25	20	-	10	5	25	30	20	30	21.25
Cyclops vicinis	25	-	20	35	-	25	30	30	-	15	10	20	25	30	25	20.42
Diaptomus glicialis	70	50	40	35	30	25	20	20	-	20	10	40	50	30	20	35
Total copepods	95	80	105	70	55	70	75	70	-	45	25	85	105	80	75	76.67
Crustacea: Ostracoda																
Stenocypris malcomsoni	20	30	10	30	25	-	30	10	-	10	5	35	40	50	20	24.58
Nauplius larvae	20	40	20	-	35	30	20	-	-	-	10	15	30	40	30	24.17
Total ostracods	40	70	30	30	60	30	50	10	-	20	15	50	70	90	50	48.75
Total crustacean	255	210	215	190	165	150	195	20	-	30	70	235	260	210	195	195
Insecta																
Chironomus larvae	30	20	30	-	-	15	30	20	-	10	10	20	40	35	25	21.25
Total insect larvae	30	20	30	-	-	15	30	20	-	10	10	20	40	35	25	21.25
Total Zooplankton population	525	425	430	335	310	315	440	250	-	195	155	485	555	455	420	404.17

The maximum amount of zooplanktons was found in month of September. The class of zooplanktons includes Protozoa having 4 genera of different species and *Paramecium caudatum* was found to be maximum, Rotifera includes 4 genera of different species with *Keratella quadrata* as maximum, Crustacea having 2 general in which *Daphnia carinata* was found to be maximum. Overall 260 species of crustaceans were found. Total Zooplankton population was found to be 555 in the month of September, 2013 which was maximum. Average biomass was found to 404.17

Average biomass was found to be variations of Phytoplankton Community was been evaluated in Table 3. Total 3 classes viz Chlorophyceae having 5 genera, Bacillariophyceae having 6 genera and Cyanophyceae having 4 genera were observed.

The phytoplankton biomass showed apparent seasonal variations. Average biomass was found to be 3337.5

DISCUSSION

The density and diversity of the plankton are greatly influenced by the different physicochemical parameters of water[35]. Species composition of the plankton community is an efficient indicator of water quality. Zooplankton consist of Protozoans, Cladocera, Copepod, Rotifers, etc. which may serve as indicators of water quality. The zooplanktons play an important tropic level in the aquatic ecosystem as they constitute the most import link in the energy transfer between phytoplankton and higher aquatic fauna[18]. Whole aquatic life relies on phytoplankton population as they constitute the primary producers of most water bodies.

Table 3 Phytoplankton population (units x 10^3/l) at Sansolav pond of Bikaner (from September 2012 to November 2013)

	Monsoon			Winter			Summer				Monsoon			Winter		
Months→ / Phytoplankton↓	**Sep**	**Oct**	**Nov**	**Dec**	**Jan**	**Feb**	**Mar**	**Apr**	**May**	**Jun**	**Jul**	**Aug**	**Sep**	**Oct**	**Nov**	**Ave.**
Chlorophyceae																
Spirogyara	500	400	400	200	100	250	250	300	-	100	200	600	600	500	400	366.67
Cladophora	200	300	-	100	-	150	100	100	-	100	200	300	200	250	200	166.67
Oedogonium	400	300	300	-	200	200	200	-	-	-	100	400	500	200	300	258.33
Scenedesmus	300	200	-	100	250	200	100	100	-	100	100	400	300	250	100	191.67
Zygnema	200	300	100	200	200	100	100	-	-	150	200	200	200	300	100	183.33
Total greens	1600	1500	800	600	750	900	750	500	-	450	800	1900	1800	1500	1100	1166.67
Bacillariophyceae																
Coscinodiscus	400	300	250	-	300	300	200	200	-	100	200	400	350	300	200	266.67
Navicula	200	-	300	300	200	300	300	300	-	200	300	300	200	200	100	225
Nitzschia	300	250	400	-	200	200	-	100	-	-	200	400	300	350	300	241.67
Diatoma	200	300	200	200	-	100	-	150	-	200	300	300	250	200	200	187.5
Synedra	100	200	200	100	200	100	100	100	-	100	100	250	300	300	300	187.5
Scylonema	300	400	200	250	200	200	200	100	-	-	200	200	200	250	350	245.83
Total diatoms	1500	1450	1550	850	1100	1200	800	950	-	600	1300	1850	1600	1600	1450	1354.17
Cyanophyceae																
Spirulina	200	300	350	100	200	150	100	100	-	100	300	200	300	200	200	216.67
Nostoc	300	300	200	-	100	-	100	100	-	-	200	250	200	200	100	162.5
Microcystis	200	100	200	200	-	250	200	-	-	100	200	350	400	300	300	225
Anabaena	300	200	200	250	200	200	100	200	-	100	200	300	200	200	200	212.5
Total blue greens	1000	900	950	550	500	600	500	400	-	300	900	1100	1100	900	800	816.67
Total phytoplankton population	4100	3850	3300	2000	2350	2700	2050	1850	-	1350	3000	4850	4500	4000	3350	3337.5

Apart from forming an important food item of commercially important fishes, the phytoplankton communities have been extensively used as biological monitors from various parts of the world[6]. In ecologically zooplankton is one of the most important biotic components influencing all the functional aspects of an aquatic ecosystem such as food chains, food webs, energy flow and cycling of matter[28]. Zooplankton diversity responds rapidly to changes in the aquatic environment. Several zooplankton species are served as bio indicators[1&25].

The freshwater communities *i.e*., phytoplankton, zooplankton, macrophytes and macro invertebrates are sensitive to environmental factors. Different species of plankton vary in different seasons due to the changes in physical chemical nature of water. The phytoplankton community shows high diversity with the seasonal fluctuation, which indicates the diversity in ecological niches. The zooplankton occupying the secondary level in the food chain play a key role in the transformation of food energy synthesized by the phytoplankton to the higher trophic level. Both phytoplankton and zooplankton supports the economically important fish populations[19].

Zooplankton population was observed similar in the area between the north-east coast of Australia and Indonesia by[14]. Similar observations were noted by[9, 22]&[15] in different working areas. The study of[29] in Halda River in Bangladesh showed similar plankton composition. The bulk of the zooplankton consisted of Rotifers, Cladocerans, Copepods, Crustacean and Insect Larvae. Temperature is one of the most outstanding and biologically significant phenomena of aquatic environment; it has the relationship on zooplankton variation. Zooplankton abundance showed slightly positive relationship with Hardness in semi-intensive culture system (r = +0.402). These results have similarity with the findings of[5&23]. Zooplankton abundance showed slightly negative relationship with water salinity in semi-intensive culture (r = -0.486). These results have similarity with the findings of[15].

Phytoplankton species richness not only influenced the temporal stability of its own trophic level, but also affected the stability of zooplankton. The temporal stability of different plankton taxa responded variously to the range of species richness. These results confirmed the insurance hypothesis to some extent that biodiversity reduces the temporal variability of community biomass[32]. These results suggested that Cyanophyceae diversity affected the temporal stability mainly through the portfolio effect. Cyanophyceae was much more efficient in resource use and sensitive to the variations of environmental factors (e.g., temperature and pH value) than other taxa[27]. Thus, the negative relationship between Cyanophyceae biomass and diversity in Lake Nansihu was consistent with its properties[32]. The biodiversity effects observed in the present study were consistent with the findings of most previous studies[33]. However, obtained a negative relationship between phytoplankton evenness and stability (community turnover)[12]. The phytoplankton community was dominated by a few Cyanophyta genera and lost the ability to respond to environmental changes, i.e., low community turnover. Therefore, Cyanophyta generally exhibits low stability in eutrophic lakes, but when its dominance exceeds a threshold point, the stability will be enhanced.

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