Abh. Geol. B.-A.	ISSN 0378-0864 ISBN 3-900312-61-3	Band 41	S. 301–305	Wien, April 1988

STUDY OF AGGLUTINATED FORAMINIFERA FROM THE MOTRIL-NERJA LITTORAL REGION, SPAIN

by

M. DEL CARMEN SÁNCHEZ ARIZA

With 1 figure and 3 tables

ZUSAMMENFASSUNG

Oberflächenproben der Litoralregion von Motril-Nerja in Spanien lagen zur Untersuchung vor. Insgesamt konnten 8 rezente, agglutinierte Foraminiferenarten der Gattungen *Iridia?*, *Reophax, Spiroplectammina, Textularia, Bigenerina, Trochammina* und *Eggerella*? in der Gesamtfauna von 81 Arten und 4 Varietäten festgestellt werden.

An gesplitteten Probenrückständen wurde die relative Häufigkeit gezählt und die mathematische Distanz $d_{i,k}$ zwischen je zwei Artenpaaren berechnet. Diese Distanz bezeichnet ein Maß der Relation einer Art in ihrer Abhängigkeit zur Wassertiefe, sowie die Konstanz des Vorkommens und die Häufigkeit der Taxa.

ABSTRACT

The present study is based on superficial sediments samples collected from the Motril-Nerja littoral region of Spain.

A total of eight Recent agglutinated species of foraminifera belonging to the genus *Iridia?*, *Reophax*, *Spiroplectammina, Textularia, Bigenerina, Trochammina* and *Eggerella*? are studied. The mathematical distance, $d_{i,k}$, between pairs of species is calculated. This index relates each pair with the total number of benthic foraminifera, waterdepth and the constancy of occurrence and abundance of taxa.

INTRODUCTION

The Recent benthic foraminifera of the superficial sediments in the Motril-Nerja littoral region have been the subject of several studies (Sánchez Ariza 1979, 1983, 1984a and 1984b).

Eighty-one species and 4 varieties were identified and the ecological environmental conditions were measured. Agglutinated foraminifera are represented by 7 genera and 8 species. The relationships existing among the species as a function of depth was determined by a mathematical method establishing the distance $d_{i,k}$ between each two species of Recent benthic foraminifera (Sánchez Ariza 1983). Constancy and abundance indices are also determined. This method differs from a variety of multivariate clustering techniques as for example utlilized by Kaesler (1966), Mello and Buzas (1968), Buzas (1970), Wall *et al.* (1977), McMillan and Casey (1978), Coulbourn *et al.* (1980), Culver and Buzas (1981), Finger and Lipps (1981) and Sen Gupta and Strickert (1982).

CHARACTERISTICS OF THE ZONE

The climatic zone of Motril-Nerja is typically Mediterranean, with moderate temperatures and without sharp changes from one season to another. The zone is exposed to intense isolation during the whole year, leading to considerable evaporation of

Sánchez Ariza, M. del Carmen, Departamento de Zoologia, Colegio Universitario de Jaén (Universidad de Granada), Jaén, SPAIN.

the water. This water deficit is compensated for by the flow of water from the Atlantic to the Mediterranean through the Strait of Gibraltar (Instituto Hidrográfico de la Marina de Cádiz 1969). Sea chart 354 of the Hydrographic Institute of the Navy, Cádiz, shows that the sea bottom surface layer in this area is mainly composed of sand and mud, with rock at some isolated points. The material studied belongs to the sand group with grain size very fine to medium and calcium carbonate content ranges from 7.9 to 61.1% and average value equal to 21.27% (Sánchez Ariza 1979). The water has stable physico-chemical properties for the factors measured. The average value of the ion chloride concentration is equal to 21.5 gr/l and the CO_3H^- and $CO_3^=$ are equal to 0.05 and 0.33 gr/l respectively. The studied zone is shown in the bathymetric map of figure 1.

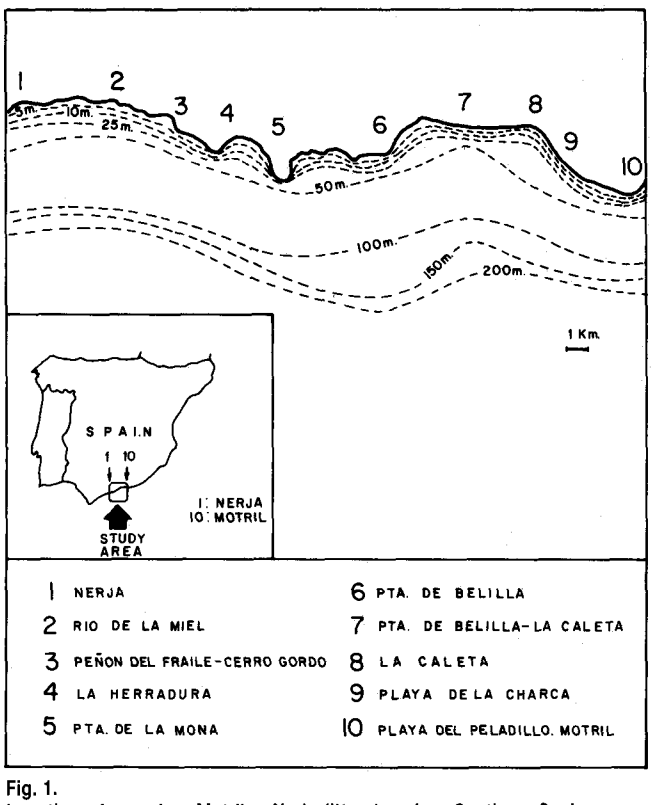

Fig. 1.
Location of samples, Motril – Nerja littoral region, Southern Spain.

MATERIAL AND METHODS

The samples were collected from Motril to Nerja at depths of 5, 10, 25, 50, 100, 150 and 200 m at the points of the map in figure 1 in July and August 1973 and 1974 using the method described in Sánchez Ariza (1979).

In the laboratory the samples were treated and washed on sieves of 1.0, 0.5 and 0.15 mm mesh and dried in an oven at 70°C. The taxonomic and mathematical study was conducted using specimens counted in 0.1 gram of each residue. Eighty-one species and 4 varieties of benthic foraminifera were identified; 8 of them are agglutinated foraminifera. The distance $d_{i,k}$ between two species i and k was determined by the following formula, which utilizes relative frequencies (f of table 1):

$$d_{ik} = \sqrt{\sum_{j=1}^{7} (f_{ij} - f_{kj})^2}$$

where j is the depth where the species i and k appear. A total of 70 samples were taken, 10 at each depth, 7 depths in total. For each species, frequencies (f) were calculated by dividing the number of individuals of each species at each depth by the total number of individuals of the species and multiplying by 100. The relative frequencies of the 8 agglutinated species are shown in table 1 and the $d_{i,k}$ between each two agglutinated species in relation with the total species found in the zone are shown in table 2.

Constancy of occurrence was calculated by the expression:

$$C = \frac{p \times 100}{P}$$

in which p is the number of samples containing the species and P is the total number of samples studied.

According to this expression Dajoz (1974) considers three specific categories of the value C:

Table 1.
Agglutinated species found [relative frequences in percent].

Species	Depth in Meters 5	10	25	50	100	150	200
Iridia diaphana? Heron-Allen and Earland					43	14	43
Reophax scorpiurus Montfort					100		
Spiroplectammina wrightii (Silvestri)						93	7
Textularia agglutinans d'Orbigny		1	12	16	12	34	26
Testularia gramen d'Orbigny			12	10	10	31	37
Bigenerina nodosaria d'Orbigny				5	19	29	48
Trochammina inflata (Montagu)		33	33		33		
Eggerella sp.?	1	5	77	15	2		1

Table 2.
Value of $d_{i,k}$ [$d_{i,k}$ = the mathematical distance between the species i and k].

Taxa	1.	2.	3.	4.	5.	6.	7.	8.
1. I. diaphana?	0.0	72.8	96.9	45.1	40.3	28.6	66.0	99.0
2. R. scorpiurus		0.0	137.0	99.8	103.0	98.0	81.6	126.0
3. S. wrightii			0.0	66.9	72.1	79.1	109.9	122.3
4. T. agglutinans				0.0	13.1	28.8	63.7	78.4
5. T. gramen					0.0	19.5	66.9	81.1
6. B. nodosaria						0.0	74.4	97.0
7. T. inflata							0.0	63.1
8. E. sp.?								0.0

1. Constant species, present in more than 50% of the samples.
2. Accessory species, present in 25-50% of the samples.
3. Accidental species, present in less than 25% of the samples.

A third index calculated is the abundance index. This index shows the number of individuals by area or volume unit. In this study the abundance index is determined by weight unit and is expressed in percent.

One species is very abundant (*VA*) when it is present in more than 25% of the total of agglutinated foraminifera, abundant (*A*) if it is present in more than 5%, frequent (*F*) if it is present in more than 1% and rare (*R*) if it is present in less than 1%. The constancy and abundance values are shown in table 3.

These methods have also been used by Ericson and Wollin (1956), Dajoz (1974) and Sanchez Ariza (1984b).

Table 3.
Value constancy of occurrence (C).
For explanation see text.

Species	Value of C/Character		Value of Abundance/Character	
I. diaphana?	42.86%	accessory	1.29%	R
R. scorpiurus	14.29%	accidental	0.74%	R
S. wrightii	28.5%	accessory	2.76%	F
T. agglutinans	85.71%	constant	37.20%	VA
T. gramen	71.43%	constant	9.02%	A
B. nodosaria	57.14%	constant	3.87%	F
T. inflata	42.86%	accessory	0.55%	R
E. sp.?	85.71%	constant	44.57%	VA

SYSTEMATIC PART

The taxonomy of Loeblich and Tappan 1964 is followed. At each taxonomic level a short diagnosis is given.

Eight agglutinated species are recognized. One of which probably belongs to suborder *Allogromiina* and 7 to suborder *Textulariina*.

Suborder *Allogromiina* Loeblich and Tappan, 1961
Diagnosis: membranous or pseudochitinous test, may rarely have small quantities of agglutinated material.

Superfamily Lagynacea Schultze, 1854
Diagnosis: character of the suborder.

Family Lagynidae Schultze, 1854
Diagnosis: small test, membranous to pseudochitinous, may have ferruginous encrustations and rarely agglutinated matter.

Genus *Iridia* Heron-Allen and Earland, 1914
Diagnosis: test attached, hemispherical or irregularly dome-shaped chamber; wall pseudochitinous or with some agglutinated material.
Iridia diaphana Heron-Allen and Earland, 1914
Description: irregular test with agglutinated

covering, and sometimes with test of other little foraminifera.
Remarks: there is not sufficient argument to establish if the individuals belong to Lagynacea or Ammodiscacea. They are not very frequent in the zone, less than 0.1% of the total of Recent benthic foraminifera species.

Suborder Textulariina Delage and Hérouard, 1896
Diagnosis: test composed of agglutinated foreign matter held together by various cements.
Superfamily Lituolacea de Blanville, 1825
Diagnosis: multilocular, typically coiled spirally or uncoiled or straight, reduction of chambers in each whorl may result in triserial or biserial arrangement; wall siliceous or agglutinated; aperture single or multiple.

Family Hormosinidae Haeckel, 1894
Diagnosis: test free, chambers arranged in straight or curved series; wall agglutinated; aperture terminal.
Subfamily Hormosininae Haeckel 1894
Diagnosis: chambers typically in regular rectilinear series; wall agglutinated; aperture single or multiple.
Genus *Reophax* Montfort, 1808
Diagnosis: test elongate, with few chambers with rapid increase in chamber size; wall agglutinated, surface rough. Aperture at end of broad neck.
Reophax scorpiurus Montfort, 1808
Diagnosis: characteristics of the genus.
Remarks: this species represents less than 0.1% and has been found at a depth of 100 m in the studied zone.

Family Textulariidae Ehrenberg, 1838
Diagnosis: test free or attached, generally biserial and may become uniserial; wall agglutinated; aperture single to multiple.
Subfamily Spiroplectammininae Cushman 1927
Diagnosis: early stage planispiral, later biserial.
Genus *Spiroplectammina* Cushman, 1927
Diagnosis: test elongate; characteristics of the subfamily; aperture low arch at inner margin of final chamber; wall agglutinated.
Spiroplectammina wrightii (Silvestri, 1903)
Diagnosis: characteristics of the genus.
Remarks: this species represents 0.1% and appears at a depth of 150 to 200 m.

Subfamily Textulariinae Ehrenberg, 1838
Diagnosis: test biserial, at least in early stage, may become uniserial.
Genus *Textularia* Defrance, 1824
Diagnosis: test elongate, biserial, more or less compressed; wall agglutinated; aperture single low arch at base of last chamber.
Textularia agglutinans d'Orbigny, 1839
Diagnosis: characteristics of the genus.
Remarks: this species represents 1.5% and appears at a depth of 10 to 200 m.
Textularia gramen d'Orbigny, 1846
Diagnosis: similar characteristics to *T. agglutinans* but with bordering keel.
Remarks: this species represents 0.4% and appears at a depth of 25 to 200 m.
Genus *Bigenerina* d'Orbigny, 1826
Diagnosis: test elongate; early portion biserial with basal aperture as in *Textularia*, later uniserial with terminal and rounded aperture.
Bigenerina nodosaria d'Orbigny, 1826
Diagnosis: characteristics of the genus; initial part pointed.
Remarks: this species represents 0.1% and has been found at a depth of 50 to 200 m.

Family Trochamminidae Schwager, 1877
Diagnosis: test free or attached, trochospiral; wall agglutinated; aperture interiomarginal or areal.
Subfamily Trochammininae Schwager, 1877
Diagnosis: characteristics of the family; interior simple.
Genus *Trochammina* Parker and Jones, 1859
Diagnosis: troshospiral; chambers increasing gradually in size; aperture low interiomarginal arch which may have a narrow bordering lip.
Trochammina inflata (Montagu, 1808)
Diagnosis: characteristics of the genus.
Remarks: this species represents 0.1% and has been found at a depth of 10 to 100 m.

Family Ataxophragmiidae Schwager, 1877
Diagnosis: test free, trochospiral uncoiling or uniserial; aperture basal, later may be terminal.
Subfamily Globotextulariinae Cushman, 1927
Diagnosis: test trochoid; 3 or more chambers to whorl, tending to decrease with growth to 2 or 1; aperture single interiomarginal.
Genus *Eggerella* Cushman, 1933
Diagnosis: 5 chambers to whorl in early stage, gradually reduced to 3 to whorl in adult; wall finely agglutinated; aperture a low interiomarginal slit.
Eggerella sp.
Diagnosis: wall agglutinated. It is not sure that this species belongs to genus *Eggerella*; characteristics not clear; aperture a high arch with narrow border.
Remarks: this species represents 2% and has been found at a depth of 5 to 200 m.

RESULTS AND DISCUSSION

The agglutinated species found are not abundant in relation to the total Recent benthic foraminifera studied. *Eggerella* sp. is the most abundant, especially at 25 m depth. But this species represents only 2% of the total of benthic foraminifera (Sánchez Ariza 1979).

The rest of agglutinated species are abundant near a depth of 100 m where the sediments present the greatest concentration of $CaCO_3$ content and are fine and medium grained sands.

The benthic foraminifera species have been treated by a simple relational technique that ranks taxa according to the distance $d_{i,k}$ between pairs of species. This distance is a measurement of the tendency of the relationship of the species as a function of depth. The maximum distance is equal to 137.0 and the minimum distance is equal to 13.1 between *R. scorpiurus-S. wrightii* and *T. agglutinans-T. gramen* respectively. Distance and tendency of the relationship of pairs of species are inversely proportional.

On the other hand, there are four constant species. Two of them have *VA* character (*T. agglutinans* and *E.*? sp.), one of them has *A* character (*T. gramen*) and the other has *F* character (*B. nodosaria*). These four species are the most abundant. *R. scorpiurus* and *T. inflata* present the *R* character, the first is an accidental species and the second an accessory species (table 4). The group structure is supported by *T. agglutinans* and *E?.* sp. fundamentally. They are the only constants and *VA* species although their bathymetric distribution is different. *T. agglutinans* has a homogeneous distribution from 25 to 200 m depth and *E.* sp. has a slight preference at 25 m depth.

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