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MONTHLY VARIATION OF ZOOPLANKTON DENSITY AND DIVERSITY IN THE THREE EPHEMERAL STREAMS OF LAKHIMPUR DISTRICT OF ASSAM, INDIA

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ABSTRACT

This study is based on assessment of ecological health of the three forested ephemeral streams situated on the Lakhimpur district of Assam using zooplankton as biomonitoring agent and also physicochemical parameters. A total of 10 zooplankton species belonging to four groups, cladocera, ostracoda, rotifera and copepoda have been recorded from the three streams with monthly fluctuation in the percentage composition of (30-36%:, cladocera), (17-21%, ostracoda), (25-28%, rotifera),(22-23%,copepoda). Post monsoon showed comparatively more numbers of zooplankton than monsoon. Less stable condition of the three streams was clearly understood through the present assessment. Correlation analysis was also performed among physicochemical parameters and zooplankton density.

Keywords: ***Density, Diversity Indices, Ephemeral, Monsoon,Post Monsoon, Zooplankton***

I. INTRODUCTION

Zooplanktons are 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 [1].They play an important role in energy transformation from producer to consumer. Zooplanktons play an integral role and may serve as bio indicator and it is a well-suited tool for understanding water pollution status [2]. Due to their short life span, the zooplankton community often exhibits quick and dramatic changes in response to the changes in the physico-chemical properties of the aquatic environment [3]. They do not only form an integral part of the lentic community but also contribute significantly, the biological productivity of the fresh water ecosystem [4].The zooplankton community is influenced by the physico chemical parameters of the water also bring about seasonal changes in their life process and population dynamics [5]. The main objective of the present study was` to study the ecological health of the three forested ephemeral streams through zooplankton as biomonitoring agent and analysis of physicochemical parameters.

II. MATERIALS AND METHODS

2.1 Study Area

The three different ephemeral streams viz. Baghjan, Singijan and Ghagorjan originate from the foothills of Arunachal Pradesh and located about 20-25 kilometres away from North Lakhimpur of Assam traversed through

Dulung reserve forest in the Assam Arunachal border region. Baghjan lies within 27 $^{0}26'522''$N and $94^{0}12'599''$E, while Singijan is located within $27^{0}26'701''$N and $94^{0}12'869''$E and Ghagorjan lies between $27^{0}26'608''$N and $94^{0}12'691''$E. Since the streams are ephemeral, so they completely dependent on monsoon rain. Monsoon starts from June and from the end part of November the streams starts dry up. Therefore the analysis of physicochemical parameters and biological assemblages were done only for two seasons viz. monsoon and postmonsoon.

2.2 Study Period

All the selected parameters were studied for consecutive three years (June 2011-May 2014) on monthly (June, July, August, September, October and November) basis.

2.3 Zooplankton

Collection of zooplankton and qualitative study of species conducted in accordance with the standard methods of [6,7,8]. For quantitative study of plankton species Sedgewick-Rafter counting chamber was used. Population densities were calculated in units per litre (Ul^{-1}).

2.4 Planktonic Quantification

Plankton abundance and density was calculated in counts/ml of the original sample using the equation: [9, 10]

$D = [T(1000)\times Vc] / (AN\times Vs)$

Where, D= Density of plankton (ind/ml)

T= Total number of plankters counted

A= Area of grid in mm^2

N= Number of grids employed

1000= Area of counting chamber (mm^2)

Vc and Vs= Volumes of concentrate and sample respectively

2.5 Biological Indices

Four diversity indices, Shannon diversity index [11] Simpson diversity index [12] Margalef diversity index [13] and McIntosh diversity index [14] and two evenness indices Pielou evenness index [15] and McIntosh evenness index[14] were used in this study.

2.6 Measurement of Water Quality (Physical and Chemical Variables)

The location of the three study sites were measured by GPS (GarminGPSMAP76), water temperature was measured by using a Mercury thermometer graduated up to 110°C, pH was measured by portable pH meter (Cyber scan pH 300 series), conductivity was measured by Digital conductivity meter (CD600, Milwaukee), current velocity was measured by Digital flow meter (Swoffer 3000 Flow Meter, GeoScientific Ltd.). Dissolved

Oxygen was measured by following the Winkler's modified method [16], free carbondioxide, total acidity, total alkalinity and chloride were measured titrimetrically following the method of [17] and [16].

III. RESULT

A total 10 numbers of zooplankton species, viz. *Daphnia sp., Bosmina sp., Diaphanosoma sp., Cypris sp., Cyclops sp., Diaptomus sp., Brachionus sp., Keratella sp., Polyarthra sp., Lecane sp.*, belonging to 9 families Daphnidae, Bosminidae, Sididae, Cyprididae, Cyclopidae, Diaptomidae, Brachionidae, Synchaetidae, Lecanidae of 5 orders- Cladocera, Podocopida, Cyclopoida, Calanoida, Ploima of 4 classes- Branchiopoda, Ostracoda, Maxillopoda, Monogonta of 2 phyla Arthopoda and Rotifera have been recorded from the three ephemeral streams during the study period.

Table 1: Percent composition of zooplankton in three ephemeral streams

Group	Streams		
	Baghjan	Singijan	Ghagorjan
Cladocera	31	36	30
Ostracoda	18	17	21
Copepoda	23	22	23
Rotifera	28	25	26

Cladocera was recorded to be the dominant zooplankton group in all the three streams (Baghjan, 31%; Singijan, 36%; Ghagorjan, 30%) and ostracoda was recorded as least available group (Baghjan, 18 %; Singijan, 17%; Ghagorjan, 21%).

3.1 Zooplankton Density

Total density of zooplankton was recorded highest at Ghagorjan in October (11.24±3.28 no./l) and lowest at Baghjan in August (5.67±2.39 no./l). Highest density of cladocera was recorded at Ghagorjan in October (3.34±0.97 no./l) and lowest at Baghjan in July (2.12±1.67 no./l). Ostracoda showed highest density at Singijan in September (3.26±1.03 no./l) and lowest at Singijan in June (1.11±0.87 no./l). Copepoda showed highest density at Ghagorjan in September (3.08±1.23 no./l) and lowest at Singijan in June (1.09±0.08 no./l). Highest density of Rotifera was recorded at Ghagorjan in July (4.07±1.43 no./l) and lowest density at Singijan in September (1.09±0.76 no./l).

Table 2: Monthly mean variation of zooplankton density (no./l)

Group	Streams	Months					
		Jun	Jul	Aug	Sep	Oct	Nov
Cladocera	Baghjan	3.21± 1.12	2.12± 1.67	---	3.11± 1.08	2.42 ±1.21	2.19± 1.23
	Singijan	3.23 ±1.34	2.15± 1.34	2.19 ±1.22	3.06± 1.07	2.33 ±0.96	3.21± 1.23
	Ghagorjan	3.19 ±1.34	3.27 ±1.06	---	3.06± 1.05	3.34 ±0.97	2.23 ±0.99

Ostracoda	Baghjan	2.06 ±1.07	---	1.13 ±0.93	2.34± 1.06	2.21 ±1.13	2.41 ±1.04
	Singijan	1.11 ±0.76	---	2.21 ±0.57	3.26± 1.03	2.39 ±1.07	2.75±1.24
	Ghagorjan	---	1.65± 1.04	3.13 ±0.78	2.54± 0.88	1.43 ±1.12	3.01± 1.34
Copepoda	Baghjan	---	2.58 ±0.23	---	1.51± 0.12	2.06 ±0.11	2.45 ±1.03
	Singijan	1.09 ±0.08	2.43 ±0.65	---	1.15± 0.75	1.49± 0.59	1.37± 0.47
	Ghagorjan	2.24 ±1.12	2.54± 0.79	---	3.08 ±1.23	2.22 ±1.22	2.59± 1.04
Rotifera	Baghjan	2.87± 1.12	2.71 ±1.07	3.13± 1.2	---	1.19± 0.68	3.32 ±1.07
	Singijan	1.43 ±0.23	3.65 ±0.78	---	1.09 ±0.76	1.32± 0.87	2.03± 0.89
	Ghagorjan	1.12± 0.69	4.07 ±1.43	2.76± 1.23	1.95 ±0.37	2.01 ±0.46	3.54 ±1.21
Total	Baghjan	7.86 ±2.56	6.38± 2.54	5.67± 2.39	7.39 ±2.33	9.78 ±3.44	10.49± 3.48
	Singijan	6.39 ±1.87	6.75 ±2.45	6.78 ±2.93	8.49 ±3.12	9.92± 3.79	7.89 ±2.38
	Ghagorjan	7.37 ±3.12	8.39 ±3.14	7.39± 1.45	9.39 ±3.42	11.24± 3.28	10.78± 3.27

3.2 Zooplankton Diversity and Evenness Indices

Shannon diversity index (Ĥ) was recorded highest in October at Singijan (1.91) and lowest at Baghjan in July (1.46). Pielou evenness index (J) was recorded highest in October at Baghjan (0.98) and lowest in July at Baghjan (0.85). Simpson's index of diversity (1-D) was recorded highest in October at Ghagorjan (0.96) and lowest in July at Baghjan (0.87). Margalef diversity index (Ma) was recorded highest in October at Singijan (2.88) and lowest in June at Baghjan (2.06). McIntosh diversity index (Mc) was recorded highest in October

Table 3: Monthly mean variation of zooplankton diversity and evenness indices

Indices	Streams	Months					
		Jun	Jul	Aug	Sep	Oct	Nov
Ĥ	Baghjan	1.69	1.46	1.56	1.48	1.90	1.88
	Singijan	1.65	1.68	1.61	1.49	1.91	1.79
	Ghagorjan	1.69	1.64	1.67	1.72	1.83	1.82
J	Baghjan	0.90	0.85	0.88	0.96	0.98	0.89
	Singijan	0.92	0.89	0.90	0.91	0.97	0.94
	Ghagorjan	0.96	0.97	0.93	0.94	0.94	0.95
1-D	Baghjan	0.95	0.87	0.88	0.89	0.94	0.91
	Singijan	0.93	0.92	0.89	0.88	0.91	0.94
	Ghagorjan	0.95	0.91	0.93	0.90	0.96	0.88
Ma	Baghjan	2.06	2.18	2.19	2.09	2.78	2.71

	Singijan	2.23	2.11	2.16	2.16	2.88	2.65
	Ghagorjan	2.56	2.43	2.34	2.11	2.61	2.81
Mc	Baghjan	0.85	0.94	0.88	0.91	0.93	0.84
	Singijan	0.89	0.91	0.85	0.95	0.99	0.87
	Ghagorjan	0.90	0.93	0.81	0.92	0.89	0.88
McE	Baghjan	0.89	0.90	0.86	0.94	0.91	0.95
	Singijan	0.96	0.93	0.89	0.95	0.85	0.91
	Ghagorjan	0.83	0.87	0.82	0.93	0.80	0.94

Key: $\hat{H}$ = Shannon diversity index**, J=** Pielou evenness index**, D=** Simpson's diversity index**, Ma=**Margalef diversity index, **Mc=** McIntosh diversity index**, McE=** McIntosh evenness index

at Singijan (0.99) and lowest in August at Ghagorjan (0.81). McIntosh evenness index (McE) was recorded highest in June at Singijan (0.96) and lowest in October at Ghagorjan (0.8).

Table 4: Monthly variation of physicochemical parameters of the three streams

Parameter	Streams	months					
		Jun	Jul	Aug	Sep	Oct	Nov
Temp(^{0}C)	Baghjan	26.08±0.08	26.79±0.21	26.37±0.20	25.72±0.55	25.88±0.38	25.63±0.52
	Singijan	24.91±0.13	25.89±0.32	26.01±0.24	25.26±0.16	24.72±0.33	25.43±0.11
	Ghagorjan	25.62±0.12	25.48±0.26	25.31±0.21	25.04±0.53	25.08±0.33	25.13±0.22
pH	Baghjan	5.88±0.03	5.80±0.10	5.71±0.01	6.22±0.04	6.36±0.10	6.46±0.02
	Singijan	6.01±0.06	5.91±0.16	5.77±0.04	6.02±0.04	6.14±0.12	6.13±0.04
	Ghagorjan	5.46±0.05	5.57±0.05	5.51±0.04	6.07±0.03	6.07±0.07	6.11±0.03
Current velocity(m/sec)	Baghjan	0.39±0.02	0.54±0.07	0.63±0.02	0.37±0.02	0.48±0.08	0.57±0.05
	Singijan	0.63±0.03	0.82±0.07	0.84±0.11	0.58±0.01	0.59±0.02	0.31±0.15
	Ghagorjan	0.46±0.03	0.55±0.02	0.56±0.05	0.46±0.03	0.48±0.04	0.44±0.03
Conductivity(µS/cm)	Baghjan	618.19±1.04	618.19±1.33	620.68±2.63	593.21±4.72	597.06±4.39	586.99±2.55
	Singijan	584.51±6.06	577.92±7.22	588.86±1.73	568.72±1.77	574.69±7.13	576.81±19.77

	Ghagorjan	579.66±2.21	580.91±1.77	570.46±3.56	559.03±1.14	565.12±2.48	569.72±4.11
D.O.(mg/l)	Baghjan	3.07±0.16	3.01±0.26	3.16±0.31	5.28±0.24	4.83±0.53	4.36±0.09
	Singijan	4.18±0.12	3.79±0.14	4.01±0.11	4.71±0.18	4.53±0.5	4.61±0.16
	Ghagorjan	3.34±0.28	3.86±0.38	4.16±0.22	3.36±0.24	4.61±0.22	3.54±0.26
FCO_2.(mg/l)	Baghjan	13.64±0.61	16.15±2.61	18.79±1.11	13.14±0.52	13.94±0.67	14.51±0.39
	Singijan	18.08±1.14	18.66±0.49	17.44±1.06	13.66±0.34	14.34±1.28	17.26±1.31
	Ghagorjan	21.23±0.86	19.52±0.72	19.71±1.22	18.61±0.56	18.62±0.59	20.72±0.74
Total Acidity(mg/l)	Baghjan	19.54±0.59	20.96±0.79	19.32±0.18	18.21±0.31	19.43±1.49	20.09±1.13
	Singijan	19.31±0.76	19.93±1.43	21.16±0.88	15.81±0.31	17.12±1.17	18.55±0.31
	Ghagorjan	28.52±1.11	23.84±2.86	22.23±0.86	20.21±1.64	21.11±1.73	20.86±1.43
Total Alkalinity(mg/l)	Baghjan	21.16±0.88	67.17±1.07	68.57±2.31	73.29±0.96	77.31±3.99	82.78±3.01
	Singijan	15.81±0.31	54.52±2.06	55.97±1.08	68.67±1.11	71.87±2.05	71.42±1.15
	Ghagorjan	17.12±1.17	60.07±3.01	61.64±1.37	72.46±1.61	73.89±1.41	70.64±1.37
Chloride(mg/l)	Baghjan	18.55±0.31	19.44±0.77	19.52±0.61	23.41±0.33	22.56±1.19	21.62±0.69
	Singijan	21.26±0.37	20.67±0.72	19.87±1.15	20.93±3.12	22.78±1.01	21.48±0.78
	Ghagorjan	15.84±0.65	15.77±0.39	14.15±0.64	20.15±0.64	19.10±0.52	19.97±0.36
Stream depth(m)	Baghjan	0.38±0.05	0.37±0.04	0.39±0.03	0.29±0.01	0.29±0.01	0.26±0.01
	Singijan	0.41±0.01	0.45±0.05	0.40±0.06	0.36±0.04	0.37±0.01	0.28±0.05
	Ghagorjan	0.35±0.02	0.35±0.07	0.36±0.01	0.34±0.01	0.33±0.01	0.32±0.02
Stream width(m)	Baghjan	10.54±0.41	9.81±1.16	8.16±0.77	7.31±0.32	7.55±0.41	7.86±0.36
	Singijan	5.23±0.11	5.46±0.25	5.77±0.26	4.18±0.19	4.14±0.12	3.04±0.48
	Ghagorjan	3.51±0.16	4.04±0.22	3.80±0.14	2.26±0.08	2.46±0.15	2.21±0.11

IV. DISCUSSION

In all the three streams the most dominant zooplankton group recorded was cladocera and ostracoda was recorded as least available group. Relatively high density of zooplankton was recorded during post monsoon as compared to monsoon in all the three streams which may be attributed to comparatively higher concentration of dissolved oxygen, optimal thermal and nutritional condition of water. DO is one of the important factors vital to the survival

of aquatic biota. Zooplankton density showed positive correlation with dissolved oxygen ($p<0.01$). Similar conclusion has been drawn by [18]. After monsoon deposition of dead and decomposed materials in the stream bed provides important habitat for growth and development of planktons. Current velocity was found negatively correlated with zooplankton density ($p<0.01$). The unsettled and disturbed water column was resulting from the rain water and heavy out flow and inflow retard the zooplankton population [19].The slow-moving or stagnant aquatic habitats within riverine systems can provide zooplankton with a stable food source, as well as conditions that favor reproduction [20] and population growth. Predator pressure from juvenile fish during monsoon season is another important factor contributing to the decline in zooplankton density in the studied three ephemeral streams. There observed positive correlation with total alkalinity ($p<0.01$). This suggests that high total alkalinity is related to high yield of zooplankton [21]. Positive correlation was also observed with chloride ($p<0.05$), pH ($p<0.01$). Negative correlation was also observed with FCO_2 ($p<0.05$), total acidity ($p>0.05$), water temperature ($p<0.05$), conductivity ($p<0.01$), stream depth ($p<0.01$) and stream width ($p<0.05$).

Cladocera was recorded to be the most abundant group of all zooplankton, which may be attributed to high nutrient enrichment. The density of cladocerans were recorded to be more in postmonsoon as compared to monsoon,which may be attributed to low temperature, adequate food supply and optimum environmental factors. It has been reported that the density and biomass of cladocerans was primarily determined by food supply [22].

Lesser abundance of copepods during monsoon season at all the three streams may be due to high predator pressure from fish fauna. Copepods are the main prey items of larval and juvenile fishes that link pelagic food webs [23].The important factors which controlled the distribution of copepods were rainfall, river discharge and decreased phytoplankton abundance due to increased turbidity [24].

Rotifers and small copepods are known to be more tolerant of adverse environmental conditions than the cladocerans [25]. Rotifera was found to be abundant in monsoon as compared to postmonsoon which may be due to influx of water from other water bodies. Comparatively higher density of rotifers during rainy season may be ascribed to low density of cladocerans for which there is less competitive influence from cladocerans. Under optimum environmental conditions, cladocerans tend to out-compete the rotifers [26].

Composition and diversity of zooplankton provide information on the characteristics and quality of the water body [27].Shannon diversity index encompasses species richness. The higher value of Shannon Index ($\hat{H}$) indicated greater diversity of species, meaning larger food chain and more cases of inter-specific interactions and greater possibilities for negative feedback control which reduced oscillations and hence increases the stability of the community [28]. In the present study, Shannon diversity index ranges 1.46-1.91. This indicates that the three ephemeral streams are moderately polluted [29]. The value of Simpson's index of diversity ranges 0.87-0.96, which indicates nearly satisfactory diversity status. The value of Margalef index ranges 2.06-2.88 and clearly indicates moderate condition of the studied streams [30].The value of McIntosh diversity index ranges 0.81-0.99 which fairly reveals that the zooplankton species are nearly homogenously distributed as the observed values are closer to 1 [14]. In the present study, the value of Pielou's evenness index ranges 0.85-0.98. From the values of Pielou's index it is clear that individuals are evenly distributed [15]. McIntosh evenness index ranges 0.8-0.96, which fairly indicate that the individuals are equally distributed [31].

V. CONCLUSION

Post monsoon showed comparatively higher density of zooplankton than monsoon which can be attributed to the higher concentration of dissolved oxygen, lesser influence from predators present in the same habitat and also stable habitat which may supply proper refugia for increasing population of the zooplanktons. Cladocera was recorded as most abundant group in all the three ephemeral streams and ostracoda was considered as least available group out of the recorded four groups. The present study clearly indicate less stable and moderately polluted condition of the studied three streams which urgently needs proper steps for their conservation.

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