THE HISTORY OF OSTRACODA (CRUSTACEA) FROM THE DANUBE DELTA DURING THE UPPER PLIOCENE–RECENT TIME

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The evolution of the Danube Delta remains a real "terra incognita" and it is worth more than a mass. I have profited by one core (Cosna) traversing all the Danube Delta sediments. The oldest ostracod community belongs to the Uppermost Dacian, followed by the Apscheronian and finally by the Holocene marine, Mediterranean immigrants. I have identified almost 80 species and five successive different facies.

1. INTRODUCTION

The traditional Pliocene biostratigraphical units from the Dacic-Pontic-Caspian area have been defined by mollusks.

The Upper Pontian was the last temporal sequence with similar faunas between the Dacic and the Ponto-Caspian basins. But afterwards the correlation is very difficult to establish due to discrepancies existing between the two types of fauna, ecologically separated. There are only six *Limnocardiidae* and three *Congeria* common species, all of them having the greatest degree of intrapopulational variability. Some morphotypes have been recognized in the brackish-water sediments from circum-Mediterranean regions (Gillet, 1956).

The salinity reduction occurred in the Dacic basin sooner than in the Ponto-Caspian area and its ecological isolation generated numerous endemisms (the peculiar *Psilodon* genus, for example). Within the so-called Romanian stage, the Dacic basin became suddenly fresh. Much if not most of the fauna temporal hierarchy from that time, is totally anarchic, so that the three substages, three biostratigraphical zones and the ten subzones are further confused by inconsistencies in the criteria used as classical arguments based upon the strictly located mollusk fossils and mainly on the significance of valve morphology.

In the Ponto-Caspian area salinity was higher and more or less constant until the Quaternary with totally different taxa. No other valve-plan innovation occurred, all of them reminding of the "Pontian archetypes". Apparently at least, the ostracod species are similar within the Pontian-Kimmerian interval of time from both areas.

It should be noted that many of them have been found in the Rhone Valley region, the southern regions of Spain, in Italy or the Greek islands as "Paratethys type" of ostracodes and strained into the Messinian age (Carbonnel, 1978). This is one of the most intriguing aspects of the brackish-water fossils. Similarly to Gillet's mollusks, these "paleontological species" are not stratigraphical indicators. Likewise,

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local brackish-water intervals represent a range of water salinity occurring in particular places and times. Each type of water salinity within the brackish-ecosystem built up particular and closely related ornamental designs of valves as a similar response to environmental changes. The brackish-ecosystem of the Paratethys is not single, homogeneous, a contiguous area existing in the multiple distinct "islands" intermigled (or not) with others, each of them with their community. The presence of Pontian-type (Sarmatian or Dacian, also) mollusks and ostracod species in Spain dos not mean Pontian stage. They are rather convergence ornamental features of the valves within similar biotopes.

I found few recurrences of fresh-water sequences with Romanian ostracodes in three drillings from the Danube Delta. An interesting correlation exists between these ostracodes and the oligohaline-water "Caspian faunas".

2. THE COSNA CORE (LOCATED 1 KM SOUTH OF SF. GHEORGHE TOWN)

In a sample between 5.40 m and 14.50 m I found an association with *Darwinula stevensoni* (Brady and Robertson) (five specimens, adults and juveniles), *Paracandona albicans* (Brady) (six valves), *Ilyocypris gibba* (Ramdohr) (two specimens), *Candona angulata* G. W. Muller (juveniles abundant), *Candoniella* sp. and *Cyprinotus* sp. (abundant).

Between 16.20–19.50 m, I found only two adult valves of *Carinocythereis rubra* (G. W. Muller) showing visible erosion marks.

At 23–25 m the assemblage consists of *Leptocythere histriana* (sensu Sornikov, 1968) (four adult valves), *Amnicythere quinquetuberculata* (Livental) (eight adult valves), *A. sp ex gr cymbula* (Livental) (eight adults), *Semicytherura virgata* Sornikov (two), S. sp. (one), *Cytheroma* sp. (one), *Xestoleberis* aff. *decipiens* (G. W. Muller) (three adults), *Loxoconcha* aff. *granulata* Sars (one), *Cyprideis torosa* (Jones) (37 nontuberclated, adults and juvenils).

Between 28 and 33.40 m, allied with some anterior species, there appear *Leptocythere bacuana* (Livental) (two valves), *L. striatocostata* (Schweyer), (sensu Sornikov, op. cit.) (five adults and six juveniles), *L. reticulata* Sornikov (four), *Carinocythereis carinata* (Roemer) (one), *C. rubra* (G. W. Muller) (one), *Pontocythere* aff. *tchernjawskii* Dubowsky (two), *Costa edwardsi* (Baird) (one valve), *Callistocythere flavidofusca* Ruggieri (seven), *C. mediterranea* (G. W. Muller) (five adult specimens), C. *diffusa* (G. W. Muller) (nine adults and five juveniles), *Paracytheridea paulii* Dubowsky (one).

Between 33.50 and 44 m, the ostracod assemblage indicates remarkable marine influence: *Carinocythereis carinata, Cytherura sulcata, Cytheroma variabilis, Callistocythere diffusa, C. flavidofusca* (abundant), *Pterigocythereis jonesi* (Baird), (2 adults and 4 juveniles), *Hemicytherura* aff. videns (G. W. Muller) (2 specimens),

Hemicytherideis aff bacescoi Caraion (1), *Loxoconcha granulata* Sars (4), *Xestoleberis* sp., *Costa* sp. and many fragments of *Echinocythereis* (?) sp.

At the depth of 47 m, the community is dominated by *Candona elongata* (Schweyer) (87 specimens, adults and juveniles), *Darwinula stevensoni* (juveniles abundant), *Candona candonaeformis* Schweyer (4), *C. neglecta* (abundant), *Tyrrhenocythere amnicola donitziensis* Dubowsky (21 adults and juveniles), *Ilyocypris gibba* (nine), *Amnicythere* aff. *cymbula* (14 adults and 3 juveniles), *Cyprideis torosa* (11 tuberculated valves), *Cytherissa triformis tuberculata* Olteanu (6), *Zonocypris membranae* (Livental) (one).

Between 52 and 54 m, I found *Amnicythere caspia* (Livental) (2 valves), A. *striatocostata* (16 adults an juveniles), *A.* aff. *posterobilicata* Stepanaitys (2 adults), *A. multituberculata* (Livental) (7 adult valves), *Leptocythrere bacuana* (2), *Loxoconcha aff petasa* Livental (1), *L.* aff. *gibboides* Schweyer (2 valves), *L.* aff. *rugosa* Stepanaitys (1), *Tyrrhenocythere amnicola donitziensis* (7 adults and 5 juveniles), *T. azerbaidjanica* (Livental) (4 adult valves), *Cytherissa bogatschovi bogatschovi* (Livental) (4 adult and juvenile valve), *C. triformis tuberculata* (1).

At 59–61 m, the ostracod assemblage consists of *Cyprideis torosa* (abundant nontuberculated *valves), Paracandona albicans, Darwinula stevensoni, Candona neglecta, C. candida, C. elongata, C.* aff. *abichi (Livental), Limnocythere* aff. *nodula* (Mandelstam), *Romaniella dacica, Amnicythere aff cymbula* (with 2 posterior-ventral tubercles), *A. caspia, A.* aff. *strigosa* Mandelstam, *A.* aff. *martha, A.* aff *transformis* Mandelstam, each of them with less than five valves, *Tyrrhenocythere amnicola donitziensis* (27 adults and juveniles).

At 70.10 m the assemblage is: *Amnicythere caspia* (7), *A. quinquetuberculata* (14 adults and 11 juveniles), *A.* aff. *arevina* (Livental) (3), *A.* aff. *variatuberculata* Livental (3), *Tyrrhenocythere* sp. *ex gr pseudoconvexa* (Livental) (3), *Caspiolla gracilis* (sensu Mandelstam *et al.*, 1962) (extremely abundant), *Cyherissa plana tuberculata* (4 adult valves), *Eucypris famosa* Schneider (2 adults), *Cypris mandelstami* Lubimova (one juvenile).

Between 97 m and 104 m, I found only species of *Caspiolla gracilis* (7), *Amnicythere* aff. *malva* (2), *Paracandona albicans, Ilyocypris bradyi, Romaniella dacica* (3–5 adult valves).

Between 104 m and 109 m, I found *Cytherissa plana tuberculata* and *Caspiolla gracilis* (both, very abundant), *Tyrrhenocythere amnicola donitziensis* (5 adults), *T.* aff. *pseudoconvexa* (1), *Amnicythere quinquetuberculata* (13 adults and 18 juveniles), *A. reticulata* (9 adults and 2 juveniles), A. aff. *litica* (Livental) (5 adults), *Loxoconcha aff gibboides* (3 adult valves), *Carinocythereis* sp (fragments).

From the depth of 111 m and 129 m, the community consists of almost only *Cyprideis torosa* (valves and carapaces, adults and juveniles, tuberculated and non-tuberculated), *Candona elongata* (very abundant) and two adult valves of *Candona candonaeformis*.

At the depth of 130.10 m there appear *Cytherissa triformis tuberculata* (abundant), *C. triformis triformis, C. plana plana and Caspiolla gracilis, Loxoconcha* aff. *gibboides, L.* aff. *petasa, Tyrrhenocythere azerbaidjanica, T. sp., Amnicythere quinquetuberculata, A. sp. ex. gr. cynbula, A. caspia* (less then 5 valves) and morphotypes of *Cytherissa bogatschovi bogatschovi* (with hyaline, translucent and very thin valves).

Between 133.80 m and 158 m there appear *Candona (Caspiocypris) filona* (Livental), (1–2 valves on each samples), *Candona (Caspiolla)* aff. *rurica* Krstic, *C. (C.)* aff. *parscoviensis* Olteanu, *C. (C.)* aff. *dacica* Olteanu, *C. (C.)* aff. *lobata* (Zalany). The ostracod community components remain unmodified to 254 m.

3. FIRST CONCLUSIONS

The vertical distribution of the species inevitably reflects the order in which these species "evolved" *hic et nunc*, while the relationship between biochronological analyses and paleontology is rather empirical and does not pretend to be applicable to the whole Ponto-Caspian area.

Generally, the transportation possibility has to be excluded due to reasonable abundance, simultaneous presence of adults and juveniles and absence of valve abrasion.

Most of the species live today both in the Black Sea and the Caspian Lake (*Amnicythere histriana, A. quinquetuberculata, A. cymbula, A. reticulata, A. striatocostata, Leptocythere lopatici, Callistocythere bacuana, Tyrrhenocythere amnicola donitziensis, Carinocythereis rubra pontica).*

The marine species (*Carinocythereis carinata, Xestoleberis decipiens, Loxoconcha granulata, Callistocythere mediterranea, C. flavidofusca, C. diffusa, Pterigocythereis jonesi* etc) are found only within the Black Sea area with rather high individual densities. They have colonized widely varying types of shallow water of the Black Sea during Würm time (Lower Würm?).

Some ecological observations on living ostracodes (Caraion, 1966, Sornikov, 1968) can be extrapolated to fossils, especially when dealing with the same closely related and allied species (for example *Amnicythere striatocostata* and A. *cymbula* have been found within biotopes with salinity between 3–5%, *Amnicythere reticulata, A. relicta, A. pediformis, Callistocythere bacuana, Leptocythere lopatici* and *Candona elongata*, between 3–7%. *Tyrrhenocythere amnicola donitziensis* is abundant at 10% salinity. *Xestoleberis decipiens, Semicytherura virgata, Carinocythereis rubra pontica* live around the salinity of 11–13%.).

Many if not most species of the Black Sea, occupy the same brackish-water ecosystem (between 3 and 18%) and display several morphological forms. The champion is the Leptocythere group. It has been suggested (Peypouquet, 1977 and Carbonnel, 1980) that valve ornamentation is tied to the rhopic factor (Mg-Ca ratio

in water) and not strictly genetically fixed (its intensity is physiologically controlled). Its effect consists in the paleontological species.

I identified almost 80 species in our cores: 56 are fresh and oligohaline organisms; many of them have always been found in association with other species due to their overlapping ecological range (12 species were found in the Upper Dacian, 18 in Romanian sediments and 17 in Apscheronian sediments). Five successive facies could be distinguished, in accordance with this distribution.

As a paleontologist of brackish-water ostracod, I am suspicious when anyone says that fresh-water sediments are correlated not merely with marine sediments but also with brackish-water sediments and their fossils (see the utopian correlation of Jiricek, 1974, 1975, Krstic, 1975 and Marinescu 1992 which, unfortunately is practically meaningless. Moreover, the biostratigraphic methods vary from one author to another, often with different meanings. Actually, all their good intentions were overthrown by Archambault-Guezou, 1976).

4. OSTRACOD STORY

The study of brackish-water Pliocene ostracodes has a long history with the pioneering works of Mehes (1907, 1908), Livental (1929) and Zalany (1929). Many workers have contributed significantly to the interpretation of the ostracodes and the stratigraphic units within the Paratethys area. Recent syntheses of regional biostratigraphy and ostracod paleontology included Mandelstam *et al.* (1962) and especially Mzia Vekua (1975). However, almost all post-Meotian genera and species originally described from the Apscheronian sediments. Their "time of existence", from the Pontian to the Upper Quaternary is rather exagerated. The inaccuracy of the author drawings and descriptions, besides ornamental intraspecific variations of the "design-valves" made their taxonomy highly ambiguous. Striatae Leptocytherinae have been found from the Badenian to the Quaternary, but only later *L. striatocostata* (Schweyer). Valves with two postero-ventral tubercles are numerous, but only one is *L. andrussovi* (Livental). Such situations are numerous and they have been subject of disputed literature. As Simpson (1961) noted long ago, biological classification throughout its long history has been as much an art as a science. The list of considerations that influence paleontological classifications is long, almost anyone is liable to come up with very noisy data sets.

Generally, within the Paratethys brackish-water ecosystem, three successive fauna cycles may be recognized: the Sarmatian, the Meotian and the Pontian. Each of them might be characterized by a special typology of ostracod fauna (like archetypes). For all that, we would remind what Bergson said "... *since the past never dies, life becomes richer by retaining this past*".

The definition of species based on purely morphological criteria often reduced systematic problems to mere cataloguing mechanisms rather than questions of biological importance. However, the confusion in nomenclature persists. I have attempted, as far as possible, to display and to point out other paleobiological aspects such as intraspecific variability, changes in fossil diversity or the problem of heterochronous homeomorphy in order to integrate them into a rational interpretation. The first conclusion would be that several oligohaline ostracodes do not possess unique valve morphologies, being rather variable from individual to individual, from time to time and from place to place, confirming further a remarkable plasticity of valves triggered by this particular environment.

The three cores traversed a few saline facies (with almost 80 species). Vertical segregation of components is obvious and change in diversity is necessarily associated with an ecological event. Within each ecological sequence there is a continuum of community structure.

The marine community appears in the Cosna core only between 28.00 m and 44.00 m. At the opposite pole is the fresh-oligohaline community with *Darwinula, Ilyocypris, Limnocythere* (with the largest ecophenotypic variability) and more bizarre forms of *Eucypris, Cypris, Romaniella, Kowalevskiella, Zonocypris* species restricted to salinity below 5%. But there remained a saline framework with ambiguous outline and arbitrary boundaries between 5% and 11%, where two fluid communities exist: the first appears somewhere within the Lower Quaternary (= Caspian community) and the second which disappears within this interval (= Dacian community). They would be considered as two brackish-water subsystems.

The Upper Dacian community has a long range which begins somewhere in the Upper Pontian-Lower Dacian (Getian) interval and consists of *Amnicythere arevina* (Livental), all *Cytherissa* species, *Caspiolla gracilis* (sensu Mandelstam *et al., op. cit.*), *Caspiolla parscoviensis* Olteanu, *Caspiolla danensis* Olteanu, *Caspiolla* aff. *lobata* (Zalany), *Caspiolla* aff. *dacica* Olteanu, *Loxoconcha* aff. *petasa* (Livental). Most of them dislocated by "the Caspian wave".

The Caspian community consists of *Amnicythere striatocostata* (Schweyer), *A. quinquetuberculata* (Livental), *A. cymbula* (Livental), *A. relicta* (Sornikov), *A. reticulata* (Sornikov), *A.* aff. *transformis* (Mandelstam), *A.* aff. *babenkoi* (Markova), *A. longa* (Negadaev-Nikonov), *Leptocythere bacuana* (Livental), *L. lopatici* Sornikov, *Tyrrhenocythere azerdbaidjanica* (Livental), *T. pontica* (Livental), *Loxoconcha gibboides* (Schweyer). They appear within the Apscheronian interval and are found in the entire Ponto-Caspian area.

4.1. REMARKS AND DISCUSSION

Genus Candona Baird, 1845. Today there are almost 50 subgenera of brackish-water Upper Neogene Candonae. Caspiolla Mandelstam, 1960 is one of them.

Candona (Caspiolla) gracilis (sensu Mandelstam *et al.*, 1962, p. 129, pl. XIV, Figs. 1–3 and not Livental, 1929) was found in so-called Bacu-beds (presumably Lower Quaternary). I found it in all the brackish-water ante-Karagatian sequence.

Candona (Caspiolla) parscoviensis Olteanu is known from numerous localities throughout the Dacic basin during the Upper Dacian time. This species occurs most commonly in low-energy facies, usually fine sands and mudstones where it is often associated with abundant Caspiollae, nontuberculated *Cyprideis* and *Cyprinotus*. Our specimens are longer than the majority of standard valves reminding of some *C. balcanica* (Zalany) morphotypes. Generally, in Upper Dacian times there are many anteriorly globulous and posteriorly acuminated Candonae. Several of them were found in the lowermost intervals of our core: *Candona (Caspiolla) danensis* Olteanu, *C. (C.)* aff. *dacica* Olteanu, *C. (C.)* aff. *lobata* (Zalany) or *C.(C.)* aff. *acronasuta* (Livental). All of them are species with very elongated and pointed posterior valves which are considered to have a low fecundity. In our samples, they developed very rich populations.

Candona candonaeformis (Schweyer) has been described in Apscheronian sediments (Schweyer, 1949, p. 63, pl. IV, Figs. 4–6). It appears in the Dacic basin at the uppermost Dacian levels and in the first Romanian sequences.

Sunbgenus Candoniella Schneider, 1956, is of course, as many Canodoniae subgenera, a conventional taxonomic unit which clustered all fresh-water valves without angles and straight lines in their shape. Very widespread during the Pliocene, "Candoniella" appeared in the fresh-water Uppermost Meotian interval and evolved without any morphological changes or noticeable diversification during the Pliocene and Post-Pliocene (its "species" are difficult to determine with accuracy). *Candona (Candoniella) elongata* (Schwyer) (very abundant in our samples) is frequently found from Apscheronian sediments to Recent fauna of Black Sea (as *Candona schweyeri* Sornikov). I have found similar shape-valves in all fresh-water levels beginning with the Upper Meotian, Lower Pontian and especially in the so-called "Viviparidae Beds" from the Lower Dacian (part of the Dacian stratotype).

Genus Cyprinotus Brady, 1885 has triggered a real cascade of species and subspecies in all brackish-water facies. The valves are oval, elongated, triangular-like (*Cypris maculosa* Bronstein), smooth, slightly tuberculated (*Cypris tantilla* Stepanaitys or *C. slavianensis* Mandelstam), or with fine punctuations (*C. odiosa* Mandelstam), all of them being assigned to the *Cypris, Cyclocypris* or *Cyprinotus*. *Cyprinotus reniformis* (Schweyer) has been described from Apscheronian sediments (Schweyer, 1949, p. 26, pl. IV, Figs. 2, 3). I found it in Upper Dacian, Romanian and Pleistocene sediments from the Dacic basin. *Cyprinotus* sp. 1 is a very large valve (L = 0.93–0.97 mm) but with an episodic presence only in fresh-oligohaline sequences.

Cypris mandelstami Lubimova was found in Middle Romanian sediments and in oligohaline intervals from the Danube Delta core.

Genus Zonocypris G. W. Muller, 1898 is a valve ornated with concentric striae. *Z. membranae* (Livental) appears in fresh-oligohaline facies. It is frequent in the Romanian sediments but also in Post-Pliocene sediments from circum-Caucasus regions.

Genus Eucypris Vavra, 1891 is represented by only one species, *E. famosa* Schneider found in Middle Romanian sediments. Similar valves have been described from the Upper Pliocene (?) (*E. punctata* Mandelstam, *E. cristata* Mandelstam or *E. reticulata* Mandelstam) from the Akchiaghilian (*E. puriformis* Mandelstam) and from the Bacu Beds (*E. magis* Stepanaitys, *E. inflata* Sars). Of course, it is difficult to estimate their taxonomic value. More important is their remarkable morphological plasticity in oligohaline facies.

Genus Kowalevskiella Klein, 1963 and *Romaniella dacica* Olteanu are relatively frequent in fresh-water sediments in the Romanian time.

Genus Limnocythere Brady, 1867 is another luxuriant taxon of fresh and oligohaline facieses. *L. inopinata* (Baird) is sporadically present within the Romanian interval. On the other hand, it was found (as *Limnocythere luculenta* Livental) in Akchiaghilian (?)-Apscheronian sediments from the Ponto-Caspian regions (Livental, 1929). *Limnocythere magna* (Olteanu) occupies a relatively well defined area in the eastern region of the Dacic basin where it displays a single morphological theme. In the Pardina core (at 63.50–76.00 m) I found several specimens which would be ecomorphotypes of *L. magna*. *Limnocythere lanceolatus* (Olteanu) and *L. textilis* Stepanaitys coexisting in Romanian time from the eastern region of the Dacic basin. It is uncertain whether we can interpret them as ecophenotypic variants within a single biological species or as interspecific hybridizations or merely as valid species.

Genus Cytherissa Sars, 1928. In the Dacic basin, the first *Cytherissa* appears in the Upper Pontian interval as *Cytherissa bogatschovi bogatschovi* (Livental). It was gradually subsituted (during Upper Dacian time) for mono-tuberculated "species". Within the Ponto-Caspian area, *C. bogatschovi bgatschovi* appears in Lower Kimmerian time. In the so-called Duab Beds interval (Middle and Upper Kimmerian) it sporadically appears, being substituted for smooth valves (*Cytherissa daubica* Vekua and its many variants). With the same "design" it continues to the so-called Guria and Ceauda Beds (the equivqlent of the Upper Romanian and Pleistocene from the Dacic basin). It is interesting to observe that the Ponto-Caspian valves are thin, fragile and generally small, *versus* the massive and coarse tuberculated ones from the Dacian biotopes. However, both of them have been identified in the Danube Delta core and it is clear that such distinction should be treated as suggesting an overlap community coming in from different and close biofacies.

It seems that the number of tubercles decreases with the salinity reduction and this discernible morphological change deemed significant for a paleontologist.

Genus Tyrrhenocythere Ruggieri, 1955. The last species from the Upper Dacian is *T. incerta* Olteanu. The same ornamental pattern exists in *T. davidaschvili* (Imnadzae) (from Upper Kimmerian) and (much more diluted) in *T. ammicola donitziensis* Dubowsky. In the particular facies of the Duab Beds and Guria Beds (with salinity less than 11%), the Tyrrhenocythere genus underwent a dramatic burst of origination. Only from Upper Kimmerian, the great Georgian paleontologist, Imnadzae (1971) figured on *T. devii* n. sp. (that looks quite similar to *T. filipescui* Hanganu from Lower Dacian), *T. notabilis* n. sp. (very close to *T. taurica* (Sinegub) (fide Krstic, 1975) and *T. rujalnicensis* n. sp. (it would seem to be *T. pontica* (Livental) besides other eight nonfigured new species.

In the same sediments there was found *Aurila dubowski* Sornikov from the Recent ostracod community of the Black Sea. Furthemore, there are several smooth or faintly pitted Tyrrhenocythere illustrated by Mandelstam *et al.* (*op. cit.*): *T. pseudoconvexa* (Livental), *T. dendropora* (Suzin), *T. gaurilovi* (Markova), *T. cibaria* (Sharapova), *T. immediata* (Markova), *T. bailovi* (Livental), all of them from the Lower Pliocene (?) to the Apscheronian of the Caspian regions. The differences between these smooth "species" lie in dimensions and shapes. It can be argued that there is clonal variability in the genetically determined range of the reaction norm for morphological details of the valves. In response to some still unknown environmental stimuli, many juveniles with a broad reaction norm can become smooth or pitted. The proportion of specimens with broad or narrow reaction norms can vary considerably in time and space. Furthermore, the boundary between *Hemicytheria* and *Tyrrhenocythere* inside features is always keeping the same surface ornamental structure (see Olteanu, Vekua, 1989).

All valves features are conservative, remaining fixed, except the marginal pore canals which pendulated between simple, straight canals (at *Hemicytheria*) and clustered in 9–10 fascicles (at *Tyrrhenocythere*). This differentiation process cannot be fully explained. It would be supported by the hydrochemical differences and the unequal effects of local selection or by a kind of genetic deviation of population, although their origin is the same. However, the distinction between *Hemicytheria* and *Tyrrhenocythere*, based exclusively upon ornamental characteristics of the valve surface, is made highly ambiguous by the interspecific variations. It seems clear that the effect of salinity differences on ostracodes is almost entirely due to the disturbances they set up in the osmotic pressure and the rhopic factor.

With such a genus begins, in a way, the taxonomic drama, indeed. Its first species appear in the Middle Pontian of the Dacic basin (*T. filipescui*). It remained within the same "design" until the Lower Dacian. But in this interval of time it was allied with a lot of smoothly or coarsely ornated variants. It justifies the role of the biological "crucible" of the oligohaline habitats.

Thre are many smooth, thin valves of Leptocythere in the Sarmato-Pliocene sediments: *Ammicythere paralella* (Mehes) (from the Sarmatian), the same from the Lower Meotian, a valve with two postero-ventral swellings from the Lower Meotian, the one with a posterior curved swelling from the Lower Pontian and a smooth valve from the Upper Dacian. In recent fauna of the Black Sea, Sornikov (*op. cit.*) illustrated several valves belonging to *Leptocythere cymbula* (Livental) with the postero-ventral portion of the valves differently ornated. The fossil valves of *Amnicyhere longa, A. cymbula, Leptocythere pediformis, L. reticulata* or some individuals of *L. relicta* can be hardly morphologically separated. Their ontogenetic process shows an extreme variability. A juvenile with five tubercles of *Leptocythere relicta* for example, is similar to the *L. multituberculata* ones.

There are some specimens of *L. reticulata* which looks like the Lower Meotian specimen or the Sarmatian valve or quasi-similar to the Upper Pontian one. Several individuals of "*caspia*" would be placed anywhere. However, almost 60 smooth species have been described up to now. All these "species" occur commonly in shallow oligohaline sediments where, due to the phenotypic ornamentation, no individual is similar to another. However, where similar biotopes were developed during the same interval, the species similarity was much greater. It is an older idea that the peculiarities of the valve shape of various populations within one species are most probably ecophysiological, due to the environment in which the ostracodes live and these peculiar ornaments are not genetically fixed ("*ecological factors... play the most important role in explaining the size differences*").

Leptocythere incerta Olteanu (1995) is similar to the specimen described by Mandelstam *et al.* (*op. cit.* p. 194, pl. XXXV, Fig. 12) as *L. olivina* (Livental) and by Agalarova (1967, pl. VIII, Fig. 2) as *L saljanica* (Livental). Our specimens are extremely inconstant from the morphological point of view.

Leptocythere transformis Mandelstam (*op. cit.*, p. 234, pl. XXXVIII, Fig. 2). The few specimens found up to now have different sizes of the postero-ventral ridge.

Leptocythere aff babenkoi (Markova) (in Mandelstam *et al., op. cit.*, p. 220, pl. XXV, Fig. 8) has a slight posterior thickness and one or two (or even three) posterior tubercles. Its position, dimension and shape differ from individual to individual.

Leptocythere arevina (Livental) (sensu Mandelstam *et al., op. cit.*, p. 221, pl. XXXVI, Fig. 1) looks like some juveniles of *Leptocythere lata* Schneider (sensu Agalarova, *op. cit.*, pl. X, Figs. 2, 3, 4).

Leptocythere pediformis Sornikov has a genuine play of the posterior ornamental details. It seems that its origin are to be found in *Ammicythere gratiosa* Olteanu from the Upper Dacian.

Leptocythere lopatici Sornikov is very close to *L. bacuana* (Livental) (the specimens from the Lower Pontian).

Amnicythere ultima ultima Olteanu is the last species of brackish-water history of the Dacic basin. It looks like some juvenile specimens of *Leptocythere*

(Maeotocythere) cellula (Livental) figured by Agaralova (*op. cit.*, pl. XII, Fig. 2), another species with a long temporal range from the Lower Pontian to the Apscheronian. The two species belong to two separated subgenera *(Amnicythere* and *Maeotocythere*) with totally different hinges.

Finally, *Amnicythere caspia* (Livental) is much more unitary and stable in the samples from the Cosna core at the depth of 152 m and it is highly variable in some samples from the Pardina core (between 10.40 m and 10.80 m and 31.50–31.80 m).

The oldest known species of the *Amnicythere* subgenus is *A. praebacuana* (Livental) from the Lower Pontian of the Dacic basin. Often it is found in monotypic assemblage within which it develops a strong polymorphism mainly marked by the appearance of tubercles and coarse reticulation. During the Pontian, *A. praebacuana* displayed a much wider geographical distribution, being well represented in the Pannonian basin, the Dacic basin and the Ponto-Caspian area. *Leptocythere (Maeotocythere) infera* Olteanu, from the Meotian is its possible ancestor.

A. *multituberculat*a (Livental) appeared in the Upper Pontian time, and became especially common in the Dacian time. It is still present in the geographical area in which it was already known, suggesting in this way a similar "mode of life". It is commonly accepted as characterizing brackish-water paleoenvironment (salinity less than 13%), being able to live under mesohaline and especially oligohaline conditions.

In the Pannonian area, *A. multituberculata* was reported within Pontian time (Campia-Langenfeld, Crivina, Criciova, etc. until very recently considered as Pannonian age), especially in the Upper Pontian being represented by very large specimens. It seems that the sizes of *A. multituberculata* and *A. quinquetuberculata* are linked to salinity – the forms of low salinity being smaller, translucent, tending to fragile ornamentation. However, *A. quinquetuberculata* is undoubtedly another form of *A. multituberculata*.

Loxoconcha petasa (Livental) has been quoted within all brackish-water facieses of the Upper Neogene and Quaternary (often as *L. rhomboidea*). I found it in its orthodox pattern only in the Cosna core (at 152 m). The specimens are similar to the Upper Kimmerian ones illustrated by Vekua (1975) from the so-called Duab Beds, associated with fresh and oligohaline faunas.

Loxoconcha aff. *granulata* (Sars) develops dense populations in the littoral and sublittoral zones of the Black sea. I found it in all our core.

Loxoconcha gibboides Livental is a massive valve with a great swelling in the centro-ventral portion of the valve. I found it with two variants: individuals with concave dorsal margin and others with straight dorsal margin and prominent cardinal angles. Both valves have the same number of marginal pore canals and type of hinge (26–29 denticles on the median bare, many of them being bifurcated). Schweyer (1949) figured it from Apscheronian sediments, and Mandelstam *et al.* (*op. cit.*) from Middle Pliocene (?) and Apscheronian sediments. In the Cosna core

I found few valves quasi-similar to "*gibboides*". One of them would be *Loxoconcha endocarpa* Sharapova figured in Mandelstam's monograph on pl. XXVII, Fig. 12 and vaguely described on p. 174.

Loxoconcha lepida Stepanaitys (sensu Sornikov, *op. cit.*, p. 109, pl. XXV, Fig. 2) is somewhat different from Stepanaitys drawing (pl. XXVIII Fig. 7 from their monograph) and also from the synonymous (Sornikov's opinion) *Loxoconcha unonodosa* Mandelstam (*op. cit.*, pl. XVIII, Fig. 9). However this species is abundant in all our core.

Finally, *Loxoconcha aff abundata* Stepanaitys (in Mandelstam *et al.*, p. 175, pl. XXVIII, Fig. 1) or in any case something looking like it, I found only in the Cosna core (at 152 m).

5.THE LAST WAVE OF MARINE IMMIGRATION

It is the last geological event from the Paratethys history (in Lower Holocene).

Few remarks: *Callistocythere diffusa* (G. W. Muller) is quasi-similar to *Callistocythere canaliculata* (Reuss) from the Upper Badenian (a level which marks the beginning of brackishening of the Paratethys area).

Carinocythereis rubra (G. W. Muller) seems to be similar to *Carinocythereis* aff. *rubra* from the Lower Meotian of Abkchazia (Georgia) associated with marine ostracode species: *Bairdia, Hermanites* (?), *Quadracythere.*

6. MISCELLANEOUS CONSIDERATIONS

The Black Sea and the Caspian Lake are Paratethysean relicts having a long and complex history. Many details are less known. The geological time is segregated in a lot of ecological sequences, each of them with its own kind and nature of community, sometimes forming more or less several "parallel words" each under "private" ecological umbrella and implicity with their local stratigraphy. This mosaic of biofacies guided the fauna development (ostracodes and mollusks). The planktonic foraminifera and nannofosils-scale cannot be useful since they are either absent or extremely rare. The role of the ostracodes becomes most important. The brackish-water is almost exclusively ostracodes's realm. For these reasons, the Upper Neogene biostratigraphy within the Paratethys area remains a difficult trial whose scale must be always reconciled as new methodological and theoretical options suggest other explanations. The brackish-water fossils kingdom needs more than a horse.

The Paratethys fauna has been investigated exclusively on near-shore sequences. Some of them were chosen as stratotype, like an "ideal" place and fauna. Unfortunately, neither the boundaries nor the so-called "fossil marker" can

be defined with rigor, although a plan between the two sorts of fauna could be distinguished. But only a local one. It belongs to that local sequence and not to a precise instant of the geological time for a larger area. Besides, a lot of "syncopes" appear: episodic sedimentary processes with repeated moments of erosion and redeposition, regressions and transgressions. The "datum" can be justified like a "deus ex machina", which hid the real causes. A stratotype represents only a small fragment of life diversity and hence the possibility of errors in the correlation from one local sequence to another, from one basin to another. The Lower Dacian stratotype is just an example, it being a sole, unique sedimentary sequence. On the other hand, many paleontologists revealed each rather particular fauna, breaking the geological time in lots of fragments like new geological episodes. Today, we have two Sarmatians, two Dacians, an uncertain Pannonian (without fauna support), and a Romanian, very short but, of course segmented into three substages.

Similar situations are also present in the Euxinic basin or circum-Caucasus areas. Each of them has its kinds of scale. Now we have almost hundred stages. Their reconciliation seems to be impossible. For the Black Sea sediments we have actually neither a clear lithological succession nor a main fauna deciphered. The species would have another distribution and position on the geological scale. The Meotian sediments from the circum-Caucasus area bear, for instance, microfaunas sending to the Sarmatian from the Carpathian regions, like another paradoxical act. Each basin of the Paratethys has a specific pattern of the fossil community.

The same situations occurred with the "markers". Only few species tend to "survive" without a morphological change. Its rate, slow or rapid, led to the appearance of numerous new archtectural details within each "archetype": *Congeria, Limnocardium, Candona, Hemicytheria,* etc. For the entire time of the Pontian, for instance, only *Congeria rhomboidea* was dispersed over several basins (Pannonian, Dacic and Ponto-Caspic); although it seems less probable, it was a unitary and constant taxon. The convergence phenomenon is in fact the most frequent one within the brackish-water biocenosis. A few forms under similar ecological conditions reshape in older forms once more. The Akchiaghylian mollusks for instance, reveal "designs" reminding of the Sarmatian ones (Avimactra, Avicardium), like an arch over the time. The reason is a strong but permissive marine transgression from the south (?). The new "invaders" were dispersed over a very large surface (almost 2,000 km toward the north of the Caspian Lake). However, this resemblance (homeomorphy) is not synonymous with a specific identity.

Another problem is the non objectivity of the species and the non-stability in nomenclature, although the species concept is only a concept (an intellectual construct) and fauna has its "personal purposes". Most of the brackish-water species consist of a long lineage, without gaps and with moments of "explosion" and relaxed ones like a fluid stream of morphological variants (ecotypes), each of them, whatever

it is, developed only once and only at one place. The reason forsuch an impossible disorder would be the main feature of the brackish-water organisms: their morphological lability during ontogenesis. I seem to have advocated cenogenesis, but fortunately its process is fully justified in the light of the present observations.

This new core can trigger a new stratigraphical venture with beneficial effects on the stratigraphic reconstruction of the Black Sea area.

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