



Spatial and Temporal Distribution of Calanoida (Crustacea: Copepoda) from Lake Ohrid Pelagic Zone[#]

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Abstract: The representatives of Calanoida: *Eudiaptomus gracilis* Sars and *Arctodiaptomus steindachneri* Richard are the most important links in the food chain in lake ecosystems. Their postembryonic development is very complicated and its duration is more months. So great part of its life they are in larval stage and have great role in total zooplankton biomass. In this paper the review of the spatial and temporal distribution of calanoids in the Lake Ohrid pelagic zone during 2008 is given. According to obtained results, density of calanoids is variable and seasonal successions in the temporal distribution of their maximal development were noted. *E. gracilis* is perennial form permanently present in open water. The continuous dominance of copepodid stages were noted during the year. The intensive reproduction and development of the larval stages is during winter-summer period. *A. steindachneri* is perenial form permanently present in open water. During the autumn, winter and summer period the population is presented only with developmental stage copepodid V, less stage IV. The intensive reproduction and development of the larval stages is during summer period. The obtained results are contribution to our long-term investigations of Lake Ohrid zooplankton and enable registration of possible changes in function of time.

Key words: Lake Ohrid, pelagic zone, Calanoida, distribution.

Introduction

Long-time investigations data shows that the most of the plankters has successive appearance, in different time and in certain water layers, searching for the optimal conditions for their life strategies and for the plankton community at whole. Depends on environmental conditions, according to different authors, the dynamic and seasonal successions are closely connected with different factors: food, temperature, light intensity, competition, predation and allelopathy (Hutchinson, 1967; Gliwicz, 1977; Sommer, 1989). According to the Lake Ohrid zooplankton investigations, the Copepoda species are at the first place with its number. They are the most stabile element in the lake plankton community (Kozminski, 1935; Serafimova-Hadžišče, 1957). In the zooplankton, there are two permanently present copepods from the order Calanoida: *E. gracilis* and *A. steindachneri*. Their postembryonic development is very complicated and its duration is more months, so they have great role in the total zooplankton biomass, which is very important in the food chain and for the biological transformation of the energy in the lake ecosystem.

According to the former investigations of the dynamic of the maturity stages (adult) as of the developmental stages (naupliar and copepodid), certain successions or temporal displacing of their populations were noted (Kostoski, 1997; Guseska, 2007).

In this paper, the population dynamics of *E. gracilis* and *A. steindachneri* during year 2008 is showed. Our investigations continued the former long-time zooplankton investigations and its aim is to determine the age structure of the populations, their developmental stages, life cycle of this two species in the Lake which is very important for the determination of its stability in the plankton community.

Material and Methods

The material was collected in the period February - December, 2008, from the pelagic zone of the Lake Ohrid, with monthly dynamic. Material was sampled with Ruttner-sampler from one

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stationary point from the following depths: 0m, 10m, 20m, 30m, 40m, 50m, 75m, 100m and 150m and than collected in plastic bottles of 100 ml, and fixed with 4% formalin.

The qualitative and quantitative analyses are made under the inverted Leica DM IRB microscope in 50 ml chambers after 24 hours sedimentation (Utermöhl, 1958). The numerical values are calculated as individuals per m cubic water.

Results and Discussion

The results of the population dynamics of the *E. gracilis* and *A. steindachneri* are given in Figures 1-7. The chart of Figure 1 shows domination of the *E. gracilis* population during the winter and spring. In the zooplankton, with great numerical values are presented adults (females, males and ovigerous females), as larval developmental stages (naupliar and copepodid). This point to their intensive reproduction, when in this period of year, the population reaches its maximum. The highest maxima were noted in April (8165 ind.m^{-3}) when the larval stages are in the greatest number (Figures 2 and 3).

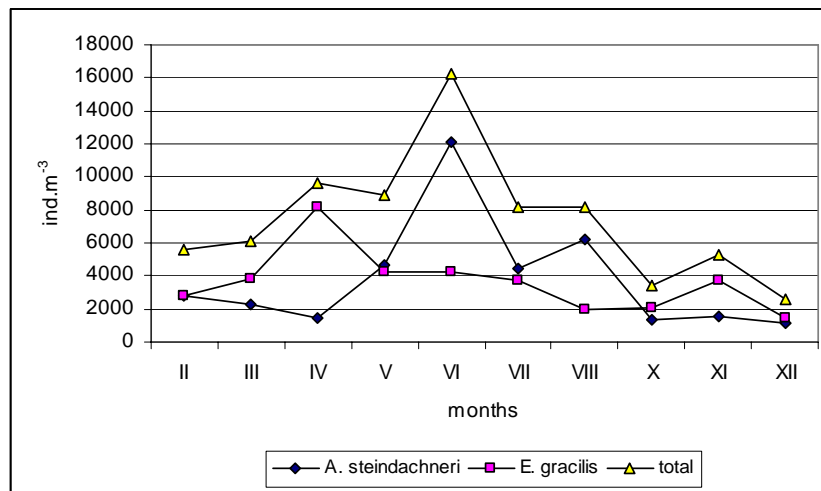


Figure 1. Population density of *E. gracilis* and *A. steindachneri* from the Lake Ohrid pelagic zone during 2008

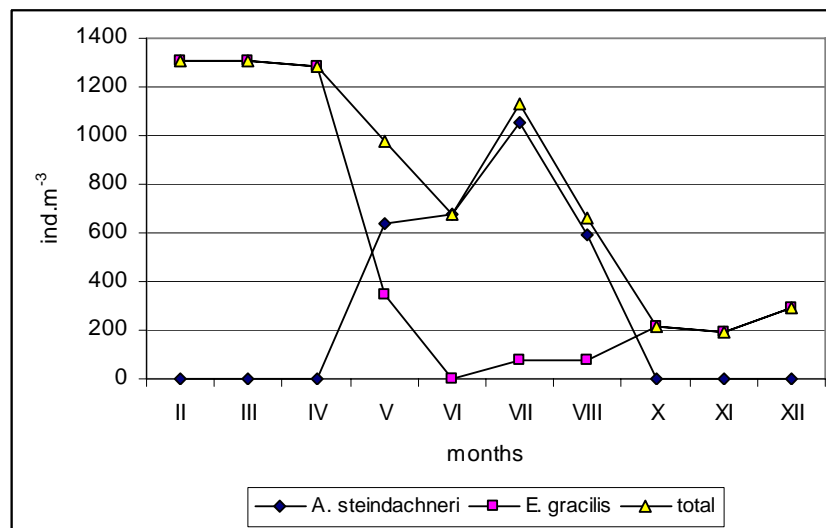


Figure 2. Population density of naupliar stages of *E. gracilis* and *A. steindachneri* during 2008

This is in accordance with density of the silicate algae which are dominated in the winter and early spring period of the year (Mitić, 1990; Mitić et al. 2001). These algae have great part in *E. gracilis* nutrition and as it known, the diatoms are very important for the egg and larval stages development (Beklemišev, 1954). Probably, the food is one of the most important factors for this population maximum of *E. gracilis* in this period of the year.

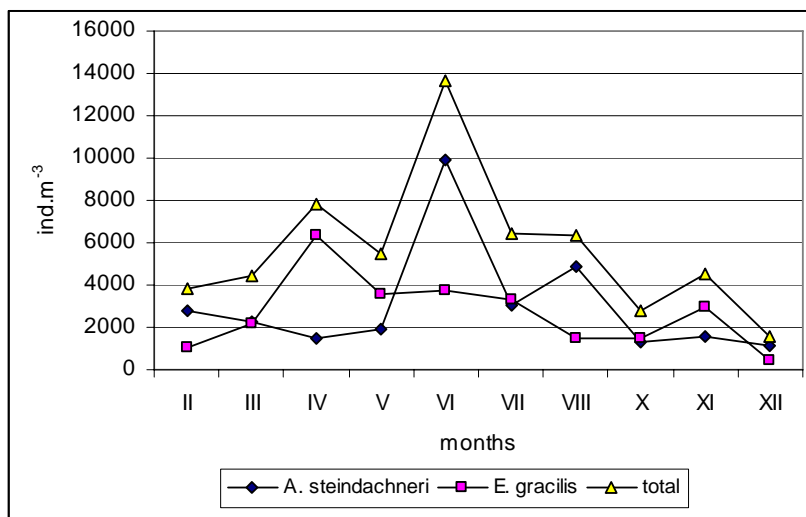


Figure 3. Population density of copepodid stages of *E. gracilis* and *A. steindachneri* during 2008

In the same period, the population of *A. steindachneri* has low density (Figure 1). In the zooplankton, the naupliar stages and adult organisms are absent; only the presence of the copepodid stages IV and V was noted.

During the summer period dominated *A. steindachneri* population (Figure 1). In the zooplankton, with great numerical values are present adult organisms (females, males and ovigerous females), as larval stages (naupliar and copepodid) which shows the intensive reproduction. In this period the population reaches its maximum. The highest maxima were noted in June (12154 ind.m⁻³) when the larval stages are in the greatest number (Figures 2 & 3).

In the same period of the year the greatest density of the phytoplankton was registered on 20 m depth with insignificant dominance of *Cyclotella fottii* and *Dinobryon divergens*. (At the same depth was noted dominance of the *A. steindachneri* in all developmental stages).

The population of *E. gracilis* in this period showed significant decrease and is dispersed in the deeper water layers. Its reproduction is with small intensity and the dominance of copepodid stages was noted.

With this different spatial distribution, probably competition between this two species is avoided. Although, the little is known about the food interrelations among freshwater calanoids. There are some indications that close related species can exist side by side due to the differences in their body size which lead to different food type, or different size particles as food.

During the autumn period, in the *E. gracilis* population the presence of adult females, ovigerous females and copepodid stages IV and V was noted. Their reproduction is still run.

The population of *A. steindachneri* in great number was composed of IV and V copepodid stages. In the open water they are in active state, but their development is in stagnation.

At the end of the May, with water warming, they finished their ontogenetic development and continued their life cycle.

In the Prespa Lake *A. steindachneri* is perennial, eurythermic species. During the whole year, the population was composed of all developmental stages and reproduction goes continuously during the whole year (Popovska-Stanković, 1988; Kostoski, 1998; Gušeska, 2003).

The differences in the life cycle of this species in these Macedonian lakes probably are due to differences in the trophic state and temperature oscillations in the lakes.

According to Ravera (1954), in Magiorre Lake one of the reasons for the development hampering in V-th stage is food.

Wetzel (1975) pointed out that the temperature has impact on the movement, nutrition, level of reproduction, length of the life cycle and embryonic development of the eggs. The results of the vertical distribution of the two investigated species are shown in Figures 4-7.

E. gracilis is present during the whole year in all developmental stages which direct to eurythermic species. It can be found from the surface to 150 m depth. The individuals in naupliar

phase are present from the surface to 150 m depth, but they are the most abundant in 10 - 75 m depth. During the winter and spring they are the most abundant in the surface layers from 10 to 40 m and during the summer and autumn period from 30 to 50 m depth (Figure 4).

The individuals of copepodid phase are the most abundant in layers from 10 to 75 m: from 10 to 50 m during the spring and summer months, and from 30 and 10 m in late autumn and winter (Figure 5). These results are in accordance with the previous investigations by Serafimova-Hadžišć (1957, 1975), Kostoski (1998), Gušeska (2003).

A. steindachneri in the pelagic region is permanently present and there are periods of intensive reproduction and period of slow development which is characteristic for the postembryonic development (copepodid).

During the winter and spring period, the individuals of copepodid phase are the most abundant in the water layers from 10 to 50 m depth, while in summer and autumn they are in layers from 10 to 30 m depth (Figure 7)

During the summer period the individuals of naupliar phase can be found from the surface to 150 m depth, but the greatest abundance was noted in the layers from 10 to 20 m depth (Figure 6). The adult males and females, as ovigerous females are the most abundant in the upper water layers where the temperature is higher (in the frame of 15 to 23 °C).

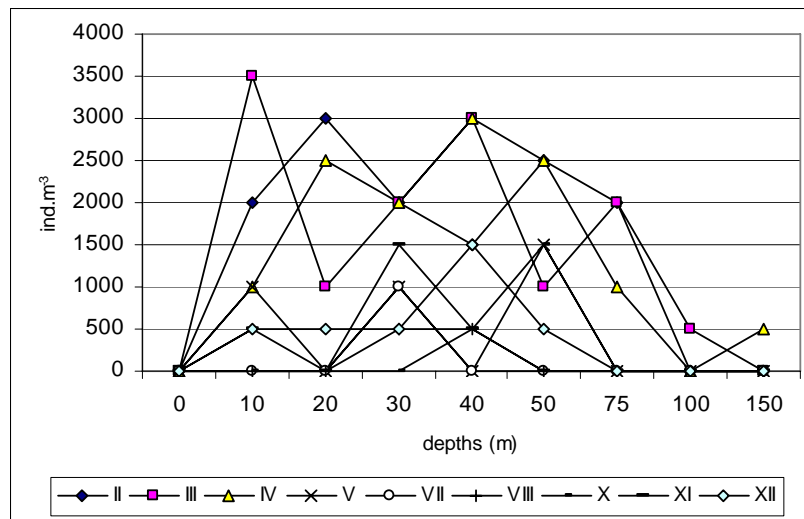


Figure 4. Vertical distribution of naupliar stages of *E. gracilis* during 2008

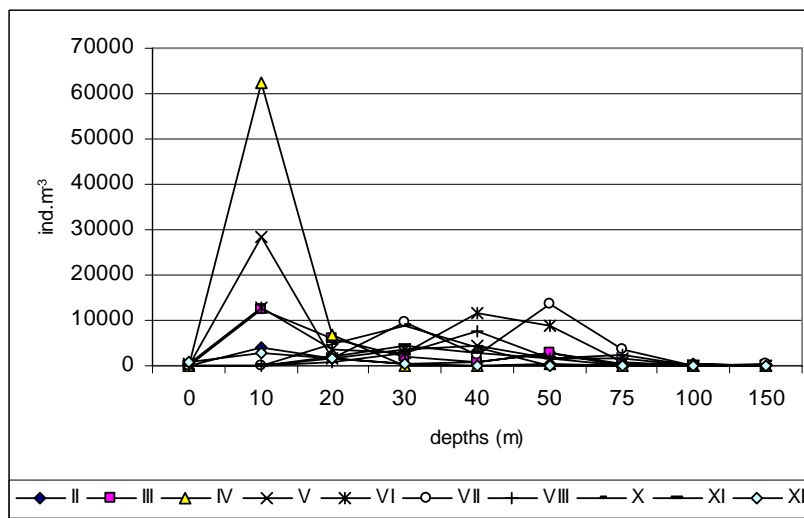


Figure 5. Vertical distribution of copepodid stages of *E. gracilis* during 2008

The obtained results showed that during the investigated period the greatest part of the population of the investigated species inhabit the water layers in the trophogenic zone of the lake, which coincide with upper heterothermic layer.

In this zone there are favourable temperature conditions, high oxygen concentrations, great quantity of dissolved organic matters, high phytoplankton production: Mitić (1987), Naumoski (2000), Patčeva (2001).

Our investigations showed that in the Lake Ohrid, although oligotrophic, these perennial species (*E. gracilis* and *A. steindachneri*) existed side by side due to the temporal and spatial distribution of their populations.

As result of this, probably competition between this two species is avoided. According to Hutchinson (1967), the competition is the decisive factor for the spatial and temporal distribution of certain planktonic populations. According to Wetzel (1975); Ruttner (1962), temperature of the lake water, as an abiotic factor is very important for the copepod distribution.

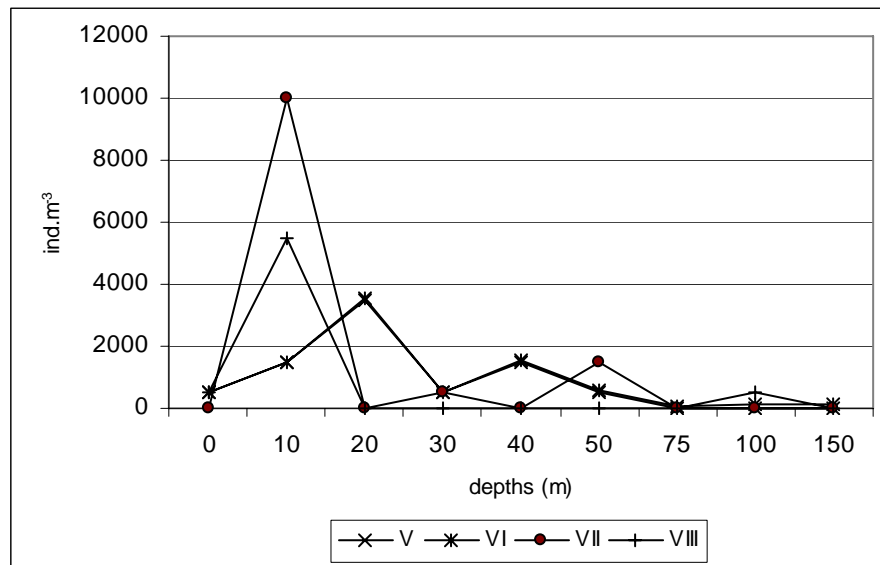


Figure 6. Vertical distribution of naupliar stages of *A. steindachneri* during 2008

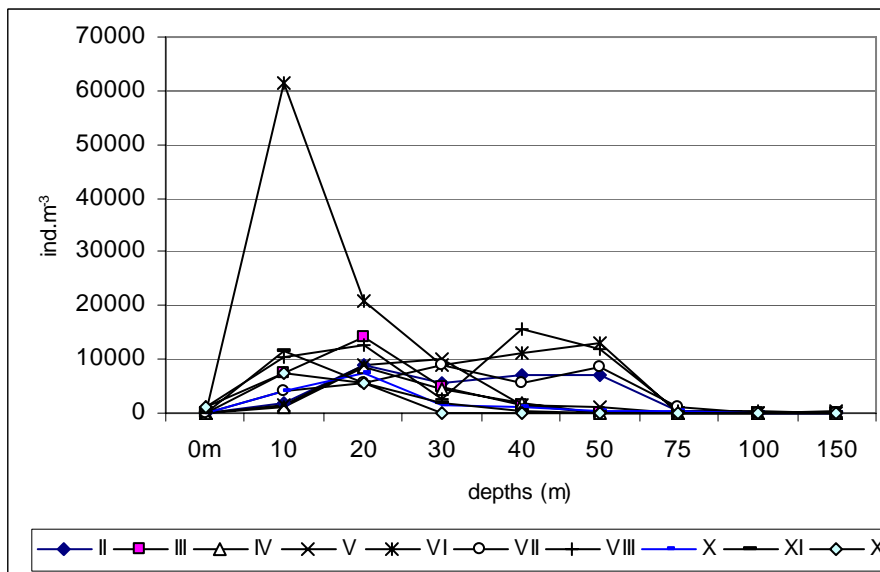


Figure 7. Vertical distribution of copepodid stages of *A. steindachneri* during 2008

The successive changes (temporal and spatial) of *E. gracilis* and *A. steindachneri* noted with our investigations are in accordance with former long-time investigations and confirm their stability in the plankton community.

Conclusions

In the period February - December 2008, the investigations of the population dynamics of species *E. gracilis* and *A. steindachneri* in the Lake Ohrid pelagic zone was done. *E. gracilis* is present during the whole year in all developmental stages, which suggested to eurythermic species.

- In the winter and spring it reached the maximal reproductive activity and maximal density: in the zooplankton with great numerical values were presented adults and developmental stages nauplii and copepodid.
- Can be found from the surface to 150 m depth, especially in the water layers from 10 to 75 m. *A. steindachneri* is permanently present in the pelagic zone, with the periods of intensive reproduction and period of slow development which is characteristic for the postembryonic development (copepodid).
- In the summer period reached maximal reproductive activity and maximal density: in the zooplankton with great numerical values were presented adults and developmental stages nauplii and copepodid.
- Can be found in the upper water layers (from 10 to 30 m depth) where the temperatures are in the frames from 10 to 23°C.

In the Lake Ohrid, although oligotrophic, these perennial species (*E. gracilis* and *A. steindachneri*) existed side by side due to the temporal and spatial distribution of their populations. The stated successive seasonal changes of the investigated species confirm their stability as in former long-time investigations.

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