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ZOOPLANKTON ABUNDANCE IN THE ALIAKMON RIVER, GREECE

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ABSTRACT. The zooplankton of the River Aliakmon was studied from February 1995 to January 1996 at two sampling stations. Seventy nine different taxa were recorded, including a possible new species (*Pleurotrocha* n.sp.). The zooplankton community was dominated by rotifers, which made up to 96% of the total abundance. The two stations differed in terms of abundance ($p<0.05$) and species composition. Upstream, abundance was less than 1131 ind m^{-3}, while it varied from 712 to 13870 ind m^{-3} downstream. The highest zooplankton densities were recorded in autumn but no seasonal pattern was observed. Water temperature, dissolved oxygen and the nitrogen and phosphorus nutrients were the main environmental parameters which were found to influence zooplankton abundance in the Aliakmon.

KEY WORDS: Zooplankton, River Aliakmon, Greece.

INTRODUCTION

Relatively little attention has been paid to river zooplankton compared with lake zooplankton, although data on zooplankton composition and seasonal dynamics exist for some rivers in Europe and America (e.g. Klimowicz, 1981; Pourriot et al., 1982; Krzeczkowska-Woloszyn, 1985; Saunders & Lewis, 1988a; Ferrari et al., 1989; Pace et al., 1991; Van Dijk & Van Zanten, 1995).

In Greece, although some information is available on the zooplankton community in lakes (Zarfdjian et al., 1990; Michaloudi et al., 1997), the present work is the first contribution to the ecology of river zooplankton. This paper describes the seasonal and spatial distribution of zooplankton in the River Aliakmon, as well as the possible influence of environmental parameters on the zooplankton community.

STUDY AREA AND METHODS

The Aliakmon river is 310 km long, and its springs are situated in the Grammos and Vernon mountains, in north-western Greece. It discharges into the Thermaikos gulf. It has a catchment area of 8443 km^2 and a mean discharge, at the mouth, of 80 m^3 sec^{-1}. The upper part of the catchment drains a mountainous area before entering a series of artificial lakes resulting from the construction of three hydroelectric dams. The river receives urban, rural and industrial wastes, which are mainly confined to the lower reaches of the river below the influence of the irrigation canal, T-66.

Samples were collected at biweekly intervals from February 1995 to January 1996 at two stations. One station was situated above the dams (upstream) (St. 1) and one (downstream) after the dams and canal T-66 (St. 2). A total of 105 l of water were taken with an electric pump at approximately 30% of the measured depth at each station. The zooplankton were retained with a 35 μm mesh size and preserved in a 4% formalin solution. All zooplankton were identified and counted.

In parallel with the zooplankton sampling, selected water quality parameters were measured *in situ* (temperature, oxygen, pH, water discharge), while water samples were taken for the analysis of nitrogen (N-NO_3, N-NO_2, ammonia-N) and phosphorus (P-PO_4), total-P, chl-a and suspended solids. For the analytical results of these

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parameters see Bobori & Mourelatos (1999) and Montesanto et al. (in press).

In order to identify the homogeneity of the taxonomic units, cluster analysis using the Bray-Curtis similarity coefficient (Bray & Curtis, 1957) was applied to the (species abundance) x (samples) table for both stations and for each station separately. Principal components analysis (PCA) was also employed in order to reduce the environmental parameters in factors that may correlate with the zooplankton abundance.

RESULTS

Species composition

A total of 79 zooplankton taxa were identified in the River Aliakmon (Table 1). The majority were found at the downstream station. Twenty three species (29%) have not previously been recorded in Greece and one may be an entirely new species (*Pleurotrocha* n.sp., R. Pourriot pers. communication). Although the list of species is large, only

TABLE 1

Zooplankton taxa identified in the Aliakmon river, February 1995-January 1996

ROTIFERA	ROTIFERA
Ascomorpha ecaudis (Perty)	*P. vulgaris* Carl.
Asplanchna priodonta Gosse	[n] [b] *Proales theodora* (Gosse)
Brachionus angularis Gosse	*Ptygura* sp.
B. calyciflorus Pallas	*Rotaria* sp.
[n] [b] *B. quadridentatus* f. *brevispinus* (Ehrb.)	[n] [b] *Scaridium longicaudum* (o.f.m.)
[b] *B. urceolaris* Müller	[n] *Sinantherina* sp.
[b] *Cephalodella gibba* (Ehrb.)	[n] [b] *Synchaeta litoralis* Rouss.
C. cf. *catellina*	*S. pectinata* Ehr.
[b] *C.* sp.	*S.* cf. *oblonga*
[b] *Colurella adriatica* (Ehrb.)	[b] *Testudinella patina* (Herm.)
C. colurus (Ehrb.)	[n] [b] *Trichocerca elongata* (Gosse)
[b] *C. uncinata* (o.f.m.)	*T. longiseta* (Schrank)
[n] [b] *Dicranophorus uncinatus* (Milne)	[b] *T. pusilla* (Lauterb.)
[b] *D. lütkeni* (Berg.)	[b] *T. rattus* (o.f.m.)
[n] [b] *Encentrum* cf. *putorius*	[n] [b] *Trichotria tetractis* (Ehrb.)
[n] *Euchlanis deflexa* (Gosse)	[b] Bdelloidea
E. dilatata Ehrb.	
[n] *E. lyra* Hudson	**CLADOCERA**
[n] *Epiphanes* sp.	*Acroperus* sp.
Kellicottia longispina (Kell.)	[n] [b] *Alona guttata* Sars
Keratella cochlearis (Gosse)	[n] [b] *Biapertura affinis* (Leydig.)
K. c. v. *tecta* Gosse	*Bosmina longirostris* (o.f.m.)
K. quandrata (Müller)	*Ceriodaphnia pulchella* Sars
[b] *Lecane bulla* (Gosse)	*C. quadrangula* (o.f.m.)
[n] [b] *L. closterocerca* (Schmarda)	[b] *Chydorus sphaericus* (o.f.m.)
[b] *L. luna* (o.f.m.)	*Daphnia cucullata* Sars
[b] *L. lunaris* (Ehrb.)	*Diaphanosoma mongolianum* Ueno
[n] [b] *L. quadridentata* (Ehrb.)	[b] *Eurycercus lamellatus* (o.f.m.)
[b] *Lepadella ovalis* (o.f.m.)	[b] *Ilyocryptus sordidus* Lievin
[n] [b] *Lindia torulosa* Dujardin	*Pleuroxus* sp.
Lophocharis salpina (Ehrb.)	*Simocephalus exspinosus* (Koch)
[b] *Mytilina mucronata* (Müller)	*S. vetulus* (o.f.m.)
[n] [b] *M. bisulcata* (Lucks)	
[n] *Notholca acuminata* (Ehrb.)	**MOLLUSCA**
[n] *N. foliacea* (Gillard)	*Dreissena polymorpha* Pal.
N. squamula (Müller)	
[n] [b] *Notomata pseudocerberus* De Beauch.	**COPEPODA**
[b] *Platyias quadricornis* (Ehrb.)	*Cyclops* sp.
[n] [b] *Pleurotrocha petromycon* Ehrb.	*Eucyclops* sp.
[n] [b] *Pleurotrocha* n.sp.	*Eudiaptomus gracilis* Sars
Ploesoma cf. *hudsoni*	*Megacyclops* sp.
Polyarthra dolichoptera Carl.	*Thermocyclops crassus* (Fischer)
P. major (Burck.)	Harpacticoida
[n] new for the Greek fauna [b] benthic and/or littoral	

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a few were common and many were recorded only once or twice. More than half of them were benthic and/or littoral (Table 1). The dominant genera are shown in Fig. 2.

Seasonal variations

Abundance was generally very low. Upstream, zooplankton densities ranged from 19 to 1131 ind m^{-3}. No animals were found from May to June, while numbers peak in November 1995 (Fig. 1a). Downstream (Fig. 1b) abundance was much higher and varied from 713 to 13870 ind m^{-3}. From May to June abundance increased, and maximum densities occured in September 1995.

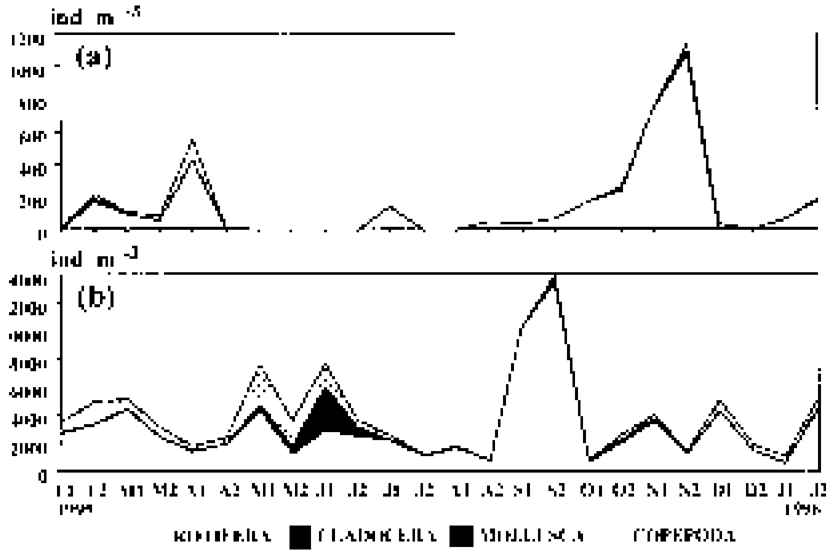

Fig. 1. – Seasonal variations of the total abundance (ind m^{-3}) and percentage contribution of the zooplankton groups in (a) St. 1 and (b) St. 2.

Rotifers dominated throughout the year, except for December 1995 at St. 1 and May 1995 at St. 2 when nauplii increased to 75 and 42%, respectively. Mollusca larvae of *Dreissena polymorpha* were present only at the downstream station (Fig. 1b), in February and from May to November of 1995, with their highest abundance (2670 ind m^{-3}) in June. Cladocera were generally only present in low numbers at both stations (0.2-11.4%), except for St. 1 in February when this group contributed 50% to the total abundance.

Spatial distribution

Abundance of zooplankton, differed significantly between the two stations (t-test=7.01, p=0.0001, DF=46). Cluster analysis also separated the two stations (Fig. 2a). All the samples of St. 2 formed group I. Group II consisted of samples of the upstream station (St. 1). Three samples from the same station formed three further groups (III, IV and V) because of the different species that dominated them compared to other samples (Fig. 2b). Group VI included all samples from the upstream station containing no animals. Cluster analysis was also performed on samples from each station separately (Fig. 2b,c). It is clear that samples were grouped mainly in relation to species dominance, and no seasonal pattern was observed.

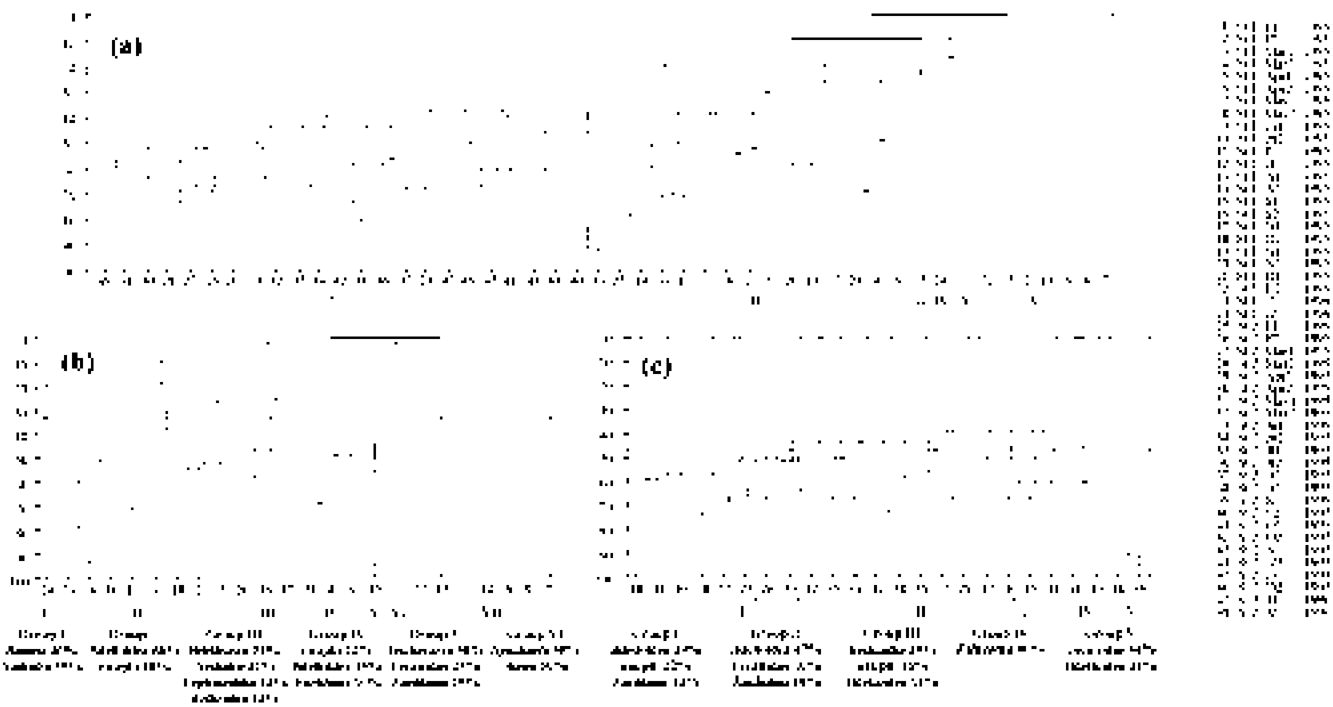

Fig. 2. – Dendrogram for clustering, based on Bray-Curtis similarities for (a) both sampling stations, (b) St. 1 and (c) St. 2, February 1995-January 1996. The species x samples combinations 1 to 48 are shown in the legend.

Influence of environmental parameters on zooplankton abundance

Principal components analysis (PCA) (Fig. 3a) extracted two main factors that explained 51% of the total variance at the upstream station. The first factorial axis (F1) associated mainly with oxygen, temperature and phosphate. Along this axis the zooplankton groups produced positive scores with oxygen and negative scores with temperature and phosphate. Nitrate, total nitrogen and rotifers showed stronger loading on the second factorial axis (F2). For the downstream station (Fig. 3b) the first two factors extracted by PCA explained 52% of the total variation. Nitrate, total nitrogen, N/P ratio and oxygen were the variables that had the stronger weighting on the first axis (F1). The distribution along the second axis (F2) was explained by nitrites and ammonium, and to a smaller degree, by pH and phosphate. The zooplankton groups were distributed on the positive part of the F1 axis. Copepods and Cladocera had positive scores on the F2 axis and were positively related to pH, while they were inversely related to nitrite, ammonia and phosphate, along the same axis. The opposite was found for rotifers and mollusc larvae.

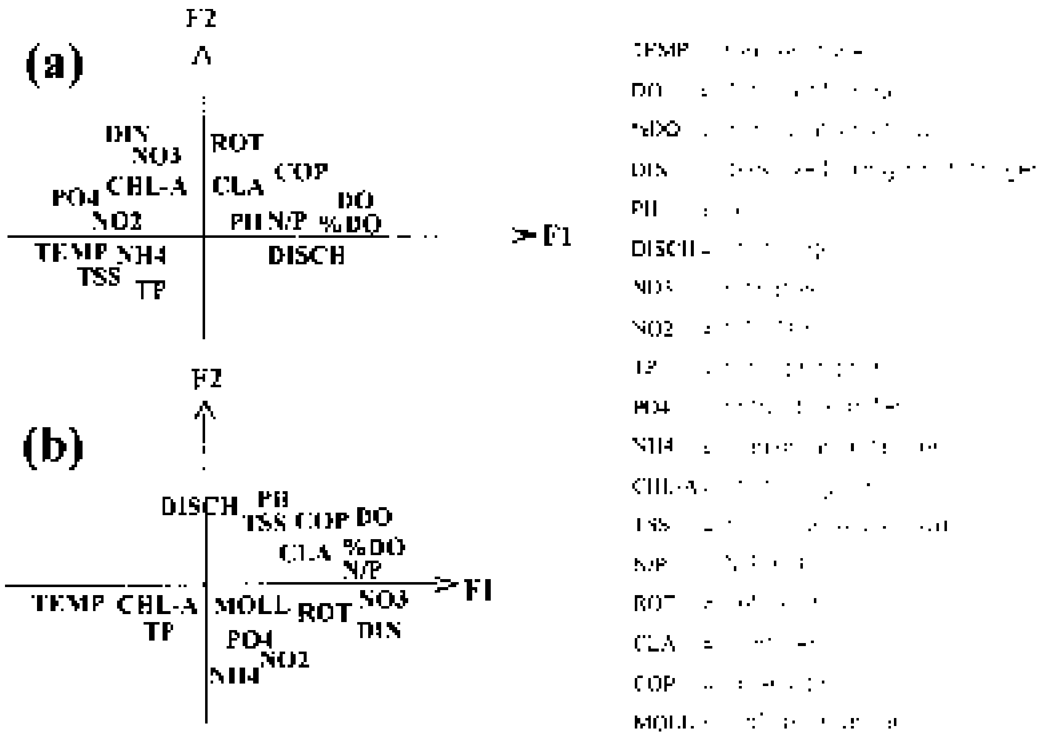

Fig. 3. – Principal components analysis of environmental parameters and abundance of the main zooplankton groups.

DISCUSSION

River zooplankton, commonly, consist of numerous species with the majority being benthic and only a few dominating (Klimowicz, 1981; Krzeczkowska-Woloszyn, 1985; Saunders & Lewis, 1988a; Brown et al., 1989; Vasquez & Rey, 1989; Zurek & Dumnicka, 1989). The same species composition was found in the river Aliakmon. However, seasonal variations in the Aliakmon exhibited no similarities with those of other rivers, where the zooplankton is characterized by low abundance in winter and high numbers in spring and summer (Klimowicz, 1981; Pourriot et al., 1982; Saunders & Lewis, 1988a,b; Van Dijk & Van Zanten, 1995). Moreover, the maximum abundance recorded in the Aliakmon was 13870 ind m^{-3}, while in large rivers densities often exceed 10^6 ind m^{-3} (Klimowicz, 1981; Ferrari et al., 1989; Van Dijk & Van Zanten, 1995). The main difference is that large rivers have high water discharge values [e.g. the river Rhine 1000-8000 $m^3 s^{-1}$ (Van Dijk & Van Zanten, 1995)] so they provide a larger water volume where animals can develop. Small rivers like the Aliakmon and the Illinois (Brown et al., 1989) with low discharge have correspondingly lower zooplankton abundance. Although water discharge is considered to be one of the main parameters affecting zooplankton seasonal variations in rivers (Saunders & Lewis, 1988a,b; Brown et al., 1989; Pace et al., 1991; Van Dijk & Van Zanten, 1995; Vranovsky, 1995), it did not explain the variations in the Aliakmon. Chlorophyll a was also of minor importance, since the majority of the species found during the present study were benthic and thus do not feed on phytoplankton. According to our results, the factors that explained the greatest percentage of the variations were nitrogen and phosphorus, which is also noted for the river Po (Ferrari et al., 1989), as well as water temperature and oxygen which are also known to influence zooplankton abundance (Allan, 1976; Wetzel, 1983).

Seasonal variations in zooplankton abundance (Fig. 1), could be partly explained by invertebrate predation since maximum abundance was recorded when the macroinvertebrates in the Aliakmon decreased in numbers (LAZARIDOU-DIMITRIADOU et al., 1999). This kind of impact has been also observed by ZUREK & DUMNICKA (1989) and BROWN et al. (1989). Fish predation is another factor affecting the zooplankton community (POURRIOT et al., 1997; POURRIOT et al., 1982; BROWN et al., 1989). The Aliakmon river has a rich fish fauna (ECONOMIDIS et al., 1981), that could have contributed to the small numbers of cladocera.

Generally, the zooplankton community of the Aliakmon was dominated by rotifers, which due to their short generation time and their high reproductive rate (ALLAN, 1976), dominate in rivers (KLIMOWICZ, 1981; POURRIOT et al., 1982; SAUNDERS & LEWIS, 1988b; VAN DIJK & VAN ZANTEN, 1995).

Considering the differences found between the two stations (Fig. 2), it seems that the distribution of zooplankton along the Aliakmon follows the general pattern noted along the course of other rivers, with higher abundance and more diverse species composition downstream (KRZECZKOWSKA-WOLOSZYN, 1985; BROWN et al., 1989). In the case of the Aliakmon the downstream station is also affected by water bodies connected to the river, such as the reservoirs, which may contribute to the species composition and abundance (KRZECZKOWSKA-WOLOSZYN, 1985; POURRIOT et al., 1997; ZUREK & DUMNICKA, 1989). The presence of mollusc larvae downstream is likely to be due to the presence of adults in the reservoirs since they are found nowhere else (LAZARIDOU-DIMITRIADOU et al., 1999). The domination of *Kellicottia* downstream coincided with the highest discharge values, probably indicating the contribution of either the resevoirs or other water bodies as was found by ZUREK (1985) in the river Brynica.

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