

SOME ZOOGEOGRAPHICAL AND ECOLOGICAL PROBLEMS
CONCERNING THE BENTHIC INVERTEBRATES OF THE BLACK SEA.

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ABSTRACT:

Some aspects concerning the benthic invertebrates of the Black Sea are presented in the paper. The origins of the fauna, than, the problem of the newcomers (Rapana thomasiana, Mya arenaria and Rhithropanopeus harrisi tridentatus) in the Pontic basin, and the importance of the meiobenthos are discussed.

The fact is well known that the present Black Sea represents a sea unique in the world in its bionomic conditions and in some particular hydrological aspects.

Its fortuous geological past, during which it radically changed its shape, dimensions, connections with other seas, physico-chemical characteristics, and qualities as habitat for living organisms, is one of the most agitated natural histories (whose permanent changes have brought about high dynamism in the ecological equilibrium).

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An analysis of the Pontic fauna shows very varied origins, heritages from varied ecological types of waters which filled the depression of the Black Sea basin in the course of geological times. At present we find in the Black Sea a veritable mosaic of forms, from those of the subarctic to those very similar to Indian Ocean forms, derived from the old and extensive Tethys Sea, to more recently invaded fresh and brackish water species and Mediterranean forms. There should be mentioned species which invaded by temporary communications established between the various basins, among which must be considered the Bosphorus straits way, closed and opened for variable periods, at least 4 times at the end of the Tertiary and open in our times. Through the Bosphorus migrated the typically Mediterranean forms and as these connections are the most recent origin, the dominant character of the Black Sea fauna is Mediterranean and not Sarmatic (from the Late Miocene).

The immigration phenomenon has been a historic process of long duration and continues to the present. The physical conditions, however, produced a particular biological medium which permitted only a very small number of restricted species, endowed with special qualities and special resistance (and accommodation mechanisms), to invade and live in the waters of the Black Sea.

As against 6,450 species of benthic invertebrates of the Mediterranean Sea (1; 5; 6; 20), only 1,790 species were recorded in the Black Sea, that is 3.6 times fewer.

The 1,790 species known in the Black Sea benthos can be divided into three large categories: 1. species of marine origin: 1,509 - 84.2 %; 2. species autochthonous, relict species of Ponto-Caspian type: 98 - 5.5 %, and 3. autochthonous, brackish or fresh water - euryhaline species: 183 - 10.3 %.

We shall refer briefly to these three categories:

1. In the category of species of marine origin we consider all the immigrated fauna living even today in the Mediterranean Sea or in the Atlantic, as well as the endemic ones of the Black Sea, which evidently have descended from marine ancestors. The differential immigration of these species, however depended on their osmotic plasticity, since entire series of organisms could not even penetrate into the Black Sea (Planuloida, Triaxo-

nida, Dendroceratida, Gnathostomulida, Echiurida, Leptostraca, Stomatopoda, Euphausiacea, Cephalopoda, Brachiopoda, Enteropneusta, Crinoidea).

The percentage of successful immigrants varies very much: over 50% for interstitial Ciliates, Nemertines, Gastrotricha, Kinorhyncha, Rotatoria, Nematoda, Copepoda, Tardigrada, Halacaridae, etc.; between 25 - 50 % for Hydroidea, Turbellaria, Polychaeta, Oligochaeta; between 10 - 25 % for Foraminifera, Anthozoa, Hirudinea, Ostracoda, Cirripedia, Decapoda, Cumacea, Anisopoda, Isopoda, Amphipoda, Pantopoda, Holothuroidea, Ophiuroidea, etc.

The average immigration index of Mediterranean species in the Black Sea is about 23 %.

I would like to mention here the fact that not all groups of organisms have been equally studied and not all marine sectors could be investigated since about 1/3 of the length of the Black Sea shore and about half of the Eastern Mediterranean Sea are nearly unknown. Anyhow, macrofauna is somewhat better known

2. As regards the relict species, we must specify that the general term "Ponto - Caspian type" has been rather used conventionally. The species of this faunistic complex do not have a common origin in time, the length of their differentiation being spread from the Tertiary to the present day. The term "Sarmatic species" is as well not enough comprehensive. Their common trait is the localization in space of their genetic area, that is, the maximum extension on limits of the different evolutionary phases of the present Ponto-Caspian basin, from the Pliocene to the historic times. Another common trait is the preference of most of these species to the brackish waters of low salinity.

Out of the 329 autochthonous metazoic species (146 crustaceans, 54 fishes, 39 turbellarians, 32 gastropodes, 19 bivalves, etc.), the invertebrates met with in the Black Sea represent about 30 %. But only 6 % of them live in the open sea (with salinities above 17 - 18 ‰). The rest inhabit the fresh water regions at the river mouth or in the littoral coast, where they contribute a great deal to the productivity of these zones. Among the Caspian forms, only fishes are more abundant in the Black Sea, while the invertebrates are found in small numbers and play a negligible role in biocenoses. Beyond the Ponto-Caspian basin, 21 species of

the "Caspian type" are known. Among these 9 are in the Baltic basin, 4 in the Arctic seas and 8 in the Mediterranean. Without any doubt, these species have penetrated from the Ponto-Caspian basin; many of them recently, through the navigational channels of river systems, other euryhaline species direct on their sea way (11; 12; 13).

It is probable that the development of communication ways will contribute to the spreading of many Caspian species and it may even be expected that in the following decades, the number and spreading of these species beyond the Ponto-Caspian basin will be increased. It is possible that in estuary zones the Caspian species could eventually prove themselves as food for fishes after acclimatization.

3. Indigenous, brackish or fresh water - euryhaline species which live in the Black Sea, comprise limnic elements of continental origin, with mechanism of osmotic adaptation to oligo- and mesohaline salinity concentrations. Also, some brackish water forms of the northern or meridional origin, immigrated through the Mediterranean or by different transcontinental ways.

Except for the species of Ponto-Caspian origin and limnic continental origin, the immigration of species of marine origin in the Pontic basin, was and is still limited by a whole series of ecological barriers: reduced salinity and different ionic composition of the Black Sea waters, as well as different thermic conditions in this sea as compared with those of the Mediterranean. Another limiting factor is the presence of hydrogen-sulphide in the bathial region of the Black Sea, which excludes the possibility of the immigration of some deep-sea animals. The lack of tides in the Black Sea also operates as a barrier.

On the other hand, salinity variations in zones directly influenced by fresh water influx ($336 \text{ km}^3/\text{year}$) of tributary rivers of the Black Sea have led to a secondary selection of immigrated fauna, particularly at the middle and infralittoral belt level, thus still more complicating the faunistic aspect of the benthos. We give one single example. The shrimp Palaemon elegans RATHKE, a Mediterranean immigrant, has spread throughout the north-western coast of the Black Sea, where the salinity decreases considerably from the Bosphorus to the Danube mouths. It has develo-

ped into several physiological races determined by the local salinity variations. The example offered by Palaemon elegans is particularly suggestive and we suspect that most invertebrate species present in the hyposaline medium of the Danube and other rivers mouths form physiological races, each as a result of the selection exerted by the severity of the physiological medium of the Black Sea (15; 16). Taking into consideration the definition of evolution as the resultant of the relationship between the recombination and mutation capacity of the genetic material and the action of the selective factors of the external medium it can be explained the formation in the Black Sea of some physiological races, becoming subspecies or even species proper to the Black Sea.

Generally speaking and in the light of our present knowledge, we can state that about 15 % of the total Quaternary and Post Quaternary metazoan fauna of the Mediterranean has penetrated into the Black Sea.

I wish to reiterate that the enrichment phenomenon of the Black Sea with new species from and through the Mediterranean is still continuing, while the problems of the function of the Bosphorus in the colonization, in "the Mediterraneanization" of the Pontic basin is more and more discussed and studied.

Recent investigations on the Black Sea fauna in the vicinity of the Bosphorus straits established an indisputable fact, that a narrow sector, with a surface of several hundreds of sq. km, disposed in a semicircle around the opening of the channel, presents unique peculiarities, not to be met elsewhere on the continental shelf of the Black Sea. The benthos of the zone (where there are more saline Mediterranean waters, brought by the deep current which enters into the Black Sea - $123 \text{ km}^2/\text{year}$), is quite unique. Thus, the prebosphoric area is harbouring numerous species which are lacking in the rest of the Black Sea. Some of the species from the prebosphoric circalittoral have high densities, unrecorded not only in the rest of the Black Sea, but neither in their seas of origin (3; 4; 5; 7; 17). Here are several instances, the polychet Sternaspis scutata (RANZANI) reaches frequently $600 \text{ specimens/m}^2$; the small raspberry coloured sea cucumber Stereoderma kirschbergi (HELLER) forms populations with up to $400 \text{ individuals/m}^2$; the amphipode Ampelisca surpasses the density of

1,000 specimens/m², as against its normal density of 300-400 specimens/m² on the rest of the continental platform; the small Ophiuroid Amphiura stepanovi DJAK., which in the Romanian littoral has for instance only exceptionally densities of 500 individuals/m², may attain there the figure of 2,500 individuals/m²; the bivalve Modiolus adriaticus (LAM.) attains the figure of 50 specimens/m²; etc.

Even the microbenthos - although less studied - offer examples of exceptional densities: of the Kinorhynchia Pycnophies communis ZELINCA - 14,000 individuals/m², or among the Tanaidacea species Pontotanaeis borceai BACESCU - 2,250 individuals/m².

Another characteristic feature of the prebosphoric continental shelf is that the species composition and their densities recorded are not the same for every station, but they are spread in a very varied mosaic, the qualitative and quantitative composition of the benthos changing radically from one point to another, at a distance of less than one mile. However, the oozy bottoms do not present important qualitative differentiation.

Another trait which differentiates the prebosphoric benthos, is that of the over 120 Mediterranean species common there, only half of them are known in the rest of the Black Sea.

The fact is incontestable that our data on the prebosphoric cenoses are still insufficient, but the continuous immigration of new forms from the Mediterranean, a process which takes place before our eyes, has been emphasized in recent expeditions, including those of Romania. It is the case of the species: Marthasterias glacialis (O.F.M.), Ophiura texturata (LAM.), Ophiura albida FORBES, Amphipholis squamata (D.CH.), Corbula gibba (OLIVI), Cyclonassa brusinae (MIL.), Phyline aperta (L.), Harpinia della-vallei CHEVR., Colomastix pusilla GRUBE, Ischyrocerus sp., Leptochelia merrellinae SMITH, Pontotanaeis borceai BACESCU, Elaphognathia monodi BACESCU, Cyathura carinata (KROYER), Drilonereis filum CLAP., Audouinia fuligera D.CH., Polydora caulleryi MBSNIL, Scrupocellaria and others, not to speak of the numerous foraminiferes and planktonic species recorded quite recently.

The deep bosphoric current which, however weak, arrives during flood periods of the peripontic rivers, always disperses

towards the Black Sea the meroplanktonic larvae of the species already established in the prebosphoric space, increasing the local populations and also bringing the larvae of other more stenobiotic species. These develop in the Black Sea but cannot reproduce themselves here for giving stable populations.

All the peculiarities seen in distribution of animals which characterize the biocenose in the prebosphoric area show a vigorous fauna, still unaffected by intra- and interspecific competition. The Bosphoric biocenosis is a "suis generis" biocenosis, one huge reservoir of Mediterranean elements, which waits nothing there but the favourable year or years to advance along the Pontic coasts and to conquer this sea. Therefore, as well as FUSANOV (17), we consider the prebosphoric sector as an important source of prepontic acclimatization and not a simple Mediterranean enclave destined to destruction and which is maintained only by continual recruitment of larvae from the Marmara, as CASPERS (2) considers.

Taking into consideration the historic factors and having in view that the last penetration of the Mediterranean warm-salty waters into the Black Sea began merely 5,000 years ago and is still continuing through an unimportant dimensioned strait, then we are bound to admit that the process of "Mediterranization" has not come to an end yet (Black Sea salinity seems to be in a slight increase - +0.19 ‰ in the last 40 years in the Soviet - Sebastopol littoral and +0.26 ‰ in the last 20 years in the Romanian-Constanța littoral - a fact which will favour the successful invasion of the Pontic basin by new marine and more stenohaline species).

Not all Mediterranean species potentially capable of naturalizing the Black Sea have done so; here there is still a great number of vacant ecological niches, here there is a surplus of primary trophic basis, here there are varied substrates, here are very few or no predators, all representing "open gates" for a great number of new species.

That this is so is shown by lightning spread throughout the Black Sea of certain species which have taken only 20 - 30 years to establish themselves. Some, such as Rhithropanopeus and Mya, have had a positive role; others - Rapana (destroyer of mo-

lluscs with commercial value) and Mercierella (component of the ship fouling) have had a negative role (2; 8; 9).

Rapana thomasiana CROSSE, a rapacious gastropod of Indo-Pacific origin, was recorded in the Black Sea on the coast of the Caucasus in 1947, but it is supposed to have penetrated into the Pontic basin in the period 1930-1940. The complete absence of natural enemies in its new medium, the lack of biological competition on the part of other species and the rich trophic basis, permitted it a rapid development, so that Rapana established itself ideally on the infralittoral rocky bottoms. In a period of about 15 years Rapana occupied a littoral band of over 1,500 marine miles in length. The rapid advance of this species from the Caucasian coasts, towards the Crimean coasts, then towards the Romanian and Bulgarian ones, may be accounted for, in the first place as an invasion dictated by trophic necessities - the search for a nutritional basis.

Rapana, which feeds mainly on oysters and mussels, have completely destroyed, in a relatively short time, the stock of these molluscs of the Gudautsk bank, radically changing in this way the faunistic composition of the biocenosis. Destroying the large species (Ostrea edule taurica SIEMASCHKO, Mytilus galloprovincialis (LAM.), Modiolus adriaticus (LAM.)) preferred in its food, Rapana was obliged to leave the stony bottoms and attack the littoral bivalves of smaller sizes on the sandy and oozy bottoms (Chione gallina L., Pitar rudis (POLI), Spisula subtruncata triangula (RENIER)), executing a real migration along the littoral from Gudautsk towards the west just in search of oysters and mussels, thus rapidly conquering all the littoral zones.

Rapana is still expanding its range in the Black Sea and the final results of its acclimatization cannot be yet fully foreseen, the decimation of the mussel population of the rocky infralittoral not being excluded.

✧ Mya arenaria L., bivalve of north Atlantic origin, well known and turned to commercial account on the USA coasts, has penetrated into the Pontic basin in the last 10 years and acclimatized itself perfectly, settling down and rapidly extending itself along the Black Sea coasts, in its north-western part, from Odessa to Mangalia. Its spread can be seen on the beaches, where Mya

shells, big and white, deposited as a result of storms, represent nowadays a dominant element, which attracts attention at first sight.

In a few years, since its introduction into the Black Sea (probably as larvae in the ballast water from oil tanks), Mya has an exuberant development, being today a common form on all the sandy and sandy-cozy bottoms down to the depth of 30 metres. In some places of the Romanian littoral Mya is so abundant that its density exceeds 8,000 individuals/m² or 16 kg/m² biomass.

In the Romanian littoral Mya has settled in the zone of fine sands, in the biocenose dominated by the bivalve Corbula mediterranea (COSTA), a biocenose very well studied and known to be one of the most eutrophic of the Black Sea. The explosive development of the new species in a biocenose so important for the sea economy has brought new problems in understanding the equilibrium established in the Corbula biocenosis in consequence of the invasion of the new element - Mya.

A comparative analysis of the situation existing after the settlement of Mya in this zone, with the data recorded in previous years, showed that densities and biomasses of psammobiotic molluscs of the newly formed biocenosis - Corbula-Mya - have values comparable with those of the previous years, while Corbula mediterranea remained nevertheless numerically the most important bivalve.

On the basis of these first observations, we may state that in the first stage of expansion in the Black Sea this species does not compete in the food with other filter-feeding molluscs of the biocenosis. The fact that it lives deep within the sediment, buried down to 20-25 cm shows that it occupies an ecological zone previously completely free in the fine sands and has been proved to be an element which enhances ecological balance. In conclusion, the invasion and settlement of the bivalve Mya in the Black Sea represents a positive factor of great importance, which contributes to the growth of biological productivity of the region.

A third example of a newcomer to the Pontic basin, and we shall stop here, is the crab Rhithropanopeus harrisi tridentatus (MAIT). This crab, of north-western Atlantic origin con-

quered in less than three decades most of the brackish European basin, including the Black Sea and its paramarine annexes. Accentuated euryhalinity of this species has led to its mass installation, especially in the oligo-brackish littoral lakes, thus contributing to the growth of the trophic basis of these lakes and becoming a constant element in the food of zander, a fish of a special economic interest.

The diversity - systematic and physiological - of the marine and brackish water fauna of the Pontic basin, the diversity which continually increases, illustrates how dynamic is the ecological equilibrium of this sea. The changes which are recorded today in the hydrological and hydrochemical structures of the Black Sea and which are due to natural causes or to human activity, accentuate still more the dynamism of the ecological equilibrium. It is therefore absolutely necessary to monitor permanently the state of ecological equilibrium by qualitative and quantitative studies on the organisms which enter into the benthic and pelagic ecosystems, especially in marine zones of importance to fisheries.

We consider the starting point for all sinecological studies should be a faunistic and floristic inventory.

I would take the permission of reminding you that the great French naturalist GEORGES CUVIER shows that the precise determination of species and of their distinctive characteristics is the first basis on which all researches of natural history should be founded. And a fellow countryman of his (14) has stated recently that a consequence of the impetus of ecology is the necessity to put systematics back in its rights; without a precise systematics ecology itself is lost and remains inefficient.

It is clear that one cannot speak today of a complete ecological knowledge of a marine zone without having a precise inventory of organisms which live in this zone. Also, we cannot establish the laws which are produced in these associations - facts of particular theoretical and practical importance, without knowing the qualitative and quantitative structure of the populations which make them up. Or, at present with rare exceptions, there is hardly any marine zone which has a perfectly inventoried fauna, especially as the microbenthos was until recently rela-

tively neglected. In neglecting the microbenthos, the marine ecologists deprive themselves of an important element in the assessment of the marine bottom **richness**. To ignore the microbenthos with its constituents - harpacticoida, ostracoda, nematoda and others, without mentioning the protozoan world (the foraminifera, the ciliates), organisms with a fairly short biological cycle, and therefore in principle high productivity - to neglect these species from the whole economy of the sea, is just like omitting from the study of the plankton, copepods, cladoceres, diatoms and of other limits of the trophic chain, which are of the greatest importance for fishes.

Particularly eloquent are a few examples concerning the macrobenthos - meiobenthos relationship. For the Black Sea in the well studied sandy zones, the average macrobenthos - meiobenthos ratio is of 1 : 95 for densities and 31 : 1 for biomasses. Comparative with other marine sectors this ratio **agrees** on general lines: 1 : 30 - 140/35 : 1 for Buzzards Bay, Mass., 1 : 170/24 : 1 for Martha's Vineyard, 1 : 100/15 : 1 for Loch Nevis Scotland, etc. (10; 18; 19), though the taxonomic fauna composition varies from one marine sector to another.

A starting point and a solid foundation of ecology and the indication of average density and biomass dynamics on bionomic sectors and belts represent an extremely useful stock of information. The utility of these data consists not only in the knowledge of the sea productivity but also in the fact that thanks to such periodical inventory of biological potential we shall be able to realize on one hand quantitative and qualitative changes which are being produced in the ecological equilibrium of the ecosystems and on the other hand what new species will be able to and have to be acclimatized by man more quickly than time can do it itself.

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