SHALLOW-WATER MARINE MOLLUSCS OF THE AZORES: BIOGEOGRAPHICAL RELATIONSHIPS

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Shallow-water marine molluscs of the Azores were surveyed from supralittoral to a depth of 45 m which yielded an up-to-date database. The resulting list of 231 confirmed taxa of the Azores was then compared with similar lists from Scandinavia, Belgium, British Isles, Gulf of Biscay to Galiza, Portugal, Western Mediterranean, Morocco and Mauritania, Madeira, Porto Santo, Desertas and Selvagens, Canary Islands, Cape Verde, Ascension Island, Saint Helena, and the Caribbean.

A total of 18 species and 1 subspecies (*Tricolia pullus azorica*) are considered to be endemic to the Azores.

There are 20 new records to the Azores: *Metaxia abrupta* (Watson, 1880), *Monophorus erythrosoma* (Bouchet & Guillemot, 1978), *Melanella* sp., *Lamellaria latens* (O. F. Müller, 1776), *Ranella olearia* (Linnaeus, 1758), *Ocinebrina edwardsi* (Payraudeau, 1826), *Fusinus* sp., *Nassarius corniculus* (Olivi, 1792), *Crassopleura incrassata* (Dujardin, 1837), *Heliacus architae* (O. G. Costa, 1867), *Cima* cf. *minima* (Jeffreys, 1858), *Odostomia conoidea* (Brocchi, 1814), *Ondina diaphana* (Jeffreys, 1848), *Chromodoris khroni* (Verany, 1846), *Chlamys flexuosa* Poli, 1795, *Loripes lacteus* (Linnaeus, 1758), *Bornia* sp., *Parvicardium exiguum* (Gmelin, 1791), *Gastrana fragilis* (Linnaeus, 1758) and *Paphia aurea* (Gmelin, 1791).

It was possible to infer the life history of only 72 species out of the 231. Of these, 38 have a free-swimming stage and 34 have a non-planktotrophic type of development (either lecithotrophic or direct development). Thirteen endemic species were found with a non-planktotrophic type of development, all belonging to the Rissoidae.

The Mediterranean, Madeira archipelago and Portugal mainland, are the regions which share a higher number of species with the Azores, whereas Saint Helena and Ascension Island share only a small number of species with the Azores.

Some comments are made regarding the influence of the Gulf Current on the composition of the marine malacofauna of the Azores, as well on the possible routes of colonization of the Azorean islands by marine molluscs.

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INTRODUCTION

The vast majority of the works about the marine molluscs of the Azores dealt with their taxonomy and systematics (MAC ANDREW 1856; DROUËT 1858; MORELET 1860; RÖMER 1871; WATSON 1886; SIMROTH 1888; DAUTZENBERG 1889; GIRARD 1892; DAUTZENBERG & FISHER 1897; NOBRE 1924, 1930; MORTON 1967, 1990a, 1990b, 1995; MARTINS 1976, 1995; MOOLENBEEK & FABER, 1987; MOOLENBEEK & HOENSELAAR 1987; BURNAY & MARTINS 1988; GOFAS 1989a, 1989b, 1990; AZEVEDO & MARTINS 1989; AZEVEDO 1990; GOFAS 1990; GOSLINER 1990; HOUBRICK 1990; MARTINS 1990; SILVA 1990; AZEVEDO & GOFAS 1990; AZEVEDO, 1991b; GONÇALVES 1991; MENEZES

1991; VAN DER LINDEN 1993; HOEKSEMA & SEGERS 1993; LINDEN & VAN AARTSEN 1994; BIELER 1995; JENSEN 1995; MIKKELSEN 1995; REID 1996; ÁVILA & AZEVEDO 1996; ÁVILA 1997; ÁVILA & AZEVEDO 1997; WIRTZ 1998; HOENSELAAR & GOULD 1998; SALAS & GOFAS 1998; ÁVILA et al. 1998), followed by ecological studies (CHAPMAN 1955; MARTINS 1980; ARRUDA & GORDO 1984; LEMOS & VIEGAS 1987; NETO & AZEVEDO 1990; BULLOCK et al. 1990; HAWKINS et al. 1990; MORTON 1990a; AZEVEDO 1991a, 1992; GONÇALVES & MARTINS 1993; BULLOCK 1995; WIRTZ 1995; ÁVILA 1998; MORTON et al. 1998). By contrast, only two papers were published dealing with biogeography: WIRTZ & MARTINS 1993 and KNUDSEN 1995.

The strong Mediterranean component of the marine molluscs of the Azores is known since the paper of MAC ANDREW (1854), but it was never quantified, only sparse families of the Azorean shallow-water marine molluscs having been well studied. I here attempt to produce a check-list of the shallow-water Gastropoda, Bivalvia and Cephalopoda of the Azores and to infer and quantify their biogeographical relationships.

MATERIAL AND METHODS

The systematic revision was based on an extensive bibliographic compilation of the references of the shallow-water marine molluscs for the Azores. During the last four years, a survey was performed of the collections of the following institutions: DBUA – The Mollusc reference collection of the Department of Biology of the University of the Azores, Ponta Delgada; *Imag*DOP – image bank of the Department of Oceanography and Fisheries of the University of the Azores, Horta; DOP/ML – The Mollusc reference collection of the Department of Oceanography and Fisheries of the University of the Azores, Horta; MCM(HN) – Museu Carlos Machado (História Natural), Ponta Delgada and MZ/MHN-FCTUC – Museu de Zoologia/Museu de História Natural da Faculdade de Ciências e Tecnologia da Universidade de Coimbra. Taxa found were entered into a database using Microsoft Access 97. Species were placed in synonymy according to the most recent published systematic treatment available. CLEMAM database (Check List of European Marine Mollusca), availabale through Internet (http://www.mnhn.fr/base/malaco.html) was particularly helpful and intensively used. Undescribed species (e.g. *Bittium* sp. and *Alvania* sp.) or species only identified to the genus level were also included.

The distribution of the larvae of the molluscs found near the Azores was extracted from LAURSEN (1981), SCHELTEMA (1971) and SCHELTEMA et al. (1989). The geographical distribution of the adult specimens of all the species existing in the Azores is based on POPPE & GOTO (1991; 1993) but specialized works were also used for some species (e.g. SEURAT & DIEUZEIDE 1933; GOSLING 1984; TEMPLADO 1986; BURNAY & MARTINS 1988; WARMOES et al. 1988; TAYLOR et al. 1993; HOUART & ABREU 1994; OLIVERIO 1995; ORTEA et al. 1997; HOENSELAAR & GOULD 1998; SALAS & GOFAS 1998). The Azorean marine molluscs database was compared with data from Scandinavia (HANSSON 1997), Belgium (BACKELJAU 1986), British Isles (TEBBLE 1966; GRAHAM 1988; THOMPSON 1976, 1988; THOMPSON & BROWN 1984; SMITH & HEPPELL 1991) Gulf of Biscay to Galiza (ROLAN 1984; BORJA 1987; LASTRA et al. 1988), Portugal (NOBRE 1931, 1936; NOBRE & BRAGA 1942), Western Mediterranean (RIEDL 1986; RASO et al. 1992), Morocco (POPPE & GOTO 1991, 1993; MENIOUI 1992), Madeira, Desertas and Selvagens (MAC ANDREW 1852; NOBRE 1889, 1937; NORDSIECK & TALAVERA 1979; ABREU 1991; GUERREIRO 1994; WIRTZ 1994; WIRTZ in press; ANDRADE 1995; CLARKE & LU 1995; SILVEIRA 1995; MALAQUIAS 1996; FONSECA et al. 1995), Canary Islands (MAC ANDREW 1852; NORDSIECK & TALAVERA 1979; TALAVERA, 1982; ORTEA et al. 1982), Cape Verde (NOBRE 1900; BURNAY & MONTEIRO 1977; COSEL 1982a, 1982b, 1982c; GARCIA-TALAVERA & BACALLADO 1978), Ascension and Saint Helena (ROSEWATER 1974, 1975), and the Caribbean (WARMKE & ABBOTT 1961; JONG & COOMANS 1988; ABBOTT & DANCE 1990).

A total of 701 samples of molluscs (DBUA collection) were collected in all the islands of the Azores except in São Jorge and Corvo, ranging from intertidal samples to 45 m depth (Table 1). Two dredge hauls made at 70 m depth were also performed off Vila Franca do Campo at São Miguel Island. All these samples were sorted and the molluscs identified.

A simple percentage similarity index was used to compare the shallow-water marine molluscs of the Azores with the selected regions. It was calculated as the ratio between the shared species and the 231 taxa confirmed for the Azores (Table 3). The use of indexes like those of Jaccard or Sørensen (KREBS, 1985), which take in account both the total number of species existing in each one of the compared regions, as well as the number of common species, would certainly be more accurate than the percentage similarity index. However, those "better" indexes were not used because there are no recent check-lists of some of the selected regions (e.g. Madeira, Cape Vert, Ascension islands and Saint Helena). Thus, with different degrees of knowledge of the molluscan fauna in the considered regions, I have chosen just to compare and infer on the similarity between a given region and the Azores, based on

Table 1

Samples collected at the Azores (DBUA collection).

Site	Number of samples
Flores	173
Pico	76
Faial	75
Graciosa	77
Tereeira	45
Banco D. João de Castro	1
São Miguel	178
Santa Maria	43
Formigas	33
TOTAL	**701**

Table 2

Shallow water marine molluscs of the Azores. N – number of species; dr – dubious record; n. id. – species identified only to genus.

	N
Azores total	281
Azores (dr)	31
Azores (n. id.)	19
Azores (endemic species/subspecies)	19

Table 3

Number of shared species with the Azores (dubious records excluded). Sim % - percentage of similarity between the malacofauna of a given region and the Azores (231 confirmed taxa).

	Azores	Sim (%)
Scandinavia	78	33,8
Belgium	23	10,0
British Isles	112	48,5
Golf of Biscay to Galiza	125	54,1
Portugal	144	62,3
Western Mediterranean	181	78,4
Morocco	64	27,7
Madeira, Porto Santo, Desertas and Selvagens	147	63,6
Canary islands	137	59,4
Cape Verde	70	30,3
Ascension island	13	5,6
Saint Helena	12	5,2
Caribbean	22	9,5

the amount of shared molluscan species in relation to the Azorean species.

The biogeographical relationships of the shallow-water marine molluscs of the Azores were studied by comparing the Azorean species with the following selected regions (Scandinavia, British isles, Gulf of Biscay to Galiza, Western Mediterranean, Morocco, Madeira, Desertas and Selvagens, Canary islands, Cape Verde, Ascension island, Saint Helena and the Caribbean). This procedure was done for all the 231 taxa, for Gastropoda and for the Bivalvia. This procedure was repeated, with the endemic Azorean species excluded. Finally, a similar study was performed on the species grouped by biogeographical Provinces and Regions: Boreal Province (Scandinavia, Belgium and British isles); Lusitanian Province divided in Franco Iberian Region (Biscay Golf to Galiza and Portugal), Mediterranean Region, and Morocco Region (Morocco, Mauritania, Madeira, Selvagens and Desertas, and Canary islands); West-African Province, with the Senegal Region (Cape Verde), South Atlantic Province (Ascension Island and Saint Helena); and the Caribbean Province.

All dendrograms were drawn using non-transformed presence-absence data, Bray-Curtis similarity index and UPGMA method, PRIMER version 4.0 Plymouth Marine Laboratory package.

The life history of the species was also investigated, both from the literature and by inference from protoconch morphology, through SEM photos, with two possibilities considered: planktonic or non-planktonic phase (THORSON 1950; SCHELTEMA 1971; SHUTO 1974; JABLONSKI & LUTZ 1983; LEAL 1991; 1999; LEAL & BOUCHET 1991).

RESULTS

A total of 281 taxa were found to be reported for the Azores. Of these, 31 were considered dubious records, so there are 250 confirmed taxa. Twenty species were identified only to the genus level, including two of the endemic species (*Bittium* sp. and *Alvania* sp.). Although confirmed for the Azores, *Assiminea eliae* Paladilhe, 1875 was removed from the biogeographic analysis because no reliable data were found about its geographic range. The multivariate analysis was conducted after removing *Assiminea eliae* and the 18 not identified species (*Bittium* sp. and *Alvania* sp. were included in the analysis) from the 250 confirmed taxa, thus making a total number of 231 taxa (229 confirmed species plus 2 endemic taxa identified down to the genus).

The *Columbella* species that exists in Macaronesia is *Columbella adansoni* Menke, 1853, a species reported from the Azores, Madeira, Canary Islands, Cape Verde and African coast south of Senegal. *Columbella rustica* (Linnaeus, 1758) is a different species recorded for the Mediterranean and African coast down to Senegal (OLIVERIO 1995).

Shells of *Mytilus edulis* Linnaeus, 1758 were collected inside of harbour walls (e. g. in Ponta Delgada harbour). Very recently, alive specimens were found inside Ponta Delgada harbour (Saco da Doca), ranging from 0,5 to 1 m depth. They probably arrived attached to ships (there are reports of *Mytilus* attached to tuna boats, João Brum pers. comm.). However, this very localized and small population has not so far spread out from this spot.

Spirula spirula (Linnaeus, 1758) (reported as *Spirula peronii* Lamarck, 1822 to the Azores, at shore, by MAC ANDREW 1856) as well as *Loligo forbesii* Steenstrup, 1856 (reported as *Loligo vulgaris* by DROUËT 1858), are species that usually do not live in the depths studied, but as they do sometimes occur in very shallow-waters, these molluscs were considered in this study.

There are 20 new records to the Azores: *Metaxia abrupta* (Watson, 1880), *Monophorus erythrosoma* (Bouchet & Guillemot, 1978), *Melanella* sp., *Lamellaria latens* (O F Müller, 1776), *Ranella olearia* (Linnaeus, 1758), *Ocinebrina edwardsi* (Payraudeau, 1826), *Fusinus* sp., *Nassarius corniculus* (Olivi, 1792), *Crassopleura incrassata* (Dujardin, 1837), *Heliacus architae* (O. G. Costa, 1867), *Cima* cf. *minima* (Jeffreys, 1858), *Odostomia conoidea* (Brocchi, 1814), *Ondina diaphana* (Jeffreys, 1848), *Chromodoris khroni* (Verany, 1846),

Chlamys flexuosa Poli, 1795, *Loripes lacteus* (Linnaeus, 1758), *Bornia* sp., *Parvicardium exiguum* (Gmelin, 1791), *Gastrana fragilis* (Linnaeus, 1758) and *Paphia aurea* (Gmelin, 1791).

A total of 18 species and 1 subspecies (*Tricolia pullus azorica*) (8,2%) are considered as endemic to the Azores (see Table 2).

Excluding the dubious records, a total number of 111 families and 181 genera were found. Rissoidae with 19 confirmed species (13 endemic) is the largest family, followed by Veneridae (9 species, 1 endemic), Pyramidellidae (9 species), Conidae (8 species), Muricidae, Chromodorididae and Pectinidae (all with 7 species) and Naticidae and Ellobiidae (both with 5 species). A total of 79 families are represented by a single genus and 65 families are represented by one species only (Appendix).

Janthina exigua, *Janthina janthina* and *Spirula spirula* although occurring in both sides of the Atlantic, are not considered as amphi-Atlantic, because they are pelagic species. Sixteen out of the 231 confirmed taxa (6,9%) are amphi-Atlantic species (13 gastropods and 3 bivalves): *Trivia candidula*, *Polinices lacteus*, *Phalium granulatum*, *Cymatium parthenopeum*, *Stramonita haemastoma*, *Philippia hybrida*, *Bulla striata*, *Atys macandrewii*, *Elysia ornata*, *Aplysiopsis formosa*, *Hypselodoris picta*, *Williamia gussoni*, *Myosotella myosotis*, *Pinna rudis*, *Limaria hians* and *Lasaea adansoni*.

The Mediterranean (78,4%), Madeira archipelago (63,6%) and Portugal mainland (62,3%) are the regions which share a higher number of species with the Azores, whereas Saint Helena (5,2%) and Ascension island (5,6%) share only a small number of species (Table 3).

A total of 112 species (48,5%) occurs simultaneously in the Azores, Madeira and the Canary Islands, and 53 species (22,9%) occur in all the Macaronesian Archipelagos.

Of the 231 confirmed taxa to the Azores, it was possible to determine the life history of only 72 species. Of these, 38 have a free-swimming stage and 34 have a non-planktonic type of development. The 13 endemic species with a non-planktotrophic type of development all belong to the Rissoidae, the endemic Phasianellidae subspecies *Tricolia pullus azorica* having a planktotrophic type of development.

Almost 47% of the total number of the Azorean shallow-water molluscan species, were reported since 1989 (Figure 8).

The following analysis concerns the confirmed 231 taxa.

When all species are considered (231 taxa), three groups appear, clustering the different locations at 70% similarity, all positioned in geographical order: in the first one, Scandinavia, British Isles and Biscay Golf to Galiza cluster. In the second group, two subgroups appear: the Azores and Mediterranean cluster at about 88% similarity, and then cluster to Portugal at 80%; the second subgroup contains Madeira, Porto Santo, Desertas and Selvagens, clustered with Canary Islands at 79%. Finally, in the third group, Ascension Island and Saint Helena cluster at about 72%. Morocco, Mauritania and Cape Verde cluster with the two first groups at about 52% and Belgium at only 25% similarity (Fig. 1).

When all species but the Azorean endemics (that is, a total of 212 species) are considered, three groups appear, clustering the different locations at 70% similarity: in the first one, Scandinavia, British Isles and Biscay Golf to Galiza cluster. In the second group, two subgroups appear: Azores and Mediterranean cluster at about 92% similarity, and then cluster to Portugal at 82%; the second subgroup contains Madeira, Porto Santo, Desertas and Selvagens, clustered with Canary Islands at 80%. In the third group, Ascension Island and Saint Helena cluster again at about 72%. Morocco, Mauritania and Cape Verde cluster with the two first groups at about 53% and Belgium at only 22% similarity (Fig. 2).

When the analysis is performed for the Gastropoda alone, once again, Belgium, Morocco and Mauritania, Cape Verde and the Caribbean cluster at less than 70%. Scandinavia and the British Isles cluster at 73% and this group joins the main group at about 53%. In this group, formed by 6 sites, three sub-groups exist. In the first one, Biscay and Portugal cluster at 76%. In the second sub-group, the Azores and Western

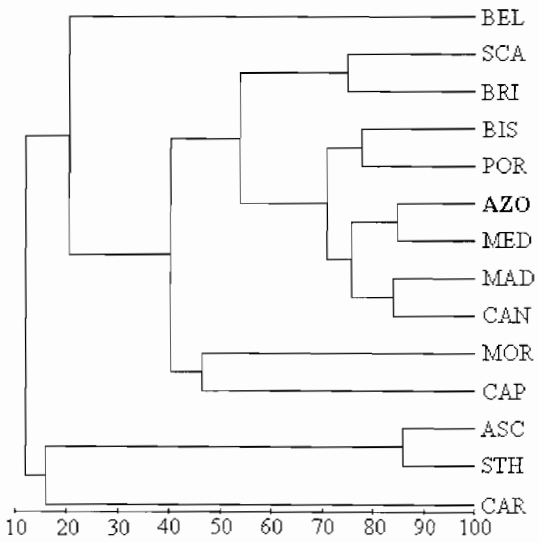

Fig. 1. Biogeographical relationships (all species). Bray-Curtis similarity index, non-transformed presence/absence data, UPGMA for all the 231 confirmed shallow-water molluscs of the Azores. AZO –Azores; SCA – Scandinavia; BEL – Belgium; BRI – British Isles; BIS – Biscay Golf; POR – Portugal; MED – Western Mediterranean; MOR – Morocco and Mauritania; MAD – Madeira, Porto Santo, Desertas and Selvagens; CAN - Canary Islands; CAP – Cape Vert; ASC – Ascension Island; STH – Saint Helena; CAR – Caribbean.

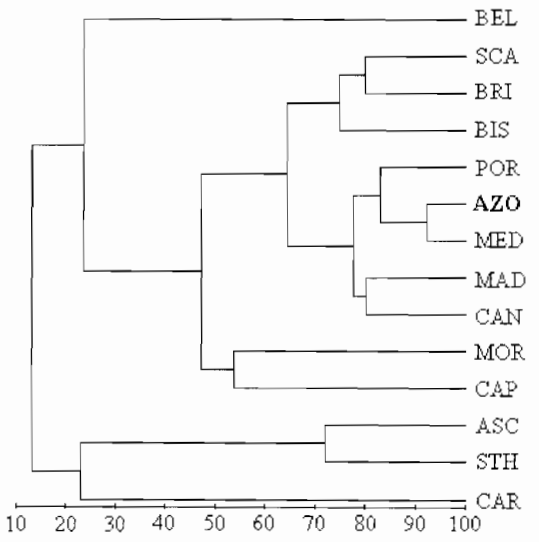

Fig. 2. Biogeographical relationships (212 species; endemic Azorean species excluded). Bray-Curtis similarity index, non-transformed presence/absence data, UPGMA. Legend as in Fig. 1.

Mediterranean cluster at 85% and in the last sub-group, Madeira Archipelago clusters with the Canary Islands at 84%. Ascension Island and Saint Helena cluster at 86% (Fig. 3).

Performing the same procedure for the Gastropoda alone (endemic Azorean species excluded), Belgium, Morocco and Mauritania, Cape Verde and the Caribbean again cluster at less than 70%. The Azores cluster with the Western Mediterranean at 90% and Portugal again clusters with the Azores/Western Mediterranean (compare with Fig. 3) (Fig. 4).

For the Bivalvia, two groups are evident at more than 70% similarity: in the smaller, Morocco and Mauritania clusters with the Canary Islands; in the second group, with 7 regions, the Azores and Western Mediterranean cluster at about 96%, and Portugal joins them at about 92% similarity. Cape Verde and Belgium cluster with these two groups at 58% and 28% similarity, respectively. A smaller group is constituted by Ascension Island and Saint Helena, that cluster at 61% to which the Caribbean joins at 50%. This group is connected to the main one at only 13% similarity (Fig. 5).

When the endemic Azorean Bivalvia species are excluded, at more than 70% similarity, two groups appear: in the smaller, Morocco and Mauritania clusters with the Canary Islands; in the second group, with 7 regions, the Azores and Western Mediterranean cluster at about 97%, and then Portugal joins them at about 91% similarity. Cape Verde and Belgium cluster with these two groups at 58% and 27% similarity, respectively. A smaller group is constituted by Ascension Island and Saint Helena, that cluster at 60% to which the Caribbean joins at 50%. This group is connected to the main one at only 13% similarity (Fig. 6).

Comparing the three dendrograms with the endemic Azorean species included (all 231 taxa, Gastropoda and Bivalvia), there is some variation between these dendrograms, especially between the Bivalvia and the other two (see Fig.s 1, 3 and 5). Belgium, consistently clustering at low levels (ranging from 22% in the case of the Gastropoda, to 28% in the case of the Bivalvia) and the Azores

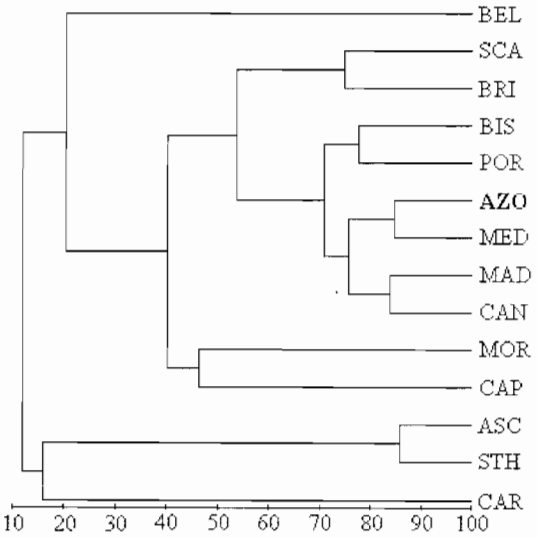

Fig. 3. Biogeographical relationships (Gastropoda only). Bray-Curtis similarity index, non-transformed presence/absence data, UPGMA. Legend as in Fig. 1.

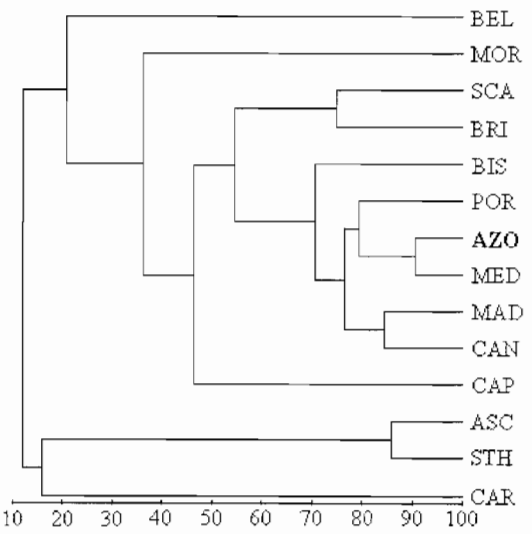

Fig. 4. Biogeographical relationships (Gastropoda only; endemic Azorean species excluded). Bray-Curtis similarity index, non-transformed presence/absence data, UPGMA. Legend as in Fig. 1.

consistently cluster with the Western Mediterranean, and than with Portugal, the main difference occurring in the case of the Gastropoda, where Portugal cluster with Biscay.

When the endemic species are excluded, a similar pattern occurs in all dendrograms (the 212 species, Gastropoda and Bivalvia), with a consistent group formed by Ascension Island, Saint Helena and the Caribbean that cluster with the other regions at low levels of similarity. Belgium is also a region whose similarity levels are quite low, clustering always at no more than 30%. The Azores consistently cluster with Western Mediterranean in all these dendrograms (Figs 3, 5, 7).

When we look at the biogeographical provinces and regions, there is a single cluster, with Franco-Iberian and Western Mediterranean Regions clustering at about 90%, to which the Azores (87%) and Morocco Region (85%) also join. At 70%, the Boreal Province (Scandinavia, British Isles and Belgium) clusters to the latter group. West-African Province (the Senegal Region with Cape Verde) clusters with the former at 50%. The South Atlantic Province (comprising Ascension Island and Saint Helena) and the Caribbean Province form a second group that clusters at about 28% and that joins the first group at only 15% (Fig. 7).

DISCUSSION

As early as the mid-19th century, MAC ANDREW stated that "(...) the islands of the Canaries, Madeira and the Azores possess a marine fauna closely allied to that of the old continent, notwithstanding that the prevailing set of currents is from America. Very few mollusca are common to both sides of the Atlantic, except such as are inhabitants of the Arctic Seas, and extend along the coasts radiating from that center. Out of 160 species of shells of the Canary Islands and Mediterranean, of which I sent specimens to the late Professor C. B. Adams, he informed me that he could only identify one (*Columbella cribaria*) with a West Indian species - he had probably overlooked *Neritina viridis* (= *Smaragdia viridis*) (Linnaeus, 1758), and perhaps one or two others." (MAC ANDREW 1854: 49). So, this biogeographic paradox is not new, and the question still remains: how to explain the disparity between the pattern

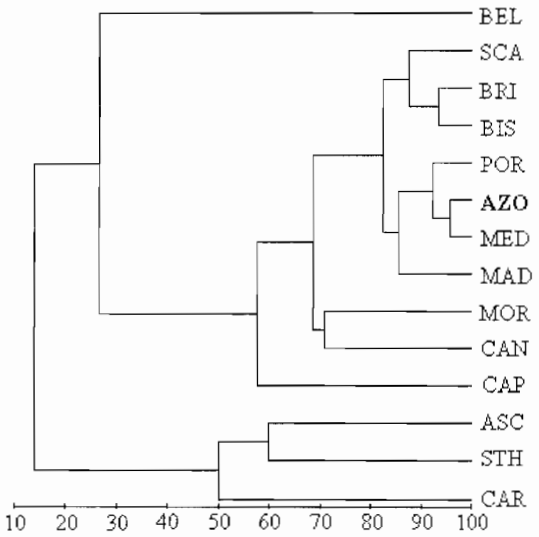

Fig. 5. Biogeographical relationships (Bivalvia only). Bray-Curtis similarity index, non-transformed presence/absence data, UPGMA. Legend as in Fig. 1.

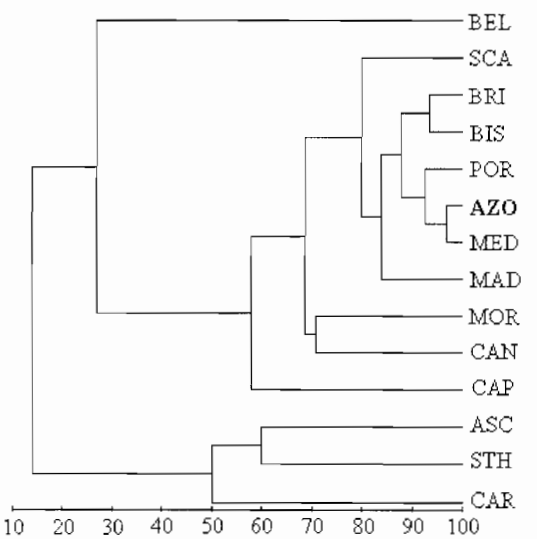

Fig. 6. Biogeographical relationships (Bivalvia only; endemic Azorean species excluded). Bray-Curtis similarity index, non-transformed presence/absence data, UPGMA. Legend as in Fig. 1.

of sea-surface currents and the geographic range of the marine species of molluscs in the oceanic islands of the North Atlantic, in particular, in the Azores?

More recent studies on marine molluscs confirm the quoted Macaronesian/Eastern Atlantic trend: SÁNCHEZ et al. (1987) studied the biogeographic affinities of 3 suborders of Nudibranchia (Doridacea, Dendronotacea and Aeolidacea) from Canary Islands and found that 56% of the species were related to the Eastern Atlantic fauna (Mediterranean, Biscay Golf and the Channel) and 24% were species with Caribbean affinities. MALAQUIAS (1996), studied the opisthobranch fauna of Madeira, and reached the conclusion that 60,7% of the reported species were related to species inhabiting Eastern Atlantic (from Scandinavia and British Isles to Angola and Western Mediterranean), 25% were amphi-Atlantic, and 14,3% of the species were endemic to Macaronesia. WIRTZ (1998), studying the opisthobranchs of the Azores, concluded that there is a higher relation to the Eastern Atlantic (and the Western Mediterranean Sea), with almost no relation to the Western Atlantic.

A similar situation happens with fish species: BRIGGS (1974) refers to the existence of 99 species of fishes inhabiting the shores of the Azores, of which 77 (78%) were related to the Eastern Atlantic, 21 (21,2%) were considered transatlantic species and 1 (1%) species was considered endemic. The most complete check-list of the marine fishes occurring at the Azores, lists 460 species, mostly related to the Eastern Atlantic (SANTOS et al. 1997).

The same pattern was also found in the Crustacea, with the fauna of the Azores having greater affinities to the European and North-African ones, and also displaying a strong Mediterranean and insular (Madeira, Canary Islands and Cape Verde) component (COSTA 1994); LOPES et al. (1993) studied the amphipods of the Azores (only Gammaridea and Caprellidea), and recorded 122 species. Of these, 48 (39,3%) were endemic species, being the Mediterranean and the Portuguese coast the regions with more species in common with the Azores: 58 (47,5%) and 57 (46,7%) species in common, respectively.

The littoral desmosponges (Porifera) of the Azores, are also strongly related to the Eastern Atlantic, in particular to the Mediterranean, with practically no endemic species (BOURY-ESNAULT & LOPES 1985).

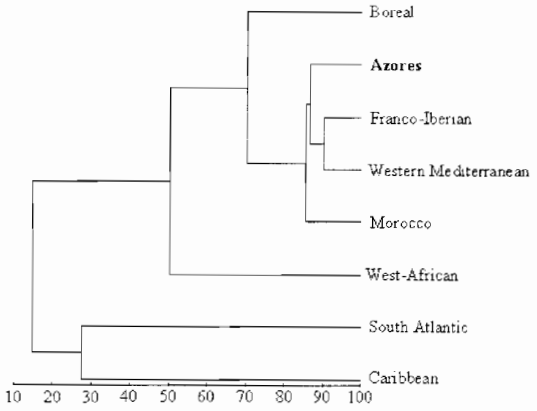

Fig. 7. Biogeographic Provinces and Regions (biogeographical relationships – all species). Bray-Curtis similarity index, non-transformed presence/absence data, UPGMA

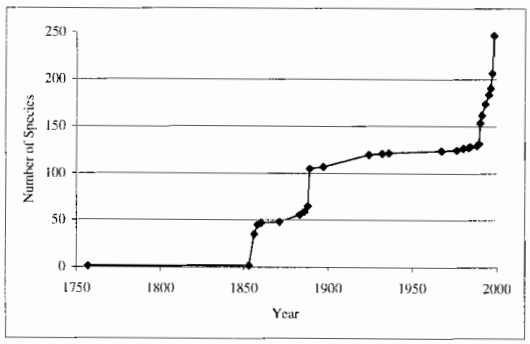

Fig. 8. Evolution of the confirmed number of species reported to the Azores.

Around the islands of the Azores, the prosobranch larvae are more evenly dispersed throughout the water layers above 200-300 m than in the rest of the Gulf Stream (LAURSEN 1981). From the 34 larvae described by LAURSEN (1981) as leaving the Western Atlantic (Caribbean and Gulf of Mexico), 17 reach the coasts of Europe and Northwest Africa, but only 8 species are recorded as adult specimens living in the Eastern Atlantic. Around the Azores, larvae of at least 18 prosobranch species were found but, of these, only *Natica canrena*, *Polinices lacteus*, *Phalium granulatum*, *Cymatium parthenopeum* and *Stramonita haemastoma* are confirmed in the islands of the Azores. All these adult specimens are also found in the Eastern Atlantic (LAURSEN 1981) (Table 4). SCHELTEMA (1971) has estimated that the time required for a larvae to cross the Atlantic from Caribbean to the Europe varies from 4 to 13 months. From a conservative standpoint, the larvae may reach the Azores from 3 to 8 months, which is within the known time span of larval life of many planktonic species (for instance, the families Triphoridae, Lamellariidae, Architectonicidae, Cypraeidae, Ranellidae, Bursidae, Muricidae and Cassidae, all well known for having long lasting free-swimming stages, are represented at the Azores). However, because larvae of many species, for which there is no records of adults living in the Azores, were found in waters surrounding the islands, we must assume that they indeed reach the Azores, but or the local conditions are not suitable for their settlement and/or further development, or the lack of adult records may be the consequence of incomplete or inadequate bottom sampling.

Some of the species that occur in the Azores were probably introduced by humans either intentionally (e.g.: *Tapes decussates*) or unintentionally (e.g.: *Truncatella subcylindrica*, *Hexaplex trunculus*) (MORTON et al. 1998). Ballast water of ships has been shown to be responsible for the transport of planktonic larvae and/or egg-masses over wide distances (CARLTON 1985; SCHELTEMA 1995). Some planktonic larvae may not behave as completely passive objects. If these larvae can control their vertical position, they may utilize countercurrents that run below the surface, precisely in the opposite direction (SCHELTEMA 1995); between Portugal and the Azores, this means from East to West.

In the North Atlantic, the main current is the Gulf Stream, which transports warm water of equatorial and tropical origin into the colder northern waters (KLEINE & SIEDLER 1989); Gulf Stream is also the main source of many instability processes, such as meanders and eddies, being this situation especially complicated when it leaves the North American coast, at about 40° to 45°N, toward the central zone of the North Atlantic (CREASE et al. 1985; GOULD 1985; KLEINE & SIEDLER 1989). In this zone, the Gulf Stream splits into two branches, the North Atlantic Current (NAC) and the Azores Current

Table 4

Teleplanic larvae reported to the Azores (based on Laursen, 1981)

Species	Larvae	Adults
Philippia krebsii (Mörch, 1875)	Caribbean, Sargasso Sea, Azores, Cape Verde	Both sides of the North Atlantic, Canary Islands
Cerithiopsis ? *greeni* (Adams, 1839)	Sargasso Sea, off the Azores	Cape Cod to Brazil, Bermuda, Gulf of Mexico
Strombus pugilis Linnaeus, 1758	Caribbean, Sargasso Sea, off the Azores	Florida to Brazil
Phalium granulatum (Born, 1778)	All the tropical and subtropical Atlantic, Mediterranean	Caribbean, Azores, Mediterranean, Madeira, Canary Islands, Cape Verde, southern Spain to Mauritania
Cymatium femorale (Linnaeus, 1758)	Caribbean, Sargasso Sea, Azores	Caribbean, Florida to Brazil, Bermuda
Cymatium pileare (Linnaeus, 1758)	Caribbean, Sargasso Sea, Azores	Caribbean, South Carolina to Brazil
Cymatium parthenopeum (von Salis, 1793)	Caribbean, Sargasso Sea, Azores, the entire North Atlantic gyre	Cape Hatteras to Brazil, Caribbean, Azores, Mediterranean, Madeira, Canary Islands, Cape Verde
Charonia variegata (Lamarck, 1816)	Caribbean, Sargasso Sea	Florida to Brazil, Caribbean, Mediterranean, Madeira, Canary Islands, Cape Verde, St. Helena
Tonna galea (Linnaeus, 1758)	Caribbean, Sargasso Sea, Azores, the entire North Atlantic Gyre	Both sides of the North Atlantic, Caribbean, Mediterranean, Madeira, Canary Islands, Cape Verde

(AC) (ISELIN 1963). Each of those branches divide also into further branches: the NAC divides in two branches, NAC1, passing north of the Azores and NAC2 passing south of the Azores. NAC2 later divides again in a branch that turns north, the Southwest European Current (SWEC) and the other towards south, the Madeira Current (MADC). Around the Canary Islands, AC1 and MADC merge originating the so called Canaries Current (CANC), which joins to AC2; the resulting current is the North Equatorial Current (NEC), which runs west, thus completing the gyre (Figure 9). This general pattern changes over the year. However, around the Azores, the general regime is from the west to the east, but there is a clear seasonal oscillation of the mean direction, with periods where NAC (coming from Northwest) has a stronger influence and periods where AC (coming from the Southwest) dominates (SANTOS et al. 1994).

ALVES (1990, 1992) has shown that even considering the means for each one of the seasons during a period of 42 years (NOAC data from 1947-1988), the complexity of the current system that surrounds the Azores is remarkable. Anomalies in the general pattern of currents were also detected in some periods, with currents moving to the northwest, that is from Africa and/or Madeira toward the Azores. During these 42 years studied, the first anomaly detected, lasted from mid-March to mid-April, with an average of 30 days, whilst the second had a duration of 25 days, beginning in October (SANTOS et al. 1995).

Within the Archipelago of the Azores, the surface currents are also complex and directly related to the submarine topography. A study by FIALHO & BARROS (1988) has shown in the Azores eddies ranging from only a few kilometers to more than 100 km occur, with cyclonic and anti-cyclonic gyres, the mean surface velocities

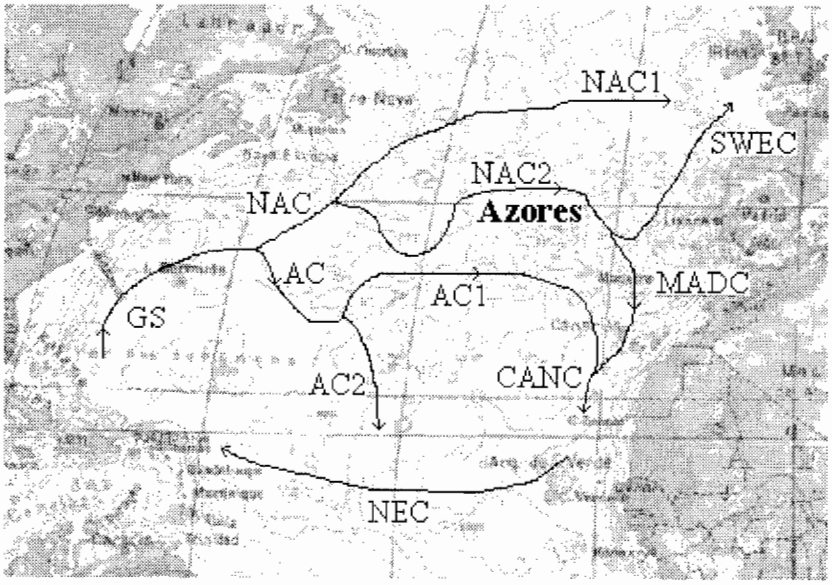

Fig. 9. Sea surface circulation in the North Atlantic: GS – Gulf Stream; NAC – North Atlantic Current; NAC1 - North Atlantic Current 1; NAC2 - North Atlantic Current 2; AC – Azores Current; AC1 - Azores Current 1; AC2 - Azores Current; SWEC – Southwest European Current; MADC – Madeira Current; CANC – Canaries Current; NEC – North Equatorial Current (adapted from ISELIN 1936; KLEINE & SIEDLER 1989)

rarely exceeding 15cm/s.

A constant pattern that emerges from the multivariate analysis (Figs. 1 to 6) is the low similarity of Belgium and of the group Ascension Island and Saint Helena plus Caribbean, which always cluster at very low values with the remaining selected regions. For Belgium, its small coast line (only a few rather uniform kilometers), may explain the small number of species. On what concerns to the South-Atlantic islands of Saint Helena and Ascension Island, their geographic position in the South Atlantic, thus quite distant from the Azores, is responsible by the small number of common species with the Azores.

Some authors suggest that the colonization of the Azores by species with European affinities must have happened under a different regime of dominant currents, thus invoking an ancient counter-clockwise gyre, which existed before the closure of the strait of Panama. The strait of Panama has closed about 3-4 MY (million years) ago (BERGGREN & HOLLISTER, 1974; RAUP, 1991), and at that time, in the region where today are the islands of the Azores, there already existed the actual islands of Santa Maria, the Formigas Islets, part of the island of São Miguel (the Nordeste volcanic complex) and maybe other islands currently submerged (ABDEL-MONEM *et al.* 1975; MOORE & RUBIN 1991). The marine fossils (predominantly bivalves) that are found at Santa Maria in the Touril complex (Praia, at +2 m), are of upper Miocene to Pliocene age (5,5 to 4,5 MY) (MADEIRA 1986) and are related to the Eastern Atlantic (VERMEIJ *pers. comm.*).

According to authors cited below, the molluscs probably reached the Azores by means of rafts/pelagic larvae, passively transported by eddies and meanders that usually form along the Azores Front, providing westward and northward transport (GOFAS 1990; KNUDSEN 1995). Recent observations of satellite-tracked surface drifters, released between the Azores and Portugal, confirm the existence of several eddies and meanders (FIÚZA & MARTINS 1996). Taking in consideration the 63,6% of Azorean species that occur also at Madeira, a probable route of colonization with a Portugal/ Mediterranean origin towards these Archipelagos is suggested. We could even speculate that the

submarine banks of Gorringe (48m depth), Josephine (50m depth) and Ampère (18m depth), located between Portugal and Madeira, probably acted and probably still do, like stepping-stones to the marine larvae in their colonization route, especially on its way to Madeira.

Further data is needed to better define the overall picture. The recent discovery of three species of Rissoidae (*Alvania mediolittoralis*, *Alvania sleursi* and *Crisilla postrema*) formerly considered as endemic to the Azores, in the Madeira Archipelago (HOENSELAAR & GOULD 1998), suggests that more new records of small widespread species will probably be found at these latter islands, thus increasing its similarity with the Azores.

I believe that the knowledge of the molluscan fauna of the seamounts between Portugal-Madeira and Madeira-Azores, would help to clarify the role of these structures in regard to the dispersal of marine invertebrates.

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Appendix

Species of molluscs recorded from the indicated locations. St – Status (dr – dubious record; e – endemic; n.id. – not identified). Dev – type of development (p – planktotrophic; np – non-planktotrophic). AZO – Azores; SCA – Scandinavia; BEL – Belgium; BRI – British Isles; BIS – Biscay Golf to Galiza; POR – Portugal; MED – Western Mediterranean; MOR – Morocco and Mauritania; MAD – Madeira, Porto Santo, Desertas and Selvagens; CAN - Canary Islands; CAP – Cape Vert; ASC – Ascension Island; STH – Saint Helena; CAR – Caribbean.

Species	Family	St	Dev	First report	AZO	SCA	BEL	BRI	BIS	POR	MED	MOR	MAD	CAN	CAP	ASC	STH	CAR
Patella candei gomesii (Drouët, 1858)	Patellidae		p	Mac Andrew, 1856: 118, 146	1								1	1				
Patella ulyssiponensis aspera Röding, 1798	Patellidae		p	Dunker, 1853: 41 *fide* Drouët, 1858: 41	1								1	1				
Acmaea virginea (Müller, O.F., 1776)	Acmaeidae		p	Jeffreys, 1882: 671	1	1		1	1	1	1		1	1	1			
Sinezona cingulata (Costa O. G., 1861)	Scissurellidae		np	Dautzenberg, 1889: 63	1						1		1	1				
Anatoma crispata Fleming, 1828	Scissurellidae	dr	np?	Jeffreys, 1883: 88	1	1		1	1		1							1
Haliotis coccinea Reeve, 1846	Haliotidae	dr		Drouët, 1858: 38	1					1				1				
Haliotis tuberculata tuberculata Linnaeus, 1758	Haliotidae		p	Mac Andrew, 1856: 119	1			1	1	1	1		1	1	1			
Calliostoma laugieri (Payraudeau, 1826)	Trochidae	dr		Mac Andrew, 1856: 120, 147	1				1	1	1							
Calliostoma zizyphinum (Linnaeus, 1758)	Trochidae		np	Mac Andrew, 1856: 119, 147	1	1	1	1	1	1	1		1	1				
Clanculus bertheloti (d'Orbigny, 1840)	Trochidae	dr		Mac Andrew, 1856: 121, 147	1								1	1				
Gibbula magus (Linnaeus, 1758)	Trochidae		p	Dautzenberg, 1889: 63	1	1	1	1	1	1	1		1	1	1			
Jujubinus exasperatus (Pennant, 1777)	Trochidae		np	Mac Andrew, 1856: 147	1			1	1	1	1		1	1	1			
Jujubinus pseudogravinae Nordsieck, 1973	Trochidae	e		Ávila & Azevedo, 1996: 106	1													
Jujubinus striatus (Linnaeus, 1758)	Trochidae	dr	np	Mac Andrew, 1856: 120	1			1	1	1	1		1	1	1			
Bolma rugosa (Linnaeus, 1767)	Turbinidae	dr		Mac Andrew, 1856: 148	1				1	1	1		1	1	1			
Tricolia pullus azorica Dautzenberg, 1889	Tricoliidae	e	p	Mac Andrew, 1856: 121, 148	1													
Bittium sp.	Cerithiidae	e; n. id.		Mac Andrew, 1856: 124, 150	1													
Cerithium zebrum Kiener, 1842	Cerithiidae	dr		Drouët, 1858: 30	1													

Species	Family	St	Dev	First report	AZO	SCA	BEL	BRI	BIS	POR	MED	MOR	MAD	CAN	CAP	ASC	STH	CAR
Fossarus ambiguus (Linnaeus, 1758)	Fossariidae		p	Mac Andrew, 1856: 123, 149	1				1	1	1	1	1	1	1	1	1	
Litiopa melanostoma Rang, 1829 = *Litiopa grateloupeana* Drouët, 1858	Litiopidae			Drouët, 1858: 28-29	1													1
Cheirodonta pallescens (Jeffreys, 1867).	Triphoridae		p	Ávila & Azevedo, 1997: 327	1			1		1	1				1			
Marshallora adversa (Montagu, 1803)	Triphoridae		p	Mac Andrew, 1856: 150	1	1		1	1	1	1			1	1			
Metaxia abrupta (Watson, 1880)	Triphoridae		p	This work	1								1	1				
Monophorus erythrosoma (Bouchet & Guillemot, 1978)	Triphoridae		p	This work	1			1	1	1	1				1			
Monophorus perversus (Linnaeus, 1758)	Triphoridae		p	Jeffreys, 1885: 57	1				1		1	1		1				
Monophorus thiriotae Bouchet, 1984	Triphoridae		p	Bouchet, 1984	1						1				1			
Cerithiopsis barleei Jeffreys, 1867	Cerithiopsidae		p	Ávila & Azevedo, 1997: 327	1	1		1	1	1	1		1		1			
Cerithiopsis jeffreysi Watson, 1885	Cerithiopsidae			Dautzenberg, 1889: 43	1				1	1	1		1	1	1			
Cerithiopsis minima (Brusina, 1865)	Cerithiopsidae			Dautzenberg, 1889: 43	1				1	1	1		1	1	1			
Cerithiopsis tubercularis (Montagu, 1803)	Cerithiopsidae		p	Drouët, 1858: 31	1	1		1	1	1	1			1	1			
Janthina exigua Lamarck, 1816	Janthinidae		p	Mac Andrew, 1856: 119, 147	1			1		1	1		1	1	1			1
Janthina janthina (Linnaeus, 1758)	Janthinidae		p	Mac Andrew, 1856: 119, 147	1			1	1	1	1	1	1	1	1	1	1	1
Janthina pallida Harvey in Thompson, 1841	Janthinidae		p	Morton et al., 1998: 133	1			1	1	1	1		1					
Epitonium algerianum (Weinkauff, 1866)	Epitoniidae			Dautzenberg, 1889: 56	1				1	1	1	1		1				
Epitonium clathratulum (Kanmacher *in* G. Adams, 1798)	Epitoniidae			Mac Andrew, 1856: 123, 149	1	1	1	1	1	1	1		1	1				
Epitonium lamellosum (Lamarck, 1822) = *Epitonium commutatum* (Monterosato, 1877)	Epitoniidae			Drouët, 1858: 27	1			1	1	1	1		1	1				

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Opalia crenata (Linnaeus, 1758)	Epitoniidae			Nobre, 1924: 81	1				1	1	1		1	1	1			
Eulima glabra (da Costa, 1778)	Eulimidae	dr	p	Jeffreys, 1884b: 365-366	1			1	1		1							
Melanella sp.	Eulimidae	n. id.		This work	1													
Parvioris sp.	Eulimidae	n. id.		Azevedo & Gofas, 1990: 85	1													
Parvioris ibizencus (Nordsieck, 1968)	Eulimidae			Dautzenberg, 1889: 58	1													
Vitreolina antiflexa Monterosato, 1844	Eulimidae	dr		Mac Andrew, 1856: 125, 150	1						1			1				
Vitreolina incurva (Bucquoy, Dautzenberg & Dollfus, 1883)	Eulimidae			Dautzenberg, 1889: 57	1					1	1		1	1				
Vitreolina sp. 1	Eulimidae	n. id.		Azevedo & Gofas, 1990: 85	1													
Vitreolina sp. 2	Eulimidae	n. id.		Azevedo & Gofas, 1990: 85	1													
Littorina nigrolineata J. E. Gray, 1839	Littorinidae	dr	np	Jeffreys, 1883: 112-113	1			1	1									
Littorina obtusata (Linnaeus, 1758)	Littorinidae	dr	p	Jeffreys, 1883: 112	1	1	1	1	1	1	1							
Littorina saxatilis (Olivi, 1792)	Littorinidae		np	Reid, 1996: 327	1	1	1	1	1	1	1	1		1				
Littorina striata King & Broderip, 1832	Littorinidae		p	Mac Andrew, 1856: 123, 149	1								1	1	1			
Melarhaphe neritoides (Linnaeus, 1758)	Littorinidae		p	Drouët, 1858: 26	1	1	1	1	1	1	1	1	1	1				
Skeneopsis planorbis (Fabricius O., 1780)	Skeneopsidae		np	Nobre, 1924: 80	1	1		1	1	1	1		1	1				
Alvania abstersa (Van der Linden & van Aartsen, 1993)	Rissoidae	e	np	Van der Linden, 1993: 80	1													
Alvania angioyi van Aartsen, 1982	Rissoidae	e	np	Dautzenberg, 1889: 51	1													
Alvania beani (Hanley in Thorpe, 1844)	Rissoidae	dr		Mac Andrew, 1856: 121	1	1		1	1		1			1				
Alvania cancellata (da Costa, 1778)	Rissoidae		p	Mac Andrew, 1856: 121, 148	1			1	1	1	1		1	1	1			
Alvania cimex (Linnaeus, 1758)	Rissoidae	dr		Mac Andrew, 1856: 121	1				1	1	1							
Alvania formicarum Gofas, 1989	Rissoidae	e	np	Gofas, 1989a: 40-41	1													
Alvania internodula Hoenselaar & Gould, 1998	Rissoidae	e	np	Hoenselaar & Gould, 1998: 83	1													

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Alvania mediolittoralis Gofas, 1989	Rissoidae		np	Dautzenberg, 1889: 49	1								1					
Alvania poucheti Dautzenberg, 1889	Rissoidae	e	np	Dautzenberg, 1889: 49-50	1													
Alvania sleursi (Amati, 1987)	Rissoidae		np	Watson, 1886: 593	1								1					
Alvania tarsodes (Watson, 1886)	Rissoidae	e		Watson, 1886: 595	1													
Alvania sp.	Rissoidae	e; n. id	np	Ávila & Azevedo, 1997: 326	1													
Botryphallus ovummuscae (Gofas, 1990)	Rissoidae	e	np	Dautzenberg, 1889: 53	1													
Cingula ordinaria Smith	Rissoidae	dr		Chapman, 1955: 803	1													
Cingula trifasciata (Adams J., 1798)	Rissoidae		np	Mac Andrew, 1856: 148	1	1		1	1	1								
Crisilla postrema (Gofas, 1990)	Rissoidae		np	Dautzenberg, 1889: 52	1								1					
Manzonia crassa (Kanmacher, 1798)	Rissoidae	dr		Morton et al., 1998: 88	1				1	1	1							
Manzonia unifasciata (Dautzenberg, 1889)	Rissoidae	e	np	Dautzenberg, 1889: 51, 52	1													
Onoba moreleti Dautzenberg, 1889	Rissoidae	e	np	Dautzenberg, 1889: 52	1													
Rissoa guernei Dautzenberg, 1889	Rissoidae	e	np	Dautzenberg, 1889: 47-48	1													
Rissoa guerini Récluz, 1843	Rissoidae	dr		Chapman, 1955: 803	1			1	1		1	1		?				
Setia pulcherrima (Jeffreys, 1848)	Rissoidae	dr	np	Bullock et al., 1990: 45	1			1	1	1	1		1	1				
Setia quisquiliarum Watson, 1886	Rissoidae	e	np	Dautzenberg, 1889: 53	1													
Setia subvaricosa Gofas, 1990	Rissoidae	e	np	Dautzenberg, 1889: 52	1													
Setia sp.	Rissoidae	n. id.		Azevedo & Gofas, 1990: 85	1													
Pisinna glabatra (Von Mühlfeldt, 1824) = *Pisinna punctulum* (Philippi, 1836)	Anabathridae			Dautzenberg, 1889: 53	1						1			1				
Assiminea eliae Paladilhe, 1875	Assimineidae		p?	Ávila & Azevedo, 1996: 106	1													
Paludinella littorina (delle Chiaje, 1828)	Assimineidae		np	Morton et al., 1998: 106	1			1			1		1	1				
Caecum armoricum De Folin, 1869	Caecidae			Hoeksema & Segers, 1993: 86	1						1							
Caecum cf. *clarkii* Carpenter, 1858	Caecidae			Ávila & Azevedo, 1996: 106	1			1	1		1							

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Caecum glabellum	Caecidae			Morton et al., 1998: 89	1													
Caecum vitreum Carpenter, 1858	Caecidae			Dautzenberg, 1889: 43	1				1				1	1	1			
Caecum sp.	Caecidae	n. id.		Ávila et al (1998)	1													
Truncatella subcylindrica (Linnaeus, 1767)	Truncatellidac		np	Martins, 1980: 9	1			1	1	1	1	1		1	1			
Thylaeodus cf. *rugulosus* (Monterosato, 1878)	Vermetidae		?	Bieler, 1995: 175	1						1							
Vermetus triquetrus Bivona-Bernardi, 1832	Vermetidae		?	Dautzenberg, 1889: 43	1					1	1		1	1				
Lamellaria latens (O F Müller, 1776)	Lamellariidae		p	This work	1	1		1	1									
Lamellaria perspicua (Linnaeus, 1758)	Lamellariidae		p	Dautzenberg, 1889: 54	1	1	1	1	1	1	1		1	1	1			
Trivia candidula (Gaskoin, 1835)	Triviidae		p	Watson, 1886: 696	1				1	1	1		1	1	1			1
Trivia pulex (Solander *in* Gray J.E., 1828)	Triviidae			Mac Andrew, 1856: 127	1					1	1		1	1				
Luria lurida (Linnaeus, 1758).	Cypraeidae		p	Drouët, 1858: 36	1					1	1	1	1	1	1	1	1	
Euspira pulchella (Risso, 1826) = *Lunatia alderi* (Forbes, 1838)	Naticidae			Morton et al., 1998: 144	1	1	1	1	1	1	1							
Natica adansoni de Blainville, 1825	Naticidae			Dautzenberg, 1889: 54	1						1		1	1	1			
Natica canrena (Linnaeus, 1758)	Naticidae		p	Morton et al., 1998: 194	1													1
Naticarius dillwyni (Payraudeau, 1826)	Naticidae	dr		Simroth, 1888	1						1		1	1	1			
Payraudeautia intricata (Donovan, 1804)	Naticidae			Mac Andrew, 1856: 127, 151	1						1							
Polynices lacteus (Guilding, 1834)	Naticidae		p	Morton et al., 1998: 194	1						1	1	1	1	1			1
Phalium granulatum (Born, 1778) = *Phalium undulatum* (Gmelin, 1791)	Cassidae			Drouët, 1858: 33	1					1	1	1	1	1	1			1
Charonia lampas lampas (Linnaeus, 1758)	Ranellidae		p	Mac Andrew, 1856: 132, 154	1			1	1	1	1	1	1	1	1			
Cymatium corrugatum (Lamarck, 1816)	Ranellidae			Simroth, 1888	1				1	1	1	1	1	1				
Cymatium muricinum (Röding, 1798) = *Triton tuberosus* Lamarck, 1822	Ranellidae	dr		Mac Andrew, 1856: 132, 154	1									1				1

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Cymatium parthenopeum (Von Salis, 1793)	Ranellidae		p	Nobre, 1924: 78	1					1	1	1	1	1	1			1
Ranella olearia (Linnaeus, 1758)	Ranellidae			This work	1			1	1		1			1				
Bursa scrobiculator (Linnaeus, 1758)	Bursidae			Mac Andrew, 1856: 132, 154	1					1	1		1	1	1			
Hexaplex trunculus (Linnaeus, 1758)	Muricidae			Nobre, 1924: 77	1					1	1		1	1				
Ocenebra erinacea (Linnaeus, 1758)	Muricidae		np	Drouët, 1858: 33	1	1	1	1	1	1	1		1	1	1			
Ocinebrina aciculata (Lamarck, 1822)	Muricidae		np	Mac Andrew, 1856: 133, 154	1			1	1	1	1		1	1				
Ocinebrina edwardsi (Payraudeau, 1826)	Muricidae			This work	1				1	1	1		1	1				
Orania fusulus (Brocchi, 1814)	Muricidae			Poppe & Goto, 1991: 140	1				1	1	1			1				
Stramonita haemastoma (Linnaeus, 1766)	Muricidae		p	Mac Andrew, 1856: 130, 153	1				1	1	1	1	1	1	1			1
Trophonopsis muricatus (Montagu, 1803)	Muricidae		np	Poppe & Goto, 1991: 138-139	1	1		1	1	1	1	1						
Coralliophila meyendorffi (Calcara, 1845)	Coralliophilidae			Nobre, 1924: 78	1				1	1	1	1	1	1	1			
Fusinus sp.	Fasciolariidae	n. id.		This work	1													
Buccinum hepaticum Montagu, 1803 = (?) *Nassarius nitidus* (Jeffreys, 1867)	Buccinidae	dr		Adanson, 1757 *fide* Drouët, 1858	1						1							
Engina turbinella (Kiener, 1835)	Buccinidae			Morton et al., 1998: 194	1													1
Pisania striata (Gmelin, 1791)	Buccinidae	dr		Mac Andrew, 1856: 133	1						1							
Nassarius corniculus (Olivi, 1792)	Nassariidae		np	This work	1					1	1	1		1				
Nassarius cuvieri (Payraudeau, 1826)	Nassariidae			Nobre, 1924: 77	1				1		1		1	1	1			
Nassarius incrassatus (Ström, 1768)	Nassariidae		p	Mac Andrew, 1856: 131	1	1	1	1	1	1	1		1	1				
Columbella adansoni Menke, 1853	Columbellidae		p	Mac Andrew, 1856: 130	1								1	1	1			
Vexillum zebrinum (d'Orbigny, 1840)	Costellariidae	dr		Mac Andrew, 1856: 128, 152	1								1	1				
Volvarina sp.	Marginellidae	n. id.		Ávila & Azevedo, 1997: 327	1													

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Volvarina oceanica Gofas, 1989	Marginellidae	e		Gofas, 1989b: 179	1													
Gibberula sp.	Cystiscidae	n. id.		Ávila & Azevedo, 1997: 327	1													
Mitra cornea Lamarck, 1811 = *Mitra nigra* (Gmelin, 1791)	Mitridae		p	Mac Andrew, 1856: 128, 152	1				1		1	1	1	1	1			
Mitra corniculum (Linnaeus, 1758)	Mitridae			Simroth, 1888: 214	1					1	1	1	1	1	1			
Mitra zonata Marryat, 1818	Mitridae			Burnay & Martins, 1988	1					1	1	1	1	1				
Crassopleura incrassata (Dujardin, 1837) = (?) *Crassopleura maravignae* Bivona Ant. *in* Bivona And., 1838	Drilliidae			This work	1						1			1				
Haedropleura septangularis (Montagu, 1803)	Turridae		p	Mac Andrew, 1856: 129, 152	1	1		1	1	1	1		1	1				
Bela menkhorsti van Aartsen, 1988 = *Bela turgida* [(Forbes) Reeve, 1844]	Conidae			Dautzenberg, 1889: 28	1						1							
Bela nebula (Montagu, 1803)	Conidae		p	Simroth, 1888	1	1		1	1	1	1		1					
Lusitanops sp.	Conidae	n. id.		Ávila & Azevedo, 1997: 327	1													
Mitrolumna crenipicta (Dautzenberg, 1889)	Conidae			Dautzenberg, 1889: 31	1						1		1	1				
Mitrolumna olivoidea (Cantraine, 1835)	Conidae			Nobre, 1924: 77	1					1	1							
Raphitoma carnosula (Jeffreys, 1869)	Conidae			Ávila & Azevedo, 1997: 327	1			1										
Raphitoma linearis (Montagu, 1803)	Conidae		p	Dautzenberg, 1889: 29	1	1		1	1	1	1		1	1	1			
Raphitoma purpurea (Montagu, 1803)	Conidae			Dautzenberg, 1889: 28	1	1		1	1	1	1		1					
Philippia hybrida (Linnaeus, 1758)	Architectonicidae			Drouët, 1858: 30	1				1	1	1		1	1				1
Heliacus architae (O. G. Costa, 1867)	Architectonicidae			This work	1					1	1		1	1				
Rissoella diaphana (Alder, 1848)	Rissoellidae		np	Ávila & Azevedo, 1996: 106	1	1		1	1		1							
Ammonicera fischeriana (Monterosato, 1869)	Omalogyridae		np	Ávila & Azevedo, 1996: 106	1				1		1							
Ammonicera rota (Forbes & Hanley, 1850)	Omalogyridae		np	Ávila & Azevedo, 1996: 106	1	1		1	1	1	1		1	1				

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Omalogyra atomus (Philippi, 1841)	Omalogyridae		np	Dautzenberg, 1889: 46	1	1		1	1	1	1		1	1	1	1		
Cima sp.	Cimidae	n. id.		Azevedo & Gofas, 1990: 85	1													
Cima cf. *minima* (Jeffreys, 1858)	Cimidae			This work	1			1										
Graphis sp.	Cimidae	n. id.		Azevedo & Gofas, 1990: 85	1													
Odostomella doliolum (Philippi, 1844)	Pyramidellidae			Dautzenberg, 1889: 59	1						1		1	1				
Odostomia conoidea (Brocchi, 1814)	Pyramidellidae			This work	1	1			1	1	1		1	1				
Odostomia scalaris (Macgillivray, 1843)	Pyramidellidae			Dautzenberg, 1889: 59	1	1		1		1	1		1					
Odostomia unidentata (Montagu, 1803)	Pyramidellidae			Dautzenberg, 1889: 59	1	1		1	1	1	1		1					
Odostomia sp.1	Pyramidellidae	n. id.		Azevedo & Gofas, 1990: 86	1													
Odostomia sp. 2	Pyramidellidae	n. id.		Azevedo & Gofas, 1990: 86	1													
Odostomia sp. 3	Pyramidellidae	n. id.		Azevedo & Gofas, 1990: 86	1													
Ondina diaphana (Jeffreys, 1848)	Pyramidellidae			This work	1			1			1							
Turbonilla lactea (Linnaeus, 1758)	Pyramidellidae			Mac Andrew, 1856: 125, 150	1	1		1	1	1	1		1	1				
Ebala nitidissima (Montagu, 1803)	Ebalidae			Dautzenberg, 1889: 56	1	1		1	1	1	1		1	1				
Cephalaspidea incertae sedis = *Retusa multiquadrata* Oberling, 1970	?			Mikkelsen, 1995: 205	1						1							
Cylichnina umbilicata (Montagu, 1803)	Retusidae			Ávila & Azevedo, 1996: 106	1	1		1		1	1	1	1					
Retusa truncatula (Bruguière, 1792)	Retusidae			Dautzenberg, 1889: 21	1	1		1	1	1	1		1	1				
Runcina adriatica T. Thompson, 1980	Runcinidae			Gosliner, 1990: 141	1						1		1					
Runcina aurata Garcia, Lopez, Luque & Cervera, 1986	Runcinidae			Gosliner, 1990: 138	1			1										
Runcina sp.	Runcinidae	n. id.		Gosliner, 1990: 143	1													
Bulla striata Bruguière, 1792	Bullidae			Dautzenberg, 1889: 24	1					1	1			1	1			1

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Atys macandrewii E. A. Smith, 1872	Haminoeidae			Mikkelsen, 1995: 200	1								1	1				1
Haminoea hydatis (Linnaeus, 1758)	Haminoeidae			Garcia-Talavera Casañas, 1983 (1981)	1			1	1	1	1		1	1	1	1	1	
Haminoea cf. *Orteai* Talavera, Murillo & Templado, 1987	Haminoeidae			Mikkelsen, 1995: 201	1						1		1					
Philine quadrata (S. V. Wood, 1839)	Philinidae		dr	Watson, 1886: 696	1	1		1		1	1							
Cylichna cylindracea (Pennant, 1777)	Cylichnidae		dr	Pilsbry, 1895: 289-290	1	1		1	1	1	1		1	1	1			
Diacria trispinosa (Lesueur, 1821).	Cavolinidae			Ávila & Azevedo, 1997: 328	1	1		1	1	1	1		1	1	1			
Elysia ornata (Swainson, 1840)	Elysiidae			Wirtz, 1998: 2	1								1	1				1
Elysia viridis (Montagu, 1804)	Elysiidae			Azevedo, 1991a: 27	1	1		1	1	1	1	1	1	1				
Aplysiopsis formosa Pruvot-Fol, 1953	Hermaeidae			Jensen, 1995: 218	1							1		1				1
Placida verticillata Ortea, 1981	Stiligeridae			Wirtz, 1998: 2	1				1		1		?	1				
Umbraculum umbraculum (Röding, 1798)	Umbraculidae			Menezes, 1991: 101	1					1	1	1	1	1	1	1	1	
Tylodina perversa (Gmelin, 1791)	Tylodinidae			Dautzenberg, 1889: 25	1				1	1	1	1	1	1	1		1	
Berthellina edwardsi (Vayssière, 1896)	Pleurobranchidae			Wirtz, 1995: 163	1			1		1	1		1					
Pleurobranchus testudinarius Cantraine, 1836	Pleurobranchidae			Wirtz & Martins, 1993: 56	1						1							
Akera bullata O F Müller, 1776	Akeridae			Nobre, 1924: 77	1	1	1	1	1	1	1		1	1				
Aplysia depilans Gmelin 1791	Aplysiidae			Wirtz, 1998: 3	1			1	1	1	1	1	1	1	1			
Aplysia fasciata Poiret, 1798	Aplysiidae			Wirtz & Martins, 1993: 56	1			1	1	1	1	1	1	1	1			
Aplysia punctata Cuvier, 1803	Aplysiidae			Simroth, 1888	1	1		1	1	1	1	1	1	1				
Diaphorodoris luteocincta (M. Sars, 1870)	Onchidoridae			Wirtz & Martins, 1993: 56	1	1		1		1	1							
Kaloplocamus ramosus (Cantraine, 1835)	Triophidae			Wirtz, 1998: 12	1			1			1			1				
Doris ocelligera (Bergh, 1881)	Dorididae			Azevedo & Gofas, 1990: 86	1				1	1	1							
Aldisa binotata Pruvot-Fol, 1953 = *Aldisa smaragdina* Ortea, Perez & Llera, 1982	Aldisidae			Wirtz, 1998: 8	1				1	1			1	1				

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Chromodoris britoi Ortea & perez, 1983	Chromodorididae			Gosliner, 1990: 148	1						1		1	1				
Chromodoris krohni (Verany, 1846)	Chromodorididae			This work	1				1	1	1							
Chromodoris purpurea (Laurillard, 1831)	Chromodorididae			Gosliner, 1990: 146-147	1				1	1	1	1	1	1	1			
Glossodoris edmundsi Cervera, García-Gómez & Ortea, 1989	Chromodorididae			Gosliner, 1990: 159	1								1	1				
Hypselodoris fontandraui (Pruvot-Fol, 1951)	Chromodorididae			Wirtz, 1995: 169	1						1			1				
Hypselodoris tricolor (Cantraine, 1835) = *Hypselodoris midatlantica* (Gosliner, 1990)	Chromodorididae			Gosliner, 1990: 152	1				1	1	1		1	1				
Hypselodoris picta (Schultz in Philippi, 1836)	Chromodorididae			Gosliner, 1990: 156	1						1	1	1	1	1			1
Discodoris atromaculata (Bergh, 1880)	Discodorididae			Wirtz & Martins, 1993: 56	1				1		1		1	1				
Discodoris cf. *Millegrana* (Alder and Hancock, 1854).	Discodorididae	dr		Ávila & Azevedo, 1997: 328	1			1										
Platydoris argo (Linnaeus, 1767)	Platydorididae			Wirtz & Martins, 1993: 56	1				1	1	1	1	1	1				
Limacia clavigera (O F Müller, 1776)	Polyceridae			Wirtz, 1995: 171	1	1	1	1	1	1	1							
Polycera elegans (Bergh, 1894)	Polyceridae			Wirtz & Martins, 1993: 56	1			1		1	1							
Polycera quadrilineata (O F Müller, 1776)	Polyceridae			Wirtz, 1995: 171	1	1		1	1	1	1		1					
Tambja ceutae Garcia-Gomez & Ortea, 1988	Gymnodorididae			Wirtz & Martins, 1993: 56	1						1		1	1				
Tambja sp.	Gymnodorididae	n. id.		Wirtz, 1995: 175	1								1					
Dendrodoris herytra Valdés & Ortea *in* Valdés, Ortea, Avila & Ballesteros, 1996	Dendrodorididae			Odhner, 1932	1				1	1	1	1	1	1				
Doto floridicola Simroth, 1888	Dotidae			Simroth, 1888	1					1	1							
Scyllaea pelagica Linnaeus, 1758	Scyllaeidae			Simroth, 1888	1	1		1										
Marionia blainvillea (Risso, 1818)	Tritoniidae			Wirtz, 1998: 2	1					1	1		1					
Caloria elegans (Alder & Hancock, 1845)	Facelinidae			Wirtz, 1995: 183	1	1		1		1	1		1	1				

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Fiona pinnata (Eschscholtz, 1831)	Fionidae			Wirtz, 1998: 6	1			1			1		1	1	?			
Flabellina pedata (Montagu, 1815)	Flabellinidae			Wirtz, 1998: 6	1	1		1	1	1	1							
Aeolidiella sanguinea (Norman, 1877)	Aeolidiidae			Morton et al., 1998: 171	1			1	1		1		1					
Williamia gussonii (da Costa, 1829)	Siphonariidae			Mac Andrew, 1856: 118	1						1					1	1	1
Onchidella celtica (Cuvier, 1817)	Onchidiidae			Martins, 1980: 13-14	1			1	1	1	1	1						
Auriculinella bidentata (Montagu, 1808)	Ellobiidae			Mac Andrew, 1856: 116	1	1	1	1	1	1								
Myosotella myosotis (Draparnaud, 1801)	Ellobiidae			Morelet, 1860: 206	1	1	1	1	1		1		1					1
Ovatella vulcani (Morelet, 1860)	Ellobiidae	e		Morelet, 1860: 207	1													
Pedipes pedipes (Gmelin, 1790)	Ellobiidae			Drouët, 1858: 25-26	1					1		1	1	1	1			
Pseudomelampus exiguus (Lowe, 1831)	Ellobiidae			Martins, 1976: 18	1				1									
Arca noae Linnaeus, 1758	Arcidae	dr		Jeffreys, 1879: 571	1				1	1	1	1		1	1	1	1	
Arca tetragona Poli, 1795	Arcidae			Jeffreys, 1879: 571	1	1		1	1	1	1		1	1	1	1		
Mytilus edulis Linnaeus, 1758	Mytilidae	dr		Morton et al., 1998: 133	1		1	1	1	1	1		1					
Trichomusculus semigranatus (Reeve, 1858)	Mytilidae			Azevedo, 1991a: 28	1						1	1	1	1	1			
Pinna rudis Linnaeus, 1758	Pinnidae			Jeffreys, 1879: 565	1						1	1		1	1	1	1	1
Pteria hirundo (Linnaeus, 1758)	Pteriidae			Jeffreys, 1879: 565	1			1	1	1	1	1	1	1	1			
Aequipecten commutatus (Monterosato, 1875)	Pectinidae			Poppe & Goto, 1993	1					1	1	1		1	1			
Aequipecten opercularis (Linnaeus, 1758)	Pectinidae			Jeffreys, 1879: 558	1	1	1	1	1	1	1		1	1				
Chlamys flexuosa Poli, 1795	Pectinidae			This work	1					1	1		1	1	1			
Crassadoma multistriata (Poli, 1795)	Pectinidae			Mac Andrew, 1856: 112	1			1	1	1	1	1	1	1	1	1	1	
Crassadoma pusio (Linnaeus, 1758) = *Hinnites distortus* (da Costa, 1778)	Pectinidae			Morton, 1967: 37	1	1		1	1	1	1	1	1	1				
Nodipecten corallinoides (d'Orbigny, 1839)	Pectinidae			Nobre, 1924: 84	1					1			1	1	1		1	
Palliolum incomparabile (Risso, 1826)	Pectinidae			Ávila & Azevedo, 1997: 328	1	1			1	1	1	1		1				

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Spondylus senegalensis Schreibers, 1793	Spondylidae			Ávila & Azevedo, 1997: 328	1							1	1	1	1	1		
Anomia ephippium Linnaeus, 1758	Anomiidae			Ávila & Azevedo, 1997: 328	1	1	1	1	1	1	1	1	1		1			
Monia aculeata (Müller, 1776) = (?) *Heteranomia squamala* (Linnaeus, 1758)	Anomiidae			Azevedo & Gofas, 1990: 86	1	1		1	1		1							
Limaria hians (Gmelin, 1791)	Limidae			Mac Andrew, 1856: 112	1	1		1	1	1	1		1	1				1
Limea loscombii (G W Sowerby I, 1823)	Limidae			Jeffreys, 1879: 564	1	1		1	1	1	1		1		1			
Limatula subauriculata (Montagu, 1808).	Limidae			Ávila & Azevedo, 1997: 328	1	1		1	1	1	1		1	1				
Neopycnodonte cochlear (Poli, 1795)	Gryphaeidae			Dautzenberg, 1889: 72	1	1		1	1	1	1	1	1		1			
Loripes lacteus (Linnaeus, 1758)	Lucinidae			This work	1		1	1		1	1	1	1	1				
Lucinoma borealis (Linnaeus, 1758)	Lucinidae			Dautzenberg, 1889: 59	1	1		1	1	1	1	1	1	1	1			
Myrtea spinifera (Montagu, 1803)	Lucinidae	dr		Jeffreys, 1881a: 701	1	1		1	1	1		1	1	1	1			
Thyasira fluxuosa (Montagu, 1803)	Thyasiridae	dr		Jeffreys, 1881a: 701	1	1		1	1	1		1		1				
Bornia sp.	Kelliidae	n. id.		This work	1													
Lasaea adansoni (Gmelin, 1791)	Lasaeidae			Nobre, 1924: 85	1	1		1	1	1	1		1	1	1	1	1	1
Montacuta ferruginosa (Montagu, 1808)	Montacutidae			Dautzenberg, 1889: 81	1	1	1	1	1	1	1	1	1					
Mysella bidentata (Montagu, 1803)	Montacutidae			Martins, 1980: 17	1	1	1	1	1		1		1					
Neolepton cancellatum Salas & Gofas, 1998	Neoleptonidae	e		Salas & Gofas, 1998: 44-45	1													
Cardita calyculata (Linnaeus, 1758)	Carditidae			Mac Andrew, 1856: 107	1					1	1	1	1	1				
Acanthocardia aculeata (Linnaeus, 1758).	Cardiidae			Nobre, 1924: 85	1	1		1	1	1	1	1	1					
Parvicardium exiguum (Gmelin, 1791)	Cardiidae			This work	1	1		1	1	1	1		1					
Parvicardium ovale (G B Sowerby II, 1840)	Cardiidae			Jeffreys, 1881a: 708	1	1		1	1		1		1	1				
Plagiocardium papillosum (Poli, 1795)	Cardiidae			Mac Andrew, 1856: 141	1			1	1	1	1	1	1	1	1			

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Solen marginatus Pulteney, 1799	Solenidae	dr		Jeffreys, 1881b	1	1	1	1	1	1	1	1						
Gastrana fragilis (Linnaeus, 1758)	Tellinidae			This work	1	1		1	1	1	1	1		1				
Tellina donacina Linnaeus, 1758	Tellinidae			Dautzenberg, 1889: 86	1			1	1	1	1	1	1					
Tellina incarnata Linnaeus, 1758	Tellinidae			Römer, 1871: 127	1	1		1	1	1	1		1	1				
Gari costulata (Turton, 1822)	Psammobiidae			Dautzenberg & Fisher, 1897: 217	1	1		1	1	1	1	1	1	1	1			
Abra alba (W. Wood, 1802)	Semelidae			Morton et al., 1998: 144	1	1	1	1	1	1	1		1					
Ervilia castanea (Montagu, 1803)	Semelidae			Mac Andrew, 1856: 104	1			1		1	1		1	1				
Glossus humanus (Linnaeus, 1758)	Glossidae	dr		Jeffreys, 1881a: 710	1	1		1	1	1	1	1						
Callista chione (Linnaeus, 1758)	Veneridae			Mac Andrew, 1856: 106	1			1	1	1	1	1	1	1				
Dosinia cf. *lupinus* (Linnaeus, 1758)	Veneridae			Ávila & Azevedo, 1997: 329	1	1		1	1	1	1	1		1	1			
Globivenus effossa (Bivona, 1836)	Veneridae			Nobre, 1936: 257	1					1	1	1	1	1			1	
Gouldia minima (Montagu, 1803)	Veneridae			Ávila & Azevedo, 1997: 329	1	1		1	1	1	1	1	1	1	1			
Irus irus (Linnaeus, 1758)	Veneridae	dr		Poppe & Goto, 1993: 123	1			1	1	1	1		1	1				
Paphia aurea (Gmelin, 1791)	Veneridae			This work	1	1		1	1	1	1		1					
Pitar rudis (Poli, 1795)	Veneridae			Nobre, 1924: 85	1				1	1	1	1	1	1	1			
Tapes decussata (Linnaeus, 1758)	Veneridae			Morton, 1967: ADDITIONS	1			1	1	1	1	1						
Timoclea ovata (Pennant, 1777)	Veneridae			Dautzenberg, 1889: 82	1	1	1	1	1	1	1	1		1	1			
Venus casina Linnaeus, 1758	Veneridae			Jeffreys, 1884a: 145	1	1		1	1	1	1	1	1		1			
Hiatella arctica (Linnaeus, 1758)	Hiatellidae			Poppe & Goto, 1993: 131	1	1	1	1	1	1	1			1				
Nototeredo norvegica (Spengler, 1792)	Teredinidae			Dautzenberg, 1889: 85	1	1		1		1	1							
Xylophaga dorsalis (Turton, 1819)	Xylophagidae			Dautzenberg, 1889: 85	1	1		1	1	1	1		1					
Cardiomya costellata (Deshayes, 1835)	Cuspidariidae			Dautzenberg & Fischer, 1897	1	1		1	1	1	1	1	1	1				
Spirula spirula (Linnaeus, 1758)	Spirulidae			Mac Andrew, 1856: 133	1	1		1	1	1	1	1	1	1				1

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Loligo forbesi Steenstrup, 1856	Loliginidae			Girard, 1892: 214	1	1	1	1	1	1	1		1	1				
Octopus macropus Risso, 1826	Octopodidae			Gonçalves, 1991: 79	1				1		1		1					
Octopus salutii Vérany, 1837	Octopodidae			Gonçalves, 1991: 78	1					1	1							
Octopus vulgaris Cuvier, 1797	Octopodidae			Drouët, 1858: 22	1	1	1	1	1	1	1		1			1		
Tremoctopus violaceus delle Chiaje, 1830	Tremoctopodidae			Gonçalves, 1991: 76	1						1			1				
Ocythoe tuberculata Rafinesque, 1814	Ocythoidae			Gonçalves, 1991: 76	1					1	1		1					
Argonauta argo Linnaeus, 1758	Argonautidae			Drouët, 1858: 21	1					1	1		1					