Journal of Limnology and Freshwater Fisheries Research
limnofish
http://www.limnofish.org

# The Determination of Body Size and Eggs Number of Zooplankton (Rotifera, Cladocera and Copepoda) in Tahtaköprü Dam Lake (Gaziantep, Turkey)

**Ahmet BOZKURT[1,*], Mitat ÜLGÜ[2], Önder DUYSAK[1]**

[1] Iskenderun Technical University, Marine Sciences and Technology Faculty, 31200, Iskenderun, Hatay, Turkey
[2] Mustafa Kemal University, Samandağ Vocational School, Antakya, Hatay, Turkey

## ABSTRACT

The study was carried out in Tahtaköprü Dam Lake between March 2007 and February 2008 period. Rotifera, Cladocera, Copepoda body size and number of eggs were analyzed on monthly basis. It was found that mean annual body size of Rotifera, Cladocera, Copepoda species were high in cold winter season and low in autumn with relatively high temperature. Rotifera species had the highest number of eggs in February (1.79 ± 1.030), while it had the lowest number of eggs in December (1 ± 0). Cladocera species had the highest number of eggs in warm summer months (August, 2.09 ± 1.014) and the lowest number of eggs in cold winter months (February, 1.20 ± 0). Finally, Copepoda species had the highest number of eggs in August (80.67 ± 1.154) and the lowest number of eggs in October (14.75 ± 3.594)

**Keywords:** Rotifera, Cladocera, Copepoda, body size, egg amount, inland water

## ARTICLE INFO

RESEARCH ARTICLE

*Received* : 21.01.2016
*Revised* : 15.03.2016
*Accepted* : 22.03.2016
*Published* : 20.04.2016

DOI: 10.17216/LimnoFish-5000169228

*** CORRESPONDING AUTHOR**

ahmetbozkurt1966@hotmail.com
*Tel* : +90 326 614 16 93
Fax: +90 326 614 18 77

**Tahtaköprü Baraj Gölü'nde (Gaziantep, Türkiye) Zooplanktonun (Rotifera, Kladosera ve Kopepoda) Vücut Büyüklüğü ve Yumurta Miktarının Belirlenmesi**

**Öz:** Çalışma, Tahtaköprü Baraj Gölü'nde Mart 2007-Şubat 2008 tarihleri arasında yürütülmüştür. Çalışmada rotifer, kladoser ve kopepod boy uzunluğu ve yumurta sayısı aylık olarak araştırılmıştır. Rotifer, kladoser ve kopepod türlerinin yıllık ortalama boy uzunluğunun soğuk kış mevsiminde yüksek, sıcaklığın kısmen yüksek olduğu sonbaharda ise düşük olduğu belirlenmiştir. Rotifer türlerinin yumurta miktarları en çok şubat ayında (1,79±1,030 adet), en az aralık ayında (1±0 adet) belirlenmiştir. Kladoser yumurta miktarları sıcak yaz aylarında çok (ağustos, 2,09±1,014 adet), soğuk kış aylarında ise az miktarda (şubat, 1,20±0 adet) olduğu tespit edilmiştir. Kopepod yumurta miktarı aralık ayında en çok (80,67±1,154 adet), ekim ayında ise en az (14,75±3,594 adet) olduğu tespit edilmiştir.

**Anahtar kelimeler:** Rotifera, Cladocera, Copepoda, vücut uzunluğu, yumurta miktarı, içsular

**How to Cite**
Bozkurt A, Ulgu M, Duysak O, 2016. The determination of body size and eggs number of zooplankton (Rotifera, Cladocera and Copepoda) in Tahtaköprü Dam Lake (Gaziantep, Turkey). LimnoFish. 2(1):1-9. doi: 10.17216/LimnoFish-5000169228

## Introduction

Zooplanktons are the main source of food to many aquatic animals in lake ecosystem such as insects, fish and fish larvae. Due to their crucial role in food pyramid Rotifera, Cladocera and Copepoda species provide essential food source in natural environment and aquaculture. Today, zooplanktons need to be produced in aquaculture (Hessen et al. 2007; Gaudy and Verriopoulos 2004).

Biologic capacities of the water resources of the country, in other words, the amount and distribution of the food stock they naturally have should be known to make use of the water products at adequate levels.

Zooplanktonic organisms have an important role in fish and crustacean farming. Investigation of the abundance and development of zooplanktonic organisms become a priority issue for the production of these organisms. Furthermore, knowing the zooplankton body size, egg amount and abundance of species is of great importance for natural life (Vijverberg 1989).

Decreased zooplankton size causes these

organisms to lose their characteristics as a suitable food and results in a reduction in secondary production amount as the small females in the population produce less and smaller eggs and slow down population growth and development. More importantly, the zooplankton with smaller body structure cannot be consumed by fish that hunt using their eyes and might disrupt food chain. Furthermore, zooplankton with decreased body size has a negative impact on trophic level and biomass development in addition to population growth ratio (McLaren 1965; Kerfoot 1974; Gaudy and Verriopoulos 2004; Crawford and Daborn, 1986).

In this study, body size and egg amounts of Rotifera, Cladocera and Copepoda species in Tahtaköprü Dam Lake were determined on monthly basis.

## Materials and Methods

Zooplankton samples were collected on monthly basis from Tahtaköprü Dam Lake (Figure 1) in Gaziantep province of Turkey in March 2007-February 2008 period. Tahtaköprü Dam is on Karasu River near Syrian border, and its construction was started in 1968, completed in 1977, and became operational in 1977. The fishery in the dam lake is an important source of income for the local people. Tahtaköprü Dam Lake constructed for irrigation purposes, has an 11900 ha land irrigation capacity, covering Hassa and Kırıkhan districts. Reservoir volume is 200 $hm^3$, active volume is 185 $hm^3$, and reservoir area at the normal water level is 2340 ha, and its water source is the Karasu River (DSI 1975, General Directorate of State Hydraulic Works [DSI]). First station was the deepest station with 39 m and followed by third station with 25 m. Second and fourth stations were 9 m and 14 m depth respectively.

Samples of zooplankton were collected from 4 stations by vertical hauls of a standard net (60 µm mesh size). Plankton samples were fixed with 4% buffered formaldehyde and analyzed in the laboratory under a stereomicroscope (Olympus CH40) for taxonomic features. The species were identified with the aid of Edmondson (1959); Borutsky (1964); Scourfield and Harding (1966); Dussart (1969); Damian-Georgescu (1970); Ruttner-Kolisko (1974); Kiefer (1978); Koste (1978); Stemberger (1979); Segers (1995) and Dodson (2002).

Zooplankton body size values were measured in binocular microscope using micrometric ocular at 10× magnification. Whole body size was measured in Rotifera; the longest part of the body from the head to the end of the abdomen was measured in Cladocera and whole body size from the rostrum to the end of furca was measured in Copepoda. Zooplankton eggs were counted in binocular microscope. The eggs of the Rotifera were counted outside of the body. Cladocera eggs in brood pouch were counted one by one. As for the Copepoda, egg sac was split, the eggs were detached from each other and the scattered eggs were counted. Temperature was measured in the field using YSI type oxygenmeter. Chlorophyll-*a* was measured in the laboratory according to APHA (1995).

All computations, and statistical analyses were performed in Microsoft Excel.

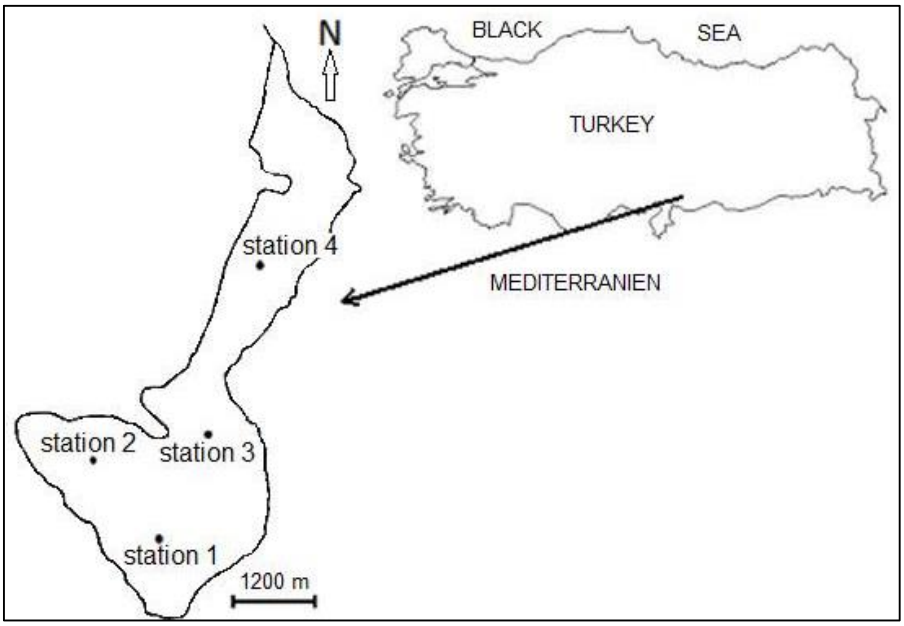


**Figure 1.** Tahtaköprü Dam Lake and sampling stations.

## Results

Mean temperature was found to be high in summer months. The highest temperature was measured in July (27 °C), the lowest temperature was measured in February (10 °C). Chlorophyll-*a* values were found to be quite high in summer and autumn. The highest chlorophyll-*a* value was identified in July (139.2 mg $L^-$), the lowest value was identified in May (9 mg $L^-$) (Table 1).

Mean Rotifera body size was found to be the highest in January (0.289 ± 0.245 mm), and the lowest in September (0.174 ± 0.125 mm). It was found that in Rotifera, *Asplanchna girodi* (de Guerne, 1888) (January, 0.734 ± 0.025 mm), *Brachionus angularis* Gosse, 1851 (January, 0.192±0.010 mm) *Filinia longiseta* (Ehrenberg 1834) (February, 0.167 ± 0.027 mm), *Keratella tecta* (Lauterborn 1900) (February, 0.165 ± 0.005 mm), *Brachionus budapestinensis* Daday, 1885 (November, 0,182 ± 0,010 mm) reached the highest body size in the months with the lowest temperatures, while *Brachionus calyciflorus* Pallas, 1766 (March, 0.428 ± 0.124 mm), *Hexarthra mira* (Hudson, 1871) (May, 0.209±0.006 mm), *Keratella cochlearis* (Gosse, 1851) (March, 0.116 ± 0.009 mm), *Polyarthra dolichoptera* Idelson, 1925 (March, April, 0.131 ± 0.012 mm) and *Pompholyx sulcata* (Hudson, 1885) (March, 0.122 ± 0.008 mm) reached the highest body size in spring months. On the other hand, the individuals with the lowest body size in Rotifera were identified generally in warm summer and autumn months (*K. tecta* 0.116 ± 0.006 mm, *P. dolichoptera* 0.103 ± 0.005 mm June, *B. budapestinensis* 0.121 ± 0.008 mm, *P. sulcata* 0.098 ± 0.006 mm July, *A. girodi* 0.404 ± 0.008 mm, *B. calyciflorus* 0.318 ± 0.022 mm, *F. longiseta* 0.094 ± 0.006 mm August, *H. mira* 0.140 ± 0.009 mm September) (Table 2)

The highest mean number of eggs was detected in February (1.79 ± 1.030), while the lowest number of eggs was detected in December (1 ± 0) (Table 3).

Mean body size of Cladocera was found to be the highest in July (0.617 ± 0.255 mm) and the lowest in November (0.371 ± 0.038 mm). *Bosmina longirostris* (Müller, 1785) reached the highest body size in March (0.437 ± 0.054 mm); *Ceriodaphnia pulchella* Sars, 1862 reached the highest body size in February (0.559 ± 0.015 mm); *Diaphanosoma birgei* Korinek, 1981 (0.923 ± 0.107 mm) and *Moina micrura* Kurz, 1874 (0.728 ± 0.110 mm) reached the highest body size in July. The smallest body size was determined in *B. longirostris* (0.293 ± 0.026 mm) and *C. pulchella* (0.364 ± 0.040 mm) in October and in *D. birgei* (0.646 ± 0.041 mm) and *M. micrura* (0.554 ± 0.061 mm) in September (Table 2).

Eggs number of Cladocera showed an unsteady distribution. It was found that *B. longirostris* produced the highest number of eggs in August (3.25 ± 3.862); *D. birgei* produced the highest number of eggs in May (2.5 ± 1.098), *C. pulchella* produced the highest number of eggs in October (2 ± 0.632) (Table 3).

Mean body size of male Copepoda was found to be the highest in January (1.368 ± 0.063 mm) and the lowest in November (0.630 ± 0.012 mm). Mean body size of female Copepoda was found to be the highest in February and the lowest in November (0.807 ± 0.037 mm). Body size of female *Cyclops vicinus* Uljanin, 1875 individuals was found to be the highest in February (1.830 ± 0.118 mm) and the lowest in April (1.342 ± 0.093 mm); body size of female *Mesocyclops leuckarti* (Claus, 1857) individuals was found to be the highest in December (1.222 ± 0.128 mm), and the lowest in August (0.998 ± 0.059 mm); body size of female *Thermocyclops crassus* (Fischer, 1853) individuals was found to be the highest in December (0.845 ± 0.021 mm) and the lowest in September (0.779 ± 0.052 mm) (Table 2).

It was found that the number of Copepoda eggs was the highest in November (80.67 ± 1.154) and the lowest in October (14.75 ± 3.594).

Number of *C. vicinus* eggs was found to be the highest in December; number of *M. leuckarti* and *T. crassus* egg was found to be the highest in June (Table 3).

**Table 1.** Mean temperature and chlorophyll-*a* values in Tahtaköprü Dam Lake.

| Parameters | Months | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | 2007 | | | | | | | | | | 2008 | |
| | Mar | Apr | May | Jun | Jul | Aug | Sep | Oct | Nov | Dec | Jan | Feb |
| Temperature (°C) | 14 | 15 | 22 | 24 | 27 | 26 | 22 | 20 | 13 | 12 | 12 | 10 |
| Chlorophyll-a (mg $L^-$) | 11.5 | 11.8 | 9.0 | 32.4 | 139.2 | 130.9 | 121.9 | 127.2 | 35.2 | 13.4 | 16.6 | 14.5 |

**Table 2**. Mean body size values of zooplankton (Rotifera, Cladocera and Copepoda) species (-: Absent).

| | | Months | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | **Mar 07** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** | **Jan 08** | **Feb** |
| **Rotifera** | | Body length (mm) | | | | | | | | | | | |
| *Asplanchna girodi* | | 0.583±0.074 | 0.556±0.046 | 0.499±0.054 | 0.487±0.048 | 0.521±0.047 | 0.404±0.008 | 0.482±0.038 | 0.495±0.048 | 0.513±0.045 | 0.577±0.043 | 0.734±0.025 | 0.649±0.082 |
| *Brachionus budapestinensis* | | - | - | - | - | 0.121±0.008 | 0.140±0.009 | 0.131±0.010 | 0.149±0.021 | 0.182±0.010 | - | - | - |
| *B. calyciflorus* | | 0.428±0.124 | 0.319±0.070 | 0.385±0.023 | 0.352±0.033 | 0.364±0.029 | 0.318±0.022 | 0.352±0.019 | 0.353±0.030 | 0.339±0.022 | 0.358±0.025 | 0.421±0.047 | 0.400±0.068 |
| *B. quadridentatus* | | - | - | - | - | - | - | - | - | - | - | - | 0.293±0.010 |
| *B. angularis* | | 0.185±0.006 | 0.158±0.006 | 0.118±0.006 | 0.117±0.010 | 0.117±0.015 | 0.116±0.005 | 0.108±0.006 | 0.101±0.010 | 0.114±0.012 | 0.139±0.015 | 0.192±0.010 | 0.178±0.019 |
| *Filinia longiseta* | | 0.165±0.023 | 0.148±0.021 | - | 0.137±0.014 | 0.101±0.010 | 0.094±0.006 | 0.102±0.010 | 0.134±0.012 | 0.141±0.019 | 0.145±0.010 | 0.152±0.010 | 0.167±0.027 |
| *F. opoliensis* | | - | - | - | - | - | - | 0.167±0.014 | 0.202±0.010 | 0.182±0.010 | - | - | - |
| *Hexarthra mira* | | - | - | 0.209±0.006 | 0.148±0.006 | 0.148±0.006 | - | 0.140±0.009 | 0.152±0.014 | 0.165±0.021 | 0.182±0.010 | - | - |
| *Keratella cochlearis* | | 0.116±0.009 | 0.111±0.007 | 0.105±0.005 | - | - | 0.108±0.006 | 0.104±0.006 | - | 0.101±0.010 | 0.101±0.008 | - | 0.111±0.010 |
| *K. tecta* | | 0.158±0.012 | 0.132±0.006 | 0.121±0.010 | 0.116±0.006 | - | - | - | - | - | 0.152±0.010 | - | 0.165±0.005 |
| *K. tropica* | | - | - | - | - | 0.127±0.007 | 0.130±0.005 | 0.128±0.006 | - | - | - | - | |
| *Notholca squamula* | | - | - | - | - | - | - | - | - | - | - | - | 0.162±0.010 |
| *Polyarthra dolichoptera* | | 0.131±0.012 | 0.131±0.010 | - | 0.103±0.005 | 0.104±0.008 | - | 0.106±0.008 | 0.116±0.010 | 0.106±0.011 | 0.115±0.017 | 0.126±0.010 | 0.129±0.010 |
| *Pompholyx sulcata* | | 0.122±0.008 | 0.113±0.008 | 0.101±0.009 | - | 0.098±0.006 | 0.105±0.005 | 0.098±0.006 | 0.099±0.007 | 0.105±0.006 | 0.111±0.006 | 0.112±0.006 | 0.112±0.006 |
| *Synchaeta* sp. | | - | - | - | - | - | - | - | - | - | 0.235±0.015 | - | |
| **Average** | | **0.236±0.173** | **0.208±0.156** | **0.219±0.159** | **0.208±0.149** | **0.189±0.141** | **0.176±0.116** | **0.174±0.125** | **0.200±0.135** | **0.195±0.132** | **0.211±0.149** | **0.289±0.245** | **0.236±0.170** |
| **Cladocera** | | | | | | | | | | | | | |
| *Coronatella rectangula* | | 0.412±0.026 | - | - | - | - | - | - | - | 0.331±0.010 | - | - | - |
| *Bosmina longirostris* | | 0.437±0.054 | 0.387±0.039 | 0.352±0.026 | 0.353±0.020 | 0.372±0.073 | 0.310±0.022 | 0.315± 0.029 | 0.293±0.026 | 0.375±0.032 | 0.412±0.027 | 0.429±0.031 | 0.434±0.050 |
| *Ceriodaphnia pulchella* | | - | 0.465±0.010 | 0.444±0.038 | 0.449±0.027 | 0.445±0.038 | 0.398±0.034 | 0.380±0.049 | 0.364±0.040 | 0.406±0.033 | 0.459±0.047 | 0.489±0.051 | 0.559±0.015 |
| *Diaphanosoma birgei* | | - | 0.875±0.103 | 0.809±0.117 | 0.891±0.091 | 0.923±0.107 | 0.736±0.099 | 0.646±0.041 | - | - | - | - | - |
| *Moina micrura* | | - | - | 0.604±0.018 | 0.675±0.051 | 0.728±0.110 | 0.663±0.079 | 0.554±0.061 | 0.662±0.007 | - | - | - | - |
| **Average** | | **0.425±0.018** | **0.576±0.262** | **0.552±0.200** | **0.592±0.240** | **0.617±0.255** | **0.526±0.204** | **0.474±0.153** | **0.440±0.196** | **0.371±0.038** | **0.436±0.033** | **0.459±0.042** | **0.497±0.088** |
| **Copepoda** | | | | | | | | | | | | | |
| *Cyclop vicinus* | ♀ | 1.680±0.109 | 1.342±0.093 | 1.408±0.089 | 1.354±0.09 | - | - | - | 1.455±0.014 | - | 1.715±0.100 | 1.755±0.075 | 1.830±0.118 |
| *C. vicinus* | ♂ | 1.318±0.059 | 1.174±0.072 | 1.101±0.027 | - | - | - | - | 1.076±0.007 | - | 1.216±0.051 | 1.368±0.063 | 1.403±0.085 |
| *Mesocyclops leuckarti* | ♀ | - | - | - | 1.143±0.066 | 0.999±0.108 | 0.998±0.059 | 1.026±0.070 | - | - | 1.222±0.128 | - | - |
| *M. leuckarti* | ♂ | | | | 0.701±0.009 | 0.671±0.018 | 0.687±0.016 | 0.653±0.021 | - | - | - | - | - |
| *Thermocyclops crassus* | ♀ | - | - | - | 0.844±0.025 | 0.806±0.029 | 0.781±0.054 | 0.779±0.052 | 0.806±0.036 | 0.807±0.037 | 0.845±0.021 | - | - |
| *T. crassus* ♂ | | | | | 0.650±0.018 | 0.639±0.013 | 0.651±0.024 | 0.617±0.013 | 0.625±0.016 | 0.630±0.012 | 0.658±0.009 | - | - |
| *Eucyclops speratus* | ♂ | - | - | - | - | - | - | - | - | - | - | - | 0.818±0.013 |
| **Average** | ♀ | **1.680±0.109** | **1.342±0.093** | **1.408±0.089** | **1.114±0.060** | **0.902±0.068** | **0.889±0.056** | **0.898±0.061** | **1.130±0.025** | **0.807±0.037** | **1.261±0.083** | **1.755±0.075** | **1.830±0.118** |
| | ♂ | **1.318±0.059** | **1.174±0.072** | **1.101±0.027** | **0.675±0.013** | **0.655±0.015** | **0.669±0.02** | **0.635±0.017** | **0.850±0.012** | **0.630±0.012** | **0.937±0.03** | **1.368±0.063** | **1.110±0.049** |

**Table 3**. Mean number of zooplankton eggs (Rotifera, Cladocera and Copepoda) (-: Absent).

| | Months | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | **Mar 07** | **Apr** | **May** | **Jun** | **Jul** | **Aug** | **Sep** | **Oct** | **Nov** | **Dec** | **Jan 08** | **Feb** |
| **Rotifera** | Egg number | | | | | | | | | | | |
| *A. girodi* | - | | - | - | - | - | - | - | - | - | - | - |
| *B. budapestinensis* | - | - | - | - | - | - | - | 1±0 | - | | | |
| *B. calyciflorus* | 1±0 | - | 2.12±0.114 | 1.11±0.021 | 1.09±0.24 | - | 1.82±1.286 | 1±0 | 1.33±0.565 | 1±0 | 2.27±0.907 | 3.58±1.452 |
| *B. quadridentatus* | - | - | - | | | - | - | - | - | - | - | - |
| *B. angularis* | - | - | 1.98±0.875 | 1.31±0.365 | - | - | - | - | - | - | 1.67±0.577 | 1.93±0.857 |
| *F. longiseta* | 2.30±1.488 | 1.23±0.856 | - | 2.81±1.216 | - | - | 1±0 | - | 1.54±0.820 | - | 1±0 | 2.25±0.866 |
| *F. opoliensis* | - | - | - | | | - | 1.64±0.245 | - | - | - | - | |
| *H. mira* | - | - | - | 1.21±0.863 | - | - | 1.12±0.215 | 1.27±0.647 | 2±1.732 | - | - | |
| *K. cochlearis* | 1±0 | 1±0 | 1±0 | - | - | - | - | - | - | 1±0 | - | - |
| *K. tecta* | 1±0 | 1±0 | - | - | - | - | - | - | - | 1±0 | - | 1±0 |
| *K. tropica* | - | - | - | - | 1±0 | 1.36±0.563 | - | - | - | - | - | |
| *N. squamula* | - | - | - | - | - | - | - | - | - | - | - | - |
| *P. dolichoptera* | 2.25±1.258 | - | - | - | - | - | 2.56±1.231 | 2.11±0.956 | 1.63±0.542 | - | 1.33±0.492 | 1±0 |
| *P. sulcata* | 1±0 | 1.35±0.546 | 1±0 | - | 2±0.634 | - | 1.22±0.223 | 1.25±0.746 | 1.14±0.378 | 1±0 | 1±0 | 1±0 |
| *Synchaeta* sp. | - | - | - | - | - | | - | - | - | - | - | |
| **Average** | **1.42±0.658** | **1.15±0.174** | **1.52±0.608** | **1.61±0.804** | **1.36±0.553** | **1.36±0** | **1.56±0.582** | **1.33±0.678** | **1.53±0.325** | **1±0** | **1.45±0.534** | **1.79±1.030** |
| **Cladocera** | | | | | | | | | | | | |
| *C. rectangula* | 1.33±0.577 | - | - | - | - | - | - | - | - | - | - | - |
| *B. longirostris* | 2.15±0.988 | 1.32±0.477 | 1.33±0.577 | - | - | 3.25±3.862 | - | 1.29±0.487 | 1.14±0.441 | 1.07±0.258 | 1.25±0.441 | 1.2±0.427 |
| *C. pulchella* | - | - | 1.86±1.069 | 1.09±0.436 | 1.17±0.387 | 1.67±0.577 | 1.92±0.515 | 2±0.632 | 1.69±0.480 | 1.69±0.480 | 1.38±0.506 | - |
| *D.birgei* | - | - | 2.5±1.098 | 1.33±0.577 | 1.33±0.516 | 1.36±0.497 | - | - | - | - | - | - |
| *M.micrura* | - | - | - | - | - | - | 1±0 | - | - | - | - | - |
| **Average** | **1.74±0.579** | **1.32±0** | **1.89±0.586** | **1.21±0.169** | **1.25±0.113** | **2.09±1.014** | **1.46±0.651** | **1.64±0.502** | **1.41±0.389** | **1.38±0.438** | **1.31±0.092** | **1.20±0** |
| **Copepoda** | | | | | | | | | | | | |
| *C. vicinus* ♀ | 62±9.798 | - | 21.25±4.351 | 34.5±7.778 | - | - | - | - | - | 80.67±1.154 | 69.3±11.21 | 77.31±16.778 |
| *M. leuckarti* ♀ | - | - | - | 59.75±6.962 | 47.5±5.97 | 37.83±6.524 | 42.6±2.881 | - | - | - | - | - |
| *T. crassus* ♀ | - | - | - | 20.91±3.449 | 15.88±2.522 | 16±3.464 | 20±4.175 | 14.75±3.594 | - | - | - | - |
| **Average** ♀ | **62±9.798** | **-** | **21.25±4.351** | **38.38±6.063** | **31.69±4.246** | **26.91±4.994** | **31.3±3.528** | **14.75±3.594** | **-** | **80.67±1.154** | **69.3±11.21** | **77.31±16.778** |

The relationship between some water parameters and Rotifera body size and number of eggs is presented in Table 4. It is understood from the table that there was a significant relationship between temperature and body size of *Asplanchna girodi* ($R^2$ = 0.585), *B. angularis* ($R^2$ = 0.50), *F. longiseta* ($R^2$ = 0.75), *K. tecta* ($R^2$ = 0.86), *P. sulcata* ($R^2$ = 0.52). There was a significant relationship between chlorophyll-*a* and body size of *F. longiseta* ($R^2$ = 0.78), *H. mira* ($R^2$ = 0.54), *P. sulcata* ($R^2$ = 0.53) and there was a significant relationship between temperature of number of eggs of *P. dolichoptera* ($R^2$ = 0.74) and *P. sulcata* ($R^2$ = 0.50). However, there was no relationship between chlorophyll-*a* - eggs number and body size - eggs number.

We found that there was a significant relationship between *B. longirostris* body size - temperature ($R^2$ = 0.56) and body size - chlorophyll-*a* ($R^2$ = 0.56). Similarly there was a significant relationship between temperature and eggs number of *D. birgei* ($R^2$ = 0.68).

It was found that there was a significant relationship between temperature and body size of male and female *C. vicinus* individuals and female *M. leuckarti* individuals ($R^2$ = -0.71, $R^2$ = -0.76, $R^2$ = -0.70 respectively). Similarly, there was a significant relationship between chlorophyll-*a* and body size of female *M. leuckarti* and *T. crassus* individuals ($R^2$ = 0.97, $R^2$ = 0.62). We found a significant relationship between temperature and eggs number of *C. vicinus* ($R^2$ = 0.89) and between chlorophyll-*a* and eggs number of *M . leuckarti* and *T. crassus* ($R^2$ = 0.87, $R^2$ = 0.79) (Table 4).

Rare species, found in a few months, *Brachionus quadridentatus* Hermann, 1783, *Filinia opoliensis* (Zacharias, 1898), *Keratella tropica* (Apstein, 1907), *Notholca squamula* (Müller, 1786), *Synchaeta* sp., *Coronatella rectangula* (Sars, 1862) and *Eucyclops speratus* (Lilljeborg, 1901) have not been evaluated.

## Discussion

It was reported in the literature that body size of zooplankton species typically show variations in temperate, subtropical and boreal (Northern) waters depending on seasons and temperature (Kiefer and Fryer 1978; Crawford and Daborn 1986). Vijverberg (1989) reported that there was a strong relationship between body size of zooplankton species and temperature in culture conditions. Some scientists reported that water temperature was the primary factor in determining body size of zooplankton species and that body size increases when food amount increases (Coker 1933; McLaren 1963; McLaren 1965).

In the present study we obtained similar results. We found that *A. girodi*, *B. angularis*, *F. longiseta*, *K. tecta*, *B. budapestinensis*, *C. pulchella*, *C. vicinus*, *M. leuckarti*, *T. crassus* reached the highest body size in winter months with low temperature; while *B. calyciflorus*, *H. mira*, *K. cochlearis*, *P. dolichoptera*, *P. sulcata* and *B. longirostris* reached the highest body size in spring with relatively lower temperatures. On the contrary *D. birgei* and *M. micrura* reached the highest body size in July. It was found that *K. tecta*, *P. dolichoptera*, *B. budapestinensis*, *P. sulcata*, *A. girodi*, *B. calyciflorus*, *F. longiseta*, *H. mira*, *B. longirostris*, *C. pulchella*, *D. birgei* and *M. micrura* generally had the lowest body size in warm summer and autumn months. On the other hand, female *C. vicinus* individuals had the lowest body size in April; female *M. leuckarti* had the lowest body size in August and *T. crassus* reached the lowest body size in September. Furthermore, it was found that there was an inverse and significant relationship between temperature and most of Rotifera species. There was significant relationship between temperature and body size of only *B. longirostris* from Cladocera. We found that there was a significant relationship between temperature and body size values of male and female of *C. vicinus* individuals from Copepoda and female of *M. leuckarti* individuals.

This indicates that direct impact of water temperature on zooplankton body size. However, other environmental factors such as abundance of food and favorable conditions should also be taken into account to determine annual size differences (Kerfoot 1974; Czeczuga et al. 2003).

It was reported that primary factors that affect zooplankton eggs number were temperature, dissolved oxygen and population density. Furthermore, number of eggs varies in case of high level of competition. However, the significance and effect of these factors under natural conditions are not exactly known (Green 1966). On the other hand, it was reported that number of eggs was related with food and metabolic stages (Kerfoot, 1974). Decrease of food sources or deterioration of environmental conditions decreases number of eggs. Eggs number is known to be higher in favorable environment and abundant food conditions (Czeczuga et al. 2003).

In this study we observed that *B. calyciflorus* and *P. sulcata* carried eggs for 10 months; *B. longirostris* and *C. pulchella* carried eggs for 9 months; *F. opoliensis* carried eggs for 7 months; *C. vicinus* carried eggs for 6 months; *T. crassus* carried eggs for 5 months. Since *A. girodi* species from Rotifera gives birth, it does not carry eggs.

**Table 4.** The relationship between water parameters and zooplankton (Rotifera, Cladocera and Copepoda) body size, and eggs number (-: Absent).

| **Rotifera** | | **Temperature-Body Length** | **Chlorophyl-*a*- Body Length** | **Temperature–Egg Number** | **Chlorophyl-*a*- Egg Number** | **Body Length-Egg Number** |
|---|---|---|---|---|---|---|
| *A. girodi* | | $R^2$ = -0.585 | $R^2$ = -0.35 | - | - | - |
| *B. calyciflorus* | | $R^2$ = -0.18 | $R^2$ = -0.19 | $R^2$ = -0.16 | $R^2$ = -0.11 | $R^2$ = 0.17 |
| *B. angularis* | | $R^2$ = -0.50 | $R^2$ = -0.41 | - | - | $R^2$ = 0.06 |
| *F. longiseta* | | $R^2$ = -0.75 | $R^2$ = -0.78 | $R^2$ = 0.03 | $R^2$ = -0.15 | $R^2$ = 0.18 |
| *H. mira* | | $R^2$ = -0.12 | $R^2$ = -0.54 | - | - | $R^2$ = 0.17 |
| *K. cochlearis* | | $R^2$ = -0.01 | $R^2$ = -0.04 | - | - | $R^2$ = #N/A |
| *K. tecta* | | $R^2$ = -0.86 | $R^2$ = -0.18 | - | - | $R^2$ = #N/A |
| *P. dolichoptera* | | $R^2$ = -0.48 | $R^2$ = -0.35 | $R^2$ = 0.74 | $R^2$ = 0.43 | $R^2$ = -0.19 |
| *P. sulcata* | | $R^2$ = -0.52 | $R^2$ = -0.53 | $R^2$ = 0.50 | $R^2$ = 0.49 | $R^2$ = -0.25 |
| **Average** | | $R^2$ = -0.39 | **$R^2$ = -0.44** | **$R^2$ = 0.001** | **$R^2$ = -0.001** | **$R^2$ = 0.02** |
| **Cladocera** | | | | | | |
| *B. longirostris* | | $R^2$ = -0.56 | $R^2$ = -0.56 | $R^2$ = 0.43 | $R^2$ = 0.31 | $R^2$ = -0.12 |
| *C. pulchella* | | $R^2$ = -0.31 | $R^2$ = -0.44 | $R^2$ = -0.04 | $R^2$ = 0.02 | $R^2$ = -0.43 |
| *D. birgei* | | $R^2$ = -0.0003 | $R^2$ = -0.13 | $R^2$ = -0.68 | $R^2$ = -0.46 | $R^2$ = -0.07 |
| *M. micrura* | | $R^2$ = 0.37 | $R^2$ = 0.06 | - | - | - |
| **Average** | | **$R^2$ = 0.39** | **$R^2$ = 0.03** | **$R^2$ = 0.12** | **$R^2$ = 0.06** | **$R^2$ = -0.02** |
| **Copepoda** | | | | | | |
| *C. vicinus* | ♀ | $R^2$ = -0.71 | $R^2$ = -0.07 | $R^2$ = -0.89 | $R^2$ = -0.05 | $R^2$ = 0.87 |
| | ♂ | $R^2$ = -0.76 | $R^2$ = -0.26 | - | - | - |
| *M. leuckarti* | ♀ | $R^2$ = -0.70 | $R^2$ = -0.97 | $R^2$ = -0.02 | $R^2$ = -0.76 | $R^2$ = 0.79 |
| | ♂ | $R^2$ = 0.12 | $R^2$ = -0.46 | - | - | - |
| *T. crassus* | ♀ | $R^2$ = -0.16 | $R^2$ = -0.62 | $R^2$ = -0.003 | $R^2$ = -0.55 | $R^2$ = 0.12 |
| | ♂ | $R^2$ = -0.0008 | $R^2$ = -0.21 | - | - | - |
| **Female Average** | | **$R^2$ = -0.41** | **$R^2$ = -0.47** | **$R^2$ = -0.74** | **$R^2$ = -0.46** | **$R^2$ = 0.47** |
| **Male Average** | | **$R^2$ = -0.39** | **$R^2$ = -0.46** | **-** | **-** | **-** |

The Rotifera had the mean highest number of eggs in February; it had the lowest number of eggs in December. It was found that *C. vicinus* produced the highest number of eggs in December, while *M. leuckarti* and *T. crassus* produced the highest number of eggs in June. Number of Cladocera eggs showed an unsteady distribution. *B. longirostris*, *D. birgei*, *C. pulchella* were found to produce the highest number of eggs in August, May and October respectively. Thus, analysis of seasonal number of eggs in Cladocera showed no significant difference in number of eggs in any season.

It was reported that number of egg was strongly related with especially temperature, food amount and food quality (Huntley and Boyd 1984; Gaudy and Verriopoulos 2004). On the other hand, some researchers (Armitage et al. 1973; Smyly 1973; Crawford and Daborn 1986) reported that there was an insignificant relationship between fecundity and temperature increase.

In the present study, we found a significant relationship between temperature and number of eggs in *P. dolichoptera*, *P. sulcata* species from Rotifera; *D. birgei* species from Cladocera and *C. vicinus* species in Copepoda. However, we found no significant relationship between chlorophyll-*a* and number of eggs in Rotifera and Cladocera species. There was a significant relationship between chlorophyll-*a* and eggs number of *M. leuckarti* and *T. crassus* from Copepoda.

Some studies indicated that number of eggs both in sea and fresh water was strongly related with female Copepoda body size. It was reported that number of eggs increased in parallel to increase of Copepoda body size (Smyly 1968; Crawford and Daborn 1986).

We identified no significant relationship between size and number of eggs in Rotifera and Cladocera species. However, we found a significant relationship in *C. vicinus* and *M. leuckarti* species from Copepoda. In other words, number of eggs increased in parallel to body size increase.

In conclusion, it was found that body size showed seasonal variations due to the temperature. Body size was shorter in higher temperature. Only the body size of *D. birgei* and *M. micrura* showed a difference and were longer in summer (July). We also found that number of eggs was related with body size in Copepoda species excluding Rotifera and Cladocera and that body size generally increased in direct proportion to number of eggs. We found that the relationship between number of eggs and temperature increased in direct proportion in *P. dolichoptera* and *P. sulcata*, while it increased in reverse proportion in *D. birgei* and *C. vicinus*.

## Acknowledgements

This study was supported by Mustafa Kemal University, Scientific Research Projects commission (Project Number: BAP-07 M 1703).

## References

APHA 1995. Standard methods for the examination of water and wastewater. 19th ed. Washington DC.

Armitage KB, Saxena B, Angino EE. 1973. Population dynamics of pond zooplankton 1. *Diaptomus pallidus*. Herrick. Hydrobiol. 42(2-3):295-333.

Borutsky EV. 1964. Fauna of U.S.S.R., Crustacea, 3(4): Freshwater Harpacticoida. Israel Program for Scientific Translations, Jerusalem, pp. 396.

Crawford P, Daborn GR. 1986. Seasonal variations in body size and fecundity in a copepod of turbid estuaries. Estuaries 9(2):133-141.

Czeczuga B, Kiziewicz B, Mazalska B. 2003. Further studies on aquatic fungi in the river Biebrza within Biebrza National Park. Pol J Environ Stud. 12(5):531-543.

Coker RE. 1933. Influence of temperature on size of freshwater copepods (Cyclops). Int Rev Hydrobiol. 29(5-6):406-436. doi: 10.1002/iroh.19340300119

Damien-Georgescu A. 1970. Copepoda Harpacticoida (forme de apa dulce). Fauna Republicii Socialiste Romania. Crustacea. 4:1-252.

Dussart BH. 1969. Les Copepodes des eaux continentales d'Europe occidentale. Vol. 11: Cyclopodes et Biologie. Edit. Boubee & Cie, Paris, pp. 292.

Dodson SI. 2002. Rotifera. Volume 6: Asplanchnidae, Gastropodidae, Lindiidae, Microcodidae, Synchaetidae, Trochosphaeridae and Filinia. Nogrady, T. and H. Segers. ds. volume 18. Guides to the identification of the microinvertebrates of the continental waters of the World. H.J.F. Dumont, Ed.

DSI. 1975. Tahtaköpru Dam Lake Project. General Directorate of State Hydraulic Works. [in Turkish]

Edmondson WT. 1959. Rotifers, p. 420-494. In: W.T. Edmondson (ed.) Fresh-water Biology, 2nd Ed., Wiley, New York, pp. 1248.

Gaudy R, Verriopoulos G. 2004. Spatial and seasonal variations in size, body volume and body proportion (prosome: urosome ration)of the copepod *Acartia tonsa* in a semi closed ecosystem (Berre lagoon, western Mediterranean). Hydrobiol. 513(1):219-229. doi: 10.1023/B:hydr.0000018190.34856.d2

Green J. 1966. Seasonal variation in egg production by Cladocera. J Anim Ecol. 35(1):77-104. doi: 10.2307/2691

Hessen DO, Bakkestuen V, Walseng B. 2007. Energy input and zooplankton species richness. Ecography, 30(6):749-758. doi: 10.1111/j.2007.0906-7590.05259.x

Huntley ME, Boyd C. 1984. Food-limited growth of marine zooplankton. Am Nat. 124(4):455-478.

Kerfoot WC. 1974. Egg-size cycle of a cladoceran. Ecol. 55(6):1259–1270. doi: 10.2307/1935454

Kiefer F. 1978. Copepoda non-parasitica. In Illies (ed.), Limnofauna Europaea. Gustav Fischer Verlag, Stuttgart, pp. 209–223.

Kiefer F, Fryer G. 1978. Das Zooplankton der Binnengewasser. 2 teil. E. Schweizerbart'sche Verlagsbuchhandlung, Stuttgart, pp. 380.

Koste W. 1978. Rotatoria. Die Rädertiere Mitteleuropas. Ein Bestimmungswerk, begründet von Max, vol. 1, 2. Voigt Überordnung Monogononta (Germany), pp. 907.

McLaren IA. 1963. Effects of temperature on growth of zooplankton and adaptive value of vertical migration. J Fish Res Board Can. 20(3):685-727. doi: 10.1139/f63-046

McLaren IA. 1965. Some relationships between temperature and egg size, body size, development rate, and fecundity, of the copepod *Pseudocalanus*. Limnol Oceanogr. 10(4):28-538. doi: 10.4319/lo.1965.10.4.0528

Ruttner-Kolisko A. 1974. Plankton Rotifers: Biology and Taxonomy. Die Binnengenwasser, Volume XXVI/I, Suppl. Stuttgart, pp.146.

Scourfield DJ, Harding JP. 1966. A key to the British Freshwater Cladocera. Scientific Publications of the Freshwater Biological Association, No. 5 (3rd edn.), pp. 55.

Segers H. 1995. Rotifera 2: The Lecanidae (Monogononta). In: Guides to the identification of the microinvertebrates of the continental waters of the world 9 (eds. J.F. Dumont and T. Nogrady). SPB Academic Publishing, The Hague, the Netherlands.

Smyly WJP. 1968. Observations on the planktonic and profundal Crustacea of the lakes of the English Lake District. J Anim Ecol. 37(3):693-708. doi: 10.2307/3082

Smyly WJP. 1973. Bionomics of *Cyclops strenuus abyssorum* Sars (Copepoda: Cyclopoida). Oecologia 11(2):163-186. doi: 10.1007/BF00345130

Stemberger RS. 1979. A guide to rotifers of the Laurentian Great Lakes. U.S. Environmental Protection Agency, Office of Research and Development, Environmental Information Centre, Cincinnati, Ohio, pp. 226.

Ülgü M. 2008. Investigation of Tahtaköprü Dam Lake zooplankton succession. Mustafa Kemal University, Institute of Sciences, Department of Fisheries, M.Sc. Thesis, p. 43. [in Turkish]

Vijverberg J. 1989. Culture techniques for studies on growth, development and reproduction of copepods and cladocerans under laboratory and in situ conditions: a review. Freshwater Biol. 21(3):317-373. doi: 10.1111/j.1365-2427.1989.tb01369.x