Mesopot. J. Mar. Sci., 2015, 30(1): 67 -80

Ecological study of zooplankton in the Shatt Al-Basrah canal, Basrah-Iraq

M.F. Abbas
Marine Science Center, University of Basrah, Basrah, Iraq
e-mail: mohamadfaris29@yahoo.com

(Received: 30 April 2015 - Accepted: 15 June 2015)

Abstract - Seasonal abundance and distribution of Zooplankton were studied at three stations in the Shatt Al-Basrah canal, during the period from 2 April 2011 to 2 January 2012. The lowest value of zooplankton density recorded was 5 ind./m^3 at station one in winter 2012, and the highest was 621200 ind./m^3 at station three in spring 2011. Rotifera were dominated the zooplankton community (55%), followed by Copepoda (27%) then by Cirripede larvae (13%). Water temperatures, salinity, pH, dissolved oxygen and turbidity were measured at each station, as well as some ecological indices were calculated. Water temperature ranged from 12 to 33.2 ^{o}C at stations one and three, respectively. Salinity values changed from 15.6 to 35.1 psu at stations one and three respectively with a decline in spring and an increase in summer. pH values were on the alkaline side, dissolved oxygen varied from 2.53 to 8.7 mg/l in spring and autumn at stations three and one, respectively. The maximum diversity index value was 0.7 at station one, richness index values was 0.54 at station three and evenness index value was 0.87 at station two. Higher similarity was obtained between stations 1 and 3 and lower value recorded between stations 2 and 3.

Keywords: Ecological study, zooplankton, Shatt Al-Basrah canal.

Introduction

Zooplankton are important component of aquatic ecosystems. They transfer energy from first consumers to the third consumers (Ramdan *et al.*, 2001). There are few previous studies on the plankton of Shatt Al-Basrah canal, the first was that of Abdullah (1989) who studied the phytoplankton of the region. The zooplankton study on this region were that of Morad (2011); Ajeel (2012) and Jebir (2013) whom carried out sampling from near the Barrage station and stations at Khor Al-Zubair, they found that the population density of the zooplankton ranged between 6671-194245 ind./m^3 in autumn and spring, 5811-95514 ind./m^3 in August and April,21-53211ind./m^3 in May and December, respectively.

Material and Methods

Study Area:

Shatt Al-Basrah river is an artificial canal opened in 1983 to transfer the flood water from Al-Hammar marshes into Khor Al-Zubair and then to the Arabian Gulf (Al-Aesawi, 2010). The canal is connected to the so called the third River, which is also an artificial canal constructed to carry waste irrigation waters from the middle and southern region of the Mesopotamia.

Shatt Al-Basrah canal is located between (47^{o} 45′ 00″ & 47^{o} 49′ 00″ E) and (30^{o} 18′ 00″ & 30^{o} 39′ 00″ N), it started from Harrier at Qarmat-Ali, north of Basrah and runs south east to connect with Khor Al-Zubair (Al-Aesawi, 2010).

It extended for about 38 Km, near the point of union of the canal and Khor Al-Zubair there is a Barrage to regulate the water at both sides of the canal (Al-Khayat, 2007). It can drain water at about 325 m^3/sec during the flood and 1050 m^3/sec during the ebb tides to Khor Al-Zubair (Al-Badran *et al*., 1996). The width of the canal is 59 m and the depth at neap tide is 3.5 m (Al-Katib, 1972).

Seasonal zooplankton samples were collected from three stations in the Shatt Al-Basrah canal, at the period from 2 April 2011 to 2 January 2012. Station one at the high-way Bridge Baghdad-Nasiriah road, station two at Al-Zubair Road Bridge and station three near the Barrage (Fig. 1).

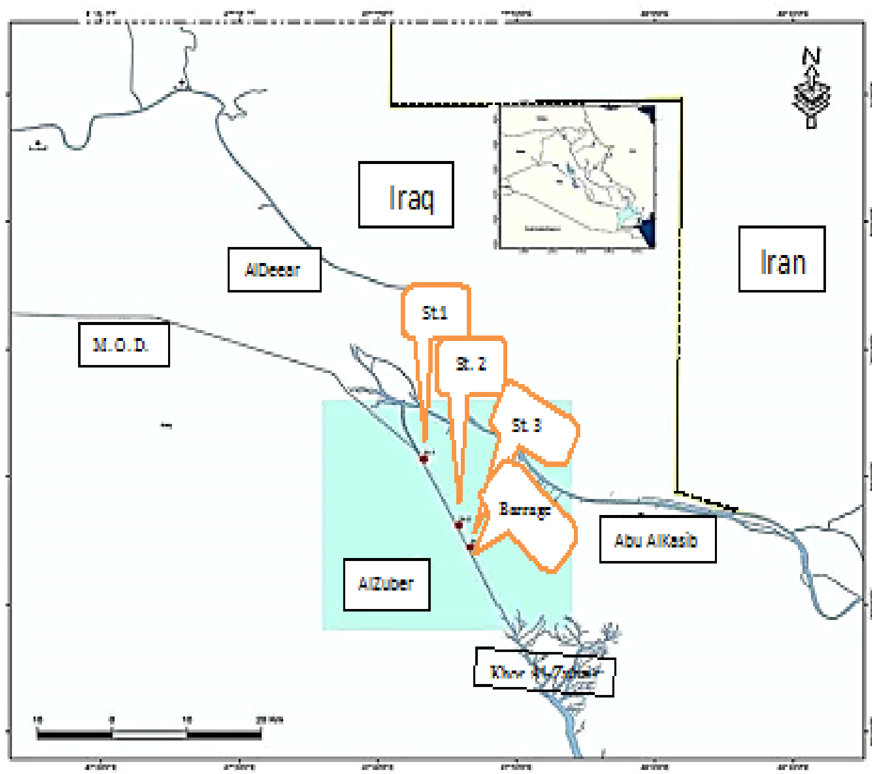

Figure 1. Map showing the sampling stations in Shatt Al-Basrah canal.

Sampling were done by using a plankton net with a mouth aperture of 30 cm and a mesh size of 100 µm. The net was towed for a distance (15 meters) near the canal's bank. Samples were transferred into plastic containers and diluted to a known volume 10 ml subsample was taken and poured into a Bogorov tray where counting was done.

The subsample then poured again in the same container and the process was repeated again until appreciable numbers of each group was enumerated.

The volume of the filtered water by the net was calculated from the expression of the volume of a cylinder as:

$$V = r^2 \pi h$$

Where V is the volume filtered by the net, r = radius of the net, π = 3.14 and h is the distance through which the net was towed in centimeters. Then the result was divided by 10000 to convert to cubic meters. The number of individuals per sample was then calculated from the following (APHA, 2005):

$$No / m^3 = (C \times V_I) / (V_{II} \times V_{III})$$

Where:

C is the no. of individuals in the subsample.
V_I is the volume of diluted sample (500 ml).
V_{II} is the volume of subsample (10 ml).
V_{III} is the volume of the sample filtered by the net (in cubic meters).

Various environmental factors at the three stations were measured throughout the period of sampling, these were: Water temperature; salinity; dissolved oxygen; pH and turbidity which were measured by using a multimeter of the type Mutti 350i/SET. Various ecological indices were calculated these were: Diversity index (Shannon-Weaver, 1949), richness (Margalef, 1968), evenness (Pielou, 1966) and Jaccarad's index (Jaccard, 1908).

Results

Water Temperature:

Water temperature varied from 12 °C at station 1 in winter to 33.2 °C at station 3 in summer (Fig. 2). The difference in water temperature between the stations at the same season does not exceed 1.4 °C.

Salinity:

Salinity ranged from 15.6 psu at station 1 in spring to 35.1 psu at station 3 in summer (Fig. 3). Salinity differences between stations 1, 2 and 3 were high during spring and summer, about 7 and 16.68 psu during the two seasons, respectively.

Dissolved Oxygen:

Dissolved oxygen fluctuated between 2.53 mg/l at station 3 during spring and 8.7 mg/l at station 1 in autumn (Fig. 4). The differences between the stations were 0.8 mg/l between stations 2 and 3during summer, and 5.63 mg/l between stations 1 and 3during spring.

pH:

The pH values ranged from 6.4 at stations 1 and 3 during autumn to 8.6 at station 2 in winter (Fig. 5). The pH varied from alkaline at most of the times or neutral (at station 3 in spring) to slightly acidic at all the stations in autumn.

Turbidity:

Turbidity changed from 19.5 NTU at station 2 during summer to 52.42 NTU at station 1 during autumn (Fig. 6). The differences between the stations were ranging from 3.56 NTU between stations 1 and 3 during spring to 27.2 NTU between stations 1 and 2 in winter.

Zooplankton Community:

Rotifera dominated the zooplankton community by 55%, followed by Copepoda with 27 % then by Cirripede larvae 13 % (Fig. 7). Nauplii of Copepoda made a substantial contribution to the zooplankton at station 1 in spring, followed by Calanoida and Rotifera. The Calanoida *Bestiolina arabica* and *Acartiella (Acartiella) faoensis* were most common in spring at station 1. Rotifera were dominating the zooplankton during summer and autumn at the same station. However the study area was very poor with zooplankton in winter (Table 1).

At station 3, Calanoida were dominating the Shatt Al-Basrah during spring, with *Bestiolina arabica*as the most dominant species. Cirripede larvae come next, followed by copepod nauplii and Ostracoda. During summer and winter Rotifera were dominant while the calanoid *Bestolina arabica* trailing second during summer (Table 1).

At station 3, Rotifera, by far, forming a substantial contribution to the zooplankton of Shatt Al-Basrah, throughout the year (Table 1), followed by Calanoida; with *Bestiolina arabica* was the major contributor in spring, cirripede larvae comes next and followed by *Pseudodiaptomus ardjuna*. In summer Calanoida was forming 8100 ind./m^3 and copepod nauplii formed 4200 ind./m^3.

Diversity index (Fig. 8) of the calanoid copepods at station 1 fluctuated between 0.34 and 0.70 in autumn and spring, respectively, whereas in winter and summer only one species was encountered. At station 2, it ranged from 0.14 (in autumn)-0.60 (in spring), again winter and summer were represented by a single species. The diversity index at station 3, changed from 0.22 (in summer) to 0.62 (in spring).

The richness (Fig. 9) of Calanoida at station 1 varied from 0.23 (in spring)-0.41 (in autumn), it was 0.00 in winter and summer. At station 2, it fluctuated between 0.08 (in spring) and 0.26 (in autumn), here again winter and summer were indicated by a single species. However, at station 3, the richness changed from 0.11 (in summer)-0.54 (in autumn). The evenness (Fig. 10) at station 1 fluctuated between 0.31 (in autumn) and 0.64 (spring), at station 2, it ranged from 0.2 (in autumn) to 0.87 (in spring), whereas at station 3, it varied from 0.20 (in autumn) to 0.57 (in spring).

Similarity index (Fig. 11) was 56 % between stations 1 and 3, and 42 % between stations 2 and 3.

Analysis of the correlation coefficients between 4 species of Calanoida and the environmental parameters using (CCA) Canonical Correlation Analyses (CANOCO) (Fig. 12). CCA-ordination showed that the three species of Calanoida (*Acartiella (Acartiella) faoensis*, *Bestiolina Arabica*, *Pseudodiaptomus ardjuna*) were closely related to all environmental parameters, except, *Parvocalanus crassirostris* which exhibit weak correlation.

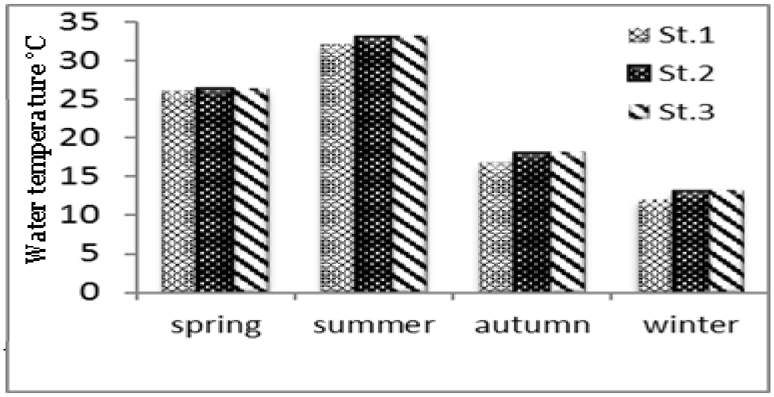

Figure 2. Seasonal variation in Water temperature at the Shatt Al-Basrah canal.

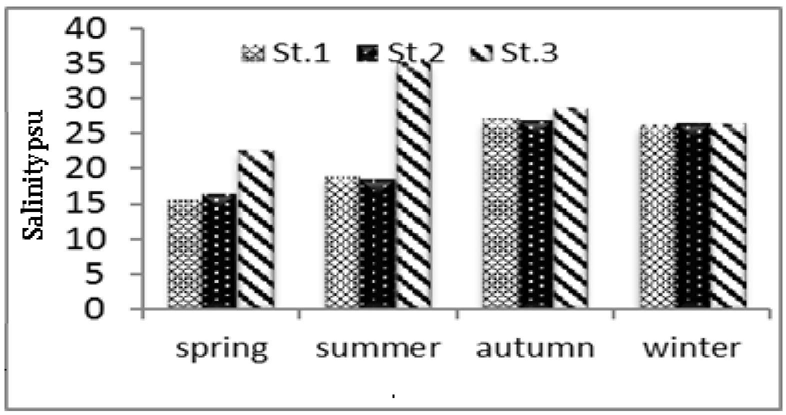

Figure 3. Seasonal variation in salinity at the Shatt Al-Basrah canal.

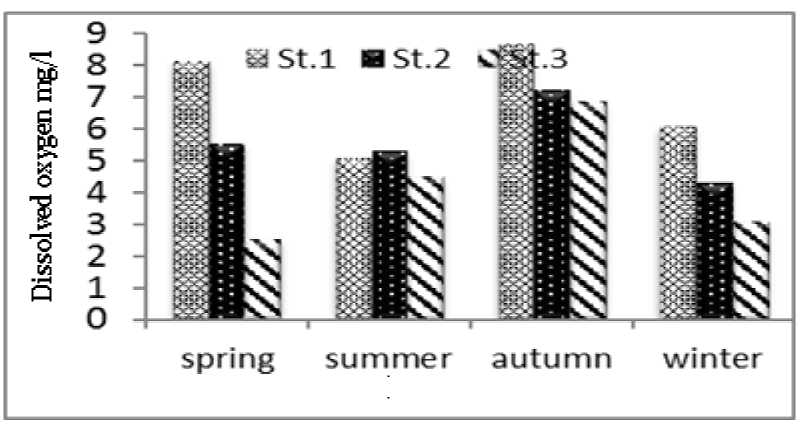

Figure 4. Seasonal variation in dissolved oxygen at the Shatt Al-Basrah canal.

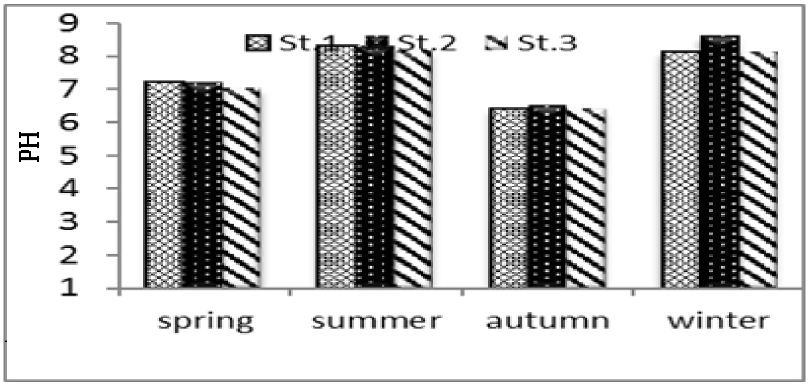

Figure 5. Seasonal variation in pH at the Shatt Al-Basrah canal.

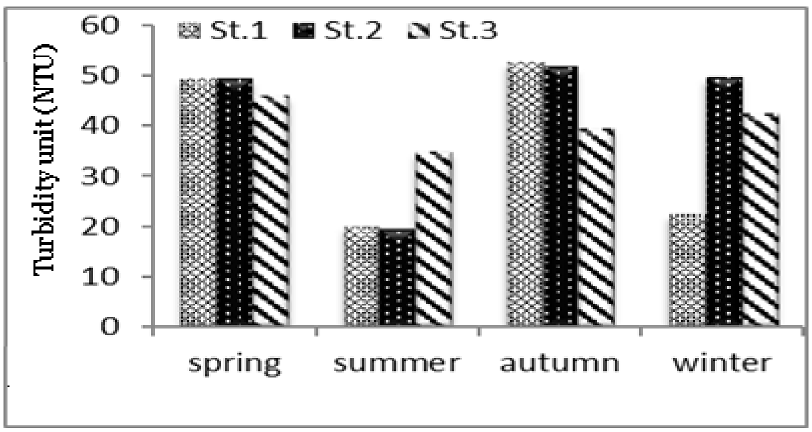

Figure 6. Seasonal variation in turbidity at the Shatt Al-Basrah canal.

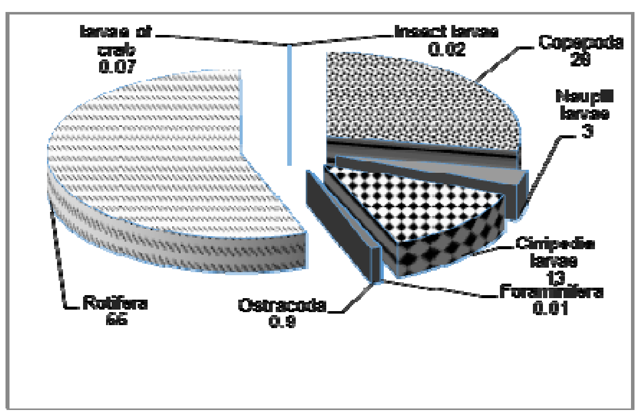

Figure 7. Percentage total zooplankton recorded at the Shatt Al-Basrah canal.

Table 1. Total zooplankton community ind./m^3 at the three Stations of Shatt Al-Basrah canal during 2011-2012.

	St.1				St.2				St.3				
	spring	summer	autumn	winter	spring	summer	autumn	winter	spring	summer	autumn	winter	Total
Copepoda	ind/m^3	ind/m^3	ind/m^3	ind/m^3	ind/m^3	ind/m^3	ind/m^3	ind/m^3	ind/m^3	ind/m^3	ind/m^3	ind/m^3	ind/m^3
Calanoida													
Acartiella (Acartiella) faoensis	1470	0	10	0	0	0	0	0	8000	0	28	0	9536
Bestiolina arabica	4500	3766	30	0	43400	1400	40	0	140000	6000	161	5	204023
Parvocalanus crassirostris	0	0	0	0	0	0	7	0	0	2100	36	3	4275
Pseudodiaptomus ardjuna	240	0	90	3	106400	0	0	0	29000	0	21	0	135775
Harpacticoid	0	0	2	0	0	0	0	0	0	0	21	0	44
Total of copepoda	6210	3766	132	3	149800	1400	47	0	177000	8100	267	8	353653
copepod nauplii	10200	0	30	0	25200	0	0	0	0	4200	0	0	43830
Cirriped larvae	525	0	210	0	103600	40	70	0	55000	100	350	6	160241
Foraminifera	0	41	0	0	0	0	0	0	0	0	0	0	41
Ostracoda	300	4	3	0	7000	0	0	0	3500	0	18	1	10844
Rotifera	1470	34550	78000	2	0	42000	2	112000	385000	28000	7000	3000	684022
larvae of crab	0	0	0	0	0	0	0	0	700	0	0	0	700
Insect larvae	0	3	3	0	0	0	15	120	0	0	14	45	199
final total	18705	38364	78378	5	285600	43440	134	112120	621200	40400	7649	3060	1253530

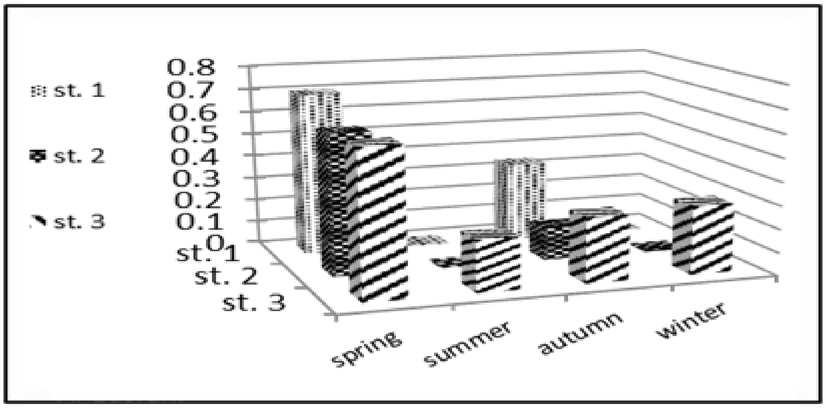

Figure 8. Seasonal variation in the Diversity (H) of Calanoida at the Shatt Al-Basrah canal.

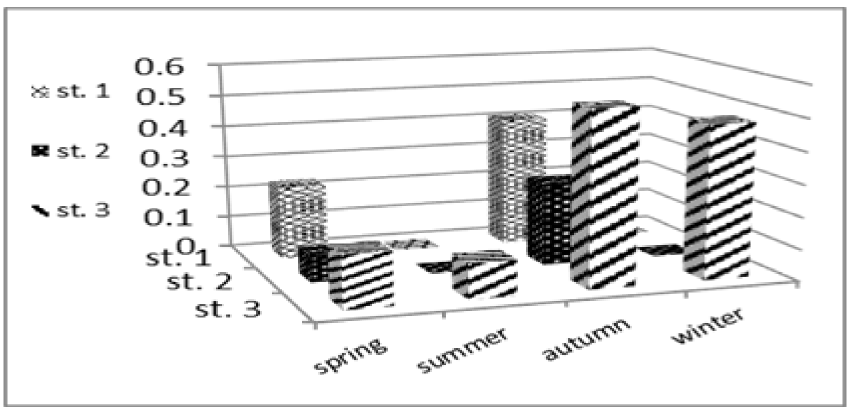

Figure 9. Seasonal variation in the Richness (D) of Calanoida at the Shatt Al-Basrah canal.

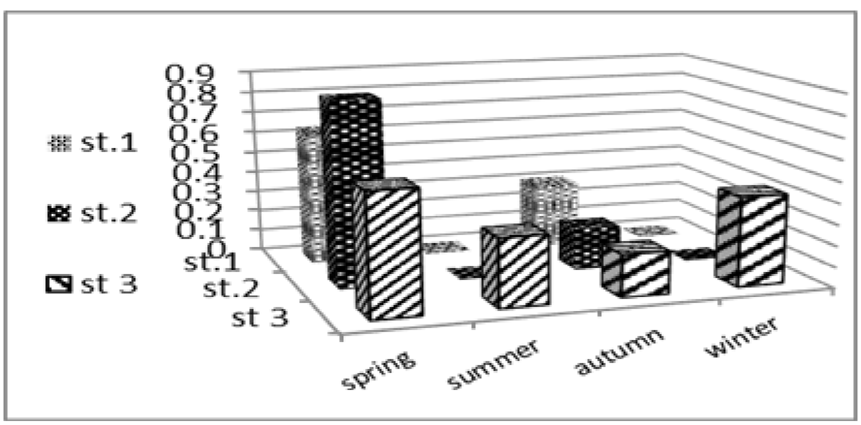

Figure 10. Seasonal variation in the Evenness (J) of Calanoida at the Shatt Al-Basrah canal.

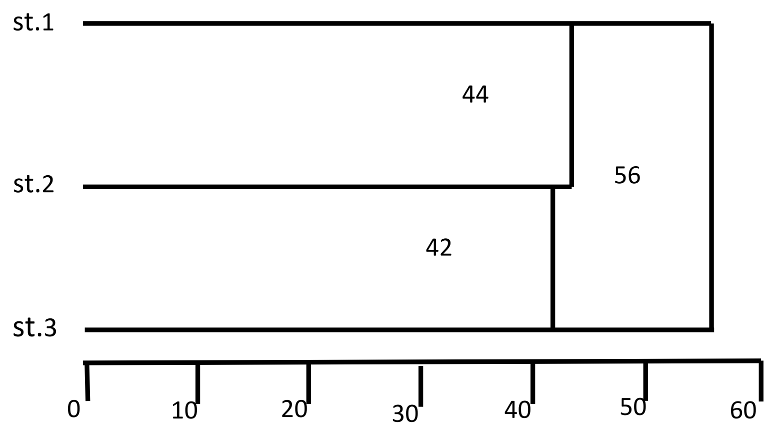

Figure 11. Cluster of the Similarity index (Jaccard's) values of Calanoida at the Shatt Al-Basrah.

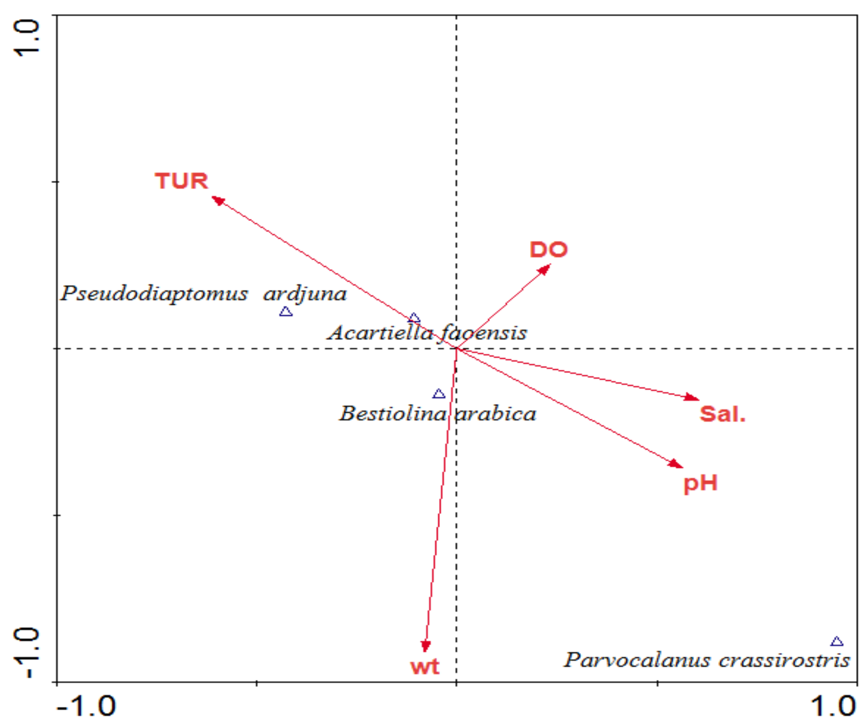

Figure 12. CCA analysis of the correlation coefficients between species of Calanoida and the environmental factors during four seasons from three stations in the Shatt Al-Basrah canal.

Discussion

There was no significant difference apparent in the water temperature at the three studied stations.

Salinity in spring and summer at stations 1 and 2 were, generally, very much less than that of autumn and winter, so as at station 3 during these two seasons. However, salinity at station 3 during summer was very much higher (35 psu) than the other seasons. Higher salinities during autumn and winter were due to exceptionally higher water discharge from Thi-Qar Governorate which was highly saline and affected both Shatt Al-Arab and Shatt Al-Basrah canal.

Salinity records in the Shatt Al-Basrah canal during March 2005-May 2010, ranged during most of the year between 5-10 psu, whereas in August 2009 and April 2010 it rises to 21 psu and 39 psu, respectively (Ajeel, 2012). Salinity values recorded in 1987-1988, indicated that higher values were recorded during autumn (4.03psu), whereas lower values were recorded in summer (1.4 psu) (Abdullah, 1989).

DO values were, generally, higher during spring and autumn than in summer and winter at stations 1 and 2. Whereas, a very low values (2.53 mg/l) was detected in spring at station 3. Lower values of DO may be caused by higher input of sewage waters through three outlets in the middle and lower reaches of Shatt Al-Basrah canal.

Previous reports of DO in the region showed that higher values were in winter (11.1 mg/l) and spring and lower values in summer (5.2 mg/l) and autumn (Abdullah, 1989).

pH values were mostly alkaline, but changed to slightly acidic in autumn, which was soon return to normal in winter 2012. However, Abdullah (1989) recorded values of 7.55-8.58.

Lower values of turbidity were recorded during summer at the three stations, whereas higher values were recorded in autumn at stations 1 and 2 and in spring at station 3.

Higher values of light penetration were reported earlier (20-135cm) by Abdullah (1989).

Although, no attempt was done here to estimate the phytoplankton numbers and primary productivity, but previous counts of phytoplankton in the region indicated that a range of 3534-3792870 cell/l in autumn and summer, respectively were recorded (Abdullah, 1989), while (Jebir, 2013) recorded chlorophyll-a values from 1.1 to 18.0 mg/m^{3}in the third station.

Although the lists of zooplankton at the three stations were very brief corresponding to the detailed list of a station near the Barrage made by Morad (2011) and Ajeel (2012), yet stations 1 and 2 of the present study may be considered far from the only stations at Shatt Al-Basrah canal sampled by Morad (2011) and Ajeel (2012), however, station 3 may be considered close to that of Morad (2011) and Ajeel (2012).

Nevertheless, a comparison of the results of the three stations were made with that of Ajeel (2012). At all the three present stations and that of Ajeel (2012), Rotifera was reported in appreciable numbers, but greater in the present study than thatof Ajeel (2012), although, both nets used for sampling were of larger mesh-size, 100 µm in the present study and 120 µm by Ajeel's study.

Numbers like 112000 ind./m^3 and 385000 ind./m^3 were recorded here, whereas Ajeel (2012) reported 44430 ind./m^3 in April 2009 as the highest value of rotifers. Such as a difference may be due to the difference in the mesh-size of the 2 nets.

An important point of difference between the two studies was that the Cladocera was not recorded in the present study, while Ajeel (2012) recorded Cladocera on five occasions only ranging from 1 ind./m^3 in December 2009 to 5267 ind./m^3 in March of the same year. This was apparently due to comparatively low salinity values in 2009-2010 than in 2011-2012.

Calanoid Copepoda represented in the present study by only four species these were *Acartia (Acartiella) faoensis*, *Bestiolina arabica*, *Parvocalanus crassirostris* and *Pseudodiaptomus ardjuna*, recorded during the four occasions of sampling underwent here, three of which were recorded at stations 1 and 2, whereas at station 3, the four species were recorded.

This result is very close to that of Ajeel (2012) who recorded five species in April at a station near the Dam, one of which was represented by a single individual *viz Acartia* sp.

Ajeel had no sample in July, yet November sample near the Dam in the present study recorded the 4 species all together, whereas, that of Ajeel (2012) reported only 2 species.

On the other hand Cyclopoida were totally absent in the present study, while, Ajeel (2012) recorded 38006 ind./m^3 in April 2009. Moreover, Harpacticoida were only recorded here in November by very few specimens at stations 1 and 3, whereas no harpacticoid were detected in November 2009, while, 152 ind./m^3 were encountered in April 2011 and 123 ind./m^3in April2009 (Ajeel, 2012.).

Moreover, cirripede larvae, Foraminifera and Ostracoda were detected here and found also by Ajeel (2012). However the rest of groups recorded by Ajeel were not detected in the present study.

There is no much diversity detected in the present study corresponding to more diversified list represented by Ajeel (2012) as the occasions of sampling were only four and not covered the whole year.

The present study indicates a dramatic changes in the zooplankton communities during 2011-2012 due to changes of the inputs of waste waters into the canal.

Table (2) shows comparison between some biodiversity indices obtained from Shatt Al-Arab, Shatt Al-Basrah canal and Iraqi marshes as the following:

Generally, the values of diversity index ranged from 0-2.66, richness ranged from 0-63.34, evenness ranged between 0 and 0.95 and similarity index ranged between 24.9 and 100.

In general, the low levels of biodiversity index values in the present study were due to the presence of organic pollution because there is a lot of sewage flowing into Shatt Al Basrah, especially, at the second station, and this is consistent with the conclusion of Al-Jizani (2005) that the pollution is reducing the biodiversity index, and Jonge (1995) who noted that when the environmental conditions are natural, the water quality will be suitable for the high rates of biodiversity and vice versa.

Table 2. A comparison of Biodiversity index of zooplankton in the Sothern Iraqi waters from different sources.

Environmental sites	Diversity index (Ĥ)		Richness index (D)		Evenness index(J)		Jacquard' Similarity index		References
	Min.	Max.	Min.	Max.	Min.	Max.	Min.	Max.	
Shatt Al-Arab	0.29	2.66	0.55	9.65	0.13	1	24.9	35.5	Hammadi, 2010
Shatt Al-Arab	0	2.11	0	63.34	0.29	0.47	26	66	Abbas *et al.*, 2014
Shatt Al-Arab	0	0.92	0	0.87	0	0.84	40	100	Khalaf, 2011
Shatt Al-Arab	0	1.8	0	7.62	0.46	0.75	31	34.4	Ajeel & Abbas, 2012
Shatt Al-Arab &Shatt Al-Basrah canal	0	2.37	0	3.14	0	0.95	48	67	Jebir, 2013
Iraqi Marshes	-	-	-	-	-	-	33	84	Salman *et al.*, 2014
Shatt Al-Arab	1	2.9	1.66	4.04	0.46	0.91	35	96	Al-Khafaji, 2014
Shatt Al-Basrah canal	0	0.7	0	0.54	0	0.87	42	56	Present study

References

Abbas, M.F., Salman, D.S. and Al-Mayahy, S.H. 2014.Abundance and Diversity of Cladocera and some other zooplankton in the Northern part of Shatt Al-Arab River. Mesopotamian Journal of Marine Science, 29(1): 51-70.

Abdullah, D.S.M. 1989. Phytoplankton primary production and the affecting ecological factors in the Shatt Al-Basrah canal.M.Sc. thesis, College of Agriculture, University of Basrah, 95 pp.

Ajeel, S.G. 2012.Distribution and abundance of zooplankton in Shatt Al-Basrah and Khour Al-Zubair Channels, Basrah, Iraq. J. Basrah Res., 38(4): 10-28.

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

Al-Aesawi, Q.M. 2010.Hydraulic Operation of Shatt Al-Basrah Canal using on dimensional model. M.Sc. thesis, College of Science, University of Baghdad, 105 pp.

Al-Badran, B., Al-Sadoon, B. and Jassim, T. 1996. Flow characteristic measurement of Shatt Al-Basrah canal, south of Iraq. Marina Mesopotamica, 11(2): 299-310.

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 AlRobat Channels. M.Sc. thesis, College of Education, University of Basrah, 82 pp. (in Arabic).

Al-Katib, M.T. 1972. Shatt Al-Arab and Shatt Al-Basra and the history.Iraqi port Estab.Publ., 190 pp. (in Arabic).

Al-Khafaji, K.K. 2014. Functional analysis of community structures of Macroinvertebrate in the Shatt Al -Arab River, Basrah - Iraq. Ph.D.

thesis, College of Agriculture, University of Basrah, 129 pp. (in Arabic).
Al-Khayat, N.N.M. 2007. Hydrological status of the Shatt Al-Basrah canal and some of their environmental. J. Coll. Arts. Univ. Basrah, 43: 214-229.
APHA (American Public Health Association) 2005.Standard methods for the examination of water & wastewater.21st ed. Washington, DC. 1400pp.
Hammadi, N.S. 2010. An Ecological study of the Rotifera of Shatt Al-Arab Region .Ph.D. thesis., College of Agriculture, University of Basrah, 351pp.
Jaccard, P. 1908. Nouvelles researches sur la distribution florale. Bull Soc. Vand Sic. Nat., 44: 223-270, cited by Cairns,Jr. andKaesler, R.L. (1969).
Jebir, A.M. 2013. Ecological Study of Zooplankton in Shatt Al-Arab River and Shatt Al-Basrah Canal South of Iraq. M.Sc. thesis, College of Science, Universityof Basrah, 119pp. (in Arabic).
Jonge, V.N. 1995. Response of the DutchWaddenSea ecosystem to phosphorus discharges from the river Rhine. Hydrobiologia, 195: 49-62.
Khalaf, R.Z. 2011. Ecological Study of Gastropods in Intertidal Zone of the Northern Part of Shatt Al-Arab, Iraq. M.Sc. thesis, College of Science, University of Basrah, 103pp. (in Arabic).
Margalef, R. 1968. Perspectives in ecology theory, University of Chicago Press,Chicago, 111pp.
Morad, M.S.S. 2011. Zooplankton in Iraqi Marine Coastal and Estuarine Brackish Water and their Role as Hosts of Some Parasite. M.Sc. thesis, College of Education, University of Basrah, 116 pp.
Pielou, E.C. 1966. Shannon′s formula as measure of specific diversity: Its use and misuse. Am. Nat., 100: 463-465.
Ramadan, M., Elkiati, N., Flower, R.J., Birks, H.H., Kraiern, M.M., Fathi, A. and Patrick, S.T. 2001. Open water zooplankton communities in North African wetland lakes. Aquatic Ecology, 35: 319-333.
Salman, D.S., Abbas, M.F., Ghazi, A.M., Ahmed, H.K., Akash, A.N., Douabul, A.A.Z., Warner, B.G. and Asada, T. 2014. Seasonal changes in zooplankton communities in the re-flooded Mesopotamian wetlands, Iraq. J. of Freshwater Ecology, 29(3): 397-412.
Shannon, C.E. and Weiner, W. 1949. The mathematical theory of communication, Univ. Illinois press, Urbana, I, 11.117 p., Cited by Fausch, K.D., Lyons, J.D., Karr, J.R.and Angermeier, P.L. (1990).

دراسة بيئيةللهائمات الحيوانية في شط البصرة، العراق

محمد فارس عباس
قسم الأحياء البحرية، مركز علوم البحار، جامعة البصرة، البصرة - العراق

المستخلص - جمعت عينات الهائمات الحيوانية من قناة شط البصرة خلال الفترة من نيسان 2011 لغاية كانون الثاني 2012 بواسطة شبكة الهائمات

الحيوانية قطر فتحاتها 0.100 ملم. تراوحت كثافة الهائمات الحيوانية بين (5-621200) فرد/م^3 خلال فصل الشتاء والربيع في المحطتين الأولى والثالثة على التوالي، وكانت مجموعة الدولابيات هي السائدة إذ تراوحت كثافاتها بين (0-385000) فرد/م^3 بنسبة55%، تلتها مجذافية الأقدام بنسبة 28% ثم يرقات البرنقيلات بنسبة13% من العدد الكلي للهائمات الحيوانية. تراوحت درجة حرارة المياه المقاسة ما بين (12-33.2)°م كما تباينت قيم الملوحة فقد تراوحت بين (15.6-35.1)psu مع انخفاض في فصل الربيع وزيادة في فصل الصيف. أما الدالة الحامضية فكانت قيمها تميل إلى الجانب القاعدي. تباينت قيم الأوكسجين المذاب بين 2.53 ملغم/لتر في فصل الربيع و 8.7 ملغم/لتر في فصل الخريف. درست أيضا بعض الأدلة البيئية مثل دليل شانون ودليل الغنى ودليل التشابه جاكارد، وكانت القيمة القصوى لدليل التنوع 0.7 في المحطة الأولى ودليل الغنى 0.54 في المحطة الثالثة ودليل التكافؤ 0.87 في المحطة الثانية بينما كانت أعلى قيم لدليل التشابه بين المحطة الأولى والثالثة وأدناها بين المحطة الثانية والثالثة.