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IMPACT OF PHYSICOCHEMICAL PARAMETERS OF WATER ON POPULATION DYNAMICS OF COPEPODS FROM SAFARI ZOO LAKE, LAHORE, PAKISTAN

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خلاصہ

Copepod کی آبادی کا تجزیہ لاہور کے سفاری چڑیا گھر کی ایک تازہ پانی کی جھیل سے کیا گیا اور اس کی کثرت کو ستمبر 2013 سے اگست 2014 تک خالص نمونوں میں افقی اور عمودی طور پر جانچا گیا۔ ہوا اور پانی کے درجہ حرارت (AT) ، تحلیل آکسیجن (DO) ، آکسیجن سنترپتی (OS) ، پیچ، برقی چالکتا (EC) ، سچی ڈسک کی شفافیت (STD) اور گدلا پن (TB) میں مختلف فزیو کیمیکل پیرامیٹرز میں موسمی تبدیلیاں دیکھنے میں آئیں۔ مطالعے کے دوران Copepods حیوانات کی تشکیل اور کثرت میں سخت تبدیلیاں دیکھنے میں آئیں۔ جون اور جولائی کے مہینے میں Copepods کا تنوع زیادہ سے زیادہ پایا گیا تھا اور کم سے کم ستمبر اور اکتوبر میں۔ پیئرسن کا ارتباط کا حساب Copepods اور فزیو کیمیکل پیرامیٹرز کے مابین کیا گیا تھا پیئرسن (Pearson correlation) کا ارتباط کا حساب Copepods اور فزیو کیمیکل پیرامیٹرز کے مابین کیا گیا تھا۔ تغیر کے تجزیہ نے کوپپڈس کی آبادی اور فزیو کیمیکل پیرامیٹرز کے مابین اہم تعلقات کو ظاہر کیا۔ موجودہ مطالعے میں، دو مختلف آرڈرز (cyclopoida and Calanoida) اور 11 مختلف جینیرا سے تعلق رکھنے والے Copepods کی 12 پرجاتیوں کی نشاندہی کی گئی تھی۔ Diacyclopsthomas thomasi تمام مہینوں میں غالب نوعیت کی تھی۔ Shannon-Weaver Index(H) کا Copepods کے اعتدال پسند تنوع کی نمائندگی کرنے والے 1.75 سے 2.90 تک کا تھا۔ اس مطالعے کا مقصد پاکستان کے تازہ آبی وسائل سے تعلق رکھنے والے حیاتیاتی عوامل کو تنوع اور Copepods کی کثرت پر اثر انداز کرنے کا ہے

Abstract

The Copepod populations were analyzed from an artificial fresh water lake of Safari Zoo in Lahore and its abundance was examined horizontally and vertically in net samples from September 2013 to August 2014. Seasonal changes in different physicochemical parameters such as the air and water temperature, dissolved oxygen (DO), Oxygen saturation (OS), pH, electrical conductivity (EC), Sacchi disk transparency (SDT) and turbidity (TB) were observed. Drastic changes were observed in composition and abundance of copepods fauna during the study. Copepods diversity was found maximum in the month of June and July and minimum in September and October. Pearson correlation was calculated between copepods and physicochemical parameters. Analysis of variance showed significant relationship between copepods population and physicochemical parameters. In the present study, 12 species of copepods belonging to two different orders (Cyclopoida and Calanoida) and 11 different genera were identified. *Diacyclopsthomas thomasi* was dominant species in all months. Shannon-Weaver Index (H) ranged from 1.75 to 2.90 representing moderate diversity of copepods. The study aims to explore relationship of biotic factors impact on the diversity and abundance of copepods from fresh water resources of Pakistan.

Key Words: Zooplanktons**,** Copepods, Protozoa, *Diacyclops bicupidatus*, physicochemical parameters

Introduction

Great stress has been observed in the aquatic ecosystem due to contamination of water with physical, chemical and biological agents. This contamination is the result of over exploitation of the lake resources due to increase urbanization and human globalization. Overuse of the lake water for irrigation and contagion of water by industrial agricultural effluents and municipal sewage is slumming water quality of lake water making it unfit for aquatic life especially plankton's life cycles and seasonal variations.

Zooplanktons are microscopic heterotrophic hovering organisms present in aquatic ecosystem of world (Throp, 1991). These include variety of protozoa, microscopic crustacean like copepods, rotifers and cladocera influencing all parameters like energy flow, food chain, trophic network and circulation of materials. Copepoda is one of the imperative groups of zooplanktons in the aquatic ecosystem. Copepods originated in the marine environment but later dominated in both fresh water and marine environment. Huys and Boxshall (1991) hypothesized that all ten orders of copepods produced in marine benthic environment. The diversity of these animals is due to huge range of their habitat.

As they are able to survive in both marine and fresh waters (Marten and Reid, 2007). They are prominent metazoans of the water community and comprise about 80% of zooplankton in the ocean (Mauchiline, 1998). Different studies revealed that physicochemical parameters of water body regulate diversity and density of flora and fauna of water body (Ayodele and Adeniyi 2006; Abdul Razak *et al*., 2009). It is thought that almost all animals of different phyla are found to be associated with the members of copepod, which help in the recycling of organic matters. Various studies have shown that the physicochemical parameters of the water body determine the major flora and fauna of the aquatic water body. In natural fresh waters and lakes, copepods are one of the main source of food for fingerlings and adult fish (Vandromme *et al*., 2010). Failure of the fishery was reported in many countries due to decline in zooplankton fauna especially copepods (Stottrup, 2000). Copepods are regarded as water quality indicator due to rapid response of fluctuation in water quality (Thor *et al*.,2005).

They are also valuable for fingerling as they feed copepods as intermediate consumers (Sommer *et al*., 2001; Feuchtmayr *et al*., 2004). From Pakistan, a little work has done on copepods. Diversity analysis of the copepods from Arabian Sea was reported by Kazami in 2004. Twenty one species of the copepods are by Naz in 2014. Shah *et al*., (2013) described distribution, abundance and diversity of Walnur Lake of Kashmir Himalaya. In 2016, significant contribution has been made by Maqbool *et al*., 2014 working on diversity of copepods and reported twenty species of copepods from Gujranwala fresh water pond. The present study was conducted to determine copepods diversity in Safari Zoo Lake that will prove helpful for aquaculture management especially in fish hatchery sector of Pakistan.

Materials and Methods

Study Site

Water reservoirs are important in local economics and ecological stability (Arslan and Ergul, 2014). Lahore Safari Zoo Lake is located in Lahore Zoo Safari (31.3870181085217 °N, 74.2111404677369 °E) or “Woodland Wildlife Park” which is eminent wild life and recreational park located on Raiwind Road, District Lahore, Pakistan. It was established in 1982 working under Punjab Wildlife and Parks Department (PWPD). An artificial lake known as “Safari Zoo Lake” contains five small islands was selected for sampling of copepods. This lake is spread over 5 acres and its depth is 5.5 feet. (Fig.1)

Sampling Procedure and Extraction of Copepods

Sampling was started from September, 2013 to August 2014. Copepods samples were collected on monthly basis from 10 am to 12 pm from the Safari Lake. The whole lake was divided into four sites, Eastern Safari Lake (SS-1), Western Safari Lake (SS2-2), Northern Safari Lake (SS3-3) and Southern Safari Lake (SS-4). Each site was further divided into four sites A-D. In order to stud the diversity and population density of planktonic copepods, samples were collected from lake in sample bottles.

Copepods sampling was done by taking about 100 liters of water in a bucket and passing through a sieve of mesh size 341 µm. The water was then filtered with a sieve having mesh size of 50 µm (Koste, 1978 ; Sulehria and Malik, 2012) and contents were preserved in 4 % formalin in 500 ml pre- cleaned bottles immediately after collection (APHA, 1995). The physico-chemical parameters analyzed include: Dissolved oxygen, salinity, turbidity, pH, electrical conductivity and temperature. Water temperature was measured in the field with thermometer. Other parameters were measured by using standard methods.

Quantitative Analysis and Biological Identification of Copepods

The numerical estimation of the Copepods in water sample was done by using Sedgewick-Rafter Counting chamber. Photographs of copepods were taken with the help of LEICA HC 50/50 microscope on which a 5.0 megapixel Cannon camera was fitted. In the laboratory, specimens were counted with the help of Sedgwick-Rafter (S-R) cell. The identification of the copepods were made on basis of the morphological features, body shape , number of body segments and segments of antennae of body and caudal ramii were observed for their identification. An attempt was made to identify copepods using standard keys for zooplanktons identification (Ward and Whipple, 1959; Kasturirangan, 1963; Dussart, 1968; Runttner-Kolisko, 1974; Harding and Smith, 1974; Keifer, 1936, 1978; Stemberger, 1984; Negrea, 1983; Battish,1992; Yunfang, 1995; and Koste, 2000)

Statistical Analysis

To find the significant differences among members of Copepods, Analysis of Variance (ANOVA) was performed. Pearson correlation was applied to find relationship between Copepods species abundance and physico-chemical parameters. Correlation test was applied to find out the relationships between the observed environmental parameters and copepod species. The software used for ANOVA and Pearson's correlation was Minitab 13. Simpson and Shannon -Weaver Indices, species richness and species evenness were utilized to find the diversity among different species of the Copepods of the Safari Zoo Lake.

Results and Discussion

In the present study, 12 species of copepods belonging to two different orders (Cyclopoida and Calanoida) and 11 different genera were identified (Table-I). Rich density of copepods was recorded during the month of May, June and July with highest in the month of June and July with 10 species in each month. *Diacyclopsthomasi*, *Mesocyclops sp.* and *Diacyclops bicupidatus were* found almost in all months but quantitatively showed variation. *Calanus australis* was found only in December, June, August and it was declared as least common among all months. *Diacyclops thomasi* , was the most abundant among all species and indicated its presence at all sites of study area. Copepods diversity was found maximum in the month of June and July and minimum in September and October (Figure 2). The values of Shannon Weaver Index ranged from 1.3572 to 2.9282 in September and May respectively. Simpson Index of dominance was at peak in the month of June with range of 0.9932. The value of Simpson Index of Diversity ranged from 0.6514 to 0.9906 in October and July respectively. Species richness was observed highest in the month of March (1.4771) and lowest in the month of October (0.3142). Species Evenness was recorded almost constant throughout the study period from September 2013 to August 2014. Minimum value of species evenness was recorded in the month of September (0.8433) and maximum in the month of March (1.1035). Simpson Reciprocal Index was recorded minimum in October (2.8691) and maximum in July (10.684) (Figure 3).Analysis of Variance of physico-chemical parameters showed that the air and water temperature, dissolved oxygen, Oxygen saturation pH, electrical conductivity, turbidity and transparency were statistically significant, as the value of P was less than 0.05. Copepods diversity was found maximum in the month of June and July and minimum in September and October. Pearson correlation was calculated between copepods and physicochemical parameters. Water temperature (0.224), dissolved oxygen (0.444), oxygen saturation (0.360) and electrical conductivity (0.437) showed positive correlation while pH (-0.086), turbidity (-0.240), salinity (-0.050) and transparency (-0.183) showed negative correlation. Species abundance curve revealed highest and lowest copepods abundance in all months. *Diacyclopsthomasi),* was at the highest peak point and *Calanusaustrilis*was present at least spot. Cluster Analysis (Dendrogram) was plotted for 12 different identified species for their comparative study. It showed 3 groups of different species. First group comprised *Mesocyclops* sp. and *Diacyclops bicupidatus,* Group II consist of *Eucyclops agilis, Ectocyclops phaleratus, Onychodiaptomus sanguineus* and *Macrocyclops albidus. Acanthodiaptomu spacificus, Macrocyclops fuscus, Calanus australis, Eucyclops agilis* and *Acanthocyclops viridis comprise* group III. *Diacyclops thomasi (Forbes, 1882),* show separate line (Figure 5).

Abundance and distribution of copepods is determined by many biological factors of a specific water body. Considering the data of various months, it was revealed that copepods species abundance and distribution is determined and regulated by various physicochemical parameters. Copepods population density and diversity was also found to be correlated positively or negatively with physicochemical parameters. These physicochemical parameters also interact with each other and overlapping pattern makes it difficult to check individual parameter is regulating copepods population density. In the current research all the physicochemical data was statistically supported and found to be highly significant (P=0.000).

In the current survey, 12 species of copepods belonging to two different orders and 11 genera were identified. This moderate density of copepod species was due to poor ecological conditions of Safari Zoo Lake. Availability of low quantity of organic matter was the main factor responsible for moderate population diversity of copepods. Subhamma (1992) also reported that organic matter decomposition is responsible for increase population density of copepods in sluggish water of the lake. Water and air temperature are important in regulating population density of copepods. Water temperature in Safari Zoo Lake during all study period ranged from 14.50 ºC to 33.50 and air temperature range from 18 ºC to 33.50 ºC. Water and air temperature are important in regulating population density of copepods. Water temperature in Safari Zoo Lake during all study period ranged from 14.50 ºC to 33.50 ºC and air temperature range from 18 ºC to 33.50 ºC. Highest water temperature was recorded in June and minimum in December. The present research shows positive correlation between temperature and copepods density. Increase in water temperature resulted in multiplication and high metabolic rate. Same record of temperature correlation was also observed by Joshi (2011), Salve and Hiware (2010).

Table 1: Abundance of Copepods in different months of study period from Safari Zoo Lake

Species	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apr	May	June	July	Aug	Sum
Acanthocyclops varidis	3.5	2.25	0	0	0	0.75	3	0	0	0	2.75	0	12.25
Acanthodiaptomusc pacificus	0	0	0	0	0	0	0	0	1.5	1.75	4.5	2.5	10.25
Calanus australis	0	0	1	2.75	0	0	0	0	0	1.75	3	0	8.5
Diacyclops bicupidatus	0	4.5	2.25	0	3.5	0	2.25	5.5	1.5	4	6.5	0	30
Diacyclops thomasi	4	4.5	3.35	0	2	3.75	3.75	3.75	4.25	5	6.5	1.75	42.6
Ectocyclops phaleratus	3.5	0	0	0	1.75	3.75	2.75	4	2.75	2.5	**0**	1.5	22.5
Microcyclops varicans	0	0	0	2.75	0	0	0	2.25	1	2.5	0	0	8.5
Eucyclops agilis	3.5	0	0	2.25	0	3	0	4.25	3	3.5	5	1.25	25.75
Macrocyclops albidus	0	0	0	2.75	3	0	3.75	2.5	0	1.5	5.5	2	21
Macrocyclops fuscus	2	0	0	0	0	1.875	0	0	1.5	0	3.5	0	8.875
Mesocyclops sp.	0	2.75	3.5	0	2.5	3.25	3.25	3	4	5.25	4.25	2.5	34.25
Onychodiaptomus sanguineus	0	0	2.75	2.25	0	0	0	4.5	3.25	3.75	3.5	2	22

Table 2: Physico- Chemical parameters of Safari Zoo Lake

AT: Air Temperature, WT: Water Temperature, DO: Dissolved Oxygen, OS: Oxygen Saturation, EC: Electrical Conductivity AT: Air Temperature, WT: Water Temperature, DO: Dissolved Oxygen, OS: Oxygen Saturation, EC: Electrical Conductivity, Tur: Turbidity, S: Salinity, T: Transparency

Parameters	AT (ºC)	WT (ºC)	DO (mg/L)	OS	pH	EC µS/Sec	Tur FTU	S ppt	T Inches
September	33.55	30.42	6.25	13.50	6.81	520	445	0.1	2.50
October	30.40	27.49	9.39	13.80	7.49	531	447	0.2	2.50
November	26.50	22.33	8.35	14	7.50	550	435	0.1	2
December	18	14.25	13.30	16.50	7.53	553	440	0.2	2
January	21.40	19.89	11.50	15	7.50	555	429	0.2	3.5
February	26.50	24.60	8.35	14	7.47	549	435	0.1	2
March	27	25.50	7.50	17.50	7.85	556	435	0.2	2
April	31.80	28.50	7.50	13	8.50	550	425	0.2	2.50
May	35	32	8	14.50	9.50	558	376	0.2	2.50
June	36	34	6.50	20.90	7.90	567	360	0.1	1.50
July	36	32	8	15	8.50	559	395	0.2	2
August	35	33.50	9	13	9	562	370	0.1	2

Dissolved oxygen is important physicochemical parameter which affects population density of zooplanktons in aquaculture. Dissolved oxygen showed positive correlation with abundance of copepod species .These results also considers with the Roman *et al*., (1993) also reported that hypoxic conditions can decrease the abundance of copepods through increased mortality. Copepods were found to be abundant in the upper layers of water with due to increased concentration of oxygen**.** pH value during study period ranged from minor acidic (6.50) to almost alkaline (9.50). Negative correlation was noted between pH and copepod population density. Maiphae and Sa-ardrit (2011) also described that the pH of the stagnant water mostly ranges from 7.4 to 8.7.pH showed negative correlation with copepods. *Sharma et al*., (2010) also reported that copepod population was periodically correlated with pH lake water throughout the year. Electrical conductivity of water samples show variation between 520 µS/Sec to 567 µS/Sec in September and June respectively. Ahangar *et al.*, (2012) studied relationship of copepods with electrical conductivity of water and found positive correlation between them. Negative correlation was observed between copepods abundance and turbidity of water. Salinity showed negative correlation with copepod population. Low level of salinity favors the growth and reproduction of copepods. Turbidity show negative correlation (-0.240) with copepod population. Similar results were also reported by Ahmad *et al.*, (2011). Increase in turbidity of lake water results in low feeding and increase mortality rate of copepods. Salinity also showed negative correlation with copepod population. Saline environment result in increased death rate of copepods. A negative correlation was observed between transparency and copepod population in the present studies. Joshi (2011) also studied negative correlation between transparency and copepods. A negative correlation was found between depth and electrical conductivity. Similarly Joshi (2011) observed that population of zooplankton negative correlation with transparency and it was well coincided with my results. Transparency is an important parameter in aquatic ecosystem and thus directly affects productivity, However in contras Transparency was observed to be lowest (167cm) in January 2005 and highest (178cm) in April (Koli and Muley, 2012).

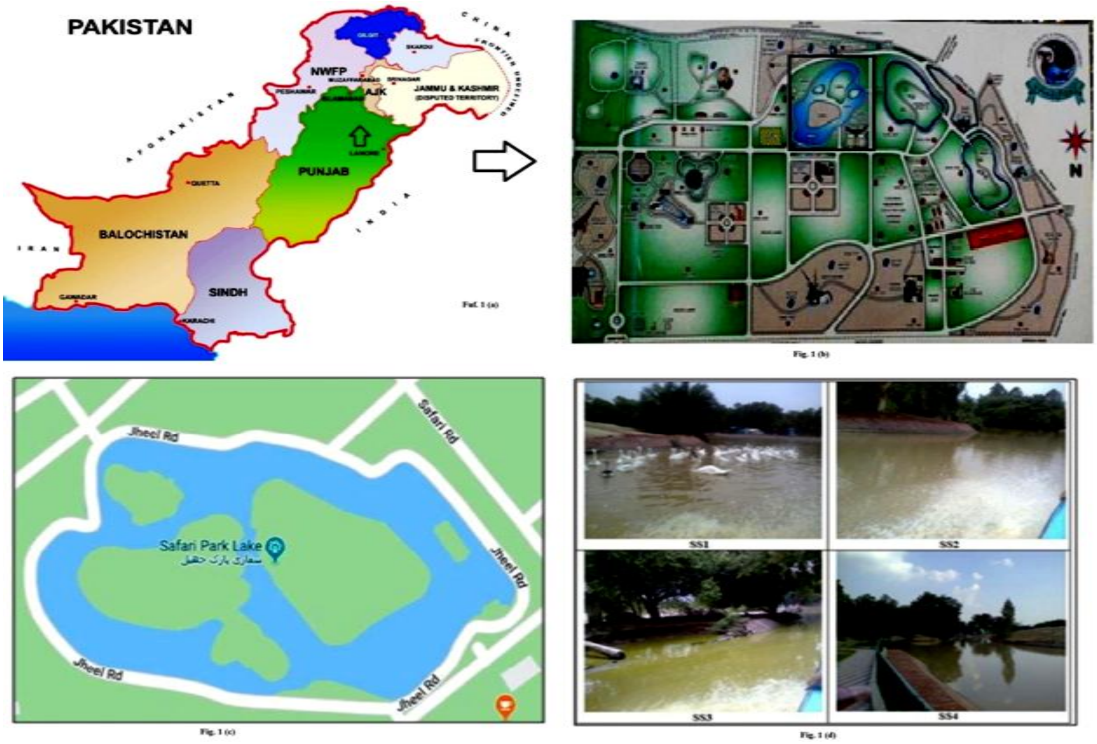

Fig.1. (a) Map of the study site in District Lahore; (b) Map of the Safari Zoo, Lahore ; (c) Safari Zoo Lake; (d) Different study Sites in Safari Zoo Lake.

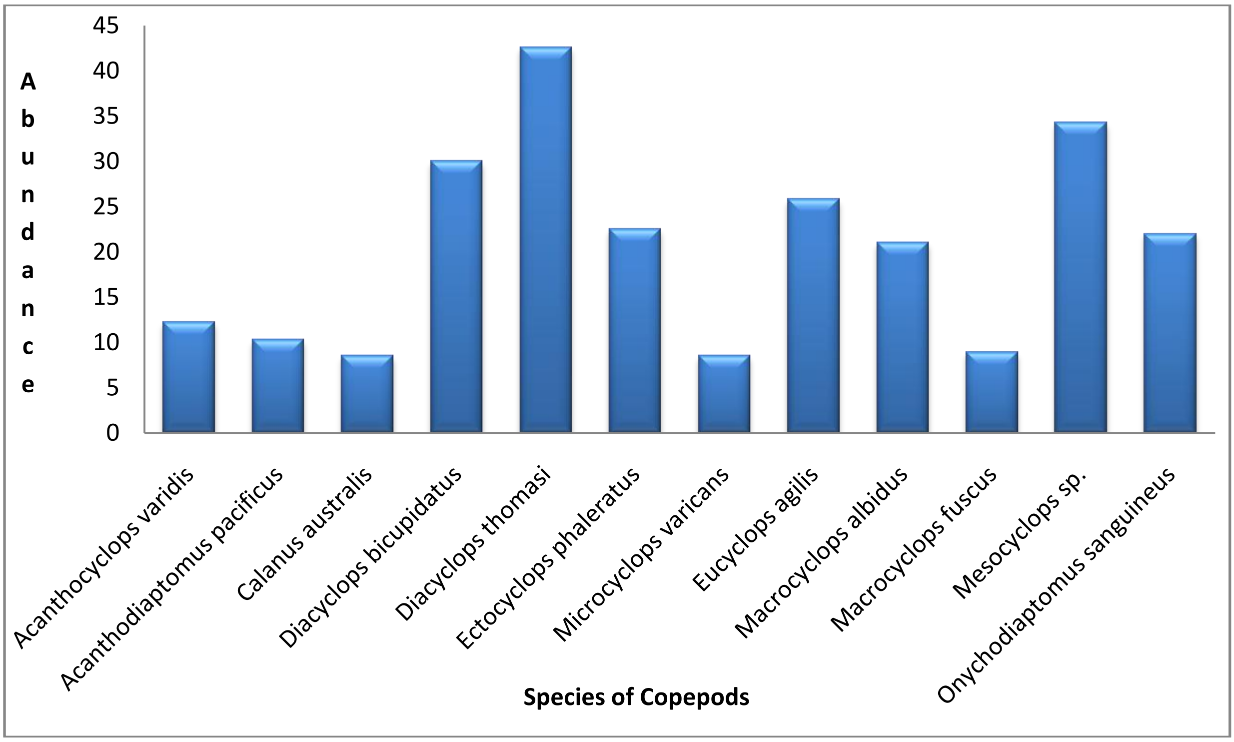

Fig.2. Relative percentage of the copepods of Safari Zoo Lahore from 2013-2014

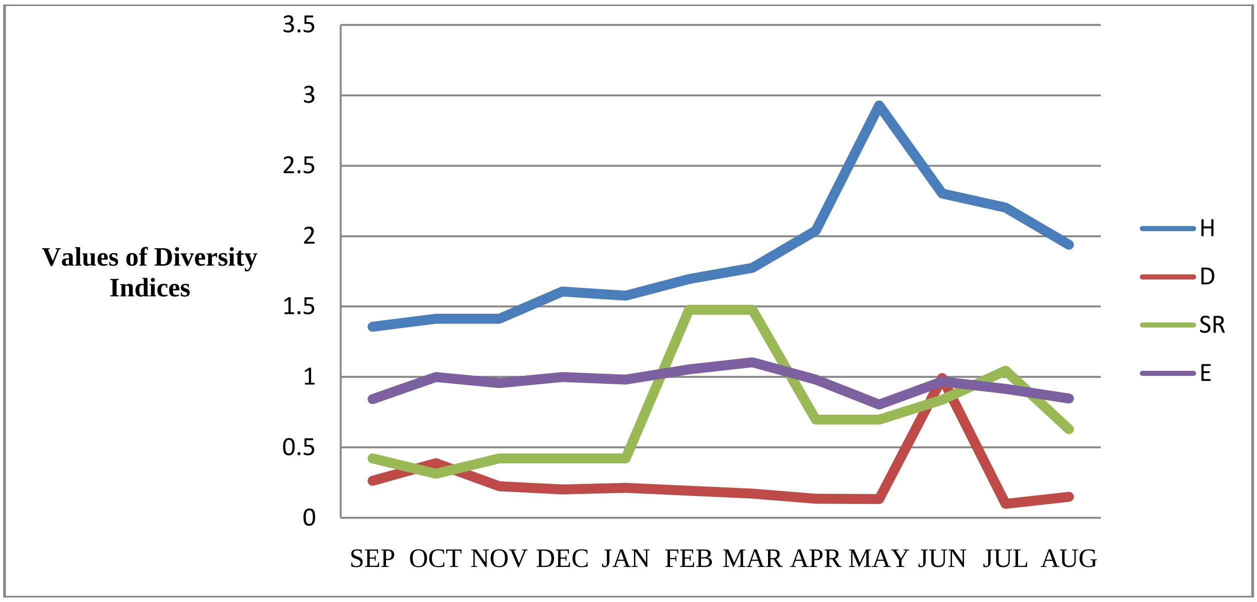

Fig.3. Graphical Representation of Variation Of Diversity Indices (H= Shannon Weaver Index; D= Simpson Index of Dominance; SR= Species Richness; E= Species Evenness)

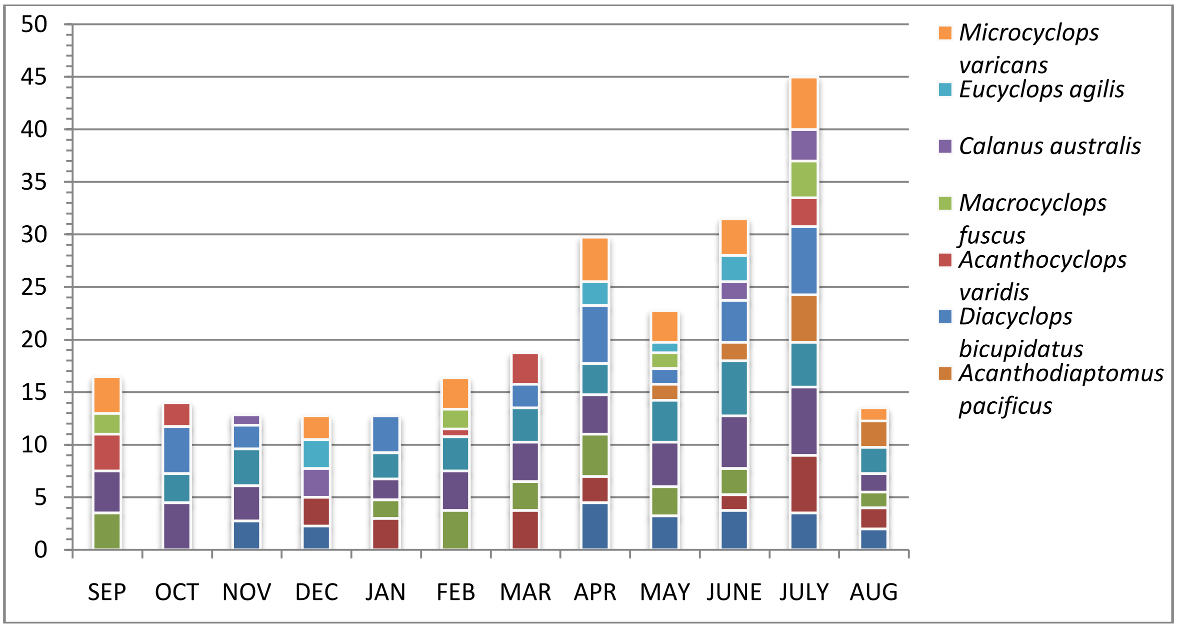

Fig.4. Monthly Percentage of different species of copepods during study period 2013-14

Three major groups or clusters were found in the cluster analysis. First cluster was composed of two species. This cluster consisted of *Mesocyclops* sp. and *Diacyclops bicupidatus.* Cluster II was composed of four species i.e., *Eucyclopsagilis, Ectocyclops phaleratus, Onychodiaptomus sanguineu* sand *Macrocyclops albidus. Ectocyclops phaleratus* and *Onychodiaptomus sanguineus*were more close to each other than *Macrocyclops albidus* and *Eucyclopsagilis.* Cluster III comprised 5 species i.e., *Acanthodiaptomus pacificus, Macrocyclops fuscus, Calanus australis, Eucyclops agilis* and *Acanthocyclops viridis. Calanusaustralis* and *Eucyclops agilis* were found to be more closely related as compared to others species.

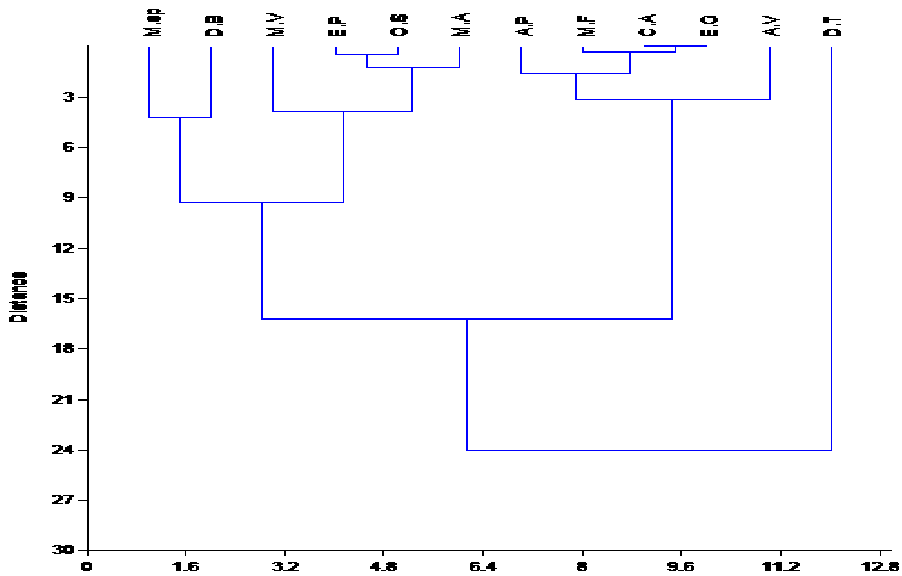

Fig.5. Dendogram of Copepods

(M.sp. = Mesocyclops *sp*; D.B = *Diacyclops bicupidatus;* M.V. = *Eucyclops agilis;* E.P = *Ectocyclops phaleratus;* O.S = *Onychodiaptomussanguineus;* M.A= *Macrocyclops albidus; A.P= Acanthodiapto muspacificus;* M.F= *Macrocyclops fuscus;C.A= Calanus australis;* E.A = *Eucyclops agilis;* A.V= *Acanthocyclops viridis;* D.T= *Diacyclops thomasi)*

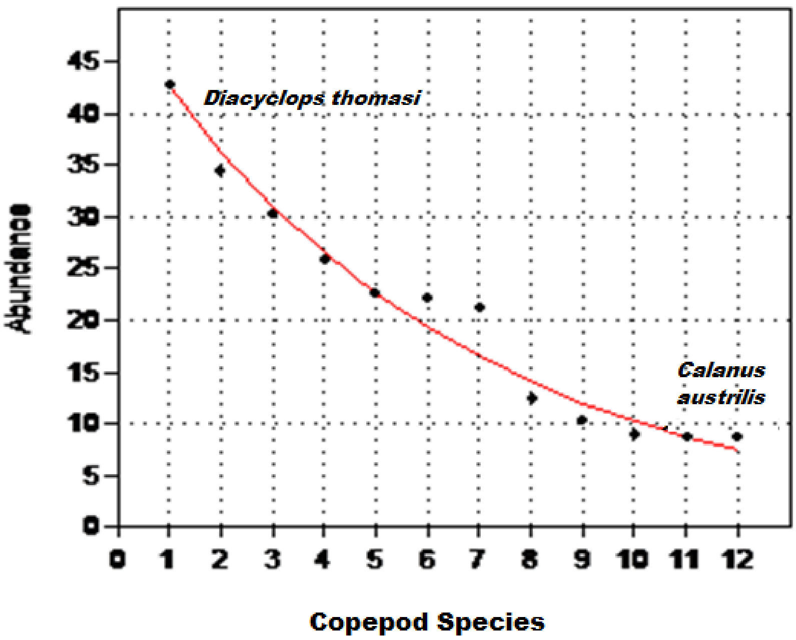

Fig.6. Abundance Curve of Copepods

(1: *Diacyclopsthomasi*; 2:*Mesocyclops sp.*; 3:*Diacyclopsbicupidatus*; 4:*Ectocyclops phaleratus*;5:*Macrocyclopsfuscus*; 6:*Microcyclopsvaricans*; 7:*Acanthodiaptomus pacificus*;8:*Acanthocyclopsvaridis*; 9:*Onychodiaptomussanguineus* ; 10:*Macrocyclopsalbidus*; 11:*Eucyclopsagilis* ; 12:*Calanusaustralis*)

Conclusion

Copepods exist in wide range of environments i.e., fresh water to brackish water. They are affected by a number of physicochemical parameters as evident in this study. *Diacyclops thomasi* found in the present investigation may be utilized to control larvae of *Aedes aegypti* which is the major vector for the spread of dengue fever as proposed by Nam *et al*., 2005 and Kalimuthu *et al*., 2017. Nauplius larvae of copepods may also be used as initial diet for fish fry culture. Copepod nauplii, which are just-hatched copepods, are important first foods for larval fish. Protozoans may also be eaten, but little is known about their contribution to fry diets. As little research work is done on copepods in Pakistan, there is need of extensive research work on zooplanktons especially copepods so that Aquaculture industry may impart significant role in country economy.

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