Online: ISSN 2771-5868
Print: ISSN 2771-585X

## Original Research Article

# Physico-chemical Factors Regulating Cladoceran Community Dynamics in the Floodplain Wetlands of Subansiri River Basin, N.E. India

Budhin Gogoi[1,3*], Santoshkumar Abujam[2] and Debangshu Narayan Das[3]

[1,3]Department of Zoology, Moran College, Moranhat-785670, Assam, India.

[2]Department of Zoology, Pravabati College, Mayang Imphal - 795132, Manipur, India.

[3]Department of Zoology, Rajiv Gandhi University, Rono Hills, Doimukh-791112, Arunachal Pradesh, India.

*Corresponding author: budhinrgu2012@gmail.com

https://doi.org/10.5281/zenodo.11190377

Received: March 29, 2024; revised: May 10, 2024; accepted: May 25, 2024

Available Online: 15 June, 2024

**Abstract:** The present study evaluated population dynamics of cladoceran in relation to water quality parameters in the flood plains of Subansiri River basin. The correlation coefficient (r) between cladoceran abundance and water quality parameters such as dissolved oxygen (DO), biological oxygen demand (BOD), free carbon dioxide ($FCO_2$), total alkalinity (TA), total hardness (TH), calcium hardness (CaH), chlorides, nitrate-nitrogen ($NO_3$-N), phosphate phosphorus ($PO_4$-P), pH, air temperature (AT), water temperature (WT), salinity, specific conductivity (SC) and total dissolved solids (TDS) in three categories of flood plains: deep water rice field (DWR), flood plain lakes (FPL) and oxbow lake (OBL) demonstrate location specific variability in the regulation of cladoceran abundance. A positive correlation with TA (r=0.118, 0.153, 0.123); $NO_3$-N (r=0.019, 0.355, 0.383); AT (r=0.381, 0.094, 0.267); WT (r=0.519, 0.033, 0.287) and negative correlation with TDS (r=-0.752, -0.230, -0.045) in DWR, FPL and OBL respectively indicated more influence of chemical factors on community dynamics of cladoceran rather physical factors. All other parameters like DO, BOD, TH, CaH, pH Chloride, $PO_4$-P also influences cladoceran abundance. Study revealed that seasonality of water quality parameters influence dynamics of floodplain biotic community.

**Keywords:** Cladocera, Community dynamic, Correlation, Density, Flood plain wetland, Water quality.

## Introduction

Flood plain wetlands are heterogeneous ecosystems in floodplains of river system which tend to integrate upstream and catchment in all geographic regions (Tockner *et al.*, 2000; Junk and Wantzen, 2006). A large numbers of diversified floodplain wetlands are existed at the corridor of river Barak, Brahmaputra and their tributaries in Assam (Sugunan, 1997). River Subansiri is one of the major tributary of Brahmaputra basin with a large numbers of floodplain wetlands viz. flood plain lakes, oxbow lakes and deep water rice fields. These wetlands harbour rich biological diversity besides supporting significant fishery and agriculture in the downstream area of river Subansiri (Gogoi, 2017). The ecology of these floodplain wetland are regulated by four major factors: dry season, a high and sudden increase of river flow, increase in particulate material and clear water conditions (Gabellone *et al.,* 2001). The temporal variability of flood plain community dynamics is linked to the magnitude of ecological process (Ward *et al.,* 2002).

Cladoceran are zooplankton which serves as an intermediate in energy transfer and play essential role in recycling of nutrients in aquatic ecosystems (Urabe *et al.,* 2002; Hessen *et al.,* 2003). They are filter feeders that feed on nanoplanktons, detritus, bacteria and phytoplankton (Balayla and Moss, 2004; Gogoi *et al.,* 2016) finally available as natural diet for the fishes (Qin and Fast, 1997; Suresh Kumar, 2000). They can respond to variety of ecological factor thus have long been recognized as useful ecological and paleolimnological indicators (Drenner *et al.,* 2009; Rumes *et al.,* 2011). They are often used as alternative to reconstruct past environmental conditions of any aquatic ecosystems as their shells preserve well in sediments (Kamenik *et al.,* 2007; Smol, 2008).

Floodplain wetlands experiences large fluctuation in volume of water which greatly influences dynamics of plankton or production of plankton within the habitat. Cladoceran community dynamic is particularly distinctive as population maxima developed rapidly as the wetlands are filled with water (Twombly and Lewis, 1989). The parthenogenetic reproduction favours cladoceran to colonise rapidly in favourable environment (Brendonck and De Meester, 2003). The water quality, nutrients, algal source, macrophytes, invertebrates and fish influences community dynamics of cladoceran (Peretyatko *et al.,* 2009; Boven and Brendonck, 2009). Cladocerans are

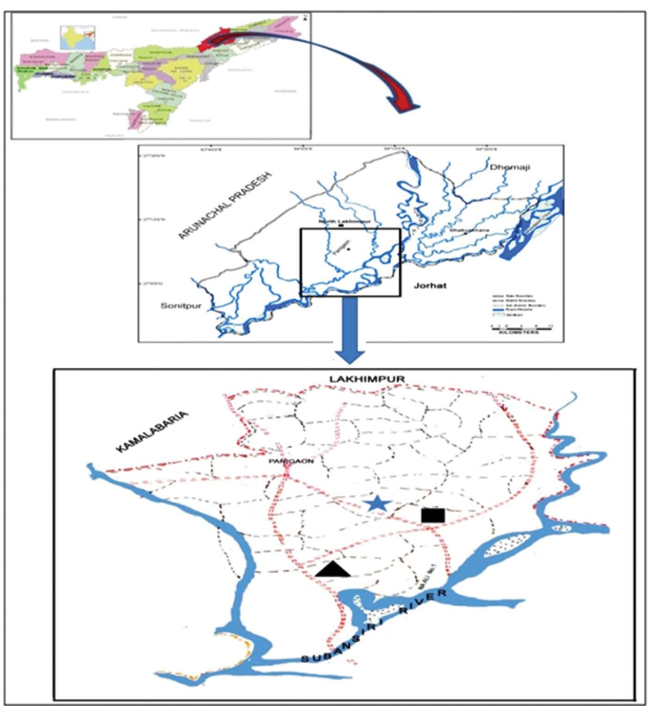


**Fig. 1.** Map showing the study areas in Subansiri flood plain (★ Hatimora DWR, ■ Morikhaboli floodplain lake and ▲ Halmora oxbow lake).

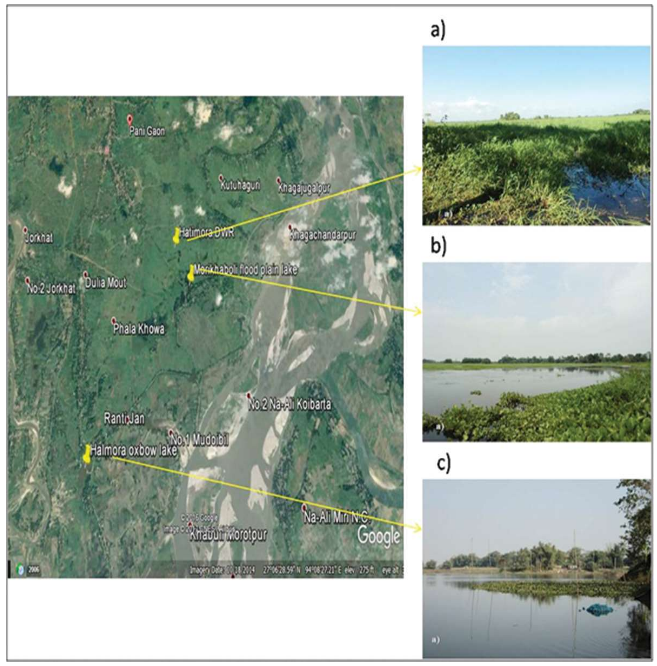


**Fig. 2.** Study area- a) Morikhaboli deep water rice field b) Morikhaboli floodplain lake and c) Halmora oxbow lake.

highly sensitive to water quality and could serve as model species in environmental toxicology (Siciliano *et al.,* 2015). However, no any scientific endevour had ever made to understand the role of water quality parameters on population dynamics of cladoceran in the floodplain habitats of N.E India. Therefore, the present study was designed to evaluate influences of varying physico-chemical factors in regulating cladoceran community.

## Materials and methods

### Study area

The present investigations were conducted in Hatimora DWR (deep water rice field), Morikhaboli beel (floodplain lake) and Halmora dubi (oxbow lake) located in between $27^{0}.02$ and $27^{0}.15$ northern latitude and $93^{0}.99$ and $94^{0}.15$ east longitude in the floodplain of Subansiri river of Lakhimpur district, Assam (Fig. 1 and 2).

### Sampling and analysis

Sampling of plankton and water were accomplished in three different categories of floodplain wetlands at monthly interval from 12 selected sampling sites at morning hour (6.00

am to 10 am) for a period of two years from May, 2013 to April, 2015. A total of 144 numbers of plankton samples were collected from four selected sites of each study area through filtration of 100 litres of subsurface water with the aid of plankton net (mesh size 60 µm). The filtrate collected in vial attached at the bottom core of plankton net were transferred to labeled plankton vial and immediately preserved in 5% formalin. In DWR field, sampling period was restricted for six months in a year. Dissolved oxygen, biological oxygen demand, free carbon dioxide, total alkalinity, total hardness, calcium hardness, chloride, nitrate-nitrogen and phosphate phosphorus were determined using standard laboratory methods (APHA, 2005; Dutta, 2011; Saikia and Das, 2014). A celsius thermometer (scale ranging from 0-100°C) was used to measure surface water temperature of water. Water analyser (Model: 371, Systronics) was used to measure pH, salinity, specific conductivity, total dissolved solids of water.

### Statistical analysis

The quantitative studies were carried out following Lackey's (1938) drop count method and the values were expressed in terms of individual$L^{-1}$. All the statistical analysis was performed by using Microsoft Excel statistical program (MS-Excel), PAST (Version 3.07) and SPSS. The coefficient of correlation (r) was calculated following Pearson's correlation analysis.

## Results

### Cladoceran Community dynamics

Cldoceran diversity was represented by the occurrence of both common and rare species (Fig. 3). The community dynamics exhibited ecosystem variability however attaining maximum peak in summer season in the entire study area. Population density was maximum during July followed by August whereas it was minimum during June exhibited a higher peak followed by two lower population peaks in DWR. It was maximum during April whereas it was minimum during December in floodplain lake. Highest density was recorded in July whereas it was lowest during December in oxbow lake

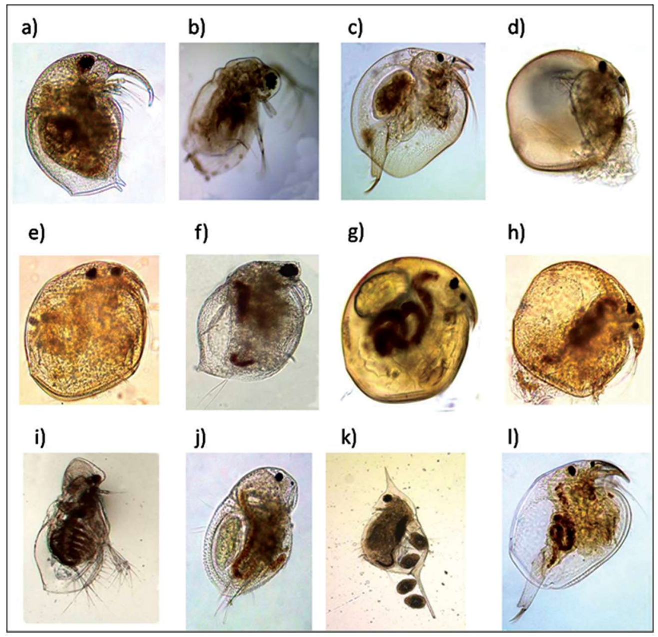


**Fig. 3**. Some of the common and rare species of cladoceran documented in Subansiri floodplain wetland a) *Bosmina longirostris* b) *Moina micrura* c) *Celsinotum macronyx* d) *Chydorus eurynatus* e) *Chydorus ovalis* f) *Ceriodaphnia reticulata* g) *Chydorus parvus* h) *Chydorus sphaericus* j) *Diaphanosoma dubium* k) *Macrothrix spinosa* k) *Daphnia lumholtzi* and l) *Kurzia longirostris.*

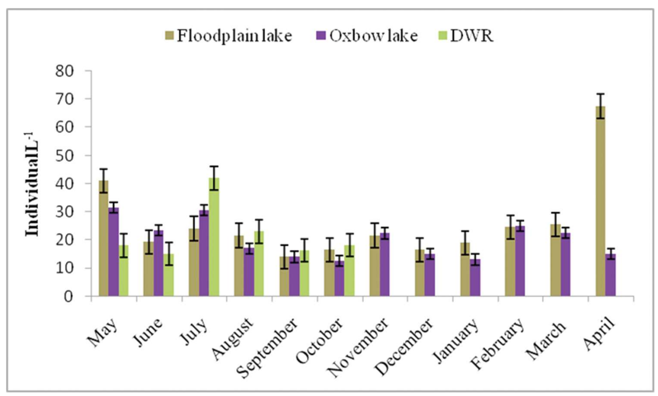


**Fig. 4.** Density of cladocera (indL-1) in different months in Hatimora DWR, Morikhaboli floodplain lake and Halmora oxbow lake during 2013-2015.

(Fig. 4). Month has significant effect on population density and pattern ($p<0.05$; ANOVA).

### Physico-chemical characteristic of water

The maximum and minimum ranges of water quality recorded in the study are presented in Table- 1. The DO ranges between

**Table 1.** Physico-chemical parameters of water in the wetlands of Subansiri floodplain.

| SL. No. | Parameters | Hatimora DWR | Morikhaboli floodplain lake | Halmora oxbow lake |
|---|---|---|---|---|
| 1 | DO ($mgL^{-1}$) | 3.50-7.20 | 4.00-8.10 | 3.75-9.20 |
| 2 | BOD ($mgL^{-1}$) | 1.00-2.18 | 1.00-2.52 | 1.00-3.20 |
| 3 | FCO2($mgL^{-1}$) | 6.00-14.1 | 4.00-12.10 | 2.20-12.10 |
| 4 | TA ($mgL^{-1}$) | 21.06-113.50 | 21.90-98.0 | 19.0-93.0 |
| 5 | TH ($mgL^{-1}$) | 20.80-86.00 | 31.40-87.20 | 32.4-65.00 |
| 6 | CaH ($mgL^{-1}$) | 8.00-25.00 | 8.00-25.26 | 8.00-18.97 |
| 7 | Chloride ($mgL^{-1}$) | 7.00-18.85 | 8.00-31.00 | 6.20-24.81 |
| 8 | NO3-N ($mgL^{-1}$) | 0.22-1.37 | 0.21-2.36 | 0.23-1.62 |
| 9 | PO4- P ($mgL^{-1}$) | 0.39-1.36 | 0.03-1.11 | 0.10-1.33 |
| 10 | pH | 6.00-7.80 | 6.00-9.10 | 6.00-9.00 |
| 11 | AT (°C) | 25.00-32.00 | 18.00-32.00 | 18.0-32.00 |
| 12 | WT(°C) | 26.00-29.00 | 20.00-31.00 | 18.0-29.00 |
| 13 | Salinity (ppt) | 0.06-2.05 | 0.08-2.16 | 0.08-2.03 |
| 14 | SC (mS) | 0.18-1.24 | 0.06-1.47 | 0.08-1.29 |
| 15 | TDS (ppt) | 0.04-0.97 | 0.04-0.83 | 0.04-0.76 |

DO: Dissolved oxygen, BOD: Biological oxygen demand, TA: Total alkalinity, TH: Total hardness, CaH: Calcium hardness, NO3-N : Nitrate-nitrogen, PO4- P : Phosphate phosphorus, AT: Air temperature, WT; Water temperature, SC: Specific conductivity, TDS: Total dissolved solids.

3.00 and 9.20, being highest in oxbow lake and lowest in DWR. BOD ranges between 1.00 and 3.20, being highest in oxbow lake and lowest in all study area. $FCO_2$ ranges between 2.20 and 14.1, being highest in DWR and lowest in oxbow lake. TA ranges between 19.00 and 113.50, being highest in DWR and lowest in oxbow lake. TH ranges between 20.80 and 87.20, being highest in floodplain lake and lowest in DWR. CaH ranges between 8.0 and 25.26, being highest in floodplain lake and lowest in all study area. Chloride ranges between 6.20 and 31.00 being highest in floodplain lake and lowest in oxbow lake. $NO_3$-N ranges between 0.21 and 2.36, being highest and lowest in floodplain lake. $PO_4$-P range between 0.03 and 1.36, being highest in DWR and lowest in floodplain lake. pH ranges between 6.00 and 9.10, being highest in floodplain lake and lowest in all study area. AT ranges between 18.00 and 32.00, being lowest in both floodplain lake and oxbow lake and highest in all study area. WT ranges between 8.00 and 31.00, being highest in floodplain lake and lowest in oxbow lake. Salinity ranges between 0.06 and 2.03, being highest in DWR and lowest in oxbow lake. SC ranges between 0.08 and 1.47, being highest in oxbow lake and lowest in floodplain lake. TDS ranges between 0.04 and 0.83, being highest and lowest in floodplain lake.

**Table 2.** Coefficient of Correlation (r) between cladoceran density and physico-chemical parameters in the wetlands of Subansiri flood plain wetlands during the study period.

| SL. No. | Parameters | Hatimora DWR | Morikhaboli floodplain lake | Halmora oxbow lake |
|---|---|---|---|---|
| 1 | DO ($mgL^{-1}$) | -0.297 | 0.092 | -0.170 |
| 2 | BOD ($mgL^{-1}$) | 0.341 | 0.284 | -0.126 |
| 3 | FCO2 ($mgL^{-1}$) | 0.177 | -0.546 | -0.590 |
| 4 | TA ($mgL^{-1}$) | 0.118 | 0.153 | 0.123 |
| 5 | TH ($mgL^{-1}$) | 0.008 | 0.109 | -0.388 |
| 6 | CaH ($mgL^{-1}$) | -0.320 | 0.267 | -0.454 |
| 7 | Chloride ($mgL^{-1}$) | -0.153 | 0.313 | -0.177 |
| 8 | NO3-N ($mgL^{-1}$) | 0.019 | 0.355 | 0.383 |
| 9 | PO4-P ($mgL^{-1}$) | -0.022 | 0.004 | 0.210 |
| 10 | pH | -0.209 | 0.511 | 0.075 |
| 11 | AT(°C) | 0.381 | 0.094 | 0.267 |
| 12 | WT(°C) | 0.519 | 0.033 | 0.287 |
| 13 | Salinity (ppt) | 0.275 | -0.693 | 0.159 |
| 14 | SC (mS) | 0.223 | -0.550 | -0.083 |
| 15 | TDS (ppt) | -0.752 | -0.230 | -0.045 |

**Correlation of cladoceran density with water quality**

The correlation coefficient (r) value between cladoceran density and water quality parameters are presented in Table- 2. The estimated correlation coefficient (r) values indicated ecosystem variability of water quality parameters in regulating cladoceran community. DO exhibit inverse correlation in both DWR (r=-0.297) and oxbow lake (r=-0.170) and positive correlation in floodplain lake (r=0.092) (Fig. 5). BOD shows positive correlation in both DWR (r=0.341) and floodplain lake (r=0.284) and negative correlation in oxbow lake (r=-0.126). $FCO_2$ shows positive relation in DWR (r=0.177) and inverse relation in both floodplain lake (r=-0.546) and oxbow lake (r=-0.590). TA exhibit positive correlation in entire studied ecosystem (DWR, r=0.118; FPL, r=0.153; and OBL, r=0.123) (Fig. 6). TH shows positive relationship in both DWR (r=0.008) and floodplain lake (r=0.109) and negative relation in oxbow lake (r=-0.388). CaH shows negative relation in both DWR (r=-

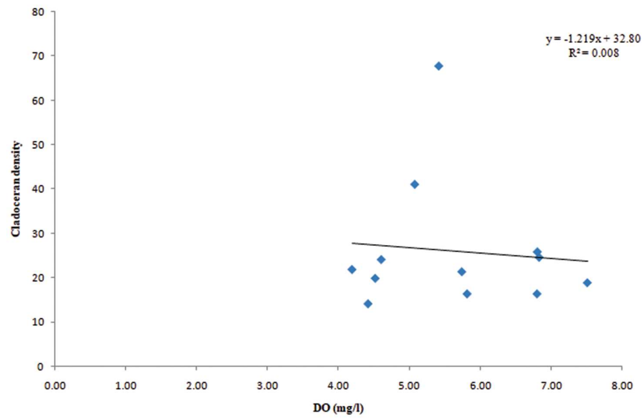


**Fig. 5.** Correlation between Cladocera and dissolved oxygen.

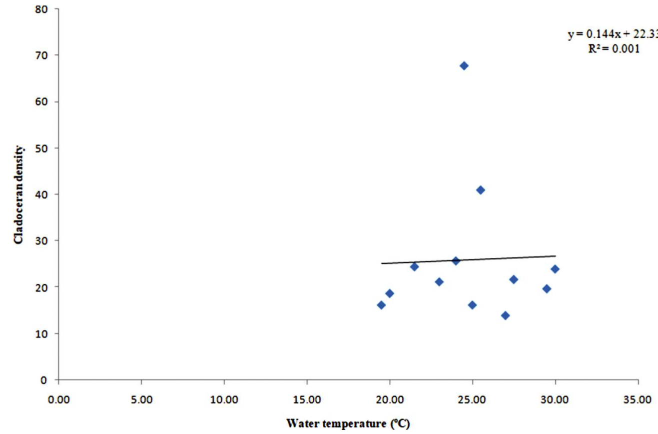


**Fig. 8.** Correlation between Cladocera and water temperature.

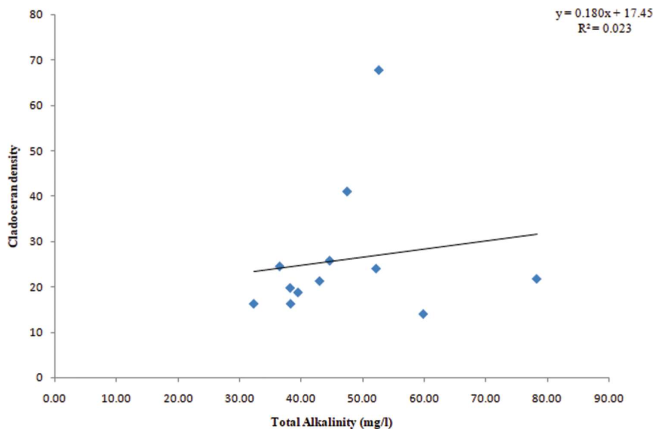


**Fig. 6.** Correlation between Cladocera and total alkalinity.

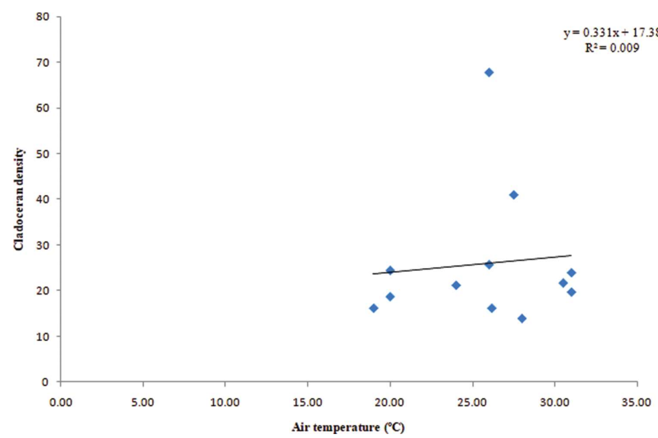


**Fig. 9.** Correlation between Cladocera and air temperature.

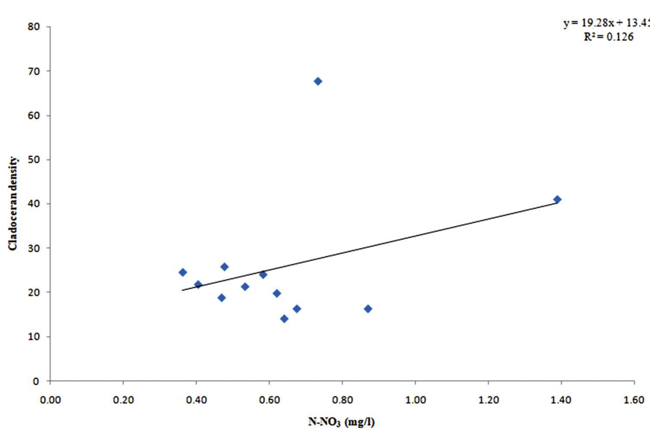


**Fig. 7.** Correlation between Cladocera and nitrate nitrogen.

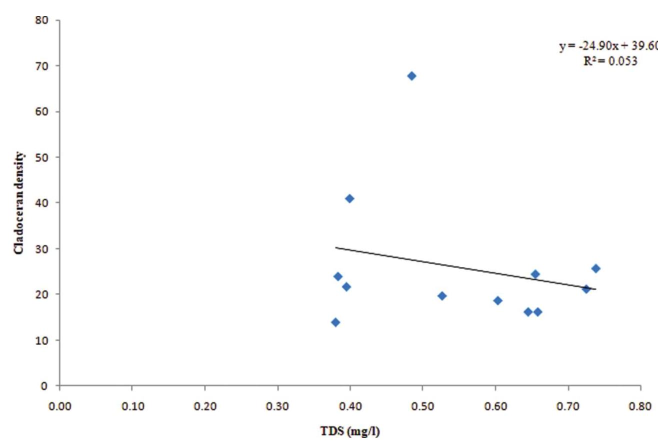


**Fig. 10.** Correlation between Cladocera and total dissolved solids.

0.320) and oxbow lake (r=-0.454) and positive relation in floodplain lake (r=0.267). Chloride exhibit negative relation in both DWR (r=-0.153) and oxbow lake (r=-0.177) and positive relation in floodplain lake (r=0.313). $NO_3$-N exhibit positive correlation in entire studied ecosystem (DWR, r=0.019; FPL, r=0.355; and OBL, r=0.383) (Fig. 7). $PO_4$-P shows positive relationship in both floodplain lake (r=0.004) and oxbow lake (r=0.210) and negative relation in DWR (r=-0.022). pH exhibited positive relation in both floodplain lake (r=0.511) and oxbow lake (r=0.075) and negative relationship in DWR (r=-0.209). WT exhibit positive correlation in entire studied ecosystem (DWR, r=0.519; FPL, r= 0.033; and OBL, r=0.287) (Fig. 8). AT also exhibit same positive relationship in the entire studied areas (DWR, r=0.381; FPL, r=0.094; and OBL, r=0.267) (Fig. 9). Salinity exhibited positive relationship in both DWR (r=0.275) and oxbow lake (r=0.159) and negative relationship in floodplain lake (r=-0.693). SC exhibited positive relationship in DWR (r=0.223) and negative relationship in both floodplain lake (r=-0.550) and oxbow lake (r=-0.083). TDS show inverse correlation in all the habitats (DWR, r=-0.752, FPL, r=-0.230; oxbow lake, r=-0.045) (Fig. 10).

## Discussion

The abundance of cladocera in wetlands habitats were influenced by temperature, rainfall, water quality, nutrients, macrophytes and flood pulse (Ghidini *et al.,* 2009; Kiss *et al.,* 2014). The pattern of community dynamic observed in the study was in agreement with bimodal peak observed by Yarwood (2005), Shah and Pandit (2013) and Kiros *et al.* (2014). The highest population density observed in the present study (May to July) were analogous with the observation of Bothár and Kiss (1990) and Gulyás (1995). The summer peak might have been ascribed to multiple factors that include favorable temperature, high nutrient condition, food availability and hatching of resting eggs (Dejen *et al.,* 2004; Yarwood, 2005; Okogwu, 2010). The low population density during autumn and winter seasons were attributed to unfavorable temperature, limited availability of food and other physico-chemical parameters during this period.

The ranges of various physico-chemical parameters found to be conducive for the planktonic growth and the community dynamics of cladoceran are regulated by a group of physico-chemical factors operating differently in each of the ecosystem. The variation in measure of water quality parameters among the studied ecosystem are related to several ecological factors operated in different environmental conditions. Seasonal and climatic changes, precipitation, wind action and the pattern of hydrological cycle determine the water quality of an aquatic ecosystem (Tundisi and Straskraba, 1999; Basu *et al.,* 2010).

The positive correlation of cladoceran abundance with total alkalinity, nitrate nitrogen ($NO_3$-N), air temperature, water temperature and inverse relation with TDS signifies that these parameters has significant role in pattern of community dynamics. The positive correlation of cladoceran with TA was similar with the observation of Deepthi and Yamakanamardi (2014) and Lingampally *et al.* (2018). Cladoceran abundance was correlated with the increase in nitrate content as it may surplus the growth of phytoplankton. The increasing amount of surface run off during summer could enhance the total alkalinity and nitrate content resulting in growth of cladoceran population. Cladocerans are indicators of eutrophic nature of water as cladoceran density increase with increase in nutrient content (Shah and Pandit, 2013). Similarly, positive relation with temperature concurred with findings of Güntzel *et al.* (2010); Shukla *et al.* (2012) and Shah and Pandit (2013), however disagreement with the findings of Lingampally *et al.* (2018). Temperature is the key factor which could influence all other physico-chemical parameters of any aquatic ecosystem thereby could regulate the occurrence and abundance of cladoceran. The inverse correlation with TDS was concurred with observation of Sharma and Sharma (2009) and in disagreement with Lingampally *et al.* (2018).

The positive correlation with DO in floodplain lake was in concordance with the observation of Sharma and Sharma (2009) and Güntzel *et al.* (2010). However, negative correlation with DO in both DWR and oxbow lake was in agreement with findings of Rossa *et al.* (2001), Antunes et al. (2003) and Lingampally *et al.* (2018). The positive relation with $FCO_2$, and SC in DWR was concurred with Bera *et al.* (2014) and Sharma and Sharma (2019). Positive relation with TH in both DWR and floodplain lake was in agreement with observation of Shukla *et al.* (2012). However, negative relation with TH in oxbow lake was similar with Sharma and Sharma (2009) and Tiwari *et al.* (2011). The negative relation with SC in both floodplain and oxbow lake was in agreement with findings of Green *et al.* (2005) and Güntzel *et al.* (2010).

Cladoceran density was negatively correlated with chloride in DWR and oxbow lake, while positively related in floodplain lake. Shukla *et al.* (2012) found positive correlation of cladoceran with chloride whereas Sharma and Sharma (2009) found negative correlation with chloride. Positive relation with pH in both floodplain lake and oxbow lake was concurred with findings of Shukla *et al.* (2012) and Bera *et al.* (2014). However negative relation with pH in DWR was in agreement with findings of Tiwari *et al.* (2011) and Sharma and Sharma (2019). Cladocerans are sensitive to acidification and highly responsive to changes in pH (Zawisza *et al.,* 2016). Inverse relation of cladoceran with $PO_4$-P in DWR was concurred with Bera *et al.* (2014), which might be due to uptake of dissolved phosphate by phytoplankton and aquatic weeds in submerged condition. The cladoceran community dynamic in floodplain wetland was influenced by the multiple abiotic factors as the cladocerans are highly sensitive to the water quality of aquatic ecosystem (Milan *et al.,* 2017).

## Conclusion

The regulation of community dynamics of cladoceran by the various physico-chemical factors related to the ecosystem variability. Spatial variation has great influence on temporal variation of water quality of any aquatic bodies, thus in the present study it was observed that some of the influential parameters in one ecosystem become less influential in other ecosystem. The parameters especially the air temperature, water temperature, total alkalinity, nitrate nitrogen and total dissolved solids has potential effect on occurrence and abundance of cladoceran despite of ecosystem variability. Apart from the dissolved oxygen, biological oxygen demand, pH, phosphate phosphorus, total hardness and salinity also has significant effect on cladoceran dynamic.

## Acknowledgement

The authors gratefully acknowledge the University grants commission for providing fellowship for the accomplishment of the work. We also like to acknowledge those people who helped during sampling of plankton and water.

## References

**Antunes SC, Abrantes N and Gonçalves F. 2003.** Seasonal variation of the abiotic parameters and the Cladoceran assemblage of Lake Vela: comparison with previous studies. Ann. Limnol. - Int. J. Lim. 39(3): 255-264. https://doi.org/10.1051/limn/2003020

**APHA. 2005.** Standard method for the examination of water and waste water. American Public Health Association/ American Water Works Association/Water Environment Federation. WPEC, 21st edition. Washington DC, USA.

**Balayla DJ and Moss B. 2004.** Relative importance of grazing on algae by plant-associated and open-water microcrustacea (Cladocera). Arch. Hydrobiol. 161(2): 199-224. https://doi.org/10.1127/0003-9136/2004/0161-0199

**Basu M, Roy N and Barik A. 2010.** Seasonal abundance of net zooplankton correlated with physico-chemical parameters in a fresh water ecosystem. IJLR. 3(1): 67–77.

**Bera A, Dutta TK, Patra BC and Sarkar UK. 2014.** Monthly variation of physico-chemical parameters and zooplankton density in Kangsabati Reservoir, West Bengal, India. IJAR. 2(12): 279-289.

**Bothár A and Kiss KT. 1990.** Phytoplankton and Zooplankton (Cladocera, Copepoda) relationship in the eutrophicated river Danube. Danubialia Hungarica CXI. Hydrobiologia. 191: 165-171. https://doi.org/10.1007/BF00026050

**Boven L and Brendonck L. 2009.** Impact of hydroperiod on seasonal dynamics in temporary pool cladoceran communities. Fundam. Appl. Limnol. 174(2): 147-157. DOI: 10.1127/1863-9135/2009/0174-0147

**Brendonck L and Meester LD. 2003.** Egg banks in freshwater zooplankton: evolutionary and ecological archives in the sediment. Hydrobiologia 491: 65 84.

**Deepthi S and Yamakanamardi SM. 2014.** Abundance of cladoceran zooplankton in Varuna, Madappa and Giribettethe lakes of Mysore, Karnataka State, India. International Journal of science, environment and Techn. 3(3): 885-900.

**Dejen E, Jacoubs V, Nagelkerk AJ and Sibbing FA. 2004.** Temporal and spatial distribution of micro crustacean zooplankton in relation to turbidity and other environmental factors in a large tropical lake (Lake Tana, Ethiopia). Hydrobiologia. 513: 39-49.

**Drenner SM, Dodson SI, Drenner RW and Pinde JE. 2009.** Crustacean zooplankton community structure in temporary and permanent grassland ponds. Hydrobiologia. 632: 25-233. DOI 10.1007/s10750-009-9843-4

**Dutta NK. 2011.** Water Analysis. 1st edition. Eastern Book House Publisher, India. Pp: 1-310.

**Gabellone NA, Solari LC and Claps MC. 2001.** Plankton and Physicochemical dynamics of a markedly fluctuating backwater pond as with a lowland river (Salado river, Bueonos Aires) Argentina. Lakes Reserv.: Res. Manag. 6:133-142.

**Ghidini AR, Serafim-Júnior M, Perbiche-Neves G and Brito LD. 2009.** Distribution of planktonic cladocerans (Crustacea: Branchiopoda) of a shallow eutrophic reservoir (Paraná State, Brazil). Pan-Am. J. Aquat. Sci. 4(3): 294-305.

**Gogoi B, 2017.** The Cladoceran diversity with special emphasis on feeding ecology of fish in floodplain wetlands of Subansiri river basin, Assam. Ph.D. thesis, Rajiv Gandhi University, Itanagar. Pp: 1-295.

**Gogoi B, Safi V and Das DN. 2016.** The Cladoceran as live feed in fish culture: A brief review. Research Journal of Animal, Veterinary and Fishery Sci. 4(3): 7-12.

**Green AJ, Fuentes C, Moreno-ostos E and De Silva R. 2005.** Factors influencing cladoceran abundance and species richness in brackish lakes in Eastern Spain. Ann. Limnol. - Int. J. Lim. 41(2): 73-81.

**Gulyás P. 1995.** Rotatoria and Crustacea plankton of the River Danube between Bratislava and Budapest. Miscnea zool. hung. 10: 7-19.

**Güntzel AM, Panarelli EA, Silva WMda and Roche KF. 2010.** Influence of connectivity on Cladocera diversity in oxbow lakes in the Taquari River floodplain (MS, Brazil). Acta Limnol. Bras. 22(1): 93-101. doi: 10.4322/actalb.02201012

**Hessen DO, Faafeng BA and Brettum P. 2003.** Autotroph: herbivore biomass ratios; carbon deficits judged from plankton data. Hydrobiologia. 491: 167-175. https://doi.org/10.1023/A:1024456825718

**Junk WJ and Wantzen KM. 2006.** Flood pulsing, and the development and maintenance of biodiversity in floodplains. In: Ecology of Freshwater and Estuarine Wetlands. Eds. Batzer DP and Sharitz RR. University of California Press, Berkeley, USA. Pp: 407-435.

**Kamenik C, Szeroczyñska K and Schmidt R. 2007.** Relationships among recent Alpine Cladocera remains and their environment: implications for climate change studies. Hydrobiologia. 594: 33-46. DOI 10.1007/s10750-007-9083-4

**Kiros S, Subash KK and Alemayehu E. 2014.** Population dynamics of freshwater Cladocera (Crustacea: Branchiopoda) in Manmade ponds at Boye Wetland, Jimma Zone, Southwestern Ethiopia. j. applied sci. & agric. 9(9): 93-102.

**Kiss A, Ágoston-Szabó E, Dink M, Schöll K and Berczik Á. 2014.** Microcrustacean (Cladocera, Copepoda, Ostracoda) diversity in three side arms in the Gemenc Floodplain (Danube River, Hungary) in different hydrological situations. Acta Zool. Bulg. 7: 135-141.

**Lackey JB. 1938.** The manipulation and counting of river plankton and changes in some organisms due to formalin preservation. Public Health Rep. 53(47): 2080-2093.

**Lingampally V, Solanki VR, Anuradha DL and Raja S. 2018.** Cladoceran abundance in relation to water quality parameters of Chakki Talab, Bodhan, Telangana. Int. J. Curr. Eng. Technol. 8(1): 1-4.

**Milan M, Bigler C, Tolotti M and Szeroczyn′ska K. 2017.** Effects of long term nutrient and climate variability on subfossil Cladocera in a deep, subalpine lake (Lake Garda, northern Italy). J. Paleolimnol. 58(3): 335-351.

**Okogwu IO. 2010.** Seasonal variations of species composition and abundance of zooplankton in Ehoma Lake, a floodplain lake in Nigeria. Rev. Biol. Trop. 58(1): 171-182.

**Peretyatko A, Tessier S, De Backer S and Triest L. 2009.** Restoration potential of biomanipulation for eutrophic peri-urban ponds: the role of zooplankton size and submerged macrophyte cover. Hydrobiologia. 634: 125-135.

**Pinto-coelho R, Pinel-alloul B, Methot G and Havens KE. 2005.** Crustacean zooplankton in lakes and reservoirs of temperate and tropical regions: variation with trophic status. Can J Fish Aquat Sci. 62(2): 348-361. https://doi.org/10.1139/f04-178

**Qin JG and Fast AW. 1997.** Food selection and growth of young snake head *Chana striatus*. J. Appl. Ichthyol. 13(1): 21-25. doi.org/10.1111/j.1439-0426.1997.tb00093.x

**Rossa DC, Lansac-tôha FA, Bonecker CC and Velho LFM. 2001.** Abundance of cladocerans in the littoral regions in two environments of the Upper Paraná River Floodplain, Mato Grosso do Sul, Brazil. Braz. J. Biol. 61(1): 45-53.

**Rumes B, Eggermont H and Verschuren D. 2011.** Distribution and faunal richness of Cladocera in western Uganda crater lakes. Hydrobiologia. 676: 39-56. doi:10.1007/s10750-011-0829-7

**Saikia SK and Das DN. 2014.** Laboratory hand book on basic Ecology (soil, water, plankton and feeding ecology with special mention to periphyton). Science publishing group. New York. Pp: 1-128.

**Shah JA and Pandit AK. 2013.** Relation between physico-chemical limnology and crustacean community in wular lake of kashmir Himalaya. Pak J Biol Sci. 16(19): 976-983. DOI:10:3923/pjbs.2013.976.983.

**Sharma A and Sharma M. 2019.** Zooplankton Diversity in Relation to Physico-Chemical Parameters in Subtropical Pond of Jammu, Jammu and Kashmir, India. Biosci. Biotechnol. Res. Asia. 16(2): 425-439. doi.org/10.13005/bbra/2758

**Sharma BK and Sharma S. 2009.** Microcrustacea (Crustacea: Branchiopoda) of Deepor Beel, Assam, India: richness, abundance and ecology. J Threat Taxa 1(8): 411-418.

**Shukla A, Shukla JP and Mishra M. 2012.** Biotic spectrum of Chando Lake in context of ecological status and zooplankton diversity. Curr. Res. J. Biol. Sci. 4(6): 690-695.

**Siciliano A, Gesuele R, Pagano G and Guida M. 2015.** How Daphnia (Cladocera) Assays may be used as Bioindicators of Health Effects? J Biodivers Endanger Species. S1(005):1-6 doi.org/10.4172/2332-2543.S1.005

**Smol JP. (2008).** Pollution of lakes and rivers: A paleoenvironmental perspective. 2nd edition. Blackwell Publishing. Oxford, UK. Pp: 1-362.

**Sugunan VV. 1997.** Fisheries management of small bodies in seven countries in Africa, Asia and Latin America. FAO Fisheries Circular, Rome. No. 933. Pp: 149.

**Suresh Kumar R. 2000.** Studies of freshwater cladocerans use as live food in aquaculture. PhD thesis. University of Madras, Tamil Nadu. Pp: 1-147.

**Tiwari RP, Sharma C and Tiwari RB. 2011.** Studies on Cladoceran zooplanktonic population and their correlation coefficient with some physicochemical factors of Lony dam Theonthar, Rewa (M.P.). Int. J. of Pharm. & Life Sci. 2: 1059-1061.

**Tockner K, Malard F and Ward JV. 2000.** An extension of the flood pulse concept. Hydrol Process. 14 (16-17): 2861-2883. doi.org/10.1002/1099-1085(200011/12)14:16/17%3C2861::AID-HYP124%3E3.0.CO;2-F

**Tundisi JG and Straskraba M. 1999.** Theoretical reservoir ecology and its applications. International Institute of Ecology, Brazilian Academy of Sciences, Rio de Janeiro, Brazil. Pp: 1-585.

**Twombly S and Lewis WM Jr. 1989.** Factors regulating cladoceran dynamics in a Venezuelan floodplain lake. J. Plankton Res. 11(2): 317-333.

**Urabe J, Elser JJ, Kyle M, Yoshida T, Sekino T and Kawabata Z. 2002.** Herbivorous animals can mitigate unfavourable ratios of energy and material supplies by enhancing nutrient recycling. Ecol. Lett. 5: 177-185.

**Ward JV, Tockner K, Arscott DB and Claret C. 2002.** Riverine landscape diversity. Freshwater Biol. 47(4): 517-539. https://doi.org/10.1046/j.1365-2427.2002.00893.x

**Yarwood SB. 2005.** Cladoceran assemblages of small freshwater bodies in lowland England and Wales. PhD. Thesis, Oxford Brookes University, England: Pp: 1-243.

**Zawisza E, Zawiska I and Correa-Metrio A. 2016.** Cladocera Community Composition as a Function of Physicochemical and Morphological Parameters of Dystrophic Lakes in NE Poland. Wetlands 36: 1131–1142. doi.org/10.1007/s13157-016-0832-x