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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STATE OF ZOOPLANKTON IN THE BULGARIAN AND ROMANIAN BLACK SEA COASTAL WATERS DURING THE SUMMER OF 1992

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Surveys of the composition, quantity development and distribution of zooplankton in the Black Sea are important for ascertaining trophic stability, as well as for clarifying the process mechanisms and phenomena related to translocation, transformation and sedimentation of organic matter, inflowing acutely polluting agents and the resulting high rate of eutrophication (KONSOULOV, 1986)

The results herewith, regarding the state of zooplankton within the above mentioned areas, have been obtained from a number of research expeditions within the programme Coms-Black 92/07/07-17/07/92 in particular. Zooplankton samples were collected on board R/V "Akademik" by means of Jeddy plankton net (mesh size 100 microns) at stations located in front of the Bulgarian and Romanian coast vertically off the 10-0, 25-10, 50-25, 100-50 and 150-200 metre horizons (Fig. 1). Monospecific biomass is calculated according to standard weights (IASHNOV, 1984). Highest quantitative abundance and biomass with quasi-homogeneous water structure in front of the Bulgarian and Romanian coasts during the summer of 1992 (July) were those of *Pleopis polyphemoides*, *Acartia clausi* and *Noctiluca scintillans*. Quantitative abundance of these three species varies both vertically and horizontally. The *P. polyphemoides* biomass amounted to 62.24 mg/m^3 in front of the Romanian coast, whereas it was 26.41 mg/m^3 in front of the Bulgarian coast. Results were similar with *N. scintillans* showing 428.36 mg/m^3 in Romanian coastal waters compared to 138.49 mg/m^3 in Bulgarian coastal waters. Quantitative abundance of *A. clausi* compared to that of the *Cladocera* species showed opposite results with 36.49 mg/m^3 of biomass at a 20 metre depth in front of the Bulgarian coast and 13.26 mg/m^3 at the estuary of the Danube, in front of Konstantza.

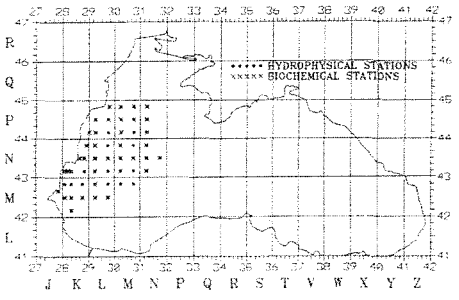
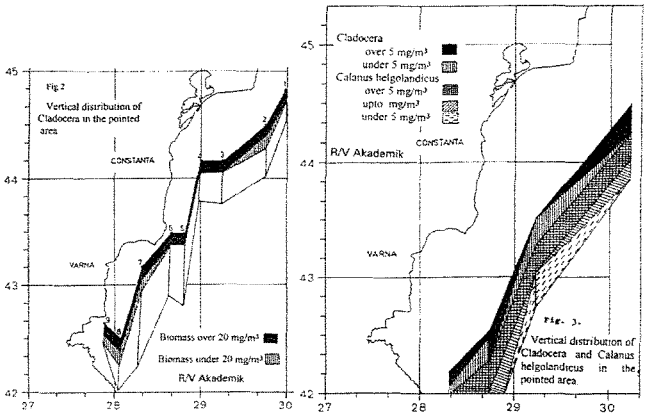


Fig. 1 : Academik station network

Vertically, surface strata ranging from 10 to 15 metre are chiefly inhabited by the *Cladocera* species (Fig. 2). Deeper down as far as the 20-25th metric isobath and 20-40 miles offshore, both biomass areas are dominated by *Pseudocalanus elongatus* and *Calanus helgolandicus* together with their copepodites and nauplii (Fig. 3). Together with the constantly living unicellular euriphague *N. scintillans* in the surveyed areas, there have been records the new invader in the Black Sea the *Ctenophora Mnemiopsis leidyi*, amounting to 68 ind/m^3 and sizing 20 mm along the Romanian coast, and 26 ind/m^3 in the shallow shelf of Bulgaria. More detailed analyses of data related to the composition of zooplankton and its quantitative development along the western parts of the Black Sea, as well as comparisons with previous years, show that during the summer 1992 the species *Oithona minuta* and *Oithona similis* were registered singularly, whereas over the 1984-1989 period mean values were 1928 and 424 ind/m^3 respectivelyThere is a similar trend of decrease with *Sagitta setosa*, *Paracalanus parvus*, *Centropages kroyery* and *Penilia avirostris*. Thus the average number of these species for the middle and western parts of the basin over the 1984-1989 period is respectively 29 ind/m^3, 178 ind/m^3, 96 ind/m^3 and 487 ind/m^3 dropping down to 4, 18, 31 and 63 ind/m^3 just in the summer 1992.

The surveyed process of destruction of pelagic zoocenoses during the ComsBlack'92 expedition can be explained with the high rate of eutrophication in the coastal zone. It is our opinion that the negative changes taking place within pelagic zoocenoses are not a result of the direct impact of eutrophication but a result of the favourable conditions created for the development of the predatory *Ctenophora - M. leidyi*. This species (together with *N. scintillans*) while developing and permanently spawning (KONSOULOV, 1990) consumes enormous quantities of juvenile and mature forms of lower *Crustacea* mainly at surface strata of coastal areas. Therefore if biodiversity is to be preserved, *M. leidyi* has to be most seriously considered as a part of the Black Sea ecosystem which by the rights of its existence undoubtedly influences ecosystemic composition and structure.



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