DIATOMS IN HYPERSALINE SOLAR SALTERN PONDS (EBRO DELTA, SPAIN)

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Benthic diatoms constitute an important component of the microbial mats developed in the lower range of salinities in hypersaline environments, although few studies on diatom communities in such environments have been published to date (EHRLICH & DOR, 1985, NOËL, 1984). This paper presents the diatoms that thrive in the solar saltern ponds "La Trinitat" and their distribution as function of salinity.

In these salt fields (Ebro delta, 40°35'N, 0°40'E, South Catalonia, Spain) halite is obtained by pumping sea water to an array of evaporation ponds. The water flows through this system, and evaporates and increases in salinity through successive ponds. The salt concentration within each pond changes only slightly owing to human control, hence communities of each lagoon develop in a high but constant salinities. After the halita is harvested, from August through November, the pools are once again flooded with sea water.

Diatoms appear in the first three ponds of the circuit, with salinity ranging from that of sea water to 120‰. In these ponds (called Deposits 0, 1 and 2), sedimentation of sand and organic matter and carbonate precipitation occurs (CLAVERO *et al.*, this volume). Samples for optical, SEM and TEM examination and measurements of physical and chemical parametres were obtained monthly in 1994. When possible, depending on the presence and abundance of photosynthetic organisms, the sediment was sampled by taking cores. These cores were sliced in roughly 1 mm-thick sections, corresponding to the sediment layers.

In the lowest salinity pond, Deposit 0 (mean salinity 48‰), either the floor was nude or the organisms did not produce layers. Under the shallow water, *Ruppia maritima, Chaetomorpha* sp. and *Cladophora* sp. developed in spots. Some diatom species, e.g., *Striatella unipunctata* (Lyngbye) Agardh, *Achnantes brevipes* Agardh, *Cocconeis placentula* var *euglypta* (Ehr.) Cleve, appeared in high quantities among the macrophytes or epyphiting them. Surrounding the pond, in spring, there is a temporarily flooded ring with a water covering of only few mm, in which a distinct laminated mat of filamentous cyanophytes develops with a golden-brown upper layer built by diatoms. This community was dominated by species of the genera *Amphora, Navicula* and *Nitzschia : Nitzschia lembiformis* Meister, *Nitzschia sigma* (Kütz.) W. Smith and *Nitzschia vidovichii* (Grun.) Peragallo. As summer went on the marginal ring dried up with a leathery appearence.

In Deposit 1 (mean salinity 64‰) the most abundant diatom was *Pleurosigma elongatum* W. Smith, which appeared abundantly on the surface sediment, associated with filaments of cyanophyta. It also appeared on sporadically wet sediments and forming floating lumps together with *Lyngbya aestuarii* Liebm. Other diatoms that also appeared in abundance were *Scoliopleura tumida* (Brev.) Rabenhorst and some species of *Navicula* and *Amphora : A. coffeaeformis* (Agardh) Kützing, *A. acutiuscula* Hustedt, *A. hyalina* Kützing. *Cocconeis placentula* var *euglypta, Pleurosigma elongatum* and *Nitzschia sigma* were also observed associated with *Cladophora* sp. In summer, the partially flooded borders developed a green and white mass of *Beggiatoa* sp. and L. *aestuarii* mixed with living *Surirella striatula* Turpin and *Pleurosigma elongatum.*

In Deposit 2 (mean salinity 97‰) the number of species and individuals was smaller. The most abundant was *Nitzschia lembiformis* (which also appeared in Deposit 1, but less frequently). *Surirella striatula, Amphora coffeaeformis, Nitzschia frustulum* (Kützing) Grunow and *Nitzschia sigma* were also well represented.

Heaters (subsequent ponds with salinities over 120‰) were devoid of diatoms, except for empty valves and girdle bands of *Nitzschia* sp., probably allochtonous.

Some of the taxa found in the least saline pond (Deposit 0) are known from the nearby marine waters, e.g., *Striatella unipunctata, Surirella fastuosa* (Ehr.) Kützing, and *Achnantes brevipes*, and were not observed in ponds of higher salinities. Others, like *Nitzschia vidovichii, Pleurosigma elongatum* and *Gyrosigma spencerii* (Quek.) Grif. et Henfr., occurred only in waters with 44-80‰. *S. Nitzschia lembiformis* was found only with salinities from 53‰ to 150‰ predominantly in the hypersaline pond Deposit 2 (85-105‰ S). The salinity range gives this species an "hyperhalobius" character (EHRLICH & DOR, 1985). Most of the diatoms recorded were euryhaline, but their halotolerance varied. A general decrease of diatom diversity in increasing salinity was found. Some species dissapeared at lower salinities, while several species were present throughout the entire area at salinities of 44-115‰, e.g., *Amphora angusta* (Gregory) Cleve, *A. coffeaeformis, Nitzschia frustulum* and *Nitzschia sigma*, in accordance with their classification as euryhaline forms (EHRLICH & DOR, 1985, NOËL, 1984).

A remarkable fact is that no frustules of central diatoms were found in sediments, which points out that in these shallow saline waters central diatoms did not develop, which agrees with previous results (NOËL, 1984).

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ZOOPLANKTON TEMPORAL VARIATION IN A SPRING-POOL OF THE ALBUFERA NATURAL PARK

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The aquatic ecosystems of the Albufera Natural Park have been subject to intense human impact. They consist mainly in a large lagoon of 23 km^2, surrounded by 223 km^2 of rice fields. However, there are still a number of spring-pools, i.e. small and shallow pools fed by subterranean water inflow, which are less polluted and could be regarded as refuge areas for rare species. The succession of zooplanktonic populations has been studied during two annual cycles in the most well kept of these spring-pools : "Baldovina", by means of monthly quantitative water samples taken with a 2.6 l Ruttner bottle and filtering by a 45 µm mesh. Physical and chemical parameters of the spring waters should be rather constant, but they are influenced by rice field water which occasionally drain into the spring-pool in early summer. When this occurs, a rise in temperature and a diminution of conductivity can be observed in the pool (Fig.1C). Rice field influence varies from one year to another; in 1986 the perturbation was restricted to June and the beginning of July, while in 1987 the pool was perturbed during a much longer period. The water from the rice field is loaded with fertilisers and pesticides which impoverishes faunal composition and the effects on the zooplankton community are very apparent. We can easily observe drastic differences between the two years in Fig.1. During the more perturbed year cladocerans were not observed and the number of species of copepods diminished and changed to more opportunist ones (Fig.1B). Moreover, zooplankton succession in 1986 (rotifers and crustaceans) was as expected from the theoretical point of view (Fig.1A), i.e. a biomass peak in spring is followed by a later increase of diversity in summer. However, during the more perturbed year 1987, this cycle was interrupted, so a high development of biomass in summer occurred, which determined a reduction of diversity. Therefore, diversity did not increase until September, at the end of rice culture.

The richness of species in this biotope is very high; beside the crustaceans of Fig.1, we have found 95 species of rotifers. Moreover, a single net tow sample in the littoral zone can yield a Shannon diversity index, for rotifer fauna, as high as 4.6. Previous studies in this and other spring-pools (COLOM and MIRACLE, 1990; ALFONSO and MIRACLE, 1987) also showed that plankton communities are subject to wide fluctuations, however they still keep a very high diversity. The total number of species found, until now, in the plankton in four of these spring-pools is : 107 rotifer species, 6 cladocerans and 13 copepods.

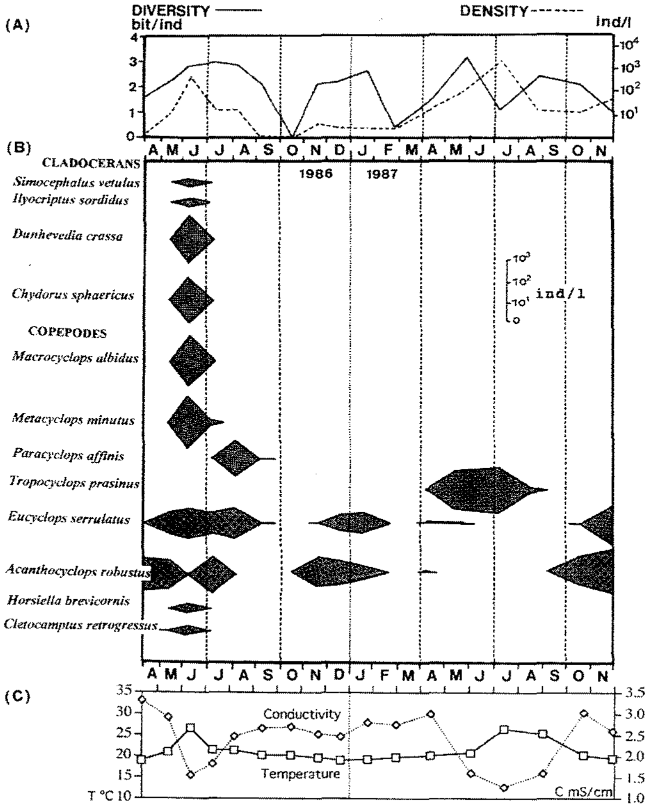

Fig.1. Temporal variation in Baldovina spring-pool of: (A) zooplankton (crustaceans and rotifers) density (ind/l) and diversity, (B) abundance of crustacean species (ind/l) and (C) temperature and conductivity.

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