A PALEOECOLOGIC ANALYSIS OF THE BASSARABIAN (MIDDLE SARMATIAN) VERTEBRATE ASSOCIATION FROM CREDINȚA AND CIOBĂNIȚA (SOUTHERN DOBROGEA) BASED ON THE TAPHONOMIC CHARACTERS PROCESSED THROUGH METHODS OF NUMERICAL TAXONOMY

DAN GRIGORESCU, VLADIMIR CONSTANTINESCU, LIVIU DRAGOMIRESCU

On présente les caractères taphonomiques de chaque groupe de vertébrés (poissons téléostéens, oiseaux, phoques, cétacés) de l'orictocénose des sables quartzeux du Bassarabien (Sarmatien moyen) de la zone de Credinţa-Ciobăniţa (sud de la Dobrogea). Les données quantitatives résultées de l'analyse taphonomique sont traitées par quatre méthodes de taxonomie numérique dont 3 satisfont la problématique du cas.

INTRODUCTION

The fossil associations recorded in the sedimentary deposits formed in the marine environment around some exondate regions above the shoreline (continent or islands) ordinarily gather organisms from several biotops. The dynamic factors carrying the sedimentary material to this environment, i.e. continental water courses on the one hand and tide, waves, littoral marine currents on the other hand, are particularly active, leading through their action to the mixing up of the continental organisms with the marine ones and to their fragmentation.

Often, a paleontologic association discovered in a certain layer or group of layers which represents an orictocenosis (orictoss digged out, in Greek)[1] includes organisms that belonged to several biocenoses.

In the paleoecologic analyses of the orictocenoses gathering organisms from different biotops and biocenoses, it is extremely important to recognize the "autochthonous" elements (represented by organisms whose biotop cores-

[1] The orictocenosis is different from the tanatocensis (an association of dead organisms and unburied organic remains) and from the taphocenosis (an association of buried organisms that undergo the diagenetic processes which strengthen the long lasting process diminishing the organic remains that began immediately after the death of the organisms).

ponds to the environment where the sedimentation took place), and respectively "allochthonous" (organisms from other biotops whose remains were carried within the sedimentation basin).

The Middle Sarmatian (Bassarabian) quartzose sand vertebrate orictocenosis of southern Dobrogea, southwards of Cobadin (near the Credința and Ciobănița localities) is formed of teleost fishes (Sparidae and Clupeidae), birds, mostly peri-aquatic and pelagic *(Sasmatosula dobrogensis, Ciconia sarmatica, Grus miocaenicus, Anas cf. velox, Anas sp., Anser sp., Aythia sp., Larus sp., Diomedea rumana)*, pinnipeds *(Pusa pontica)*, cetaceans *(Delphinidae, Cetotheriidae)*, the seals representing the most characteristic element (Grigorescu, 1976; Chiriac, Grigorescu, 1975). The fragments of turtles and terrestrial carnivora are very rare in the association.

The paleogeographic picture resulted from some of these studies (Grigorescu, 1978; Grigorescu and Dinu, 1978) is that of an eulittoral sedimentation, in an area close to some inland regions.

TAPHONOMIC DATA

The taphonomic studies (regarding the way of association of the organic remains and the transformations undergone by them until their discovery) play an important role in establishing the autochthonous or allochthonous character of the groups of organisms from an orictocenosis.

In the case of the quartzose sand vertebrate orictocenosis of southern Dobrogea, the identification of the autochthonous taxa can be made on the basis of the following taphonomic and statistic criteria: the presence of entire skeletons or of skeleton parts in a semi-connection state, the lack of the erosion signs due to the transportation, the presence of individuals of different ages (ontogenical associations), the high frequency of the respective taxon. On the contrary, the allochthonous fossils are indicated by isolated bones, fragmented or bearing obvious erosion signs, the weak dispersion of the individuals on the age categories, the low frequency of the taxon.

Taking these criteria into account, the main taphonomic characters shown by the vertebrate groups present in the southern Dobrogea quartzose sand orictocenosis are the following:

I. The *sparids* are represented by isolated, unworn bones consisting of vertebrae, teeth, cranial bones, opercular bones, rays of fins, pterigophores the jaws with partially preserved triturating teeth disposed on several rows being the only skeleton elements found in connection. The association includes both juveniles and adults. The Sparidae fragments represent about 40% of the Credința and Ciobănița sand vertebrate fauna.

II. The *clupeids* exclusively include isolated, unworn skeleton elements represented by vertebrae, opercular parts, rays that seem to have belonged only to adult individuals. The clupeid remains represent about 20% of the vertebrate orictocenosis.

III. The *chelonians* are represented by very rare skeleton remains (less than 1% of the vertebrate orictocenosis) consisting of carapace and vertebrae fragments, strongly eroded through aquatic transportation.

IV. The *birds* exclusively include isolated bones partly fragmented, and generally not eroded; the different ecological types present in the fauna

(peri-aquatic and pelagic forms) do not show obvious differences of the taphonomic characters except the relative frequency of the peri-aquatic forms as compared to the pelagic ones. The signs of weathering under sub-aerial conditions have rarely been observed (cf. Behrensmeyer, 1978). The bones seem to belong exclusively to adult individuals. The bird bones stand for about 3% of the vertebrate fauna. Their scarcity is explained by the nature of the bird skeleton, formed of pneumatic bones, much more fragile and therefore fossilizing less than the bones of the other tetrapods. The bird bones in the studied orictocenosis are more often represented only by the epiphysis, with a denser histological structure, and therefore more resistant, while the shafts are either lacking or fragmented.

V. The *seals :* the osteologic material mostly consists of isolated, unfragmented bones, devoid of obvious tracks of underwater, or subaerial erosion. Skeleton parts with bones in a state of semi-connection have been exceptionally recorded in the area.

The long bones rarely show superficial longitudinally oriented desquamations on one side, the other side being not affected. Similar aspects have been mentioned in the case of the bones of some present-day large mammals exposed to the action of the atmospheric agents under the conditions of the warm and arid climate of the African savanna regions (Behrensmeyer, 1978). Moreover, bones showing pronounced signs of erosion on both faces due to continuous rolling by waves, are rarely recorded.

The seal bones in the orictocenosis belong to different age-categories: new-borns, juveniles, old individuals, a fact very well illustrated by the limb bones, for which all these individual ages are well represented in the collection. The seal remains represent about 35% within the orictocenosis.

VI. The *cetaceans* are represented by isolated bones, especially vertebrae, that show the most advanced degree of erosion through marine transport, as compared to the whole osteological material of the entire orictocenosis. A skull fragment that belonged to a small whale *(Cetotherium sp.)* was discovered at Ciobănița. The cetacean bones represent less then 1% within the orictocenosis; they seem to be more frequent in the diatomite deposits from western part of the Sarmatian sea (Adamclisi and Urluia localities), that represents a pelagic environment of sedimentation.

The taphonomic characters mentioned above for the vertebrates of the studied orictocenosis are illustrated in fig. 1 in the terms of a relative quantitative appreciation: very rare, rare, frequent, very frequent.

THE PROCESSING OF THE INFORMATION (TABLE IA) THROUGH NUMERICAL TAXONOMY METHODS

The numerical taxonomy is a collection of explicit cluster and/or classification methods. A detailed presentation of some of the theoretical principles of this field can be found in the papers of Sneath and Sokal (1973) and of Anderberg (1973).

Given that the observations generally have a complex character, Anderberg (1973) recommends the applications of as many algorithms as possible which render evident the multiple significations of the data.

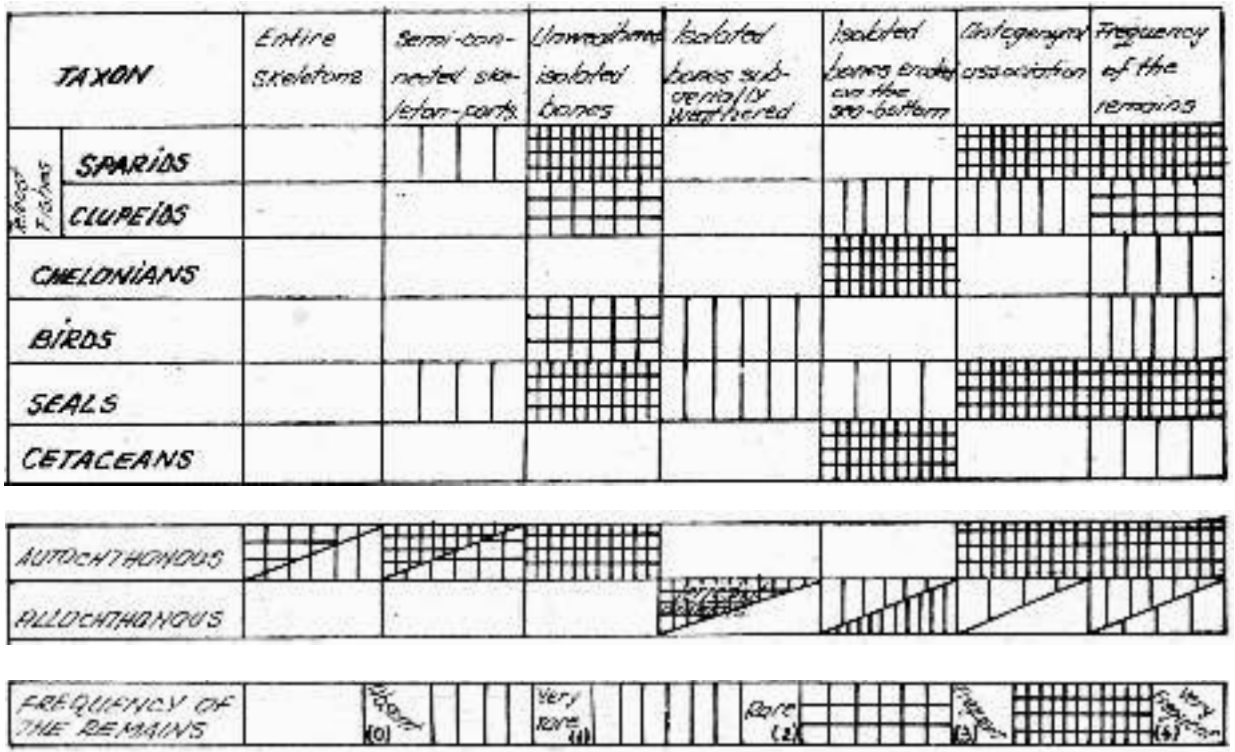

Fig. 1. The taphonomic characters of the studied orictocenosis of vertebrates in terms of a relative quantitative appreciation.

In the above mentioned case, there are at least three important classes of "relations" between the taxa (objects) of the orictocenosis:

A) the taphonomic *resemblances* completed by the fossil frequencies;

B) the ecological *connections* among taxa, of which at least the trophic ones lead to the partial and temporary super-position of some of the ecological location;

C) the *localization* of fossils in a common area which additionally justifies the treatment of all taxa as a whole. The following methods of numerical taxonomy of the two large classes of algorithms have been applied:

	Isolated bones	Bones in connection	Isolated bones, weathered subaerially	Isolated bones, eroded on the sea bottom	Ontogenic associations	Frequency of the remains	Intersection of niches
Taxon	1	2	3	4	5	6	7
I SPARIDS	4	1	0	0	4	4	4
II CLUPEIDS	3	0	0	2	2	2	3
III CHELONIANS	0	0	0	4	0	1	1
IV BIRDS	3	0	2	0	0	2	2
V SEALS	4	1	2	0	4	4	2
VI CETACEANS	0	0	0	4	0	2	2

Table I a: It results from fig 1 (the last column exclusively) through the following approximate codification: 1 — very rare; 2 — rare; 3 — frequent; 4 — very frequent; The last column represents the (qualitative) measure in which the ecological niches of taxa intersect.
The table was used to calculate a "homogeneity" for the Buser-Baroni Urbani method.

Taxon	1	2	3	4	5	6	7
I	1111	1	00	0000	1111	1111	1111
II	1110	0	00	1100	1100	1100	1100
III	0000	0	00	1111	0000	1000	1000
IV	1110	0	11	0000	0000	1100	1100
V	1111	1	11	0000	1111	1111	1100
VI	0000	0	00	1111	0000	1100	1100

Table I b: It is obtained through the binary codification of the data from table I a. Except the "homogeneity" obtained by L. Dragomirescu, all the other resemblance indices and the Watanabe cost are applied on this table.

I. Methods based on the concept of taxa whole cohesion which, in the studied case better reveals the paleoecologic (functional) groups; the

Watanabe algorithm (cladogram d. of fig. 2) gave a non significant result because of the non functional ecologic character of the attributes, of the greater importance of the sedimentation process within this orictocenosis and because of the poor ecological significance of the taxa of higher categories (orders; see table Ia,).

II. Agglomerative methods based on the resemblance between objects (taxa) and/or groups. They revealed the relations of type *A*.

The following methods of this group have been applied:

a) the single linkage method that specifies the taxa responsible for the fusion of two groups, thus better shaping the linked resemblances of the taxa (cladogram a in fig. 2);

b) the average linkage method (the arithmetic average UPGMA) that specifies the reciprocal "attraction" of the taxa groups, thus shaping the resemblance between two or more ensembles (cladogram b in fig. 2).

The precursory stage of the grouping in the cases *II. a* and *II. b* is the application, on table Ib, of an index of reciprocal similarity between all the possible pairs of taxa (objects). The Rao-Russel index (in L. Legendre and P. Legendre, 1979 S_1, index) proved to be the most adequate because it highly marks the importance of the existence of characters to the detriment of their absence when comparing a pair of taxa (1—1 non null piece of information; 0—0 a null piece of information; in comparing any two lines of table Ib).

The algorithms II. a and II.b have then been applied to a Russel-Rao indices table obtained from table Ib.

c) A modern classification method belonging to M. Buser and C. Baroni-Urbani (1982) that shapes the resemblance within the framework of an ensemble. This method directly works with the table of encoded characters — Ia. The significance and efficiency in measuring the "homogeneity" of this table were increased thanks to some ideas of Dragomirescu, Constantinescu and Bănărescu (1985).

CONCLUSIONS

1. The autochthny or the allochthony of the components of the studied orictocenosis were more influenced by the transportation of the material than by the ecological functional relations.

2. The agglomerative II a-c methods correspond to the situation and reveal the fossilization on the spot of the taxa which are closely linked through ecologic and trophic relations (i.e. sparids seals (I—V) in cladograms a, b and c). The clupeids (II) are in the same way, but less strongly, linked to the sparidsseals group. This material may be considered as autochthonous from a paleoecologic point of view.

3. The birds-cetaceans group (IV—VI) is poorly represented in the association and has a weak "homogeneity". The statement about its semi-autochthony is based, besides the information of table Ia, on direct taphonomic observations.

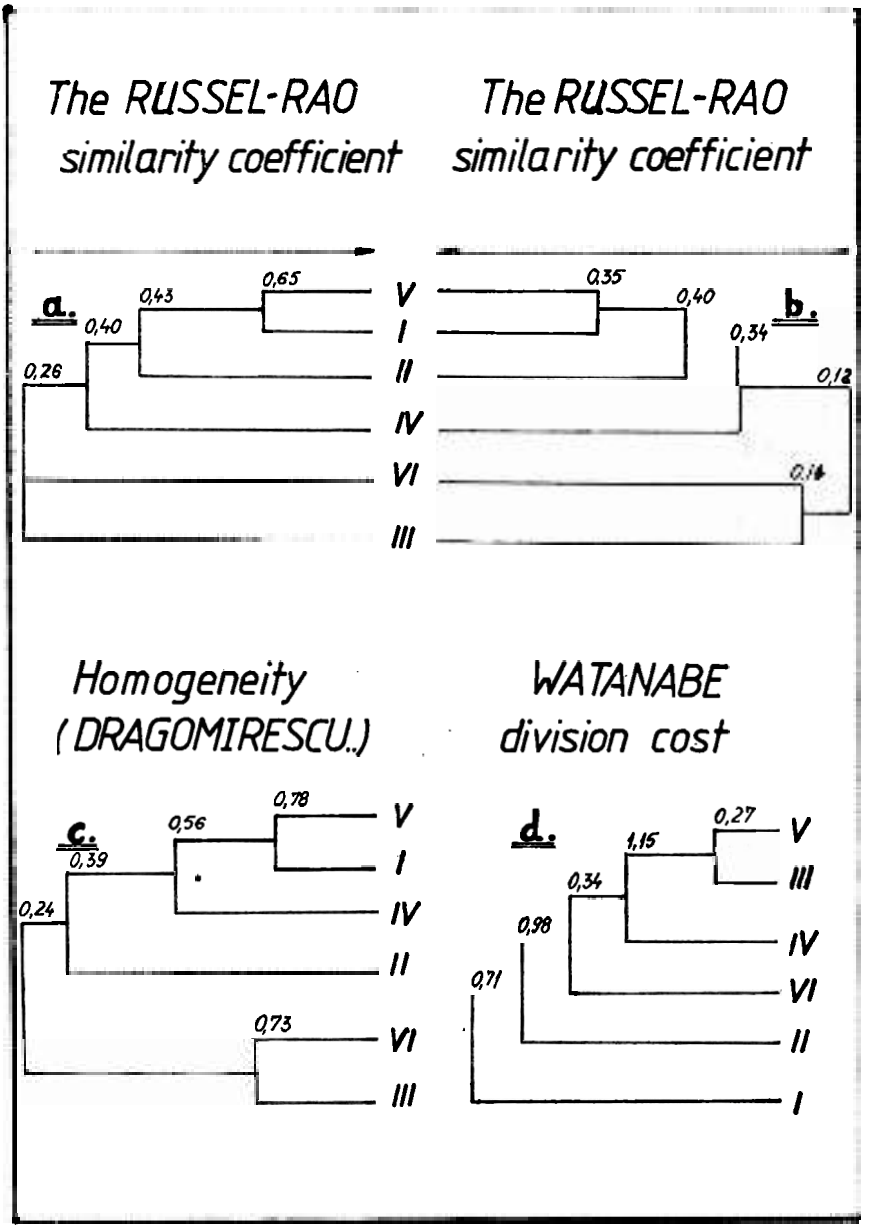

Fig. 2. The following methods were used: a) the single linkage method; b) the unweighted arithmetic average linkage method; c) the method of M. W. Buser and C. Baroni-Urbani, with a change (Dragomirescu et al. 1985).
The dendrogram a, b and c result from adequate methods. One may observe the invariant clustering V—I and the periferic situation of taxa VI—III. d) the method of S. Watanabe is partially inadequate to the case.

4. The cetaceans-chelonians group (VI—III in cladograms a, b and c) is an accident due to the insufficient information (1% and less than 1%, respectively, of the orictocenosis). Consequently it cannot be taken into account.

5. The taphonomic research processed through methods of numerical taxonomy, completed with data offered by the sedimentological research (Grigorescu and Dinu, 1978) reveals some paleoecological relations of the following communities: rocky superlittoral (seals, birds), psammitic benthic eulittoral (sparids), pelagic eulittoral (clupeids) and pelagic sublittoral (cetaceans) — at the level of the studied orictocenosis.

ANALIZA PALEOECOLOGICĂ A ASOCIAȚIEI DE VERTEBRATE DIN BASSARABIANUL (SARMAȚIAN MEDIU) DE LA CREDINȚA ȘI CIOBĂNIȚA (DOBROGEA DE SUD), BAZATĂ PE CARACTERE TAFONOMICE PRELUCRATE PRIN METODE DE TAXONOMIE NUMERICĂ.

REZUMAT

Sînt analizate tafonomic elemente fosile de vertebrate din grupurile: sparide, clupeide, chelonieni, păsări, foci și cetacee. În figura 1 sînt date caracterele tafonomice extrase, exprimate în raport cu frecvența lor. În tabelele I a și I b este dat modul de codificare aproximativă a caracterelor în vederea analizei grupelor (cluster analysis). Pe informația codificată sînt aplicate următoarele metode de taxonomie numerică: (a) metoda *simplei legături*, (b) metoda *legăturii medii neponderate*, (c) metoda *Buser și Baroni-Urbani* cu o complectare și o extindere — Dragomirescu et al. (1985), (d) eleganta metodă a lui *Watanabe*. Rezultatele analizei sînt date în figura 2 (notate cu aceleași litere ca și în rezumat) și interpretate în contextul paleoecologic, în cadrul concluziilor.

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Dan Grigorescu:
Laboratorul de paleontologie
Facultatea de Geologie şi Geografie
B-dul N. Bălcescu nr. 1
70111 Bucureşti, România
Vladimir Constantinescu:
Muzeul de Istorie Naturală «Grigore Antipa»
Şos. Kiseleff 1
71243 Bucureşti, România
Liviu Dragomirescu:
Laboratorul de antropologie
Institutul «Victor Babeş»
Splaiul Independenţei 99—101
76201 Bucureşti, România