EUROPEAN ACADEMIC RESEARCH
Vol. IV, Issue 10/ January 2017

Impact Factor: 3.4546 (UIF)
DRJI Value: 5.9 (B+)

ISSN 2286-4822
www.euacademic.org

Distribution and Occurrence of Copepoda in Tigris River, and effect of Diyala River on its Biodiversity

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Abstract:

Quantitative and qualitative composition of copepoda communities was studied during the period from January to December 2014 at five stations that were selected on the Diyala and Tigris River in the south of Baghdad Province. One of the stations2 located at Diyala River to represent the ecological features of it on the Tigris River, whereas other stations 1 were located on the Tigris River before joining the Diyala River as a control station to investigate the ecological characters of the Tigris River.

Moreover, the three other stations 3, 4 and 5 were located down to the impact of the Diyala River to reflect the possible effects of the Diyala River on the ecology of the river by comparison with the control stations. 40 taxonomic units for the period from January 2014 until December 2014 for all study stations, represented by 13 taxonomic unit's belonging to Calanoida, 17 taxonomic units belonging to Cyclpoida and 8 taxonomic units belonging to Harpacyicoida, two taxonomic units belonging to Parasitic Copepoda and one taxonomic units belonging to the larvae of copepoda formed 18%, 22%, 3%, 0%, 57%, percentages respectively. Generally the result of biodiversity indicators shows the negative effect of Diyala River on the copepoda community.

Key words: Diyala River, Biodiversity, Copepoda, Tigris River

INTRODUCTION

Tigris River pelvic area of about 190,000 Km^2, a length of about 1970 Km, flows from the highlands of southeastern Turkey, the river is characterized by freshwater with many tributaries when he entered Iraq. Five natural tributaries, namely: - KHabur Upper Zab, Lower Zab, Al-Adam and Diyala, all of which are in the northern and central regions in Iraq and north of Baghdad City, with the exception of the Diyala River which flows into the south [12]. Diyala River stems from in eastern Iraq on the outskirts of Hörmann Mountains within the Iranian Mountain Highlands of this river is about 386 Km from its source up to its confluence with the Tigris south of Baghdad and near Altoutha towns [11]

Diyala River, which is a major tributary of the hydrochemical that affecting especially in the water of the Tigris River system [12]. So it is necessary to study the biological composition, especially copepoda fauna of Tigris and Diyala River to see the impact of Diyala on the Tigris River. Also the current study is the first study after the war of 2003, so the current study was aimed to determine the effect of the Diyala River in the quantity and the diversity of copepoda community.

MATERIAL AND METHODS

Monthly sampling was starting from January until December 2014 from the five stations under from a depth of 0.5 - 1 meter below the water surface, then 45 liters was passing through the zooplankton network with mesh size 55 microns and preserved samples by adding formalin 4%. The sample was examined under a compound microscope and diagnosed the

species depending on the following diagnostic keys [15, 35, 37]. The results expressed for individual / m^3.So was chosen four stations to know the effect of the Diyala river in copepoda community (Fig. 1), as follows: -

Station (1) Located on the Tigris River before joining the Diyala River (which represents the control station) in the Zaafaraniya City near the Animal and Fish Resources Center/ Directorate of Agricultural Research / Ministry of Science and Technology, before 2 Km from the joining point.

Station (2) This station was located on the Diyala River after sewage treatment plant, waste Rusafa (Rustumiya) before 3 Km from its joining with the Tigris (near the old Diyala Bridge).

Station (3) This station was located on the Tigris River, after its joining with Diyala, just 500 meters from the joining of two rivers which represents the mixing between the two rivers.
Finally, the two stations (4 and 5) were located down of the Tigris River, about 3 and 5 Km from the station (3), respectively.

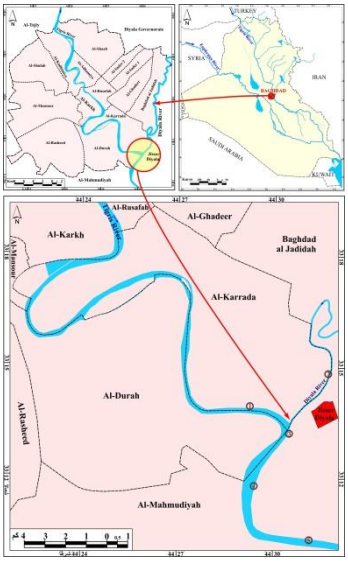


Figure 1: Map represents the study stations.

The following Ecological Indices were account:
Relative Abundance Index (Ra): The calculated of (Ra) was depending on the formula contained in [34]. **Constancy Index (S):** By the presence and frequency of each species, calculated according to the formula contained in [41]. **The Species Richness Index (D):** This indicator is calculated monthly according to the formula contained in [43] .**Shannon – Weiner Diversity Index (H):**Values of this indicator were calculated monthly for all groups of invertebrates by using the equation of Shannon and Weiner according in the [17]. And the result expressed as the unit bit / Ind.as a bit equal one piece of information. Values less than 1 bit / Ind. is a little diversified while the values more than 3bit/Ind. is most highly diversified [37]**. The Species Uniformity Index (E)**: The species uniformity index measured according to the formula contained in the [33] .Considered values greater than 0.5 as equal or uniformity in appearance.

RESULTS AND DISCUSSION

The density of copepoda in the present study varied between great value reached 4999.97 Ind./ m^3 during of October 2014 at station 5 and does not appear in the station 2 during April 2014 (Figure 2).

At station 1 before join Diyala with Tigris River the density varied between great value reached to 4266.64 Ind./ m^3 during October and minimum 99.99 Ind./ m^3 in April, Whereas great value at station 2 on Diyala River was recorded 1766.63 Ind./ m^3 in January and does not appear in April, while as great value at stations down of join Diyala with Tigris River reached at 4999.98 Ind./m^3 in October at station 5 and the minimum value was 53.33 Ind./ m^3 in January at same station.

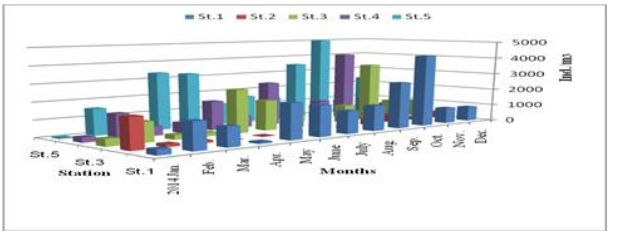


Figure 2: Seasonal variations of the copepoda total density Ind./ m^3 in the study stations during the period from January 2014 until December 2014.

In general, many of the local and global studies indicated that the appearance or disappearance of copepoda depends on many environmental factors, it can adapt itself to different environmental conditions such as high temperature or decline or lack of food or predation, where Copepoda stage and adult tend to dormancy and this explains her disappearance in some months, and the numbers affected by the concentrations of salts and organic matter in the Diyala River in combination with increased food appropriate [14] , so the decline in members of this group in aquatic environments is a good evidence indicates of the higher plant nutrient percentages in the aquatic environments [40].

The high densities of copepoda in the present study during of October may be due to the intensity influenced by water temperature and food availability [29] . The positive correlation of copepoda with temperature indicates that they grow and develop better in warm periods [46]. The result of this study agree with the findings of the study all of [8 , 10 , 23] with all of these studies have shown that the increase in density of copepoda in the fall associated with increased appropriate food and lack of predators of the vertebrate organisms and aquatic invertebrates which It may be an selection for a certain reluctance [30] .

The minimum densities for copepoda in winter, may be due to the fall rains, increased river discharge and increase

turbidity that cause the lack of an abundance of phytoplankton.[45] has noted that the relative abundance of copepoda affected by fish prey and inorganic turbidity while [19] showed that the Higher rainfall , discharge of the river and the lack of an abundance of phytoplankton, which may be due to increase turbidity that important factors which regulate the presence and distributed of copepoda.

The highest quantities abundance of copepod after join Diyala with Tigris River, at station 5 may be due to the abundance of algae, which is the Main food of this group [22] . Whereas the lowest values recorded in the Diyala River at station 2 may be related to the high pollution, as well as the high level of the turbidity level of this station. [24] has noted that the lack of copepoda in the Haraz River in Iran due to an increase turbidity which caused the death of their immature stage, and the inhibition growth of available selected food. In this study the Nuplii formed a high percentage of their density and this agree with [33] when they mentioned that the dominant majority of immature stage especially the Nuaplii, which due to continuous reproduction of copepoda and the lack of predation by invertebrates and vertebrate predators [15] as well as the predation of cladocera and copepoda offers algae to copepod larvae [39].

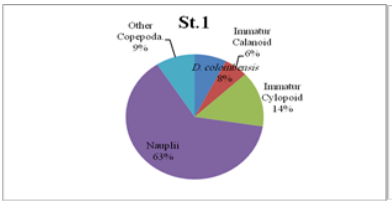
Regarding to the Relative Abundance index Table (1) the percentages of species copepod appearance in the study period for each station of the study stations, as follows:- at station 1 showed nuaplii of copepoda was with the highest percentage(63.34%) compared to the total density of other species followed by Immature Calanoid was recorded 5.68%, and then *Halicyclops* sp. was recorded 4.84%. As at the station 2 has Nuaplii appeared the highest percentage was reached to 61.33% fallowed by Immature Cyclops was recorded 21.8%, while at station 3 Nuaplii appeared highest rate reached to 56.27%, then followed by *Diaptomus sarsi* was recorded 10.95%,

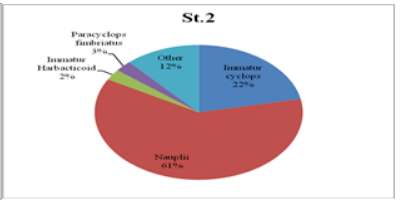
and then *Diaptomus bacillifer* was recorded 7.3%. Also at station 4 Nuaplii appeared highest rate was reached to 53.62%, followed by Immature Calanoid 11.54%, and *Diaptomus colombiensis* 10.95%. But at the station 5 Nuaplii has appeared the highest ratio was reached to 49.94%, followed by *Halicyclops* sp. 9.1% and then Immature Calanoid 8.19%. Generally Nuaplii appeared high up at station 1, and then began to decline at all stations bellow join Diyala with Tigris River 3, 4, 5 which was reached to 49% and this may be due to increased concentrations of salts and organic material in the Diyala River, that affected to some weak and inactive larvae so the survival of them was resist abnormal conditions [7,8] . Immature Calanoid has appeared by 5% at station 1 and did not appear at station 3 that located below join Diyala with Tigris River, then appeared on stations 4 and 5 by 11% 0.8% respectively. The rising of turbidity in the Diyala River may be due to disappear Immature Calanoid [24], which had a negative impact on the appearance of these species at station 3, (a confluence of two rivers point) and then appear in the following stations may be due to dilution ratio of turbidity at these stations. Also *Halicyclops* sp. appeared by 4% at station 1 then has not been seen at all stations except at station 5 by 5% and this may be due to the unfavorable presence in the previous stations and force their numbers by these circumstances conditions.

Table 1: Copepoda taxonomic units, relative abundance and constancy Index of study stations.

	Ra%						S%				
Copepoda Station	**1**	**2**	**3**	**4**	**5**		**1**	**2**	**3**	**4**	**5**
CALANOIDA											
Diaptomus albuquerquensis	-	-	R				0	0	A	0	0
Diaptomus amatitlanensis	-	-	R		R		0	0	A	0	A
Diaptomus arapahoensis	-	-	R		-		0	0	A	0	0
D.bacillifer	-	-	R	R	-		0	0	A	A	0
D.clavipoides	-	-			-		0	0	0	0	0
D.colombiensis	-	R		La	R		A	A	0	A	A
Ds.dorsali	-	R			-		0	A	0	0	0

D.gracilis	-	-	R		R		0	0	A	0	A
D.floridanus	-	-	R		R		0	0	A	0	A
D.franciscanus	-	-	R	R	R		0	0	A	A	A
Diaptomu novemdecimus	-	R	R		-		0	A	A	0	0
D.sarsi	R	-	La		R		A	0	Ac	0	A
Diaptomus sp	-	-			R		A	0	0	A	A
Immature Calanoid	R	R		La	R		Ac	A	0	Ac	Ac
CYLOPOIDA											
Cyclops crassicaudis brachycercus	-	R	-	-	-		-	A	-	-	-
Cyclops jeanneli puti	-	-	-	R	-		0	0	-	A	0
Cyclops lattipes	R	-	-	-	-		A	0	-	0	0
Cyclops magna	-	-	R	-	-		0	0	A	0	0
Cyclops vernalis	-	-	-	-	R		0	0	0	0	A
Cyclops venustoides	-	-	R		-		0	0	A	0	0
Ectocyclops sp.	R	-	R	R	R		A	0	A	A	C
Ectocyclops phaleratus	-	-	R	R	-		0	0	A	A	0
Eucyclops agilis	R	-	-	-	R		A	0	0	0	A
E.spertus	-	-	-	R	-		0	0	0	A	0
Halicyclops sp.	R	-	R	R	R		C	0	C	C	C
Macrocyclops ater	-	-	R	-	-		0	0	A	0	0
P. affinis	R	R	R	R	R		Ac	A	A	A	A
P. fimbriatus	R	R	R	R	R		Ac	A	Ac	C	C
♂ Cyclops	R	-	R	R	R		Ac	0	Ac	A	C
Cyclops sp.	R	R	R	R	R		A	A	A	A	A
Immatur Cyclops	R	La	R	R	R		C	A	Ac	Ac	C
HARPACTICOIDA											
Nannopus palustris	-	-	R	-	-		0	0	A	0	0
Nitocra lacustris	R	R	R	R	R		A	A	A	A	A
Nitocra spinipes	R	-	-	-	-		A	0	0	0	0
Nitocra.sp	R	-	R		R		A	0	A	0	A
Harpaticoia sp.	R	-	R	R	R		A	0	A	A	A
♂*Harbactecoida*	R	-	-	-	-		A	0	0	0	0
Onychocamtus mohammed	-	-	R	-	-		A	0	A	0	0
Immature Harpacticoida	R	R	R	R	R		Ac	A	Ac	Ac	Ac
Nauplii of Copepoda	A	A	A	A	A		C	C	C	C	C
PARACITIC CYCLOPS											
Ergasilus	R	-	-	-	R		A	0	0	0	A
Lernae	R	-	-	R	-		A	0	0	A	0





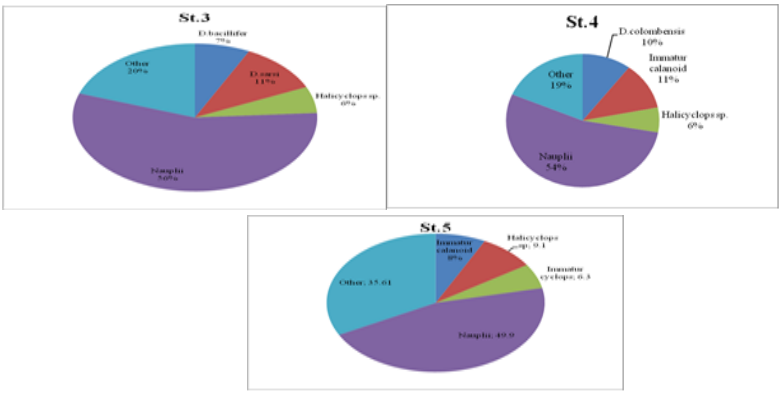


Figure (3): Relative abundance of the dominant copepoda in the study stations during the period January 2014 until December 2014.

The highest values appearance of Nuaplii within the relative abundance of index in all stations could be due to a number of reasons, including that this group represents developmental stages of copepoda that pass through her life in five or six stages of Nauplius Stages, and six stages Copepodid stages, these last is similar to an adult also many this larval stages and copepoda difficult diagnosis, therefore count toward taxonomic unit of Nuaplii [15] . The dominated of these larval stages on other taxonomic units may return to the appropriate environmental conditions, continuous reproduction of this group, as well as to the presence of predators that feed on adult as well as carry around with a wide range of environmental conditions species [7,8] also noted all of[44] That control Nauplii in the Tigris River was due to the impact of suspended solids within the water column resulting from wind act or as a result of predatory fish pressure, As Immature Cyclops belonging to Cyclopoida group was highly appearances at station 2 was reason it is that as if it prefers living in oligohalin water [15] . Also, the high-density of Immature Calanoida compared to other types could be due to the fact that this kind is under Calanoida group that most species be planktoic compared with other level that prefer coast of water bodies in

the living[21] Also this group is dominated among copepoda It is closer to 80% of the total copepoda [31].

According to constancy index the following species were constant species in the Tigris River: Nauplii*, Halicyclops* sp. Imature Cyclops*, Paracyclops fimpriatus, Ectocyclops* sp.*, Cyclops*♂.

Which included three constant species at station 1 while dropped to two constant species at station 3 that located at the joint point, whereas appeared three constant species at station 4 and finally the number of constant species increased to six constant species after removal the influence of the Diyala River at station 5.While the constants species of the Diyala River represent by 83.33% of Nauplii only.

These constant units, totaling eight taxa unequally distributed in the study stations so station 5 were contain constant species more than other stations, while at station 2which is on the Diyala River were less contain and the reason for this may be related to the fact that at station 5 more stable environmentally than the rest stations also it located far away from the joint point of Diyala with Tigris River, on the other hand it was observed a high total density and diversity of this station while the opposite appeared at station 2. Also, species that appear with abundance frequency in the Diyala River, which recorded high densities in the current study, the reason may be due to wide-spread in warm water with contaminated organically [20] , or perhaps that have a wide range to endure environmental conditions [29] . The presence of large numbers in Station 1 and 5 with high frequency in the current study agree with the clean environm ent description by Proto-Neto [37] that contains a large number of species and high-frequency especially species that do not tolerance the pollution.

It was identified in this study, 40 taxonomic units for the period from January 2014 until December 2014 for all study stations, represented by 13 taxonomic unit's belonging to

Calanoida, 17 taxonomic units belonging to Cyclpoida and 8 taxonomic units belonging to Harpacyicoida, two taxonomic units belonging to Parasitic Copepoda and one taxonomic units belonging to the larvae of copepoda formed 18%, 22%, 3%, 0%, 57%, percentages respectively (Figure 4). Compared with the previous local studies, [9] recorded 13 species of copepoda in the Tigris River and Al Tharthar Arm also [6] record 22 taxonomic units in the Euphrates River represent by *Diaptomus* was the largest number of species, it was recorded 9 species of it in the current study then followed by 4 species of *Cyclops* and 3 species of *Nitocra* and two species for each of Ectocyclops and Paracycolps, Considers this species is a common species in freshwater [15]. Also, when compared the differences in the number of taxonomic units of the current study with previous studies may be due to several reasons, including the nature of prevailing in the area of environmental conditions as well as the nature of the distribution of phytoplankton and wall mounting body of copepoda and the size of the aperture size of plankton net that control the amount of these organisms and their collected quality as well as returning to the difference in the taxonomic aspects which relating to non-identified some orders to taxonomic genera and species levels [1].

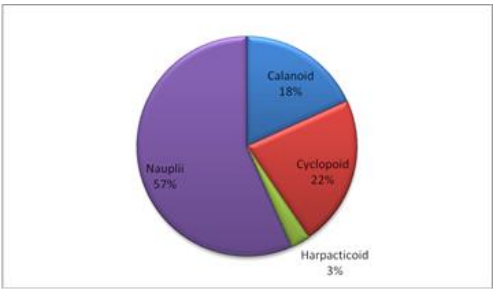


Figure 4: Copepoda percentages in the study stations during the period from January 2014 until December.

The highest value of the species richness index of copepoda was recorded in February 2014 and amounted to 3.139% at station 5

while the lowest values was disappear have been recorded during April 2014 at station 2 (Figure 5).The species richness index values varied in the station 1 from 1.1 – 2 was recorded in the October to April respectively, either at stations that located after joint Diyala with Tigris River the values of this index was decreased, so at station 3 the value ranged from 0.5 - 0.86 in October to April respectively, whereas at station 4 the value ranged from 1.38-2.03 in January to October respectively finally at station 5 which the value of this index has increased to 3.13 in February. On the other hand the values of this index show a decline in values throughout the period of the current study, which had an impact clearly on the stations that located close to the meeting point.

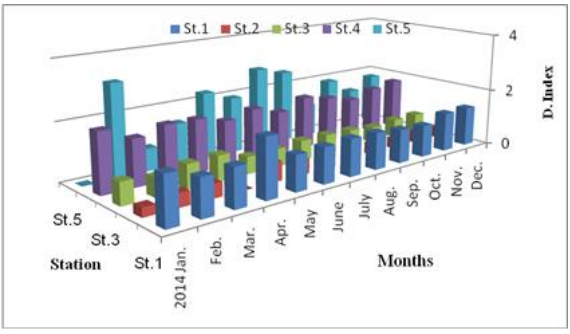


Figure (5): Seasonal variations of the species richness index (D) of copepoda in the study stations during the period of January 2014 until December 2014.

Higher values of copepoda species richness index in the present study during the spring may be due to the increased density and diversity of phytoplankton, which provides a favorable environment for the increase density and diversity of copepoda [47] as the record high values to the species richness index indicates suitable environment for the development certain species and success [13] , The increase in environmental stress with the increase in dissolved solids and salinity may be the cause of the lack of species richness value of small crustaceans which have the ability to adapt to living in the low content of

oxygen concentration [25] . Rabee [38] Record of the values species richness index of copepod ranged from 1.1-1.44 in the Al-Tharthar Canal and from 1.25-1.58 in the Euphrates River.

It was clear as for copepoda Shannon Weiner index at station 1 values did not lower than 0.99 bit / Ind. during the period of study, whereas the values of this index decreased when the stations after joint Diyala with Tigris River, especially at the meeting point in Station 3 as ranged from 0.4-1.63% in November 2014. Either at stations 4 and 5, it was a clear decline in the effect of the Diyala River on the values of this index to reach the highest value 1.88% in February 2014 at Station 5(Figure 6).

The Diyala River distinguishes decrease its diversity values during the period of the study except in November 2014 to reach 1.09 bit / Ind. may be the reason almost a lack of diversity of life in this river, which is an indication of the intensity of organic pollution and its impact on the presence of these organisms in the region, which is working on a low of biodiversity [5] . According to Neves *et al.* [33] the environments in rich with organic matter characterized by having low diversity with a few dominated species.

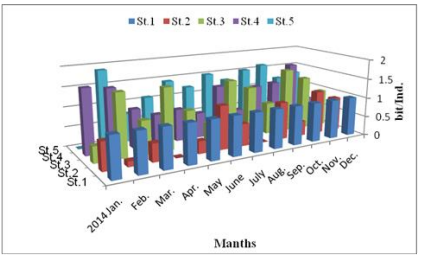


Figure (6): Seasonal variations of copepoda Shannon - Wiener index diversity (H) bit / Ind. in the study stations during the period from January till December 2014.

Recorded high values of the copepoda Shannon Weiner Index in the Autumn and Winter, Maybe return to the increased water content of dissolved oxygen, transparency and increased

vegetation cover that provides food source density [26] it also provides them with haven to avoids it from predation by many predators [27] . Whereas recorded the low values in the Summer is attributable to several reasons, including the large amount of total suspended solids and turbidity [33], or for in the absence of good growth for the aquatic plant flora, or for depletion of dissolved oxygen, which affects in the species abundance and richness [42] .Wetzel [45] explained that the mechanism in the reduction of diversity is the presence of substances with a high consuming of oxygen.

As for the variations in the station, station5 recorded high value of the Shannon Weiner index along the study period, which is a sign of the availability of a suitable environmental condition such as high concentrations of dissolved oxygen and the abundance of food in the station. While station 2 recorded the lowest value of this index and maybe largely due to lack of food or a decrease of some important factors such as transparency, dissolved oxygen and pH [29] .

It was found that the highest value of copepoda uniformity index at station 1 was 1.4 in April 2014, while these values decreased at the stations after the confluence of the Diyala with Tigris River to the minimum value of 0.9 in January at station 4, whereas repeated non-appearance of this value of for several time appeared at station2 on the Diyala River (Figure 7).

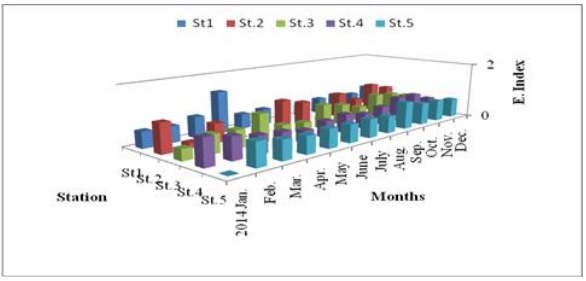


Figure (7:) Seasonal variations of the coepoda uniformity index (E) in the study stations during the period from January 2014 till December 2014.

Higher values of this index in the study stations indicate that the species was uniformity in appearance because of the absence of any environmental stress, which provides a favorable environment for the stability of the zooplankton community and allow to dominate of the larger species, and this is what happened at the station 1 where they exceeded the values of 0.5 throughout the study period, thus considered uniformity species in appearance. While indicating low values of this index to the dominated by a few species with a high density of it, which is a indicate of the presence of environmental stress, and this agrees with [18] when he referred that the decline in the value of uniformity species index indicates the presence of stress prevents appearance of the dominated many species, which is what happened at the station 2, where that the decline the value of uniformity index of the species due to increasing organic matter, low of dissolved oxygen concentrations, high nutrient requirement of life and values to the degree of food abundance that allowed to dominated of few species with high densities of it. Thadeus and Lekinson [44] record the values for this index was 0.993-0.99 in of the Equatorial forest River in Nigeria also record [16] recorded values ranged from 0.870 - 0.978 in Maceio Sombreiro River in Nigeria and is a little like to the record in this study. On the level of local studies [23] recorded values to the uniformity species index of appearance species in the Diwaniyah and Dagharah River ranged from 1.62-1.45 whereas [32] recorded values ranged from 00.99-0.7 on the Tigris River also [4] recorded values ranged from 0.000108 - 0.725 in the Tigris River while [3] record values ranged from 0.63 -1.01 in the Tigris River.

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