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The Second Study on Zooplankton in the Tigris River in Misan Province, Iraq Since 1921: Evidence to Include Zooplankton in Ecosystem Monitoring

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ABSTRACT

The present study was conducted in one of the most significant water sources in Iraq, the Tigris River in Misan Province. The aim was to examine the zooplankton community, specifically Cladocera, Copepoda, and Rotifera. Samples were collected 30cm below the water surface using a plankton haul net with a mesh size of 64µm from September 2023 to February 2024. Sampling took place at three stations: the first in Kumait, located in the north of Misan Province; the second in Amarah City, the capital of Misan Province, and the third about 20km south of Amarah City. The results revealed seventeen species of zooplankton, belonging to two phyla, three classes, four orders, and eight families. A comparison between the historical and current status in the study area indicated a noticeable shift in zooplankton composition toward species more tolerant of pollution. For instance, the appearance of the family Brachionidae and its common species *Brachionus* sp. in the study area, alongside the absence of *Daphnia* species, suggests ecological degradation in the inland waters of Iraq, particularly in Misan Province. This study recommends incorporating zooplankton into water quality monitoring programs (WQMPS) in Iraq.

INTRODUCTION

Zooplankton are important groups in aquatic ecosystems (i.e. rivers, lakes, swamps and oceans) due to their central position in the food webs of these systems **(Persson & Vrede, 2006)**. The productions of the lower food webs components which are mainly derived from algae, bacteria and protozoa are mostly linked with higher trophic levels (e.g. macroinvertebrates and fish) via zooplankton **(Semyalo *et al.*, 2009)**. Thus, they play a crucial role in the energy flow through aquatic food webs and in maintaining the efficiency of these organisimis **(Azam *et al*., 1983; Vadstein *et al*., 1989; Arndt, 1993)**. In addition, zooplankton play an important role in nutrient recycling through the remineralization of essential nutrients such as N and P, which can be taken by algae and bacteria, and thus encouraging their growth **(Walve & Larsson, 1999; Likens, 2010)**. Due to their small size, short lifespans, and sensitivity to different pollutants and impacts of climate change, zooplankton composition serves as an indicator for water quality, helping to determine the ecological state of different aquatic ecosystems **(Wetzel, 2001; Lampert & Summer, 2007; Jeppesen *et al*., 2011; Chiba *et al*., 2018; Labuce *et al*., 2020)**.

The most important components of zooplankton are Rotifera, Copepoda and Cladocera. Rotifera are an essential component of the aquatic food webs **(Gilbert, 2022)**. Rotifers are composed of 2000 species **(Ricci & Balsamo, 2000)**. Most rotifers can be found in freshwater, but about 100 species live in brackish or marine habitats **(Likens, 2010)**. They comprise about 30% of the biomass of freshwater plankton in some habitats **(Nogrady *et al*., 1993)**. They are more important consumers in feeding on small phytoplankton and components of the microbial loop (i.e. bacteria, ciliates and flagellates) in freshwater ecosystems in comparison with copepods and cladocerans **(Thorp & Covich, 2009)**.

Cladocera are crustaceans found in fresh, brackish and marine water, found in permanent and temporary water bodies. Cladocerans are considered as filter-feeders **(Forro *et al*., 2008)**, feeding on bacteria, phytoplankton and protozoans. The numbers of species of Cladocera are less than 600, and only 2% live in marine ecosystems **(Dumont & Negrea, 1996)**. Typically, their size ranges from 0.2 to 6mm **(Forró *et al*., 2008)**. Additionally, it is also reported that their size can reach 18mm in species such as *Leptodora kindtii* **(Fryer, 1987)**.

Crustacean copepods live in fresh and hypersaline water habitats with about 900 species and form a significant part of plankton communities **(Dole-Olivier *et al*., 2000; Mondal *et al*., 2013)**. The copepods are selective feeders**(Djeghri *et al*. 2018)**. They mainly feed on bacteria **(Wroblewski, 1980; Zöllner *et al*., 2003)**. Besides, they feed on phytoplankton **(Calbet *et al*., 2000)**. Thus, they serve as an important trophic link between the bases of the food web with higher trophic levels **(Verity & Smetacek, 1996)**.

The first study on the composition of zooplankton in Iraq was conducted by **Gurney (1921)**, who studied zooplankton around Amara City near the Tigris River in Misan Province during the period between 1917 and 1918. **Gurney (1921)** recorded 9 species of Cladocera, 4 species of Copepoda and 3 species of Rotifera. These species which were mainly collected from permanent marsh and temporary pools close to the Tigris River were approximately representative of the zooplankton community in the river. To the author knowledge, no studies have been conducted on zooplankton in this part of the

Tigris River since 1921. The aim of this study was to provide the second information about zooplankton composition in this area.

MATERIALS AND METHODS

1. Study area

The Tigris River was an important river for people during Mesopotamian civilization **(Varol *et al*., 2010)**, and is considered to be one of the main water sources in addition to the Euphrates River in Iraq **(Al-Ansari *et al*., 2019)**. The Tigris River primarily originates from Turkey. The length of the river is 1900km, and most of the river length is located in Iraq with a percentage of approximately 77% by about 1415km of its actual length **(Kibaroglu, 2002)**. The part of the river in Misan Province is about 160km long. The map was prepared using SimpleMappr **(Shorthouse, 2010)** (Fig. 1). The first station is located to the north of Misan Province, called Kumait (32°02'00.6"N 46°52'49.5"E); the second station is approximately in the center of Amarah City (31°45'21.2"N 47°09'00.5"E), and the third station is located to the south of Amarah City by about 20km from the last station (31°41'16.7"N 47°09'56.8"E). Several stations were chosen to collect representative samples. The second and three stations receive huge amounts of untreated wastewater discharges from households and hospitals in Amarah City. The population of Misan Province is about 1.025.862 (NIC 2023), and most of them living in Amarah City.

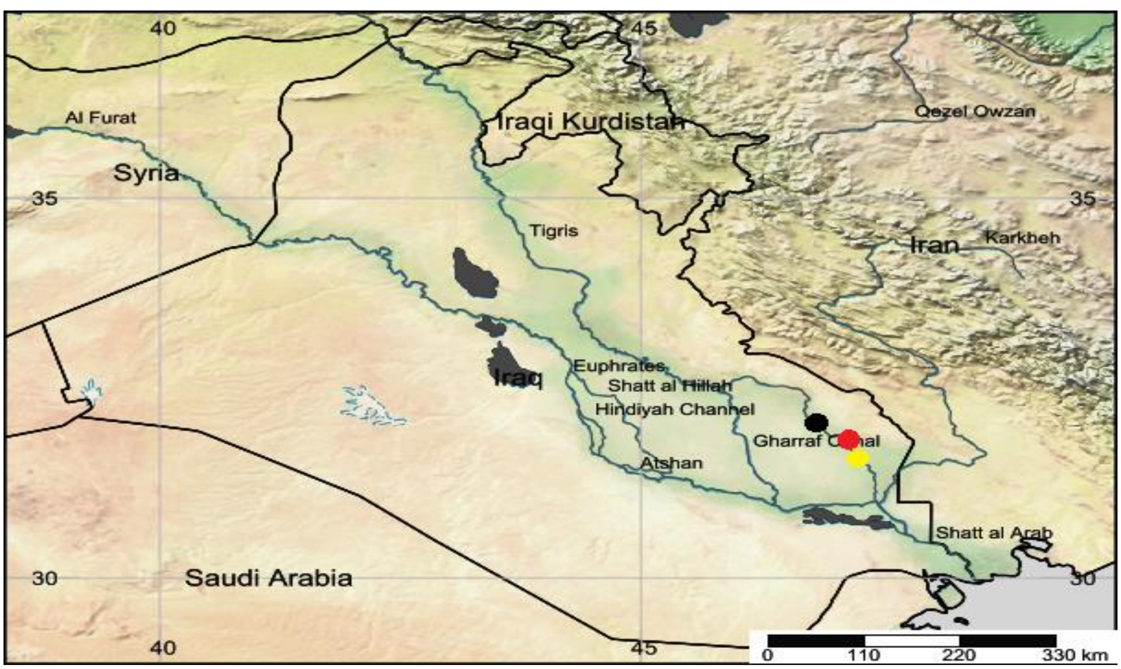

Fig. 1. Sample collection stations on the Tigris River in Misan Province, Kumait district (Black circle), Amarah City (Red circle), south of Amarah City (Yellow circle)

2. Collection of zooplankton samples

Zooplankton samples were collected from September 2023 to February 2024 from three stations on the Tigris River in Misan Province.

Samples were collected 30cm below the water surface using a plankton haul net with a mesh size of 64μm. After each sampling, the net was washed to avoid potential contamination of gathered samples from previous sampling **(Goswami, 2004)**. Then, they were preserved in 70% ethanol, and all preserved samples were transferred back to the laboratory. A Sedgewick Rafter chamber and Olympus compound Microscope were used for classifying zooplankton. Identification of zooplankton groups (Cladocera, Copepoda and Rotifera) was based on the taxonomic keys of **Edmondson (1959)**, **Korinek (1999)** and **Fernando (2003)**. Zooplankton were classified to species level.

RESULTS AND DISCUSSION

In this study seventeen species of zooplankton were recorded in the Tigris River in Misan Province which are shown in Tables (1, 2, 3). These species belong to two phyla, three classes, four orders and eight families. Station one was more diverse in its species composition than other stations. This may be due to these stations receiving direct high discharge of wastewater without treatment. Many studies on the Tigris River and in its part in Misan Province **(Amteghy, 2014; Al-Mussawy *et al*., 2023; Al-Budeiri *et al*., 2024; Hameed, 2024)** have reported high levels of pollutants in this river. These studies indicated that lacking wastewater treatment was the main reason. It is now known that the zooplankton community structure is affected by pollution, thus zooplankton species are considered to be indicators for assessing the environmental condition **(Singh & Sharma, 2020; Boldrocchi *et al*., 2023)**. **Jeppesen *et al*. (2011)** showed that zooplankton are significant biological quality element and should be included as a central element in aquatic monitoring programs of the EU.

Gurney (1921) who studied zooplankton in Amara City between 1917 and 1918, recorded nine species of cladocerans, and four species of Copepoda, and three taxa of rotifers (Table 4). The comparison between data on the species composition of **Gurney (1921)**, and data about zooplankton species presented here in this study (Table 4) showed a change in the species of zooplankton community, suggesting that the current ecological status in the study area is unfavorable for most species of zooplankton which is recorded by **Gurney (1921)**. Recently, the major decline in environmental condition of the Tigris River due to the impacts of pollution and climate change associated with high temperatures and low precipitation **(Al-Saady & Abdullah, 2014; Abbas *et al*., 2016; Price, 2018; Al-Saedi *et al*., 2024)**. This is expected to be the main drivers for such sharp change in species composition of zooplankton **(Sterza & Fernandes, 2006; Jeppesen *et al*., 2015)**, and in the study area . For example, many species recorded by **Gurney (1921)**, such as *Daphnia lumholtzi, Daphnia longispina, Scapholeberis* sp., *Ceriodaphnia* sp., and *Alona* sp. **(Greenwald & Hurlbert, 1993; Gonçalves *et al.*, 2007; Dao *et al.*, 2018)**, are specialized for freshwater habitats and are less tolerant to chemical and biological pollutants, such as pesticides, increased salinity, heavy metals, and toxins produced by cyanobacteria. These pollutants have become common in Iraqi waters and worldwide **(DouAbui *et al.*, 1988; Le, 2020; Gummaa *et al.*, 2021; Hmoshi & Mohammed, 2022; Hameed, 2024)**. As a result, these zooplankton, particularly *Daphnia* species, are frequently used in aquatic biomonitoring due to their high sensitivity to pollution **(Tomasiks & Warren, 1996; Le *et al.*, 2016; Abdullahi *et al.*, 2022)**. Zooplankton can serve as bioindicators based on species-level changes **(De Eyto *et al.*, 2003)**. The zooplankton species recorded in this study, such as *Anuraeopsis fissa*, *Bosmina longirostris*, *Bosmina meridionalis*, *Brachionus angularis*, *Brachionus plicatilis*, *Chydorus sphaericus*, *Eucyclops agilis*, *Filinia longiseta*, *Mesocyclops edax*, *Notholca acuminata*, *Simocephalus vetulus*, and *Trichocerca longiseta*, along with the first occurrence of the family Brachionidae and its common species *Brachionus* sp., indicate low water quality in the study area **(De Eyto *et al.*, 2003; Ezz *et al*., 2014; Costa *et al.*, 2016; Perbiche-Neves *et al.*, 2016; Al-Kalidy *et al.*, 2017; Loria, 2017; Leppänen, 2018; Muñoz-Colmenares *et al.*, 2021; de Paiva *et al.*, 2023)**.

The tolerance or sensitivity of zooplankton species for disturbances in aquatic ecosystem or for polluted water are mainly dependent on their range of responses, adaptations and evolution to ecological changes **(Thackeray & Beisner, 2024)**. These changes, for example, could appear in seasonal cycle, thus, zooplankton will show patterns of seasonality in their structure **(Salman *et al*., 2014; Ajeel & Abbas, 2019; Van Engeland *et al*., 2023)**, if ecological changes last for decades or for centuries with ongoing dramatic increases in the levels and effects of these changes due to anthropogenic activities combined with climate change impacts; this will cause a shift or changes in zooplankton community **(Marques *et al*., 2024; Pershing & Kemberling, 2024)**.

The changes in zooplankton composition will ultimately have huge impact on structure and function of aquatic ecosystems **(Nielsen *et al*., 2003)**.

Table 1. Zooplankton composition in the Tigris River in Misan Province at station 1

Zooplankton Groups	Taxon
Phylum Arthropoda	
Subphylum Crustacea	
Class Branchiopoda	
Order Cladocera	

1-Family Bosminidae	*Bosmina longirostris* Müller,1776
2- Family Chydoridae	*Chydorus sphaericus* Müller,1776
3- Family Daphniidae	*Simocephalus vetulus* Schoedler,1858
Class Maxillopoda	
Subclass Copepoda	
Order Cyclopoida	
1-Family Cyclopidae	*Mesocyclops edax* Forbes, 1891
	Cyclops scutifer Sars, 1863
	Eucyclops agilis Koch, 1838
	Orthocyclopes modestus Herrick, 1883
Phylum Rotifera	
Class Monogononta	
Order Flosculariaceae	
1-Family Trochosphaeridae	*Filinia longiseta* Ehrenberg, 1834
Order Ploima	
2-Family Brachionidae	*Anuraeopsis fissa* Gosse, 1851
	Brachionus angularis Gosse, 1851
	Brachionus rotundiformis Tschugunoff, 1921
	Notholca acuminata Ehrenberg,1832
3- Family Euchlanidae	*Euchlanis deflexa* Gosse, 1851
4-FamilyTrichocercidae	*Trichocerca longiseta* Schrank, 1802

Table 2. Zooplankton composition in the Tigris River in Misan Province at station 2

Zooplankton Groups	Taxon
Phylum Arthropoda	
Subphylum Crustacea	
Class Branchiopoda	

Order Cladocera	
1-Family Bosminidae	*Bosmina longirostris* Müller, 1785
2- Family Chydoridae	*Chydorus sphaericus* Müller, 1776
Class Maxillopoda	
Subclass Copepoda	
Order Cyclopoida	
1-Family Cyclopidae	*Mesocyclops edax* Forbes, 1891
	Cyclops scutifer Sars, 1863
	Diacyclops thomasi Forbes, 1882
Phylum Rotifera	
Class Monogononta	
Order Ploima	
1-Family Brachionidae	*Brachionus angularis* Gosse, 1851
	Brachionus rotundiformis Tschugunoff, 1921

Table 3. Zooplankton composition in the Tigris River in Misan Province at station 3

Zooplankton Groups	Taxon
Phylum Arthropoda	
Subphylum Crustacea	
Class Branchiopoda	
Order Cladocera	
1-Family Bosminidae	*Bosmina longirostris* Müller, 1776
	Bosmina Meridionalis Sars, 1904
2- Family Chydoridae	*Chydorus sphaericus* Müller,1776
Class Maxillopoda	
Subclass Copepoda	
Order Cyclopoida	
1-Family Cyclopidae	*Mesocyclops edax* Forbes, 1891
	Cyclops scutifer Sars, 1863
Phylum Rotifera	
Class Monogononta	
Order Ploima	
1-Family Brachionidae	*Brachionus angularis* Gosse, 1851
	Brachionus rotundiformis Tschugunoff, 1921
	Brachionus plicatilis Müller, 1786

Table 4. Zooplankton species recorded in the present study and by **Gurney (1921)**

Zooplankton Groups	Taxon recorded in the present study	Taxon recorded by Gurney (1921)
Phylum Arthropoda		
Subphylum Crustacea		
Class Branchiopoda		
Order Cladocera		
1-Family Bosminidae	*Bosmina longirostris* Müller,1776	Present
	Bosmina Meridionalis Sars, 1904	Not present
2- Family Chydoridae	*Chydorus sphaericus* Müller,1776	Present
	Alona rectangular Sars, 1862	Not present
	Alona costata Sars, 1862	Not present
3- Family Daphniidae	*Simocephalus vetulus* Schoedler,1858	Not present
	Not present	*Ceriodaphnia reticulata* Jurine, 1820
	Not present	*Daphnia lumholtzi* Sars, 1885
	Not present	*Daphnia longispina* Müller,1776
	Not present	*Scapholeberis mucronate* Müller,1776
	Not present	*Simocephalus exspinosus* De Geer, 1778
Class Maxillopoda		
Subclass Copepoda		
Order Cyclopoida		

1-Family Cyclopidae	*Mesocyclops edax* Forbes, 1891	Not present
	Cyclops scutifer Sars, 1863	Not present
	Eucyclops agilis Koch, 1838	Present
	Orthocyclopes modestus Herrick, 1883	Not present
	Diacyclops thomasi Forbes, 1882	Not present
	Not present	*Cyclops vicinus* Uljanin, 1875
Order Calanoida		
1-Family Diaptomidae	Not present	*Diaptomus vulgaris* Schmeil, 1896
Order Harpacticoida		
1-Family Canthocamptidae	Not present	*Canthocamptus staphylinus* Jurine, 1820
Phylum Rotifera		
Class Monogononta		
Order Flosculariaceae		
1-Family Trochosphaeridae	*Filinia longiseta* Ehrenberg, 1834	Not present
Order Ploima		
2-Family Brachionidae	*Anuraeopsis fissa* Gosse, 1851	Not present
	Brachionus angularis Gosse, 1851	Not present
	Brachionus rotundiformis Tschugunoff, 1921	Not present
	Brachionus plicatilis Müller, 1786	Not present
	Notholca acuminata	Not present

	Ehrenberg,1832	
3- Family Euchlanidae	*Euchlanis deflexa* Gosse, 1851	Not present
4-Family Trichocercidae	*Trichocerca longiseta* Schrank, 1802	Not present
5- Family Trichotriidae	Not present	*Dinocharis pocillum,* Müller, 1776
6- Family Gastropodidae	Not present	*Ascomorpha* sp. Perty, 1850
7- Family Asplanchnidae	Not present	*Asplanchna* sp. Gosse, 1850

CONCLUSION

The comparison between the historical and present status of the study area reveals a noticeable shift in zooplankton composition toward species that are more tolerant of pollution. For example, the emergence of the family Brachionidae and its common species, *Brachionus* sp., and the absence of *Daphnia* species in the current study indicate ecological degradation in the inland waters of Iraq. This study suggests that zooplankton should be included in water quality monitoring programs (WQMPs) in Iraq. More comprehensive studies are needed, employing a wide range of ecological tools, to investigate the responses of zooplankton to different stressors.

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