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THE ALPINE LAKE GISTOVA (MOUNT GRAMOS, ALBANIA-GREECE BORDER) BIODIVERSITY OF AN ISOLATED MICROCOSM

SUMMARY

The zooplankton composition of the lake Gistova has been studied for the first time. The lake is a small, permanent water body, of glacial origin, at 2365 m above the sea level on mount Gramos on the border between Albania and Greece. The lake has been visited 5 times over 4 years, during the ice/snow free period (July-September). A total of 6 zooplankton samples were collected (with nets of different mesh size), and 2 samples of the muddy sediments, too. Crustacea were represented by 7 species: a large anostracan, three copepods, three cladocerans. Five rotifer species completed the zooplankton composition. Sediments contained at least 12 different types of resting stages, whose correspondence with active stages has been ascertained only in 4 cases. The faunal assemblage of the lake Gistova has been discussed on the basis of its extreme isolation, young age, and geographic position, representing a reference point for further researches on high mountain lakes of the Balkan region.

INTRODUCTION

High altitude (Alpine) lakes show simple biological assemblages characterised by cold stenothermal species, with no endemism (Füreder *et al.*, 2006; Oertli *et al.*, 2008). This allows us to consider these biological assemblages as useful indicators in the monitoring of external perturbations (Thuillier *et al.*, 2005; Füreder *et al.*, 2006; Horicka *et al.*, 2006).

The water bodies out of any stream network (glacial ponds) perfectly correspond to the MacArthur and Wilson (1967) concept of "oceanic isle". As the oceanic islands, glacial lakes are new formed environments. They were born as desert habitats, without a pre-existing set of living beings. As a consequence, their biodiversity assemblages derive from a process of colonization mostly from neighbouring similar habitats.

The main difference between oceanic islands and glacial lakes is probably the age. In fact, the existence of oceanic islands that inspired the theory commonly spans over million years, whilst the age of present day glacial lakes cannot pass the order of few thousand years. This means that on oceanic islands the isolation favoured the evolution of typical, endemic living forms, whilst in glacial lakes this has been not allowed.

Considering the altitude as inversely correlated with the age of water habitats, this agrees with the negative correlation between number of species and altitude recognized by some Authors (Patalas, 1964; Liss *et al.*, 1998; Füreder *et al.*, 2006). However this trend is not followed by the abundance of individuals (Füreder *et al.*, 2006). When smaller organisms are considered, the zooplankton assemblage of Alpine lakes appears surprisingly rich of phytoplankton and rotifer species, overall under the ice-cover, spring period (Tolotti *et al.*, 2006).

Among planktonic crustaceans Cladocera are always more represented than Copepoda and, among these, Cyclopoida species diminish with altitude more than Calanoida, thus giving to the high altitude ponds a Calanoida biased composition (Gauthier 1928; Jersabeck *et al.*, 2001; Marrone and Naselli-Flores, 2004). In any case, Calanoida easily dominate numerically (as individuals) the zooplankton assemblages (Stoddart, 1987). As a consequence of the negative correlation existing between altitude and species richness, each lake hosts a small number of Crustacea, with a decreasing importance from Cladocera to Copepoda (an average of 3.3 species per lake, minimum 1 maximum 9, in 102 Alpine lakes on Tatra mountains, Horicka *et al.*, 2006).

Although caution has been repeatedly recommended (Hutchinson, 1967; Jeppesen *et al.*, 2000), the relative abundance of Cladocera/Copepoda species or of the Calanoida/Cyclopoida species has been repeatedly proposed as indicator of the habitat quality (Jersabeck *et al.*, 2001, Margaritora *et al.*, 2003) and could be used as an additional index to measure the variations in such sensible habitats.

Apart the negative correlation existing between species number and altitude, which leads to consider as important the extreme conditions in which the lakes stay, the small species number of Alpine lakes has been recently considered as possibly dependent by the youth of such environments (see Alfonso and Belmonte, 2009) which is inversely correlated with altitude, too, due to the relatively recent ice melting of Alpine areas.

In the framework of increasingly interest in the study of the Alpine lake ecology, here we submit the first contribution regarding a single habitat (the lake Gistova, m 2365 a.s.l.) in a region (Balkans) where we programmed to carry out such kind of studies in the next future.

MATERIALS AND METHODS

Lake Gistova is a small lake (size, 150 x 70 m) with a regular elliptic shape, and a maximum depth of about 4 m. It derives from the melting of ice-snow in a caldera on the tip of a pike (2365 m a. s. l.) of the Gramos mountain complex (maximum altitude 2523 m a. s. l.) on the border line between Southern Albania and North Greece. The lake is free of ice for about 4 months (July - October), and it never dried during the period studied. Due to its depth (maximum about 4 m) it probably exists also during winter under the ice-snow covering (Fig. 1).

The lake is about 10 Km far from any road, and has to be reached with horses. It has been visited five times during its free-ice period, on July 2006, July and September 2007, July 2008, July 2009. In two occasions (July 2008, July 2009) some abiotic features (temperature, conductivity, pH) have been measured with a multiparametric probe (HYDROMAR). The zooplankton has been collected with two plankton nets (mesh sizes, 200 and 50 μm) and immediately fixed with formalin at a final concentration of 3 % (Fig. 2).

In September 2007 also samples of bottom mud (2 replicates, each of about 200 cm^3) have been taken to search for resting stages. These samples were stored in the dark and at 4° C without any fixative.

All the samples were stored at University of the Salento (Laboratory of Zoogeography and Fauna) and, in replicates, at University of Vlorë.

Plankton collections never considered the filtered volumes, hence they have exclusively a qualitative value, although a comparative evaluation has been carried out on July 2008 on relative abundances of single *taxa*.

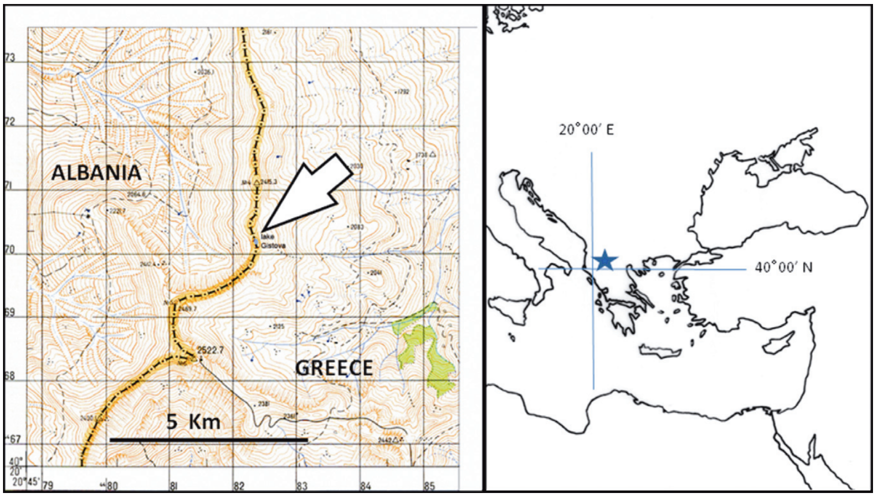

Fig. 1 - Map of the geographic position of the lake Gistova.

Fig. 2 - A. Lake Gistova at end of summer season (September 2007). B. the collecting glass at the end of the plankton net, punctuated of Calanoida copepods (red spots).

Rotifera, Cladocera, Cyclopoida, Calanoida, and Anostraca have been determined at the species level. Other *taxa* (Ostracoda, Trichoptera, Chironomida, Rhincota, Coleoptera, Protista, Nematoda, Bivalvia), even vertebrates (Amphibia, Reptilia) have been considered just to complete the information on the biodiversity of the site.

Resting stages have been isolated from sediments by means a fractionated filtration through sieves of 150, 50, and 20 μm. All the >150 μm fraction has been analyzed under the stereomicroscope to pick up organisms and resting stages (mainly Bivalves, Ostracoda, Nematoda, Cladocera ephippia, Chironomidae larvae, and Anostraca cysts). Other fractions have been analyzed in aliquots for the isolation of metazoan eggs (150 > fraction > 50 μm) and/or protistan cysts (50 > fraction > 20 μm) and classified according to size (maximum diameter), shape (oval, spherical, or other), external (type and colour of envelope), and internal (colour and type of grains) features.

RESULTS

The present is the first report on the biodiversity of the lake Gistova, and on the biodiversity of high altitude, glacial lakes in Albania.

The abiotic parameters (measured in July 2008, and July 2009) measured with a multiparametric probe, are showed in Table 1.

Table 1 abiotic parameters of the water of lake Gistova measured with the multiparametric probe HYDRONAUT. In 2008, the PAR sensor did not worked.

Date	time solar	depth cm	Temp ° C	Cond mS/cm	pH	PAR ln(µW/cm^2)	S ‰
09 July 2008	10:54	- 50	13.9	0.02	7.59	-	0.02
07 July 2009	08:20	- 50	12.1	0.02	7.70	2659.5	0.02

A general, not accurate, survey on the vertebrate fauna showed a good representation of Amphibia, with at least 3 species: *Bufo viridis, Mesotriton alpestris, Salamandra salamandra*. Fishes are completely absent from the lake.

The zooplankton samples appeared contaminated by not strictly planktonic animals as Ostracoda, and Insecta of the *taxa* Rhincota Notonectidae, Diptera Chironomidae (larvae), and Coleoptera Girinidae.

A total of 17 categories (11 species) were found in the 6 zooplankton samples collected using both the 200 and the 50 µm mesh sized plankton nets. Generally the July samples showed juvenile stages, and adults were well represented in September. Notably, Rotifera (5 species) were collected only with the 50 µm mesh sized net, and the sample of 03-July-2006 (the most precocious in the year) was lacking of Cladocera.

The most conspicuous species of the zooplankton assemblage was the anostracan here tentatively classified as *Chirocephalus* sp. (Fig. 3), whose adults were found in late summer (September 2007). The crustacean assemblage reached a total species number of 7. The rate anostracans/cladocerans/copepods was 1/3/3 (comprising one species, unidentified, of Harpacticoida). Although a quantification of numerical abundance of individuals was not carried out, the calanoid copepod *Mixodiaptomus tatricus* (nauplii, juveniles, adults) was evidently the dominant component of the assemblages (see Fig. 2B) reaching 98% of total individuals of the 200 µm net plankton, and the 94% of the 50 µm one.

The list of species found in the zooplankton at different times, is reported in Table 2.

Table 2 - list of species and organisms (not classified at the species level) found in the lake Gistova zooplankton in 5 different dates with a sampling carried out with nets having two different mesh sizes (50 and 200 µm)

taxa	**50 µm**			**200 µm**			
	15/07/07	09/07/08	07/07/09	03/07/06	15/07/07	14/09/07	09/07/08
Notholca labis	X	X					
Ascomorpha ovalis	X	X					
Lecane luna	X	X	X				
Trichocerca pusilla	X	X					
Trichocerca similis		X					
Daphnia longispina					X	X♂♀	
Chydorus sphaericus	X		X		X	X	X
Alona quadrangularis	X		X		X	X	X
Mixodiaptomus tatricus adults		X	X		X	X♂♀	X♂♀
M. t. copepodids			X	X			
M. t. naupli				X			
Acanthocyclops trajanii adults			X				X
Cyclopoida copepodids				X	X	X	
Harpacticoida undet.				X			
Chirocephalus sp. adults						X	X
C. sp. juvenes				X			
C. sp. naulpli	X						

A B

Fig. 3 - A. *Chirocephalus* sp., adult male, from lake Gjistova. B. living sample of zooplankton from lake Gistova showing the relative large size of anostracans in comparison with cladocerans (white spots) and copepods (red spots).

The analysis of sediments showed the presence of Bivalvia, Ostracoda, Chironomidae larvae, Trichoptera larvae, and Nematoda in the fraction > 150 µm. Many of them were still alive and active after 2 years of conservation in the fridge. The resting stages present in this fraction were cladoceran ephippia (each with one-two eggs), and spherical cysts (diameter of about 200 µm) attributed to *Chirocephalus* sp. Resting stages (cysts) were subdivided according 12 morpho-types in total (see Table 3) with a total abundance of more than 50,000 cysts litre^{-1} of sediment volume. Most of them (7 types) were not attributed to any metazoan species. The most represented types were *Daphnia*, *Alona*, type 2, type 1, and *Mixodiaptomus*, each with more than 5,000 cysts sediment litre^{-1}.

As it is easy to observe from Table 3, all the Cladocera of the plankton were found in the sediment also, and the only anostracan and calanoid species, too. Most of these cysts hatched an active stage which allowed the secure attribution to the species. The anostracan cysts did not hatch, but have been assigned to the only anostracan species either for dimensions and for sculptures on the surface. The remaining 7 types of resting stages were not attributed to any *taxon* because they did not hatch any active stage.

Tab. 3: resting stages in sediments of lake Gistova, July 2007, with indication of their abundance.

species/type	**n.eggs/ 1000 cc**
Alona quadrangularis	7928
Chidorus sphaericus	1128
Chirocephalus sp.	3024
Daphnia longispina	11720
Mixodiaptomus tatricus	5944
Type 1	6992
Type 2	7464
Type 3	2048
Type 4	1896
Type 5	1400
Type 6	3648
Type 7	1312
total	**54544**

DISCUSSION

The present is the first study carried out on lake Gistova and in similar habitats in the Albanian territory. As a consequence, the species list is rich of faunal novelties for the Country. Due to the absence of similar studies also in Greece, the present results represent a first reference point for the southern Balkan area, too.

Notwithstanding the small surface of the lake Gistova, and its relatively simple perimeter, the species number of zooplankton (12 in total, 7 crustaceans) was apparently higher than that of other Alpine lakes recently studied (Starkweather, 1990; Jersabeck *et al.*, 2001; Horicka *et al.*, 2006; Tolotti *et al.*, 2006). This result is probably due to the replication of the sample collection (4 different years, and at least 2 different seasons) and to the use of different mesh sized nets, which has been adopted. In fact, each sample does not contain more than 7 *taxa*. Also considering that some of the *taxa* could not be considered properly planktonic (e.g. Harpacticoida undet., and *Alona quadrangularis*) the species richness remains comparatively high. If the sampling effort obviously affects the final number of species collected (see also Belmonte *et al*., 2006), more has to be done to correctly establish the species richness of such environments, typically considered as poor due to their generally small size, oligotrophy, low temperature of the water (Jersabeck *et al*., 2001) and/or youth of the community structure (as suspected by Jersabeck *et al*., 2001; Dodson *et al*., 2007 and Alfonso and Belmonte, 2008). The recent consideration of alpine lakes as habitats particularly sensitive to global climate changes (Theurillat and Guisan, 2001; Füreder *et al*., 2006) justifies an increased attention of the studies devoted to them, in terms of sampling effort.

In this direction goes also the additional contribution of the present paper which proposes to integrate the plankton sampling with the sediment collection (as proposed for other habitats by Moscatello and Belmonte, 2004; 2009; Rubino *et al*., 2009). If non-producing cysts categories are eliminated (for example, Harpacticoida, and Cyclopoida) from the plankton-sediment comparison, we remain with a resting/active stage bias of 12/10 which needs to be clarified, in order to determine the actual species richness of the lake Gistova.

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REFERENCES

Alfonso G., Belmonte G., 2008 - Expanding distribution of *Boeckella triarticulata* (Thomson, 1883) (Copepoda: Calanoida: Centropagidae) in Southern Italy. *Aquatic Invasions* **3**: 247-251.

Belmonte G., Alfonso G., Moscatello S., 2006 - Copepod fauna (Calanoida and Cyclopoida) in small ponds of the Pollino National Park (South Italy), with notes on seasonality and biometry of species. *Journal of Limnology* **65** (2): 107-113.

Dodson S.I., Everhart W.R., Jandl A.K., Krauskopf S.J. 2007 - Effect of watershed land use and lake age on zooplankton species richness. *Hydrobiologia* **579**(1): 393-340.

Füreder L., Ettinger R., Boggero A., Thaler B., Thies H., 2006 - Macroinvertebrate diversity in Alpine lakes: effects of altitude and catchment properties. *Hydrobiologia* **526**: 123-144.

Gauthier H., 1928 - *Recherches sur la faune des eaux continentals de l'Algerie et de la Tunisie*. Imp. Minerva, Alger: 416 pp.

Hořická Z., Stuchlík E., Hudec I., Černý M., Fott J., 2006 – Acidification and the structure of crustacean zooplankton in mountain lakes: the Tatra Mountains (Slovakia, Poland). *Biologia*, Bratislava **61** (Suppl. 18): 121-134.

Hutchinson, E. 1957 - *A treatise on limnology*. Vol. I. John Wiley and Son, New York.

Jeppesen, E., Jensen J. P., Sondergaard M., Lauridsen T., Landkildehus F., 2000 - Trophic Structure, Species Richness and Biodiversity in Danish Lakes: Changes Along a Phosphorus Gradient. *Freshwater Biology* **45**, no. 2: 201-218.

Jersabeck, C.D., Brancelj A., Stoch F., Shabetsberger R., 2001 - Distribution and Ecology of copepods in mountainous regions of the Eastern Alps. *Hydrobiologia* **453/454**: 309-324.

Liss W. J., Larson G.L., Deimling E.A., Ganio L.M., Hoffman R.L., Lomnicky G.A., 1998 – Factors influencing the distribution and abundance of diaptomid copepods in high elevation lakes in the Pacific Northwest, USA. *Hydrobiologia* **379**: 63-75.

MacArthur R. H., Wilson E. O., 1967 - *The Theory of Island Biogeography.* Princeton University Press, Princeton, NJ, USA.

Margaritora F. G., Bazzanti M., Ferrara O., Mastrantuono L., Seminara M., Vagaggini D., 2003 - Classification of the ecological status of volcanic lakes in Central Italy. Papers from Bolsena Conference (2002). *Residence time in lakes: Science, Management, Education. J. Limnol.* **62**(Suppl. 1): 49-59.

Marrone F., Naselli-Flores L., 2004 - First record and morphological features of *Hemidiaptomus (Occidodiaptomus*) *ingens* (Guerney, 1909) (Copepoda Calanoida) in Italy. *Journal of Limnol*ogy, **63**(2): 250-255.

Moscatello S., Rubino F., Saracino O. D., Belmonte G., Boero F., 2004 - Plankton biodiversity around the Salento Pensinsula (South East Italy): an integrated water/ sediment approach. *Scientia Marina* 68 (1): 85-102.

Moscatello S., Belmonte G., 2009 - Egg banks in hypersaline lakes of the South East Europe. *Saline Systems*, doi: 10.1186/1746 - 1448-5-3.

Oertli B., Indermuhle N., Angélibert S, Hinden H., Stoll A., 2008 – Macroinvertebrate assemblages in 25 high alpine ponds of the Swiss National Park (Cirque of Macun) and relation to environmental variables. *Hydrobiologia* **597**: 29-41.

Patalas, K. 1964 - The crustacean plankton communities in 52 lakes of different altitudinal zones of Northern Colorado. *Verh. Internat. Verein. Limnol*. **15**: 719-726.

Rubino F., Saracino O. D., Moscatello S., Belmonte G., 2009 - An integrated water/ sediment approach to study plankton (a case study in the Southern Adriatic Sea). *J. Mar. Sys*. **78**: 536-546.

Starkweather P., 1990 - Zooplankton community structure of high elevation lakes: Biogeography and predatory-prey interactions. *Verh. Internat. Verein. Limnol*. **24**, 513-517.

Stoddart J. L., 1987 - Micronutrient and phosphorus limitation of phytoplankton abundance in Gem Lake, Sierra Nevada, California. *Hydrobiologia* **154**: 103-11.

Thuiller W., Lavorel S., Araujo M. B., Sykes M.T., Prentice I. C., 2005 - Climate change threats to plant diversity in Europe. *Proc Natl Acad Sci USA* **102**: 8245-8250.

Theurillat J.P., Guisan A., 2001 - Potential Impact of Climate Change on Vegetation in the European Alps: A Review. *Climate Change* **50**: 77-109.

Tolotti M., Manca M., Angeli N., Morabito G., Thaler B., Rott E., Stuchlik E., 2006 - Phytoplankton and zooplankton associations in a set of Alpine high altitude lakes: geographic distribution and ecology. *Hydrobiologia* **562**: 99-122.