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A Study of Zooplankton Community in Dukan Lake, Kurdistan Region-Iraq, with a New Record of *Craspedacusta sowerbii* Lankester (1880) Medusa (Cnidaria: Hydrozoa)

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Abstract:

A study of Zooplankton community has been carried out at four selected sites on Dukan Lake. Samples of water and zooplankton were collected monthly for the period from July 2015 to February 2016. Some physical and chemical properties of water were studied and the results showed that the air temperature were ranged from 0 to 36.16 °C, water temperature ranged from 2.83 to 34.66 °C, hydrogen ion concentration of studied sites were found to lie in alkaline side, it was ranged between 6.87 to 8.57, electrical conductivity ranged from 190.79 to 850.08 µs.cm^{-1}, turbidity ranged from 0.9-7.7 NTU, and dissolved oxygen from 3.3 to 6.8 mg.l^{-1} while BOD_5 were ranged from 0.53 to 34.66 mg.l^{-1}. Concerning to the zooplankton, 37 species were identified which belonged to Cladocera (48.38%), Copepod (43.28%), Rotifera (8.23%), Targigrada (0.08%) and Cnidaria (0.1%). The medusa of *Craspedacusta sowerbii* Lankester (1880) was recorded for the first time in Iraq. Regarding to zooplankton community, rotifer were ranged between 0 to 690.91 ind.m^{-3}, Copepoda from 54.55 to 5927.27 ind.m^{-3} and Cladocera ranged from 18.18 to 6072.73 ind.m^{-3}. According to Shanon-Weiner index, species diversity for zooplankton invertebrates was ranged from 0.325 to 1.091 bits/ind. Jaccard's similarity index showed that the highest similarity was recorded between site (1) and site (4) with 40.74%.

Keywords: Zooplankton community, Dukan Lake, Iraq.

Introduction:

Zooplanktons are invertebrates occupy a central position in the food webs of aquatic ecosystem and they form a food webs for the carnivorous as well as omnivorous fishes. They are depending heavily on algae, bacteria, protozoa and other invertebrates for their feeding [1, 2].

Zooplanktons are classified according to their size and developmental stages. Size categories involved: picoplankton that mesure less than 2µm, nanoplankton measure from 2 to 20 µm, microplankton measure from 2o to 200 µm, mesoplankton measure from 0.2 to 20mm, macroplankton measure from 20 to 200mm and megaplankton measure over 200mm [3].

Several researches have been done concerning the zooplanktonic Invertebrate, including Rotifera, Cladocera and Copepoda in different Iraqi water surface such as Himreen Damp [4], Al-Qadisia lake [5], Greater Zab river [6,7,8 and 9]. Moreover, 14 genera of Rotifera were recorded by [10] in Darbandikhan lake, the results showed that density of Rotifera in the studied sites ranged from 4 to 134 ind.m^{-3}. Finally, this present study aims to survey and study of zooplankton community in Dukan Lake Some chemical and physical parameters of lake water were also measured.

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Materials and Methods:

Dukan Dam is located On the Lower Zab River, about 295 Km north of Baghdad and 65 Km south east of Sulaimani city situated on the longitude and 44°55'E latitude 36°08'N. This Dam was constructed in 1959 as an arch dam upstream of the city of Dukan with maximum storage capacity of 6.870 BCM. For this study for sites were selected, three on the lake and one on the lake outlet "river" (Fig. 1). Samples from studied sites were collected during periods extended from July 2015 until February 2016. Surface water samples were taken at each site for chemical, physical and biological

analysis using polyethylene bottles (2.5 L) which had been rinsed twice with the same water of the lake sample before filling at each site. All samples were analyzed within 24 hours [11]. The time of sampling started from 8 am to 2 pm at summer and 10 am to 4 pm at winter. Zooplankton samples were collected by passing 55 L of lake water through a planktonic net with 55µm pore size, and then the concentrated samples were fixed with 5% formalin and later preserved in ethanol alcohol 70% [11]. The zooplankton samples were identified and counted according to [12, 13, 14, 15, 16 and 17]. On the other hand, Shanon-Weiner index and Jaccard similarity index were used to calculate the species diversity and the similarity between studied sites.

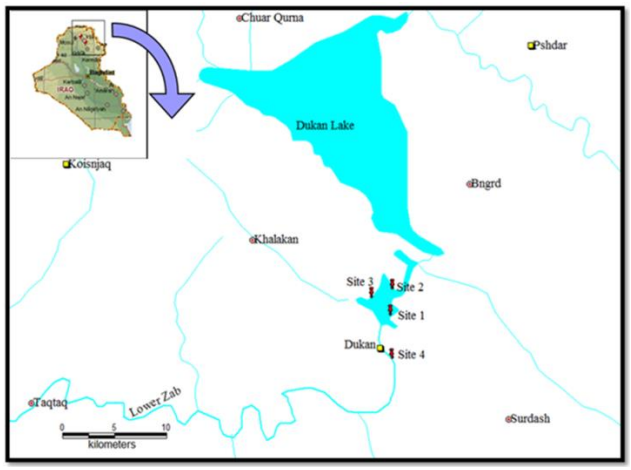

Figure 1. Map of Northern part of Iraq showing studied sites

Results and Discussion:

From the table (1) appear that the physico-chemical properties of Dukan Lake in studied sites showed that the air temperature ranged from 0 to 36.16 ˚C. The minimum value of air temperature was recorded in site 1 and site 4 during January 2016, while the maximum value of air temperature was recorded in site 1 during July 2015. On the other hand, water temperature of studied lake was ranged from 2.83˚ to 34.66˚C. The minimum value of water temperature was recorded in site 2 during January, 2016, whereas, the maximum value was recorded in site 3 during July, 2015. The monthly variations of water temperature of studied sites may be due to change in climate during seasons which affected by air temperature [18].

The hydrogen ion concentrations for most sites were more than 6 (up to 8) many times during the sampling period. It ranged between 6.87 to 8.57, which is normal condition for Iraqi Inland water [19]. The higher value was recorded in site 4, while, the lower value was recorded in site 1 and both values were recorded during August 2015. Generally, in Kurdistan region the pH value of water is alkaline and this may be due to the geological formation of the area, which mainly composed of $CaCo_3$ [20]. Electrical conductivity level at the selected sites during the study ranged between 190.79 to 850.08 $\mu s.cm^{-1}$. Results showed that minimum value was presented in site 3 during July 2015 while, the maximum value was observed in the same site during January 2016. The fluctuation of EC may be linked to the presence of Chloride and dissolved ions that are the main constituents in water and directly affect the EC values.

On the other hand, the turbidity level of the present study ranged from 0.9 to 7.7 NTU. The higher value was recorded in site 3 during September 2015, while the maximum value was recorded in site 1 during August 2015. Generally, site 1 characterized by highest turbidity values among other sites, this may be attributed to several reasons such as the activities of fishermen, tourists and discharge of many pollutants.

During this study, dissolved oxygen concentrations were ranged between 3.3 to 6.8 $mg.l^{-1}$. The minimum value was recorded at site 3 during September 2015, while the maximum value was recorded in site 2 during February 2016. Dissolved oxygen is one of the important factors in the aquatic system; it is influenced by temperature, chemical or biological processes [21]. Whereas, BOD_5 levels fluctuated slightly between all sites and ranged from 0.53 to 34.66 $mg.l^{-1}$. The higher value was recorded in February 2016 in site 3, while, lower BOD_5 value was recorded in site 4 during August 2015. The fluctuation of BOD_5 may related to many reasons; such as pollution resulted from human activities by throwing pollutants directly into the lake and high decomposition of organic matters in the lake during summer due to high water temperature and the release of domestic wastes from Dukan city to site 4 that could enhance DO depletion in water and increase BOD_5 values during August.

Table 1. minimum and maximum value of studied parameters during study period

Physico-chemical Parameters	Site 1	Site 2	Site 3	Site 4
Air temperature	0-36.16 ˚C	1-35.33 ˚C	1.5-33.66 ˚C	0-33.66 ˚C
Water temperature	4.83-31˚C	2.83-33.33 ˚C	4-34.66 ˚C	4.33-19.66 ˚C
Hydrogen ion concentration (pH)	7.02-8.57	7.28-8.45	7.1-8.54	6.87-8.07
Electrical conductivity (EC)	194.63-724.73 $\mu s.cm^{-1}$.	215.61-718.62 $\mu s.cm^{-1}$.	190.79-850.08 $\mu s.cm^{-1}$.	378.11-612.94 $\mu s.cm^{-1}$.
Turbidity	2.13-7.7NTU	1.6-6.96 NTU	0.9-7.5 NTU	1.1-6.16 NTU
Dissolved oxygen	3.6-5.06 $mg.l^{-1}$	4.26-6.8 mg $.l^{-1}$	3.3-6.13 mg $.l^{-1}$	3.6-5.06 mg $.l^{-1}$
Biochemical oxygen demand ($BOD_{5)}$	4-26.66 mg $.l^{-1}$	0.93-2.66 $mg.l^{-1}$	0.53-2.53 mg $.l^{-1}$	5.33-34.66 mg $.l^{-1}$

A variation of zooplankton distribution was recorded among sites and during the study. A total of 37 species zooplankton were identified, the result for the phyla, classes, orders, families, genus/species and percentage composition of the zooplankton invertebrate were presented in table (2). Zooplankton in the present study represented by the Cladocera 48.38% with 8 species these species belonged to two families; Bosminidae and Daphinidae, Copepoda 43.28% with 10 species belonged to two families; Cyclopoidea and Diaptomidae and Rotifera 8.23% with 17 species belonged to six families; Philodinidae, Branchionidae, Lecanidae, Lepadellidae , Synchaetidae and Euchlanidae. Only one species of Tardigrada 0.08% was *Dactylobiotus dispar* recorded in site 4 during August 2015 and this regarded the first record of this species in the studied lake. Medusa of *Craspedacusta sowerbii* Lankester (1880) was recorded for the first time in Iraq and the recorded species was observed in site 2 during November 2015 and it is belonged to the family Olindilidae 0.1%. It's worth to mention that the Craspedacusta genus was recorded for the first time in Iraq by [22]. Cladocera ranked as the first zooplankton group in order of abundance in this study and occupied the major part of the zooplankton population followed by Copepod and then Rotifer.

Craspedacusta sowerbii Landkester (1880) was consider as a new record to the Iraq, it is a hydromedusa measures about 5–25 mm. the identified of it become easily when it takes the form of a small, bell-shaped jelly fish. Translucent with a whitish color (Plate 1). Water forms 99% of the body. Lack head, skeleton and has no special organs for respiration or excretion. Five opaque-white canals, which form the gastrovascular cavity: four are radial and one is medially dorsoventral. Four large flat sex organs (gonads) attached to the four radial canals, opaque white. A whole of up to 400 tentacles tightly packed around the bell margin. Tentacles protrude from the upper margin of the velum (arranged with 3 to 7 short tentacles between the four longer ones). Tentacles are parallel to a radial canal at the edge of the velum. Shorter tentacles facilitate feeding. Long tentacles give stability for swimming. Thousands of cells called cnidocytes, contain nematocysts that forcefully penetrate the skin of prey. A large stomach structure called a manubrium. Mouth opening with four frilly lips. This organism is heterothermic with radial symmetry.

Concerning to zooplankton community, Rotifera were ranged between 0 to 690.91 $ind.m^{-3}$, the minimum value were observed in all sites during January and February 2016 this may be related to low temperature that causes their cystation, while the maximum value was recorded in site 1 during July 2015. The Copepoda population ranked second in order of zooplankton abundance in the studied sites and formed 43.28% of zooplankton population.

Table 2. List of zooplankton recorded during the study period.

Invertebrates			Site1	Site 2	Site 3	Site 4
Rotifera (8.23)	Class: Bdelloidea Order: Bdelloidae Family: Philodinidae	*Philodina roseola* Ehrenberg, 1832		+		+
		Rotaria citrina (Ehrenberg, 1838)				+
		Rotaria tardigrada (Ehrenberg, 1832)				+
	Class: Monogonata Order: Ploima Family: Branchionidae	*Anuraeopsis fissa* Lauterborn, 1900				+
		Keratella cochlearis (Gosse, 1851)	+	+		+
		Keratella tropica (Apstein 1907)				+
		Notholca squamula (Muller 1786)				+
	Family: Lecanidae	*Lecane bulla* (Gosse, 1851)		+		
		Lecane elasma Harring & Myers, 1926				+
		Lecane punctate (Murray, 1913)				+
		Lecane tenuiseta Harring, 1914	+			+
		Lecane undulata Hauer 1937	+			+
	Family: Lepadellidae	*Lepadella ovalis* (Muller, 1896)	+			
		Lepadella patella (Muller 1773)	+			
		Lepadella patella persimilis De Ridder, 1961				+
	Family: Synchaetidae	*Polyarthra vulgaris* Carlin (1956)	+			
	Family: Euchlanidae	*Euchlanis diliatata* (Ehrenberg 1832)			+	
Arthropoda	Class: Crustacea Order: Copepoda (43.28%) Family: Cyclopida	*Cyclops gigas* Claus 1857		+		
		Cyclops nanus Sars 1863		+		+
		Cyclops scutifer Sars 1863		+		
		Cyclops vernalis Fischer 1853		+	+	
		Diacyclops languidoides Lilljeborg 1901			+	
		Eucyclops macrurus Sars 1863		+		+
		Tropocyclops parsinus (Fischer 1860)	+	+	+	+
	Family: Diaptomidae	*Diaptomus dilobatus* Wilson 1958	+	+		+
		Diaptomus saltillinus Brewer 1898	+	+		
		Diaptomus theeli Lilljeborg 1889	+	+		+
	Class: Branchiopoda Order: Cladocera (48.38%) Family: Bosminidae	*Bosmina coregoni* Baird, 1845	+	+	+	+
		Bosmina longirostris (Müller 1776)				+
		Eubosmina tubicen (Brehm, 1953)			+	
	Family: Daphinidae	*Daphnia laevis* Birge 1879				+
		Daphnia longiremis Sars 1861		+		+
		Daphnia rosea Sars 1862	+	+	+	+
		Daphnia similis Claus 1876	+		+	+
		Diaphanosoma brachyurum (Liévin, 1848)		+		
Tardigrada	Class: Eutardigrada Order: Parachela Family: Macrobiotidae (0.08%)	*Dactylobiotus dispar* (Murray, 1907)				+
Cnidaria	Class: Hydrozoa Order: Limnomedusae Family: Olindilidae (0.1%)	*Craspedacusta sowerbii* Lankester 1880		+		

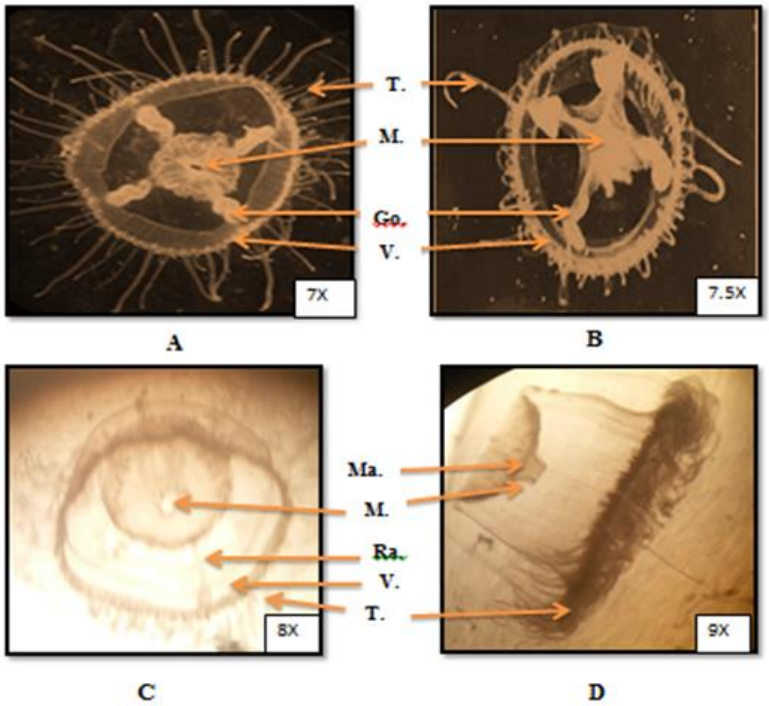

Plate 1. *Craspedacusta sowerbii* (Go. Gonads, M. Mouth, Ma. Manubrium, Ra. Radial canal, T. tentacles, V.vellum).

The minimum value of Copepoda was 54.55 ind.m^{-3} that recorded in site 2 during November 2015, while maximum value was 5927.27 ind.m^{-3} recorded in site 1 during December 2015. However, Cladocera occupied the major part of zooplankton community to be considered as the first group in order of abundance in the studied sites with a rate of 48.38%. The density value of Cladocera ranged between 18.18 to 6072.73 ind.m^{-3}. The lower value was recorded in site 1, whereas the higher value was recorded in site 4 both records were during February 2016. The depleted Cladocera value may related to larval fish that were observed in the studied sites, and caused the Cladocera depletion as in site 1 where a high fish density is present as compared to other sites this observation confirmed by [23, 24].

Shannon-Wiener Index

Diversity indices used to reflect the effect of environmental fluctuation on invertebrate communities. According to Shannon-Wiener index, the species diversity of zooplankton ranged between 0.325 to 1.091 bits/ind. (Table 3). The minimum value of species diversity was observed in site 3 during December 2015, while maximum value of diversity recorded at site 1 during July 2015. In this study, the results of Shannon-Wiener index showed relatively a good diversity of zooplanktonic organisms. The variation in diversity between site 1 and site 3 it may be related to many factors like air and water temperature, nutrition availability (phytoplankton) and pollution.

Jaccard's Similarity Index

Jaccard's similarity index is a statistical index used for comparing the similarity of sampling locations [25]. The results of Jaccard's similarity index for zooplankton invertebrates showed highest percentage of similarity between site 1 and site 4 reached to 40.74%, this probably related to the number of identified taxa. While, the lowest percentage of similarity observed between sites 3 and site 4 which is about 13.793% this may be due to the absence of Rotifer in site 3 (Table 4). The higher similarity between site 1 and site 4 may be related to pollution in both sites and to the environmental conditions; physical factors like air temperature, water temperature; chemical factors like minerals and biological factors like microorganisms at those both sites.

Table 3. Shannon diversity index between study sites and during the study period.

Month	July	August	September	October	November	December	January	February
site 1	1.091	1.033	1.068	0.856	1.004	0.687	0.692	0.451
site 2	0.997	1.046	0.977	0.699	1.067	0.645	0.673	0.597
site 3	0.512	0.686	0.612	0.526	0.562	0.325	0.679	0.477
site 4	1.051	0.876	1.072	0.86	0.951	0.494	0.689	0.441

Table 4. Jaccard similarity index (%) between study sites and during the study period.

Sites	1	2	3
2	29.16		
3	21.05	18.18	
4	40.74	28.125	13.793

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دراسة مجتمع الهائمات الحيوانية في بحيرة دوكان، أقليم كوردستان العراق مع تسجيل جديد للنوع *Craspedacusta sowerbii* Lankestr (1880)

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الخلاصة:

تم دراسة مجتمع الهائمات الحيوانية في اربع محطات مختارة في بحيرة دوكان. جمعت عيناة المياه و نماذج اللافقريات شهريا خلال الفترة من تموز 2015 الى شوباط 2016. تمت دراسة بعض العوامل الفزياوية والكيمياوية لمياه البحيرة وق اظهرت النتائج بان درجة حرارة الهواء تراوحت بين 0- 36.16 م° وتراوحت درجة حرارة المياه بين 2.83- 36.66 م° بينما كانت قيم تركيز ايون الهايدروجين في محطات الدراسة مائل بالاتجاه القاعدي حيث تراوحت بين 6.86- 8.56 وتراوحت قيم التوصيل الكهربائي بين 190.79- 850.08 مايكروسمنس/سم^3، بينما تراوحت مستوى العكورة بين 0.9-7.7 وحدة عكورة وقد تراوحت قيم الاوكسجين المذاب بين 3.3- 3.6 ملغم/ لتر وكانت قيمة المتطلب الحيوي للاوكسجين بين 0.53- 34.66 ملغم/لتر. فيما يتعلق بالهائمات الحيوانية فقد تم تشخيص 37 نوع تعود الى المجاميع متفرعة الاوامس بنسبة 43.38% و مجذافية الارجل بنسبة 43.28% والدولابيات بنسبة 8.23% ودب الماء بنسبة 0.08% وجوفية المعي (الميدوزة) بنسبة 0.1%. ومن الجدير بالذكر بانه قد تم تسجيل الميدوزة Craspedacusta sowerbii Lankestr (1880) للاول مرة في العراق . بالنسبة الى دراسة مجتمع اللافقريات فقد تراوحت عدد الدولابيات بين 0- 691.91 فرد/م^3 وتراوحت اعداد المجذافيات الارجل بين 54.55- 5927.27 فرد/م ^{3} وتراوحت اعداد متفرعة الاوامس بين 18.18- 6072.73 فرد/م^3 . سجل مؤشر شانون وينر لتنوع العوالق الحيوانية قيم تراوحت من 0.325- 1.091 بت/فرد. استخدم دليل جاكارد للتشابه للمقارنة بين المحطات الدراسة واظهر النتائج بان اعلى تشابه كان بين المحطة الاولى والرابعة وبنسبة تشابة 40.74%.

الكلمات المفتاحية: مجتمع الهائمات الحيوانية، بحيرة دوكان، العراق.