Proceedings of the International Academy of Ecology and Environmental Sciences, 2013, 3(3): 238-246

Article

Diurnal variation of zooplankton in Bhoj Wetland, Bhopal, India

Najeeb Ahmad Bhat[1], **Ashwani Wanganeo**[1], **Parvaiz Ahmad Bhat**[1], **Rajni Raina**[2]
[1]Department of Environmental Sciences and Limnology, Barkatullah University, Bhopal
[2]Department of Zoology, Govt. Benazir P.G College Bhopal (MP) India
E-mail: najahbhat@gmail.com

Received 11 April 2013; Accepted 15 May 2013; Published online 1 September 2013

Abstract

The diurnal dynamics of the vertical distribution of zooplankton was studied in Bhoj Wetland, Bhopal. Vertical distribution of the zooplankton community in general showed a clear diurnal variation in the water column of a typical stratified lake. Zooplankton concentration was found to be high at the surface layer during night hours with peak abundance around the middle of the night and another peak was observed just before sunrise, followed by a rapid nadir after sunrise. Zooplankton can offset the loss of daytime foraging opportunity by moving up into the water column to graze at night, when predation by visual predators is greatly reduced and it can be also attributed to light intensity which is responsible for vertical migration during the twenty four hour cycles. Among different classes, cladocerans and the copepod showed nocturnal migration conversely rotifers, had a relatively uniform distribution throughout the water column Out of the twenty three species, *Bosmina* species and *Cyclops* species ascended at night and descended during day hours, however, *Keratella cochlearis* showed uniformity in distribution throughout the water column during the study.

Keywords Cladocera; Copepoda; diurnal migration; Bhoj wetland.

Proceedings of the International Academy of Ecology and Environmental Sciences
ISSN 2220-8860
URL: http://www.iaees.org/publications/journals/piaees/online-version.asp
RSS: http://www.iaees.org/publications/journals/piaees/rss.xml
E-mail: piaees@iaees.org
Editor-in-Chief: WenJun Zhang
Publisher: International Academy of Ecology and Environmental Sciences

1 Introduction

Behaviour is an important factor in zooplankton population dynamics (Steele and Henderson, 1981; McCauley and Murdoch, 1987). Diel vertical migration (DVM) is one of the most important behaviours of zooplankton in terms of their structure and function in aquatic ecosystems (Ohman, 1990). The importance of light on influencing daily vertical migration patterns has been thoroughly studied, generally showing that with increased light intensity, downward movement occurs, and upward movement occurs during decreased light intensity (Bollens et al., 1994; Rhode et al., 2001). There are a few proposed driving factors for this activity; with the most commonly stated reason being predator avoidance (Zaret and Suffern, 1976; Clark and Levy, 1988; Lampert, 1989; Bollens and Frost, 1991).

2 Materials and Methods

The observations were made during 21–22 February 2008. The samples were collected at 4 hourly intervals over a period of 24 h, from surface (upto 1m), middle (4m) and bottom layers (7m). The various limnological methods for physical measurements and chemical analysis of water have been described as per methods given by APHA (1995). The numerical enumeration of zooplankton population was carried out by filtering known volume of water from various depths through a standard net of mesh size 63µm. The zooplankton samples were preserved in 4% of formaldehyde. Identification of species was based on standard keys (Edmondson, 1959). One ml of the concentrated sample was taken in a Sedgwick-rafter counting chamber and the entire contents were counted.

Ten liters of water were filtered and concentrated to 100 ml and were preserved by adding 2ml of 4% formalin simultaneously. The quantitative analysis of zooplankton was done by using Sedgwick-Rafter cell with dimensions of 50mm × 20mm × 1mm, following the method given in APHA (2000). 1ml of concentrated sample was taken in a Sedgwick-Rafter counting cell and the entire contents were counted. The results have been expressed as individuals/l (Wanganeo and Wanganeo, 2006).

$$\text{Number of zooplankton“n”} = \frac{C \times 1000\ \text{mm}^2}{A \times D \times E}$$

where C= Number of organisms recorded, A = Area of field of microscope, D = Depth of field (SRC depth) in mm, E = Number of fields counted.

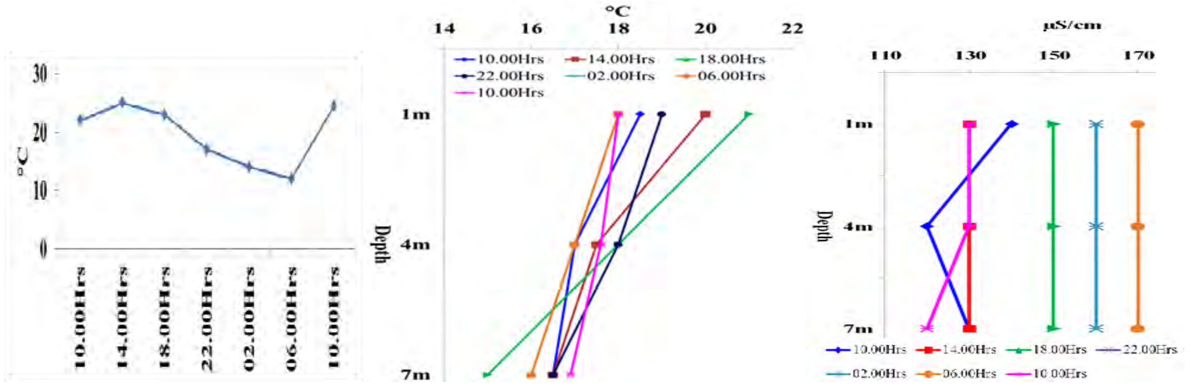
$$\text{Number of zooplankton/l} = \frac{n \times \text{Vol. of concentrate (ml)}}{\text{Vol. (litres) of water filtered}}$$

3 Results

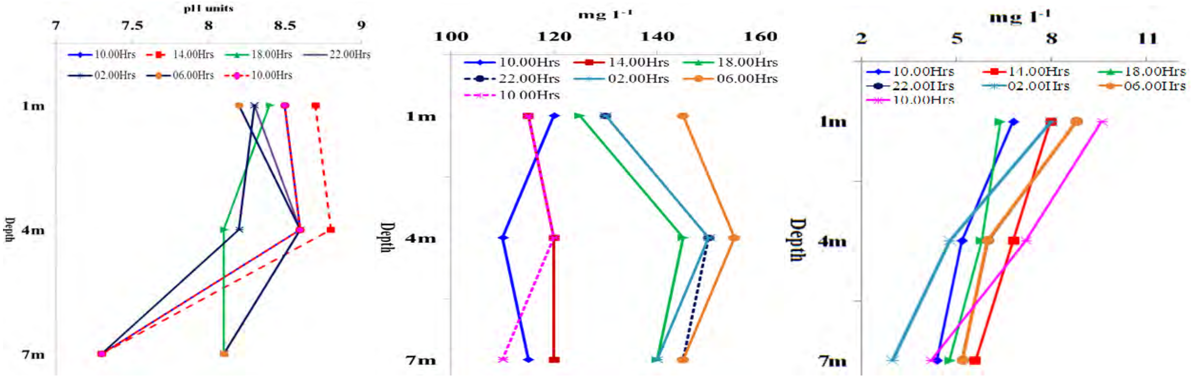
The physicochemical parameters were presented in Fig. 1. In the zooplankton composition (Table 1), 23 species were recorded; 10 species of Cladoceran (43.47%), seven species of rotifera (30.43%), three species of Copepoda (13.04%), two species of Ostracoda (8.69%) and one species of Protozoa (4.34%).

Table 1 List of zooplankton species encountered in the study period.

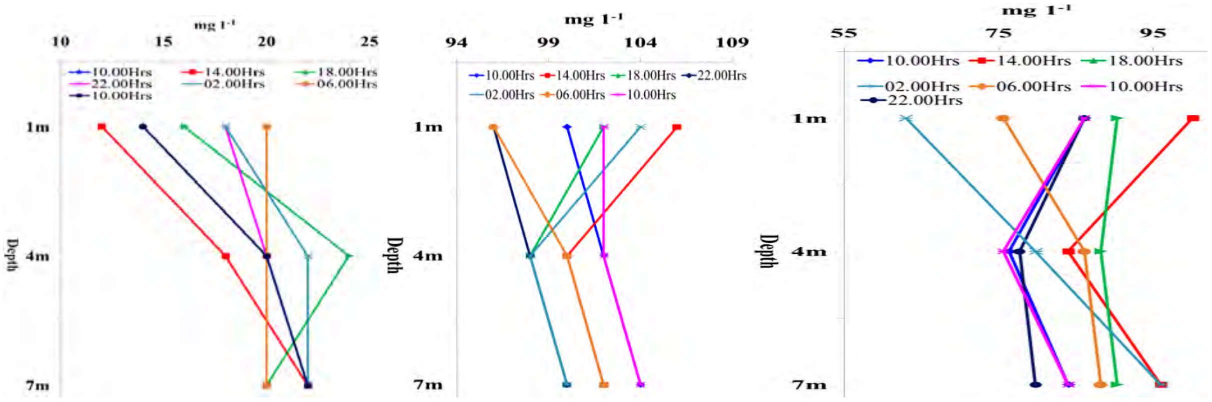
Group/Species	Group/Species
Cladocera	**Rotifera**
Alona sp.	*Gastopus* sp.
Alonella sp.	*Keratella* sp.
Bosmina sp.	*Keratella cochlearis*
Ceriodaphnia sp.	*Keratella tropica*
Daphnia sp.	*Lecane* sp.
Daphnia pulex	*Notholca* sp.
Moina sp.	*Trichocerca* sp.
Moina daphnia	**Copepoda**
Sida sp.	*Cyclops* sp.
Simocephalus sp.	Nauplius sp.
Ostracoda	*Tropocyclops* sp.
Cypris sp.	**Protozoa**
Stenocypris sp.	*Paramecium* sp.



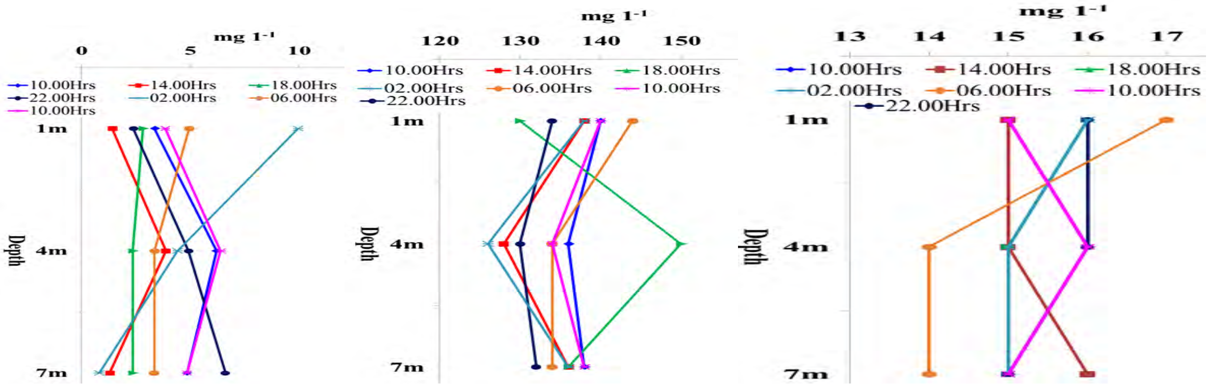
Air Temp (°C) Water Temp (°C) Elect.Conductivity (µS/cm)



pH units Total Dissolved Solids (mg/l) DO (mg/l)



CO_2 (mg/l) Total Hardness (mg/l) Calcium Hardness (mg/l)



Magnesium Hardness (mg/l) Total Alkalinity (mg/l) Chloride (mg/l)

Fig. 1 Variation of physico–chemical characteristics of Bhoj Wetland, Bhopal.

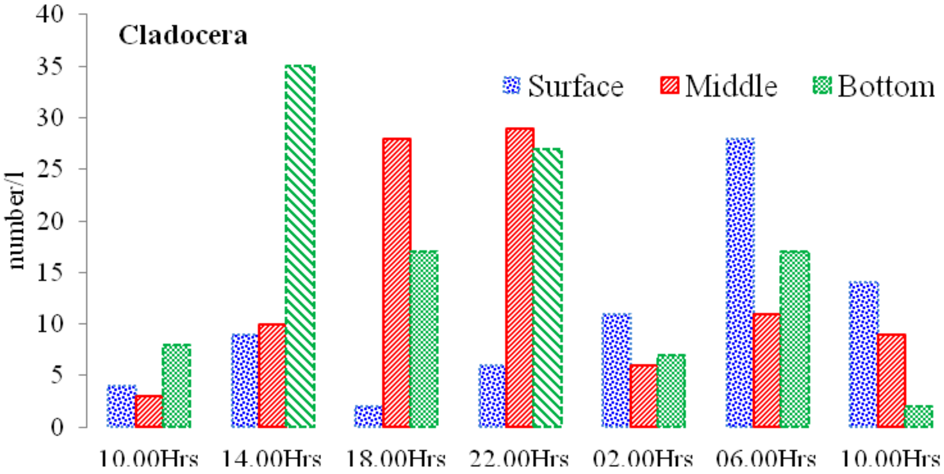


Fig. 2 Cladocera showing variation in a 24 hour interval among three layers.

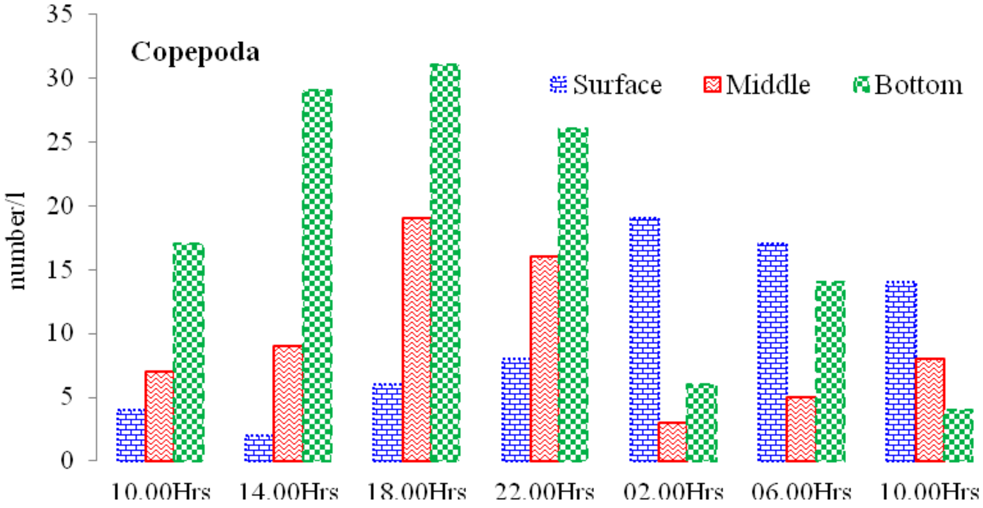


Fig. 3 Copepoda showing variation in a 24 hour interval among three layers.

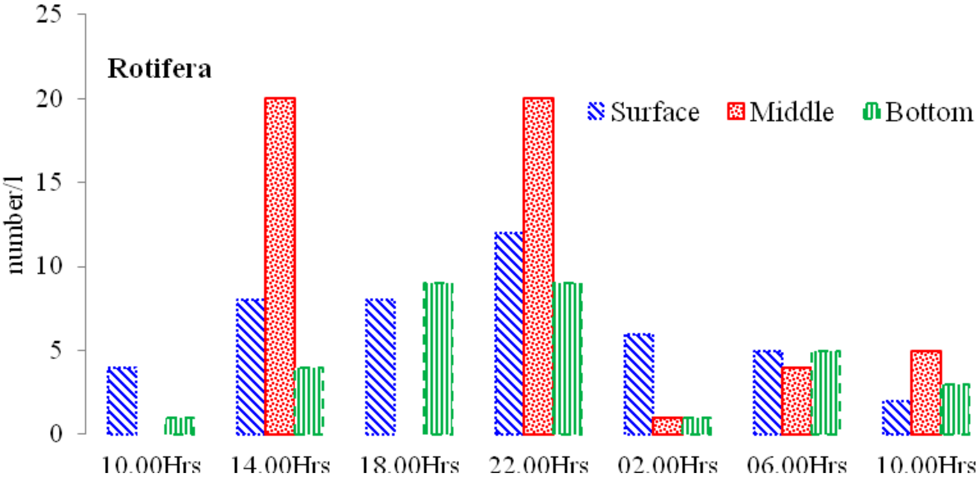


Fig. 4 Rotifera showing variation in a 24 hour interval among three layers.

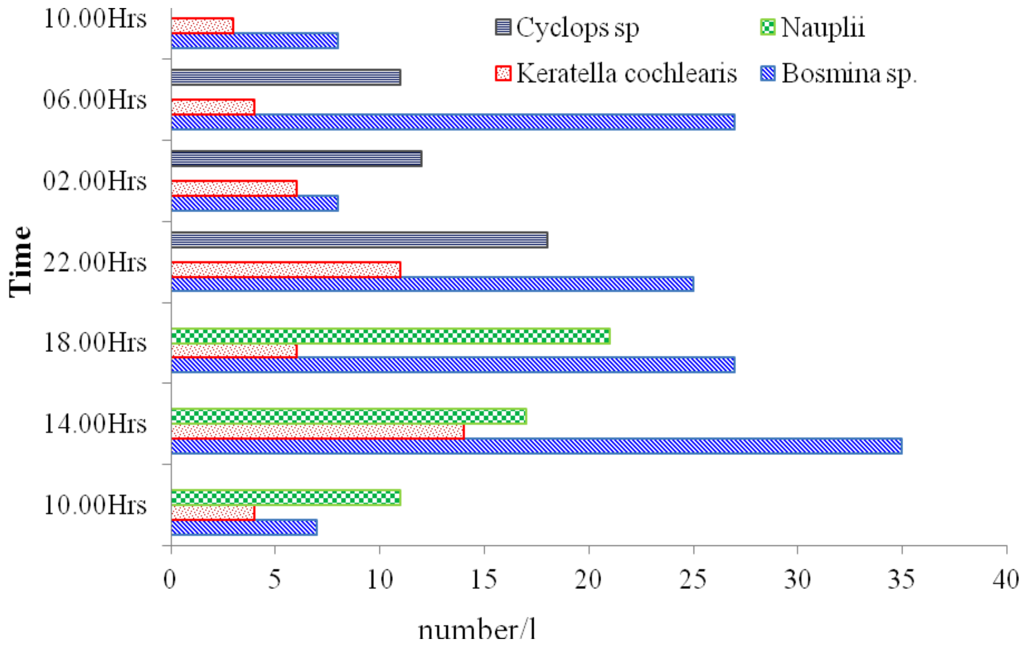


Fig. 5 Temporal variation of dominant species (number/l).

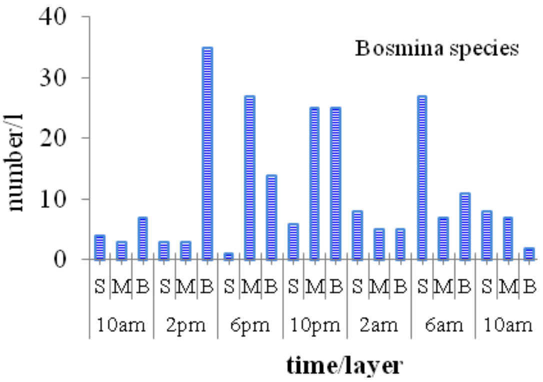


Fig. 6 Vertical abundance of *Bosmina* sp.

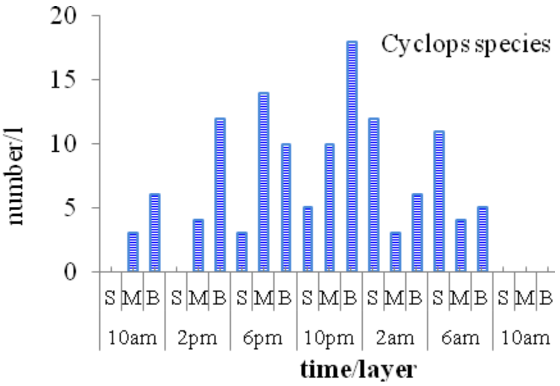


Fig. 7 Vertical abundance of *Cyclops* sp.

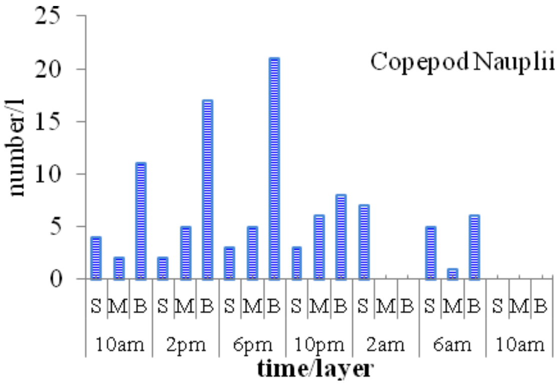


Fig. 8 Vertical abundance of *Copepod nauplii*.

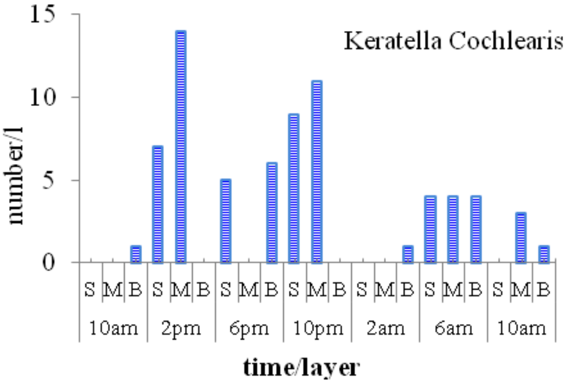


Fig. 9 Vertical abundance of *Keratella cochlearis*.

Among the three groups, during day hours Cladoceran population were mostly found in lower layers and night hours they were found in surface layers (Fig. 2). Similarly in the Copepoda group, maximum population were found in bottom layers during day hours while they were recorded minimum during night hours at this layer and maximum in surface layers (Fig. 3). No significant diel variation was found in Rotiferan population (Fig. 4).

Bosmina sp. was the most abundant species (35.79% of the zooplankton abundance in terms of density, followed by *Cyclops* (19.35%), *Copepod nauplii* (16.28%) and *Keratella cochlearis* (10.75%). The other 19 species represented 18% of zooplankton population. Thus, only four species (*Bosmina* sp., *Cyclops* sp., *Copepod nauplii, and Keratella cochlearis*) were evaluated.

The vertical distribution of *Bosmina* sp. during the 24 h in the lake is shown in Fig. 5 & 6. At 10.00am most individuals (50%) were found at the bottom, at 02.00pm they were mostly (85%) found also at the bottom, at 06.00pm they were mostly found (64%) at middle layers, but at 10.00pm they were mostly located in two layers middle and bottom layers, during the last hours of the study most of the individuals were found at surface layers, at 02.00am (60%) and 10.00am (47%) they were noted in surface layers. Individuals of *Cyclops* showed similar pattern of vertical distribution to that of *Bosmina* sp. (Fig. 5 & 7). At 10.00am the individuals were distributed mainly at the middle (34%) and bottom (66%) and at 02.00pm most of the individuals were (75%) located at bottom waters. At 06.00pm the individuals migrated towards the middle layers (51%), at 10.00pm most of the individuals were found (54%) at the bottom. However, the individuals were found at 02.00am (57%) and at 06.00am the individuals were found (55%) at the surface layers. Individuals of *copepod nauplii*, the maxima of abundance was noted at 10.00am in the bottom water, at 02.00pm (71%), 06.00pm (72%) and 10.00pm (47%) were also noted at bottom waters (Fig. 8). However, at 02.00am the whole species were observed in the surface (100%) and last at 10.00 am (morning hours) the abundance was maxima (50%) at bottom waters. *Keratella cochlearis* at 10.00am and 02.00am only one species was observed (i.e., 100%) in bottom layers (Fig. 9), but at 02.00pm the *K. cochlearis* was found in the surface and middle only, the abundance was in the middle layer (67%). At 06.00pm the abundance was in the bottom (56%) and at 10.00pm in the middle (55%). Late night at 06.00am the species abundance was found equally distributed (33.3%) in each layer. Finally, the maximum was found in the middle layer (75%) at 10.00am.

4 Discussion

The diurnal dynamics of the vertical distribution of zooplankton was studied in Bhoj Wetland, Bhopal. Vertical distribution of the zooplankton community in general showed a clear diurnal variation in the water column of a typical stratified lake. Temperature, oxygen concentration, light, predation and the distribution of food are some of the factors that influence the vertical distribution of zooplankton species (Gophen, 1972; Orcutt and Porter, 1983; Geller, 1986; Levy, 1990; Hanazato, 1992). We found in our study that *copepod nauplii* almost stayed at the bottom layer, same findings were reported by Wetzel (2001), copepods during winter can create resting eggs or enter diapause and stay near the bottom of the lake. The zooplankton concentration at the surface layer was high only during the night hours and bottom during day hours. Zooplankton can offset the loss of daytime foraging opportunity by moving up into the water column to graze at night, when predation by visual predators is greatly reduced (Zaret and Suffern, 1976; Iwasa, 1982). For lakes where DVM occurs, most organisms move into the upper layers of the water column in the evening, with peak abundance around the middle of the night. Individuals then descend slowly and rise again, with another peak usually occurring just before sunrise, followed by a rapid descent after sunrise (Pennak, 1944; Wetzel, 1975; Schleuter and Eckmann, 2006). Overall zooplankton abundance of 651individuals/l was found similar to those found in Lake Okeechobee by Beaver and Havens (1996) and in Lake Mize by Nordlie (1976). Rotifer, Copepoda and Cladoceran species composition were similar to those found in Lake Monroe by Yount and Belanger (1988). The vertical distribution of zooplankton is regulated by both biotic and abiotic factors such as temperature, oxygen, food availability, interspecific competition and predation (Dumont, 1972; Kerfoot et al., 1985; Bosselmann and Riemann, 1986). During the present study, *Bosmina* species were abundant at depth layers during day hours, because the bosminids are the main food item for roach (Horppila, 1994a), which is active by day (Persson, 1983; Jamet et al., 1990) and concentrates at depth in the pelagic zone, (Peltonen and Horppila, 1992). The water temperature fluctuated between 21°C and 15°C and dissolved oxygen 9.6mg/l to 3.0mg/l from surface to bottom. Numerous studies have shown that physical or chemical gradients (e.g., temperature, dissolved oxygen) may restrict the distribution of predators and that such boundaries may play a role in reducing the mortality of cladocerans (Zaret, 1975; Confer et al., 1978; Lampert, 1987; Shapiro, 1990; Wright and Shapiro, 1990). Cladocerans can tolerate concentrations below 1 mg/l (Prepas and Rigler, 1978 and Murtaugh, 1985). However, their feeding rate is rapidly reduced at oxygen levels below3 mg/l (Heisey and Porter, 1977). The relation of *Bosmina* species and the physical environment is more elusive, since we found a significant (inverse) relation between oxygen and abundance only after the descending phase during the reverse DVM. In our study we found that *Keratella cochlearis* were uniform throughout the column, same findings were reported by Paggi (1995), the vertical migration of rotifers, found that they had a relatively uniform distribution throughout the water column. Of the three types of vertical migration behaviours described by Hutchinson (1967), nocturnal, twilight and reverse, the first type was the only one observed for the cladocerans and the copepod herein. Nocturnal migration is described as the movement of individuals from deeper to superficial layers at night (Hutchinson, 1967) and, according to Bayly (1986), represents the typical type of vertical migration exhibited by most zooplanktonic species. The species that showed vertical patterns of migration were bigger than the ones that did not. These larger species are more susceptible to being detected and eaten by diurnal predators, who use sight to detect and capture their prey (Iwasa, 1982). Thus, during the day zooplanktonic individuals tend to stay on the bottom where light penetration is low or absent, and at night and dawn they migrate to the surface where food concentration is higher and predation is minimum. For the smaller species, the problem of being detected is less significant and this may explain why the rotifers showed a more homogenous distribution.

Acknowledgements

The author deems his heartfelt gratitude to Prof. Ashwani Wanganeo, Dean (Faculty of Life Sciences), Head, Department of Environmental Sciences and Limnology, Barkatullah University, Bhopal for providing necessary facilities and valuable time during manuscript preparation.

References

APHA. 1995. Standard Methods for the Examination of Water and Waste Water. American Public Health Association, Washington DC, USA

Bayly IAE. 1986. Aspects of diel vertical migration and its enigma variations. In: Limnology in Australia (Dedeckker P, Williams WD, eds). Monographiae Biologicae, 61: 349-368, Dr.W Junk, Amsterdam, Netherlands

Beaver JR, Havens KE. 1996. Seasonal and spatial variation in zooplankton community structure and their relation to possible controlling variables in Lake Okeechobee. Freshwater Biology, 36:45-56

Bollens SM, Frost BW, Cordell JR. 1994. Chemical, mechanical and visual cues in the vertical migration behavior of the marine planktonic copepod Acartia-hudsonica. Journal of Plankton Research, 16(5): 555-564

Bollens SM, Frost BW. 1991. Diel vertical migrations in zooplankton: Rapid individual response to predators. Journal of Plankton Research, 13: 1359-1365

Bosselmann S, Riemann B. 1986. Zooplankton. In: Carbon dynamics in eutrophic temperate lakes (Riemann B, Søndergaard M, eds). 199-235, Elsevier Science Publishers, Amsterdam, Netherlands

Clark CW, Levy DA. 1988. Dielvertical migrations by juvenile sockeye salmon and the antipredation window. American Naturalist, 131: 271-290

Confer JL, Howick GL, Corzette MH, et al. 1978. Visual predation by planktivores. Oikos, 31: 27-37

Geller W. 1986. Diurnal vertical migration of zooplankton in a temperate great lake (L. Constance): a starvation avoidance mechanism? Archivfür Hydrobiologie, Supplement 74: 1-60

Gophen M. 1972. Zooplankton distribution in Lake Kinneret (Israel), 1969-1970. Israel Journal of Zoology, 21: 17-27

Hanazato T. 1992. Direct and indirect effects of low oxygen layers on lake zooplankton communities. Archivfür Hydrobiologie Beiheft, 35: 87-98

Heisey D, Porter K. 1977. The effect of ambient oxygen concentration on filtering and respiration rates of *Daphnia galeatamendotae* and *Daphnia magna*. Limnology and Oceanography, 22: 839-845

Horppila J. 1994. The diet and growth of roach (Rutilusrutilus L) in Lake Vesijarvi and possible changes in the course of biomanipulation. Hydrobiologia, 294: 35-41

Hutchinson GE. 1967. A Treatise on Limnology (2). John Wiley & Sons, New York, USA

Iwasa Y. 1982. Vertical migration of zooplankton: A game between predator and prey. American Naturalist, 120(2): 171-180

Jamet JL, Gres P, Lair N, et al. 1990. Diel feeding cycle of roach (*Rutilusrutilus* L.) in eutrophic Lake Aydat (Massif Central, France). Archiv Fur Hydrobiologie, 118: 371-382

Kerfoot WC, DeMott WR, DeAngelis DL. 1985. Interactions among cladocerans: food limitation and exploitative competition. Archives für Hydrobiologie–Beiheft Ergebnisse der Limnologie, 21: 431-451

Lampert W. 1989. The adaptive significance of diel vertical migration of zooplankton. Functional Ecology, 3: 21-27

Lampert W. 1987. Vertical migration of freshwater zooplankton: indirect effects of vertebrate predators on algal communities. In: Predation: Direct and Indirect Impacts on Aquatic Communities (Kerfoot C, Sih A, eds). 291-299, University Press of New England, USA

Murtaugh PA. 1985. Vertical distribution of zooplankton and population dynamics of Daphnia in Ameromictic Lake. Hydrobiologia, 123: 47-57

Nordlie FG. 1976. Plankton communities of three central Florida Lakes. Hydrobiologia, 48(1): 65-78

Ohman MD. 1990. The demographic benefits of diel vertical migration by zooplankton. Ecological Monographs, 60(3): 257-281

Orcutt JD, Porter KG. 1983. Diel vertical migration by zooplankton: Constant and fluctuating temperature effects on life history parameters of Daphnia. Limnology and Oceanography, 28: 720-730

Paggi SJ. 1995. Vertical distribution and diel migration of rotifers and in a Paraná River floodplain lake. Hydrobiology, 310: 87-94

Peltonen H, Horppila J. 1992. Effects of mass removal on the roach stock of Lake Vesij¨arvi estimated with VPA within one season. Journal of Fish Biology, 40: 293-301

Pennak RW. 1944. Diurnal movements of zooplankton organisms in some Colorado mountain lakes. Ecology, 25(4): 387-403

Persson L. 1983. Food consumption and the significance of detritus and algae to intraspecific competition in roach Rutilusrutilus in a shallow eutrophic lake. Oikos, 41: 118-125

Prepas E, Rigler FH. 1978. The enigma of Daphnia death rates. Limnology and Oceanography, 23: 970-988

Rhode SC, Pawlowski M, Tollrian R. 2001. The impact of ultraviolet radiation on the vertical distribution of zooplankton of the Genus Daphnia. Nature, 412(5): 69-72

Schleuter D, Eckmann R. 2006. Competition between perch (Percafluviatilis) and ruffe (Gymnocephalus cernuus): the advantage of turning night into day. Freshwater Biology, 51: 287-297

Steele JH, Henderson EW. 1981. A Simple Plankton Model. American Naturalist, 117: 676-691

Wetzel RG. 1975. PA Limnology. WB Saunders Comp., Philadelphia, USA

Wright DI, Shapiro J. 1990. Refuge availability: a key to understanding the summer disappearance of Daphnia. Freshwater Biology, 24: 43–62

Yount JR, Belanger TV. 1988. Population trends in the phytoplankton and zooplankton of the Upper and Middle St. John’s River, Florida, 1983-1984. Florida Scientist, 51(2): 76-85

Zaret TM. 1975. Strategies for existence of zooplankton prey in homogenous environments. Verhandlungen des Internationalen Verein Limnologie, 19: 1484-1489

Zaret TM, Suffern JS. 1976. Vertical migration in zooplankton as a predator avoidance mechanism. Limnology and Oceanography, 21(6): 804-813