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Abundance, biomass and seasonal dynamics of Cyclopoida (Crustacea, Copepoda) in Vaya Lake (Burgas Lake), Bulgaria

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Abstract: A quantitative analysis of Copepoda abundance and biomass in Vaya Lake (Burgas Lake, Bulgaria) was conducted at 11 sampling stations during 2003–2007, with samples collected seasonally (autumn, winter, spring and summer). The cumulative abundance recorded during the study period was 26.48 × 10^6 ind./m^3, corresponding to a mean abundance of 6.62 × 10^6 ind./m^3. Copepodites dominated the community (14.89 × 10^6 ind./m^3), followed by Nauplii (9.96 × 10^6 ind./m^3). Among adult copepods, *Cyclops vicinus* Uljanin, 1875 ranked third in abundance (1.36 × 10^6 ind./m^3), whereas *Thermocyclops oithonoides* (G.O. Sars, 1863) showed the lowest abundance (271,500 ind./m^3). The cumulative biomass recorded during the study period was 258.97 g/m^3, with the highest seasonal value observed in spring 2006. Biomass was dominated by *Cyclops vicinus* (175.05 g/m^3), followed by Copepodites (74.32 g/m^3), Nauplii (4.98 g/m^3) and *Thermocyclops oithonoides* (4.62 g/m^3). Cluster analysis based on the Bray–Curtis similarity index revealed more than 85% similarity among most sampling stations with respect to abundance. Station 12 was clearly separated from all other stations because of its exceptionally high biomass, dominated by *C. vicinus* and Copepodites, whereas stations 3, 4, 8, 1, 11, 2 and 6 showed approximately 87% similarity. Seasonal dynamics were characterized by contrasting patterns in juvenile and adult development: Nauplii and Copepodites reached maximum abundance during winter, whereas biomass peaked in spring due to the development of the dominant species *C. vicinus*.

Key words: Copepoda, hypertrophic lake, Black Sea coastal lakes.

Introduction

Burgas Lake (Vaya) is the largest natural coastal lake in Bulgaria and is characterized by high trophic status and considerable anthropogenic pressure. Copepods, especially Cyclopoida, are an important component of zooplankton and a sensitive indicator of the ecological status of aquatic ecosystems. The hydrobiological characteristics of Burgas Lake have been addressed in several studies (Dimov, 1967; Naidenow, 1964; Nenova, 2020), but data on the quantitative development and seasonal dynamics of Copepoda remain limited. Despite previous studies on the zooplankton of Vaya Lake, long-term quantitative data on the abundance, biomass and seasonal dynamics of Cyclopoida during the period 2003–2007 have not been published.

The aim of the present study was to analyze the abundance, biomass, and seasonal dynamics of Copepoda (Cyclopoida) in Burgas Lake during the period 2003–2007.

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Material and Methods

The study was conducted during 2003–2007 at 11 hydrobiological stations (St. 1, 2, 3, 4, 5, 6, 7, 8, 9, 11 and 12) in Vaya Lake (Fig. 1), with seasonal sampling (spring, summer, autumn, winter). Station 10 was not included due to its location outside the main sampling area. The winter 2006 sampling was not conducted due to ice cover; the annual cycle for 2006 was completed during winter 2007 and both years are treated as a combined period (2006–2007). A total of 167 quantitative zooplankton samples were collected using a small Apstein plankton net by direct filtration of measured water volumes and fixed with 4% formaldehyde. Laboratory processing followed the modified Hensen–Dimov method (Dimov 1959). Copepods were identified to species level; juvenile stages were grouped as Nauplii and Copepodites. Abundance was expressed as individuals per cubic metre (ind./m³) and biomass as g/m³, calculated using standard individual weights (Zhadin 1960). Cluster analysis was performed using the Bray–Curtis similarity index in PRIMER v.6.1.6.

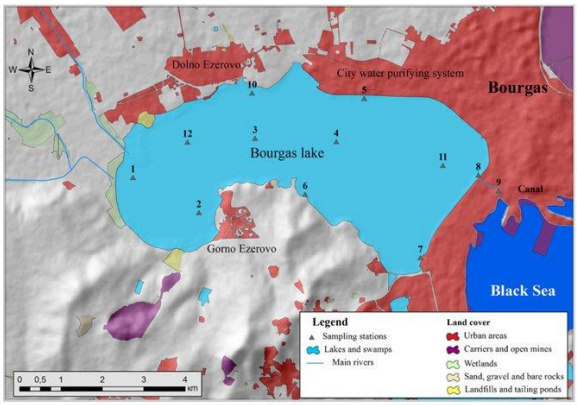

Fig. 1. Location of sampling stations on Vaya Lake.

Results

Seasonal Dynamics of Abundance. The total abundance of Copepoda during the study period was 26.48 × 10⁶ ind./m³, with a maximum recorded in 2006–2007 (10.36 × 10⁶ ind./m³) and a minimum in 2005 (6.02 × 10⁶ ind./m³). The peak occurred in winter 2004 (4.49 × 10⁶ ind./m³), coinciding with maxima of Nauplii, Copepodites, and *Cyclops vicinus*, characterized as a cryo-stenothermic euplanktonic species (Maier 1998). Seasonal fluctuations in cyclopoid abundance were associated with diatoms and cryptomonads, the main food source for adults (Hansen & Jeppesen 1992).

In 2006–2007, the abundance maximum shifted to spring. In eutrophic water bodies, copepodite stages (IV) enter diapause from mid-summer until the following spring, depending on depth and organic carbon in the substrate (George 1973). The highest abundance was recorded at St. 12, 3, and 4, and the lowest at St. 5 and St. 9 (Fig. 2, Fig. 3). The summer maximum in 2005 may be related to high temperature, elevated pH, and oxygen saturation. *C. vicinus* and *Acanthocyclops vernalis* (Fischer, 1853) tolerate increased pH (Hansen et al. 1992), which may reduce fish predation on cyclopoids (Jeppesen et al. 1990). In 2006–2007, the spring maximum coincided with peak nauplii and *C. vicinus*. Copepodites numerically dominated the community (14.89 × 10⁶ ind./m³), exhibiting two peaks — during the winter and autumn of 2004. Nauplii ranked second in abundance (9.96 × 10⁶ ind./m³), with peaks recorded in the winter of 2004 and the spring of 2006. The abundance of *Cyclops vicinus* reached 1.36 × 10⁶ ind./m³, with a maximum observed in the spring of 2006. *Thermocyclops oithonoides* (271,500 ind./m³) occurred only during the warm months and showed an increasing trend over the study years.

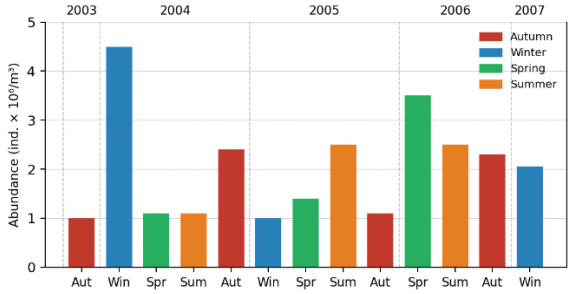

Fig. 2. Seasonal dynamics of total Copepoda abundance.

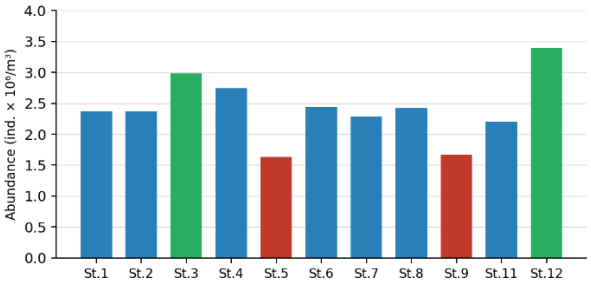

Fig. 3. Distribution of abundance by sampling station.

Seasonal Dynamics of Biomass. The total biomass of Copepoda was 258.97 g/m³, with a maximum recorded in 2006–2007 (107.50 g/m³) and a minimum in 2004 (52.11 g/m³). The seasonal peak occurred in the spring of 2006 (Fig. 4), in contrast to abundance, whose maximum was observed during the winter of 2004. During the entire study period, biomass was dominated by Cyclops vicinus (175.05 g/m³), Copepodites (74.32 g/m³), Nauplii (4.98 g/m³), and Thermocyclops oithonoides (4.62 g/m³). Among the sampling stations, St. 12 was clearly distinguished by the highest biomass (50.16 g/m³), followed by St. 3 and St. 4 (approximately 28.4 g/m³). The lowest biomass values were recorded at St. 5 (12.87 g/m³) and St. 9 (14.54 g/m³) (Fig. 4, Fig. 5).

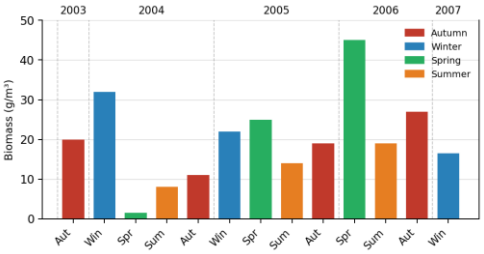

Fig. 4. Seasonal dynamics of total Copepoda biomass.

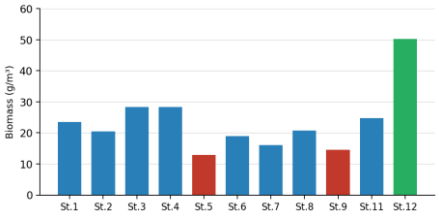

Fig. 5. Distribution of biomass by sampling station.

Similarities and Differences. Cluster analysis based on abundance (Fig. 6) showed that most stations formed a single cluster with more than 85% similarity. St. 5 and St. 9 were separated as a distinct group (approximately 98% mutual similarity), characterized by consistently lower values associated with low conductivity and alkalinity. The dendrogram based on biomass (Fig. 7) clearly distinguished St. 12 due to the exceptionally high biomass of Cyclops vicinus and Copepodites. Approximately 87% similarity was observed among St. 3, 4, 8, 1, 11, 2, and 6, whereas St. 5, 7, and 9 shared around 77% similarity.

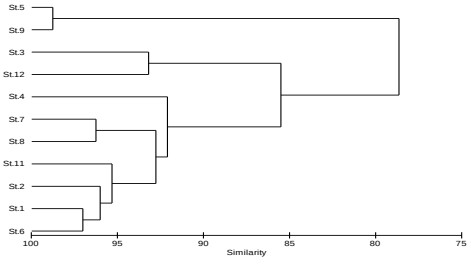

Fig. 6. Dendrogram of similarity in Copepoda abundance (Bray-Curtis index).

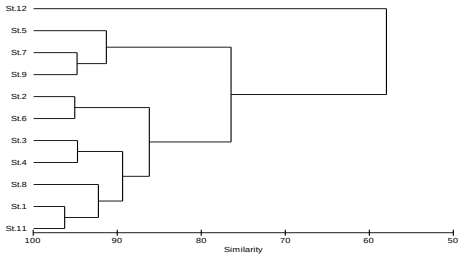

Fig. 7. Dendrogram of similarity in Copepoda biomass (Bray-Curtis index).

Copepoda constituted 95.3% of the zooplankton community, consistent with of Burgas Lake. This finding is consistent with previous studies indicating that hypertrophic lakes are typically characterized by the dominance of cyclopoid copepods and reduced zooplankton diversity (Jeppesen et al. 2000). The inverse relationship between abundance (winter maximum dominated by juvenile forms) and biomass (spring maximum dominated by *Cyclops vicinus*) represents a typical pattern for the temperate climatic zone. The antiphase development of *C. vicinus* and *Thermocyclops oithonoides* reflects their different temperature preferences. The low values recorded at St. 5 and St. 9 are associated with low conductivity, alkalinity, and oxygen deficiency (Dimov 1967), whereas the exceptionally high biomass at St. 12 is related to the predominance of the large-sized *C. vicinus*.

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