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Distribution of Zooplankton in the South of Al-Hammar Marshes, Southern Iraq

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Abstract - Seasonal variation of the quality and quantity of zooplankton was studied in four selected stations of Southern Al-Hammar Marshes, from October 2018 to July 2019. Plankton net (0.1 mm. mesh size) was used to collect the samples of zooplankton. The population density of zooplankton in the study area ranged from 725 ind./m3 in Summer 2019 at station 1 (Al-Barga station) to 151413 ind./m3 in Autumn 2018 at station 3 (Hareer station), with an average of 39336 ind./m3. The Crustacea was the dominant group; it was accounted for (96.3%) of the total zooplankton, Copepoda constituted about (80.3%) followed by Cirripede larvae (13%), Rotifera (3.3%), and Cladocera (2.4%) of the total zooplankton. The Cyclopoida was the dominant group of Copepoda at all stations (95.6%), followed by the nauplii of Copepoda (2.8 %), Calanoida (1.3 %) and Harpacticoida (0.3 %).

توزيع العوالق الحيوانية في جنوب هور الحمّار جنوب العراق

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قسم الاحياء البحرية، مركز علوم البحار، جامعة البصرة - العراق

المستخلص - تمت دراسة الهائمات الحيوانية فصليا ونوعيا وكميا في أربعة محطات مختارة في جنوب منطقة هور الحمار خلال الفترة من تشرين الأول 2018 الى تموز 2019. جمعت العينات بواسطة شبكة الهائمات ذات قطر فتحات 0.1 ملم. تراوحت الكثافة السكانية للهائمات الحيوانية في محطات الدراسة بين 725 فرد/م^3 خلال فصل الصيف 2019 في المحطة 1 (منطقة البرگة) الى 151413 فرد/م^3 خلال فصل الخريف 2018 في محطة 3 (منطقة حرير) وكان المعدل 39336 فرد/م^3. أظهرت النتائج ان مجموعة القشريات كانت هي السائدة حيث بلغت نسبتها المئوية 96.3% من مجموع الهائمات الحيوانية. وقد شكلت مجذافية الاقدام 80.3% تلتها يرقات البرنقيلات 13% والدولابيات او العجليات 3.3% ثم متفرعة اللوامس2.4% من مجموع الهائمات الحيوانية. بينما ضمن مجموعة مجذافية الاقدام كانت الـ (Cyclopoida) هي السائدة حيث بلغت نسبتها 95.6% وبعدها يرقات مجذافية الاقدام 2.8% والـ (Calanoida) 1.3% ثم الـ (Harpacticoida) 0.3%.

الكلمات المفتاحية: مياه عذبة، اهوار، جنوب العراق ، عوالق

Introduction

Al-Hammar Marshes include a large area located in southern Iraq, west of the Euphrates River, 360 km south of Baghdad. The marshes area represents a distinct ecosystem and is a suitable environment for the growth of reeds, papyrus and others aquatic plants (Atiwi *et al.*, 2010). In addition, Al-Hammar marsh is a shallow area even during the flood season; the greatest depth does not exceed three meters. The highest level is reached in Spring as a result of snow melting in the fountainhead areas of the Tigris and Euphrates Rivers, during the ebb, large of the littoral zone is exposed (Al-Hamed, 1960).

Zooplankton, which are very small animals, floating or weak swimmers near the water surface and feed by other aquatic organisms, make up the food supply on which nearly all aquatic

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organisms depend. Mostly still microscopic but some can be seen with the naked eyes. Published data on zooplankton community are still scarce in the Marshes of Southern Iraq. Zooplankton comprises of various sizes of organisms including from small protozoans to large metazoans.

It includes floating organisms whose complete life cycle is within the plankton, as well as floating organisms that spend part of their life in the plankton before they transform into a nekton or a sessile bottom organism. Although zooplankton is mainly transported by surrounding water currents, many of them move to avoid predators such as in the vertical migration of the zooplankton (Simoncelli *et al*., 2019).

Zooplankton form an important food web in the food chain of the aquatic environment, they feed greatly on phytoplankton and detritus, they convert organic matter in phytoplankton to protein and lipids, and they also an important food to fishes and crustaceans (Groisbois, 2017).

The first study on zooplankton in the marshes of southern Iraqi waters was conducted by Gurney (1921) during the British campaign to Iraq, followed by that of Mohammad (1965), Al-Hamed (1966), Khalaf and Smirnov (1976) Al-Saboonchi *et al.* (1986), Abdul-Hussein *et al.* (1989), Al-Qarooni (2005), Ajeel *et al.* (2006). Ajeel and Abbas (2013), Salman *et al.* (2014) and Ajeel *et al.* (2015).

Because of the importance of zooplankton as food for freshwater carnivorous fishes in Iraqi southern marshes especially juveniles, it represents a link between different trophic levels, the present study was conducted in the aim of providing an idea about the zooplankton taxa and its seasonal variations in the restored Iraqi marshes

Materials and Methods

Seasonal horizontal surface plankton samples were taken from Autumn 2018 to Summer 2019, from four selected stations at the Southern Al-Hammar Marshes; St. 1 Al-Barga (30°30′46″N, 47°50′57″E), St. 2 Al-Sallal (30°48′12″N, 47°35′1″E), St. 3 Hareer (30°35′35″N, 47°42′43″E) and St. 4 Garmat Ali River (31°0′24″N, 47°26′26″E) (Fig. 1). A plankton net of a mesh size of 100 μm with a mouth diameter of 40 cm was used. A digital flowmeter was mounted at the mouth of the net. The net was towed behind a boat running at its lowest speed for 10 minutes and the reading of the flowmeter was taken before and after towing. Samples were fixed with 4% formalin.

In the laboratory, samples were placed in a graduated flask, diluted to a 500 ml. and three replicates of 10 ml. each were taken. Counting was carried out using a Bogorov chamber with the aid of a dissecting microscope and the average was taken, then the whole sample was examined for the rare species.

Figure 1. Map of lower Mesopotamia showing the sampling stations

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The volume of water filtered through the net was calculated according to the following expression (De Bernardi, 1984).

$$V = \Pi r^2 d$$

Where:

V = volume of water filtered by the net and is measured in cubic meters

Π = (3.14)

r = radius of the net mouth aperture (20 cm).

d = number of revolutions of the flow meter multiplied by 0.3.

Then the result was divided by 10,000 to convert to unit cubic meter. The number of individuals were calculated in the sample diluted to 1000 ml in the manner prescribed by APHA (2006) and the result was expressed in a cubic meters.

$$No./m^3 = (C \times V^I)/(V^{II} \times V^{III})$$

Where:

C = number of individuals in the subsample

V^I = volume of sample (ml).

V^{II} = size of the subsample (10 ml).

V^{III} = volume of water filtered in cubic meters

Results

Environmental Conditions:

Water temperatures at the study stations are very close to each other it ranged between 17˚C at St.2,3 and 4 during Winter and 33.3˚C at St. 2 and 3 during Summer. Moreover, salinity ranged from 2 ‰ at St. 4 during Summer, and 17.5 ‰ at St. 1 during Autumn. While the dissolved oxygen (DO) ranged from 4 mg/L at St. 1 during Winter to 12 mg/L at St. 3 during Spring. Hydrogen ion concentration (pH) ranged from 7.4 at St. 1 during Autumn to 8.4 at St. 3 during Spring (Fig 2).

The Total Dissolved Solids (TDS) values are ranging from 0.234 g/L at St. 4 during Summer to 16.45 g/L at St. 1 during Autumn. Biological Oxygen Demand (BOD) fluctuated between 1 mg/L at St. 1, 2, 3 and 4 during Summer and 14 mg/L at St. 1 during Spring. Chlorophyll-a changed from 1.1 mg/L at St. 1 during Autumn to 3.2 mg/L at St. 1 during Summer (Fig. 2).

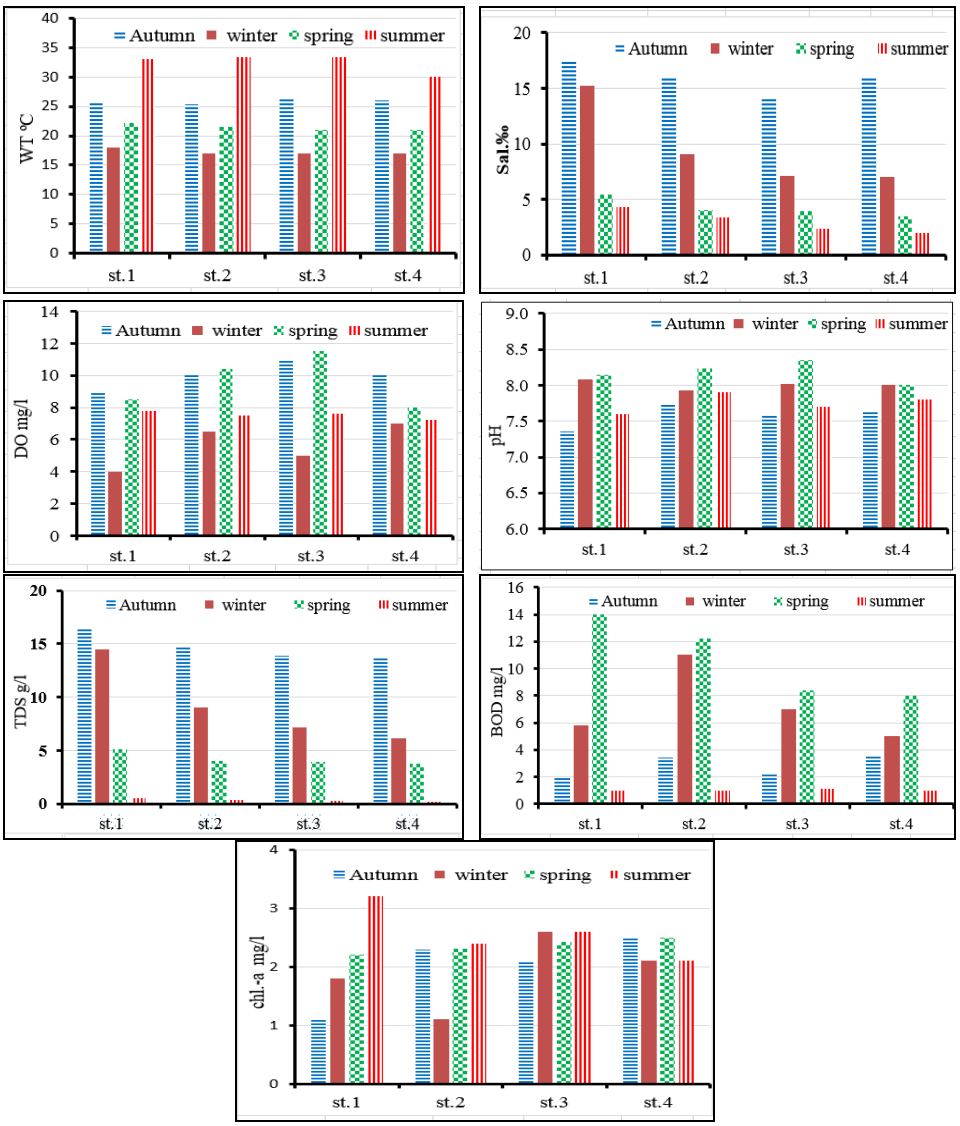

Figure 2. Water temperatures, Salinity, dissolved oxygen, pH, TDS, BOD and Chlorophyll-a concentration at the Study area between October 2018 and July 2019.

Zooplankton:

The density of zooplankton in the study area ranged from 725 ind./m^3 in Summer 2019 at station 1 (Al-Barga station) to 151413 ind./m^3 in Autumn 2018 at station 3 (Hareer station). The average density was 39336 ind./m^3. Most zooplankton belong to crustaceans which ranged from 193 ind./m^3 in Spring at station 1 to 150694 ind./m^3 during Autumn at station 3 (Table 1). It accounted for 96.3% of the total zooplankton. Copepoda was the dominant group of crustaceans it ranged from 79 ind./m^3 during Summer at station 1 to 137174 ind./m^3 during Autumn at station 3, and accounted for 80.3% of the total zooplankton. While cirripede larvae reached a density of 55468 ind./m^3 during Winter at station 3 and accounted for 13% of the total zooplankton. As for the Cladocera 5 species were recorded in the study area, the highest density of Cladocera and Rotifera reached 6120 and 12240 ind./m^3 during Summer at station 3 and accounted for 2.4% and 3.3% of the total zooplankton, respectively (Fig 3). Among Copepoda, Cyclopoida was dominant at all the stations (95.6 %), while the Calanoida (1.3 %), Harpacticoida (0.3 %) and nauplii of Copepoda (2.8 %) were rare groups at all stations (Fig. 4).

Table 1. Seasonal zooplankton density (ind./m^3) in the study area from October 2018 to July 2019.

Zooplankton	St. 1 Al-Barga	St. 2 Al-Sallal	St. 3 Hareer	St. 4 Garmat Ali River	Total	%
Alona costata	0	6	0	0	6	0.0009
Chydorus sphaericus sphaericus	0	27	0	6	33	0.005
Daphnia exilis	0	0.01	0.01	37	37	0.006
Diaphanosoma brachyurum	0.12	39	0	3	42	0.007
Moina affinis	493	6512	7230	821	15056	2.4
Total of Cladocera	493.12	6584	7230	867	15174	2.4
Calanoida	2201.6	1680.05	986	1636	6504	1.03
Cyclopoida	67334	135800	149122	131183	483439	76.8
Harpacticoida	976	178	78	93	1325	0.21
Nauplii larvae	3654	1192	7857	1466	14169	2.25
Total of Copepoda	74165.6	138850	158043	134378	505437	80.3
Cirripede larvae	3707.8	5972	68328	4000	82008	13.0
Isopoda	0	0	3.01	0.01	3	0.0004
Ostracoda	181	1029	648	1356	3214	0.5
Zoea of crab	0	6	0	0	6	0.0009
Zoea of shrimp	0.43	27	9.9	0	37	0.006
Total of Crustacea	78548	145884	226383	139734	605879	96.3
Insect larvae	180	3.12	22.2	7.1	212	0.03
Fish larvae	3.1	0.01	0	0	3.1	0.0004
Foraminifera	7.25	1	2574	5	2587	0.4
Rotifera	5760	11	13211	1731	20713	3.3
Final Total	84498	152483	250069	142344	629394	

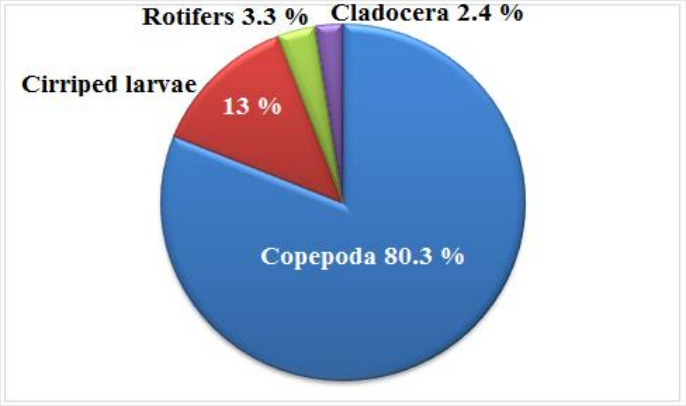

Figure 3. Percentage of the main groups of zooplankton in the study area.

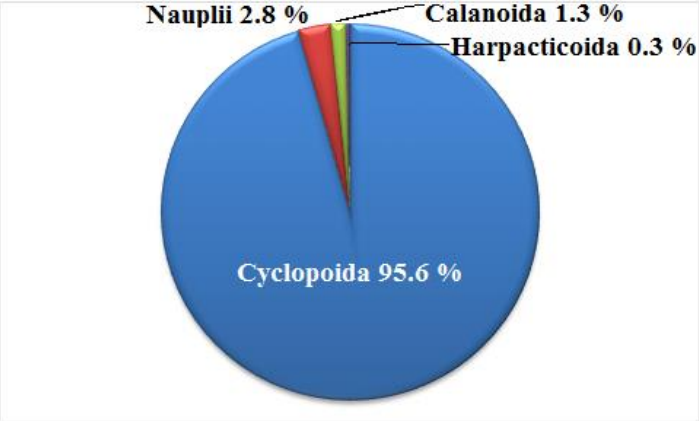

Figure 4. Percentage of the Copepoda groups in the study area.

Station 1 (Al-Barga):

The density of zooplankton at station 1 (Al-Barga station) ranged from 725 ind./m^3 in Spring 2019 to 72195 ind./m^3 in Autumn 2018. The average density was 21124 ind./m^3. The crustaceans changed between 193 ind./m^3 in Spring and 66821 ind./m^3 during Autumn and the percentage was 93 % of the total zooplankton (Table 2).

The dominant group was Copepoda, it ranged from 79 ind./m^3 during Summer to 63777 ind./m^3 during Autumn, with a percentage of 87.8% of the total zooplankton. Then followed by the Rotifera (6.8 %), cirripede larvae (4.4 %). While 2 species of Cladocera were recorded and reached 350 ind./m^3 during Summer and accounted for 0.6 % of the total zooplankton (Fig. 5).

Table 2. Seasonal Zooplankton density (ind./m^3) at Station 1- Al-Barga

Zooplankton	Autumn	Winter	Spring	Summer	Total
Diaphanosoma brachyurum	0	0	0	0.12	0.12
Moina affinis	0	0	143	350	493
Total of Cladocera	0	0	143	350.12	493
Calanoida	1074	1125	2.6	0	2202
Cyclopoida	58175	9000	117	42	67334
Harpacticoida	948	0	26	2	976
Nauplii larvae	3580	0	39	35	3654
Total of Copepoda	63777	10125	184.6	79	74166
Cirripede larvae	2685	630	7.8	385	3708
Ostracoda	179	0	0	2	181
Zoea of shrimp	0	0	0.3	0.13	0.4
Total of Crustacea	66641	10753	193	816.25	78٥٤٨
Insect larvae	180	0	0	0	180
Fish larvae	0	0	0.1	3	3.1
Foraminifera	4	3	0	0.25	7.2
Rotifera	5370	0	390	0	5760
Final Total	72195	10756	582.8	819.5	84499

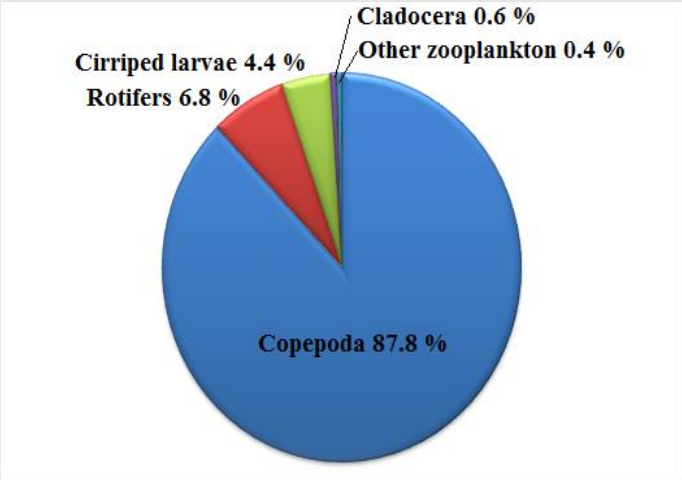

Figure 5. Percentage of the main groups of zooplankton at Station 1- Al-Barga

Station 2 (Al-Sallal):

The density of zooplankton at station 2 (Al-Sallal station) ranged from 1446 ind./m^3 in Summer 2019 to 140385 ind./m^3 in Autumn 2018. The average density was 38121 ind./m^3. The crustaceans ranged between 60 ind./m^3 in Spring to 140385 ind./m^3 during Autumn 2018 (Table 3), and the percentage was 99.99 % of the total zooplankton.

The dominant group was Copepoda, it ranged from 341 ind./m^3 during Summer to 134946 ind./m^3 during Autumn. Its percentage reached 91.06 % of the total zooplankton. Then become the Cladocera which included 5 species with a percentage of 4.3 %, cirripede larvae formed (3.9 %).

While Ostracoda reached a density of 1029 ind./m^3 during Autumn and accounted for 0.6 % of the total zooplankton (Fig. 6).

Table 3. Seasonal Zooplankton density (ind./m^3) at Station 2- Al-Sallal

Zooplankton	Autumn	Winter	Spring	Summer	Total
Alona costata	0	0	6	0	6
Chydorus sphaericus sphaericus	0	0	27	0	27
Diaphanosoma brachyurum	0	0	26	13	39
Moina affinis	0	0	5875	637	6512
Daphnia exilis	0	0	0.01	0	0.01
Total of Cladocera	0	0	5934.01	650	6584
Calanoida	1470	210	0.05	0	1680
Cyclopoida	132300	216	2959	325	135800
Harpacticoida	0	0	162	16	178
Nauplii larvae	1176	0	16	0	1192
Total of Copepoda	134946	426	3137.05	341	138850
Cirripede larvae	4410	1080	27	455	5972
Ostracoda	1029	0	0	0	1029
Zoea of crab	0	0	6	0	6
Zoea of shrimp	0	0	27	0	27
Total of Crustacea	140385	1506	9131.06	1446	152468
Insect larvae	0	3	0.02	0.1	3.1
Fish larvae	0	0	0.01	0	0.01
Foraminifera	0	1	0	0	1
Rotifera	0	0	11	0	11
Final Total	140385	1510	9142.09	1446.1	152483

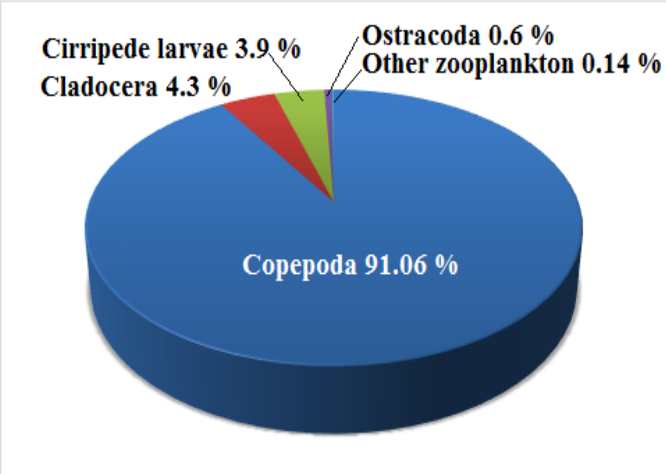

Figure 6. Percentage of the main groups of zooplankton at Station 2- Al-Sallal

Station 3 (Hareer):

The density of zooplankton at station 3 (Hareer) ranged from 11604 ind./m^3 in Spring 2019 and 151413 ind./m^3 in Autumn 2018. The average density was 62516 ind./m^3. The crustaceans ranged between 11383 ind./m^3 in Spring and 150694 ind./m^3 during Autumn (Table 4), and the percentage was 93.7 % of the total zooplankton.

The dominant group was Copepoda, it ranged from 3146 ind./m^3 during Winter to 137174 ind./m^3 during Autumn. Its percentage reached 63.2 % of the total zooplankton. Then cirripede larvae formed 27.3 %, Rotifers 5.3 %. The Cladocera group represented by two species with a percentage of 2.9 % and other zooplankton formed 1.3% of the total zooplankton (Fig. 7).

Table 4. Seasonal Zooplankton density (ind./m^3) at Station 3- Hareer

Zooplankton	Autumn	Winter	Spring	Summer	Total
Moina affinis	0	0	1110	6120	7230
Daphnia exilis	0	0	0.01	0	0.01
Total of Cladocera	0	0	1110.01	6120	7230
Calanoida	107	858	0	21	986
Cyclopoida	134820	572	9990	3740	149122
Harpacticoida	0	0	37	41	78
Nauplii larvae	2247	1716	222	3672	7857
Total of Copepoda	137174	3146	10249	7474	158043
Cirripede larvae	12840	55468	0	20	68328
Isopoda	0	3	0.01	0	3.01
Ostracoda	642	6	0	0	642
Zoea of shrimp	8	0	1.4	0.5	9.9
Total of Crustacea	150694	58623	11361	13614.5	234256
Insect larvae	0	0	22.2	0	22.2
Foraminifera	0	2574	0	0	2574
Rotifera	749	0	222	12240	13211
Final Total	151413	61197	11604.62	25854.5	250063

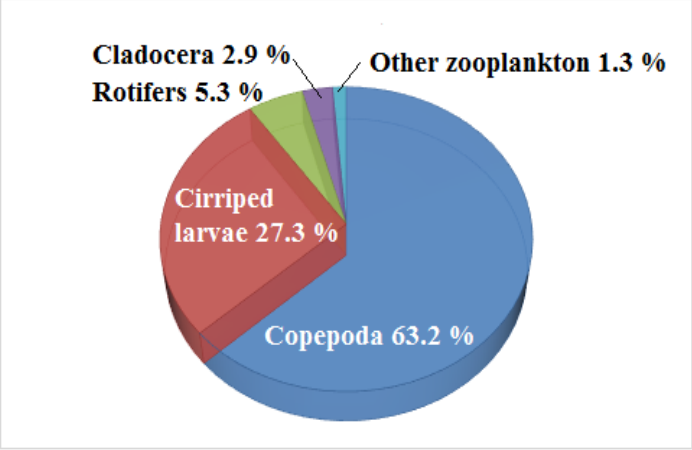

Figure 7. Percentage of the main groups of zooplankton at Station 3 - Hareer

Station 4 (Garmat Ali River):

The density of zooplankton at station 4 (Garmat Ali River) ranged from 2410 ind./m^3 in Winter 2019 to 128303 ind./m^3 in Autumn 2018. The average density was 35586 ind./m^3. The crustaceans ranged between 1223 ind./m^3 in Summer and 8677 ind./m^3 during Spring (Table 5), and the percentage was 98.8 % of the total zooplankton.

.The dominant group was Copepoda, and it ranged from 542 ind./m^3 during Winter and 124805 ind./m^3 during Autumn. Its percentage reached 94.4 % of the total zooplankton. Then followed the cirripede larvae (2.8 %), Rotifers (1.2 %), Ostracoda (1 %). While the Cladocera group included 4 species and formed 0.6 % of the total zooplankton (Fig. 8).

Table 5. Seasonal Zooplankton density (ind./m^3) at Station 4 - Garmat Ali River

Zooplankton	Autumn	Winter	Spring	Summer	Total
Chydorus sphaericus sphaericus	0	0	6	0	6
Diaphanosoma brachyurum	0	0	0	3	3
Moina affinis	0	0	371	450	821
Daphnia exilis	0	0	37	0	37
Total of Cladocera	0	0	414	453	867
Calanoida	1381	255	0	0	1636
Cyclopoida	122422	287	7799	675	131183
Harpacticoida	0	0	93	0	93
Nauplii larvae	1002	0	371	93	1466
Total of Copepoda	124805	542	8263	768	134378
Cirripede larvae	3498	500	0	2	4000
Isopoda	0	0	0.01	0	0.01
Ostracoda	0	1356	0	0	1356
Total of Crustacea	128303	2398	8677	1223	140601
Insect larvae	0	7	0.1	0	7.1
Foraminifera	0	5	0	0	5
Rotifera	0	0	111	1620	1731
Final Total	128303	2410	8788.11	2843	142344

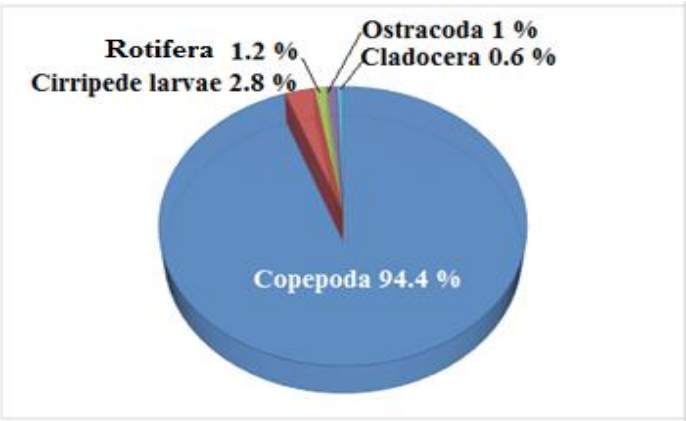

Figure 8. Percentage of the main groups of zooplankton at Station 4 - Garmat Ali River.

The relationships between the density of the zooplankton and the environmental factors:

The Copepoda exhibit a significant correlation with salinity whereas the other factors such as dissolved oxygen and temperatures had little effect. The effect of other physical factors are destitute. While the Cladocera and Rotifera groups correlated with chlorophyll-a and pH (Fig. 9).

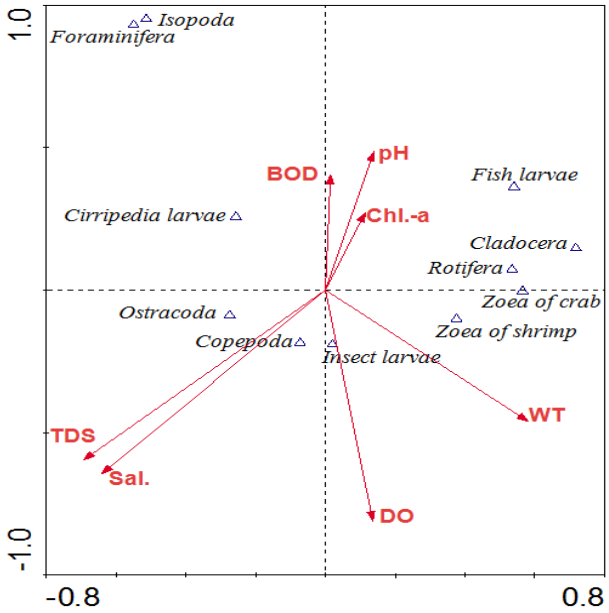

Figure 9. CCA analysis of the correlation coefficients between zooplankton and the environmental factors during the study period.

Discussion

Zooplankton distribution is influenced by many Physical, Chemical and Biological factors such as temperature, transparency, light, salinity, nutrients, pH, DO, predation, quantity and quality of phytoplankton. The pH is one of the environmental factors affecting the aquatic environment and the basic characteristic prevails in Iraqi waters due to the abundance of bicarbonate and carbonate ions (Al-Saadi *et al*., 1993; Al-Robaie, 1997; Hassan, 1997).

The results showed that the distribution of zooplankton at the study areas was different from region to the another, and from season to season because of different environmental conditions prevailed on the and due to normal differences in the distribution of zooplankton so-called patchiness which may cause on increase in the differences in the net yield (Raymont, 1983). In the absence of human influences, zooplankton population structure determined by physical environmental variables (Vidjak *et al.*, 2007).

The results of the current study showed that the density of zooplankton increases when the salinity concentration increases in the four study stations, this is consistent with the study of Madhupratap, (1979) and Khalaf and Ajeel (1994). Although, higher densities of zooplankton were recorded in Autumn at all the stations and these are due to the rise in the abundance of phytoplankton in Autumn and its decline in Winter and Summer (Al-Zubaidi, 1985).

The study showed that the Copepoda was the most dominant group of zooplankton, accounting for 80.3% in the study area. This is consistent with the results of Ajeel *et al.* (2006) in the Al-Hawaizah and Al-Hammar marshes.

The seasonal average zooplankton densities reported in the present study ranged between 21124 and 62516 ind./m^3, at stations 1 and 3, respectively, and This is consistent with the conclusion of Brooks (1959) that the zooplankton are more abundant in the shallow water and enclosed areas than in the main rivers. However, the monthly average zooplankton density in the Shatt Al-Arab River was 118 ind./m^3 (Salman *et al.*, 1986), 3676 ind./m^3 at Al-Faw and 2399 ind./m^3 at Al-Seba (AL-Zubaidi, 1998), and 5743 ind./m^3 in the Tigris River, north of Baghdad, and 5295 ind./m^3 in the Euphrates River, east of Falluja (Mohammad, 1986). These differences are entirely due to differences in the environmental conditions prevailing in these areas and the mesh-size of the nets used.

The correlation coefficients between the physical and chemical properties included in the current study were correlated with the distribution of zooplankton. The results (as in Figure 8) showed that correlation between zooplankton and environmental factors, the Copepoda and Ostracoda group appears to correlate with salinity and TDS significantly and affected by other factors with little effect of other factors such as dissolved oxygen and temperatures. The effect of other physical factors is destitute. Cladocera, Rotifera and Fish larvae are also affected by Chlorophyll-a and pH, while BOD, water temperature and DO have little effect. Significant positive relationships were found between zoea of crab, zoea of shrimp, insect larvae and water temperature and DO while the effect of other environmental factors were weak.

Conclusions

1. The zooplankton groups showed distinct differences in species and densities between different stations due to different environmental conditions.
2. The results showed that the concentration of salinity and total dissolved solids (TDS) reached a noticeable increase during Autumn 2018 and began to decrease gradually during the other seasons due to the intrusion of the sea water deep into the inland areas of the Shatt Al-Arab River.
3. The Crustaceans was the dominant group, accounting for 96.3% of the total zooplankton due to the dominance of the Copepoda.
4. The density of Cladocera was very low compared with the previous studies due to the increase of salinity concentration and their inability to adapt to such environmental conditions.

Recommendations

1. Performance of a study of the effect of high salinity on the composition of the zooplankton community.
2. Conducting a taxonomic study of all zooplankton in the marshes and using them as bio indicator.
3. Establishing a continuous environmental monitoring system to programme environmental changes that would affect the zooplankton community.

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