Mesopot. J. Mar. Sci., 2012, 27 (2): 126 - 139

Diversity of Cladocera of the Shatt Al-Arab River, Southern Iraq

S.G. Ajeel and M.F. Abbas
Marine Science Centre, University of Basrah, Basrah-Iraq
e-mail: shaker_ajeel@yahoo.com

(Received: 5 December 2012 - Accepted: 26 December 2012)

Abstract - Samples of zooplankton were collected monthly from three stations in the Shatt Al-Arab region (Al-Hartha, Garmat Ali and Al-Ashaar) for the period from June 1996 to May 1997 using a plankton net with a mesh-size of 120 µm. Twenty species of Cladocera belonging to 14 genera were recorded in the study area. The total number of Cladocera ranged between 0.3 ind./m^3 during October 1996 and 7207 ind./m^3 during April 1997. The highest values of Shannon Weaver diversity index and Richness index were recorded at station 3 during December and June (1.8 and 7.62, respectively), and the lowest values were (0) and 0.23, reported in July at station 3 and in March at station 2. The highest value of Evenness (1.0) was recorded at station 3, during October and the lowest (0.01) was recorded at station 2 during April. The Jaccard index indicates that the highest similarity was between stations 1 and 3 (34.48) and the lowest was between stations 2 and 3 (30.49).

Key words: Cladocera, Diversity, Shatt Al-Arab, Iraq.

Introduction

Zooplankton are small aquatic organisms inhabiting fresh and salt water, floating or drifting in them. They play an important role in the aquatic environment by transferring energy from lower to higher trophic levels. They convert organic matter in the phytoplankton to protein and fat. They are of great importance as food for many fish species, especially juvenile stages (Scott, 2006). They have a limited horizontal migration, and some of them have the ability to vertical migration, so the quality of water is certainly dependent on the presence of these organisms, as their vertical migration through the water column is of great importance in the movement of their contents of organic matter along the depths to provide food for other types of animals in different water levels (Kaestner, 1970).

The Cladocera also called water fleas, is one of the groups of zooplankton found especially in fresh water while a few species are living in salt water. They are small crustaceans, with the thoracic appendages phyllopod and hence are polyphagous filter feeders, most types feed on algae and bacteria and non-living particles, but some species are predators, like *Leptodora* (Hino and Hirano, 1980). Cladocera is an Arthropoda, Crustacea, Class Branchiopoda, which is divided to 4 suborders, 11 families, 80 genera and 400 species (Dumont and Negerea, 2002).

In Iraq the scientific work on Cladocera began before about 90 years ago, the first published work was that of Gurney (1921), who recorded eighteen species of Cladocera. Mohammad (1965) recorded 23 species of

Cladocera, from central and southern Iraq.

Al-Hamed (1966) studied the zooplankton of the inland waters of Iraq including the Cladocera as a group. Khalaf and Smirnov (1976) recorded some crustaceans, including Cladocera from the littoral zone of the central and southern Iraq, they reported 23 species of Cladocera. Khalaf and Shihab (1979) monitored the seasonal variation in the populations of two species of water fleas in fish farm in Al-Zoafaraniyah.

Moreover, Shihab and Khalaf (1980) studied the impact of temperatures on the life of *Moina micrura* females and found that temperatures 5°C and 38°C are located outside the limit of tolerance of female while the fastest rate of growth was at a temperature of 35°C. Mohammad (1980) concluded that the species of Cladocera are prevalent within the zooplankton in the Euphrates river at Al-Fallujah, while the sovereignty of the Copepoda was in the Tigris River in Baghdad. Salman *et al.* (1986) studied the seasonal variations in zooplankton at Shatt Al-Arab, they found that Cladocera was dominating the zooplankton, followed by Copepoda. In the Al-Hammar Marshes near Garmat-Ali River, Al-Saboonchi *et al.* (1986) recorded seven species of Cladocera.

Mohammad (1986) made report on thirteen species of Cladocera in the Tigris River in Baghdad and recorded eighteen species in the Euphrates River in Al-Falluja. And Mangalo and Akbar (1986) studied population density of *Moina affinis* in Diyala River for a year and noted that the highest density was in June and the least in October 1984.

In Al-Zoafaraniyh, Lazim and Zeki (1987) recorded *Scapholeberis kingi*, and reported it also in Arbil. Mangalo and Akbar (1988) found that the population density of Cladocera in Diyala River is higher than that in the Tigris River. Then Sabri *et al.* (1989) studied the vertical distribution of zooplankton in Samarra dam and found that most species of zooplankton avoid the surface layer, while the water fleas were distributed mainly in the upper water layers and recorded four species of Cladocera.

Ajeel *et al.* (2000) noted that density of *Simocephalus vetulus* in Basrah reached its peak during February 1997 in Garmat Ali. While Poltorak *et al.* (2001) found 99 species of zooplankton in Al-Therthar, Al-Razzazah and Al-Habbaniya Lakes including 20 species of Cladocera, and Ajeel *et al.* (2001) recorded 23 species of Cladocera in the Shatt Al-Arab River and some temporary ponds in Basrah. While Ajeel (2004) noted that Cladocera formed 5.4-35 % of the total zooplankton in Shatt Al-Arab region. Al-Qaroni (2005) made records of 14 species of Cladocera in the marshlands of Southern Iraq.

Ajeel *et al.* (2006) estimated the Secondary production of *Simocephalus vetulus* in a temporary pool in Basrah. And Al-Nimrawi (2006) recorded 15 species of Cladocera in the Tigris and Euphrates Rivers. Abbas (2010) recorded 23 species of Cladocera in the North of Shatt Al-Arab River. There are some other reports on Cladocera at different parts of Iraq (Murad, 1977, Lazem, 1977, Shihab, 1977, Abdul-Ahad, 1980 and Ajeel and Abdul-Sahib, 2006.

The aim of the present study is to investigate the Cladocera of the south of Iraq and monitor some physical and chemical parameters and their effect on the abundance of Cladocera together with some ecological Indices.

Materials and Methods

Description of the study area:

Shatt Al-Arab is located in the southeastern part of Iraq at latitude 31° 00' 15" N, and longitude 47° 26' 35" E, at the confluence of Tigris and Euphrates Rivers, and extends downstream to the Arabian Gulf a distance of 204 kilometers at latitude 31° 53' 28" N, and longitude 47° 39' 50" E (Al-Mansouri, 1996). The width of Shatt Al-Arab varies from 200 to 2250 m., the minimum width is at the Al-Khaniq region, which is located 5 km south of the confluence of Al-Karun River, while the wider area is at the estuary of the Shatt Al-Arab (Al-Wuhaily, 2009). The depth of the channel is changing from one place to the other with maximum depth 24 m, near the island of Sindbad while the minimum depth (6 m) nears the island of Al-Shmshomea (Mohammed *et al*., 1999). Three tributaries disembogue in the south of Shatt Al-Arab, these are Al-Swaib River, which is located south of Qurnah district at a distance of 15 km, Garmat Ali River, which carries water from Hour Al-Hammar in addition to the Karun River, which is located south of Basrah, at a distance of 35 km (Al-Mansouri, 1996). The Shatt Al-Arab River is influenced by the semi tidal rhythm of the Arabian Gulf (Al-Ramadan and Pasteur, 1987). Three stations were selected in the Shatt Al-Arab region (Fig. 1), the first station at Al-Hartha near the desalination plant with a water depth of 8-10 m, the second station is located in Garmat Ali River with a water depth of 10-12 m, while the third is near the Cornish, Al-Ashaar, water depth 10-12 m.

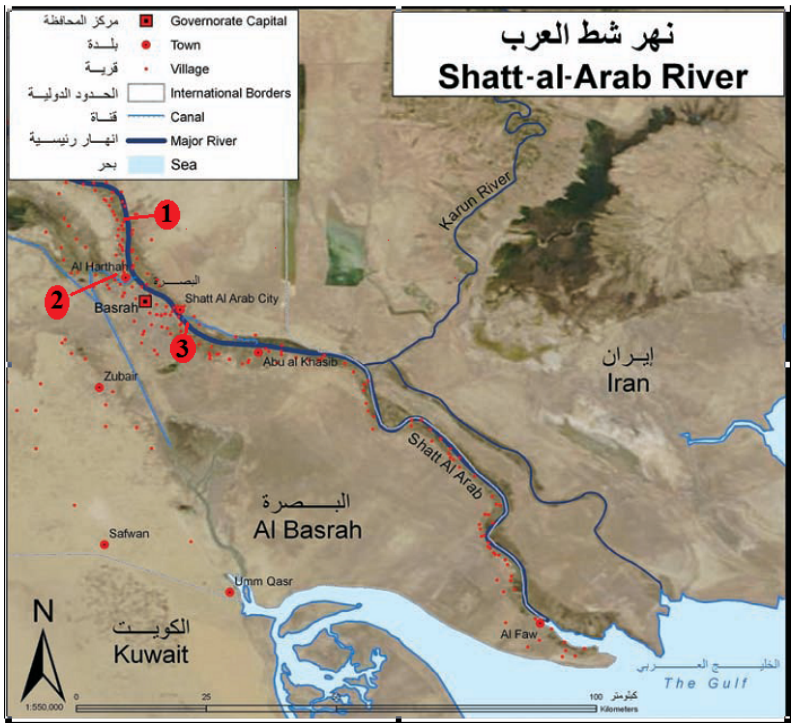

Figure 1. Map of lower Mesopotamia showing the sampling stations.

Physical and chemical parameters:

Some hydrographic aspects were recorded in the field; water temperatures, salinity, pH and dissolved oxygen (DO). All of these aspects were measured immediately in the field by a digital multi meter Multi 350i/SET Germany.

Sample collection:

Zooplankton samples were collected monthly for the period from June 1996 to May 1997 from stations 1 (Shatt Al-Arab/Al-Hartha) (30° 39′ 11.76″ N and 47° 45′ 42.95″ E) and station 2 (Garmat Ali River) (30° 34′ 40.00″ N and 47° 44′ 22.64″ E) and station 3 (Shatt Al-Arab River/Al-Ashaar) (30° 31′ 32.39″ N and 47° 50′ 33.43″ E) (Fig. 1).

Samples were collected by a net of a mesh-size of 120 μm, with a diameter of mouth aperture of 40 cm with a digital flow meter mounted to the mouth aperture. The net was towed behind a boat for 10-15 min. The samples were fixed immediately with 4% formalin.

In the laboratory, the samples were placed in a beaker and water was added to the mark 1 L, a 10 ml. subsamples were taken and placed in a Bogorov chamber and examined under a dissecting microscope, where identification and counting of Cladocera were done. The process was repeated three times for each sample and the average was taken. The volume of water was calculated according to De Bernardi (1984).

Ecological Indices:

Shannon Weaver diversity index (H) was calculated according to the expression of Shannon-Weaver, (1949):

$H = - \sum (ni / N) \ln (ni / N)$, where:

ni = Number of members of the same species

N = Total number of individuals in the sample.

Jaccard's similarity index $S_s\%$ was calculated according to Jaccard (1908):

$$S_s\% = \frac{a}{a + b + c} \times 100$$, where:

a = number of species of Cladocera at stations A and B

b = number of species of Cladocera present at station B and not present at station A

c = number of species of Cladocera present at station A and not found at station B.

Evenness index (J) was calculated following the equation of Pielou (1966):

$J = H / \ln S$, where:

H = Shannon Weaver diversity index

S = Number of species

Richness index (D) was calculated by the equation of Margalef (1968):

$D = S\text{-}1 / \ln N$, where:

D = Richness index

S = Total number of species

N = Total number of individuals

Relative abundance index (Ra) was calculated according the formula 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)

Results

Ecological Measurements:

Water temperature ranged between 14 °C (in February 1997) at station 1 and 34 °C (in July 1996) at station 2 (Fig. 2). Salinity changed from 0.90 ‰ (in December 1996) at station 1 to 1.5 ‰ (in July of the same year) at station 2 (Fig. 3). The pH varied from 7.4 during June 1996 and January 1997 at station 2 to 8.5 during December 1996 at station 1 (Fig. 4), and the dissolved oxygen changed from 4.6 mg/l (in July and December 1996) at station 3 to 8.1 mg/l (in February 1997) at station 3 (Fig. 5).

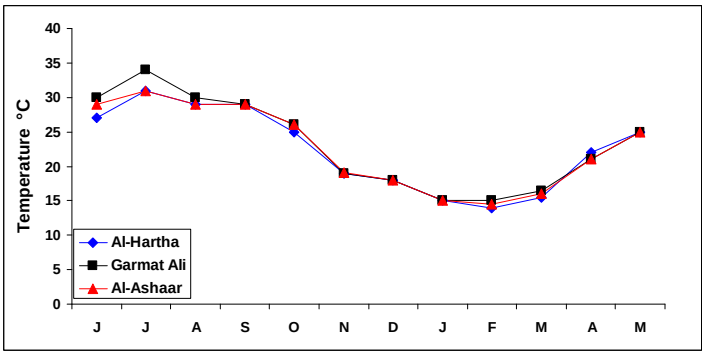

Figure 2. Water temperature at the three stations in the Shatt Al-Arab region for the period from June 1996 to May 1997.

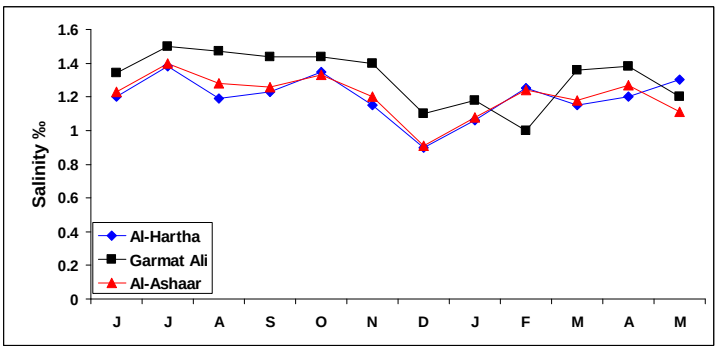

Figure 3. Salinity at the three stations in the Shatt Al-Arab region for the period from June 1996 to May 1997.

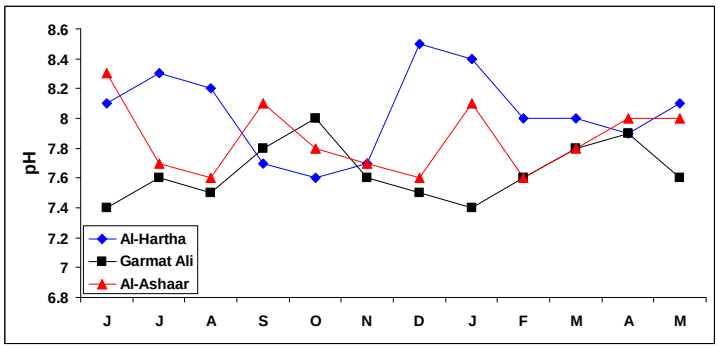

Figure 4. pH values at the three stations in the Shatt Al-Arab region for the period from June 1996 to May 1997.

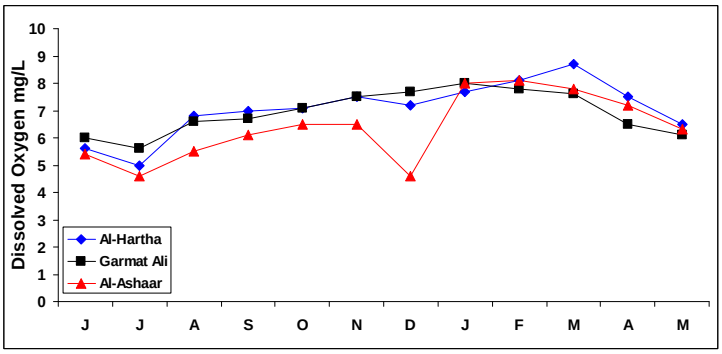

Figure 5. Dissolved oxygen at the three stations in the Shatt Al-Arab region for the period from June 1996 to May 1997.

Abundance:

Twenty species of Cladocera belonging to 14 genera were recorded in the study area (Table 1). At station 1 (Shatt Al-Arab river / Al-Hartha), the total number of Cladocera ranged between 5 ind./m^3 during August 1996 and 229 ind./m^3 during May 1997, and 14 species of Cladocera were identified throughout the entire period. The highest numbers of species were 9 which were recorded in May 1997, while the lowest number were 2 and recorded in July 1996.

A station 2 (Garmat Ali River) the total number of Cladocera ranged between 18 ind./m^3 during June 1996 and 7207 ind./m^3 during April 1997. The total species of Cladocera recorded were 15 species, the highest number of species were 9 which were recorded in May 1997. Whereas the lowest number were 3 and recorded in July 1996 and April 1997.

At station 3 (Shatt Al-Arab river/Al-Ashaar) the total number of Cladocera ranged between 0.3 ind./m^3 during October 1996 and 145 ind./m^3 during April 1997. The total species of Cladocera recorded were 14, the highest number of species were 7, recorded in December 1996, April and May 1997, while the lowest number was 1 which was recorded in July 1996 (Fig. 6).

Table 1. Density of Cladocera (ind./m^3) at the three stations in the Shatt Al-Arab region for the period from June 1996 to May 1997.

	June 1996			July			August			September			October			November			December			January 1997			February			March			April			May		
	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3	1	2	3
Alona cambouei	5	0.3	0.7	-	-	-	0.8	-	-	4	-	-	-	0.1	0.1	-	-	-	-	0.7	1	-	-	1.1	-	-	-	14	0.2	-	14	-	1	16	12	4
A. karua	-		-	-		-	0.2		-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		-	-	-	-
Bosmina longirostris	10	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	-	-	1	-	10	1955	0.6	2	7197	98	16	12	38
Camptocercus uncinatus	-	1	0.3	-	-	-	-	-	1.5	-	-	-	-	-	-	-	-	-	-	-	0.2	4	5	-	0.2	-	2.6	7	-	0.1	2	1.3	0.2	0.4	-	-
Ceriodaphnia rigaudi	-	-	-	-	-	-	0.2	-	-	0.3	-	-	-	-	-	-	-	-	-	-	0.2	1	-	-	4	-	-	7		-	-	-	-	-	-	
Chydorus sphaericus	112	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	5	2	-	8	-	0.5	76	113	6.6	49	146	2	123	-	37	106	43	27
Daphnia hyalina	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.2	-
D. magna	-		-	-	-	-	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5	-	-	-	-	-	-	-	-
D. pulex	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-		2	0.2	-		-	-		-	-	-	-	-
Diaphanosoma brachyurum	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	8	-	-	0.2	-	-	91	-	-	-	-	-	-	-	-	-	-	-	0.1	-
D. orghidani	32	8	-	-	106	-		180	-	-	43	-	1.3	343	-	5	25	2.9	5	14	1	-	-	-	-	-	-	-	-	-	-	-	-	24	25	-
Dunhevedia crassa	6	-	0.3	1	-	-	1	0.1	3	7	0.3	2.3	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	10	-	-	2	-	-	8	-	4
Ilyocryptus agilis	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	2	-	-	-	7	0.6	-	-	7	-	-	-
I. spinifer	-		-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.5	-	-	-	-	-	0.6	-	-	-	-	-	-	-	-	-
Kurzia longirostris	-	1	-	-	-	-	-	4	-	-	4	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Lynceus sp.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	0.1	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Macrothrix spinosa	3	0.2	-	-	-	3.5	3	7	4.5	4.5	0.2	0.5	7	-	-	5	-	-	2	0.1	0.8	1	-	-	7.6	1	2.6	-	-	-	47	-	1	16	2	0.1
Moina brachiata	32	-	-	5	-	-	0.2	-	-	44	-	0.4	9	-	-	15	8	5.8	16	-	0.5	0.6	-	-	-	-	-	-	-	-	-	-	-	40	-	-
M. micrura	-	7	-	-	240	-	-	27	-	-	34	-	-	1588	-	-	33	-	-	9	-	-	142	-	-	-	-	-	-	-	-	-		-	67	23
Simocephalus vetulus	5	-	-	-	0.1	-	-	4	-	-	-	-	-	-	-	-	-	-	-	1	-	0.4	-	-	1	1	-	3.5	0.5	-	9	9	1	3	2	0.3
Total	205	17	1.3	6	346	3.5	5	222	9	60	81	3.2	17	1931	0.3	25	74	8.7	28	27	4.2	15	243	1.6	923	116	12	101	2181	3.3	199	7207	145	229	164	96

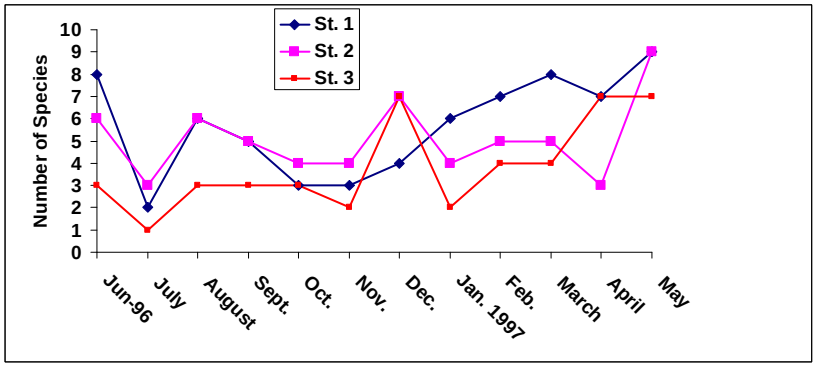

Figure 6. Number of species of Cladocera at the three stations in the Shatt Al-Arab region during the study period.

The highest number of species of Cladocera in the three stations were 12, which were recorded in May 1997, and the lowest number were 5 and recorded in November 1996.

Ecological Indices:

Shannon Weaver Diversity index (H):

Monthly variation in values of diversity is quite apparent and differences between stations are also obvious. The highest value was in December (1.8) at station 3, while the highest values at stations 1 and 2 were in May (1.64 and 1.51, respectively) (Fig. 7). The lowest value (0) was in July at station 3, while at station 1, the lowest level of diversity was in July (0.45), whereas the lowest value at station 2 (0.01) was recorded in April. The relationship between diversity (H) and water temperature were significantly negative.

Evenness index (J):

The highest value of evenness of Cladocera was 0.75 at station 3, and the lowest was 0.46 at station 2, whereas at station 1 the value was 0.69.

Species Richness (D):

Figure (8) showed the monthly values of richness at the three stations. A peak was apparent at station 3 during June (7.62), the lowest level was during July (0). Whereas, at station 1 the lowest values (0.56) was reached in July and the highest value (2.96) was recorded in August. At station 2 the highest value was (1.82) recorded in December, while the lowest (0.23) was reported in April.

Jaccard's similarity index:

Similarity index of Cladocera calculated between the different stations, indicates that stations 1 and 3 are closely similar and the least similarity was obtained between stations 2 and 3 (Fig. 9).

Relative abundance index (Ra):

Table (2) showed that *Bosmina longirostris* was dominant at station 2, and *Chydorus sphaericus* was abundant at station 1 and *Bosmina longirostris* was abundant at station 3, while three frequent species were

recorded *viz Moina brachiata* at station 1, *M. micrura* at station 2 and *Chydorus sphaericus* at station 3 whereas the rest of species recorded were rare.

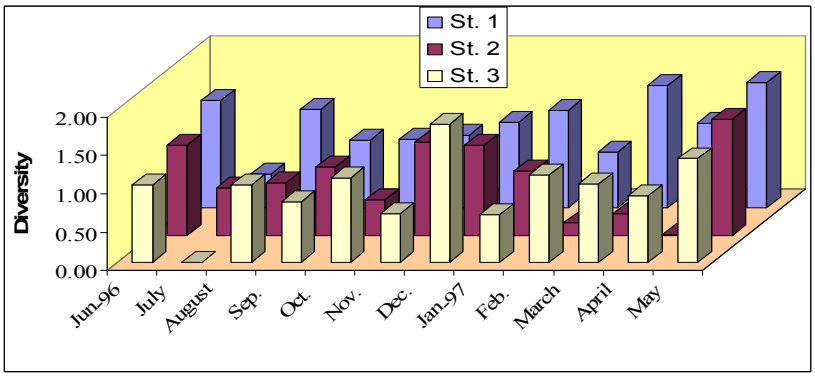

Figure 7. monthly changes of diversity index at the three stations in the Shatt Al-Arab region during the study period

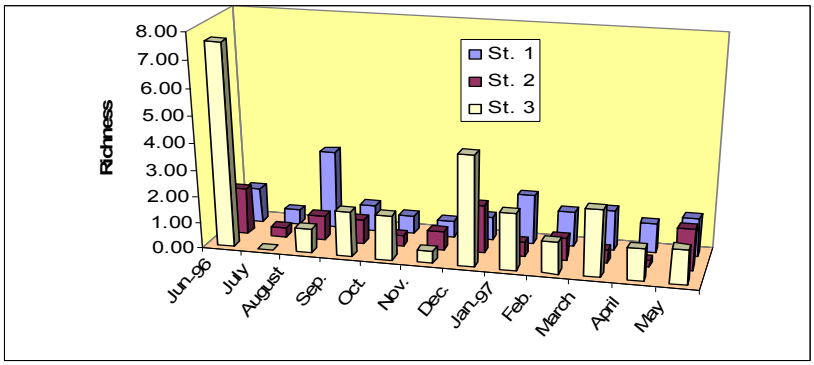

Figure 8. Monthly changes of Richness index at the three stations in the Shatt Al-Arab region during the study period.

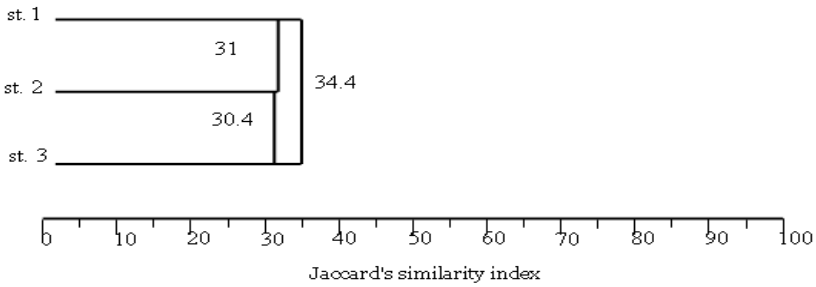

Figure 9. Average value of similarity index of Cladocera between the three stations.

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

Cladocera species	Relative Abundance		
	St. 1	St. 2	St. 3
Alona cambouei	R	R	R
A. karua	R	-	-
Bosmina longirostris	R	D	A
Camptocercus uncinatus	R	R	R
Ceriodaphnia rigaudi	R	-	R
Chydorus sphaericus	A	R	F
Daphnia hyalina	-	R	-
D. magna	R	-	-
D. pulex	R	R	-
Diaphanosoma brachyurum	-	R	-
D. orghidani	R	R	R
Dunhevedia crassa	R	R	R
Ilyocryptus agilis	R	R	R
I. spinifer	-	-	R
Kurzia longirostris	-	R	-
Lynceus sp.	-	-	R
Macrothrix spinosa	R	R	R
Moina brachiata	F	R	R
M. micrura	-	F	R
Simocephalus vetulus	R	R	R

Discussion

In an environment when the conditions are normal, the quality of water should be appropriate for high rate of diversity, on the contrary, when an imbalance has occurred in that environment, this may lead to loss of diversity, such as the fewness of species that feed on other types causes a lack of diversity and increases the opportunity for the growth of types of high densities which were originally present in small quantities in natural conditions (Jonge, 1995).

The Cladocera as part of zooplankton varies in distribution 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). Moreover, the mesh-size of the net is an important factor controlling the quality and quantity of the catch. Generally the smaller the mesh-size the larger is the catch (Ajeel, 1990).

Normally, the Cladocera present typically in the quiet water and swamps (Schram, 1986), but their presence in the Shatt al-Arab River is due to the fact that they are carried by waters from the Tigris and Euphrates and the concomitant availability of environmental conditions necessary for the diversity of neighborhoods that feed the group of Cladocera may contributed to the increase of diversity in this region.

The present results indicate that there were differences in the abundance of Cladocera among the three stations sampled, station 2 (Garmat Ali River) apparently is the richest. This is probably due to the presence of dense populations of aquatic plant. Fifteen species of Cladocera were identified in this station, and fourteen species in each of the two other stations. This is in accordance with the findings of Ajeel *et al.* (2006) that fourteen species of Cladocera were identified in the near by region of southern marshes (Hour Al-Hammar) of Iraq. Similarly in Al-Therthar Lake 14 species were recorded (Poltorak, 1984), as well as in the region from Shatt Al-Arab estuary to the Amara city 14 species were also reported (Gurney, 1921).

The results of the Ecological Indices (Shannon Weaver diversity index (H)) show high value at station 1, and low value at station 2, while the values of Richness index (D) and Evenness index (J) were high at station 3 and low at station 2. The high diversity may be attributed to the lack of pollution in this region and this is consistent with the conclusion drawn by Al-Jizani (2005) who suggested that pollution would lead to reduce the diversity index.

The results of the current study showed that *Bosmina longirostris* was dominant at station 2 and abundant at station 3, while *Chydorus sphaericus* was abundant at station 1 and frequent at station 3.This indicate that these species have wide range of tolerance to the different environmental conditions, whereas those species of Cladocera which were rare in abundance such as *Alona karua, Daphnia hyalina, D. magna, D. pulex, Ilyocryptus spinifer and Lynceus* sp. may have narrow range of tolerance to these environmental conditions.

Acknowledgements

We would like to thank Prof. Dr. Salman D. Salman, Head of Department of Marine Biology, Marine Science Center, University of Basrah, for reading the manuscript and for his critical advice.

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. 1990. Ecological and biological study of some important species of marine copepods in NW Arabian Gulf. MSc, Thesis. University of Basrah, Marine Science Center, 149 pp. (In Arabic).

Ajeel, S.G. 2004. Abundance and distribution of zooplankton in some waters in southern region of Iraq. Marina Mesopotamica, 19(1): 95-115. (In Arabic).

Ajeel, S.G. and Abdul-Sahib, I.M. 2006. Growth of *Daphnia magna* (Crustacea: Cladocera) under different diet conditions. Marina Mesopotamica, 21(2): 225-235.

Ajeel, S.G., Ali, M. H. and Salman, S. D. 2000. Population dynamics of

Simocephalus vetulus (Crustacea: Cladocera) in Basrah. Marina Mesopotamica, 15(2): 593-612. (In Arabic).

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., Ali, M.H. and Salman, S.D. 2006. Secondary production of the Cladocera *Simocephalus vetulus* in a temporary pool at Basrah, Iraq. Marina Mesopotamica, Online. 1(1): 38-47.

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

Al-Jizani, H.R.G. 2005. Organic pollution and its impact on the diversity and abundance of plankton in the Shatt Al-Arab, Al-Ashaar and Al-Robat Channel. M.Sc. Thesis, College of Education, University of Basrah. 82 pp. (In Arabic).

Al-Mansouri, F.Y. 1996. Study of sediment transport in the southern part of the Shatt al-Arab. M.Sc. Thesis, College of Agriculture, University of Basrah. 119 pp. (In Arabic).

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, 95 pp. (In Arabic).

Al-Ramadan, B. and Pasteur, M. 1987. Tidal characteristics of Shatt Al-Arab river. Marina Mesopotamica, 2(1): 15-28.

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

Al-Wuhaily, O.Q.K. 2009. Sedimentological and geomorphological study of Shatt Al-Arab Islands between Basrah and Saybah. M.Sc. Thesis, College of Science, University of Basrah. 68 pp. (In Arabic).

De Bernard, R. 1984. Methods of the estimation of zooplankton abundance. In: Dowing J.A. and Rigler F.H. (eds.). A manual on methods for the assessment of secondary productivity in fresh waters. Black Well Sci. Pub. Oxford., pp: 59-86.

Dumont, H.J. and Negerea, S.V. 2002. Introduction to the Branchiopoda. guides to the identification of microinvertebrates of the continental waters of the world. H.J. Dumont (ed.). Backhuys Publishers, Leiden. 19: 398 p.

Gurney, R.M.A. 1921. Freshwater crustacean collected by Dr. P.A. Buxton in Mesopotamia and Persia. Bombay Nat. Hist. Soc., 27(4): 835-843.

Hino, A. and Hirano, R. 1980. Relationship between body size of the rotifer *Brachionus plicatilis* and maximum size of particles ingested. Bull. Jpn. Soc. Sci. Fish., 46: 1217-1222.

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

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

Kaestner, A. 1970. Invertebrate Zoology. Crustacea. Wiley, New York, 3.

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

Khalaf, A.N. and Shihab, A.F. 1979. Seasonal variation in the populations of *Moina macrocopa* Strauss and *Moina micrura* Kurz (Crustacea: Cladocera) in Zoafaraniyh pools. Hydrobiologia, 62 (1): 75-77.

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. 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. 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.

Mohammad, M.B. 1965. A Faunal study of the Cladocera of Iraq. Bulletin of the biological Res. Center, 1: 1-11.

Mohammad, M.B. 1980. A hydrobiological survey of a polluted canal. Hydrobiology, 74: 179-186.

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.

Mohammed, A.M., Akkash, B.N. and Hussein N.A. 1999. Topographic survey of the course of the Shatt Al-Arab from the Garma until the Arabian Gulf. Marine Science Center, University of Basrah, 48 pp.

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.

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. 1984. The zooplankton of Lakes Thrthar, Habbaniy and Razzazah. Detailed report on the development of fisheries in Thrthar, Habbaniy and Razzazah lakes. Draft V.B.P., 59 pp.

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

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

Salman, S.D., Marina, B.A., Ali, M.H. and Oshana, V.K. 1986. Zooplankton studies. In final report the 18 Month Marina Pollution Monitoring and Research programme in Iraq. Marine Science Center, Basrah University, Iraq, pp: 156-166.

Scott, K. 2006. Zooplankton. http://esak.uregina.ca/about_encyclopedia. html. Retrieved 15 Dece. 2011.

Schram, F.R. 1986. Crustacea. New York, Oxford University Press.
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 growth and reproduction of *Moina micrura* (Crustacea: Cladocera). Bull. Biol. Res. Centre., 12(2): 49-72.

التنوع الأحيائي لمتفرعة اللوامس (Cladocera) في شط العرب جنوب العراق

شاكر غالب عجيل و محمد فارس عباس
مركز علوم البحار، جامعة البصرة، البصرة - العراق

المستخلص - جمعت عينات العوالق الحيوانية شهريا من ثلاث محطات في منطقة شط العرب (الهارثة وكرمة علي والعشار) للفترة من حزيران 1996 إلى أيار 1997 بواسطة شبكة حجم فتحاتها 120 مايكرون. وتم تسجيل عشرين نوعاً من متفرعة اللوامس تعود إلى 14 جنساً في منطقة الدراسة، تراوحت كثافة متفرعة اللوامس بين 0.3 فرد/م^3 خلال تشرين الأول 1996 في محطة العشار إلى 72.7 فرد/م^3 خلال نيسان 1997 في محطة كرمة علي. بلغت القيم العليا لدليل شانون-ويفر للتنوع (Shannon Weaver diversity index) ودليل الغنى (Richness index) في المحطة الثالثة خلال كانون الأول وحزيران 1.8 و 7.62 على التوالي، وأدنى قيمة (0) خلال تموز في المحطة الثالثة و 0.23 خلال آذار في المحطة الثانية. والقيم العليا لدليل التكافؤ (Evenness index) في المحطة الثالثة (1.0) خلال تشرين الأول وأدنى قيمة (0.01) في المحطة الثانية خلال نيسان. أما دليل تشابه جاكارد(Jaccard's similarity index) فقد بلغت أعلى قيمة له بين المحطتين الأولى والثالثة (34.48) واقل قيمة بين المحطتين الثانية والثالثة (30.49).