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Biomass Analysis of Dominant Zooplanktonic Organisms Living in Lake Mogan (Turkey)

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Abstract: In this study carbon–length regression was established for *Arctodiaptomus bacillifer* and length–weight relationships were established for *Diaphanosoma lacustris*, *Keratella quadrata* and *Filinia longiseta*, which are abundant in Lake Mogan.

Great individual variation was determined in the carbon and nitrogen contents of *Arctodiaptomus bacillifer*, Furthermore, the length–weight regressions varied greatly for the, other zooplanktonic organisms according to sampling dates and, for some, to sampling points.

Key Words: Biomass, carbon, nitrogen, dry weight, zooplankton.

Mogal Gölü'nde Yaşayan Dominant Zooplanktonik Organizmalarının Biyomas Analizleri

Özet: Bu çalışmada Mogan Gölü'nde sık olarak gözlenen türlerden *Arctodiaptomus bacillifer*'in karbon ve nitrojen ağırlığı, *Diaphanosoma lacustris, Keratella quadrata* ve *Filinia longiseta*'nın ağırlık uzunluk ilişkileri ortaya konulmuştur.

Arctodiaptomus bacillifer karbon ve nitrojen içeriğinde oldukça büyük farklıklar ortaya konmuştur. Aynı zamanda diğer zooplanktonik organizmaların uzunluk ağırlık ilişkilerinde örnekleme tarihlerine ve bazılarında da istasyonlara göre büyük farklılıklar görülmüştür.

Anahtar Sözcükler: Biyomas, karbon, nitrojen, kuru ağırlık, zooplankton.

Introduction

Reliable estimation of the biomass of organisms in ecosytem studies is an essential requirement in the assessment of resource size and potential to sustain different levels of exploitation either by man or by other organisms.

Zooplankton biomass is commonly estimated by using biomass–length regression because of the convenience of obtaining an estimate of body mass directly from a measurment of length (1–6).

Most of these biomass studies are based on the dry weight of the body mass (6–14). Few studies have been carried out on carbon content–length regressions of zooplanktonic organisms.

Although organic carbon content–length regression is a useful measure of body mass because the energy content of an animal is related to its carbon mass, we present here both methods: carbon–length regression of *Arctodiaptomus bacillifer* and length–weight regressions of *Keratella quadrata, Filinia longiseta* and *Diaphaosoma bacillifer.*

Biomass studies of zooplanktonic organisms are not widely conducted in Turkish lakes. This study also is the first presentation of a biomass study for this country.

Study Area:

Lake Mogan is eutrophic, shallow and alluvial and is situated 20 km south of Ankara in central Anatolia (39° 47' 4" N–39° 40'30" E See Fig.1).

This lake has a surface area of 6.3 km^2. The lake is fed mainly by Sukesen stream from the west and Çayır stream from the south, and rainwater as well as snow water. The main depth of the lake is 4 m.

Sampling was conducted at four stations: station 1, located in south of the lake near the shore; station 2, located in the southwest of the lake; station 3, located in the southeast of the lake; and station 4, located in the north of the lake.

In Mogan Lake, the most significant phytoplankton genera were *Melosira, Cyclotella, Diatoma, Fragilaria, Synedra, Cocconeis, Gyrosigma, Stauroneis, Navicula, Caloneis, Cymbella, Gomphema, Epithemia, Rhopalodia, Nitzschia, Surirella, Eudorina, Pediastrum, Oocystis, Monoraphidium, Scenedesmus, Closterium, Cosmarium, Microcystis, Oscillatoria, Cryptomonas, Euglena, Phacus,* and *Peridinium.*

The temperature of the surface water was determined to be a maximum of 24°C and a minimum of 16.1°C. Dissolved oxygen varied between 3.3–23 mg/L.

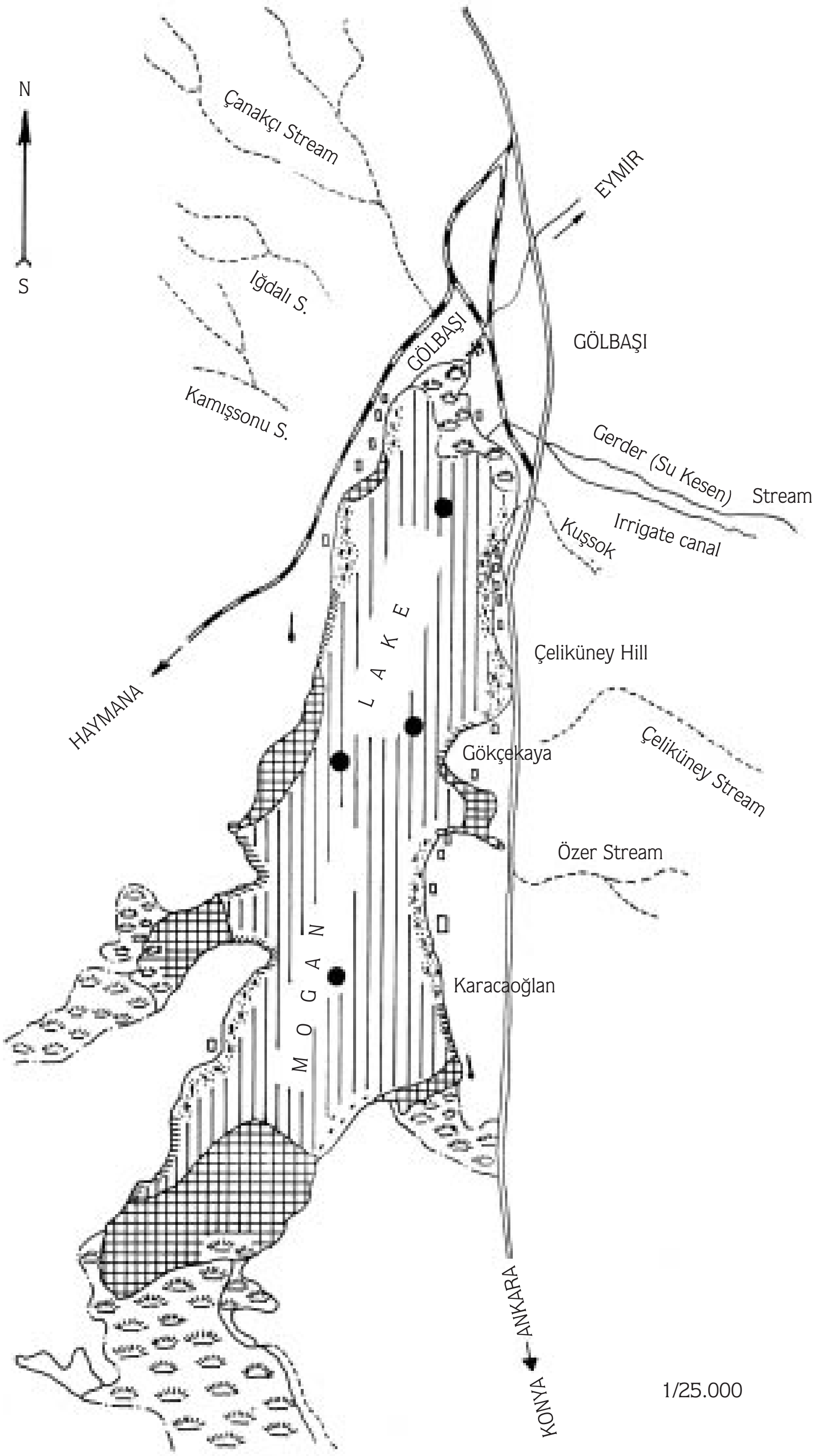

Figure 1. Sampling area.

Conductivity values ranged between 2230–3110 µS/cm. The lake water was alkaline with a pH value ranging between 8.54–9.48; the transparency of the lake varied between a maximum of 300 cm and a minimum of 200 cm. Ion concentrations were as follow: 0.26 mg/L nitrate, 0.002 mg/L nitrite, 0.28 mg/L amonium, 63.9 mg/L magnesium, 23.2 mg/L calcium, and 316 mg/L total hardness (15).

Material and Methods

Zooplanktonic organisms for biomass analysis were collected from four different stations between May and November, 1995, in Lake Mogan. The samples were taken by PATALA sampler and were preserved in 4% formaldehyde.

Thawed samples were washed with deionised water. Animals were picked up by a 10 µlt pipette and measured by a ocular micrometer under a steremicroscope, and analysed for carbon and nitrogen content.

Carbon and nitrogen analyses were performed at the institute of Gewasserökologie und Binnenfischerei by universal carbon and nitrogen analyser (CN analyser UNIQUANT Multi Sync 4 FG). The carbon analyser was calibrated with oxalic acid for carbon and with ammonium for nitrogen measurment.

Dry weight estimation was carried out according to Kolisko and Herzig (16, 12). Between 50 and 60 individuals from four different stations were measured under a stereoscopic microscope on every sampling day. Carapace length for *Diaphanosoma* and body length and width for *Keratella* and *Filinia* were measured.

All statistical analyses were carried out with the SPSS program and covariance analysis (ANOVA).

Results

Copepoda

The carbon and nitrogen analysis of *Arctodiaptomus bacillifer* is presented in Table 1:

The relation of carbon and nitrogen to length showed great individual variation, which was best described by a linear model r^2 varied from 0.629–0.849 on some sampling dates. However, no correlation was observed between length and carbon–nitrogen content.

Cladocera

Measured length and weight is shown in table 2.

According to ANOVA, there were significant differences between the sampling dates and biomass (ANOVA $F=42.8943$ $P<0.05$). However, no significant diferences were found between the stations (ANOVA $F=1.1667$ $P<0.05$) (Table 3, 4).

Rotifers

The length–weight relationship of *Keratella quadrata* and *Filinia longiseta* are shown in table 5–6.

Table 1. Average length, carbon and nitrogen analysis of *Arctodiaptomus bacillifer.*

Dates	Length (µm)	S.dev.	Carbon (µg)	S.dev.	Nitrogen (µg)	S.dev.
3.5.1995	634	142.7	2.014	1.124	0.215	0.098
30.5.1995	599	235	1.721	1.001	0.186	0.104
29.6.1995	634.8	126.8	3.49	1.236	0.211	0.211
20.7.1995	625	110	1.778	0.615	0.191	0.191
21.9.1995	691.6	126.7	3.339	2.9	0.26	0.26
21.11.1995	676.9	127.7	2.971	1.0218	0.274	0.274

Table 2. Seasonal Biomass change of Diaphanosoma lacustris.

	1. Station			2. Station			3. Station			4. Station		
Dates	Length (µm)	Weight (µg)	SD	Length (µm)	Weight (µg)	SD	Length (µm)	Weight (µg)	SD	Length (µm)	Weight (µg)	SD
3.5.1995	1395	13.99	8.13	1193	8.68	7.85	722	1.88	0.947	1281	1.079	7.102
18.5.1995	646	1.34	1.1	758	2.18	1.17	727	1.92	1.94	651	1.37	0.921
30.5.1995	840	2.98	2.34	994	4.98	2.644	1122	7.2	6.927	858	3.18	5.682
16.6.1995	694	1.66	1.12	926	4.01	4.166	852	3.11	1.052	753	2.64	1.355
29.6.1995	799	2.56	0.98	882	3.46	1.564	932	4.09	1.165	833	2.9	1.406
20.7.1995	777	2.35	1.39	787	2.44	1.729	678	1.55	0.983	745	2.06	1.279
23.8.1995	588	1.006	1.21	610	1.12	0.642	680	1.56	0.574	619	1.17	0.507
21.9.1995	618	1.17	1.07	650	1.36	1.112	631	1.25	0.914	622	1.19	0.821
12.10.1995	534	0.84	0.44	633	1.26	0.812	426	0.377	0.123	634	1.26	0.634
21.11.1995	665	1.47	0.58	–	–	–	–	–	–	–	–	–

SD = Standard Deviation

Table 3. Variance analysis of *Diaphanosoma lacustris* (ANOVA tests).

	DF	Sum of Squares	Mean Squares	F	P
Between groups	5	3754.8285	750.9657	42.895	<0.05
Within groups	474	8298.4795	17.5073		

Table 4. Variance analysis of *Diaphanosoma lacustris* (DUNCAN tests).

Dates	(Groups)	6	5	3	4	2	1
21.09.95	6						
20.07.95	5						
29.06.95	3	*					
16.06.95	4	*					
30.05.95	2	*	*	*	*		
03.05.95	1	*	*	*	*	*	

The data of variance analysis of *Keratella quadrata* showed there to be significant differences between the sampling dates and biomass (ANOVA F=44.3310 P<0.05). (Table 7, 8).

Table 5. Seasonal Biomass Change of Keratella quadrata.

	1. Station			2. Station			3. Station			4. Station		
Dates	Length (µm)	Weight (µg)	SD	Length (µm)	Weight (µg)	SD	Length (µm)	Weight (µg)	SD	Length (µm)	Weight (µg)	SD
3.5.1995	163.5	0.98	0.95	158.5	0.93	0.23	149.5	0.76	0.23	145.5	0.7	0.27
18.5.1995	147	0.72	0.17	148.2	0.73	0.1	150	0.76	0.19	145.7	0.7	0.13
30.5.1995	156	0.86	0.21	139.5	0.62	0.15	136	0.57	0.16	133.2	0.54	0.17
16.6.1995	112	0.69	0.12	146.6	0.71	0.24	116.7	0.38	0.059	131.7	0.52	0.13
29.6.1995	138.5	0.6	0.13	139	0.61	0.16	142	0.65	0.12	137.5	0.59	0.11
20.7.1995	142.5	0.66	0.14	144	0.68	0.11	145	0.68	0.12	149	0.76	0.1
23.8.1995	129.7	0.49	0.15	134.5	0.55	0.13	125.5	0.45	0.11	121	0.4	0.1
21.9.1995	113.2	0.32	0.06	120.5	0.39	0.14	114	0.33	0.07	116.5	0.36	0.1
12.10.1995	117.5	0.37	0.09	121.5	0.4	0.12	118.5	0.37	0.05	116.7	0.36	0.1
21.11.1995	139	0.61	0.06	140.5	0.63	0.13	0	0	0	140.5	0.63	0.7

SD = Standard Deviation

Table 6. Seasonal Biomass Change of Filinia longiseta.

	1. Station			2. Station			3. Station			4. Station		
Dates	Length (µm)	Weight (µg)	SD	Length (µm)	Weight (µg)	SD	Length (µm)	Weight (µg)	SD	Length (µm)	Weight (µg)	SD
3.5.1995	114	0.2	0.08	0	0	0	108	0.17	0.06	108.8	0.17	0.07
18.5.1995	124.2	0.25	0.1	0	0	0	117	0.21	0.14	–	–	–
30.5.1995	130	0.29	0.14	120	0.23	0.16	125	0.26	0.13	116.2	0.212	0.13
16.6.1995	86.6	0.094	0.06	0	0	0	124	0.25	0.54	118	0.22	0.1
29.6.1995	0	0	0	116.9	0.21	0.07	0	0	0	0	0	0
20.7.1995	122.2	0.24	0.11	140	0.37	0.1	147.5	0.43	0.037	160	0.55	0.023
23.8.1995	121	0.23	0.07	131.7	0.3	0.06	128.5	0.28	0.058	123	0.25	0.121
21.9.1995	117	0.21	0.088	120.4	0.23	0.095	118.5	0.22	0.065	123.7	0.25	0.079
12.10.1995	125.5	0.26	0.144	134.5	0.31	0.084	124	0.25	0.065	128.2	0.28	0.089
21.11.1995	118.5	0.22	0.064	0	0	0	0			155.5	0.5	0.059

SD = Standard Deviation

This data shows that biomass was highly varied in May 1995, less varied during the end of the spring and early summer, and varied through the summer. It seems that biomass was nearly uniform in September and October. Only groups 8 and 9 had no differences between them.

The variance analysis of *Filinia longiseta* showed that seasonal biomass was significantly varied (ANOVA $F=3.3291$ $P<0.05$) (Table 9). According to duncan tests, biomass was varied in September and in August, but no significant differences were found amoung the stations in terms of biomass (ANOVA $F=1.6405$ $P<0.05$).

Table 7. Variance analysis of *Keratella quadrata* (ANOVA tests).

	DF	Sum of Squares	Mean Squares	F	P
Between groups	8	19.3669	2.4209	44.3310	<0.05
Within groups	693	37.8440	.0546		

Table 8. Variance analysis of *Keratella quadrata* (DUNCAN tests).

Dates	(Groups)	8	9	7	4	5	3	6	2	1
21.09.95	8									
12.10.95	9									
23.08.95	7	*	*							
16.06.95	4	*	*	*						
29.06.95	5	*	*	*						
30.05.95	3	*	*	*	*					
20.07.95	6	*	*	*	*	*				
18.05.95	2	*	*	*	*	*				
03.05.95	1	*	*	*	*	*	*	*	*	

Table 9. Variance analysis of *Filinia longiseta* (ANOVA tests).

	DF	Sum of Squares	Mean Squares	F	P
Between groups	3	.1017	.0339	3.3291	<0.05
Within groups	280	2.8499	.0102		

Discussion

Seasonal changes in the biomass of zooplanktonic organisms showed great differences. Although some variation was found in the carbon and nitrogen contents of *Arctodiaptomus bacillifer*, no correlation was observed between the length and carbon–nitrogen content of this species, which were observed to increase in May, June and August more than the other months.

The existence of temporal variation in the length–carbon relationship for *Arctodiaptomus bacillifer* was tested by covariance analysis on six sampling dates. Only on 21 September and 21 October was the regression equation satisfied for significant correlation. There was no significant difference in intercept or slope betwen the regression for May, June and July 1995.

The body size of copepods may be influenced by food avability (17, 18) as well as by water temperature. Durbin and Durbin (19) determined that the increse in mass was higher at low temperaturs. During the time of sampling the water temperature was between 16–24°C in Mogan Lake. In addition, biomass may be influenced by the reproductive status and the quantity of lipid reserves (20).

There was great individual variation in the length–weight relation in *Diaphanosoma lacustris* according to sampling date (ANOVA $F=42.8943$ $P<0.05$), but there were no significant differences between stations in terms of biomass (ANOVA $F=1.667$ $P<0.05$) (Table 3, 4).

Cladocerans store lipids as energy reserves (21). In adults, lipid storage is dependent on the food supply. The seasonal variation in food supply influences the size of lipid stores (22). In Lake Constance Geller and Müller (23) found high variability in length–weight relationships of *D. galeata* and *D. hyalina* during the seasonal cycle in different food regimes. Many cladoceran speices also show local or temporal cyclomorphic variations in body shape, which presumably influence the relationship between length and biomass. In our data the length and biomass of *D. lacustris* were high in May, June and July, 1995, but lower in the summer and autumn, respectively.

There was great variation in the length–weight relationship in *Keratella quadrata* between the sampling dates (ANOVA F=44.3310 P<0.05) (Table 7, 8). Biomass showed the highest variation during May, and some differences also occured in June and July. Biomass was nearly uniform in autumn.

The variance analysis of *Filinia longiseta* between the biomass and sampling dates showed that there were significant differences (ANOVA F=3.3291 P<0.05) (Table 9), but no differences between the stations according to ANOVA and Duncan tests.

Weight determined for *Keratella quadrata* was much higher than those in Dumont, 1975, and Doohan and Rainbow (7) which were 0.32 and 0.35, However, the weight determined for *Filinia longiseta* was lower than the Rotifer data in the literature of 0.48 µg and 0.42 µg (13).

The present study confirms that there is significant variation in the individual length–weight relationship in zooplankton, and that it may vary locally and temporally.

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