DOI: 10.21276/ijaq.2016.13.1.6
Iraqi J. Aquacult. Vol. (13) No.(1)-2016: 66–85

Seasonal variations of the Cladocerans in the Shatt Al-Arab River, Southern Iraq

Shaker G. Ajeel and Mohammed F. Abbas
Department of Marine Biology, Marine Science Centre,
University of Basrah, IRAQ
shaker_ajeel@yahoo.com

Abstract

Samples were collected seasonally from three stations (Al-Ashar, Abu Al-Khasib and Al-Faw) in the Shatt Al-Arab River by a plankton net (85 µm mesh-size and 40 cm mouth aperture), from January to November 2013. Some physical and chemical parameters of the water were monitored such as, water temperature, salinity, pH, dissolved oxygen, Total Dissolved Solids (TDS) and turbidity. The density of Cladocera ranged between 0.0 ind/m^3 during spring and summer at Al-Faw station to 18922 ind/m^3 during summer at Al-Ashar station. Five, two and one species of Cladocera were recorded at the three stations, respectively. *Moina affinis* and *Diaphanosoma brachyurum* were the dominant species at study area. Maximum diversity index (H) (0.7) was obtained at stations 1 and 2 during winter and spring respectively and higher evenness value (J) (0.4) was recorded at station 1 and 2 during winter, while higher richness (D) (6.1) was obtained at station 1 during winter and lowest value (0.0) at station 3. Jaccard's index revealed higher similarity between stations 1 & 2 and lower values between station 1 and 3.

Key words: Cladocera, density, distribution, Shatt Al-Arab River, Basrah

Introduction

The cladocerans is a group of zooplankton, which forms the second trophic level of the food chain in the aquatic environments, they are play an important component of the faunal biodiversity of the freshwater ecosystems. They feed on phytoplankton, bacteria and detritus and thus transporting energy from plant materials into animal tissue and in turn constitute the basic food for higher animals including fishes, particularly their larvae (Goswami, 2004).

Cladocerans are found in lakes, ponds, slow-moving streams, and rivers. They are found from the Arctic to the Southern Oceans. Some cladocerans are benthic, other species live on sediments or on vegetation, virtually anywhere water is present, including swamps, puddles, ditches, and ground water (Oltra & Todolr, 1997; Dodson and Frey, 2001).

In Iraq the first study on Cladocera began more than 94 years ago, as the first report was published by Gurney (1921) in which he stated nearly forty species of aquatic invertebrates collected by Dr P. A. Buxton during 1917 and

1918 from the Amara city to NW Arabian Gulf and recorded eighteen species of Cladocera. The others studies were mainly concerned with the taxonomy, abundance and distribution of Cladocera and other zooplankton, at different parts of Iraq such as, AL-Hammed (1966); Khalaf & Smirnov (1976); Murad (1977); Khalaf *et al*. (1977a,b); Shihab (1977); Lazim (1977); Khalaf and Shihab (1977); Abdul-Ahad (1980); Shihab and Khalaf (1980); Mohammad (1980); Mohammad (1986); Lazim and Zaki (1987); Mangalo and Akbar (1986 a,b); Mangalo and Akbar (1988); Sabri *et al*. (1989); Al-Lami (1998); Poltorak *et al.* (2001); Al-Lami *et al.* (2001a,b); Rahdi *et al*. (2005); Al-Nimrawi (2006).

In Basrah Mohammed (1965) collected and identified some species of Cladocera from the central and southern part of Iraq, included the Shatt Al – Arab River from the Khour Al-Amaya to Qurna, and recorded 23 species of Cladocera, including fifteen species new record in Iraq. and found that there were differences between the downstream species and those of the rest of the other areas. Then AL-Saboonchi *et al*. (1986) studied the zooplankton of the Al-Hammar Marshes (near Garmat-Ali River), and recorded seven species of Cladocera. Moreover, Salman *et al*. (1986) investigated the monthly changes of the zooplankton in the Shatt Al-Arab River from 1982–1984, they indicated that the first important group was Cladocera followed by Copepoda. However Salman *et al*. (1990) encountered very few specimens of Cladocera on a few occasions only in Khour Abdullah, north west Arabian Gulf. Ajeel (1998) studied the population dynamics and bioenergetics of two species of Cladocera, and Ajeel *et al*. (2000 a, b) studied the population dynamics of *Daphnia magna* and *Simocephalus vetulus*. AL-Zubaidi and Salman (2001) studied the zooplankton in the Shatt Al-Arab estuary; they referred to Cladocera as comprising 58% of the zooplankton in Al-Sebah region. Ajeel *et al*. (2001) reported on the Cladocera in the Shatt Al-Arab River and made records of six species of Cladocera new in Iraq. Whereas Ajeel (2004) investigated the zooplankton in the north of Shatt Al-Arab, Shatt Al-Basrah Canal and Khour Al-Zubair, and found that the Cladocera comprised 5.4–35.4% of the total zooplankton in the Shatt Al-Arab. Whereas in Garmat-Ali River the Cladocera comprised 17.8% of the total zooplankton (Ajeel *et al*. 2004). Al-Jizany, (2005) studied the impact of organic pollution on the diversity and abundance of the plankton in the Shatt Al-Arab River, Al-Ashar and Al-Rabat channels, she found that the Cladocera constituted the third important group. Al-Qarooni (2005) studied the abundance and the presence of some zooplankton in the marshlands of southern Iraq and recorded 14 species of Cladocera.

Al-Zubaidi (1998) showed that the maximum abundance of Cladocera in Al-Faw and Al-Sebah stations were 1802 and 1057 ind/m^3 respectively. While Ajeel *et al*. (2006a) found that the Cladocera comprised 10.3% in the South of Hour Al-Hammar. Ajeel *et al*. (2008) indicated that the Cladocera comprised 8.8 % of the total zooplankton in Basrah district. Whereas in the Shatt Al-Basrah Channel constituted 3.1% (Ajeel, 2012). While in Shatt Al-Arab and Garmat Ali River Ajeel and Abbas (2012) recorded 16 and 15 species of

Cladocera, respectively. Jebir (2013) studied the ecology and structure of zooplankton community in the Shatt Al-Basrah and south of Shatt Al-Arab and recorded a few species of Cladocera in these areas.

In the view of the fact that Cladocera are of a special interest in the Shatt Al-Arab River, in that they are an important component of the aquatic systems and reported as one of the most productive group among the zooplankton of the region (Salman, *et al.,* 1986). Moreover, the studies on the Cladocera in the Shatt Al-Arab River are limited. For this reason and for reporting on the distribution of Cladocera in various localities in the Shatt Al-Arab, and monitor the effects of some physical and chemical parameters on their abundance, the present study was carried out.

Materials and Methods

Study Area

The study was carried out between January and November 2013 on a seasonal basis. Samples were taken from three stations south of the Shatt Al-Arab River (Fig. 1). The first station was near the city centre at Al-Ashar region (30° 31′ 32.39″ N and 47° 50′ 33.43″ E), this station is affected by sewage coming from side branches like Al-Ashar and Al-Khandaq creeks, in addition to wastes from boats. The second station in Abu Al-Khasib region (30° 27′ 49.88″ N and 48° 00′ 30.89″ E) opposite to one of the branches of Abu Al-Khasib creek, and the third station in Al-Faw region (29° 59′ 20.06″ N and 48° 28′ 02.22″ E) (Fig. 1).

Sample collection

Plankton samples were collected from the surface water by using 85 µm mesh-sized net with a mouth aperture of 40 cm in diameter. A digital flow-meter was mounted in the middle of the mouth of the net. The net was horizontally towed behind a boat running at its lowest speed for 10-15 minutes. The reading of the flow meter was taken before and after each tow. At each station, samples of zooplankton were collected, transferred to plastic containers. The plankton samples were immediately fixed with 4% formaldehyde.

Water temperatures were measured by a thermometer with 0.1°C sensitivity. Salinity, pH and TDS measurements were performed by YSI 556 MPS. Dissolved oxygen concentration was measured by Winkler method. Turbidity was measured by HANNA instrument, Microprocessor Turbidity Meter HI 93703. In the laboratory, samples were poured into a graduated vessel, and diluted if densely populated. Then 10 ml subsample was taken and placed in a Bogorov chamber, examined and counted under a dissecting microscope. This procedure was repeated for 3 times, then the whole sample was examined for the rare species. Tests of significance were carried out using the SPSS packages.

The volume of the water and the number of individuals were determined according to American Public Health Association (2006).

Figure 1: Map of lower Mesopotamia showing the sampling stations taken by using Google Earth program

Identification of the species were done with the aid of Brook (1959), Smirnov (1971, 1992, 1996), Benzie (2005) and Kotov and Stifter (2006).

The relative abundance index (Ra) was calculated according the formula found in Omori & Ikeda (1984):

Ra = N / Ns × 100, where:

N = Number of species in the sample

Ns = Total number of individuals in the sample

The percentages of the species are expressed as follow:

70 > %: Dominant species (D)

40 - 70 %: Abundant species (A)

10 - 40 %: Frequent species (F)

10 < %: Rare species (R)

Shannon Weaver diversity index (H) was calculated according to the expression of Shannon-Weaver, (1949), Jaccard's similarity index Ss% was calculated according to Jaccard (1908), Evenness index (J) was calculated by

the equation of Pielou (1966) and Richness index (D) was calculated by the equation of Margalef (1968).

The multivariate environmental data analysis used for calculate the correlation between environmental factors and Cladocera density using the program CANOCO (2004).

Results

Physical and chemical parameters

Water temperatures at the three stations are very close to each other, it ranged between 15 and 27.5 ^{0}C in January and July 2013, respectively. Salinity changed from 1.8 psu at station 2 (Abu Al-Khasib) in winter, to 40 psu at station 3 (Al-Faw) in summer. While pH varied from 6.2–8.7 at station 3 (Al-Faw) in spring and summer, respectively. Dissolved oxygen fluctuated from 5.1 mg/l at station 1 (Al-Ashar), in summer season, to 9.9 mg/l at station 2 (Abu Al-Khasib), in spring season. As for the total dissolved solids (TDS) values were ranging from 1467 mg/l at station 1 (Al-Ashar) in autumn, to 33590 mg/l, at station 3 (Al-Faw) in summer. While the highest value of turbidity 180.6 FTU were encountered during winter at station 3 (Al-Faw), whereas the lowest value 7.1 FTU were recorded during spring at station 1 (Al-Ashar), (Fig 2, 3, 4).

Cladocera

Total Cladocera abundance ranged from 0 ind./m^{3} in spring and summer at Al-Faw station to 18922 ind./m^{3} in summer at Al-Ashar station (Table 1). Five species of Cladocera belonging to five genera were recorded in Al-Ashar station, and two species in Abu Al-Khasib station, whereas one species only recorded at Al-Faw station. *Moina affinis* is the dominant species in three stations (Fig. 5). The density of each species at three stations were explained in Fig (6). The average seasonally density of Cladocera was ranged between 37 ind./m^{3} at station 3 to 5500 ind./m^{3} at station 1 (Fig. 7). The highest percentage of Cladocera of the total zooplankton (80.1%) was recorded at station 1 (Al-Ashar) during summer whereas not found any specimen at station 3 (Al-Faw) during spring and summer (Fig. 8).

Table (2) explained relative abundance of Cladocera species at three stations, which was *Moina affinis* dominant species (D) at three stations and *Diaphanosoma brachyurum* was frequent species (F) at station 1 and 2, whereas other three species was rare species (R) at station 1.

Station 1 (Al-Ashar)

The density of Cladocera ranged from 0.01 ind./m^{3} in spring to 18922 ind/m^{3} in summer (Table 1). The average seasonally density was 5500 ind/m^{3}. *Moina affinis* were the dominant species which comprised 71% of the total

Cladocera, the highest peak (15163 ind/m3) was reached in summer whereas not recorded at winter. The second important species was *Diaphanosoma brachyurum* (28.9 %), the high density was 3759 ind/m3 at summer and 2831 ind./m3 at autumn while not recorded at winter and spring.

Station 2 (Abu Al-Khasib)

The density of Cladocera ranged from 4.9 ind/m3 in winter to 818 ind/m3 in summer (Table 1). The average seasonally density was 333 ind/m3. There are only two species of Cladocera was recorded in this station its *Moina affinis* which comprised 83.7% of the total Cladocera, the highest peak (666 ind/m3) was reached in summer whereas the low density was 3.3 ind/m3 recorded at winter. The second species was *Diaphanosoma brachyurum* (16.3%), the high density was 152 ind/m3 at summer and the low density was 1.6 ind/m3 at winter.

Station 3 (Al-Faw):

There is one species of Cladocera was recorded in this station its *Moina affinis* which recorded only at winter (0.2 ind/m3) and autumn (149 ind/m3). The average seasonally density was 37 ind/m3.

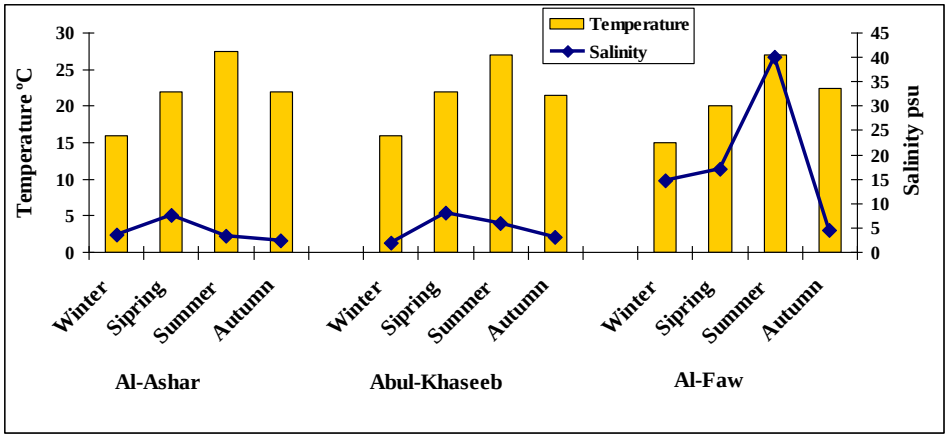

Figure 2: Water temperatures and Salinity at three stations during the study period.

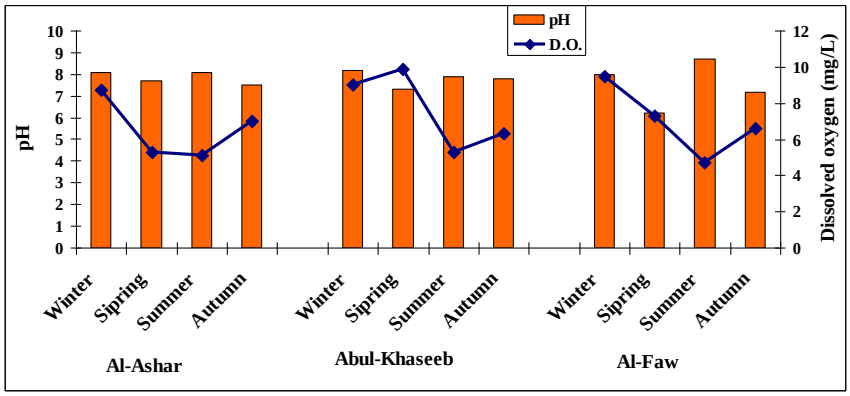

Figure 3: pH and Dissolver oxygen at three stations during the study period

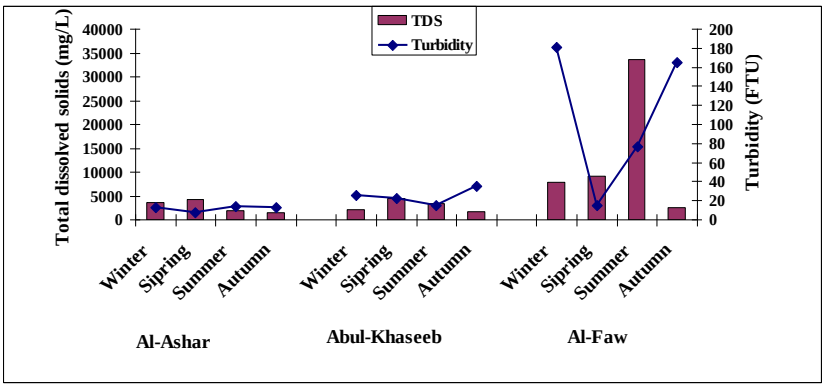

Figure 4: Total dissolved solids (TDS) and Turbidity at three stations during the study period.

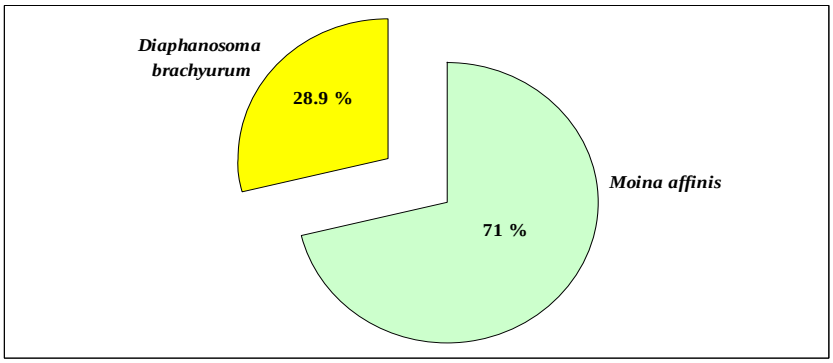

Figure 5: percentage of important species of Cladocera in study area

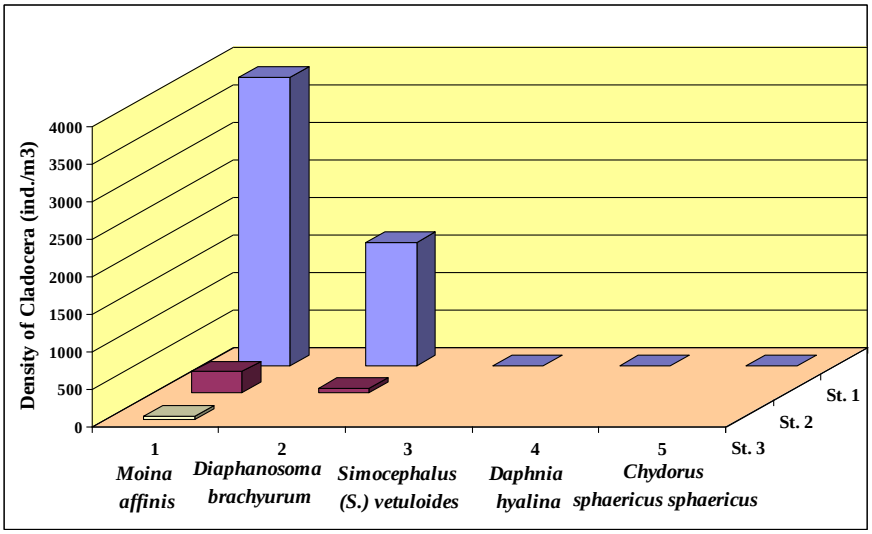

Figure 6: Annual mean density of each species of Cladocera in three stations.

Table (1): Abundance (ind/m³) and percentage of Cladocera species in the Shatt Al-Arab River during the seasons 2013.

Cladocera	Winter			Spring			Summer			Autumn			Total	Percentage %
	Al-Ashar	Abu Al-Khasib	Al-Faw	Al-Ashar	Abu Al-Khasib	Al-Faw	Al-Ashar	Abu Al-Khasib	Al-Faw	Al-Ashar	Abu Al-Khasib	Al-Faw		
Moina affinis	–	3.3	0.2	0.01	31.3	–	15163	666	–	247	414	149	16674	71
Simocephalus (*Simocephalus*) *vetuloides*	0.07	–	–	–	–	–	–	–	–	–	–	–	0.07	0.0003
Diaphanosoma brachyurum	–	1.6	–	–	45	–	3759	152	–	2831	18	–	6807	28.9
Daphnia hyaline	0.04	–	–	–	–	–	–	–	–	–	–	–	0.04	0.0002
Chydorus sphaericus sphaericus	0.41	–	–	–	–	–	–	–	–	–	–	–	0.41	0.002
Total of Cladocera	0.52	4.9	0.2	0.01	76.3	0	18922	818	0	3078	432	149	23481	

Table (2): Relative abundance index (Ra) of cladoceran species reported at the three stations during the study period.

	Cladocera species	Relative Abundance		
		St. 1 Al-Ashar	St. 2 Abu Al-Khasib	St. 3 Al-Faw
1	*Moina affinis*	D	D	D
2	*Simocephalus* (*Simocephalus*) *vetuloides*	R	-	–
3	*Diaphanosoma brachyurum*	F	F	–
4	*Daphnia hyalina*	R	–	–
5	*Chydorus sphaericus sphaericus*	R	–	–

(D): Dominant species = 70 > %
(A): Abundant species = 40 - 70 %
(F): Frequent species = 10 - 40 %

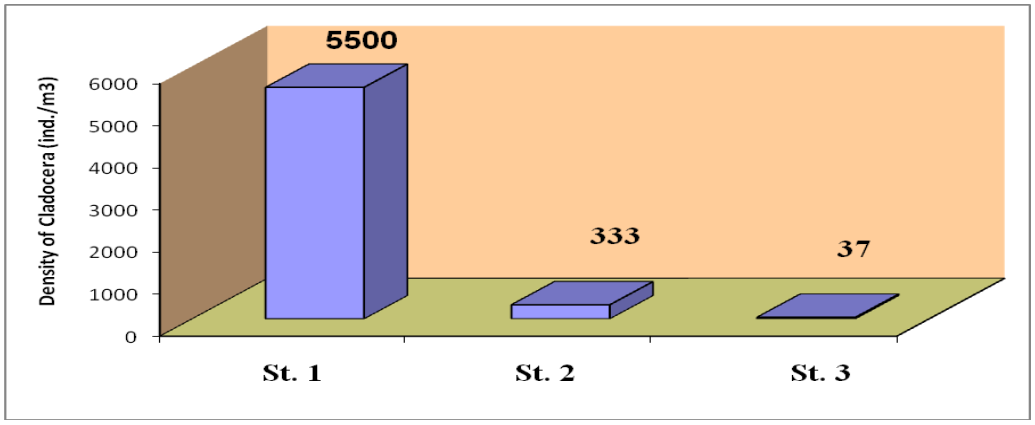

Figure 7: Average seasonally density of Cladocera in three stations

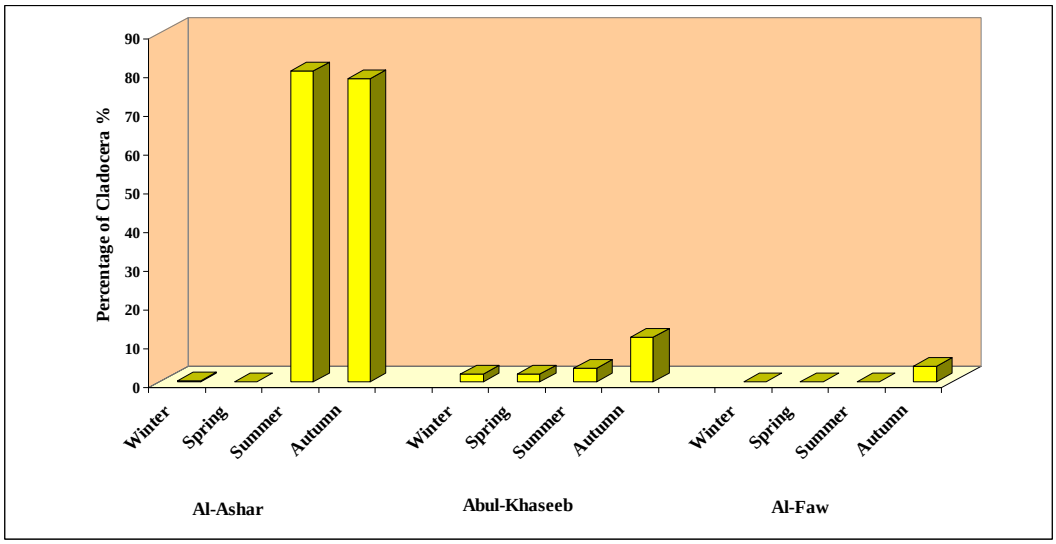

Figure 8: Percentage of Cladocera of the total zooplankton at three stations during the study periods

Diversity index (H) Shannon Weaver

Varied diversity index values in the study stations was the highest value 0.7 during the winter and the lowest value 0.0 during the spring in the first station, while in the second station the highest value 0.7 recorded during the spring and the lowest value 0.2 during the autumn. And in the third station the value of diversity index was 0.0 (Figure 9).

Evenness index (J)

Figure (10) shows the annual average of Evenness index values which were recorded in the study stations. Evenness coefficient for the Cladocera group reached highest value (0.4) during the winter in the first station and during the winter and spring in the second station.

Species Richness (D)

Seasonal changes varied in species richness values in the study stations which recorded as the highest rate (6.1) during the winter and lower rate 0.4 during the summer in the first station, while the highest rate was 2.5 during the winter and lower rate of 0.6 during the summer in the second station (Fig. 11).

Jacquard's Index

Jaccard's similarity index was calculated for the Cladocera between different stations, the highest similarity value was between stations (1) and (2) while the lowest value of the similarity between stations (1) and (3) (Fig. 12).

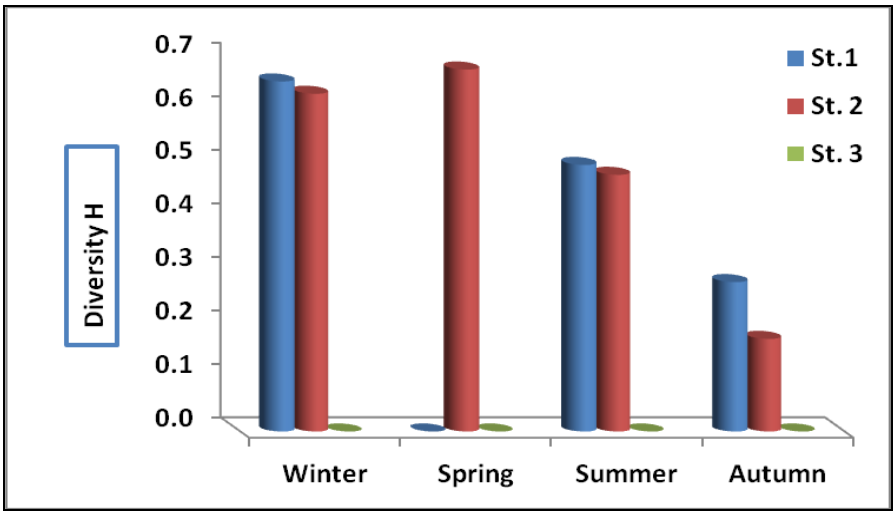

Figure 9: Seasonally changes of diversity index at the three stations in the Shatt Al-Arab region during the study period.

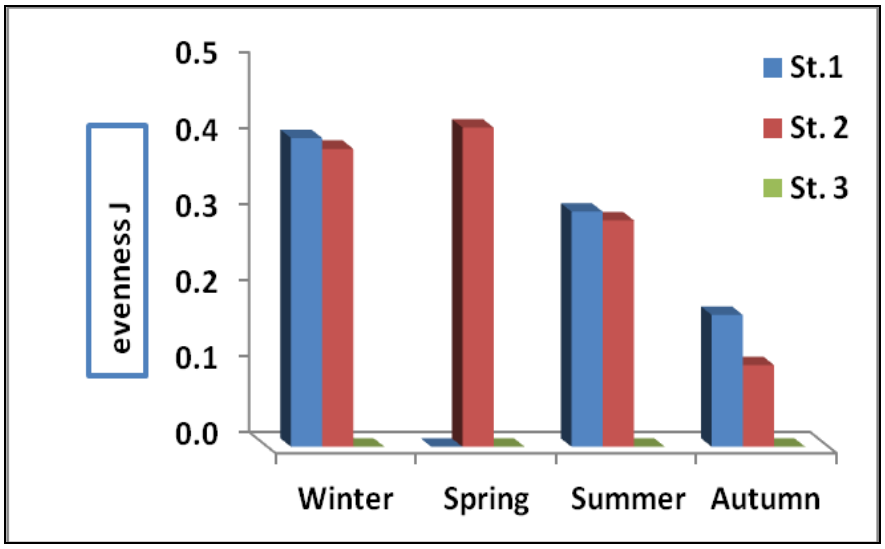

Figure 10: Seasonally changes of evenness index at the three stations in the Shatt Al-Arab region during the study period

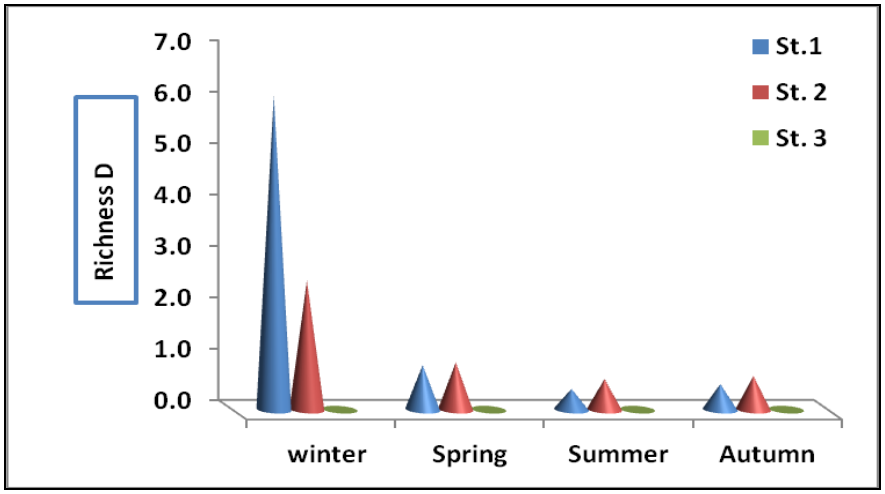

Figure 11: seasonally changes of richness index at the three stations in the Shatt Al-Arab region during the study period.

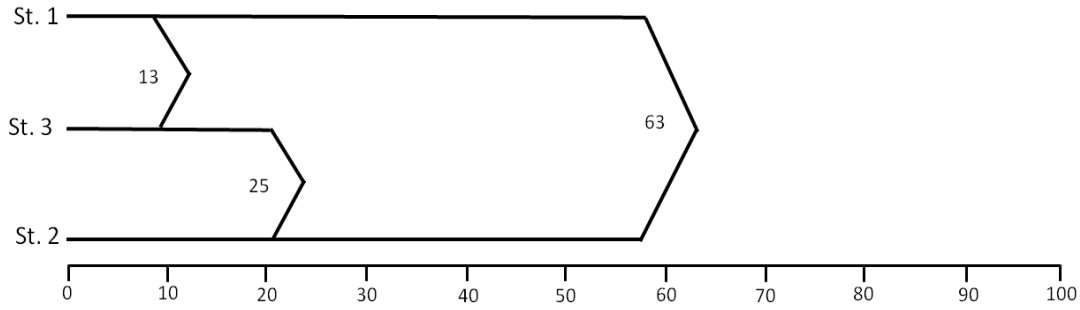

Figure 12: Dendrograph based on Jaccard's similarity index of Cladocera at the three stations of Shatt Al-Arab River between January and November 2013 on a seasonally basis

The correlation between the Cladocera and physical and chemical characteristics of the three stations that have been drawn by the statistical program Canoco explain in Figure (13) which observed the species *Moina affinis* were high positive relationship with the temperature and pH and low positive relationship with total dissolved solids and salinity and turbidity, while the associated negative relationship with dissolved solids, salinity. The species *Diaphanosoma brachyurum* had been linked negative relationship with all factors except dissolved oxygen as recorded weak positive. While *Simocephalus (Simocephalus) vetuloides*, *Chydorus sphaericus sphaericus* and *Daphnia hyaline* it linked to a weak positive relationship with dissolved oxygen and a negative relationship with the other factors

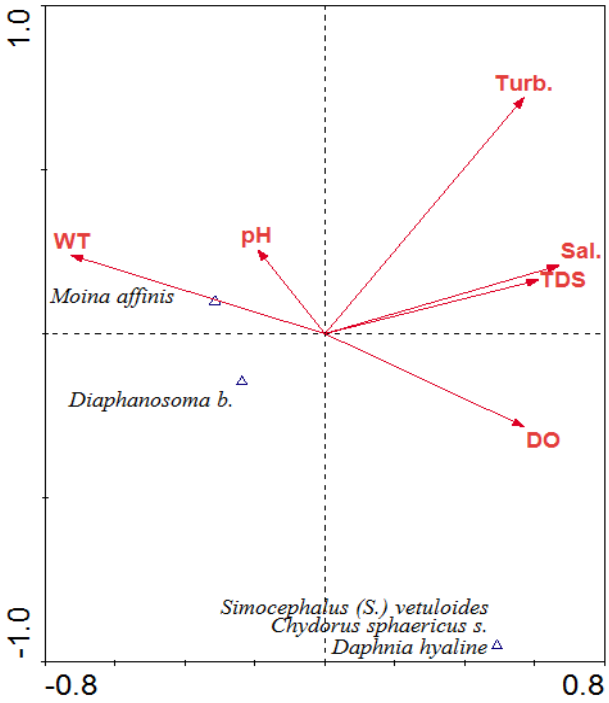

Figure 13: The correlation between Cladocera and environmental parameters that have been measured using statistical system Canoco

Discussion

Aquatic organisms in natural waters often are subjected to various stress factors of physical, chemical, and biological origin. (Greco, *et al.* 1995, Vighi, *et al.* 2003). Still, relatively little is known about the combined effects of these stress factors. Although a substantial amount of literature is available concerning the distinct effects of temperature and food, less information is at hand concerning the joint effects of two factors. Studies involving three-factor interactions are exceptional. The distribution of Cladocera varies both spatially and temporally according to the environmental conditions prevailing in the region. Differences may also arise due to the nature of distribution of the plankton, namely patchiness which may be the cause of the great variations in the catches of the nets (Raymont, 1983). Microcrustacean assemblages are noted for their marked annual fluctuations in abundance and species composition. Cladocerans are characterized by annual hundred-fold variations in population size (Dodson and Frey, 1991).

Alkaline character is dominant in Iraqi water because of the abundance of bicarbonate ions and carbonate (Al-Saadi *et al.* 1993; Hassan 1997). Several factors affect the pH, including a decrease or increase in the concentration of carbon dioxide due to photosynthesis processes that lead to the consumption of carbon dioxide and then reducing the pH values (Sabri *et al.* 1989).

The dissolved oxygen ranged from 7.4 to 9.9 mg/L at all of the present stations, and these values are correlated with temperatures. The rising value of dissolved oxygen was recorded during winter and lowest values were observed during summer and autumn, these results agree with several studies in the Shatt al-Arab, such as Al-Jizany (2005) and Al-Mahmood *et al* (2008) and in inland water, such as Al-Lami (1998) and Al-Qarooni (2005).

The turbidity is an important physical parameter in the water and has an inverse relationship with the transparency of the water, and it is an indicator and measure of materials suspended in the water such as silt and mud as well as zooplankton and phytoplankton and tiny other object, like bacteria. The turbidity value which was recorded at the third station is higher than those in the first and second stations, and this is due to the higher movement of water by tidal effect at the third station, and this is consistent with the conclusion of Hussein *et al.* (1991). It was found in the current study that the TDS is not affected by temperature and the concentration was found to be high at the third station only.

The present results indicate that there were great differences in the abundance of Cladocera among the three stations sampled. The average density of Cladocera was 5500, 333 and 37 ind/m^3 at three stations, respectively, with reduction in number toward the south, due to increase in salinity. This is in agreement with study of Jebir (2013) in the Shatt Al-Arab who recorded Cladocera during May and November only at Al-Seebah station and during December 2011 and January 2012 only at Al-Faw station. The temperature, food, pH, dissolved oxygen, salinity and other environmental factors, as well as their interactions, were important factors influencing the density and, as a consequence, the population growth rate of Cladocera.

The Shatt Al-Arab River consider as Oligohaline brackish water (Reid, 1961, McLusky & Elliott, 2004) with higher entrance in the Arabian Gulf. The rise in salinity in the southern sector of the Shatt Al-Arab River certainly is the major factor controlling the distribution of species of Cladocera. Table (4) presents a comparison of the density, average density, number of species and percentage of Cladocera at different stations in the Shatt Al-Arab River. These differences maybe related to different environmental conditions as well as different mesh-sized net used for sampling zooplankton.

The time of sampling has a significant impact on the concentration of salt, especially in the third station (Al-Faw), for at high tide, the salinity increases due to the progress of sea water, but at low tide, the concentration of salinity become low due to the progress of fresh water. In the current study the salinity ranges were very high fluctuated between 1.8 psu at station of Abu Al-Khasib during winter and 40 psu at Al-Faw during summer.

The results of the environmental evidence (Shannon Weaver diversity index (H), Richness index (D), and Evenness index (J)) show low rate this evidence in the study stations has been attributed to pollution in this region and this is consistent with Al-Jizany (2005) which reported the pollution due to reduce diversity index.

Jonge (1995) refer to when the environment conditions was natural the water quality in that environment be suitable for high diversity ratios, and on the contrary, in the event of a defect in this environment, such as the lack of species that feed on other species cause the lack of diversity and increase opportunity for the growth of the species of high densities were originally present in small quantities in natural conditions.

References

Abbas, M. F. (2010). Abundance of Cladocera and some other zooplankton and Diversity in the Northern part of Shatt Al-Arab river. M.Sc. Thesis, College of Education, University of Basrah. 114 pp. (In Arabic).

Abdul-Ahad, S. F. (1980). Effect of some environmental factors on some aspects of life for *Daphnia lumholtzi* Sars (Crustacea: Cladocera). M.Sc. Thesis, College of Science, University of Baghdad. (In Arabic).

Ajeel, S. G. (1998). Population dynamics and bioenergetics of two species of Cladocera: *Simocephalus vetulus* & *Daphnia magna* in Basrah with a reference to the zooplankton. Ph.D. thesis, University of Basrah, 154 pp. (in Arabic).

Ajeel, S. G. (2004). Abundance and distribution of zooplankton in some waters in southern region of Iraq. Mar. Mesop. 19(1): 95–115. (in Arabic).

Ajeel, S. G. (2012). Distribution and abundance of zooplankton in Shatt Al-Basrah and Khour Al-Zubair Channels, Basrah, IRAQ. Journal of Basrah Researches /Sciences. 38(4): 10-28.

Ajeel, S. G. and Abbas, M. F. (2012). Diversity of Cladocera of the Shatt Al-Arab River, Southern Iraq. Marina Mesopotamica. 27(2): 126-139.

Ajeel, S. G., Ali, M. H. and Salman, S. D. (2001). Cladocera from Shatt Al-Arab and some temporary ponds in Basrah. Marina Mesopotamica 16(1):309-329 (in Arabic).

Ajeel, S. G., Abdulla, S. B. and Mohammad, H.H. (2004). Abundance and distribution of the zooplankton in the Garmat-Ali River. Basrah J. of Agricultural Science. 17(1): 167-178.

Ajeel, S. G., Ali, M. H. and Salman, S. D. (2000 a). Population dynamics of *Simocephalus vetulus* Muller (Crustacea: Cladocera) in Basrah. Marina Mesopotamica 15(2): 593-612. (in Arabic).

Ajeel, S. G., Salman, S. D. and Ali, M. H. (2000 b). Population dynamics of the Cladoceran *Daphnia magna* in a pool in Basrah. Marina Mesopotamica 15(2):475-492. (in Arabic).

Table 4: Density, average density, number of species and percentage of Cladocera at different stations in the Shatt Al-Arab River from various sources.

	Study Area	mesh-Sized (mm)	Density (ind./m^3)	Average density of Cladocera (ind./m^3)	Number of species	Percentage of total zooplankton	References
1	Al-Qurna	0.158	-	-	4	-	Mohammad, 1965
2	Al-Qurna	0.120	1.27-2435	274.9	16	28.7	Abbas 2010
3	Al-Dear	0.120	0 - 621	178.1	-	5.4	Ajeel 2004
4	Al-Hartha near the paper mill	0.120	1.2-91225	8992.3	12	77.4	Abbas 2010
5	Saad Bridge	0.120	0.3 -2118	510.4	-	23.3	Ajeel 2004
6	Al-Hartha near the desalination plant	0.090	5 – 229	82	14	16.6	Ajeel *et al.* 2001
7	Khalid Bridge	0.120	67 - 1423	547.5	-	35.4	Ajeel 2004
8	Al-Sindibad	0.120	2 – 19800	3115.7	9	42.7	Abbas 2010
9	Al-Ashar	0.090	0.3 - 145	24	14	3.8	Ajeel *et al.* 2001
10	Al-Ashar	0.120	1 - 20721	3604.7	7	52.3	Abbas 2010
11	Al-Ashar	0.085	0.01-18922	5500	5	39.6	**Present study**
12	Abu Al-Khasib	0.085	4.9 – 818	332.8	2	4.7	**Present study**
13	Aboflos	0.120	11216	-	-	92.7	Salman *et al.* 2012
14	Al-Seba	0.090	11 - 10854	1388	-	57.8	AL-Zubaidi and Salman, 2001
15	Al-Seba	0.085	0 - 1640	148.3	-	3.1	Jebir 2013
16	Al-Wasilia	0.158	-	-	4	-	Mohammad, 1965
17	Al-Faw	0.158	-	-	2	-	Mohammad, 1965
18	Al-Faw	0.090	4 - 8781	1329	-	36.2	AL-Zubaidi and Salman, 2001
19	Al-Faw	0.120	0	-	-	0	Salman *et al.* 2012
20	Al-Faw	0.085	0 - 425	69.3	-	0.35	Jebir 2013
21	Al-Faw	0.085	0 – 149	37.3	1	1	**Present study**

Ajeel, S. G., Khalaf, T. A., Mohammad, H.H. and Abbas, M.F. (2006). Distribution of zooplankton in the Al-Hawizah, Al-Hammar marshes and Al-Izze river south of Iraq. Marsh Bulletin. 1(2): 140–153.

Ajeel, S. G., Salman, S. D. and Ali, M.H. (2008). Zooplankton of Basrah district, Southern Iraq. Marsh bulletin. 3(2): 171-191.

Al-Hammed, M. I. (1966). Limnological study on the inland water of Iraq. Bull. Iraq Nat. Hist. Mus., 3: 1- 21.

Al-Jizany, H. R. I. (2005). Organic pollution and its effect on the diversity and abundance of plankton in the Shatt Al-Arab, Ashar and Rubat canals. M. Sc. Thesis, Coll. Edu. Uni. Basrah. 82pp.

Al-Lami, A. A. (1998). The environmental effects of the Al-Therthar arm on the Tigris River before entering Baghdad city. Ph.D. Thesis. College of Science–University of Al-Mistansirea, 123 pp. (in Arabic).

Al-Lami, A. A., Abbas, A. K. and Moften, F. C. (2001a). Diversity of invertebrates Cladocera in the Euphrates River, Iraq. Journal of Al-Qadisiyah, Pure Science, 6 (4): 98-106.

Al-Lami, A. A., Ali, I. H., Abbas, A. K. and Radi, A. G. (2001b). Seasonal and position changes of Cladocera in Al-Habbaniyah, Iraq. Ibn Al-Haytham Journal of Pure and Applied Sciences, 14 (3): 77-85.

Al-Mahmood, H. K. H., Al-Shawi, I. J. M. and Al-Imarah, F. J. (2008). Survey for the evaluation of physical – chemical parameters of Shatt Al-Arab Waters, Basrah City (1974–2005). Basrah J. Agric. Sci., (special issue): 433–448.

Al-Nimrawi, A. M. (2006). Biodiversity of aquatic invertebrates in the Tigris and Euphrates center Iraq. Ph.D. Thesis. Baghdad University, College of Science, Department of Biology. 161 pp. (In Arabic).

Al-Qarooni, I. H. M. (2005). Abundance and Occurrence Studies on some of zooplankton and aquatic snails in Al- Chabaish, Al- Hammar and Al-Fuhud marshes southern Iraq. M.Sc. Thesis. College of Education–University of Basrah, 95pp. (in Arabic).

Al-Saadi, H. A., AL-Mousawi, A. H. and AL-Aarijy, M. J. (1993). Physicochemical features of AL- Hammar Marsh, Iraq. J. Coll. Educ. Women, Univ. Baghdad, 4: 35 - 40.

AL-Saboonchi, A. A., Barak, N. A. and Mohamed, A. M. (1986). Zooplankton of Garma marshes , Iraq. J. Biol. Sci. Rrs. 17(1): 33-40.

AL-Zubaidi, A. M. H. (1998). Distribution and abundance of the zooplankton in the Shatt AL-Arab estuary and North West Arabian Gulf. Ph. D. thesis, University of Basrah. 125 p

AL-Zubaidi, A. M. H. and Salman, S. D. (2001). Distribution and abundance of zooplankton in the Shatt AL-Arab estuary, North West Arabian Gulf. Mar. Mesop. 16(2): 187–199.

American Public Health Association (2006). Standard methods for the examination of water and wastewater. 21 st edition Washington, Dc. 1400 pp.

Benzie, J. A. H. (2005). Guides to the identification of the microinvertebrates of the continental water of the world. The genus Daphnia (including Daphniopsis) (Anomopoda: Daphnidae). Dumont, H. J. F. (Ed.). Kenobi productions, Ghent. 21: 376 pp.

Brook, J. L. (1959). Cladocera. In : W.T. Edmondson (ed) ward whippets fresh water biology ; John wiley and Sons, Inc. New York :587- 656.

Dodson, S. I and Frey D. G. (1991). Cladocera and other Branchiopoda. Thorp J. H. and Covich A. P (ed.). Ecology and Classification of North American freshwater invertebrates, Academic Press Inc, San Diego, California, 92101.

Dodson, S. I. and Frey, D. G. (2001). Chapter 21. Cladocera and Other Branchiopoda. In: J. H. Thorp and A. P. Covich (Eds.), Ecology and Classification of North American Freshwater Invertebrates. 2 nd Ed. Academic Press. Amsterdam, pp. 849–913.

Goswami, S. C. (2004). Zooplankton Methodology, Collection & Identification. National Institute of Oceanography Dona Paula, Goa - 403 004. Financial Support Ministry of Environment & Forests, New Delhi.

Gurney, R. (1921). Freshwater crustacean collected by Dr. P. A. Buxton in Mesopotamica and Persia. *J. Bombay Nat. Hist. Soc.*, 27(4): 835-844.

Greco, W. R., Bravo, G. and Parsons, J.C. (1995). The search for synergy: A critical review from a response surface perspective. Pharmacol Rev 47:331–385.

Hassan, F. M. (1997). A limnological study on Hilla River. Al-mustansiriyah J. Sci. , 8 (1): 22 - 30.

Hussein, N. A., Al-Najar, H. H., Al-Saad, H. T., Yousif, U. H. and Al- Saboonchi, A. A. (1991). Shatt Al-Arab Basic Scientific Studies. Marine Science Centre Publ. Basrah Univ. 139 pp. (in Arabic).

Jaccard, P. (1908). Nouvelles researches sur la distribution florale. Bull Soc. Vand Sic. Nat., 44: 223-270.

Jebir, A. M. (2013). Ecological study of zooplankton in the shatt Al-Arab River and Shatt Al-Basrah Canal - South Iraq. M.Sc. Thesis. University of Basrah. P 119. (in Arabic).

Jonge, V. N. (1995). Response of the Dutch Wadden Sea ecosystem to phosphorus discharges from the river Rhine. Hydrobiologia, 195: 49-62.

Khalaf, A. N., Lattif, M.A. and Mangalo, H.H. (1977a). Growth of *Simocephalus vetulus* (Crustacea: Cladocera) under different diet conditions. Bull. Biol. Res. Center 9: 17-26.

Khalaf, A. N.; Lattif, M. A. and Mangalo, H. H. (1977 b). Egg production of *Simocephlus vetulus* (Cladocera: Crustacea) under different diet conditions. Technical Bull. 14: 1-10.

Khalaf, A. N. and Shihab, A. F. (1977). Seasonal variation in population of *Moina macrocopa* Strauss and *Moina Micrura* Kurz (Crustacea: Cladocera) in Zoofaraniyah pools. Bull. Basrah Nat. Hist. Mus., 4: 51-57.

Khalaf, A. N. and Smirnov, N. N. (1976). On littoral Cladocera of Iraq. Hydrobiology, 51: 91-94.

Kotov, A. A. and Stifter, P. (2006). Guide to the identification of the microinvertebrates of the continental water of the world. Cladocera: Family Ilyocryptidae (Branchiopoda: Cladocera: Anomopoda). Dumont, H. J. F. (Ed.). Backhuys publishers, Leiden. 22: 1- 172.

Lazim, M. N. (1977). A study on some aspects of the biology and ecology of *Daphnia lumholtzi* (Crustacea: Cladocera) M.Sc. Thesis, Baghdad University, 134 pp. (In Arabic).

Lazim, M. N. and Zeki, M. (1987). A study of life span, instar duration, growth and reproduction in *Scapholebris kingi* Sars. Biol. Sci. Res, 18: 1-10.

Mangalo, H. H. and Akbar, M.M. (1986 a). Size and reproduction in natural population of *Moina affinis* (Cladocera: Crustacea) in Diyala river at Baghdad, Iraq. J. Biol. Sci. Res., 17(3): 85-96.

Mangalo, H. H. and Akbar, M. M. (1986 b). Seasonal variation in population density of zooplankton in the lower reaches of Diyala river, Baghdad. Iraq. J. of Biolo. Sci. Res. , 17 (3): 99-114.

Mangalo, H. H. and Akbar, M. M. (1988). Comparative study of two populations of cladocerans in the Tigris and Diyala rivers at Baghdad. J. Biol. Sci. Res., 19(1): 117-128.

Margalef, R. (1968). Perspectives in ecology theory. Univ. Chicago press, Chicago, 111 pp.

McLusky, D. S. and Elliott, M. (2004). The estuarine ecosystem: Ecology, Threats and Management. Oxford University Press, London, 214 p.

Mohammed, M. B. (1965). A faunal study of the Cladocera of Iraq. Bull. Biol Res. Centre, 1: 1-11.

Mohammad, M. B. (1986). Associations of invertebrates in the Euphrates and Tigris Rivers at Falluja and Baghdad, Iraq. Archiv Fur Hydrobiologia, 106(3): 337-350.

Murad, S. A. A. (1977). Effect of some pollutants on *Simocephalus expinosus* (Crustacea: Cladocera) under laboratory conditions. M.Sc. Thesis, College of Science, University of Baghdad.

Oltra, R. and Todolr, R. (1997). Effect of temperature, salinity and food life 130 (supplement): 29 – 33. History traits of the marine rotifer *Syncaeta Cecilia valentine*, n. sub sp. J. Plankton Res., 19 (16): 693 – 702.

Omori, M. and Ikeda, T. (1984). Methods in Marine Zooplankton Ecology. Wiley and Sons, New York., 103 pp.

Pielou, E. C. (1966). Shannon's formula as measure of specific diversity: Its use and misuse. Am. Nat., 100: 463-465.

Poltorak, T., Bartel, R. and Szczerbowski, A. (2001). Horizontal distribution of zooplankton in lakes Thrthar, Habbaniy and Razzazah. Archives of polish fisheries. 9 (1): 111-126.

Rahdi, A. G., Al-Lami, A. A., Al-Rudainy, A. A. and Nashaat, M.R. (2005). Distribution and composition of zooplankton in the Euphrates River near Al-Musaib Power Station. Iraq J. Aqua. 2, 1-20 .

Raymont, J. E. G. (1983). Plankton and productivity in the Ocean. Π. Zooplankton Pergamon Press, 824 pp.

Reid, G. K. (1961). Ecology of Inland Waters and Estuaries. D. Van Nostrand Company; New York. pp. 375.

Sabri, A. W., Ali, Z.H., Thejar, L.A., Shawkat, S.F. and Kassim, T.I. (1989). Vertical distribution zooplanktonic species in Samarra impoundment (Iraq). Proc. Sth Sci. Conf./SRC., 5 : 256-264.

Salman, S. D.; Ali, M.H.; Mohammad, H.H. and Abbas, M.F. (2012). Zooplankton in the south of Iraq. Final report of discovery journey south Iraq waters during 1/7 – 4/7/2012. Marine Science Centre of Basrah University; Basrah, Iraq.

Salman, S. D., Marina, B. A., Ali, M. H. and Oshana, V. K. (1986). Zooplankton studies. Pp. 136-166 In: Final report: The 18-month Marine Pollution Monitoring and Research Programme in Iraq. Marine Science Centre, Basrah University; Basrah, Iraq.

Salman, S. D., Marina, B. A and Ali, M. H. (1990). The zooplankton of Khor Abdullah, North West Arabian Gulf. Marina Mesopotamica 5(1): 11-26.

Shannon, C. E. and Weaver, W. (1949). The mathematical theory of communication, Univ. Illinois press, Urbana, I, 11. 117 pp.

Shihab, A. F. (1977). The effect of some environmental factors on the growth, reproduction and longevity of the water flea *Moina micrura* Kurz (Crustacea : Cladocera). M. Sc. Thesis, College of science, University of Baghdad.

Shihab, A. F. and Khalaf, A. N. (1980). Effect of temperature on the growth and reproduction of *Moina micrura* (Crustacea: Cladocera). Bull. Biol. Res. Centre. 12(2): 49 – 72.

Smirnov, N. N., (1971). Fauna of the U. S. S. R. Crustacea, chydoridae. 1 (2): 1-644 (English Translation, Israel program Scientific Translations, Jerusalem).

Smirnov, N. N. (1992). Guides to the identification of the microinvertebrates of the continental water of the world. The Macrothricidae of the world. SPB academic publishing bv. 143 pp.

Smirnov, N. N. (1996). Guides to the identification of the microinvertebrates of the continental water of the world. Cladocera: the Chydorinae and saycinae (Chdoridae) of the world. Dumont, H. J. F. (Ed.). SPB Academic Publishing bv. 11: 197 pp.

Vighi, M. Altenburger, R. Arrhenius, A. Backhaus, T. Bodeker, W. Blanck, H. Consolaro, F. Faust, M. Finizio, A. Froehner, K. Gramatica, P. Grimme, L.H. Gro¨nvall. F. Hamer, V. Scholze, M. Walter, H. (2003). Water-quality objectives for mixtures of toxic chemicals: problems and perspectives. Ecotoxicol Environ Saf 54:139–150.

التغيرات الفصلية في وفرة متفرعة اللوامس (Cladocera) في شط العرب جنوب العراق

شاكر غالب عجيل و محمد فارس عباس

قسم الأحياء البحرية – مركز علوم البحار– جامعة البصرة – العراق

الخلاصة

جمعت العينات فصليا من ثلاث محطات في نهر شط العرب بوساطة شبكة هائمات (µm85) قطر فوهتها 40 سم، خلال الفترة من كانون الثاني إلى تشرين الثاني 2013. تم قياس الخصائص الفيزيائية والكيميائية للماء مثل درجة الحرارة والملوحة ودرجة الأس الهيدروجيني والأوكسجين المذاب والكدرة والمواد الذائبة الكلية. بلغت أعلى كثافة لمتفرعة اللوامس 18922 فرد/م^3 خلال فصل الصيف في محطة الأولى (العشار) و لم يسجل أي فرد خلال فصلي الربيع والصيف في المحطة الثالثة (الفاو). تم تسجيل خمسة أنواع من متفرعة اللوامس في المحطة الأولى ونوعين في المحطة الثانية ونوع واحد في المحطة الثالثة. وكانت الأنواع السائدة في المحطتين الأولى والثانية هي *Moina affinis* و *Diaphanosoma brachyurum*، أما في المحطة الثالثة فقد سجل *Moina affinis* فقط. بلغت قيم دليل التنوع (H) 0.7 في المحطة الاولى والثانية خلال فصلي الشتاء والربيع على التوالي، وسجلت اعلى قيمة للتكافؤ (J) 0.4 في المحطتين الاولى والثانية خلال فصل الشتاء. اما قيم الغنى (D) فقد بلغت 6.1 في المحطة الأولى خلال فصل الشتاء واقل قيمة 0 في المحطة الثالثة. و بيَن دليل جاكارد أن أعلى تشابه كان بين المحطة الأولى والثانية وأدناه بين المحطة الأولى والثالثة.

الكلمات المفتاحية: متفرعة اللوامس، تغيرات فصلية، نهر شط العرب، بصرة.