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The status of *Artemia* population in tuz lake (Central Anatolia, Turkey)

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Abstract

In this study, it was aimed to determine the status of *Artemia* population in Tuz Lake The study was conducted between October 2014 and September 2015. *Artemia* and water samples were taken seasonally in autumn and winter, monthly in spring and summer from 3 stations. *Artemia* population was found in 3th station in May, June and July. Total abundance was calculated as 3.2±0.2 – 42±5 number x10³/m³. Also, the density of *Artemia* planktonic cysts were 960±110 – 271200±97000 number x10³/m³. The highest density of cysts was observed in July when the population was about to disappear and matures were dominant. The largest cysts diameter values were measured in May on hydrated cysts. The water parameters were determined in terms of temperature (6.40±0.10 °C-29.4±1.00 °C), dissolved oxygen (1.26±0.08 mg/L), salinity (226±5.77 g/L-366±20.13 g/L), pH (7.37±0.00 - 8.12±0.01), water depth (8±1.00 cm-35±1.5 cm), and transparency (7.66±0.60 cm-35±1.50 cm). In previous studies (conducted in Tuz Lake between 1994 and 2017), it was claimed that climatic change and human effects has been an important factor in fluctuations of *Artemia* population. In conclusion, data evaluated from the present study results showed that the water criteria (physically, chemically and biologically) should be monitored and taken measures against pollution for the sustainable lake management.

Key words: Tuz Lake, *Artemia*, temperature, salinity, dissolved oxygen

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Tuz Gölü'nde *Artemia* populasyonunun durumu (Orta Anadolu, Türkiye)

Özet

Bu çalışmada, Tuz Gölü'nde yaşayan *Artemia* populasyonunun son durumunu ortaya koymak amaçlanmıştır. Araştırma Ekim 2014 ve Eylül 2015 tarihleri arasında yürütülmüştür. *Artemia* ve su örnekleri, gölden seçilen üç istasyondan sonbahar ve kış mevsimlerinde bir kez, ilkbahar ve yaz aylarında aylık olarak alınmıştır. *Artemia* populasyonuna 3. istasyonda, Mayıs, Haziran ve Temmuz aylarında rastlanmıştır. Araştırmada toplam *Artemia* bolluğu 3.2±0.2–42±5 adetx10³/m³ olarak, *Artemia*'nın planktonik kistlerinin miktarı ise 960±110–271200±97000 adetx10³/m³ olarak belirlenmiştir. En yüksek kist miktarı popülasyonun kaybolmaya başladığı ve erginlerin dominant olduğu Temmuz ayında, kaydedilmiştir. En yüksek kist çapı değerleri Mayıs ayında hidrasyona maruz kalmış kistlerde ölçülmüştür. Tuz Gölünde araştırma süresince su sıcaklığı (6.40±0.10°C-29.4±1.00°C), çözünmüş oksijen (1.26±0.08 mg/L), tuzluluk (226±5.77 g/L-366±20.13 g/L), pH (7.37±0.00-8.12±0.01), su derinliği (8±1.00 cm-35±1.5 cm) ve bulanıklık (7.66±0.60 cm-35±1.50 cm) değerleri ölçülmüştür. Tuz Gölü'nde 1994-2017 yılları arasında yapılmış çalışmalarda, *Artemia* popülasyonundaki dalgalanmaların iklim değişimi ve insan kaynaklı olduğu belirtilmiştir. Araştırmadan elde edilen sonuçlara göre, Tuz Gölü'nün sürdürülebilir olabilmesi için gölün fiziksel, kimyasal ve biyolojik olarak izlenmesi ve kirlenmeye karşı önlemlerin alınması gerekmektedir.

Anahtar kelimeler: Tuz Gölü, *Artemia*, sıcaklık, tuzluluk, çözünmüş oksijen

1. Introduction

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Tuz Lake is the second big lake of Turkey, located in Central Anatolia with a closed basin and the salinity about 32% without outflowing. Tuz Lake was declared a specially protected area in 2000 years [1] and also the salt supplied from Tuz Lake is about 70% of Turkey's requirement [2]. The Lake is very important with its ecological and economical values.

Salinity degree is the determinant of the biological communities in the salt water bodies [3]. *Artemia* is the dominant zooplankton of hypersaline lakes (salinity >50 g/l). The presence of *Artemia* populations in salt water bodies increase the quality of salt crystals. Besides this, *Artemia* is a valuable living feed for fish and crustaceans larvae in aquaculture [4, 5, 6].

The presence of the *Artemia* was reported from the east side of Tuz Lake in a 10 km coastline [7,8,9]. *Artemia* population has been investigated in Tuz Lake since 1994 year by the various researches [7,8,9,10,11]. As the most of the saline lakes, Tuz Lake area is getting smaller by global warming. The aim of this study is to put forward the effects of this global warming on the *Artemia* population in Tuz Lake and making comparisons with previous studies. ([11]Eskandari, A. (2014). Türkiye'de Kıyısal ve Karasal Tuzlu Göllerde Yayılım Gösteren Artemia Popülasyonlarının Ekolojik, Sitogenetik, Moleküler, Morfometrik Yöntemler Kullanılarak Araştırılması ve Biyotopların Hidrobiyolojik Yönden İncelenmesi. Ankara: H. Ü., PhD Thesis.).

2. Materials and methods

Tuz Lake located in the Central Anatolia, it is tectonic lake and fed by ground waters and surface waters (Fig 1). It has no flowing out. It is the shallowest lake of Turkey, the deepest part of the Lake is about 0.5 m. It has an average annual rainfall of 324 mm/m^2. In the spring, the surface area of the lake reachs to 1642 km^2, the lenght and width of the lake are 90 km and 35 km, respectively. During the summer by the excessive evaporation, an average of 30 cm thick salt layer is formed, especially in August. Salt Lake and the surrounding area, according to the criteria of Turkey's Key Biodiversity Areas, claimed as " Major part of the Lake area exposed to the serious and irreversible damages, caused to irreversible lost areas" in the previous 10 years and Tuz Lake is one of the areas that urgent measures should be taken for the endemic and endangered species [12].

The research was carried out between October 2014-September 2015. Samples for *Artemia* were collected seven times from 3 stations, as once each in autumn (November) and winter (January) seasons and monthly in spring and summer seasons. Because of the dry season, *Artemia* samples couldn't be taken in August.

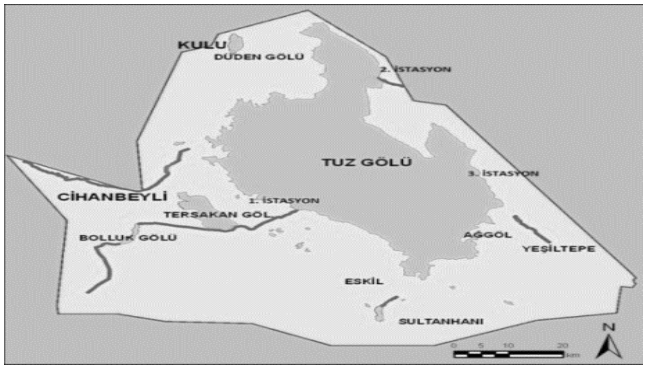

Figure 1. Tuz Lake and sampling stations

Samples were collected horizontally by a plankton net with 55µm mesh size, triplicately. Those samples were preserved in 4% formaldehyde solution [13]. *Artemia* and cyst samples were counted and measured from five subsamples each containing 1 ml under inverted microscopes (Edmondson, 1959). Abundances were calculated according to [13]. *Artemia* was sorted as nauplius, juvenil and adult. The abundance values of *Artemia* and cysts were given as individual per m^3.

The water temperature, dissolved oxygen, pH (CONSORT C5020T MODEL), salinity (SM2520B), depth and secchi depth were measured *in situ*. Statistical analysis were carried out by using SPSS 17 Statistic Program. Variance analysis (ANOVA) and Duncan multiple range test were computed to evaluate the differences in terms of the water quality parameters of the Lake [14].

3. Results

Artemia parthenogenetica was found and collected only in May, June and July from the 3rd station in the east part of Tuz Lake. During the research, total abundance values of the *Artemia parthenogenetica* juvenil and adult population changed between 3.2±0.2(x10³)-17.2±2(x10³) individual/m³ (Table 1).

Table 1**.** The average abundance of *Artemia parthenogenetica* and cysts in the 3rd station according to months in Tuz Lake, individual x10³/m³ (average ± standard deviation)

Months	Individual abundance	Cyst abundance
May	3.2±0.2	960±110
June	17.2±2.0	6720±523
July	2.04±5.0	271200±97000

In May and July, the rate of the adults was 50% and 100%, respectively (Table 2). The average length of *Artemia parthenogenetica* adults were determined as 10.1±3.7 mm, 8.8±1.2 mm and 8.4±0.8 mm in May, June and July, respectively (Table 2).

Table 2. The average percentages of adults and juveniles of *Artemia parthenogenetica* (%) and their minimum-maximum lengths (mm) in the 3rd station according to months in Tuz Lake

Months	Adult			Juvenil		
	%	Average length	Min-Max length	%	Average length	Min-Max length
May	50	10.1±3.7	7.4-12.7	50	4.5±1.3	2.7-5.8
June	75	8.8±1.2	7.2-11.4	25	4.6±1.3	2.1-6.9
July	100	8.4±0.8	7.1-10.4	-	6.0±0.6	3.5-6.9

During the sampling period, only planktonic cysts were identified. The abundances of *Artemia parthenogenetica* cyst were changed between 960 cysts/m³ and 271200 cyst/m³ in May and July (Table 1). Cyst diameters were changed between 0.24±0.35 mm and 0.26±0.00 mm (Table 3). The highest cyst diameter was measured in ones exposed to hydration in May.

Table 3. The average cyst diameters of *Artemia parthenogenetica* (mm) and their minimum and maximum diameters (mm) in the 3rd station according to months in Tuz Lake

Months	Average cyst diameter	Min-Max cyst diameter
May	0.26±0.00	0.26-0.26
June	0.23±0.36	0.16-0.29
July	0.24±0.35	0.16-0.29

During the research, The water parameters were determined in terms of average temperature values, dissolved oxygen, salinity, pH and they were ranged from 6.40±0.01°C to 29.4±1°C (Fig.2), from 1.26±0.08 mg/L to 6.27±0.24 mg/L (Fig.3), from 226±5.77 g/L to 366±20.13 g/L (Fig.4) and from 7.50±0.00 to 8.12±0.01, respectively. The average depth of Tuz Lake was changed between 8±1 cm ile 35±1.5 cm and average transparency was about 7.66±0.60 cm-35±1.5 cm. The differences in the values of water temperature, dissolved oxygen, salinity, pH, depth and transparency were found to be statistically significant according to the stations and months ($p<0.05$).

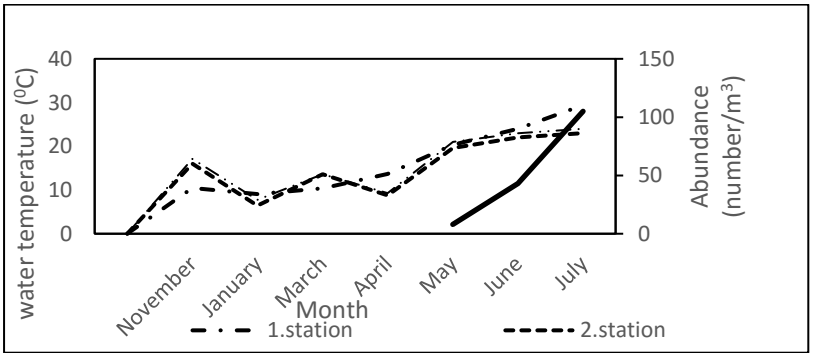

Figure 2. Average water temperatures and change of *Artemia parthenogenetica* abundance according to the months in Tuz Lake during the study

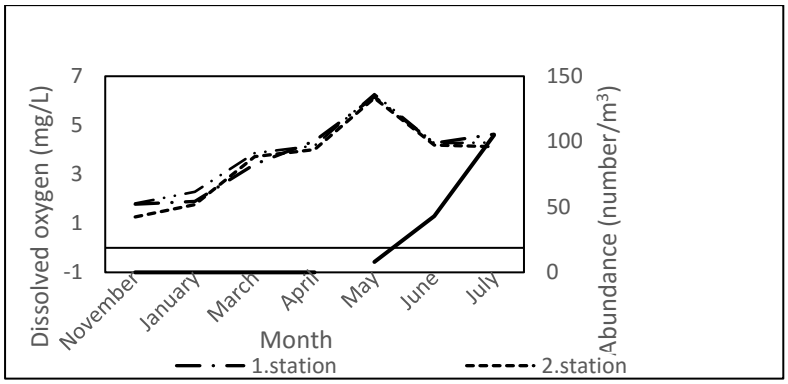

Figure 3. Average dissolved oxygen values and change of *Artemia parthenogenetica* abundance according to the months in Tuz Lake during the study

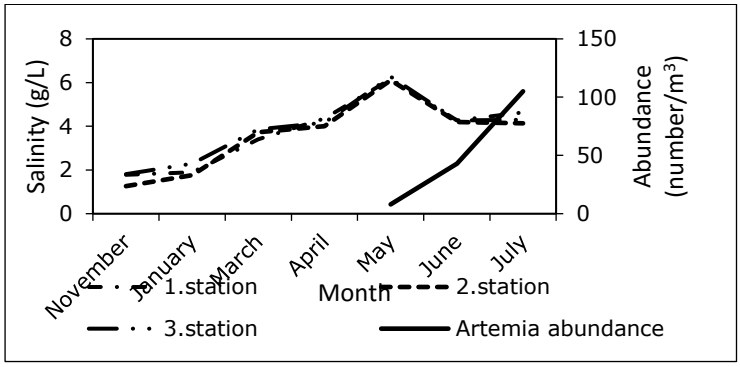

Figure 4. Average salinity values (g/L) and change of *Artemia parthenogenetica* abundance according to the months in Tuz Lake during the study

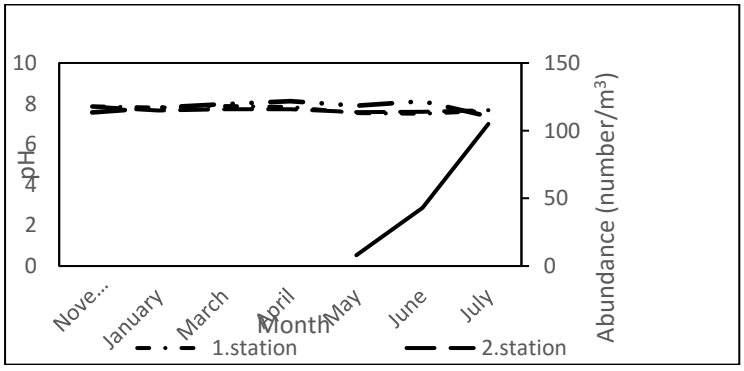

Figure 5. Average pH values and change of *Artemia parthenogenetica* abundance according to the months in Tuz Lake during the study

4. Conclusions and discussion

In Tuz Lake, the first investigation for *Artemia parthenogenetica* was carried out by Başbuğ and Demirkalp [7] and Başbuğ [8,9] between October 1993 and July 1994. So this study was conducted to put forward the last status of *Artemia* population after 21 years. *Artemia parthenogenetica* was found and collected only in May, June and July from the 3rd station in the east part of Tuz Lake. The 3rd station was located in the depth region of Tuz Lake [16]. During the research, total abundance values of the *Artemia parthenogenetica* juvenil and adult population changed between 3.2±0.2(x10³)-17.02±2(x10³) individual/m³. In May and July, the rate of the adults was 50% and 100%, respectively. In this study, *Artemia parthenogenetica* was not found in metanauplius stage, relating to sampling time. *Artemia* population was disappeared as in all previous studies in the second half of the July, in the Lake. [11], found *Artemia* just in metanauplii form only at the second half of the March as 3.67 individual$X10^3/m^3$ between 2014 and 2015 years. The researchs in Tuz Lake between 1994-2017 years showed that the fluctations in the distribution and abundances of the *Artemia* population have been affected primarily by climatic factors [17].

The average length of *Artemia parthenogenetica* adults were determined as 10.1±3.7 mm, 8.8±1.2 mm and 8.4±0.8 mm in May, June and July, respectively. There has been a significant decrease in adult lengths when it was

compared with the results of Başbuğ and Demirkalp [7]. It was reported that the adults lengths in 1993 as 11.2 mm and 10.4 mm in June and July, respectively and in 1994 as 13.5 mm and 11 mm in May and June, respectively. It was thought that some environmental parameters such as temperature, salinity could be affected the size of the individuals. [18], indicated that increasing salinity, decreased the number of setas in furca of *Artemia*. Besides this, it is thought that the reduction in the lengths of *Artemia parthenogenetica* from May to July is associated with a rise in population density.

During the sampling period, only planktonic cysts were identified and no cyst accumulation was observed on the coast and lake surface. The abundances of *Artemia parthenogenetica* cyst were changed between 960 cysts/m^3 and 271200 cyst/m^3 in May and July. The highest cyst abundance was determined in July when the population was about to disappear and the adults were dominant in that period. It is known that low abundance and highest cyst production in *Artemia* population had been occured in dry season with the increasing salinity [19]. Cyst diameters were changed between 0.24±0.35 mm and 0.26±0.00 mm. The highest cyst diameter was measured in ones exposed to hydration in May. These results were similiar to Başbuğ [7,8] and Eskandari [10]. Cysts were entered diapause period due to dehidration in July and diameter of cysts decreased. However, it is reported that the fluctations in salinity and nutrients would be effective on cyst diameter [20].

In the study, average water temperature values ranged from 6.40±0.01°C to 29.4±1.00°C. [7,10,11] were reported average temperature values in Tuz Lake as -2.5-32.4°C, 14-32°C, 8.4-30.6°C, respectively. In this study, minimum average temperature values found higher than Başbuğ (1997), maximum value was found lower than the previous studies. Water temperature values are important for *Artemia* sp. in lakes. It is reported that in the case of sudden decreases in water temperature caused mortalities in nauplius due to starvation by stopping feeding in spring when their abundances are high [21].

In Tuz Lake, dissolved oxygen levels ranged from 1.26±0.08 mg/L to 6.27±0.24 mg/L. [7,10,11] were reported average dissolved oxygen values in Tuz Lake as 1.2-10.7 mg/L, 0.98- 5.75 mg/L and 1.63-7.55 mg/L, respectively. *Artemia* sp. can not tolerate dissolved oxygen level less than 2 ppm [22]. In this study, dissolved oxygen level was determined below 2 ppm in January and November. It was found that dissolved oxygen values were higher in June and July than the other months in the third station whereas *Artemia parthenogenetica* was encountered.

Average salinity values ranged from 226±5.77 g/L to 366±20.13 g/L during the research in Tuz Lake. Salinity values has increased since April. However, salinity values found lower in the 3rd station than the other stations in May and June. According to [23] and [24], the increase in salinity causes a decrease in plankton richness and species diversity. In the study, the abundance of *Artemia parthenogenetica* increase proportionally with increasing salinity. *Artemia parthenogenetica* could be observed in waters where as salinity is 60 g/L-200 g/ L and couldn't be observed in salt lakes whereas salinity below 60 g/L due to failure to compete with the other zooplankton such as *Moina mongolica, Apocyclops rayii, B. plicatilis* [25].

The average pH value of the study ranged between 7.50±0.00 and 8.12±0.01 during the study in Tuz Lake. pH values was about above 8.00 in the 3rd station in April and June as indicated for the depth region of Tuz Lake by [16].

The average depth of Tuz Lake was changed between 8±1 cm ile 35±1.5 cm and average transparency was about 7.66±0.60 cm-35±1.5 cm. Turbidity was higher especially in January and May than the other months. It was reported that the colour of the 3rd station turned to red due to increasing of algae, *Dunelliella salina* in Tuz Lake in the spring and summer months [26,27]. The depth of 3rd station higher than in other stations in May, June and July where *Artemia parthenogenetica* has found. It was observed that there had been a decrease in water level by years. [16] reported that the deepest part of Tuz Lake is about 1.5-2 m where the 3rd station is located and it was about 60-80 cm in winter and spring months, mostly dried in at the end of the summer. It was indicated that the main Lake area was dried in summer and autumn and the depth was about 70 cm in spring. This level was decreased to minimum in September and October and reached to maximum in March and April, especially the level was above 1 m in the depth region all of the year in 1995 [28]. In this study, the maximum depth of Tuz Lake did not exceed 35 cm. Therefore, it has been observed during the study that there has been a decrease in water level by years.

In Tuz Lake, *Artemia parthenogenetica* abundances is generally lower than the other *Artemia* habitats of the World due to their short generation periods and high salinity and water temperature values in summer. This causes high mortality rates and limiting their presence [29]. [11], reported that *Artemia* sp. faced the danger of dissappearing from its natural area, Tuz Lake. In this study, it was revealed that the zooplankton of Tuz Lake, *Artemia parthenogenetica* has increased again.

This result is very important for *Artemia* sp. considering its ecological and economical values. Thus, the fluctations of *Artemia* population of Tuz Lake between the years 1994 and 2017 can be primarily dependent on climatic conditions. In addition, ionic composition, pH, hydrological contamination, geographic location, biological interaction and especially human effects are also determinants of *Artemia* presence. For continuity of *Artemia* population, Tuz Lake should be monitored physically, chemically and biologically in long terms. The human effects also should be taken under control.

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