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Distribution of zooplankton biomass in the Shatt Al-Arab River and Shatt Al-Basra Canal, Southern Iraq

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Abstract
Zooplankton is the important component of aquatic ecosystems. These organisms are important biological indicator of water quality of aquatic ecosystem due to their response to the environmental changes. In this study, we investigated distribution of zooplankton biomass in the Shatt Al-Basra Canal and Shatt Al-Arab River. Zooplankton samples were collected from two stations in the Shatt Al-Basra Canal, before (S1) and after (S2) the dam, and two stations in the Shatt Al-Arab River, Al-Siba (S3) and Al-Faw (S4). The biomass of zooplankton in the Shatt Al-Basra Canal varied between 23.102 - 520.875 mg/m^3 in terms of wet weight and 3.787 - 102.132 mg/m^3 in terms of dry weight at two stations (before the dam and after the dam) during the period of January and May, respectively. The displacement volume and standing crops also showed variations of the biomass of zooplankton. In the Shatt Al-Basra Canal, the range was from 0.06 ml/m^3 and 3.9 mgC/m^3 during January at S1 to 1.083 ml/m^3 and 70.395 mgC/m^3 during May at S2. While in the Shatt Al-Arab River, the biomass of zooplankton in terms of wet weight ranged from 10.671 - 655.78 mg/m^3 during December at S3 (Al-Siba) and may at S4 (Al-Faw) respectively. In terms of dry weight, the biomass ranged from 1.423 to 168.149 mg/m^3 in S3 during the December and in S4 during May respectively. In terms of displacement volume and standing crops, they ranged from 0.03 ml/m^3 to 1.95 mgC/m^3 during December at S3 to 1.819 ml/m^3 and 118.235 mgC/m^3 during February at S4.

Key words: Distribution, Zooplankton biomass, Shatt Al-Arab

1. Introduction
The aquatic environment plays an essential role in the distribution and preservation of life worldwide. The aquatic environment can be characterized by its diversity. The range of aquatic organisms is between microorganisms that are cover surface water such as plankton and large organisms. The productivity in any body of water depends on the number of plankton, phytoplankton or zooplankton (Reddy *et al*, 2012). Plankton are organisms that drift on or near the surface of the water and unable to swim, which depends

in movement on currents and winds. The term plankton was the first used by Hensen in 1887, which he the first used a network to quantify and study the distribution of plankton (Zheng Zhong, 1989). Zooplankton is an indicator of the nutritional status for the aquatic environment (Kulkarni and Surwase, 2013), and also can represent an indicator of water quality (Shayesthfar *et al.*, 2010). They can affect functional aspects of the aquatic environment through food chains, food webs, energy flow and organic matter cycle (Mukherjee, 1997; Murugan and Kodarkar, 1998). Zooplankton represent a great taxonomic diversity. The sizes of zooplankton ranging from a few micrometers to several meters (de Vargas *et al.*, 2015); As a link between primary producers and higher trophic levels (Ikeda, 1985). Zooplankton have central ecological roles, and they have positive social and economic impact such as food source for fish (Lehodey *et al.*, 2006) or as an indicator of water quality (Suthers *et al.*, 2019). The abundance of zooplankton usually increases towards the sea and estuarine areas (Nair and Tranter, 1971; Laprise and Dodson, 1994). Occurrence of some organisms in an ecosystem is an indicator of salinity (Nielsen *et al.*, 2003). It is also represent an important environmental factor in determining the size of the biological community in the aquatic environment (Marshal and Eliot, 1998; Abowei, 2010).

Salinity is the most important environmental factors that limit productivity of aquatic ecosystems. Salinity in the Shatt Al-Arab can be affected by several factors volume, quantity, and freshness of water, in addition to the effect of other factors such as temperature, sun brightness, rainfall, evaporation, and the quality of the soil. Shatt Al-Arab can be considered as high salinity river compared to the rivers of worldwide (Husain *et al.*, 1991). Our previous study on the biomass of zooplankton at Garmat Ali River estimated the displacement volume ranged between (0.002–0.261) ml/m^3 and the wet weight ranged between 0.560–21.826 mg/m^3. It also estimated that the dry weight ranged between 0.120–4.922 mg/m^3, while the standing crop the biomass ranged between 0.130–16.965 mg C/m^3 during winter and spring (Ajeel *et al.* 2004).

This study aims to determine the biomass of zooplankton as a function of displacement volume (ml/m^3), wet weight and dry weight (mg/m^3), and standing crop (mgC/m^3) in the Shatt Al-Arab River and the Shatt Al-Basra Canal during the period of December 2011 to November 2012. Currently, no studies exist concerning zooplankton biomass in the Shatt Al-Arab River and the Shatt Al-Basra Canal. Thus, our study contributes to information on zooplankton biomass in this understudied area.

2. Materials and methods

Four stations were chosen for the current study. Two stations at the Shatt Al-Basra Canal and two stations at the Shatt Al-Arab River (Fig. 1). The Shatt Al-Basra Canal, located immediately west of Basra, originates in the Euphrates River and drains into Khor Al-Zubair, an estuarine lagoon connected to the Arabian Gulf. It is 37 kilometers long and 59 meters broad, with depths ranging from 5 to 7 meters. Salt water intrusion in the Shatt Al-Basra Canal is mostly determined by the tidal range, water level in the Euphrates River, and the amount of water released by a water regulator located 22 kilometers from the canal's entrance. Extended floods in the Euphrates River frequently dilute the brackish water in the canal (Naser *et al.*, 2010; Yasser *et al.*, 2023). The Shatt Al-Arab River is fed by three rivers in Iraq - the Euphrates, Tigris, and Karun (Naser *et al.*, 2012) (Fig.1).

Two sampling stations were chosen at the Shatt Al-Basra Canal before the dam (S1), longitude (47º 45′ 59. 52″) and latitude (30º 25′ 47. 00″). The second station was after (S2) the dam, at 47º 46′ 58. 53″ longitude and 30º 23′ 42. 76″ latitude. The salinity of the second station was more than the first station due to the effect of Khour Al-Zubair lagoon. At the Shatt Al-Arab, two stations were chosen in the Al-Siba area (S3) opposite the Abadan refinery (Iran), at longitude 48º 27′ 51.94″ and latitude 29º 59′ 23.28″. The fourth station was chosen in Al-Faw city (S4) at the South Oil Company docks, at longitude 48º 15′ 43.82″ and latitude 30º 20′ 20.94″.

Sample collection methods

Samples were collected monthly from December 2011 to November 2012. A conical net was used with a mouth diameter of (30) cm and mesh-sized of (0.085) mm. Samples were collected vertically from the water column using a 5 kg weight tied to the end of the net. The contents of the net were placed in 1 L plastic bottles. The plankton samples were immediately preserved in deep freeze.

In the laboratory, large animals were removed such as shrimp, medusa, fish larvae, and plant**.** Hydrographic parameters (water temperature using a mercury thermometer, salinity, pH, were measured using Multimeter 350i/ SET, dissolved oxygen using the Winkler method (Azide modification) (Lind, 1979) and Chlorophyll-a. was estimated using the method given by Volenweider (1969).

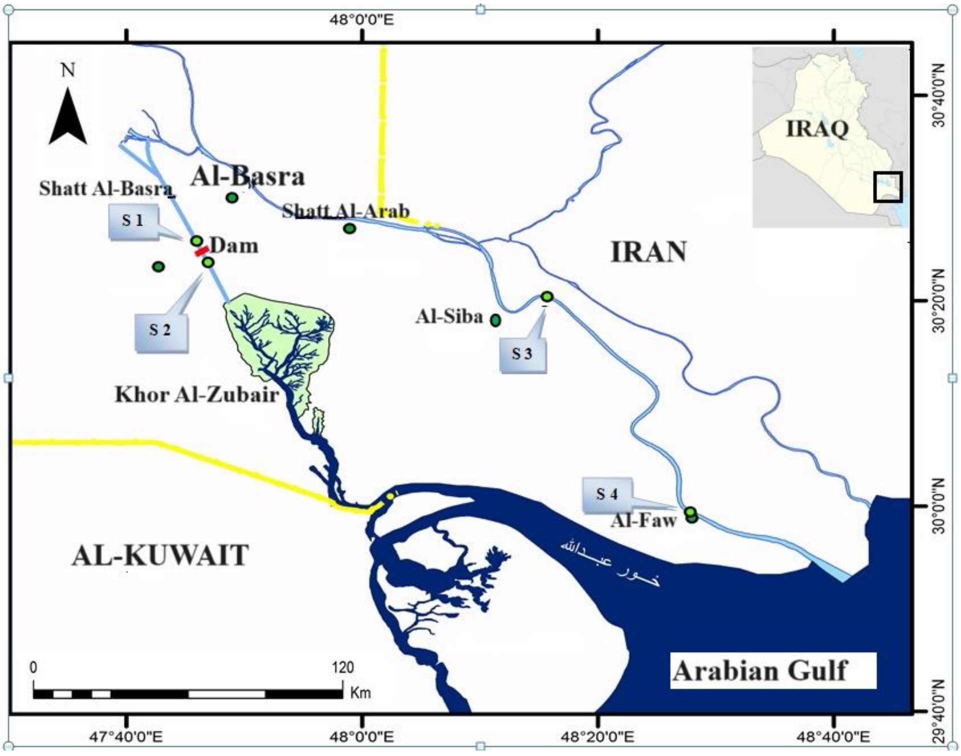

Figure 1. Map of lower Mesopotamia showing the sampling stations at Shatt Al-Basra Canal and Shatt Al-Arab River

Biomass

Displacement Volume

The displacement volume of the zooplankton was measured by pouring the sample into a 500 ml volumetric flask; distilled water was added until the total volume reached 500 ml. Then the sample was filtered into a 500 ml volumetric flask, and water was added until the mark 500 ml by using a 10 ml cylinder. The added volume of water is equal to the displacement volume of the zooplankton. The volume of zooplankton (ml/m^3) was obtained by dividing the volume of zooplankton by the volume of the sample filtered by the net. The standing crop of the zooplankton (mg C/m^3) was calculated using the conversion factor of 65 mg C/ml of displacement volume (Jacob *et al.,* 1979).

Wet weight and Dry weight
Fresh and dry weights of the zooplankton were estimated by filtering the sample through a wet filter paper of a known weight using a vacuum pump. Then, the wet weight was recorded by subtracting the weight of the wet filter paper without the zooplankton from the filter paper with the zooplankton. The filter paper was placed in the oven at 60 ºC for 24, then the dry weight was recorded. A filter paper without a sample was dried up at the same temperature for the same period to obtain the dry weight of the filter paper. These processes were repeated 3 times. By subtracting the dry weight of the filter paper without sample from that with sample we obtained the dry weight of the sample. Then the wet weight and dry weight were converted into mg/m^3 by dividing the weight of the sample by the volume of the filtered sample.

Statistical analysis
The statistical analysis of the results was carried out using the analysis of variance for Complete Random Design (C.R.D.) and finding significant differences between stations using the least significant difference Revised least significant differences test (R.L.S.D) (Al-Rawi and Khalaf Allah, 1980).

3. Results

Hydrographic parameters
Water temperature ranged between 13–28 °C in December 2011 and August 2012 at S1 and S2 respectively (Fig. 2). Statistical analysis showed no significant differences among all stations ($P \leq 0.05$). Monthly variation in salinity was observed, with the lowest observed value of 0.5 psu recorded in November 2012 at S1, and the highest value of 41.5 psu in July at S2. (Fig. 3). The results of statistical analysis showed a significant difference among studied stations ($P \leq 0.05$).

Figure (4) shows the pH values with an alkaline trend through the study period, the highest value reported was (8.9) during August 2012 at S2 (Shatt Al-Basra Canal after the dam) and the lowest values were (6) during December 2011 at S1 (before the dam). The statistical analysis showed that there were statistically significant differences among all stations ($P \leq 0.05$). Dissolved oxygen values ranged between 5-12 mg/L during December 2011 at S1 and S4, respectively (Fig. 5). The statistical analysis showed significant differences among all stations ($P \leq 0.05$).

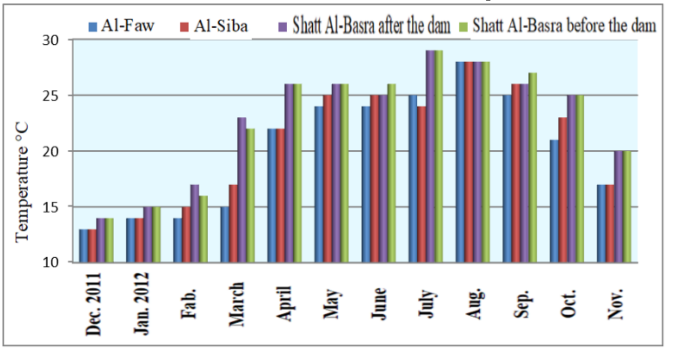

Figure 2. Water temperature °C in the Shatt Al-Basra and Shatt Al-Arab during the study period.

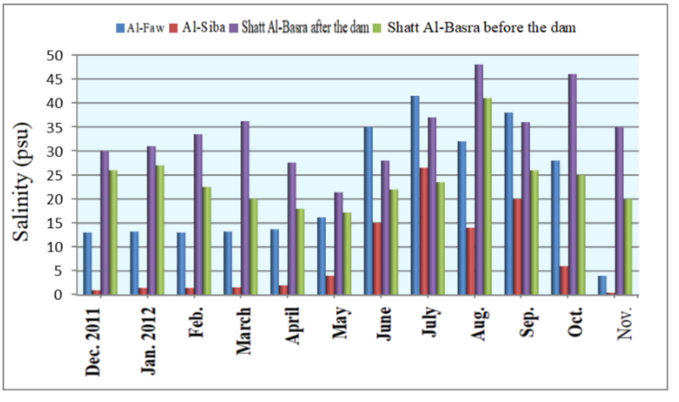

Figure 3. Salinity (psu) in the Shatt Al-Basra and Shatt Al-Arab during the study period.

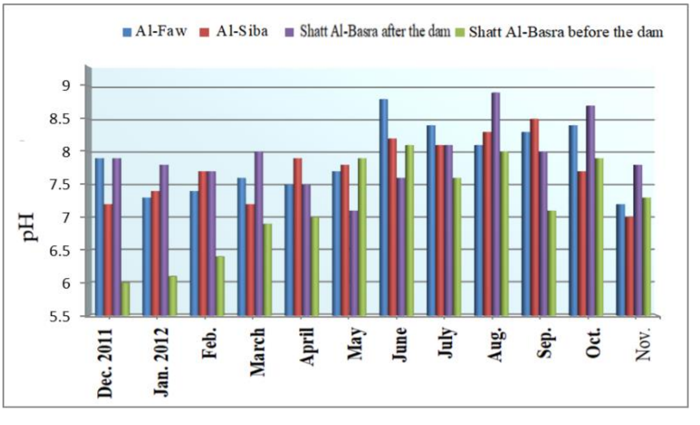

Figure (4): Hydrogen ion concentration (pH) in the Shatt Al-Basra and Shatt Al-Arab during the study period.

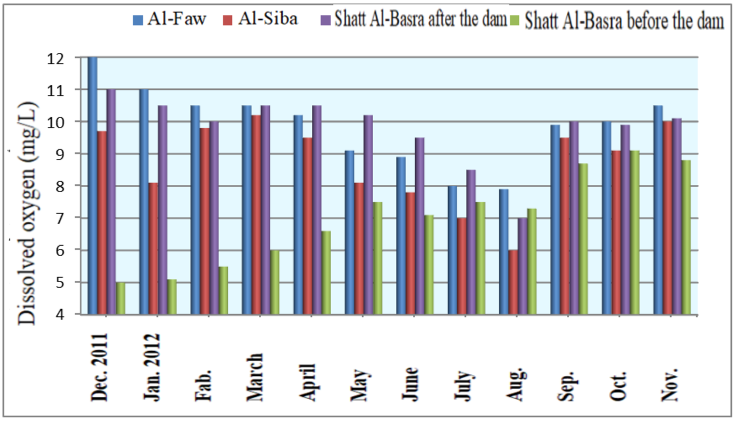

Figure 5. Dissolved Oxygen (mg/L) in the Shatt Al-Basra and Shatt Al-Arab during the study period.

Chlorophyll-*a* ranged between 1.1 mg/m^3 during December 2011 at S1 and 21.1 mg/m^3 during October 2012 at S2, respectively (Fig. 6). Statistical analysis showed no significant difference among stations ($P \leq 0.05$).

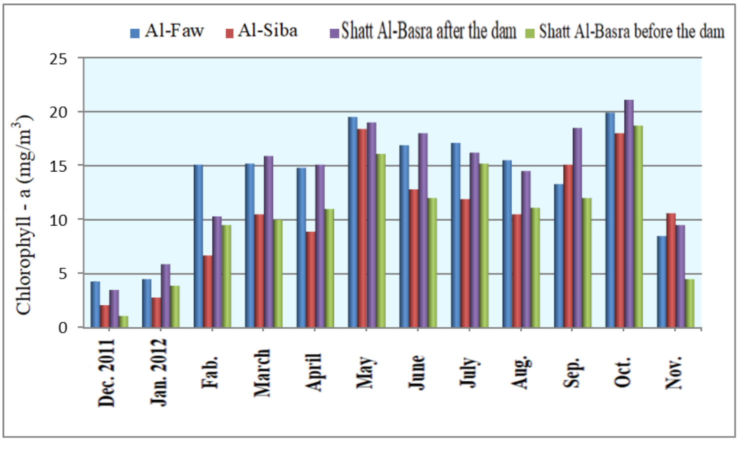

Figure 6. Chlorophyll-*a* (mg/m^3) in the Shatt Al-Basra and Shatt Al-Arab during the study period.

Biomass

The biomass of zooplankton at S1 (Shatt Al-Basra before the dam) in terms of wet weight and dry weight ranged from 23.102 - 441.260 mg/m^3 and 3.787 – 77.414 mg/m^3 during January and June, respectively. While in terms of displacement volume and standing crop ranged between 0.06 – 0.93 ml/m^3 and 3.9 - 60.45 mg C/m^3 during January and June respectively (Fig. 7 A-D). Whereas at S2 (Shatt Al-Basra after the Dam), the biomass as the wet weight and dry weight ranged between 53.924 – 520.875 and 8.840 - 102.132 mg/m^3 during November and May, respectively. Displacement volume and standing crop ranged between 0.202 – 1.083 ml/m^3 and 13.13 - 70.395 mg C/m^3 during November and May, respectively (Fig. 8 A, B, C, D).

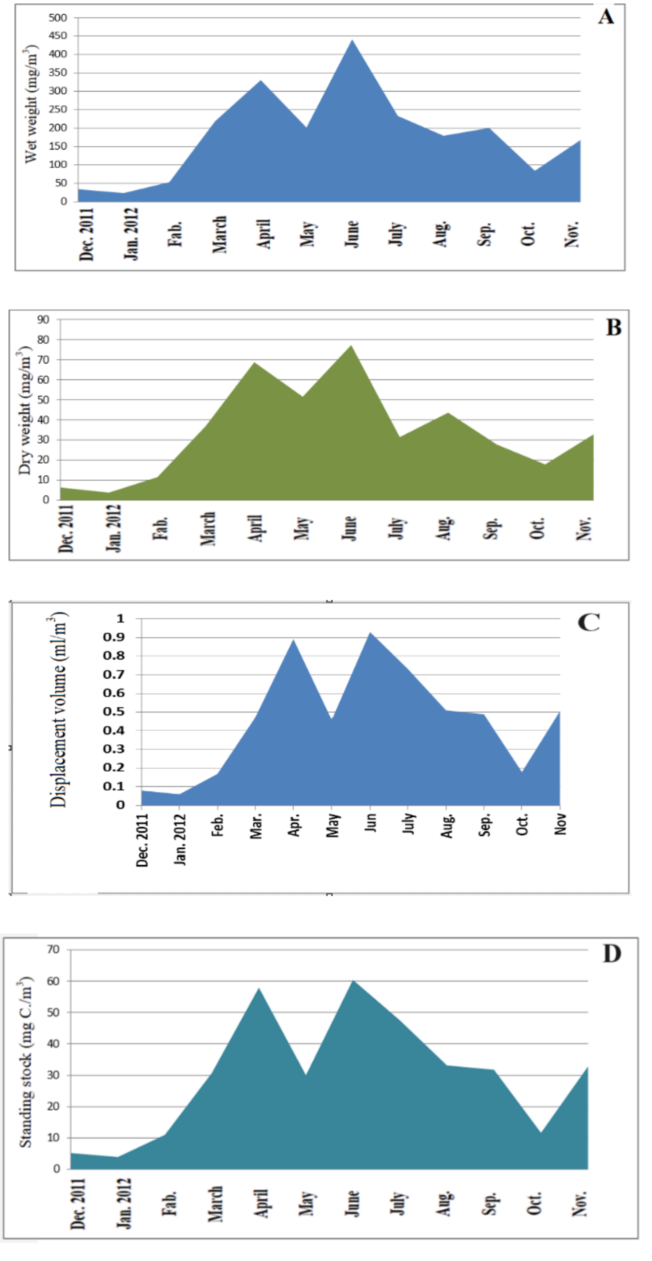

Figure 7. Monthly changes of biomass at the S1 in terms of: (A) wet weight (mg/m^3), (B) dry weight (mg/m^3), (C) Displacement volume (ml/m^3) and (D) standing crop (mgC./m^3) during the study period.

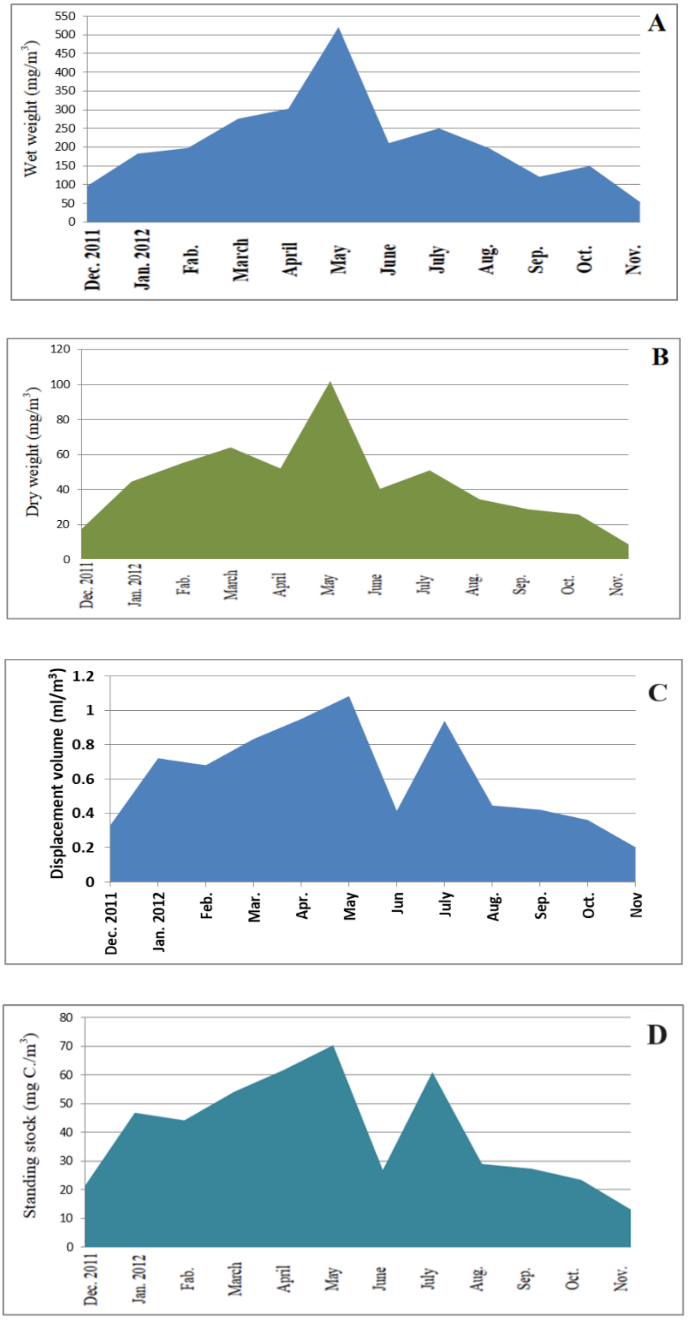

Figure 8. Monthly changes of biomass at the S2 in terms of: (A) wet weight (mg/m^3), (B) dry weight (mg/m^3), (C) Displacement volume (ml/m^3) and (D) standing crop (mgC./m^3) during the study period.

In the S3 (Shatt Al-Arab at Al-Siba), the biomass of zooplankton in terms of wet weight and dry weight ranged from 10.671 - 353.922 mg/m^3 and 1.423 - 75.303 mg/m^3 during December and August, respectively. Displacement volume and standing crop ranged between 0.03 -

1.134 ml/m^3 and the standing crop was 1.95 - 73.71 mg C/m^3 during December and August, respectively (Fig. 9A-D). Whereas at S4 (Shatt Al-Arab at Al-Faw) the biomass of zooplankton in terms of wet weight and dry weight ranged from 90.245 - 655.78 mg/m^3 and 20.987 - 168.149 mg/m^3 during December and May respectively. Displacement volume and standing crop ranged between 0.214 - 1.819 ml/m^3 and 13.91-118.235 mg C/m^3 during December and February respectively, (Fig. 10A-D).

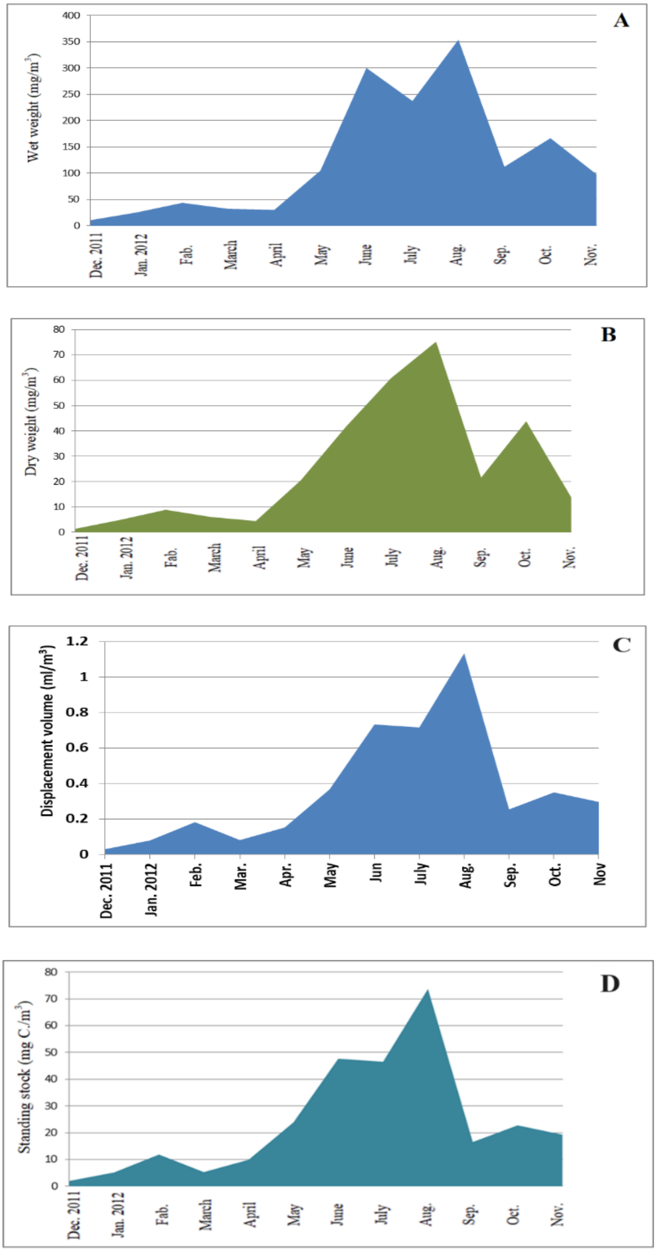

Figure (9): Monthly changes of biomass at the S3 in terms of: (A) wet weight (mg/m^3), (B) dry weight (mg/m^3), Displacement volume (ml/m^3) and (D) standing crop (mgC./m^3) during the study period.

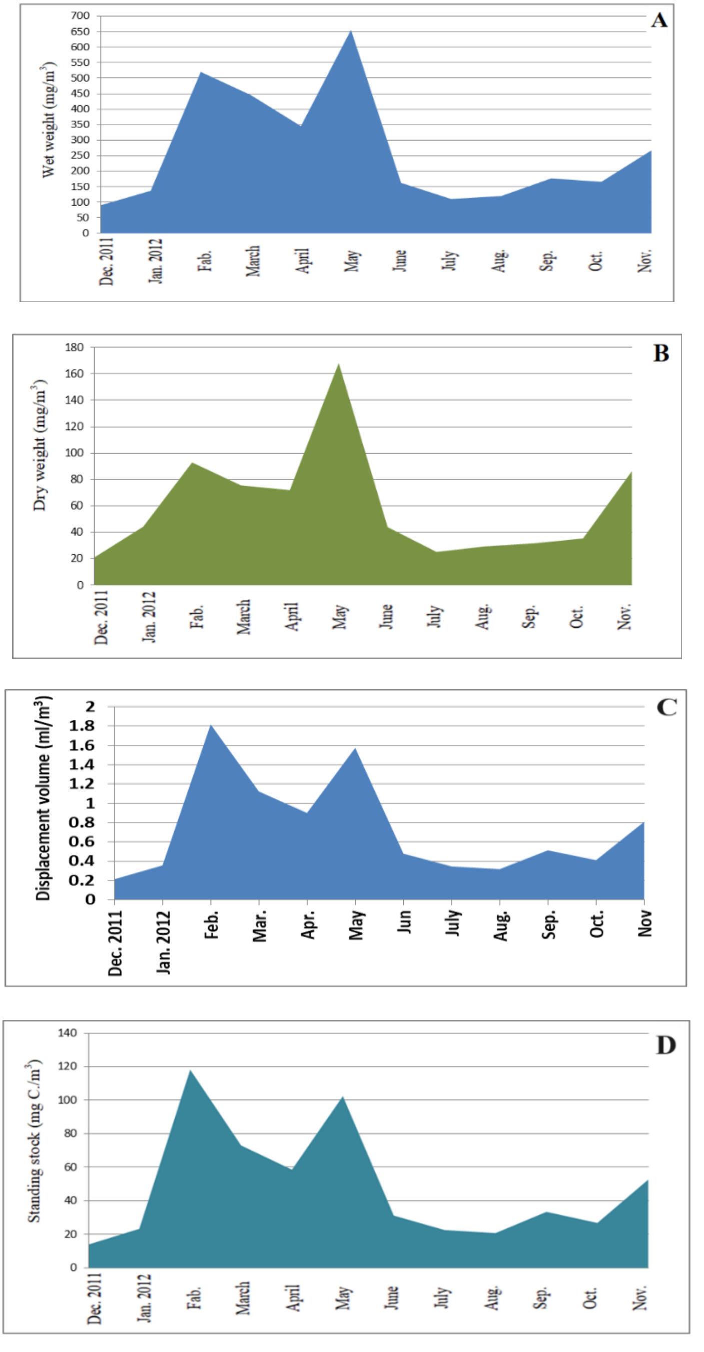

Figure 10. Monthly changes of biomass at the S4 in terms of: (A) wet weight (mg/m^3), (B) dry weight (mg/m^3) and (C) standing crop (mgC./m^3) during the study period.

Table 1. Shows a comparison between the values of biomass as a displacement volume and standing crops in the current study and previous studies.

References	displacement volume (ml/m^3)	Standing Crops (mgC/m^3)	Study area
Khor Abdullah	0.049 – 1.022	3.185 – 66.43	Salman *et al.* (1990)
Khor Abdullah	0.116 - 1.268	7.54 – 82.42	Ajeel (1990)
Khor Al-Zubair	0.081 – 3.15	52.65 – 204.75	Ajeel (1990)
Shatt Al-Arab	0.001 – 0.045	0.065 – 2.925	Ajeel (1998)
Karmat Ali River	0.002 -0.261	0.13 – 16.965	Ajeel *et al.* (2004)
Khor Al-Zubair	0.07 - 3.461	4.55 – 224.965	Ajeel (2012)
Shatt Al-Basra	0.18 – 1.90	11.7 – 123.5	Ajeel (2012)
Khor Abdullah	0.065-0.653	4.225 – 42.445	Ajeel (2017)
Shatt Al-Arab Estuary	0.379-2.005	24.635 – 130.325	Ajeel (2017)
Shatt Al-Arab	0.03 – 1.819	1.95 – 118.235	Current study
Shatt Al-Basra before the Dam	0.06 – 0.93	3.9 – 60.45	Current study
Shatt Al-Basra after the Dam	0.202 – 1.083	13.13 – 70.395	Current study

4. Discussion

Our results show that there are differences in biomass values between the four stations. The largest value of biomass observed at S4 owing to the highest number of zooplankton recorded. In the S3, a decrease in biomass was noted owing to the low density of zooplankton in this area, especially in the first five months of the current study. High values of biomass were recorded in the S1 as a result of prolific prosperity of rotifers. The biomass in the S2 was high values because this station was affected by the tidal currents waters of the Arabian Gulf that were loaded with abundant and diverse zooplankton.

The current study showed that there is no relationship between high salinity and biomass, possibly due to the participation of freshwater organisms in biomass. This agrees with Pillai *et al.* (1973), who assessed relationships between biomass, salinity, temperature, and food readiness in the Cochin River, in India. These authors found that there was no relationship between salinity and biomass. Although a global quantitative assessment of zooplankton biomass, it is often hampered by the heterogeneity of sampling methods and the uneven distribution of observations, causing high uncertainty in biomass estimates (Le Quéré et al., 2016). At station S4, biomass in February was higher than that in May, even though the latter recorded a higher number of zooplankton due to the large number of adults of the species *Pseudodiptomus ardjuna* and *Acartia (Odontacartia) ohtsukai*. We also noted the presence of two peaks that represent an increase in the biomass S1, S2 and S4. The first and largest peak was in summer while the other occurred in spring (Fig. 7). At station 3, only one peak was recorded during summer due to the increase in density of zooplankton during this period. This finding agrees with Al-Zubaidi and Salman (2001), who recorded two peaks for zooplankton biomass in the estuary of the Shatt Al-Arab, the first in summer and the other in spring. It also agrees with Ajeel (2012), who found two peaks in zooplankton biomass, the first and largest in summer, and the second in spring, at the Shatt Al-Basra and Khour Al-Zubair stations.

The diversity and dynamics of zooplankton populations in the areas of study are under control of direct factors such as physical and chemical factors, nutritional status, pollutants, and all interactions between the biological community in the aquatic environment and do not affect the diversity of zooplankton significantly. Abiotic factors control the abundance, major groups and community size of zooplankton (Vutukuru *et al.*, 2012). When the physical and chemical properties of the habitat change, species that are sensitive to this change will disappear and the species that can tolerate change in the environment will be limited (Paturej *et al.*, 2017).

5. Conclusions

1. Zooplankton are important environmental guides through which we can assess the quality and viability of the aquatic environment as organisms that are highly vulnerable to environmental conditions.
2. The biomass of zooplankton increases with increasing salinity at Shatt Al-Basrah and Shatt Al-Arab.
3. The waters of the Shatt Al-Arab were characterized as Brackish waters to salty, and salinity turned out to be the most extreme and influential factor on zooplankton.
4. The Alkaline characteristic prevailed in the waters of the Shatt Al-Arab.
5. The Shatt Al-Basra canal was characterized as contaminated water as a result of the sewage dump to the area and the agricultural drainage water of the Hamdan area.

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Conflict of interests

The authors declare that they have no competing interests.

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