ECOLOGICALLY SIGNIFICANT SYMBIOSES IN THE MICROPLANKTON OF OLIGOTROPHIC SEAS. CASE STUDIES : THE EASTERN MEDITERRANEAN, THE GULF OF AQABA, RED SEA

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The microplankton of oligotrophic warmwater seas is characterized by a large number of consortia, consisting of representative species of its plant and animal components. They vary from purely ephemeral attachment of one species to another, generally for reasons of support to truly symbiotic relationships involving metabolic dependency between the partners. These associations have been reviewed in recent years by TAYLOR, 1982; KIMOR *et al.*, 1992; and GORDON *et al.*, 1994 and references therein. Such associations involving algal consortism as well as algae with protozoans, markedly ciliates, radiolarians and acantharians, constituting ecologically significant relationships, have been documented in longterm studies in the eastern Mediterranean and the Gulf of Aqaba (KIMOR *et al.*, 1992 and GORDON *et al.*, 1994).

The Eastern Mediterranean. A case of algal consortism, involving two autotrophs, is that of the symbiosis between species of centric diatoms belonging to the genera *Rhizosolenia*, *Hemiaulus* and *Chaetoceros* with the filamentous heterocyst-bearing cyanobacterium *Richelia intracellularis* as an endobiont, the latter capable of molecular nitrogen fixation (MAGUE *et al.*, 1974). It is assumed that in this association the fragile cyanophyte provides the host diatom cell with floatation ability, due to its gas vacuoles, as well as with nitrogenous and carbohydrate compounds, while at the same time being protected by the rigidity of the diatom cell walls.

In the eastern Mediterranean the consortium of *Rhizosolenia calcar avis*, a bloom-forming diatom, large proportion of its cells containing at times filaments of *R. intracellularis*, has been found to occur mostly at the end the spring diatom increase (SDI), when the surface waters are particularly depleted of essential nutrients. Our past records (KIMOR, unpubl.) show the occurrence of this association in both neritic and open-sea waters of the Levant Basin, the latter described as highly oligotrophic (BERMAN *et al.*, 1984).

A well-known symbiotic association, consisting of the colonial radiolarian *Sphaerozoum punctatum* bearing photosynthetic zooxanthellae in the extra-cellular region of its individual cells, has been recorded in plankton samples examined live on board ship during a cruise in the eastern Mediterranean in April 1992. At that time, the colonies occurred as dense macroscopic masses over the whole grid of stations occupied by that particular cruise in the surface waters, both in neritic and oceanic waters. Although not quantified during the routine examinaton of the samples on board ship, *S. punctatum* may be assumed to have made a significant contribution to the primary productivity in that region, as has been described in the case of a taxonomically related species, *Collozoum longiforme*, from the equatorial Atlantic Ocean, with assimilation rates of one order of magnitude higher than phytoplankton - 43.2mgC/h as compared to 4-17mgC/h (SWANBERG and HARRISON, 1980). Considering the fact that the integrity of the colonies is affected by fixation in formaldehyde, the observation of live plankton on board ship in our samples was particularly important.

The Gulf of Aqaba, Red Sea. Long-term monitoring of the microplankton communities at a reference station in the northern part of the Gulf of Aqaba, Red Sea has been carried out since 1986 (KIMOR *et al.*, 1992; GORDON *et al.*, 1994) under the auspices of the National Center of Mariculture, Israel Oceanographic and Limnological Research Ltd. Among the various types of consortism described in this study, that of heterotrophic dinoflagellates with symbiotic coccoid cyanobacteria of the *Synechococcus/Synechocystis* type, similarly known for their molecular nitrogen fixation ability (MITSUI *et al.*, 1986), is of particular significance. Species belonging to the genera *Ornithocercus*, *Citharistes* and *Histioneis/Parahistioneis* harbouring clusters of the symbiotic cyanobacteria in special pouches either between the cingular lists or within the cells themselves have been recorded perennially during the months of October/November, when the nitrate concentration of the Gulf waters was at an all-time seasonal low (GORDON *et al.*, 1994). It is hypothesised that, in this particular case of algal consortism, the cynobacteria increase in concentration during the N-limitation months due to their nitrogen fixation capability, which is activated by the heterotrophic dinoflagellate hosts providing a site of low-oxygen tension. This hypothesis has yet to be proved experimentally.

The above examples of symbiotic consortism among various components of the microplankton in highly oligotrophic warm-water seas, such as those described in this study, may provide a clue to the nature and functioning of food chains in such particular marine environments.

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