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Abundance, Diversity and Distribution of Mollusca in the Gharaf River, Southern Iraq

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Abstract

This study is based on samples taken from one of the main branches of Tigris River; Gharaf River, at Kut Barrage in Wasit Governorate, Iraq. It aimes to study the quantity and quality of the mollusca Invertebrates; furthermore. The study evaluates the molluscan biodiversity of the rivers by using appropriate biodiversity indexes. Thus, the first of its kind study in the evaluation of the diversity of mollusc in Gharaf River assemblage. Monthly samples were collected randomly from the river mud, for 12 months, from January till December 2016. During the collection process; 5 stations on the river were chosen for sampling with 10(±1) Km distance between each of the stations, including Wasit Governorate. The study showed the presence of 20 Molluscs species were recorded for the first time in Gharaf River. In terms of population density, the annual average for Molluscs was 686.34 Ind./m^2 . Relative Abundance Index (Ra) showed that *Melanoid tuberculate*, *Physa acuta* and *Lymnaea auricularia* was less abundant species in Gharaf River. According to the Constancy Index (S) *Corbicula fluminalis*, *M. tuberculata*, *M. nodosa*, *Theodoxus jordani*, *L. auricularia* and *Physa acuta* considered as constancy species in Gharaf's environment. The highest recorded values of the Species Richness index were 0.0303, while the lowest values were a complete absence (zero). Regarding Jaccard Presence-Community, the results demonstrated that the highest similarity percentage between mollusca communities in Gharraf River was between stations 3 and 5, recorded at 66.66%. In the case of the Shannon-Weiner Diversity Index (H), the diversity values in Gharaf peaked at 7.819 bit/Ind. and a complete absence (zero) at its lowest point. However, the Species Uniformity Index (E) results revealed the highest uniformity values was 1, while, the lowest values were complete absence (zero).

Keywords: Invertebrate, Mollusca Biodiversity, Gharaf River, Al-Kut Barrage.

وفرة وتنوع وتوزيع النواعم في نهر الغراف، جنوب العراق

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الخلاصة

اجريت الدراسة الحالية على عينات مأخوذة من أحد الفروع الرئيسية لنهر دجلة، نهر الغراف، عند سدة الكوت في محافظة واسط، العراق. هدفت الدراسة التعرف على كمية ونوعية النواعم علاوة على تقييم التنوع الاحيائي فيهما باستخدام أدلة التنوع الاحيائي. وبذلك تعد الدراسة الاولى من نوعها في تقييم تنوع مجتمع نواعم نهر الغراف. جمعت عينات شهرية عشوائية من الطمى النهر لمدة 12 شهراً ابتداءً من كانون الثاني ولغاية

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كانون الأول 2016، تم خلالها اختيار خمسة محطات على كل نهر توزعت على مسافة 10(±1) كم بينهما وضمن محافظة واسط. أظهرت الدراسة تسجيل 20 نوع من النواعم لأول مرة في نهر الغراف. اما الكثافة السكانية للنواعم فقد كان المعدل السنوي لها 686.34 فرد/م^2. بينت نتائج مؤشر الوفرة النسبية ان الانواع *Melanoid tuberculata* و Physa acuta و Lymnaea auricularia قليلة الوفرة في نهر الغراف. ووفقاً لدليل الثباتية فان الانواع *C. fluminea* و *M. tuberculata* و *M. nodosa* و *Theodoxus jordani* و *L. auricularia* و Physa *acuta* هي الاكثر تكراراً وظهوراً وهي بذلك تعد انواع ثابتة في بيئة نهر نهر الغراف. سجلت أعلى قيم لغزارة الأنواع في بيئة نهر الغراف وكانت 0.0454 في حين تمثلت القيم الادنى بعدم الظهور. اما نتائج دليل جاكارد للتشابه فقد بينت ان اقوى نسبة تشابه كانت بين المحطتين 3 و5 وبنسبة 66.66%. بخصوص دليل شانون وينر فقد سجل اعلى قيمة لهذا الدليل بلغ 7.819 بت/فرد في حين تمثلت ادنى القيم بعدم الظهور. في حين اشار دليل تجانس ظهور الانواع الى ان اعلى قيمة له بلغت 1 في حين تمثلت ادنى قيمة بعدم الظهور.

Introduction

Mollusca is one of the most widely distributed and variable phylum's in the animal kingdom and considered a second most important invertebrate behind arthropods. There are around 110,000 species of mollusca, most of them are marine creatures, although some types do live in freshwater as well as in terrestrial environment [1]. These organisms tend to show heterogeneity in size and shape, some have shells, or doesn't, tend to free living and move slowly, they could be found epilithic to rocks or even sometimes they dig tunnels into these rocks [2].

Mollusca is characterized by its large size and limited mobility as well as being dominant in many freshwater environments and it's relatively easy to collect and identified [3]. Mollusca is divided into six classes; only two of them live in freshwater, Gastropoda and Pelecopoda (or Bivalves).

Number of studies has been done on mollusca groups in Iraq, including Ahmed [4] in Shatt Al-Arab and Arabian Gulf, Al-Dabbagh & Daoud [5] whom identified the Mollusca in Shatt Al-Arab, Murtatha *et al.* [6] when they study occurrence and abundance of the invasive snail (*Pomacea canaliculata)* with six native gastropod snails were recorded at Shatt Al-Arab, whereas Aatty [7] study these organisms in southern Iraq, While Abdulsahib [8] studied two species *Corbicula fluminea* and *Corbicula fluminalis* in Shatt Al-Arab, nevertheless Aaqrawey [9]investigate *Unio, Corbicula, Lymnaea, Melanopsis, Melanoids* and *Bellamya* in the Mesopotamian Marshes. Therewith several local studies are dealing with Mollusca as a group within benthic invertebrates, such as [10- 21]. While this study considered as the first of its kind due to it included the study of the moullsca assemblage on one of the main branches of the Tigris River called Gharaf River, in Wasit Governorate. Which we can include it's the main objectives by investigating the biodiversity and identification mollusca of the Gharaf River in Wasit Governorate, southern Iraq.

Material and Methods

Study area

Gharaf River branches from theTigris River at Al-Kut Barrage, therefore, it obtains its characteristics from theTigris River. The length of Gharaf River is 230 Km from the point of its branching in Al-Kut Governorate to its estuary in Nasiriyah marshes, while the water depth in the river varies from 13 m at its branching point from the Tigris River to 7 m at the point of its meeting with Euphrates river in the marshes area near Thi- Qar Governorate [22]. The river is located in the southeastern part of Iraq from latitudes 31° 2- 32° 27 N and from longitudes 45° 45- 46° 43 E. The river cuts the distance 90 Km in Al-Kut Governorate then enters Thi- Qar Governorate from its north side.

Study Station Description

Five stations were chosen from which samples were collected, as shown in Figure-1.

Station 1: It was located 500 m after Al-Kut Barrage near the first Barrage regulator, at the under lies between the longitudes 48 and 45° E; latitudes 28 and 32° N.

Station 2: It was located 10 Km away from the first station in Bisroghiah area, at the under lies between longitudes 54 and 45° E; latitudes 23 and 32° N.

Station 3: It was located in Al-Moafaqya area - Al-Badrya region, 10 Km away from the second station, at under lies between longitudes 57 and 45° E; latitudes 14 and 32° N.
Station 4: It was located about 10 Km away from the third station, at underlies between longitudes 00 and 46° E; latitudes 11 and 32° N.
Station 5: This station was located at the underlies between longitudes 1 and 46° E; latitudes 6 and 32° N, in about 10 Km away from the fourth station.
As for the sediment texture, Hydrometer method (ASTM58 D421 – D422) described by Lambe and Robert [23] and Hayward [24] was used to analyses the particle size of the sediment particles in the mud samples. The results were expressed in size scales, Sand >0.2 mm, Silt 0.02-0.002 mm, clay <0.002 mm, and percentage.

Four replicates samples were collections monthly by using Ekman Dredge, and were preserved in 4% Formalin after washing it with the river water through a 0.5mm laboratory sieve, and then the samples were sorted by using stereo microscope and identified and counted by using a compound microscope. The sorted individual was identified to the lowest practical taxonomic level according to the following classification keys: [4, 25- 27] while the results were expressed by Ind. /m^2.

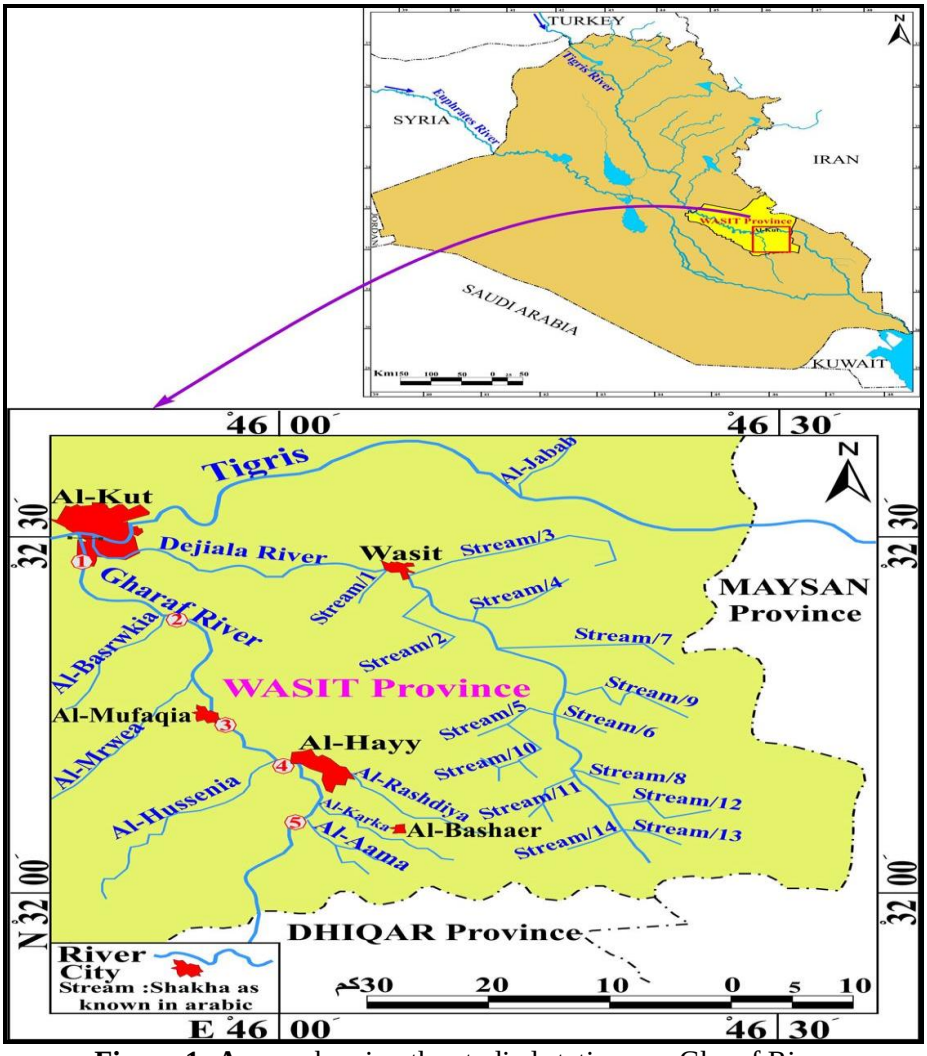

Figure 1- A map showing the studied stations on Gharaf River

The following Ecological Indices were account:
Relative Abundance Index (Ra): The calculated by (Ra) was depending on the formula contained in Omori and Ikeda[28]. Constancy Index (S): By the presence and frequency of each species, calculated according to the formula contained in Serafim *et al.*[29]. The Species Richness Index (D): This indicator is calculated monthly according to the formula contained in Sklar [30]. 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 to in the Floder and Sommer [31]. 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 [32]**. The Species Uniformity Index (E)**: The species uniformity index measured according to the formula contained in the Neves *et al*. [33]. Considered values greater than 0.5 as equal or uniformity in appearance

Results and Discussion

The results of the soil texture and the percentage of its sand, silt and mud content in the five stations of the study (Table-1), showed a significant contrast in its sediment between loam-clay-silt soil at stations 1, 2, 4 and, 5 and clay-silt soil at station 3, during the different seasons.

Table 1- The percentage of each Gharaf River sediment content during period study

Soil content Stations	Sand %	Silt %	Clay %	Soil Texture
1	11.56	54.55	34	Silt clay Sand
2	17	46	37	Silt clay Sand
3	8.82	58.98	32.2	Silt clay
4	25.6	41.4	33	Silt clay Sand
5	12	53	35	Silt clay Sand

However, the organic material content in Gharaf River sediment was between 2.3% at its lowest at station 4 during the summer and, 6.9% as the highest recorded at station 1 during the winter. 3.9% was the annual average during the study period. (Figure-2). Although, the seasonal averages were 2.3% for summer and autumn and 6.9% during winter.

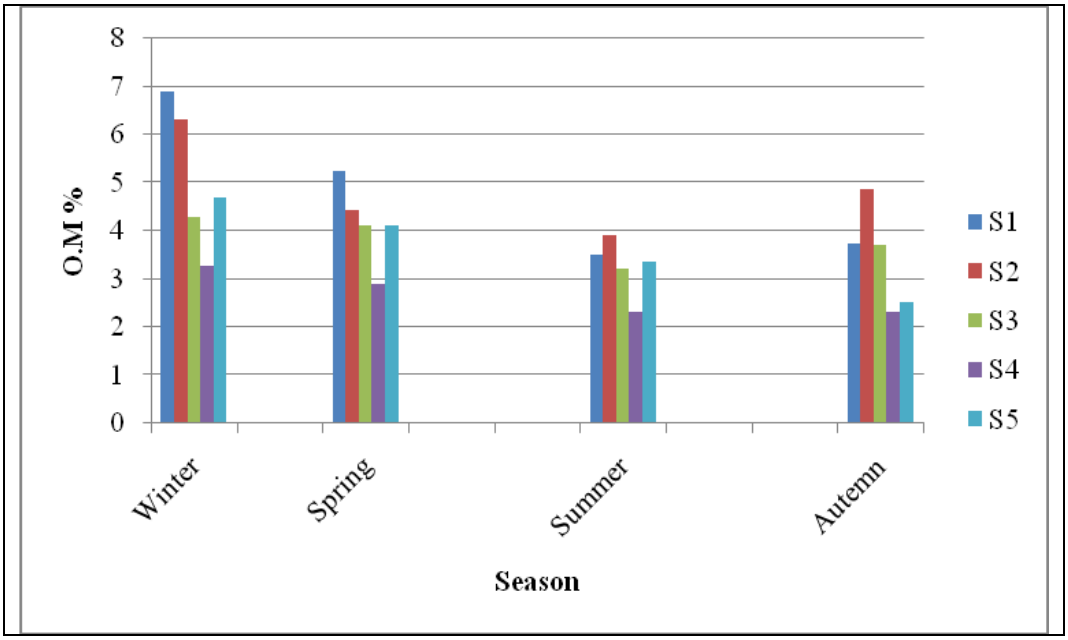

Figure 2- Seasonal variations in the organic materials percentage in Gharaf River during period study.

Moving to mollusca density, it ranged between a complete absence (zero) at station 1 during March 2016 and 7345 Ind./m^2 at its peak in station 5 during January 2016, however, the average of the five stations during the study period was 686.34 Ind./m^3 (Figure-3).

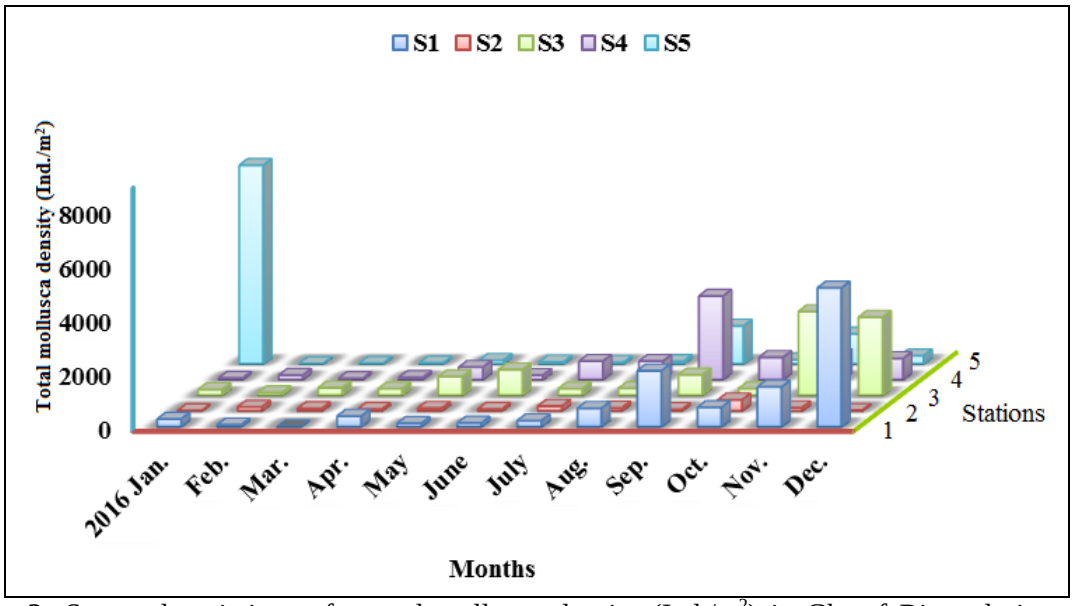

Figure 3- Seasonal variations of a total mollusca density (Ind./m^2) in Gharaf River during period study.

The statistical analysis results showed in Table-2 indicated the presence of minor differences between the stations and the seasons at p≤ 0.05.

Table 2- Seasonal averages and standard error of the total density values of mollusca in Gharaf River during period study.

Season / Stations		Win.	Spr.	Sum.	Aut.
1	M. SE	1825.33 ± 50.7 b	170 ± 8.6 b	344 ± 17.0 b	1414.33 ± 70.1 b
2		59 ± 3.0 e	85 ± 3.1 c	118.33 ± 5.4 c	196.33 ± 9.3 e
3		1065 ± 45.9 c	403.33 ± 20.4 a	481.33 ± 24.3 a	1366.33 ± 68.6 c
4		329.33 ± 16.5 d	192.33 ± 9.6 b	503.66 ± 25.2 a	1599.66 ± 74.0 a
5		2551.67 ± 29.8 a	62.33 ± 3.3 c	70.33 ± 3.1 d	888.33 ± 40.2 d
Total	Mean SE	1166.19 ± 46.3	182.6 ± 60.4	303.53 ± 44.3	1092.0 ± 25.3
		P≤0.05	P≤0.05	P≤0.05	P≤0.05

• Similar small letters indicate no significant differences P≤ 0.05between stations and seasons.

Table-3 shows that the highest densities of Mollusca appeared at stations 1 and 5 and the lowest were at stations 2, 3 and 4, respectively.

Table 3- The annual total density of mollusca (Ind./m^2) during period study.

Stations	1	2	3	4	5
Total Density of Mollusca	11.261	1376	9950	7875	10.718

It was showed an increase in the total densities of mollusca during winter and autumn seasons, while it was showed a decrease during summer and spring seasons (Table-3), the reason for that could be the stability and suitability of the environmental conditions for it to grow and settle, the temperature could be suitable for its eggs to hatch; also, the richness of Aquatic plants at the river bank provides an

appropriate environment for it to live and a source of nutrition. However, other reasons could be: benthic stability, low water levels, current water and the low river depth of Gharaf during autumn specially during November [34]. Also, the moderate temperature increases the activity of microorganisms which increases decomposition that leads to an increase in nutrition's [35].

As for spatial variation, station 1 record the lowest by recorded a complete absence (zero), while the high density was at station 5 by 7345 Ind./m^2. It is noted from the results of Table-3 that the highest total densities appeared in station 1 and 5, while the lowest was at stations 2, 3 and, 4. The reason for that could be all stations above were close to the highly populated and agricultural area that puts them under levels of human and agricultural pollutants [36]. Another study Setaita and Montaser [37] showed the same effect on the Nile River, the total densities of mollusca were affected by the presence of pollutants near populated and agricultural areas, as the riverbed works as a basin for collecting pollutants [38].

Our results did not match with densities sometimes and with season that recording of higher or lower densities with the results of other local researches such as Sabtie [39] , Al-Fannahrawi [40] , Al-Saadi[41], Agha [42] and Obaid [43] to the fact that the composition of the mollusca community in any waterbodies is affected by many factors, including: the nature of the benthic, presence of algae, temperature and, water current, as Martel *et al*. [34] indicated.

Figure-4 and Table-4 indicate the results of Relative Abundance Index (Ra) showed that *Melanoides tuberculata* is the less abundant species, it makes 50% of station 1 population, followed by *Physa acuta* 26%, *Pisidium dubium* 10% , *Melanopsis nodosa* 6%, *Lymnaea auricularia* 4% and others 4%.

While at station 2, *Physa acuta* scored the highest percentage by 43% followed by *Melanoides tuberculata* 20%, *Pisidium dubium* 13%, *Melanopsis nodosa* 9%, *Gyraulus intermixtus* 6%, and 9% for other species.

As for the station 3, *Physa acuta*, *Melanoides tuberculata* and *Lymnaea auricularia* were the less abundant species by 38%, 35% and 17% respectively; meanwhile, 5% was recorded for each of *Corbicula fluminalis* and *Melanopsis nodosa*.

Station 4 results were as follows, 57% *Melanoides tuberculata*, 19% *Physa acuta*, 14% *Corbicula fluminalis* and 5% for both of *Lymnaea auricularia* and *Melanopsis nodosa*.

Station 5, species *Melanoides tuberculata, Corbicula fluminalis, Melanopsis nodosa, Physa acuta, Pisidium dubium*, were 74%, 12%, 5%, 6% and 3%, respectively.

Akbar [44] recorded in her study on Gharaf River at the Dhi-Qar Governorate that the higher abundance of the species *M. tuberculata*, *C. fluminalis*, *M. nodosa* and *P.acuta* while to Al-Abbad and Al-Karoni [45] has been recorded two species, *Bellam. bengalensis* and M. *tuberculata* by 0.5% and 0.2% respectively in his study for variety and density of invertebrates at tide zone in Al-Garma River. But Khalaf [46] has shown the results of her study abundance species *M. tuberculata* by 69% and 83% and for *P. acuta* by 0.1% and 0.1% of the two stations and by 92% and 98% of the species *M. tuberculata* and by 0.3% and 0.1% of the species *C. fluminalis* and *P. acuta* respectively in tidal marsh, while recorded *L. auricularia* and *M. tuberculata* by 0.3% , 0.1% and *C. fluminalis* and *L. auricularia* and *M. tuberculata* and *B. bengalensis* by 69%, 80% and 2% respectively in non tidal marsh stations in her study of benthic invertebrate communities in three different aquatic environments south Iraq .

While Obaid [43] study showed for benthic invertebrate communities in the middle part of Euphrates river the species *Viviparus bengalensis* and *M. tuberculata* and *M. nodosa* and *M. costata* of Gastropoda and the species *Dreissena polymorpha* and *C. fluminalis* and *C. flumineaea* and *U. tigridis* and *Pseudodontopsis euphraticus* of bivalves are recorded relative abundance by 25% , 22%, 8%, 34%, 11%, 84%, 5%, 6%, and 2% respectively.

The increase and decrease of the density of mollusca, its diversity in the number of taxa and number of individuals in each taxa are all may be due to hydrologic change of water. Studies showed that mollusca prefer moderate water current with a high content of organic materials [47].

Table 4- Relative abundant and constancy index frequencies at the study area.

Station / Taxa	Ra%					S				
	1	**2**	**3**	**4**	**5**	**1**	**2**	**3**	**4**	**5**
Phylum: Mollusca										
Class1: Bivalvia										
Family:Corbiculidae										
Corbicula fluminea	-	-	-	**R**	**R**	-	-	-	**A**	**A**
Corbicula fluminalis	**R**	**R**	**R**	**R**	**R**	**A**	**A**	**C**	**C**	**C**
Family: Unionidae										
Unio tigridis	-	-	**R**	-	**R**	-	-	**A**	-	**A**
Family: Sphaeriidae										
Pisidium dubium	**R**	**R**	**R**	-	**R**	**Ac**	**A**	**A**	-	**Ac**
Family: Dreisseniidae	-	-	-	-	-					
Dreissena polymorpha (Pallas,1771)	**R**	-	-	**R**	-	**A**	-	-	**A**	-
Class2: Gastropoda										
Family: Bulimidae										
Amnicola limosa	-	**R**	-	-	**R**	-	**A**	-	-	**A**
Family: Thiaridae										
Melanoides tuberculata	**La**	**La**	**La**	**La**	**A**	**C**	**Ac**	**C**	**C**	**Ac**
Family: Melanopsidae										
Melanopsis nodosa	**R**	**R**	**R**	**R**	**R**	**C**	**Ac**	**C**	**Ac**	**Ac**
Family: Vivaparidae										
Bellamya bengalensis	-	**R**	**R**	-	-	-	**A**	**A**	-	-
Viviparus intertextus	**R**	-	-	**R**	-	**A**	-	-	**A**	-
Family: Ampullariidae										
Family: Naticidae										
Polynices ampla	-	-	-	**R**	-	-	-	-	**A**	-
Family: Neritidae										
Neritina schlaeflii	**R**	-	-	**R**	-	**A**	-	-	**A**	-
Theodoxus jordani	**R**	-	**R**	**R**	**R**	**C**	-	**A**	**Ac**	**A**
Family: Lymnaeidae										
Lymnaea abrussa	**R**	-	**R**	-	-	**A**	-	**A**	-	-
Lymnaea auricularia	**R**	**R**	**La**	**R**	**R**	**A**	**A**	**C**	**Ac**	**Ac**
Lymnaea palustris	-	**R**	-	-	-	-	**A**	-	-	-
Family: Physidae										
Physa acuta	**La**	**La**	**La**	**La**	**R**	**C**	**A**	**C**	**C**	**C**
Family: Planorbidae										
Gyraulus convexiusculus	**R**	-	**R**	-	**R**	**A**	-	**A**	-	**A**
Gyraulus intermixtus	**R**	**R**	**R**	-	**R**	**A**	**A**	**A**	-	**A**
Family: Pyramidellidae										
Odostomia laevis	-	-	-	-	**R**	-	-	-	-	**A**

*calculated from% occurrence in samples. Rare (R) are mollusca occurring in less than 10%, Less abundant species (La) invertebrates occurin 10% -40% of samples, Abundant species (A) occurin 40%-70% of samples and Dominant species (D) occurin more than 70%. While as for constancy index(S) are mollusca Accidental species (A) invertebrates occur in 1%-25%, Accessory species (Ac) occur in 25%-50% of samples and constant species (C) occur in more than 50% .

The percentage of mollusca at all studied stations is shown in Figure-4 and it was 21% at station 1, 19% at station 2, 18% at station 3, 19% at station 4 and 23% at station 5. Figure-5 shows the percentage of mollusca at all studied stations and it was 73%.

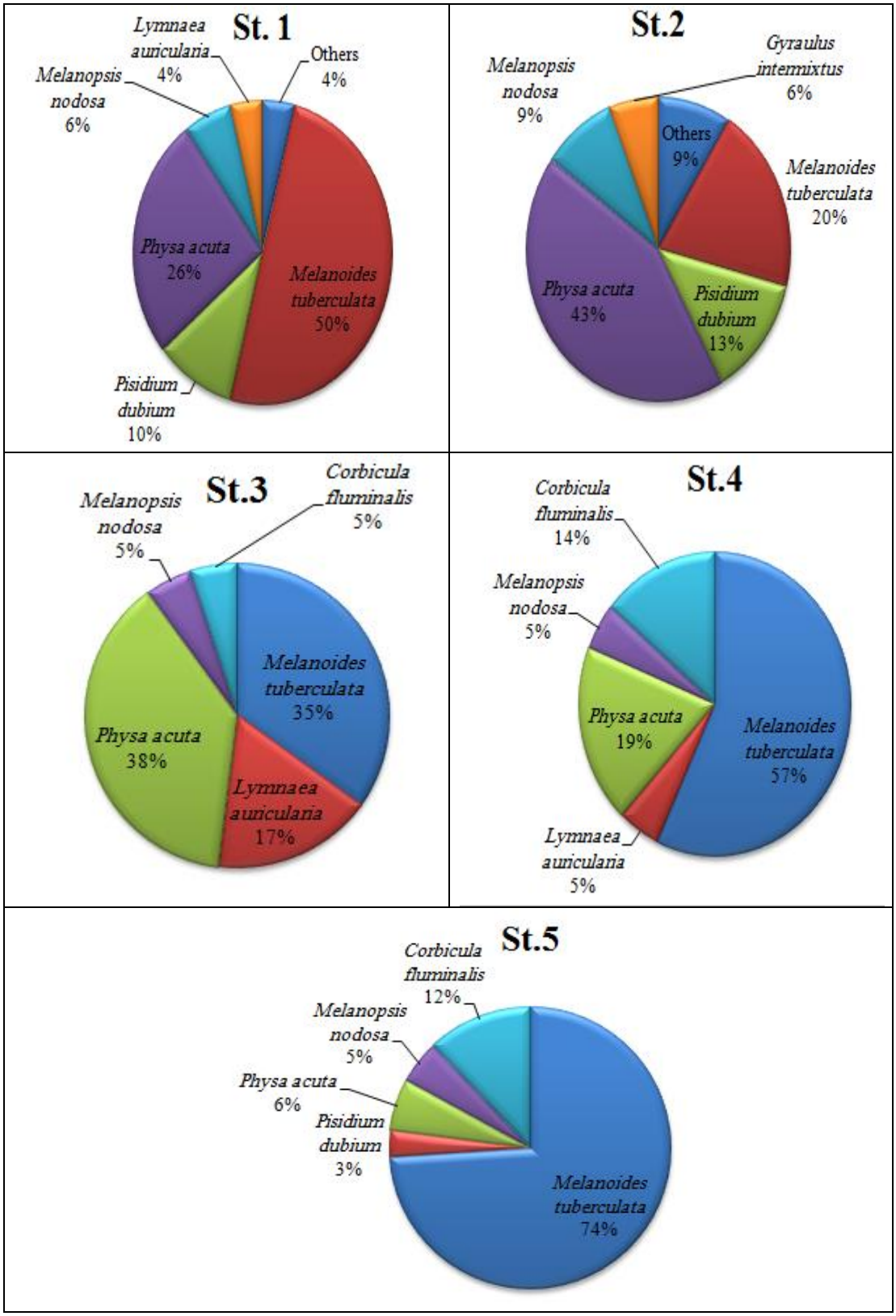

Figure 4- Relative abundance of Gharaf River Mollusca during period study.

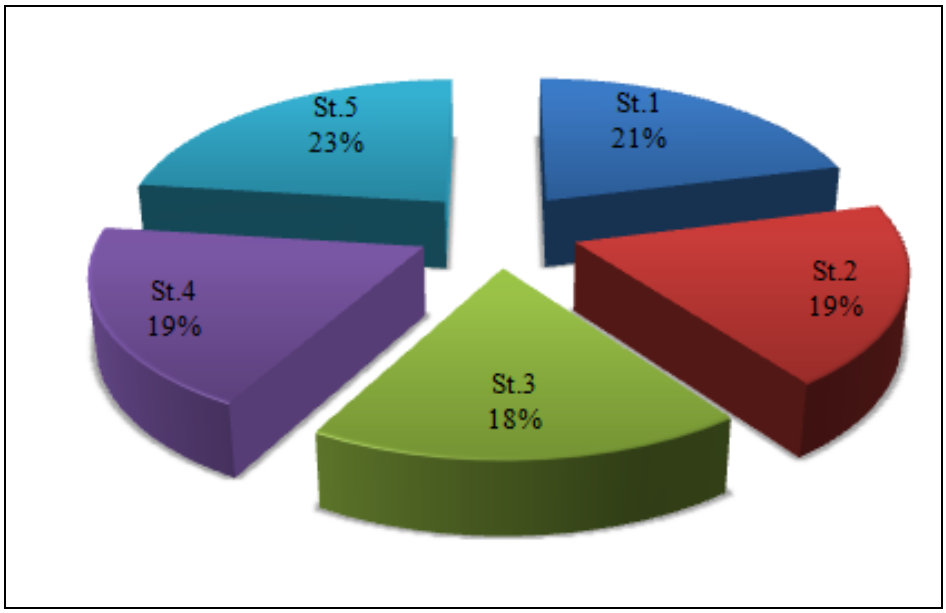

Figure 5- The percentage of mollusca in Gharaf River during the period study.

According to the Constancy Index (S), *Melanopsis nodosa*, *Theodoxus jordani*, *Lymnea auricularia*, *Physa acuta* and *Corbicula fluminalis* were the most frequent and appeared the most and considered to be constant in Gharaf environment.

As for spatial variation, station 1 showed that *Pisidium dubium* was the accidental species, while *Melanoides tuberculata*،*Melanopsis nodosa*، *Theodoxus jordani*, *Physa acuta* were the constant species. Meanwhile at station 2, *Melanoides tuberculata*, *Melanopsis nodosa* were the accidental species and the station showed no constant species.

While station 3 had all of *Corbicula fluminalis*, *Melanoides tuberculata*, *Melanopsis nodosa*, *Lymnea auricularia* and *Physa acuta* as constant species and with no accidental species.

Melanopsis nodosa, *Theodoxus jordani* and *Lymnea auricularia* were the constant species at station 4, while *Corbicula fluminalis*, *M. tuberculata* and *Physa acuta* were the accidental species.

Moving to station 5, *Corbicula fluminalis* and *Physa acuta* were constant, and *Pisidium dubium, M. tuberculata*, *M. nodosa* and *L. auricularia* were the accidental species.

The results also showed that station 3 had most of the constant species, and the least was in station 5. Meanwhile, station 4 had the most of the accidental species. However, stations 2 and 3 had the least. That could be caused by the physical, chemical and biological factors of these stations which provide a suitable living environment for these species [48].

These species were also recorded in other local Iraqi researches, including Nashaat *et al.* [12], Al-Lami *et al.* [13], Radhi *et al.* [15], Radhi *et al.* [18], Al-Lami *et al.*[16] , Al-Kinani [49] , Akbar [44] , Al-Abbad and Al-Karoni[45] , Obaid [43] , Al-Khafaji *et al.*[50]and Khalaf [46].

The appearance of few species with high frequencies does not match what described as a clean environment which is characterized by various species in high frequencies, especially species that cannot live under the pressure of such highly polluted environment [32].

Twenty species of mollusca were first recorded in Gharaf River during the current study, and it was distributed as 13, 10, 12, 11 and 13 species at station 1, 2, 3, 4 and 5 respectively.

The Species Richness Index for Mollusca recorded with a range of complete absence (zero) at stations 1, 2 and 5 during March, January and September, February, March, and April, respectively. And the highest value was 0.0454 at stations 1 and 2 during February and December, respectively (Figure-6).

Benthic Invertebrates richness is affected by a number of factors, including temperature, Oxygen concentration, organic materials [51], water depth, nutrition, plant quantity, predation and competition [52].

The recording the highest richness index values in the spring, January and August might be due to the effect of temperature, productivity, the presence of a vegetation cover and nutrition. These are all factors of a convenient environment for the development and success of certain species [53].

All these results match with another study Khalaf [46], their study also found that the highest values of the richness index for benthic invertebrates were during winter and spring, this reflects its favors on the environmental conditions during these months, which was also confirmed by Geraci *et al*. [54] who indicated the changes in the number of benthic invertebrates during the different seasons. However, Gray [55] emphasized the importance of water levels on the benthic invertebrate's richness by the reduction of the total area, aquatic plants, and algae.

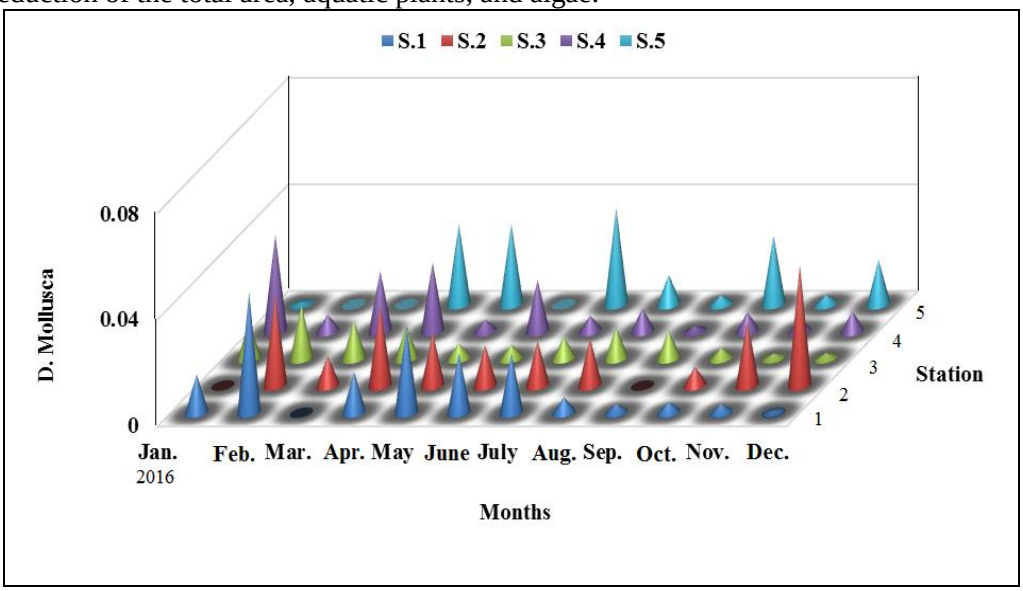

Figure 6- Variation of mollusca richness in Gharaf River during the period study.

As for spatial variation, station 1 recorded high mollusca richness index values and that could be due to the sediment texture and the levels of pollution [56]. As far as Brinkhurst [57] concerned, the up of the river has more diversity of benthic invertebrates than down to the river, however, Plazait and Younis [58] pointed out that mollusca prefer rich vegetation areas more than areas with slow water flow, that is high quantities of aquatic plants provides nutrition and protection from predators for benthos fauna [59].

By comparing the number of taxonomic units which founded in this study with other local Iraqi studies, Al-Lami *et al*.[13] found four molluscan species from a total 26 benthic invertebrate species they identified in their study on Tharthar Arm and Tigris River, whereas, Al-Lami *et al*. [14] identified 13 mollusca species out of a total of 45 species of benthic invertebrates observed in their study on Habbaniyah Lake. As for Ali [60], six molluscan species were recorded out of 32 total benthic invertebrate species. Another study about this was Nashaat [61], it was done on Tigris River, south of Baghdad, near Al-Dorah power plant where eight mollusca species were identified from a total of 24 benthic invertebrate species found. Al-Khafaji *et al.* [50] found that 17 Mollusca species live in the tidal area of Shatt Al-Arab out of 40 benthic invertebrate species existing in the area. The differences in the number of taxonomic units of the present study compared with the previous studies are may be due to several reasons, including the distribution of Aquatic plants, changes in productivity, collecting strategies and the differences in the taxonomic aspects which related with diagnosis [62, 63].

By comparing the results of the species richness index in the current study with other Iraqi studies, it was recorded the value of this index ranged from 0.31-1.25 during autumn and spring as mentioned in Al-Abbad and Al-Karoni [45] study of invertebrates in the tidal area of Al-Karamah River, whereas, Obaid [43] study recorded from 4.72-8.64 during January and February on benthic invertebrates of Euphrates . Meanwhile, Al-Khafaji *et al.* [50] have recorded value of 1.66-4.04 for the species richness index during March and September in the tidal area of Shatt Al-Arab. As for Khalaf [46], he showed that the highest values of the richness index were during winter and spring (October, January, February and March) and it was from 1.78-3.04 for the invertebrate communities in three different water bodies in southern Iraq. All these results are higher than the current study, the reason for that was these studies calculated the richness index according to the total invertebrate densities studied, while our study it was done with respect to only mollusca groups of benthic invertebrates of Garaf River.

Moving to Jaccard - Presence community coefficient Table-5 and Figure-7 was showed that the highest connection was between station 3 and 5 scoring 66.66%, then it started decreasing until it hit its lowest at 33.17% with station 4.

Jaccard Index indicated the presence of differences similarities between all studied stations, and since benthic invertebrates have an important role in the decomposition and recycling of nutrition's and organic materials through direct consumption, therefore, the differences between stations appear [64]. Or, it could be due to differences in the waste discharge between the stations, it generates different environmental conditions in each station, therefore, different communities appear depending to its ability to adapt to the different conditions [65].

Table 5- Jaccard coefficient matrix for the similarities of Mollusca communities during period study.

Stations	2	3	4	5
1	41.18	44.44	25	42.11
2		57.14	31.25	50
3			35.29	66.66
4				41.17

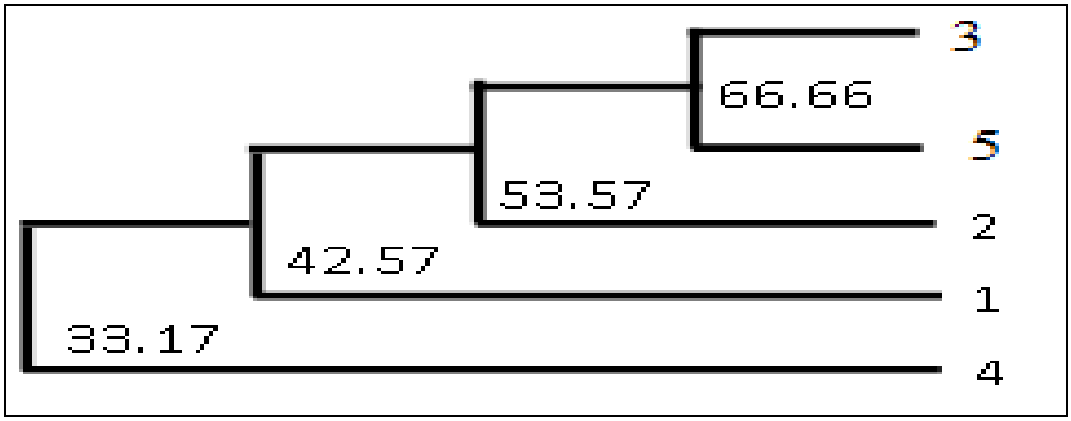

Figure 7- Dendrogram showing similarity percentages of mollusca communities between all the stations in Gharaf River during period study.

By comparing the results of this study to other local Iraqi studies, we found that Ibrahim [66] has recorded 58.6-85.1% between Al-Diwaniah River and Al-Dgharah River. However, Nashaat [61] has recorded the highest value by 92% in Tigris River. Meanwhile, it was only from 52.83-56.96% for Obaid [43] in the Euphrates River. While Radhi [67] recorded only 34.21% as the highest and 16.6% at its lowest. Some international studies related include: Suckling [68] recorded from 10-95% in Manawatu River in New Zealand. While Arazu and Ogbeibu [69] a study in Nigeria on the Niger River recorded 0.94-0.97%. The variation in this value points the variations in the physical and chemical characteristics, therefore, the presence of some species and its relationship with other species, or could point to the variation in the nature of the areas that river pass by, the areas around the river, the agricultural and industrial activities, and the density of aquatic plants [70].

Regarding Shannon-Weiner Diversity Index, results for molluscan diversity hit its peak at 7.819 bit/Ind. at station 3 during September, however, it did not appear at stations 1,2 and 5 during September, also at station 1 in March, station 2 in January and September and station 5 in February, March and April (Figure-8).

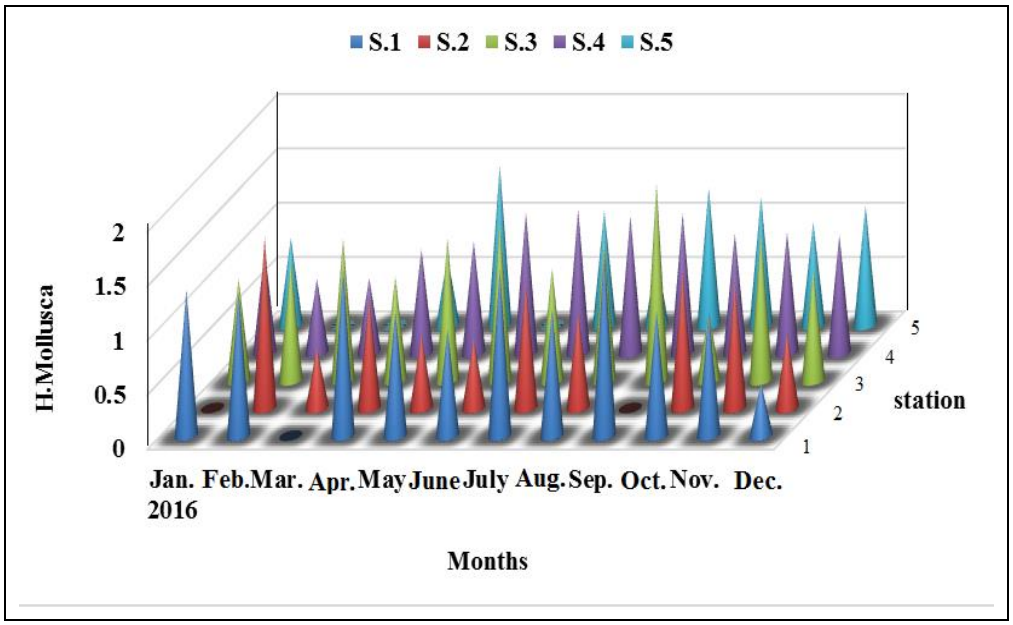

Figure 8- Variation of Shannone-Weiner values for Mollusca in Gharaf River during period study.

The highest values for species diversity were recorded at stations 3 and 5 may be due to the effect of the Kut barrage, as well as the different environmental conditions, Petts [71] pointed to the effect of dams on the diversity of benthic invertebrates in his study and found a positive effect on it. As for the recorded absent of mollusca at all stations, it indicates the organic pollution as a result of the impact of human and agricultural waste from the areas near the study stations, which works to reduce biodiversity with encourages to the domination of a few species [33].

It was revealed that from Shannon-Weiner Index results that Gharraf River is under environmental pressure due to the levels of pollution it has, that reduces biodiversity and decreases the consistency and stability of the biological community. Goel [72] explained the results of Shannon-Weiner Index as follows, 0-5 bit/Ind. is the average range of the results, >3 bit/Ind. indicates high biodiversity and clean, stable environment, <1 bit/Ind. indicates pressured, a highly polluted environment that causes death or migration of sensitive species.

The aforementioned Index is also used to evaluate the quality of water, clean water has a score of more than 3 bit/Ind., while a score between 1-3 bit/Ind. indicates that the water is moderately polluted, however, if it is below 1 bit/Ind. that means the water is heavily polluted, So and according to the represent the majority of the results of Gharaf River which makes the river from moderately to heavily polluted depending on the location and the season.

By comparing our results from this study to other Iraqi local ones, we found that Sabtie [39] has recorded values from 0.4-1.05 bit/Ind. when he his study the marshes in southern Iraq, also, Al-Kinani [49] has recorded 3.31 as the lowest value at the Tigris River and a peak of 18.6 bit/Ind. at Dialah River in her study about the effect of some environmental factors on benthic invertebrate communities in Tigris and Dialah Rivers, southern Iraq. Moving to Obaid [43], her study of the middle part of Euphrates River showed diversity values ranging from 0.3-2.86 bit/Ind. during January and November, meanwhile, Al-Khafaji *et al.*[50] recorded 2.98, 2.85, 2.61, and 2.57 bit/Ind. at station 2,3,1 and 4, respectively, in his study about the diversity, abundance and distribution of benthic invertebrates in the tidal area of Shatt Al-Arab. In another study, on the benthic invertebrate communities in three different water bodies southern Iraq, Khalaf [46] found that the highest diversity values at tidal river locations were 1.98 and 1.74 bit/Ind. during February and October, and the lowest were 0.79 and 0.46 bit/Ind. during March and November, all respectively. However, at the tidal marshes, the highest were 1.40 and 1.14 bit/Ind. during March and April, while the lowest were 0 and 0.39 bit/Ind. during August and February, respectively. The third location was at the non-tidal marshes, where the highest was 1.33, 1.78, 1.80 and, 1.69 bit/Ind. during March, June, August and January, respectively. Although, the lowest were 0, 0.4, 1.07, and 0.33 bit/Ind. during September, November and April, respectively

Al-Maliki [73] and Abbas [74], pointed to the presence of specific factors that affect the values of the diversity index, either increases or decreases, correlated with the absence of the required climate for the growth of some species that invertebrates feed on, in addition to physical and chemical factors, all these causes combined explains the differences between the studies.

As for international studies on this topic, Cai *et al.* [75] study showed values of 1.79, 1.43 and 1.33 bit/Ind. at his station in Taihu Lake in China, he referred these differences to the effect of nutritional richness caused by human pollutants, an increase of nutrition's both water and sediments and the weak ability of the lake to refine itself. Meanwhile, Arazu and Ogbeibu [69] in their study of Niger River in Nigeria have recorded values from 3.24-3.59 bit/Ind.

Moving to the Species Uniformity Index, station 1,2 and 5 have shown the lowest values for mollusca, which were complete absence (zero) during different random months, while the highest values, which were 1, which were recorded at station 2,3 and 4 during December, February and March, respectively (Figure-9).

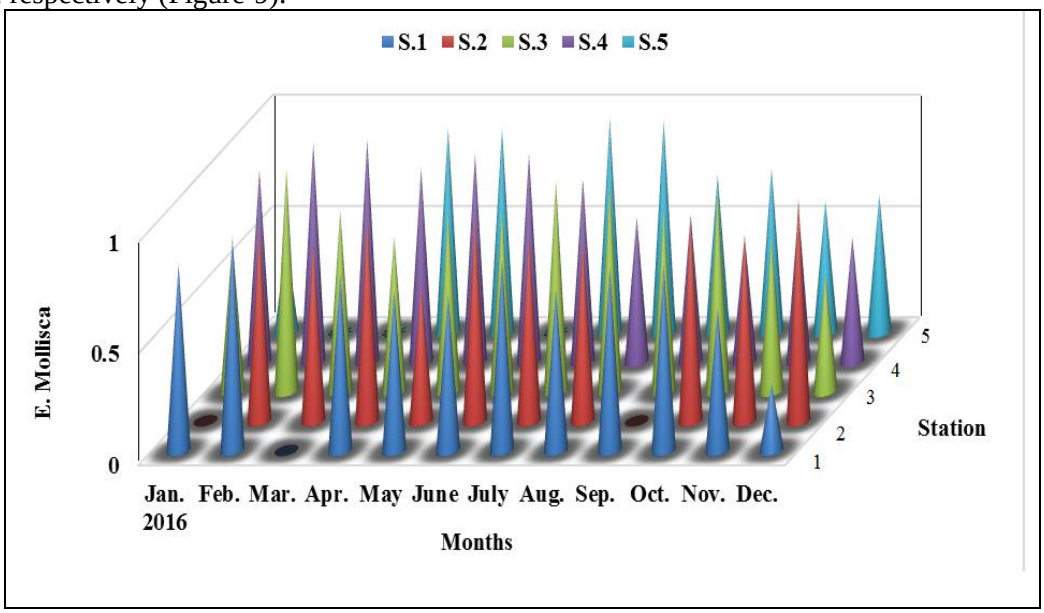

Figure 9- Variation of Species Uniformity Index for Mollusca during period study.

Species Uniformity Index indicates to the individual distribution pattern between the different species, the closer individuals are to each other density wise, the closer the value to 1 [76]. Therefore, if the value does not exceed 0.5, it indicates that the species are under environmental pressure in different locations. It is noted from the Uniformity Index results that these species are under high environmental pressure, as the values did not exceed 0.5 in most of the locations during different months. Thus, these species are considered non-uniform in its appearance and its distribution across the species [77]. Low Uniformity Index values demonstrate the dominance of few species and in high densities due to the environmental pressure as Green [78] suggested.

However, the results of this study were similar to the results of other Iraqi local studies, as Al-Jubouri [79] also recorded values less than 0.5 on the Tigris River, and Obaid [43] records were from 0.1-0.9 at the Euphrates River. However, both of their studies affirmed the presence of high environmental pressure on these species at different locations. Meanwhile, Al-Serai [80] recorded 0.7-1 at their locations in Damlaj marsh at Diwaniyah, Iraq.

The changes in the benthic invertebrate communities are related to changes in the water pattern and the physical, chemical and biological characteristics of it, the shape of the banks changed, the nature and composition of the benthic, and the distribution of the aquatic plants [71].

Some of the international studies showed higher Uniformity, Thadeus and Lekinson [81] recorded 0.990-0.993 in Nigeria, and Ojutiku *et al*. [82] study Kaduna River also in Nigeria recorded 0.78.

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