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BIODIVERSITY STUDY OF ZOOPLANKTON IN SELECTED BAHR Al-NAJAF DEPRESSION, NAJAF GOVERNORATE, IRAQ

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ABSTRACT

The current study aims to assess zooplankton diversity in Bahr Al-Najaf depression using diversity index, specimens were collected from five sites at Bahr Al-Najaf depression, Iraq during April 2017 to March 2018.

Forty- eight taxa of zooplankton were identified including 26 taxa to Copepoda, 17 taxa belonged to Rotifers and 5 taxa to Cladocera: Copepoda was the most dominant group (54.2%); Rotifera comprised (35.4%); Cladocera comprised (10.4%).

Relative abundance index of zooplankton showed Copepodite and nauplii of Harpacticoid, *Hexarthra mira*, *Daphnia* sp., *Harpacticoid* sp., and Copepodite and nauplii of Cyclops were more abundant. According to the constancy index, the Copepodite and nauplii of Harpacticoid, nauplii *Cyclops*, nauplii stage and *Hexarthra mira* can be considered as the most frequent; Shanon-Weiner diversity index values of zooplankton recorded less value 0.48 in August 2017 at site (5); while the higher value was recorded in April 2017 at site (2) was 2.42; the higher value of species richness index was recorded in April 2017 at site (2) which was (7.2), the higher value of species uniformity index was recorded in February at site (2) and March at site (1) (0.61).

The present study concluded that Copepoda was the most abundant of zooplankton with variations in zooplankton species (density and from month to another).

Keywords: Al-Najaf, Bahr, Biological, Indicators, Zooplankton.

INTRODUCTION

Zooplankton are considered an essential component in the aquatic ecosystem, which has a major of functioning as either primary or secondary links in the chain of food (Neves *et al*., 2003); and considered as a decent indicator to changes in the quality of water, as this is affected strongly by the conditions of the environment and responds very rapidly to alterations in the quality of the environment (Ismail and Adnan, 2016).

Zooplankton are aquatic small animals with a considerable capability of swimming and being manipulated by the currents of water column to transfer for long distances, moving frequently in the upper sides of water; they were found also deeply in the water, constituting heterotrophic (a nutrition variety); many of them feed on organic decaying materials such as (detritivores) and they connect the food chain as they feed on phytoplankton (Solomon *et al*., 2009). Diversity and density of Zooplankton also rely on the invertebrate's inter-specific predation (Lampert and Sommer, 1997); the diversity indicators are used as an essential device by ecologists to have insight into the structure of community regarding evenness, richness and total number of residents (Allan, 1975). This guild consists of three groups: Copepods, Rotifers, and Cladocerans; the Rotifer is one division in fresh water, but Cladocera and Copepoda, are both large groups named as crustaceans (Smith, 2001). These indicators are considered to be very important species to measure biomass production, population density, grazing and nutrient regeneration in lake ecosystems (Panwar and Malik 2015); studying zooplankton community abundance and distribution is done by using the bio-indicators as an essential proof of the water quality of Bahr Al-Najaf depression. As the study area is known to have high salinity (Al-Taee, 2017), we might find low zooplankton diversity; understanding salinity effects on zooplankton communities could help to understand consequences on the whole ecosystem.

This study was considered the first study at Bahr Al-Najaf depression; and the aim of the current study to assess zooplankton diversity using Shanon-Winner index, relative abundance index, constancy index, richness Index, and uniformity indexes.

MATERIALS AND METHODS

Sampling collection and diagnosis:

Monthly specimens were taken from five sites during the period from April 2017 to March 2018; zooplankton were collected from 30 cm depth, sampling was done from the edge of the lake and from distance 3 m from the edge by passing 60 liters of water across the plankton net with mesh 55 µm; the specimens were preserved in 4% formalin solution, then transported to the laboratory for isolating, counting and identification.

Diagnosis of zooplankton was conducted using a laboratory compound optical microscope, many keys were used Edmondson (1959), Smith (2001) and Petersen *et al*., (2010); the individuals' number was calculated for each cubic meter (Ind / m^3).

Study area:

The study area was conducted at Bahr Al-Najaf, the depression area having water body, it is located in the west and south-west of Holy Al-Najaf city at an estimated width and length of Bahr Al-Najaf (30- 60) miles, and the area is about 435 km^2; even though it is sounded by desert and with some grove lands, it has standing water seasonally depending on precipitation levels. Five sites were chosen for the study and mentioned in Map (1); the geographical coordinates of the studied sites were taken (Tab. 1).

Site one (S1): Located in the southern part of Bahr Al-Najaf depression adjacent to the main street, where there are some small tributaries that feed it like the Al Dasim River, also it is distinguished by fishing activities.

Site two (S2): Located 1 km from the first site; it's characterized by sweetness of its waters, because the source of the water is from Al-Dasim River and the presence of some aquatic plants such as Cane and Papyrus plants and some plants submersible.

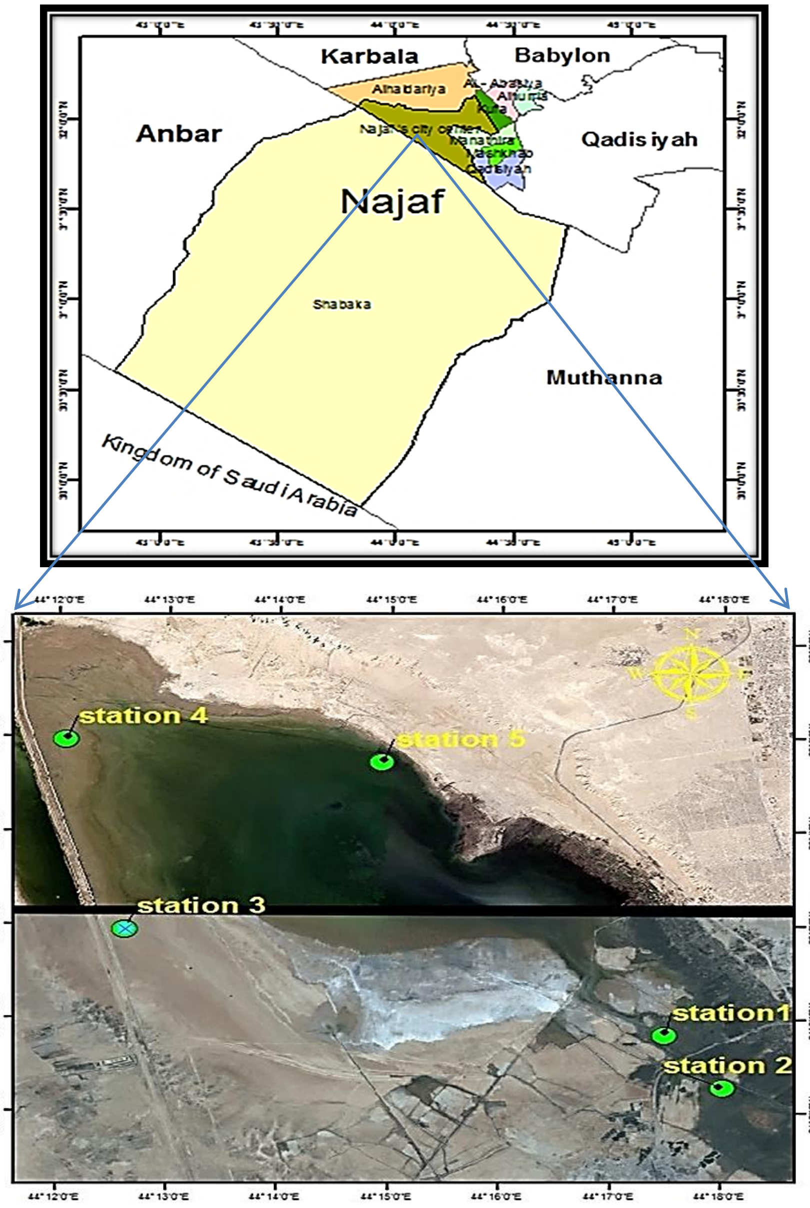
Site three (S3): Located on the western side of the depression near the oil strategic line, it's characterized by discharge of wells and spring waters.

Site four (S4): Located at the northern side of the Bahr Al-Najaf depression about 5 km away from the third site at the end of the of Bahr Al-Najaf depression, its water is highly saline and does not contain aquatic plants.

Site five (S5): Located in the northeast of the Bahr Al-Najaf depression located adjacent to Al-Hawalli street in front of the fourth station and is characterized by the presence of some aquatic plants such as Cane and Papyrus and the tributaries passing by the groves of Al-Najaf city.

Table (1): GPS values of study sites**.**

Sites	GPS	
	Longitude (East)	Latitude (North)
1	44° 17′ 49″	31° 58′ 15″
2	44° 18′ 01″	31° 57′ 05″
3	44° 12′ 44″	31° 25′ 23″
4	44° 12′ 00″	32° 01′ 44″
5	44° 14′ 57″	32° 01′ 03″



Map (1): The sites of study in Bahr Al-Najaf **(**Using Arc GIS 10 according to Landsat7).

Statistical analysis: Zooplanktons species diversity of the lake was determined through biological indicators.

Relative abundance index (Ra): This was calculated through the derivative formula proposed by Omori and Ikeda (1984), for the calculation of relative abundance:

$$Ra = \frac{N}{Ns} \times 100$$

N = individuals' total number per taxonomic unit in the specimens.
Ns = individuals' total number in the sample.
Where (R) rare less than 10% ,(La)less abundant10-40%, (A) abundant species 40 - 70 % and dominant species (D) appearing as more than 70%.

Constancy Index (S)
This index enables determining the frequency occurrence of a given species, (Serafim *et al*., 2003).
$S = n / N \times 100$
n = number of collections containing the group or species
N = total number of samples

The species groups were considered constant when they were recorded as more than 50% of the samples, accessory when present as 25 to 50% of the samples; accidental when recorded as less than 25% of the specimen.

Shannon-Weiner Diversity Index (H):
This was monthly calculated by the formula of Shannon-Weiner as explained in (Floder and Sommer, 1999).
$H' = -\Sigma (Ni /N) Ln (Ni /N)$
H = the Shannon diversity index
Ni= number of individual species
N=total number of individuals of all species.
1 < Low Diversity, (1 – 3) Moderate Diversity, 3 > High Diversity (Porto-Neto, 2003).

Species Richness Index (D)
This index was calculated from Magurran (2004) as follows:
$D =(S - 1)/ Log N$
S = number of species
N= Total number of species

Species uniformity index (E)
The species uniformity index was measured according to Neves *et al.,* (2003).
$E =H/lnS$
H= Shannon–Weiner index value.
S= number of species in the station.
Considered values greater than 0.5 as equal or uniformity in appearance.

The statistical analysis was performed with complete random design (CRD) with two ways ANOVA; the two factors include: The first was five sites and the second was 12 months. Sites include three replicates and the means of all data were separated by least significant difference (LSD) test at 0.05 level.

RESULTS AND DISCUSSION

In the present study, Copepoda was most abundant group as having 26 taxa (54.2%), 17 taxa of Rotifera (35.4%) and 5 taxa (10.4%) of Cladocera (Diag. 1). The obtained results showed that the low density of Copepoda in the August 2017 reached about 7 ind./m^3 at site

(5), and the higher density was recorded in December 2017 with 7566 ind./m^3 in site (5) (Diag. 2).

An increase in Copepoda community and their variation seasonally could come from many environmental factors. For example, increasing of salinity and temperature might cause this situation (Al-Zurfi *et al.*, 2019). This was also confirmed by previous studies (Shurin, 2000; Hampton and Gilbert, 2001); the dominance of Copepoda could come from the adaptation of these zooplankton groups to salinity and temperature factors, which could also explain our findings. For example, this group can adapt itself to different environmental conditions such as high or low temperature or lack of food, their ability to select prey, avoiding contaminated food (Gretchen *et al*., 2006).

The Rotifera recorded the lowest density in August 2017 which reached about 6 ind./m^3 in site (1) while the high density recorded in January was about 11801 ind./m^{3}in site (4) (Diag 3). This study showed, among zooplankton groups, that Rotifera were as second group in Bahr Al-Najaf, which comprised 35.4% of zooplankton; the highest densities of Rotifera were recorded during January which could be associated with the proper conditions like temperature and food availability, such as phytoplankton, detritus or bacteria (Dhanpathi, 2000).

The values of Cladocera density during the study period was illustrated in the Diagram (4). Cladocera was not recorded of any species in the August 2017; while the highest density has recorded in April 2017 with 188 ind./m^3 at the site (2). Zooplankton distribution was different in the same area from a month to another because of different environmental factors such as food availability, dissolved oxygen, salinity and temperature. All of these factors could influence the population density of zooplankton (Abbas *et al*., 2007).

Cladocera had the third lowest density in Bahr Al-Najaf, comprising 10.4% of zooplankton. Our results showed that the dominance species of Cladocera was *Bosmina longirostris* (O. F. Müller, 1776), this species could be a good food source for the Copepoda group. Our results showed that the highest densities of Cladocera was recorded in the study during March (2018) and April (2017). There was a significant decrease during the summer season (Jun, July, and August), and the current results agreed with Rasheed *et al*. (2017); phytoplankton and temperature could be the main factor impact on zooplankton species densities (Al-Taee , 2017).

Our results for relative abundance index and Constancy Index (S) of zooplankton showed that Copepodite and nauplii of Harpacticoid recorded the highest percentage with 64% at site (1) followed by *Harpacticoid* sp. 41%, and Copepodite and nauplii of *Cyclops* sp. with 40%. In site (2) *Daphnia* sp. recorded the highest percentage with 44%, followed by larvae of *Cyclops* sp. 35% and *Eucyclops* sp. 27 %. Site (3) recorded larvae of *Cyclops* sp.23 %, *Brachionus plicatilis* 18% and *Cyclops* sp. 9%. In site (4) *Hexarthra mira* (Hudson) recorded the highest percentage as 51%, *Brachionus plicatilis* 20% and larvae of *Cyclops* sp.17% ; whereas the larvae of *Cyclops* sp.46% followed by *Syncheata* sp.23% and nauplii stage 8% were recorded in the site (5) (Tab.2).

According to the constancy index, these species *Bosmina longirostris* (O. F. Müller) in the site (3), *Daphnia* sp. in the site (2); Copepodite and nauplii of Harpacticoid, Copepodite and nauplii of *Cyclops* sp. in the site (1), nauplii stage in the site (3), *Hexarthra mira* (Hudson) in site (4) could be the most frequent, and so they are the constant species of zooplankton in

Bahr Al-Najaf, according to this index as they were available in 50% or more out of the total samples in the current study (Tab. 2).

The relative abundance index values of the dominant species of zooplankton, which fail to reach to the percentage of abundant species or prevalent in all sites during the study period, this provides proof that the Bahr Al-Najaf hasn't been considered a favorable environment for the sovereignty of most species (Ahmed *et al*., 2011). On the other hand, Neves *et al*. (2003) highlights that a few species in lake Talaia in Brazil are dominant because of the high quantities of organic waste. The results showed that some species of zooplankton were a constant species in some sites of the Bahr Al-Najaf (Tab. 2), such as *Daphnia* sp., Copepodite and nauplii of Harpacticoid, Copepodite and nauplii of *Cyclops* sp., *Hexarthra mira* (Hudson), and nauplii stage. This could come from the widespread species in warm water with organic contamination (Hofman, 1977).

The obtained results showed that the minimum value of H index recorded in August (2017) at the site (5) was 0.48 while the highest value of H index was recorded in April (2017) at the site (2) as 2.42 (Diag.5); Shannon – Wiener diversity index of zooplankton ranged between 0.48- 2.42. According to this, water quality of Bahr Al-Najaf is of low to moderate diversity; most of the salt and contaminated water are a little diversity (Goel, 2008). In some previous studies of Iraqi marshes, Al- Saffar (2006) recorded diversity with a range of zero to 2.083 in the Abu Zirig Marsh.

D index values recorded the minimum value at August (2018) at site (5) and site (4), as 0.5; the higher value was recorded in April 2017 at the site (2), as 7.2 (Diag. 6); the highest value of D was recorded in April of zooplankton, the recording of high D index values in the spring may be due to the density and diversity of phytoplankton and high values indicating an environment suitable for the development and success of definite species (Badsi *et al*., 2010). This study recorded more than Rabee (2010) study, which revealed a value of D between 1.44-1.6 of Cladocera in Al Tharthar Canal.

Uniformity index of zooplankton, has shown the minimum value (E) recorded in August 2017 at the site (2), as 0.22 while the highest value of (E) was recorded in February at the site (2) and March at the site (1), as 0.61 (Diag. 7). The result of E index showed low values for zooplankton, the deficiency of E index in the current study is pointing to the dominance of a few species with high densities, which is a sign of environmental pressure, when the values of E index > 0.50. Rabee (2015) found high E index recorded in all sites and species of zooplankton were more evenly distributed in Al Habbaniyah lake.

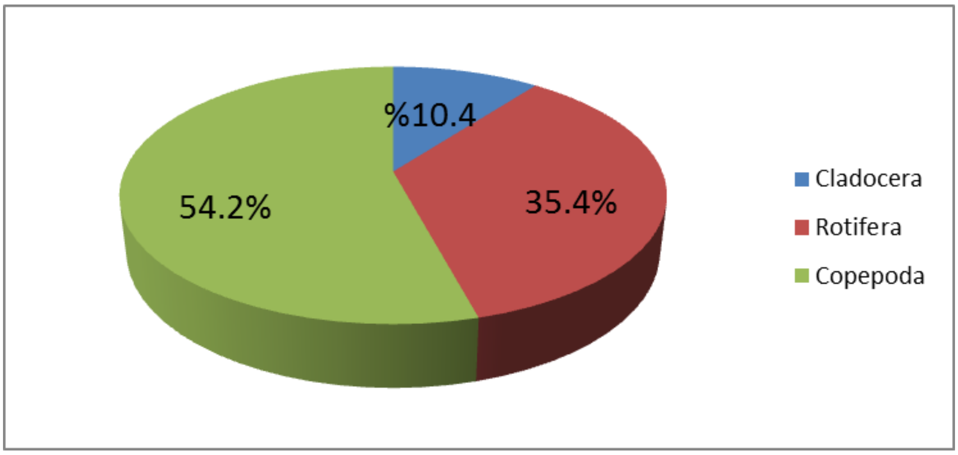


Diagram (1): The percentage of zooplankton in Bahr Al- Najaf during the study period.

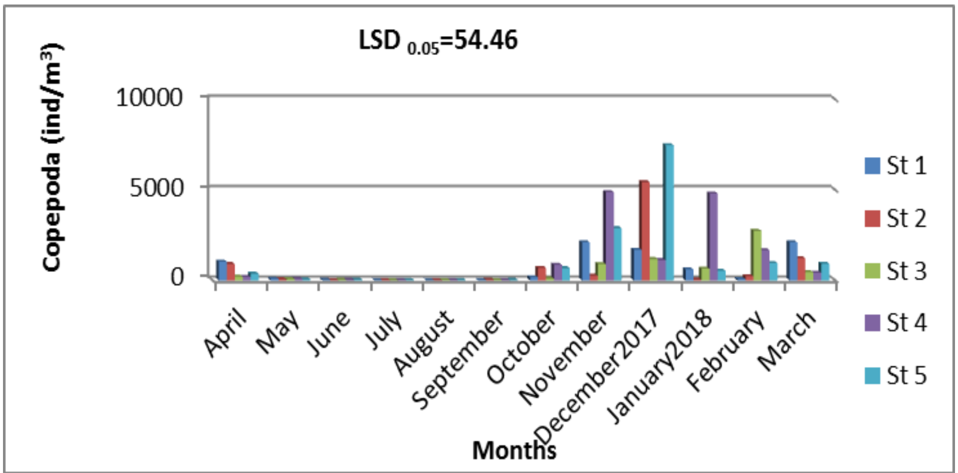


Diagram (2): The density of Copepoda (ind./m^3) in Bahr Al- Najaf during the study period.

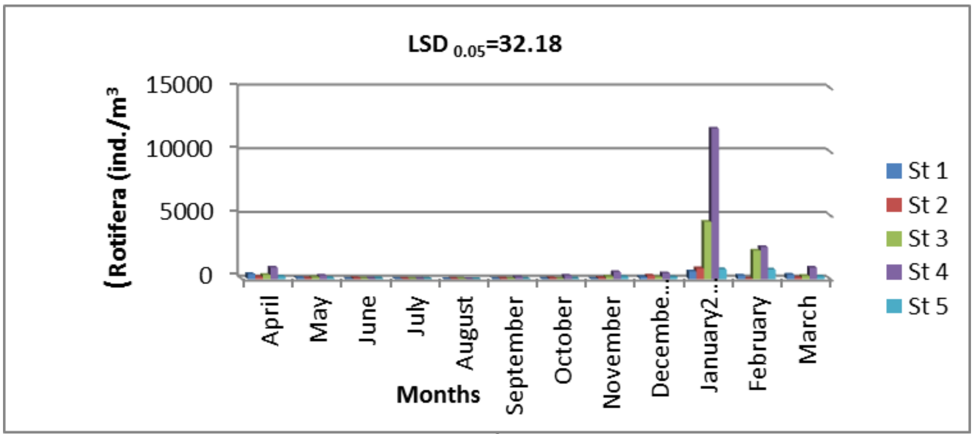


Diagram (3): The density of Rotifera (ind./m^3) in Bahr Al-Najaf during the study period.

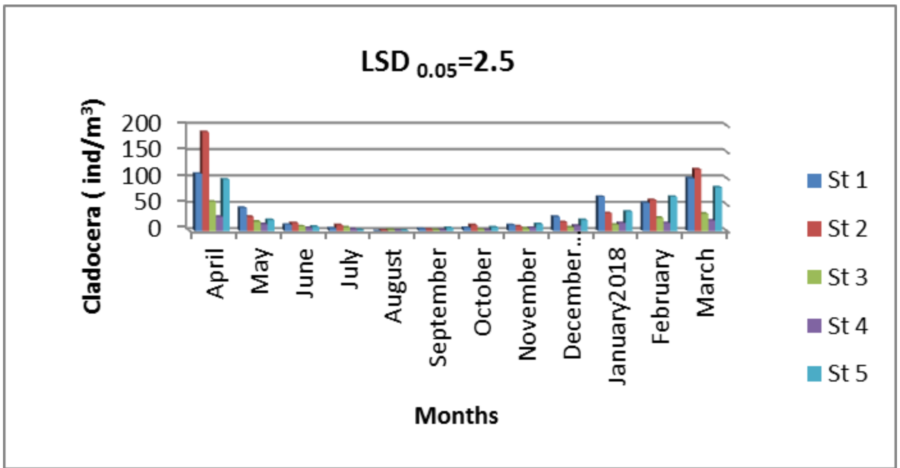


Diagram (4): The density of Cladocera (ind./m^3) in Bahr Al-Najaf during the study period.

Table (2): The Relative abundance index (Ra index) and Constancy index (S index) of zooplankton in study sites. where (R) rare less than 10%,(La)less abundant10-40%, (A) abundant species appearing 40 - 70 % and dominant species (D) more than 70%, A= Accidental species (1%-25%), Ac= Accessory species(25% - 50%), C = Constant species (greater than 50%) , — not recorded .

Group	Taxa	Sites of study									
		Relative abundance Index					Constancy Index				
		S1	S2	S3	S4	S5	S1	S2	S3	S4	S5
Cladocera	*Alona rectangular*	R	R	R	-	-	A	A	A	-	-
	Alona guttata	R	R	R	R	-	A	A	A	A	-
	Bosmina longirostris	R	R	-	-	R	A	A	C	-	A
	Chydorus sphaericus	R	R	-	R	R	A	A	-	A	A
	Daphnia sp.	R	A	-	-	-	A	C	-	-	-
Copepoda	*Bryocamptus* sp	-	-	R	-	-	-	-	Ac	-	-
	Cyclops sp.	R	R	R	R	R	A	A	Ac	A	A
	Cyclops navus	-	-	R	R	-	-	-	Ac	A	A
	Diaptomus sp	-	-	-	R	-	-	-	Ac	-	-
	Diaptomus gracilis	R	-	-	R	-	Ac	-	-	A	-
	Diaptomus sarsi	R	R	-	-	-	A	A	-	-	-
	Ectocyclops sp.	R	R	R	R	R	A	A	Ac	Ac	Ac
	Ergasilus sp.	-	R	-	-	-	-	Ac	-	-	-
	Eucyclops agalis	R	-	R	-	-	Ac	-	A	-	-
	Eucyclops sp.	R	La	R	R	R	Ac	A	Ac	A	A
	Halicyclops sp.	-	R	-	R	R	-	A	-	Ac	A
	Harpacticoid sp.	A	R	R	R	R	Ac	A	A	A	A
	Copepodite and nauplii of Harpacticoid	A	-	-	R	-	C	-	-	A	-
	larvae of *Bryocamptus*	-	-	R	-	-	-	-	A	-	-
	Copepodite and nauplii of *Cyclops*	A	La	La	La	A	C	A	A	A	A
	Limnocalanus sp.	R	-	-	-	-	A	-	-	-	-
	M .hylanus	R	-	-	-	R	A	-	-	-	A
	Macrocyclops fuscus.	R	-	-	-	R	Ac	-	-	-	A
	Macrocylops ater	R	R	R	R	R	Ac	A	A	A	A
	Mesocyclops sp.	R	R	R	La	R	Ac	Ac	A	Ac	A
	Mesocyclops sp.	R	R	R	R	R	Ac	Ac	A	Ac	A
	Nauplii stage (Lang, 1980)	La	La	R	R	R	Ac	A	C	Ac	Ac
	Nitocra sp.	R	R	R	R	R	A	A	A	A	A
	P.fimbriatus	R	-	-	-	-	A	-	-	-	-
	Paracycolps affinis	R	R	R	R	R	A	A	A	Ac	A
	Tropocyclops sp.	-	R	-	-	-	-	A	-	-	-
Rotifera	*Brachionus rubens*	R	R	R	R	R	A	A	Ac	Ac	A

	Brachionus sp.	-	R	R	R	-	-	A	A	Ac	-
	Brachionus angularis	-	R	-	-	-	-	A	-	-	-
	Brachionus plicatilis	R	R	La	La	R	Ac	A	Ac	Ac	A
	Cephalodella sp.	R	-	-	-	R	A	-	-	-	Ac
	Colurella adriactica	-	-	R	R	-	-	-	A	Ac	-
	Hexarthra mira	R	R	R	A	R	A	A	A	C	A
	Keratella quadrata	-	-	-	-	R	-	-	-	-	A
	Keratella valga	-	R	-	-	-	-	A	-	-	-
	Lecane sp.	-	-	R	-	-	-	-	A	-	-
	Macrochaetus lunaris	R	R	-	R	-	Ac	A	-	A	-
	Macrochaetus subquadratus	R	R	R	-	-	Ac	A	Ac	-	-
	Monostyla sp.	-	-	-	R	R	-	-	-	Ac	A
	Notholca squamula	-	-	-	R	-	-	-	-	Ac	-
	Philodina roseola	R	R	R	R	R	A	A	Ac	Ac	A
	Syncheata oblonga	R	-	R	R	R	A	-	Ac	A	A
	Syncheata sp.	La	R	R	R	La	Ac	A	Ac	A	Ac

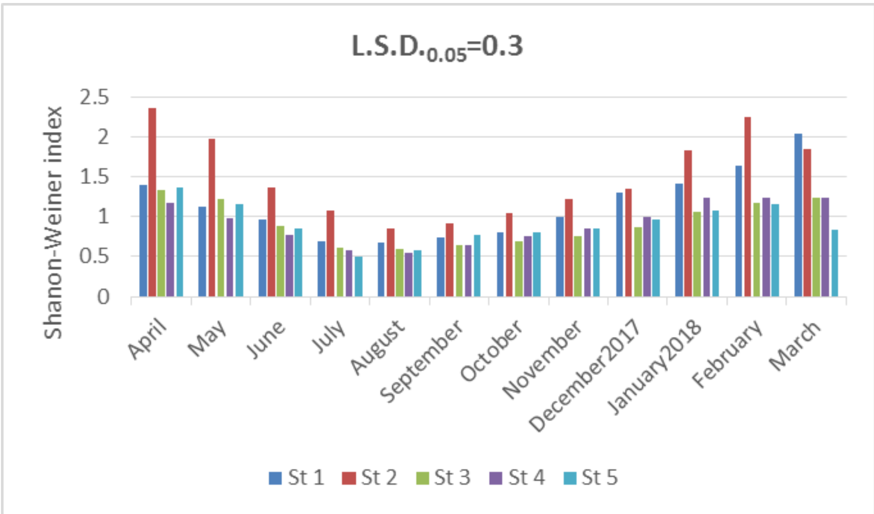


Diagram (5): Shannon-Weiner index of zooplankton in different study sites in Bahr Al-Najaf.

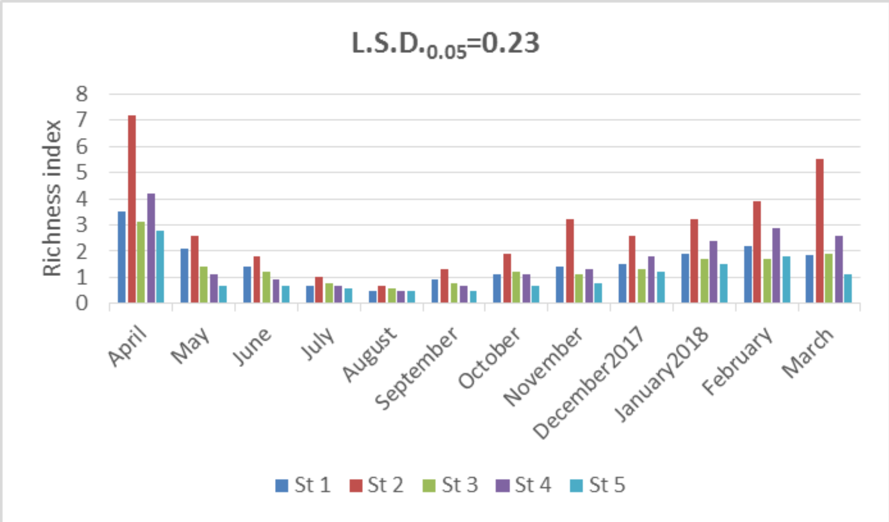


Diagram (6): Species richness index of zooplankton in different study sites in Bahr Al-Najaf.

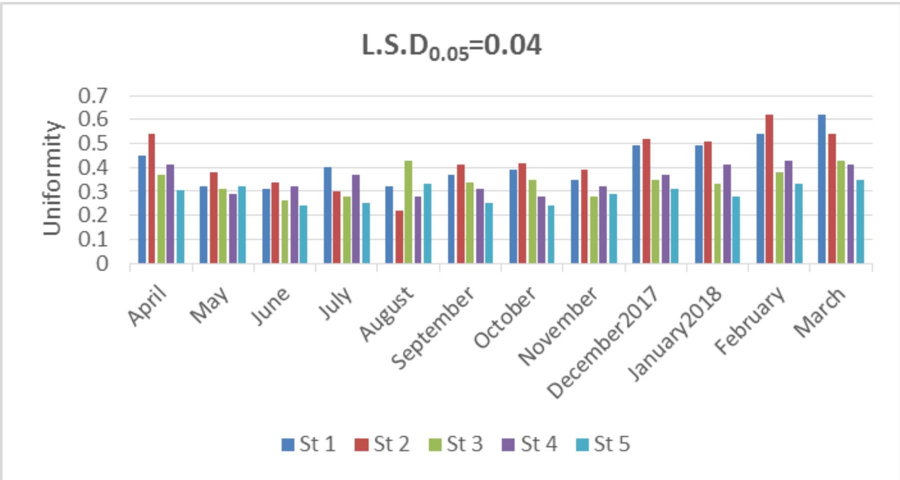


Diagram (7): Species uniformity index (E) of zooplankton in different study sites in Bahr Al-Najaf.

CONCLUSIONS

The Copepoda was the most abundant group of zooplankton; the species varied in their density from species to species, as well as from month to month; the *Hexarthra mira*, *Daphnia* sp, Copepodite and nauplii of *Cyclops* sp. , Copepodite and nauplii of Harpacticoid and nauplii stage had the highest density among all zooplankton. Bahr Al-Najaf depression had a moderate diversity in April, March, February and January, according to Shannon – wiener diversity index. Further studies focusing on the relationship between the zooplankton and phytoplankton seasonally could help understanding the whole community interactions.

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دراسة التنوع الاحيائي للهائمات الحيوانية في منطقة مختارة من منخفض بحر النجف، محافظة النجف، العراق

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الخلاصة

هدف الدراسة الحالية إلى تقييم تنوع الهائمات الحيوانية في منخفض بحر النجف باستخدام مؤشر التنوع؛ اذ جمعت عينات الهائمات الحيوانية من خمسة مواقع في منخفض بحر النجف وسط العراق خلال الفترة من نيسان ٢٠١٧ إلى اذار ٢٠١٨؛ حيث اظهرت النتائج تشخيص ٤٨ نوعًا من الهائمات الحيوانية، وشملت ٢٦ نوعاً تابع إلى صف مجموعة مجذافيات الاقدام Copepoda ، و ١٧ نوعاً تنتمي إلى الدولابيات Rotifers و ٥ أنواع تنتمي إلى براغيث الماء .Cladocera . وقد لوحظ ان مجموعة مجذافيات الاقدام Copepoda هي المجموعة السائدة وكانت نسبتها ٥٤,٢ ٪ ، وتاتي بعدها الدولابيات Rotifera ٣٥,٤% وأخيرا براغيث الماء Cladocera التي شكلت نسبة ١٠,٤ ٪ .

أظهر دليل الوفرة النسبية للهائمات الحيوانية: nauplii Harpacticoid و *Hexarthra mira* و *Daphnia* sp. و *Harpacticoid* sp. ويرقات السايكلوب هي الاكثر وفرة في منخفض بحر النجف. ووفقا لمؤشر الثبات، يمكن اعتبار كل من: Harpacticoid ويرقات السايكلوب و *Hexarthra mira*، هي الأكثر تكرارًا؛ وسجلت أقل قيم مؤشر شانون-وينر للتنوع ٠,٤٨ خلال شهر اب ٢٠١٧ في الموقع (٥) بينما سجلت اعلى قيمة خلال نيسان ٢٠١٧ في الموقع (٢) وكانت ٢,٤٢، وقد سجلت أعلى قيمة لدليل الاثراء خلال نيسان ٢٠١٧ في الموقع (٢) الذي كان ٧,٢، وتم تسجيل أعلى قيمة لمؤشر تجانس الأنواع في الموقع (٢) خلال شهر شباط واقل قيمة سجلت في الموقع (١) وكانت ٠,٦١ خلال شهر اذار.

استنتج من الدراسة ان مجموعة مجذافيات الاقدام Copepoda هي المجموعة الأكثر وفرة من الهائمات الحيوانية في منخفض بحر النجف، وتراوحت أنواع الهائمات الحيوانية في كثافتها من نوع إلى اخر، ومن شهر إلى اخر.