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A molluscan community from coastal bioclastic bottoms in the Strait of Gibraltar area

La comunidad de moluscos de un fondo bioclástico costero del Estrecho de Gibraltar

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ABSTRACT

The molluscan community of a soft bottom of bioclastic gravels and sand has been studied monthly over two years in four stations of the bay of Barbate, SW Spain at the Atlantic entrance of the Strait of Gibraltar, between 18 and 29 m depth. Species richness, dominance and frequency over the two years are recorded. Micromolluscs, less than 1 mm in size, were also recorded from the sample of April 1994.

Over the two years, 203 species of macromolluscs were found, of which 174 species (115.104 individuals) were collected alive and quantified. A total of 25 species of micromolluscs were determined, some of which usually considered as rare species. Most species richness values range between 20 to 40 species per sample, which is comparable with, or higher than, the values reported in other studies from soft bottom communities of molluscs. The qualitative analysis based on Jaccard's and Baroni-Urbani and Buser's indices show that three stations are significantly similar ($p < 0.01$), whereas the lowest similarity was found between the station close to the harbour of Barbate and the other ones. The quantitative analysis based on the Bray and Curtis index is biased by the high number of individuals of *Chamelea striatula* but consistent with the qualitative indices when this species is not taken into account.

The main community is similar to "Biocénose des fonds meubles instables (MI)" and "Biocénose des fonds detritique du large (DL)" of PÉRÈS AND PICARD (1964), but occurs shallower than in the Mediterranean. The concurrence of species from the Lusitanian, Mediterranean and Mauritanian regions results in an increment of the total number of species.

RESUMEN

Se ha estudiado la comunidad de Moluscos de fondos de grava bioclástica y arena durante dos años en la bahía de Barbate, SW de España cerca del Estrecho de Gibraltar. Se han elegido cuatro estaciones entre 18 y 29 metros de profundidad. Se ha determinado la riqueza especifica, la dominancia y la frecuencia a lo largo de los dos años. Los micromoluscos, de menos de 1 mm de talla, se han estudiado sólo para la muestra de Abril de 1994.

Se han colectado un total de 203 especies de macromoluscos a lo largo de los dos años, de las cuales 174 especies (115.104 individuos) se cogieron vivos y se cuantificaron. Se han determinado también 25 especies de micromoluscos, algunas de las cuales conside-

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radas habitualmente como especies raras. La mayoría de los valores de la riqueza específica oscilan entre 20 y 40 especies por muestra, lo que es comparable o incluso mayor que los valores reseñados en otros estudios para comunidades de moluscos de fondos blandos.
Los análisis cualitativos de afinidad basados en los índices de Jaccard y de Baroni-Urbani y Buser muestran que tres estaciones son significativamente similares (p < 0,01), mientras que la menor afinidad se encontró entre la estación próxima al puerto de Barbate y las otras. El análisis cuantitativo de afinidad basado en el índice de Bray y Curtis esta sesgado por el gran número de individuos de *Chamelea striatula*, pero si no consideramos dicha especie los resultados son similares a los obtenidos por índices cualitativos.
La comunidad es similar a la "Biocénose des fonds meubles instables (MI)" y "Biocénose des fonds detritique du large (DL)" de PÉRÈS Y PICARD (1964), pero aparece a menor profundidad que en el Mediterráneo. La comunidad de la estación próxima al puerto presenta caracteres intermedios con la "Biocénose des sables fins bien calibrés (SFBC)" de PÉRÈS Y PICARD (1964). La coexistencia de especies procedentes de las tres regiones Lusitánica, Mediterránea y Mauritánica supone un incremento de la riqueza específica.

KEY WORDS: Molluscan communities, Strait of Gibraltar, Species richness,
PALABRAS CLAVE: Comunidades de moluscos, Estrecho de Gibraltar, riqueza específica.

INTRODUCTION

The Strait of Gibraltar is an interesting area for the study of the marine fauna, including molluscs, due to the confluence of Atlantic and Mediterranean waters. According to EKMAN (1953), it is the meeting point of three biogeographic regions: Lusitanian, Mauritanian and Mediterranean. As a result of this, the species richness in this area is possibly the highest of the European coasts. In addition, there is a clear presence of North African fauna in this zone, and there also occur some endemic mollusc species (GOFAS, 1999).

Some XIX century expeditions, such as "Lightning" and "Porcupine", "Challenger" "Travailleur" and "Talisman" reported on the marine molluscs from the Ibero-Moroccan Gulf (see review in SALAS, 1996) but were mostly concerned with the bathyal fauna. Recently a French expedition "Balgim" (1984) and a Spanish survey "Fauna 1" (1989) added more information about the malacofauna, particularly bivalves (SALAS, 1996).

There are relatively few studies regarding the fauna from the Strait of Gibraltar. Some of them reported only faunistic lists (FISCHER-PIETTE, 1959; THORSON, 1965; GARCÍA-GOMEZ, 1983a; VAN AARTSEN, MENKHORST AND GITTENBERGER, 1984; CERVERA, TEMPLADO, GARCÍA-GÓMEZ, BALLESTEROS, ORTEA, GARCÍA, ROS AND LUQUE, 1988) and others added information about molluscan communities (GARCÍA-GÓMEZ, 1983b; TEMPLADO, GUERRA, BEDOYA, MORENO, REMON, MALDONADO AND RAMOS, 1993, GOFAS, 1999) or other invertebrate groups (CARBALLO, NARANJO AND GARCÍA-GÓMEZ, 1997; LÓPEZ DE LA CUADRA AND GARCÍA-GOMEZ, 1993; MEDEL-SOTERAS, GARCÍA AND GARCÍA-GÓMEZ, 1991). Some general studies have been carried out in the inner Bay of Cádiz (ARIAS, 1976; LÓPEZ DE LA ROSA, 1997; DRAKE, ARIAS AND CONRADI, 1997), but these were not directed to molluscan communities. A review of the decapods from expeditions carried out off the southern Iberian peninsula and the northern coast of Morocco is given by GARCÍA RASO (1996), and new records were added by LÓPEZ DE LA ROSA, GARCÍA RASO AND RODRIGUEZ MARTÍN (1998). The decapod crustacean community from Barbate

Table I. Physical characteristics of the sampling stations in bay of Barbate.
Tabla I. Características físicas de las estaciones de muestreo en la bahía de Barbate.

	Retín 12	Retín 16	Barra 16	Barra 10
Depth	21-22 m	28-29 m	28-29 m	18 m
Type of sediment	coarse sand with bioclasts	coarse sand with bioclasts	medium sand with bioclasts	fine sand with bioclasts
Organic matter content	0.35 - 0.40 %	0.40 - 0.60 %	0.70 - 0.80 %	0.80 - 1.10 %

was studied by MANJÓN-CABEZA AND GARCÍA RASO (1998a), and the population structure and growth of the hermit crab *Diogenes pugilator* from the same area by MANJÓN-CABEZA AND GARCÍA RASO (1998b). None of these previous studies contained data on molluscan communities from infralittoral bottoms and their changes through the year.

The present paper was aimed to a better knowledge of molluscan communities from bioclastic infralittoral bottoms in the Strait of Gibraltar, and of the influence they receive from the different water masses. The results have been obtained from monthly samples over two years of survey. These molluscan communities are poorly documented in the Spanish coasts, although some information from other European stations is available in the literature (CABIOCH, 1968; PÉRÈS AND PICARD, 1964; GLÉMAREC, 1969; TEMPLADO *ET AL.*, 1993).

AREA OF STUDY

Samples were collected in the bay of Barbate (36° 8′ N- 5° 56′ W), on the Atlantic side of the Strait of Gibraltar (Fig. 1). Four sample stations were selected and sampled monthly throughout two years. Sample stations were placed on two transects, R (Retín) and B (Barra), at different distances from the estuary and harbour of Barbate. The main characteristics of sampling stations are listed in Table I.

The station B10 is the nearest to the harbour and the estuary of Barbate river, with high level of sedimentation (fine particles) and a higher value of percentage of organic matter in the sediment than in the other stations. Hard bottoms are present in the bay as flagstones between the station R12 and the beach (Fig. 1).

The Bay of Barbate is mainly influenced by water masses from the Atlantic Ocean. Most of the flow comes from South Portugal, but due to the proximity of North Africa there are also currents of Southern origin (REY, 1983). Atlantic water currents flow in this bay in direction to the Mediterranean Sea, while Mediterranean water currents flow below 200-250 meters deep in the opposite direction (VIVES, SANTAMARIA AND TREPAT, 1975) and do not affect the bay. Tidal currents can change the direction of the dominant currents, producing local gyres. Water temperature varies from 21° C (Summer months) to 14° C (Winter months). Water salinity values (around 34 ‰) can change due to the influence of the river Barbate and some other fresh water reservoirs (ESTABLIER AND MARGALEF, 1964; SEOANE-CAMBA, 1965).

The mixed sediment (shell fragments and sand) is a habitat for some benthic algae, which were reported on by FLORES-MOYA, SOTO, SÁNCHEZ, ALTAMIRANO AND CONDE (1995a, b) and by CONDE, FLORES-MOYA, SOTO, ALTAMIRANO AND SÁNCHEZ (1996).

MATERIAL AND METHODS

Samples were collected from October 1993 to September 1995 with a small fishing boat, by towing a rectan-

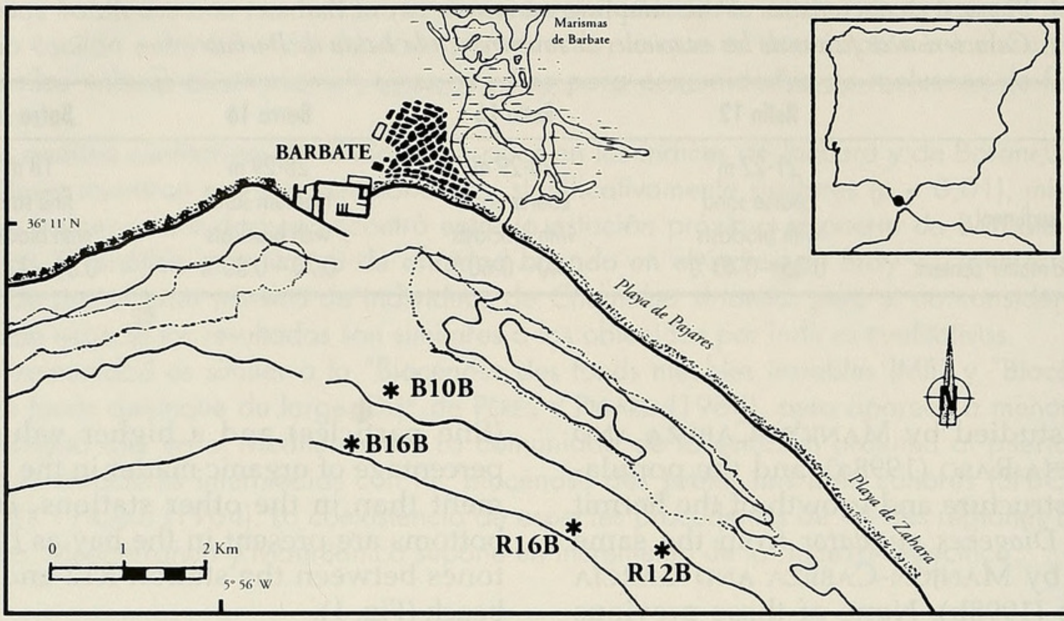

Figure 1. Location of the sampling points in Bay of Barbate. The dashed line represents rocky bottoms.

Figura 1. Localización de los puntos de muestreo dentro de los fondos de la bahía. La linea discontinua indica la presencia de lajas de roca.

gular dredge (42 cm width x 22 cm height), with a 0.5 mm mesh inner holding bag, for 15 minutes at a speed of 1 knot. The dredged area for each sample was approximately 150 m^2.

Biological samples were sieved on different mesh sizes (10, 5, 3, and 1 mm) in order to split into different size fractions and sort them. The smaller fractions were sorted under a stereomicroscope. Molluscs were separated from the rest of macrobenthos and fixed in formaldehyde 10 % and subsequently preserved in neutralized alcohol 70%.

The fraction above 1 mm shell size, representing the macrofauna, was sorted quantitatively for every sample over the two years. Both living and dead specimens were identified, although only living specimens were quantified. The taxonomical ordination is according to Sabelli, Giannuzzi-Savelli and Bedulli (1990) and current CLEMAM catalogue (www.mnhn.fr/base/malaco.html).

Species richness and dominance (percentage of individuals to the total, for a particular species) were calculated in order to describe the community. We also calculated the frequency or percentage of the samples in which the species is present over the two years. Three indices of affinity were calculated to classify the molluscan composition from the four stations, in order to check the different communities present in our study area. Two of them are qualitative (Jaccard, 1908; Baroni-Urbani and Buser, 1976), the other one quantitative (Bray and Curtis, 1957). The quantitative dissimilarity index (I) of Bray and Curtis (1957) was transformed as (1-I) so as to use it as a quantitative similarity index. The qualitative indices were chosen in view of the possibility to test the significance, following Real and Vargas (1996) for the Jaccard index and Baroni-Urbani and Buser tables (Baroni-Urbani and Buser, 1976) for their own index. The affinity between stations was represented for each index by a dendrogram, using the UPGMA algorithm.

Micromolluscs, mostly species which have a shell size smaller than the bulk of the sediment grain, need special processing to be recovered efficiently and this was done mainly on the sample of April 1994. The fraction not retained by the 1 mm sieve was sieved on the 0.5 and 0.3 mm sieves. Then, each of these fractions was winnowed in sea water, so that the water movement will carry away the lighter fraction including molluscs. The water outflow was collected on the 0.3 mm sieve, examined for living micromolluscs, and dried. The micromolluscs were sorted in this dry residue under the stereomicroscope, using a Strattman micropaleontological tray and a fine wet brush to manipulate them. Micromollusc data were studied apart due to an incomplete cuantification, only in the sample of April 1994.

Sediment samples were collected and analysed for granulometry and percentage of organic matter (% OM). The grain size distribution of the sediment was determined by sieving. The mud fraction was separated by wet sieving in a 80μm sieve, and finally the dried sand fraction was sieved over a stacked set of grade sieves. Granulometric parameters were calculated according to the method of BUCHANAN (1984). Sediment for determination of % OM was stored in formaldehyde 10% just after collection. A fraction was dried at 100° C for 24 hours and weighted for obtaining dry weight. Later on it was burnt to ashes for 2 h at 525° C and finally weighted again. Difference of dry weight and dry weight after ignition determined %OM in the sediment.

RESULTS

Analysis of the taxocoenosis of molluscs

A: Macromolluscs composition and species richness: Over the two years, a total of 203 species of macromolluscs were found. Of these, 174 species (115. 104 individuals) were collected alive (Tables II, III). Some individuals were only identified to genus level, either because diagnostic characters are seen only on living animals and could not be observed (e. g. Triphoridae, many Opisthobranchs), or because they belong to groups where taxonomic problems are not solved (see remarks below).

Number and percentage of species by class collected were similar in R12, R16 and B16. In B10, the number of species by class was lower, although the percentages of abundance were similar to those in the other stations (Table III). The families Trochidae (12 sp., Fig. 2), Nassariidae (9 sp., Fig. 3) and Muricidae (7 sp.) were the best represented among the gastropods; the Veneridae (13 sp.) and Cardiidae (10 sp.) among the bivalves.

Mean values for species richness per month were lower in B10 (between 12 to 36) than in the other sampling points: R12 (17-45 species); R16 (20-49 species); B16 (21-51 species).

The number of species of gastropods and their abundance were higher in R16 and B16, where the sediments were characterised by a mixture of bioclasts and of coarse and medium sand, respectively. Total abundances of bivalves were high in R16 and B10 due to a strong settlement of the bivalve *Chamelea striatula*, but richness for bivalves was higher in the stations with mixed sediments (gravels and fine sand) than in the most homogeneous one (B10). In global terms, bivalves were more abundant than gastropods mainly due to their gregarious occurrence in soft bottoms. The dredge was not adequate for the collection of cephalopods so that a low number of them were registered and always small individuals (2-3 cm).

The base of the ascidian *Phallusia mammillata* (Cuvier, 1815) clusters shells and small stones which provide a microhabitat for some species of molluscs such as *Chauvetia procerula* and *Ocinebrina edwardsii* which were abundant inside the holes and crevices from these structures. We also noted the presence of small individuals of the bivalves *Chlamys varia* and *Striarca lactea* both attached by byssal thread.

Some associations of molluscs with others organisms were found. The bivalve *Digitaria digitaria* usually supported colonies of the hydrozoan *Monobrachium parasitum* Meresckowsky, 1877 located on the posterior part of the umbo. Colonies of another non determined hy-

Table II. Species of macromolluscs collected in the survey. Ab: Abundance, Fr: Frequency, ††: Dead specimen, #: Non quantitative data."Total" is (Retín 12 + Retín 16 + Barra 16), excluding Barra 10.
Tabla II Especies de macromoluscos recolectadas en los muestreos. Ab: Abundancia, Fr: Frecuencia, ††: Individuo muerto, #: Datos no cuantitativos. "Total" es (Retín 12 + Retín 16 + Barra 16), excluyendo Barra 10.

	Retín 12		Retín 16		Barra 16		Barra 10		Total	
	Ab	Fr	Ab	Fr	Ab	Fr	Ab	Fr	Ab	Fr
CLASSIS **POLYPLACOPHORA** Gray J. E., 1821										
Family **LEPTOCHITONIDAE** Dall, 1889										
Leptochiton cimicoides (Monterosato, 1879)	36	20.83	86	20.83	78	54.17			200	66.67
Family **ISCHNOCHITONIDAE** Dall, 1889										
Lepidochitona cinerea (Linné, 1767)	1	4.17					1	4.35	1	4.17
Lepidochitona corrugata (Reeve, 1848)	2	4.17							2	4.17
Family **ACANTHOCHITONIDAE** Pilsbry, 1893										
Acanthochitona fascicularis (Linné, 1767)	8	16.66	5	16.66	65	58.33			78	75.00
Acanthochitona sp.							1	4.35		
CLASSIS **GASTROPODA** Cuvier, 1797										
Family **ACMAEIDAE** Carpenter, 1857										
Acmaea virginea (Müller O. F., 1776)	1	4.17	5	8.33	3	8.33			9	20.83
Family **FISSURELLIDAE** Fleming, 1822										
Diodora gibberula (Lamarck, 1822)					1	4.17			1	4.17
Diodora graeca (Linné, 1758)			2	8.33	1	4.17			3	8.33
Family **SCISSURELLIDAE** Gray J. E., 1847										
Scissurella costata D'Orbigny, 1824					2	8.33			2	8.33
Family **TROCHIDAE** Rafinesque, 1815										
Calliostoma zizyphinum (Linné, 1758)					8	12.50			8	12.50
Calliostoma sp. 1	28	45.83	48	66.67	120	95.83	7	21.74	196	95.83
Calliostoma sp. 2	1	4.17			3	12.50			4	16.67
Gibbula magus (Linné, 1758)	39	41.67	279	70.83	264	79.17	16	30.43	582	87.50
Gibbula fanulum (Gmelin, 1791)	3	12.50	1	4.17	4	8.33			8	25.00
Gibbula guttadauri (Philippi, 1836)	167	70.83	14	25.00	11	20.83	13	21.74	192	75.00
Gibbula cineraria (Linné, 1758)	1	4.17	1	4.17					2	8.33
Jujubinus dispar Curini-Galletti, 1982					40	58.33	3	8.70	40	58.33
Jujubinus exasperatus (Pennant, 1777)	2	8.33							2	8.33
Jujubinus montagui (Wood W., 1828)	12	20.83	55	50.00	68	58.33			135	79.17
Jujubinus striatus (Linné, 1758)	1	4.17	1	4.17					2	8.33
Clanculus cruciatus (Linné, 1758) ††	#	—								
Family **TRICOLIIDAE** Robertson, 1985										
Tricolia pullus (Linné, 1758)	1	4.17							1	4.17
Family **TURBINIDAE** Rafinesque, 1815										
Bolma rugosa (Linné, 1767)			5	12.50					5	12.50
Family **CERITHIIDAE** Férussac, 1819										
Bittium reticulatum (Da Costa, 1778)			1	4.17					1	4.17
Bittium submamillatum (De Rayneval a Ponzi, 1854)	619	62.50	134	20.83	73	37.50			826	75.00
Bittium simplex (Jeffreys, 1867) ††	1	—								
Cerithium vulgatum Bruguière, 1792 ††			1	—						
Family **TURRITELLIDAE** Lovén, 1847										
Mesalia varia (Kiener, 1887)	149	79.17	201	91.67	495	100	113	86.96	845	100
Turritella communis Risso, 1826	246	50.00	993	95.83	525	75.00	45	26.09	1764	95.83
Turritella turbona Monterosato, 1877	250	50.00	403	41.67	61	29.17			714	75.00
Family **RISSOIDAE** Gray J. E., 1847										
Rissoa guerinii Récluz, 1843			2	8.33	1	4.17			3	12.50
Rissoa inconspicua (Alder, 1844)	1	4.17	1	4.17					2	8.33

Table II. Continuation.
Tabla II Continuación.

	Retín 12		Retín 16		Barra 16		Barra 10		Total	
	Ab	Fr	Ab	Fr	Ab	Fr	Ab	Fr	Ab	Fr
Alvania cimex (Linné, 1758) ††					1	—				
Alvania discors (Allan, 1818) ††	#	—								
Family **APORRHAIIDAE** Gray J. E., 1850										
Aporrhais pespelecani (Linné, 1758)	104	79.17	113	58.33	61	50.00			278	83.33
Family **CALYPTRAEIDAE** Lamarck, 1809										
Calyptraea chinensis (Linné, 1758)	450	70.83	1297	91.67	645	87.50	104	56.52	2392	95.83
Family **LAMELLARIIDAE** D'Orbigny, 1841										
Lamellaria sp.	1	4.17	1	4.17					1	4.17
Family **TRIVIIDAE** Troschel, 1863										
Trivia arctica (Pulteney, 1789)					1	4.17			1	4.17
Family **NATICIDAE** Forbes, 1838										
Natica hebraea (Martyn, 1784)	2	8.33					22	52.17	2	8.33
Polinices alderi (Forbes, 1838)	8	20.83	9	16.67	13	37.50			30	62.50
Polinices guillemini (Payraudeau, 1826)	6	20.83			11	25.00	3	13.04	17	33.33
Polinices macilenta (Philippi, 1844)	11	29.17	5	12.50	10	20.83	19	56.52	26	54.17
Family **CASSIDAE** Latreille, 1825										
Phalium saburon (Bruguière, 1792) ††			#	—	#	—				
Phalium undulatum (Gmelin, 1791) ††					#	—				
Family **RANELLIDAE** Gray J. E., 1854										
Cymatium corrugatum (Lamarck, 1816)			1	4.17	2	8.33			3	12.50
Ranella olearia (Linné, 1758) ††			#	—	#	—				
Charonia lampas (Linné, 1758) ††			#	—	#	—				
Family **TRIPHORIDAE** Gray J. E., 1847										
Not determined	1	4.17	3	12.50					4	12.50
Family **CERITHIOPSIDAE** Adams H. & A., 1853										
Cerithiopsis scalaris Locard, 1892			2	8.33	1	4.17			3	12.50
Cerithiopsis tubercularis (Montagu, 1803)			1	4.17					1	4.17
Family **EPITONIIDAE** Berry S. S., 1910										
Epitonium commune (Lamarck, 1822)	3	12.50	9	20.83	1	4.17			13	33.33
Epitonium pulchellum (Bivona Ant., 1832)			2	8.33					2	8.33
Epitonium jolyi (Monterosato, 1878)			1	4.17					1	4.17
Cirsotrema cochlea (Sowerby G. B. II, 1844)							1	4.35		
Family **EULIMIDAE** Adams H. & A., 1853										
Eulima glabra (Da Costa, 1778)					1	4.17	1	4.35	1	4.17
Melanella alba (Da Costa, 1778)			1	4.17			1	4.35	1	4.17
Melanella sp.			1	4.17					1	4.17
Family **MURICIDAE** Rafinesque, 1815										
Bolinus brandaris (Linné, 1758)	61	75.00	88	79.17	78	70.83	38	65.22	227	95.83
Hexaplex trunculus (Linné, 1758)	19	37.50			4	12.50	4	17.39	23	37.50
Muricopsis cristata (Brocchi, 1814)	1	4.17							1	4.17
Ocenebra erinaceus (Linné, 1758)	2	8.33	23	58.33	72	87.50			97	95.83
Ocinebrina aciculata (Lamarck, 1822)			2	8.33	1	4.17			3	12.50
Ocinebrina edwardsii (Payraudeau, 1826)	48	58.33	32	58.33	154	79.17			234	91.67
Trophon muricatus (Montagu, 1803)	17	33.33	44	62.50	49	54.17			110	87.50
Buccinulum corneum (Linné, 1758)	1	4.17							1	4.17
Chauvetia procerula Monterosato, 1889			27	37.50	62	45.83			89	58.33
Chauvetia brunnea (Montagu, 1803) ††	#	—								
Chauvetia sp. ††			#	—						
Fusinus pulchellus (Philippi, 1844)	9	12.50	14	29.17	46	75.00			69	79.17
Fusinus rostratus (Olivi, 1792)			2	8.33	1	4.17			3	12.50

Table II. Continuation.
Tabla II Continuación.

	Retín 12		Retín 16		Barra 16		Barra 10		Total	
	Ab	Fr	Ab	Fr	Ab	Fr	Ab	Fr	Ab	Fr
Nassarius elatus (Gould, 1845)					13	25.00	202	100	13	25.00
Nassarius heynemanni (Von Maltzan, 1884)	9	12.50	1	4.17					10	16.67
Nassarius vaucheri (Pallary, 1906)	3	4.17					17	39.13	3	4.17
Nassarius incrassatus (Ström, 1768)	3	12.50			5	16.67	1	4.35	8	29.17
Nassarius pygmaeus (Lamarck, 1822)	51	50.00	69	79.17	86	62.50	59	65.22	206	95.83
Nassarius reticulatus (Linné, 1758)	8	16.67			13	33.33	276	100	21	41.67
Nassarius mutabilis (Linné, 1758)					7	8.33	243	100	7	8.33
Nassarius granum (Lamarck, 1822) ††							#	—		
Cyclope donovania Risso, 1826 ††							1	—		
Family **COLUMBELLIDAE** Swainson, 1840										
Mitrella minor (Scacchi, 1836)			3	12.50	10	29.17			13	33.33
Mitrella bruggeni van Aartsen, Menkh. & Gittenb., 1984 ††	#	—								
Columbella rustica (Linné, 1758) ††					#	—				
Family **COSTELLARIIDAE** Mc Donald, 1860										
Vexillum tricolor (Gmelin, 1791) ††	#	—								
Family **CYSTISCIDAE** Stimpson, 1865										
Gibberula epigrus (Reeve, 1865)	29	45.83			13	16.67	44	65.22	42	58.33
Gibberula miliaria (Linné, 1758)							1	4.35		
Family **VOLUTIDAE** Rafinesque, 1815										
Cymbium olla (Linné, 1758) ††			#	—	#	—				
Family **CANCELLARIDAE** Gray J. E., 1853										
Cancellaria cancellata (Linné, 1758) ††							#	—		
Family **CONIDAE** Rafinesque, 1815										
Conus mediterraneus Hwass in Bruguière, 1792 ††	#	—								
Family **TURRIDAE** Swainson, 1840										
Bela laevigata (Philippi, 1836)	81	54.17	143	83.33	111	70.83	118	65.22	335	95.83
Bela striolata (Risso, 1826)	9	12.50	16	33.33	16	33.33	9	21.74	41	50.00
Bela sp. 1	3	12.50					2	8.70	3	12.50
Bela sp. 2	2	8.33	1	4.17					3	12.50
Mangelia attenuata (Montagu, 1803)	33	45.83	19	45.83	14	41.67	13	34.78	66	79.17
Haedropleura septangularis (Montagu, 1803)					1	4.17	1	4.35	1	4.17
Crassopleura maravignae (Bivona, 1838)	2	8.33			1	4.17			3	12.50
Raphitoma aequalis (Jeffreys, 1867)			2	8.33					2	8.33
Comarmondia gracilis (Montagu, 1803)	4	16.67	10	33.33	13	29.17	1	4.35	27	58.33
Family **PYRAMIDELLIDAE** Gray J. E., 1840										
Chrysallida terebellum (Phillippi, 1844)			2	4.17					2	4.17
Eulimella acicula (Phillippi, 1836)					2	8.33			2	8.33
Eulimella scillae (Scacchi, 1835)					1	4.17			1	4.17
Odostomia acuta Jeffreys, 1848			1	4.17					1	4.17
Odostomia conoidea (Brocchi, 1814)			1	4.17					1	4.17
Brachystomia eulimoides (Hanley, 1844)	1	4.17							1	4.17
Turbonilla fulvocincta (Thompson, 1840)	25	45.83	14	20.83	17	37.50	9	26.09	56	70.83
Turbonilla rufa (Phillippi, 1836)			19	37.50	20	37.50			39	62.50
Turbonilla rufescens (Forbes,)	1	4.17					7	13.04	1	4.17
Turbonilla striatula (Linné, 1758) ††	#	—								
Family **ACTEONIDAE** D'Orbigny, 1835										
Acteon tornatilis (Linné, 1758)	1	4.17	2	8.33			1	4.34	3	8.33
Family **RETUSIDAE** Thiele, 1931										
Retusa truncatula (Bruguière, 1792)	2	4.17							2	4.17
Retusa mamillata (Philippi, 1836)	3	8.33	2	8.33					5	16.67

Table II. Continuation.
Tabla II Continuación.

	Retín 12		Retín 16		Barra 16		Barra 10		Total	
	Ab	Fr	Ab	Fr	Ab	Fr	Ab	Fr	Ab	Fr
Family **RINGICULIDAE** Philippi, 1853										
Ringicula auriculata (Menard, 1811)	17	20.83	20	41.67	19	37.50	27	43.48	56	70.83
Family **BULLIDAE** Lamarck, 1801										
Bulla striata Bruguière, 1792 ††							#	—		
Family **HAMINOEIDAE** Pilsbry, 1895										
Haminoea sp.					1	4.17			1	4.17
Family **PHILINIDAE** Gray J. E., 1850										
Philine aperta (Linné, 1767)	22	8.33					4	4.35	22	8.33
Philine sp.	2	8.33							2	8.33
Family **CYLICHNIDAE** Adams H. & A., 1854										
Scaphander lignarius (Linné, 1758)			1	4.17					1	4.17
Family **PLEUROBRANCHIDAE** Férussac, 1822										
Berthella sp.			1	4.17					1	4.17
Family **APLYSIIDAE** Lamarck, 1809										
Aplysia fasciata Poiret, 1789			12	8.33					12	8.33
Family **ARCHIDORIDIDAE** Bergh, 1892										
Archidoris tuberculata (Cuvier, 1804)	1	4.17							1	4.17
Archidoris sp.	2	4.17	1	4.17					3	8.33
Family **DENDRODORIDIDAE** O'Donoghue, 1924										
Doriopsilla sp.					3	8.33			3	8.33
CLASSIS **SCAPHOPODA** Bronn, 1862										
Family **DENTALIIDAE** Linné, 1758										
Dentalium inaequicostatum Dautzenberg, 1891	12	12.50	16	33.33	21	29.17	35	56.52	49	70.83
Dentalium vulgare Da Costa, 1778	4	8.33			6	16.67	1	4.35	10	20.83
CLASSIS **BIVALVIA** Linné, 1758										
Family **NUCULIDAE** Gray J. E., 1824										
Nucula hanleyi (Winckworth, 1931)	52	70.83	41	33.33	9	20.83			102	87.50
Family **NUCULANIDAE** Adams H. & A., 1858										
Nuculana pella (Linné, 1767)	147	91.67	314	95.83	219	95.83	387	100	680	100
Family **ARCIDAE** Lamarck, 1818										
Arca noae Linné, 1758			1	4.17					1	4.17
Anadara polii (Mayer, 1868)			10	29.17	9	25.00			19	54.17
Family **NOETIDAE** Stewart, 1930										
Striarca lactea (Linné, 1758)	2	8.33	2	8.33					4	12.50
Family **GLYCYMERIDIDAE** Newton, 1922										
Glycymeris glycymeris (Linné, 1758)	8	29.17	5	16.67	2	8.33			15	45.83
Family **MYTILIDAE** Rafinesque, 1815										
Modiolarca subpicta (Cantraine, 1835)	2	8.33	6	16.67	1	4.17			9	25.00
Modiolus barbatus (Linné, 1758)					4	8.33			4	8.33
Modiolus adriaticus (Lamarck, 1819)	326	62.50	289	75.00	154	66.67	107	47.83	769	91.67
Amygdalum agglutinans (Cantraine, 1835)			16	37.50	12	33.33			28	66.67
Family **PINNIDAE** Leach, 1819										
Atrina fragilis (Pennant, 1777)					1	4.17			1	4.17
Family **PTERIIDAE** Gray J. E., 1847										
Pteria hirundo (Linné, 1758)			1	4.17					1	4.17
Family **PECTINIDAE** Rafinesque, 1815										
Pecten maximus (Linné, 1758)	11	12.50	8	25.00	9	25.00	7	17.39	28	41.67

Table II. Continuation.
Tabla II Continuación.

	Retín 12		Retín 16		Barra 16		Barra 10		Total	
	Ab	Fr	Ab	Fr	Ab	Fr	Ab	Fr	Ab	Fr
Aequipecten opercularis (Linné, 1758)			5	16.67	5	16.67			10	29.17
Aequipecten commutatus (Monterosato, 1815)			7	12.50					7	12.50
Chlamys varia (Linné, 1758)	20	29.17	63	66.67	34	54.17			117	87.50
Flexopecten flexuosus (Poli, 1795)	73	58.33	133	62.50	51	58.33	19	21.74	259	87.50
Family **ANOMIIDAE** Rafinesque, 1815										
Anomia ephippium Linné, 1758	39	37.50	162	66.67	140	62.50	15	13.04	341	87.50
Family **LIMIDAE** Rafinesque, 1815										
Limatula subauriculata (Montagu, 1808)	11	12.50							11	12.50
Lima lima (Linné, 1758) ††					#	—				
Family **LUCINIDAE** Fleming, 1828										
Ctena decussata (Costa O. G., 1829) ††			#	—						
Family **UNGULINIDAE** Adams H. & A., 1857										
Diplodonta rotundata (Montagu, 1803)					1	4.17			1	4.17
Family **KELLIIDAE** Forbes & Hanley, 1848										
Kellia suborbicularis (Montagu, 1803)	1	4.17	1	4.17	1	4.17			3	12.50
Family **ASTARTIDAE** D'Orbigny, 1844										
Digitaria digitaria (Linné, 1758)	597	91.67	1188	100	1067	95.83	1272	91.30	2852	100
Goodallia triangularis (Montagu, 1803)							2	8.70		
Family **CARDIIDAE** Lamarck, 1819										
Acanthocardia aculeata (Linné, 1758)	4	12.50	2	8.33	2	8.33	1	4.35	8	20.83
Acanthocardia echinata (Linné,1758)					2	8.33			2	8.33
Acanthocardia mucronata (Poli, 1795)	2	8.33							2	8.33
Acanthocardia tuberculata (Linné, 1758)	40	41.67	2	4.17	4	12.50	280	100	46	41.67
Acanthocardia spinosa (Solander, 1786) ††					#	—				
Parvicardium scabrum (Philippi, 1844)	72	58.33	57	62.50	20	25.00	3	13.04	149	87.50
Plagiocardium papillosum (Poli, 1795)	4	12.50	21	50.00	8	25.00			33	62.50
Laevicardium crassum (Gmelin, 1791)	404	100	90	58.33	115	79.17	255	78.26	609	100
Laevicardium oblongum (Gmelin, 1791)					1	4.17			1	4.17
Cerastoderma glaucum (Poiret, 1789) ††							#	—		
Family **MACTRIDAE** Lamarck, 1809										
Mactra stultorum (Linné, 1758)	29	29.17			5	4.17	3	13.04	34	29.17
Spisula subtruncata (Da Costa, 1778)	388	79.17	241	75.00	182	91.67	1013	100	811	100
Spisula elliptica (Locard, 1890)	12	8.33	2	4.17					14	12.50
Lutraria angustior Philippi, 1844 ††			#	—	#	—				
Family **PHARIDAE** Adams H. & A., 1858										
Ensis ensis (Linné, 1758)	4	16.67					10	17.39	4	16.67
Ensis sp.	1	4.17							1	4.17
Phaxas pellucidus (Pennant, 1777)			1	4.17			1	4.35	1	4.17
Family **TELLINIDAE** Blainville, 1814										
Arcopagia balaustina Linné, 1758							1	4.35		
Tellina incarnata (Linné, 1758)							2	8.70		
Tellina distorta (Poli, 1791)					1	4.17			1	4.17
Tellina pygmaea Lovén, 1846	1	4.17							1	4.17
Tellina donacina Linné, 1758 ††	#	—								
Family **DONACIDAE** Fleming, 1828										
Donax venustus Poli, 1795	6	20.83					124	73.91	6	20.83
Capsella variegata (Gray J. E., 1851)	30	54.17			2	4.17			32	54.17
Family **PSAMMOBIIDAE** Fleming, 1828										
Gari fervensis (Gmelin, 1791)			3	12.50	2	8.33			5	16.67

Table II. Continuation.
Tabla II Continuación.

	Retín 12		Retín 16		Barra 16		Barra 10		Total	
	Ab	Fr	Ab	Fr	Ab	Fr	Ab	Fr	Ab	Fr
Gari depressa (Pennant, 1777)	1	4.17					4	8.70	1	4.17
Gari costulata Turton, 1822			1	4.17					1	4.17
Gari pseudoweinkauffi Cosel, 1990	51	62.50	12	16.67	5	8.33	6	4.35	68	66.67
Family **SCROBICULARIIDAE** Adams H. & A., 1856										
Scrobicularia plana (Da Costa, 1778) ††							#	—		
Family **SEMELIDAE** Stoliczka, 1870										
Ervilia castanea (Montagu, 1803)	10	20.83							10	20.83
Family **SOLECURTIDAE** D'Orbigny, 1846										
Solecurtus scopula (Turton, 1822) ††			#	—	#	—				
Azorinus chamasolen (Da Costa, 1778) ††					#	—				
Family **VENERIDAE** Rafinesque, 1815										
Venus verrucosa Linné, 1758			2	4.17	3	8.33			5	16.67
Venus casina Linné, 1758	1	4.17							1	4.17
Globivenus effossa (Philippi ex Bivona ms., 1836) ††					#	—				
Chamelea gallina (Linné, 1758)							9	17.39		
Chamelea striatula (Da Costa, 1778)	12582	75.00	26169	79.17	7028	91.67	26052	73.91	45779	100
Clausinella fasciata (Da Costa, 1778)	152	91.67	55	70.83	85	66.67	15	26.09	292	100
Timoclea ovata (Pennant, 1777)	1	4.17	9	33.33	2	8.33			12	37.50
Gouldia minima (Montagu, 1803)	1074	87.50	1941	100	1142	83.33	299	56.52	4157	100
Dosinia lupinus (Linné, 1758)	4	12.50	1	4.17					5	16.67
Pitar rudis (Poli, 1795)	12	20.83	55	66.67	42	75.00			109	87.50
Callista chione (Linné, 1758)	72	87.50	19	41.67	55	62.50	64	69.57	146	100
Tapes rhomboides (Pennant, 1777)	81	50.00	704	75.00	195	75.00	31	21.74	980	91.67
Tapes decussatus (Linné, 1758) ††							#	—		
Family **CORBULIDAE** Lamarck, 1818										
Corbula gibba (Olivi, 1792)	4715	87.50	3886	100	4076	100	1115	78.26	12677	100
Family **GASTROCHAENOIDEA** Gray J. E., 1840										
Gastrochaena dubia (Pennant, 1777)			3	8.33	1	4.17			4	8.33
Family **HIATELLIDAE** Gray J. E., 1824										
Hiatella arctica (Linné, 1767)	1	4.17	19	25.00	8	25.00			28	50.00
Panopea glycymeris (Von Born, 1778) ††			#	—	#	—				
Family **THRACIIDAE** Stoliczka, 1870										
Thracia sp. ††							#	—		
Family **PANDORIDAE** Rafinesque, 1815										
Pandora inaequivalvis (Linné, 1758)	140	45.83	132	62.50	107	58.33	322	69.57	379	91.67
Pandora pinna (Montagu, 1803)	17	29.17	116	62.50	83	50.00	8	17.39	216	79.17
Family **LYONSIIDAE** Fischer P., 1887										
Lyonsia norwegica (Gmelin, 1791)	5	20.83	11	33.33	10	33.33	7	26.09	26	62.50
CLASSIS **CEPHALOPODA** Cuvier, 1798										
Family **SEPIIDAE** Leach, 1817										
Sepia officinalis Linneo, 1758	1	4.17							1	4.17
Family **SEPIOLIDAE** Leach, 1817										
Sepietta oweniana (D'Orbigny, 1840)							1	4.17		
Family **OCTOPODIDAE** D'Orbigny, 1840										
Octopus vulgaris Cuvier, 1798	1	4.17	1	4.17	3	12.50			5	20.83

Table III. Species richness and abundance (in brackets) per sampling station, and percentages of each molluscan class.
Tabla III. Riqueza específica y abundancia (entre paréntesis) para cada estación de muestreo y porcentajes por clase de moluscos.

CLASS	RETÍN 12	RETÍN 16	BARRA 10	BARRA 16	TOTAL	%
POLYPLACOPHORA	4 (47)	2 (91)	2 (2)	2 (143)	5 (283)	*2,87 (0,24)*
GASTROPODA	58 (2.580)	60 (4.165)	35 (1.423)	58 (3.261)	99 (11.429)	*56,89 (9,92)*
BIVALVIA	44 (21.205)	44 (35.806)	30 (31.434)	44 (14.905)	65 (103.350)	*37,35 (89,74)*
SCAPHOPODA	2 (16)	1 (16)	2 (36)	2 (27)	2 (95)	*1,14 (0.082)*
CEPHALOPODA	2 (2)	1 (1)	1 (1)	1 (3)	3 (7)	*1,72 (0.006)*
TOTAL	110 (23.850)	108 (40.079)	70 (32.896)	107 (18.339)	174 (115.164)	*100 (100)*

drozoan were found in some individuals of *Corbula gibba* and were mainly located on the posterior part of the shell.

The high abundance and frequency of the shells of *Panopea glycymeris, Solecurtus scopula* and *Lutraria angustior* indicates their possible presence in these communities. These species live deeply buried in the sediment (25-40 cm), making difficult their collection with the dredge. The large valves are a substrate for *Calyptraea chinensis*, and a shelter for many other species.

Some other species such as *Cerastoderma glaucum* and *Scrobicularia plana* were transported from the estuary of Barbate which is close to B10 where they were found.

B: Micromolluscs list: A total of 25 species of micromolluscs (Table IV) were determined in the sample from April 1994. A few species (e. g. *Gibbula magus, Chamelea striatula, Tapes rhomboides*) are the juveniles of species otherwise listed in the macrofauna, but most of them are species of which the adult size is small, and which would be totally missed in the 1 mm sieve.

A few species, some of which are illustrated on Figure 4, are very abundant, and these belong to species which are usually deemed to be rare because they are found preferently on this kind of bottom, where micromolluscs are not easy to collect. The best represented families of microgastropods were Pyramidellidae (5 sp.), Skeneidae (3 sp) and Caecidae (3 sp.). The best represented family of microbivalves was Montacutidae (3 sp.). As for the number of individuals, the larger numbers correspond to the supposedly rare chiton *Leptochiton cimicoides*, the gastropods *Dikoleps nitens, Pusillina inconspicua* and *Retusa mamillata*, and to the bivalve *Limatula subauriculata*. The small cerithiid *Bittium submamillatum*, also found in the fraction over 1 mm, was quite abundant.

In addition to these species which are dominant in their size class, we found several species which are notoriously rare elsewhere and could be recovered here in moderate numbers, hence are not so rare on this kind of substrate. The gastropod *Retrotortina fuscata* was found alive for the first time in our study and reported on by Gofas and Warén (1998). The recently described bivalve *Notolimea clandestina*, described from a few specimens only, is well represented in our samples and could be observed with brooded juveniles inside.

The highest overall abundance and species richness of micromolluscs was registered in the samples from R12, with the lowest percentage of organic mater, and the lowest in B10, with the greatest percentage of organic matter (Table I).

Analysis of the Community

A: Dominance and Frequency: In spite of the high number of collected species, the molluscan taxocoenosis is dominated by few species. The main dominant species were quite similar among the 4

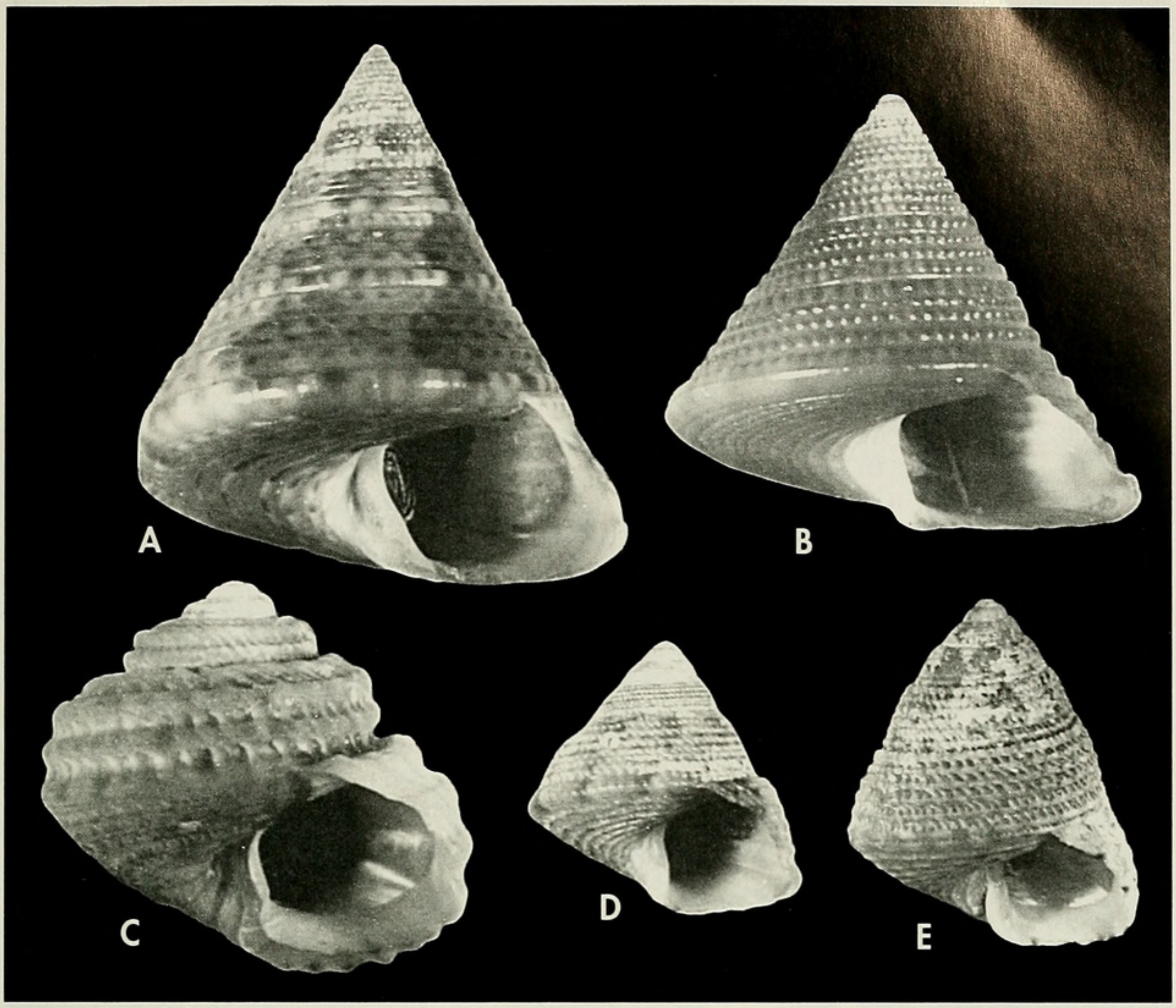

Figure 2. Species of the family Trochidae from Bay of Barbate. A: *Calliostoma* sp. 1, 8.5 mm; B: *Calliostoma* sp. 2., 7.0 mm; C: *Gibbula guttadauri*, 5.5 mm; D: *Jujubinus dispar*, 3.8 mm; E: *Jujubinus dispar*, 6.3 mm. Dimensions are for shell height.

Figura 2. Especies de la familia Trochidae presentes en la bahía de Barbate. A: Calliostoma *sp. 1, 8,5 mm; B:* Calliostoma *sp. 2., 7,0 mm; C:* Gibbula guttadauri, *5,5 mm; D:* Jujubinus dispar, *3,8 mm; E:* Jujubinus dispar, *6,3 mm. Las medidas indicadas corresponden a la altura.*

sampled stations. There were 8 to 13 species with dominance values higher than 1 % in R12, R16 and B16, but only 5 species had dominance values higher than 1 % in the station B10 (Table V). *Chamelea striatula* was the most dominant species in all sample stations: in some months it reached abundance of 5000 to 13000 individuals per sample. The strong settlement of juveniles of this species occurred during Spring months of the first year of survey (1994), then it persisted as a dominant species for a limited time in R16, and until the end of the studied period in B10. The higher amount of mud and percentage of the organic matter in the sediment from this latter station could have favoured the development of this species.

If we take into account the 20 first dominant species, it is possible to find some differences between stations. The most different composition of dominant species occurs in B10, where 5 species (*Acanthocardia tuberculata, Nassarius reticulatus, Nassarius mutabilis, Nassarius elatus* and *Donax venustus*) are typical of shallow sand bottom communities. Their dominant presence in comparison with the other stations indicates similarity with communities of well sorted fine sand (PÉRÈS AND PICARD, 1964; GLÉMAREC, 1969; GARCÍA RASO, LUQUE, TEMPLADO, SALAS, HERGUETA, MORENO AND CALVO, 1992). This is further supported by the constant occurrence of high numbers of *Ophiura texturata* Lamarck, 1816 and of some individuals of *Echinocardium cordatum* (Pennant, 1777). In R12 some species with affinities for coarse sand bottoms are listed in the first 20 dominant species: *Bittium submamillatum, Laevicardium crassum* (with the highest abundance in the 4 stations), *Turritella turbona, Gibbula guttadauri.* Some other animals collected frequently in this station, such as *Branchiostoma lanceolatum* (Pallas, 1766) and *Echinocyamus pusillus* (Müller, 1776), are common in coarse sand bottom communities (FORD, 1923; CABIOCH, 1968; GLÉMAREC, 1969).

The species occurring in a high frequency throughout the 2 years in B10 were different from those of the other three stations (Table VI), and were mainly the species with affinity for fine and shallow sandy bottoms listed with the dominance data. Species of nassarids (*Nassarius reticulatus, N. mutabilis* and *N. elatus*) and some bivalves such as *Spisula subtruncata, Nuculana pella* and *Acanthocardia tuberculata* were recorded in all monthly samples during two years. Nevertheless, other species recorded with a high frequency in the other stations, such as *Mesalia varia, Corbula gibba, Digitaria digitaria* and *Laevicardium crassum,* were also important for the community structure of B10.

Aplysia fasciata Poiret, 1789 was recorded in spring and summer months from the first year and not in samples from the second year, probably due to a decrease on the production of algae in the bay.

B: Faunal affinity between sampling points: The values of qualitative and quantitative similarity indices between sampling stations are shown in Table VII and Figure 5. A single dendrogram was found for each index with the UPGMA reconstructions. From the qualitative viewpoint, according to Jaccard's as well as to Baroni-Urbani and Buser's indices, the points Retín 12, Retín 16 and Barra 16 are significantly similar ($p < 0.01$). The lowest similarity in qualitative terms was found between the station B10 and the other stations, whereas a higher similarity is found between the two deeper stations R16 and B16. The quantitative analysis according to BRAY AND CURTIS (1957) also showed high similarity between R16 and B16, where a high number of individuals of *Chamelea striatula* were collected. Assuming the invasive character of the settlement of this species in this kind of communities, the same index was computed also without the data for this species. The influence of the flood of *Chamelea* brings a bias so as to increase the similarity between Barra 10 and other stations (Fig. 5C), whereas the quantitative data without *Chamelea* are consistent with the qualitative indices (Fig. 5D).

DISCUSSION

Taxonomic remarks: The species of the genus *Calliostoma* (Fig. 2) are problematic in the area of transition between

(Right page) Figure 3. Species of the family Nassariidae from Bay of Barbate. A: *Nassarius pygmaeus*, 11 mm; B: *Nassarius vaucheri*, 13 mm; C: *Nassarius reticulatus*, juvenile, 13 mm; D: *Nassarius incrassatus*, 11 mm; E: *Nassarius tingitanus*, 9 mm (specimen collected in Tarifa); F: *Nassarius heynemanni*, 13 mm; G: *Nassarius mutabilis*, 12 mm; H: *Nassarius elatus*, 14 mm. Dimensions are for shell height.
(Página derecha) Figura 3. Especies de la familia Nassaridae presentes en la bahía de Barbate. A: Nassarius pygmaeus, *11 mm; B:* Nassarius vaucheri, *13 mm; C:* Nassarius reticulatus, *juvenil, 13 mm; D:* Nassarius incrassatus, *11 mm; E:* Nassarius tingitanus, *9 mm (ejemplar recolectado en Tarifa); F:* Nassarius heynemanni, *13 mm; G:* Nassarius mutabilis, *12 mm; H:* Nassarius elatus, *14 mm. Las medidas corresponden a la altura.*

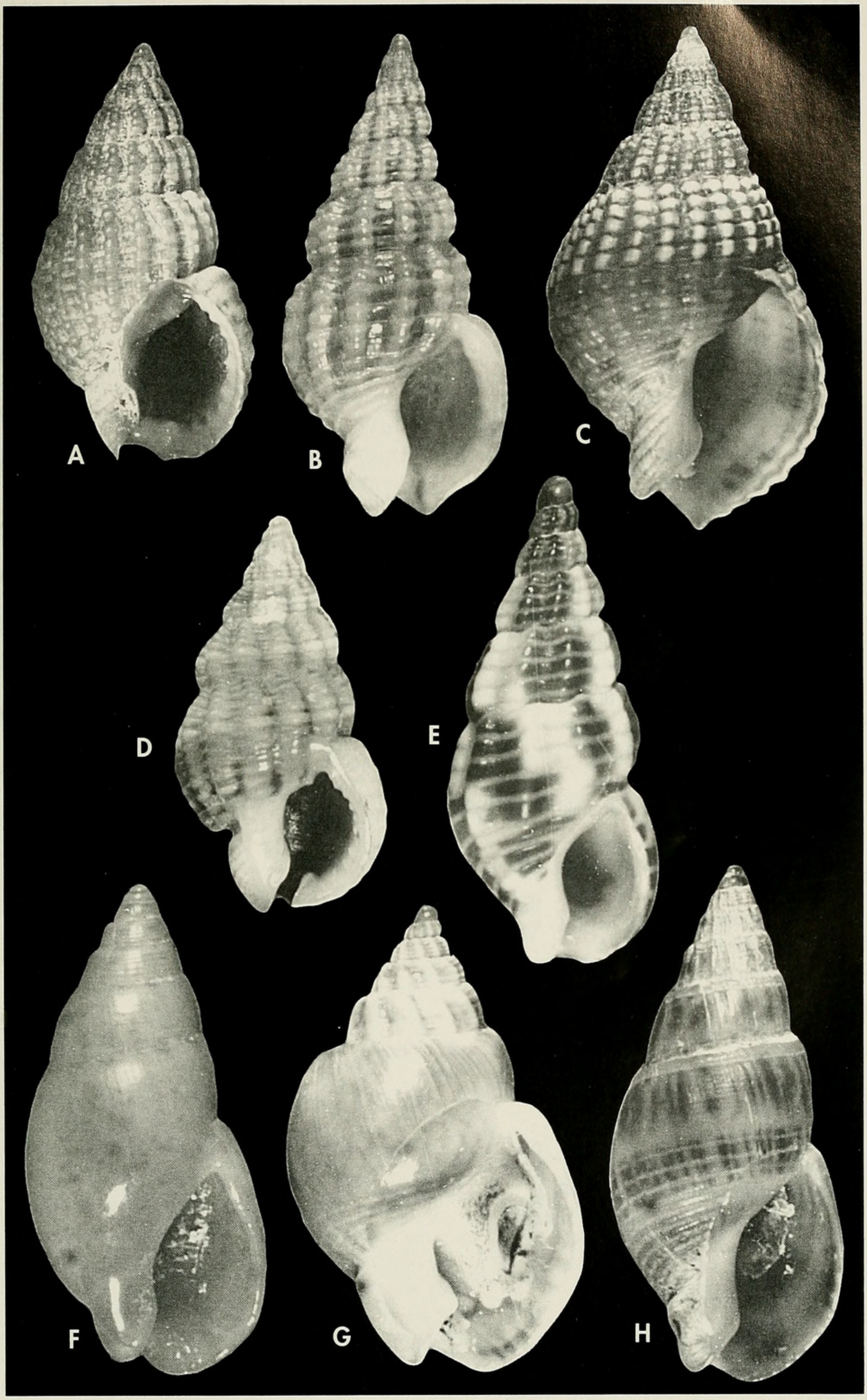
A
B
C
D
E
F
G
H

Table IV. Species of micromolluscs collected in the survey, mainly in the samples of april 1994. Numbers in brackets denote specimens collected only in thanatocenosis, >100 denotes abundant species with more than 100 live-collected specimens in the sample.
Tabla IV. Especies de micromoluscos recolectadas en los muestreos, principalmente en abril de 1994. Los numeros entre parentesis denotan ejemplares encontrados sólo en tanatocenosis, >100 indica especies abundantes con más de 100 ejemplares colectados en las muestras.

	Retín 12	Retín 16	Barra 10	Barra 16
POLYPLACOPHORA				
Leptochitonidae				
Leptochiton cimicoides (Monterosato, 1879).	>100	3	-	1
GASTROPODA				
Scissurellidae				
Scissurella costata d'Orbigny, 1824	-	-	-	3
Skeneidae				
Skenea serpuloides (Montagu, 1808)	10	-	-	
Dikoleps nitens (Philippi, 1844)	>100	-	-	
Dikoleps pruinosa (Chaster, 1896)	53	-	-	
Trochidae				
Gibbula magus (Linné, 1758)	12	-	-	
Rissoidae				
Pusillina inconspicua (Alder, 1844)	>100	-	-	
Obtusella intersecta (Wood, 1857)	(1)	-	-	
Caecidae				
Caecum trachea (Montagu, 1808)	12	-	-	
Caecum cuspidatum Chaster, 1896	2	-	-	
Caecum clarkii Carpenter, 1858	1	-	-	
Vanikoridae				
Macromphalina disciformis (Granata Grillo, 1877)	-	-	-	4
Cerithiidae				
Bittium pusillum (de Rayneval & Ponzi, 1854)	80	-	-	
Turritellidae				
Turritella turbona Monterosato, 1877	(2)	-	-	
Turritella communis Risso, 1826	-	(2)	-	
Mesalia varia (Kiener, 1887)	-	(2)	-	
Eulimidae				
Vitreolina sp.	3	-	-	2
Fasciolariidae				
Fusinus pulchellus (Philippi, 1844)	-	1	-	
Pyramidellidae				
Evalea divisa (J. Adams, 1797)	(5)	-	-	
Odostomia conspicua Alder, 1850	(2)	-	-	
Odostomia unidentata (Montagu, 1803)	-	-	-	1
Brachystomia eulimoides (Hanley, 1844)	12	1	-	4
Brachystomia sp.	2	-	-	
Omalogyridae				
Retrotortina fuscata Chaster, 1896	20	-	-	
Ebalidae				
Ebala pointeli (de Folin, 1868)	3+(10)	1	-	

Table IV. Continuación.
Tabla IV. Continuation.

	Retín 12	**Retín 16**	**Barra 10**	**Barra 16**
Retusidae				
Retusa mamillata (Philippi, 1836)	>100	-	-	
Cylichnidae				
Cylichna crossei B.D.D., 1886	(2)	-	(1)	4
Oxynoidae				
Lobiger sp.	(1)	-	-	
BIVALVIA				
Nuculidae				
Nucula recondita Gofas & Salas, 1996	(1)	-	-	
Glycymeridae				
Glycymeris glycymeris (Linné, 1758)	(2)	(1)	-	
Pectinidae				
Chlamys sp.	9	-	-	
Anomiidae				
Anomia ephippium (Linné, 1758)	5	-	-	2
Limidae				
Limatula subauriculata (Montagu, 1808)	>100	-	-	
Notolimea clandestina Salas, 1994	25	-	-	
Leptonidae				
Hemilepton nitidum (Turton, 1822)	1	-	(1)	
Kelliidaee				
Kellia suborbicularis (Montagu, 1803)	-	-	-	3
Montacutidae				
Mysella bidentata (Montagu, 1803)	5+(4)	-	-	1
Tellimya ferruginosa (Montagu, 1808)	(1)	-	5	
Montacuta goudi van Aartsen, 1996	(1)	(1)	-	
Astartidae				
Goodalia triangularis (Montagu, 1803)	2+(3)	-	-	
Digitaria digitaria (Linné, 1758)	47	3	1	2
Cardiidae				
Parvicardium scabrum (Philippi, 1844)	4	-	-	
Matridae				
Spisula subtruncata (da Costa, 1778)	-	-	6	
Tellinidae				
Tellina pusilla Lovén, 1846	2	-	-	
Semelidae				
Ervilia castanea (Montagu, 1803)	70	-	-	
Veneridae				
Tapes rhomboides (Pennant, 1777)	>100	-	-	>100
Gouldia minima (Montagu, 1803)	28	-	-	2
Chamelea striatula (da Costa, 1778)	>100	38	4	9
Corbulidae				
Corbula gibba (Olivi, 1792)	4	22	-	2
Thraciidae				
Thracia sp.	5 (+ v.)	1	2	

Mediterranean Sea and Atlantic Ocean. Atlantic forms usually have a heavier sculpture of spiral cords than Mediterranean ones, and this variation in sculpture obscures the delimitation of the species. *Calliostoma zizyphinum* was easily recognized by its broader and less conical shape, although some variability occurs between individuals. *Calliostoma* sp. 1 is close to the Mediterranean species *Calliostoma conulus* (Linné, 1758), from which it differs by the presence of heavier ribs. *Calliostoma* sp. 2 resembles *Calliostoma laugieri* (Payraudeau, 1826), but a detailed comparison of protoconchs shows a higher number of granulated whorls in *Calliostoma* sp. 2.

The genus *Chauvetia* is well represented in the area nearby Strait of Gibraltar with 10 to 15 species, and its taxonomy is difficult. *Chauvetia* sp. from our study has a white band in the shell and resembles *Chauvetia crassior* Odhner, 1923. However, the latter was described from the Canary Islands and has direct development, so that it is doubtful whether the same species is present in the Strait of Gibraltar. Other species like *Chauvetia decorata* Monterosato, 1889, described from Morocco, also show white bands, and this character may even not be constant within a single species.

Some other taxonomical or nomenclatural problems are related with the *Bela* species, which are in need of revision. In our samples some of them were named as *Bela* sp. 1 and sp. 2. Nomenclatural problems were found for the species known in the literature as *Bela striolata* Risso, 1826, a usage which is not correct considering that the type specimen belongs to the genus *Rissoina* d'Orbigny, 1840. The next available name could be *Bela smithi* Forbes, 1844, but the description is not clear and the type material is lost. We have followed the incorrect usage, as revising this question is beyond the scope of. the paper.

According to OLIVER AND COSEL (1993), *Anadara polii* (Mayer, 1868) is not the same species than the Miocene *Arca diluvii* Lamarck, 1805: the Recent species has a lower number of ribs (24-28) and a less median umbo. All individuals of *Aequipecten opercularis* were smaller and more elongate than the usual Atlantic form, and can be grouped in the form *audouinii*. Although *A. audouinii* (Payraudeau, 1826) is currently regarded as a a synonym of *A. opercularis*, a reevaluation of their relationships is needed in order to clarify if this form is a different species. *Chamelea striatula* (more Atlantic) and *C. gallina* (more Mediterranean) are two closely related species which live sympatrically in the Southern part of Iberian peninsula. BACKELJAU, BOUCHET, GOFAS AND DE BRUYN (1994) justified the separation of the two species using allozyme electrophoresis. *C. gallina* is common in shallow and sandy bottoms in our latitudes, but *C. striatula* prefers muddy and deeper

(Right page) Figure 4. Micromolluscs from the soft bottom in Bay of Barbate. A: *Bittium submamillatum*, height 3.8 mm; B: detail of the microsculpture of *Bittium submamillatum*; C: protoconch of *Bittium submamillatum*; D: *Pusillina inconspicua*, height 1.6 mm; E: *Caecum cuspidatum*, length 2.15 mm; F: detail of the microsculpture of *Caecum cuspidatum*; G: *Retusa mamillata*, height 1.85 mm; H: *Leptochiton cimicoides*, dorsal view, length 2.0 mm; I: *Leptochiton cimicoides*, lateral view, length 1.65 mm; J: detail of the girdle of *Leptochiton cimicoides*, showing the two types of spicules. Scale bars 100 µm.

(Página derecha) Figura 4. Micromoluscos de los substratos blandos de la bahía de Barbate. A: Bittium submamillatum, *altura 3,8 mm; B: detalle de la microescultura de* Bittium submamillatum*; C: protoconcha de* Bittium submamillatum*; D:* Pusillina inconspicua, *altura 1,6 mm; E:* Caecum cuspidatum, *longitud 2,15 mm; F: detalle de la microescultura de* Caecum cuspidatum*; G:* Retusa mamillata, *altura 1,85 mm; H:* Leptochiton cimicoides, *vista dorsal, longitud 2,0 mm; I:* Leptochiton cimicoides, *vista lateral, longitud 1,65 mm; J: detalle del cinturón de* Leptochiton cimicoides *mostrando los dos tipos de espículas. Escalas 100 µm.*

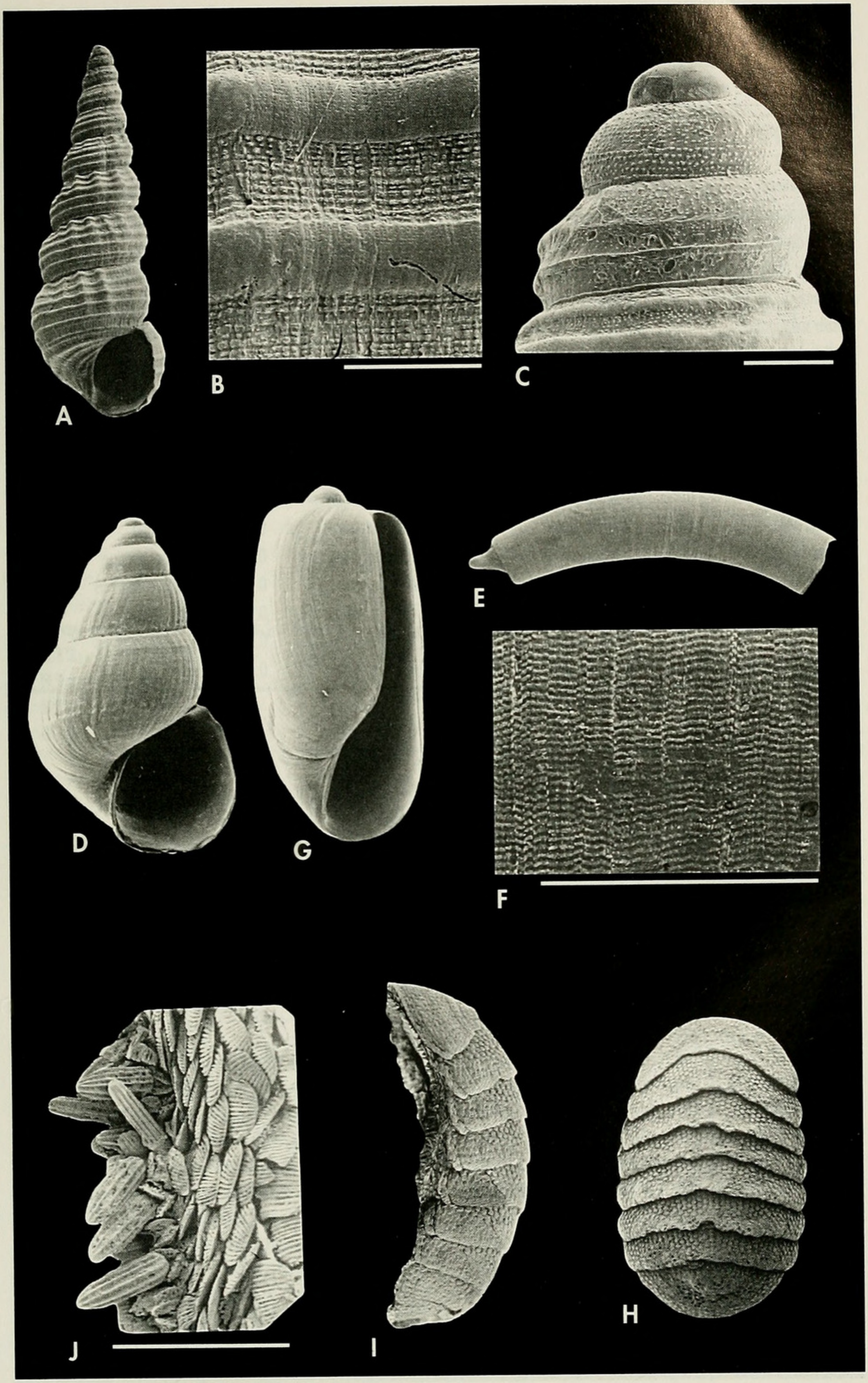
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Table V. The 20 most dominant species in each of the sampled stations.
Tabla V. Las 20 especies con mayor índice de dominancia en cada estación.

Retín 12	%	Retín 16	%	Barra 16	%	Barra 10	%
Chamelea striatula	52.47	*Chamelea striatula*	65.29	*Chamelea striatula*	47.14	*Chamelea striatula*	79.19
Corbula gibba	19.77	*Corbula gibba*	9.69	*Corbula gibba*	27.34	*Digitaria digitaria*	3.86
Gouldia minima	4.50	*Gouldia minima*	4.84	*Gouldia minima*	7.66	*Corbula gibba*	3.38
Bittium submamillatum	2.59	*Calyptraea chinensis*	3.23	*Digitaria digitaria*	7.15	*Spisula subtruncata*	3.07
Digitaria digitaria	2.50	*Digitaria digitaria*	2.96	*Calyptraea chinensis*	4.33	*Nuculana pella*	1.17
Calyptraea chinensis	1.88	*Turritella communis*	2.47	*Turritella communis*	3.52	*Pandora inaequivalvis*	0.98
Laevicardium crassum	1.69	*Tapes rhomboides*	1.76	*Mesalia varia*	1.77	*Gouldia minima*	0.91
Spisula subtruncata	1.62	*Turritella turbona*	1.00	*Gibbula magus*	1.47	*Acanthocardia tuberculata*	0.85
Modiolus adriaticus	1.36	*Nuculana pella*	0.78	*Nuculana pella*	1.31	*Nassarius reticulatus*	0.84
Turritella turbona	1.05	*Modiolus adriaticus*	0.72	*Tapes rhomboides*	1.31	*Laevicardium crassum*	0.77
Turritella communis	1.03	*Gibbula magus*	0.69	*Spisula subtruncata*	1.22	*Nassarius mutabilis*	0.74
Gibbula guttadauri	0.70	*Spisula subtruncata*	0.60	*Modiolus adriaticus*	1.03	*Nassarius elatus*	0.61
Clausinella fasciata	0.63	*Mesalia varia*	0.50	*Ocinebrina edwardsi*	1.03	*Donax venustus*	0.38
Mesalia varia	0.62	*Anomia ephippium*	0.40	*Anomia ephippium*	0.94	*Bela laevigata*	0.36
Nuculana pella	0.61	*Bela laevigata*	0.36	*Calliostoma sp.1*	0.80	*Mesalia varia*	0.34
Pandora inaequivalvis	0.59	*flexopecten flexuosus*	0.34	*Laevicardium crassum*	0.77	*Modiolus adriaticus*	0.32
Aporrhais pespelicani	0.44	*Bittium submamillatum*	0.33	*Bela laevigata*	0.74	*Calyptraea chinensis*	0.31
Tapes rhomboides	0.34	*Pandora inaequivalvis*	0.33	*Pandora inaequivalvis*	0.72	*Callista chione*	0.19
Bela laevigata	0.34	*Pandora pinna*	0.29	*Nassarius pygmaeus*	0.58	*Nassarius pygmaeus*	0.18
Flexopecten flexuosus	0.31	*Aporrhais pespelicani*	0.28	*Pandora pinna*	0.56	*Turritella communis*	0.14

Table VI. Species with a frequency of more than 75% in each of the sampled stations.
Tabla VI. Especies con frecuencia superior a los 75% en cada una de las estaciones.

Retín 12	%	Retín 16	%	Barra 16	%	Barra 10	%
Laevicardium crassum	100%	*Corbula gibba*	100%	*Corbula gibba*	100%	*Spisula subtruncata*	*100%*
Digitaria digitaria	> 90%	*Gouldia minima*	100%	*Mesalia varia*	100%	*Nuculana pella*	100%
Clausinella fasciata	> 90%	*Digitaria digitaria*	100%	*Digitaria digitaria*	> 95%	*Acanthocardia tuberculata*	100%
Nuculana pella	> 90%	*Turritella communis*	> 95%	*Nuculana pella*	> 95%	*Nassarius reticulatus*	100%
Corbula gibba	> 85%	*Nuculana pella*	> 95%	*Calliostoma sp 1*	> 95%	*Nasarius mutabilis*	100%
Gouldia minima	> 85%	*Calyptraea chinensis*	> 90%	*Chamelea striatula*	> 90%	*Nassarius elatus*	100%
Callista chione	> 85%	*Mesalia varia*	> 90%	*Spisula subtruncata*	> 90%	*Digitaria digitaria*	> 90%
Aporrhais pespelecani	> 75%	*Bela laevigata*	> 80%	*Calyptraea chinensis*	> 85%	*Mesalia varia*	> 85%
Spisula subtruncata	> 75%	*Chamelea striatula*	> 75%	*Ocenebra erinacea*	> 85%	*Corbula gibba*	> 75%
Mesalia varia	> 75%	*Bolinus brandaris*	> 75%	*Gouldia minima*	> 80%	*Laevicardium crassum*	> 75%
Chamelea striatula	> 75%	*Tapes rhomboides*	> 75%	*Gibbula magus*	> 75%		
Bolinus brandaris	> 75%	*Nodiolus adriaticus*	> 75%	*Ocinebrina edwardsi*	> 75%		
		Spisula subtruncata	> 75%	*Laevicardium crassum*	> 75%		
				Turritella communis	> 75%		
				Tapes rhomboides	> 75%		
				Pitar rudis	> 75%		
				Fusinus pulchellus	> 75%		

Table VII. Values of affinity indexes between sampling stations, qualitative (Jaccard and Baroni-Urbani and Buser) and quantitative (Bray and Curtis, with and without *Chamelea striatula*).
Tabla VII. Valores de los índices de de afinidad entre estaciones de muestreos, cualitativos (Jaccard y Baroni-Urbani y Buser) y cuantitativo (Bray y Curtis, con o sin los datos para Chamelea striatula*).*

Jaccard	**R12**	**R16**	**B10**	**B16**
R12	1.000	0.496	0.432	0.510
R16		1.000	0.296	0.536
B10			1.000	0.393
B16				1.000
Baroni-Urbani and Buser	**R12**	**R16**	**B10**	**B16**
R12	1.000	0.617	0.595	0.629
R16		1.000	0.447	0.659
B10			1.000	0.557
B16				1.000
Bray and Curtis	**R12**	**R16**	**B10**	**B16**
R12	1.000	0.667	0.579	0.742
R16		1.000	0.839	0.593
B10			1.000	0.433
B16				1.000
Bray and Curtis (Sin C.s.)	**R12**	**R16**	**B10**	**B16**
R12	1.000	0.701	0.434	0.760
R16		1.000	0.414	0.823
B10			1.000	0.449
B16				1.000

bottoms with a higher amount of organic matter.

Species richness: Values of species richness in the Bay of Barbate are comparable with those obtained in other studies from soft bottom communities of molluscs, although sometimes higher. No information about species richness per month from detritical bottoms communities of molluscs have been found in the literature, but some information for communities for other soft bottoms is available. Species richness of Molluscs in soft bottoms from the North Sea is low (10 to 15 sp.) (ELEFTHERIOU AND BASFORD, 1989; KÜNITZER, 1990), but there is an increase in the English Channel (CABIOCH, GENTIL GLAÇON AND RETIÈRE, 1977). In Northern Spain, species richness values from 15 to 25 have been recorded in soft bottom communities of molluscs (SÁNCHEZ MATA, MORA, GARMENDIA, AND LASTRA, 1993; GARMENDIA, SÁNCHEZ MATA AND MORA, 1996). In Mediterranean coasts Salas (1984) registered values for species richness of molluscs from 20 to 30 in different kinds of soft bottoms of Málaga bay (Alboran Sea). The highest values of species richness were recorded (around 40 species per sample) in fine sand bottoms with low percentage organic matter. APARICI SEGUER AND GARCÍA-CARRASCOSA (1996) recorded values of species richness between 4 to 11 per sample in the soft bottoms of Chafarines islands (close to the Mediterranean area of Morocco), but such low values probably reflect incomplete sampling. APARICI SEGUER, ROWLAND, TAYLOR AND GARCÍA CARRASCOSA (1996) found 10-20 species per sample in the soft bottoms (fine sand) from the gulf of Valencia at depths of 15 meters. Values of species richness per month comparable to those found in this study have been registered in communities from hard bottoms (TRONCOSO, URGORRI AND OLABARRÍA, 1996), from sea grass beds (HERGUETA, 1996; LEDOYER, 1966 a, b) or the calcareous algae *Mesophyllum lichenoides* (Lemoine) (HERGUETA, 1996).

Characterisation of the community: The species living sympatrically in the Bay of Barbate form communities with more components than in other areas. In the Mediterranean Sea similar communities were referred to as "Biocénose des fonds meubles instables (MI) " and "Biocénose des fonds detritique du large (DL) " (PÉRÈS AND PICARD, 1964). These have a similar faunistic compositions, although species richness is higher in Barbate bay. In our study these communities occurred in the infralittoral level (25 m), whereas in the Mediterranean they occur in the circalittoral, deeper than in the Atlantic.

The community from B10 is also similar to the "Biocénose des sables fins bien calibrés (SFBC) " (PÉRÈS AND PICARD, 1964), but there is a high influence of faunistic components from the previously mentioned communities. In R12 some similarities with the "Biocénose des sables grossiers et des fins graviers (SGFG) " (PÉRÈS AND PICARD, 1964) are found, although the instability of the bottoms due to strong currents changes the composition of the community through the year.

CABIOCH (1968) found similar and comparable communities in the English channel, named as "Peuplements des sédiments fins a *Abra alba* et *Corbula gibba*" and "Biocoenose du Maerl". In these communities a mixture of in- and epifauna occurred over a heterogeneous sediment. The depth in which these communities occurred was similar to those from Barbate, within the infralitoral. However, the biogeographical differences result in that some species have been replaced in the Strait of Gibraltar. We could not trace in the literature any reference to communities in the Mauritanian region, so that a comparison was not possible.

Structure of the community. Dominance and Frequency: High values of dominance were more common among bivalves than among gastropod species. This reflects their high abundance in soft bottoms, conforming large populations. Gastropods are less numerous than bivalves in soft bottoms samples. In order to correct this bias, we also took into account the frequency of the species in the samples. It is important to take into account both figures, because some species with a marked seasonality may show high abundance during a short period of time, and thus have a low frequency although they are important elements of the community.

The highest dominance was for the species *Chamelea striatula*, although it showed lower percentages of presence than other species. This was caused by a massive and successful recruitment of this species in these bottoms in the first sampling year, although no recruitment occurred in the second year. Such strong settlement has been registered for the same species along the Scottish coasts by ANSELL (1961). At the beginning of this study *Chamelea striatula* was found in some samples with low abundance. After spring 1994 this species was dominant in the four sample stations, although the population decreased in some stations during 1995. At the end of the sampled period, large population of *Chamelea striatula* was only present in B10 which is close to the harbour and the estuary. This species is common in fine sand bottoms from shallow coasts (3-20 m) in the North Sea (MUUS, 1973; DUINEVELD AND BELGERS, 1994). In the Strait of Gibraltar area, *Chamelea striatula* is found living sympatrically with *Chamelea gallina* which is very common in fine sand bottoms from shallow shores (2-15 m) in the Mediterranean Sea. C *striatula* is usually found in mud bottoms with high percentages of organic matter in southern Spanish

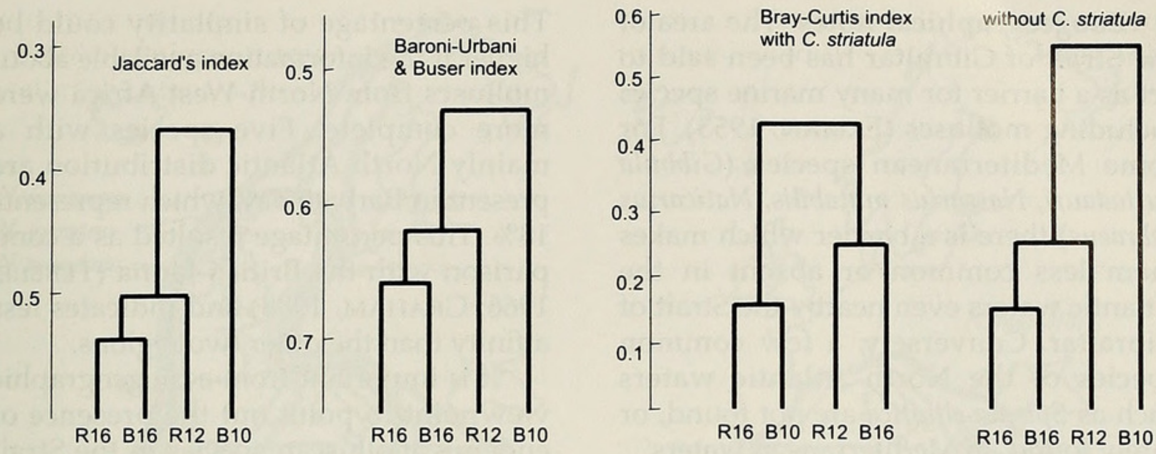

Figure 5. Dendrograms representing affinity of sampling points, according to the qualitative indices (above) and quantitative (below). Algorithm is UPGMA.
Figura 5. - Dendrogramas de afinidad de los puntos muestreados en base a los valores de los índices cualitativos (Superior) y cuantitativos (Inferior). Algoritmo de aglomeración UPGMA.

coasts and never reaches high dominance in near-shore sandy bottoms. The persistence of this species may have been favoured by the cleaning and dredging of the channel in the harbour of Barbate during our sampling period, which turned more muddy the sediments nearby.

Other molluscs of these detritic bottom communities showed high frequencies and dominance. Large populations of *Corbula gibba* were collected, but this is a rather ubiquitous species, commonly found together with *Turritella* communities on fine sandy bottoms with large pieces of graves and pebbles (HRS-BRENKO, 1981).

Digitaria digitaria is a typical species of coastal detritic bottoms from North Spanish coasts (ORTEA, 1977; BESTEIRO, TRONCOSO, PARAPAR, SALVINI-PLAWEN AND URGORRI, 1990). Among the gastropods, some of the most typical species for detritic bottoms are turritellids. In this location *Mesalia varia* is an important component of the community from Barbate and also one of the West African representatives.

In station B10, a mixed community occurs. Species from detritic bottom communities (*Digitaria digitaria, Mesalia varia, Corbula gibba*) have a high frequency and dominance but some species from communities of well sorted fine sand (*Nassarius* species, *Acanthocardia tuberculata, Spisula subtruncata*) showed also high dominances and the highest frequencies. The community from this latter sample station seems to be a transition between both. Communities of well sorted fine sands are known in other points from European coasts: in the North Sea (FORD, 1923; CABIOCH, 1968), in the Mediterranean Sea (SPADA, SABELLI AND MORANDI, 1973; SALAS, 1984; GARCÍA RASO *ET AL.*, 1992). In Barbate bay this community shows a higher species richness than other communities from European coasts. Three species of Nassariidae (*Nassarius reticulatus, Nassarius mutabilis* and *Nassarius elatus*) were found in B10 with high frequency, while *Nassarius pygmaeus* and *Nassarius vaucheri* occurred with low frequency. This kind of community in the Mediterranean Sea holds usually only two species of Nassariids (*N. mutabilis* and *N. reticulatus*) and in the North Sea *N. reticulatus* and *N. pygmaeus*. Other species like *Mactra stultorum* and *Chamelea gallina* were not found as main components in this sample point but they show high abundance in similar communities from the Mediterranean Sea (SPADA *ET AL.*, 1973; SALAS, 1984; GARCÍA RASO *ET AL.*, 1992).

Zoogeographical notes: The area of the Strait of Gibraltar has been said to act as a barrier for many marine species including molluscs (EKMAN, 1953). For some Mediterranean species (*Gibbula guttadauri, Nassarius mutabilis, Naticarius hebraeus*) there is a barrier which makes them less common or absent in the Atlantic waters even nearby the Strait of Gibraltar. Conversely, a few common species of the North Atlantic waters such as *Spisula elliptica* are not found, or rarely found, in Mediterranean waters.

On the other hand, the area of the Strait can also be regarded as one where species of quite different zoogeographical affinity will concur (PALLARY, 1907; SPADA AND MALDONADO, 1974; RUEDA AND SALAS, 1998). The fauna from tropical and temperate West African areas is represented in Barbate by *Mesalia varia, Epitonium jolyi, Nassarius elatus, Nassarius heynemanni, Nassarius vaucheri* and *Gari pseudoweinkauffi*, among others. These species share a northern limit along the coasts of South Portugal (to the North) and in the Alboran Sea (in the Mediterranean). Most Mediterranean species do occur in the Ibero-Moroccan gulf, at least to Cape St. Vincent and sometimes further north. This results in an increase of the number of species from the different biogeographical regions, and Barbate is a locality where their distribution ranges overlap. This trend is well illustrated by the distribution patterns of the seven species of Nassariids (Fig. 6) which were collected sympatrically in this bay.

The fauna of molluscs found in this study includes mostly species which are widespread in the Northeast Atlantic and Mediterranean. Among 27 species with a distribution restricted to one of EKMAN'S (1953) three regions, there is a high percentage of similarity (48%) with typical Mediterranean fauna as found along the Italian coast. Nine species are shared with the so-called Mauritanian region (mostly Morocco), according to the information of PASTEUR-HUMBERT (1962 a, b) and of NICKLÈS (1950, 1955) This represents a high similarity (33%). This percentage of similarity could be higher if the information available about molluscs from North-West Africa were more complete. Five species with a mainly North Atlantic distribution are present in Barbate bay, which represents 18%. This percentage resulted as a comparison with the British fauna (TEBBLE, 1966; GRAHAM, 1988) and indicates less affinity than the other two regions.

It is important from a biogeographic viewpoint to point out the presence of endemic molluscan species in the Strait of Gibraltar area. Recently, several species of endemic gastropods have been described from this area and the data have been summarized by GOFAS (1999). Nevertheless, most of the endemic component are linked to rocky shore in intertidal of very shallow environments. It is interesting to note the presence of *Nassarius tingitanus* (Pallary, 1901) on hard bottoms very near the sampling area, but closer to the shore. This species (Fig. 3) shows a typical endemic distribution restricted to the Strait of Gibraltar.

In our samples, we found large numbers of the endemic gastropod *Jujubinus dispar*, which occurs in a restricted area from Tangier to Ceuta (North Africa) and was only cited in European coasts by VAN AARTSEN *ET AL.* (1984) in Algeciras Bay (South Spain). Another rather well documented endemic component is the skeneid *Dikoleps pruinosa*, originally described from Tangier, where it is now very rare due to the extension of the harbour.

Other species which occur in the Barbate samples have once been thought to be endemic of the Gibraltar area but are now known to occur on other subtidal current-swept gravel bottoms. The small bivalve *Notolimea clandestina* Salas, 1994 (SALAS, 1994), which is common on the bottoms of Barbate is also known to occur near Lampedusa, in Sicily Channel (Italy). The same pattern is found for the rare skeneid *Parviturbo fenestratus*, originally described from Tangiers, and now reported from Adventure Bank, Sicily Channel (WARÉN, 1992).

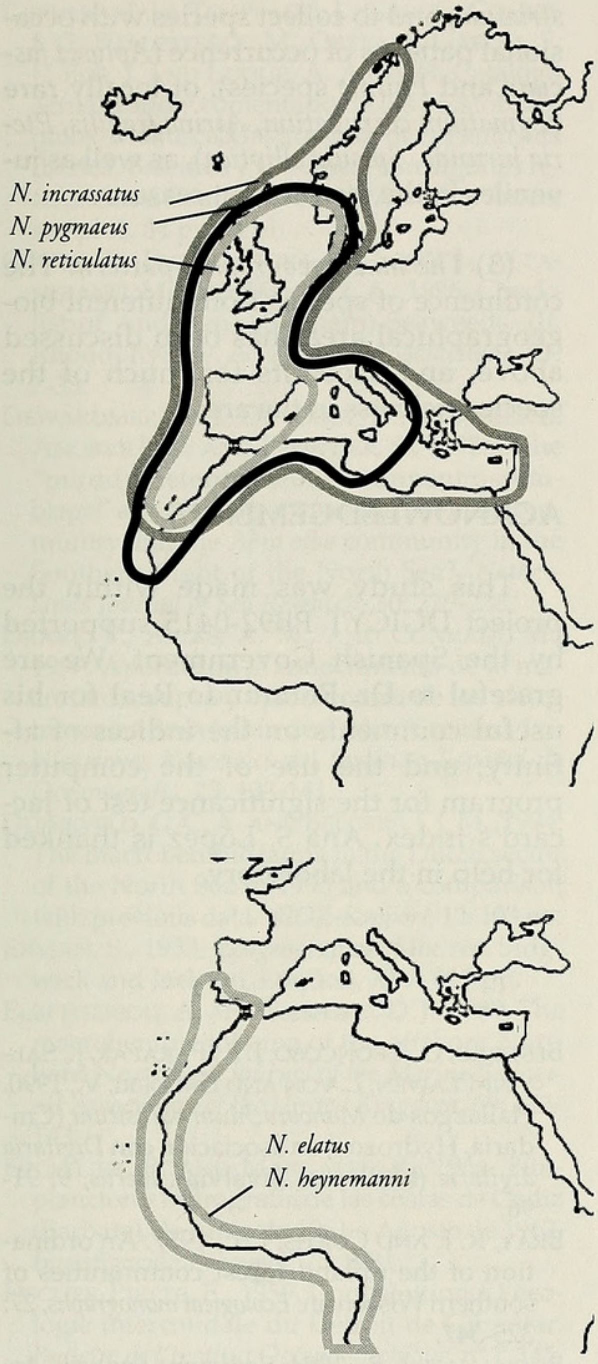

Figure 6. Range of the different species of Nassariidae found in Bay of Barbate.
Figura 6. - Distribución geográfica de las diferentes especies de Nasáridos presentes en la bahía de Barbate.

To summarize, the results of this study show that the bay of Barbate supports a rich soft bottom fauna of molluscs, which is basically the same in three of the sampled stations. The high species richness recorded in these bottoms may be influenced by three kinds of factors:

(1) *Environmental factors.* The bottom contains a mixture of hard and soft components in the sediments. The deeper stations (25 m) have more large bioclastic material (fragments of shells) deposited over a fine sand bottom. This heterogeneity of the substrates induces a diversification of the micro-habitats

(Frontier and Pichod-Viale, 1991; Dewarumez, Davoult, Sanvicente Anorve and Frontier 1992), and consequently a diversification of the fauna. The occurrence of large-size particles favours the settling and development of sessile epifaunal molluscs such as *Anomia ephippium, Modiolus adriaticus, Calyptraea chinensis,* and some mobile pectinids as *Flexopecten flexuosus, Chlamys varia* and *Aequipecten* species. In B10 with a lower amount of bioclastic material there was a decrease in the abundance of these species but an increase of others. The mixture of these with fine sand favours well established populations of infaunal molluscs, mainly bivalves as *Gouldia minima, Digitaria digitaria* or *Spisula subtruncata.*

(2) *The sampling method.* The survey spanned a longer period of time than in other reviewed researchs. This allowed to record changes in the composition of the community such as occurred with *C. striatula,* and to collect species with occasional patterns of occurrence (*Aplysia fasciata* and *Philine* species), or locally rare (*Cymatium corrugatum, Atrina fragilis, Pteria hirundo, Spisula elliptica*), as well as juveniles in the recruitment season.

(3) *The macrogeographic pattern.* The confluence of species from different biogeographical areas has been discussed above, and accounts for much of the species richness in the area.

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