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## Non-indigenous marine species of the Azores

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**Abstract** Marine benthic species introduced to the Azores are collated from scientific publications, internal reports and own data. Twelve algae and 21 invertebrates are classified as non-indigenous species, 18 as cryptogenic. Two species of algae and two ascidians are regarded as particularly invasive along the shores of this oceanic archipelago.

**Keywords** Marine introductions · Non-indigenous species · Azores

### Introduction

As volcanic islands located close to the Mid-Atlantic Ridge (França et al. 2003), the Azores are geologically recent and separated from the nearest continental coasts by at least 1,300 km (Morton et al. 1998). Natural colonization for marine organisms occurs mainly through oceanic currents. At present, the prevailing sea-surface pathway to the Azores is a descending branch from the Gulf Stream running from NW towards SE (Santos et al. 1995). Nevertheless, the major affinities of the autochthonous marine flora and fauna are with the continental coasts of Europe and Africa, the Mediterranean Sea and the other Macaronesian archipelagos of Madeira and Canary islands (Santos et al. 1995; Tittley and Neto 1995; Ávila 2000, 2005). Birds can also be vectors of introductions. This may be the case of the caenogastropod *Assimineia* sp. found at Praia da Vitória

(Ávila 2005). Factors conditioning the natural and human-mediated marine colonization of the Azores are discussed by Cornelius (1992) and Morton and Britton (2000). Besides natural pathways, various anthropogenic factors presently concur as additional vectors of entrance for marine species in areas outside their natural biogeographic range (Bax et al. 2003). Of these, hull fouling, ballast water, solid ballast, recreational boating and dive practices, fisheries and aquaria trade may be relevant for the Azores.

Little is known on marine species introductions and invasions to the Azores. However, the potential for introductions is high, considering that the transatlantic leisure boat-traffic stopping over at the islands has significantly increased over the last decade. Scattered literature (Monniot 1971; Monniot C 1974; Monniot F 1974; Cornelius 1992; Wirtz and Martins 1993; Tittley and Neto 1994, 1995; Neto 1997; Morton et al. 1998; Southward 1998; Ávila 2000, 2005; Morton and Britton 2000) together report 51 taxa as exotic marine species for the coastal areas in this NE Atlantic archipelago. The aim of this paper is to provide a commented list of these species, to delete misidentifications, to add new records and to indicate the invasive status.

### Methods

A literature review and a database query were conducted. The “DOP Database” is a computerized species list, which compiles information from 575 SCUBA dives carried out to study assemblages of conspicuous species in the Azores archipelago. During these surveys, species that could not be identified in situ were collected and preserved for later identification. Samples of new records were stored in the Department of Oceanography and Fisheries of the University of the Azores (DOP). The marine mollusc database [Department of Biology of the University of the Azores (DBUA)] of one of the authors (S. Ávila) is also included. The DBUA database contains information on geographic distribution, mode

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of development and other pertinent details of the shallow (< 50 m) marine molluscs of the Azores. The data are based on 880 samples collected in about 660 dives around all of the islands of the Azores. Species with disjunct geographic distributions (e.g., Azores and Mediterranean) as well as those commonly found nearby harbours were studied in detail in order to assess whether their occurrence was natural or human mediated. Planktonic organisms have not been considered.

In the present paper, criteria given by Boudouresque and Verlaque (2002) to consider a species as “introduced” are applied: (1) it colonizes a new area where it was not recorded previously; (2) the extension of its range is linked, directly or indirectly, to human activity; (3) widely disjunct dispersion; (4) new generations of non-native species are produced in situ without human assistance, thus constituting self-sustaining populations. To decide upon the introduction to the Azores, we adapted these criteria: (1) the species is new to the Azores; (2) occurrence in the Azores constitutes a geographic discontinuity to the species’ known range; (3) a new occurrence is at first very localized and (4) further spread within the archipelago follows a consistent pattern; (5) the species has established a persisting population. If according to these criteria there are doubts about the introduction status, populations are classified as cryptogenic (sensu Carlton 1996).

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## Results

Fifty-five taxa have been pointed as introduced in the Azores (Table 1). Eighteen are now classified as cryptogenic and 33 as established introduced species. Two taxa are rejected: the gastropod *Engina turbinella* and the crab *Carcinus maenas* previous records for the Azores are most likely misidentifications. The hydrozoan *Ventromma halecioides* may not yet be established. *Polllia dorbigny* is mentioned as an introduced species for the first time. *Caulerpa webbiana* (introduced) and *Bugula cf. dentata* (cryptogenic) are mentioned for the first time for the Azores archipelago.

### Algae

*Asparagopsis armata* is a well-known invasive species that has its origin in the southern hemisphere and was first recorded in the northern hemisphere in 1923 (summarized in Verlaque et al. 2004). This species is widely spread throughout the Azores, in rocky habitats between 0 and 20 m (DOP Database), displaying a biomass maximum during spring (Neto 1997). *Asparagopsis taxiformis* is cosmopolitan in warm-temperate to tropical waters (Chualain et al. 2004) and was first recorded for the Azores as *A. delilei* by Schmidt (1931). It was not recorded in the Faial (Tittley and Neto 1994) and Flores islands 1989 expeditions (Neto and Baldwin 1990), Flores 1994/1995 expeditions (Tittley et al. 1998)

and Santa Maria 1990 expedition (Neto et al. 1990), where it occurs nowadays. It presently occurs in Santa Maria, São Miguel, Faial, Pico, Flores, and Graciosa islands (DOP Database) and probably São Jorge due to proximity to Pico and Faial. It occupies a depth stratum similar to *A. armata* and co-occurs with the latter but its niche seems to extend to more sheltered places. According to Tittley and Neto (2005) *A. taxiformis* is now less common in São Miguel island possibly due to competition with *A. armata*. Contrastingly, unsystematic observations around Faial and Pico seem to show an expansion of the distribution and an increase in the abundance over the last decade. This variation in abundance needs further explanation.

*Caulerpa webbiana* is an invasive species recently collected in Horta harbour. It has colonized several sites around Horta harbour after its first record in 2002.

*Codium fragile tomentosoides* is a potentially invasive species for the Azores. It was first recorded by Neto (1997) for São Miguel island and then for Corvo island. Despite its capacity for spreading and replacing the indigenous species elsewhere (Nyberg and Wallentinus 2004), this has not yet been observed in the Azores.

### Ascidiacea

*Clavelina oblonga* is more widespread in Faial and Pico islands (DOP Database) than *C. lepadiformis*, but the occurrence of the former is so far limited to those two islands. It covers large areas with hundreds of individuals per m<sup>2</sup>, especially at vertical and slightly overhanging surfaces. Due to limited distance (in the order of a few tens of km) separating the three islands of the “Triangle” and the frequent boat traffic among them, there is a possibility that it may occur at São Jorge as well but no surveys have been done there recently.

*Distaplia corolla* is invasive in the Azores and is recorded for all the islands, although its abundance is low at Corvo, Flores and Santa Maria islands (DOP Database). The species was probably introduced by sailing yachts (Monniot and Monniot 1983) travelling from the Antilles. It occurs both on well-lit and shaded areas down to 35 m.

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## Discussion

The low number of introduced species compared to other areas (e.g., Coles et al. 1999) is probably a consequence of the geographic isolation of the Azores, comparatively low commercial shipping, scarcity of shallow lagoons and absence of marine aquaculture and of estuarine habitats. The low number of scientific studies on the biogeography of Azorean marine species may have also affected the results. As for *Bugula cf. dentata* and *Cinachyrella cf. alloclada*, the identification of species is doubtful due to the lack of taxonomic expertise. Molecular work should be conducted in order

**Table 1** Species, which have been reported as introduced to the Azores. Names of species accepted as established non-indigenous taxa are presented in bold

| Taxon  | Year of first record                     | Status   | Possible vector of introduction | Origin or distribution   | Other references   |
|--|--|--|---------------------------------|--|--|
| Rhodophycota   |  |  |                                 |  |  |
| <i>Anithamion diminuatum</i> Wollaston (1968)  | 1989 (Athanasiadis and Tittley 1994)     | Introduced. Reported for Faial and São Miguel islands  | Boat hulls or rafting           | South Africa, Australia  | Tittley and Neto (1994), Neto (1997)                                     |
| <i>Anithamion pectinatum</i> Verlaque et al. (2004)  | 1989 (Athanasiadis and Tittley 1994)     | Introduced. Reported for Faial island  | Hulls or rafting                | New Zealand, Japan   | Tittley and Neto (1994)  |
| <i>A. armata</i> Harvey (1855)   | 1928 (Schmidt 1931)                      | Introduced. Very common in all Azorean islands (DOP Database), especially between 5 and 20 m depth (Neto 2000a, b, for São Miguel island)  | Boat hulls or rafting           | Australia and New Zealand (Haroun et al. 2003)   | Neto (1994), (1997)  |
| <i>A. taxiformis</i> (Delile) Trevisan de Saint-Léon, (1845)                                 | 1928 (Schmidt 1931) as <i>A. delilei</i> | Cryptogenic. Recently reported for São Miguel in 1993 (Neto 1997) and afterwards for Flores, Faial, Pico, Graciosa and Santa Maria islands (DOP Database)  | Boat hulls or rafting           | Atlantic and Indian Oceans and Mediterranean   |  |
| <i>Bonnemaisonia hamifera</i> Hariot (1891)  | 1989 (Athanasiadis and Tittley 1994)     | Introduced. Reported for Faial, Graciosa and Flores (DOP Database) islands   | Boat hulls or rafting           | Japan  | Tittley and Neto (1994)  |
| <i>Caulacanthus ustulatus</i> (Turner) Kützing   | 1928 (Schmidt 1931)                      | Possibly not introduced since the first record to the Azores precedes for over several decades the cryptic introduction of a genealogically distinct population in mainland Europe. Genetic work should be carried out in order to confirm the related population (southern Europe or Asia-France)                                   | Boat hulls                      | An autochthonous genealogic lineage is naturally present in the south of France (Lebouché 1957), Spain, including Canary islands (Lawson and Norton 1971), and mainland Portugal (Zuccarello et al. 2002). A population with a distinct genealogic history based in Asia was introduced in France (Rueness and Rueness 2000) between 1966 and 1977 (Ruesink et al. 2005) | Tittley and Neto (1994), Neto (2000a, b) and Tittley and Neto (2005)     |
| <i>Scageliopsis patens</i> Wollaston (1981)  | 1989 (Athanasiadis and Tittley 1994)     | Introduced. Faial and São Miguel islands   | Boat hulls or rafting           | New Zealand, Australasia   | Tittley and Neto (1995), (1997)  |
| <i>Symphyocladia marchantioides</i> (Harvey) Falkenberg, in F. Schmitz and Falkenberg (1897) | 1971 (Ardré et al. 1974)                 | Introduced. Probably entire archipelago; e.g., Ardré et al. (1974) for Santa Maria, São Miguel and Graciosa islands and Formigas islets, DOP Database for Faial island and Flores. Only recorded for Azores and Australasia (Athanasiadis and Tittley 1994), and as introduced to the Mediterranean (Boudouresque and Verlaque 2002) | Boat hulls or rafting           |  | Athanasiadis and Tittley (1994), Tittley and Neto (1994) and Neto (1997) |

Table 1 (Contd.)

| Taxon  | Year of first record                   | Status  | Possible vector of introduction | Origin or distribution   | Other references                               |
|--|--|---|---------------------------------|--|--|
| Chlorophycota<br><i>C. webbiana</i> Montagne (1837)                          | 2002                                   | Introduced. Reported for Faial island   | Boat hulls or rafting           | Canary islands (Haroun et al. 2003), Tropical eastern Atlantic and Hawaii        | Morton et al. (1998)                           |
| <i>Cladophoropsis membranacea</i> (Hofman Bang ex C. Agardh) Borgeson (1905) | 1973                                   | Cryptogenic. Genetic work of Kooistra et al. (1992) does not confirm the “introduced” status  | Boat hulls or ballast water     | Caribbean sea  |  |
| <i>Codium fragile atlanticum</i> (Cotton) P.C. Silva                         | 1994 (Tittley and Neto 2005)           | Introduced. Recorded in Flores and São Miguel (Tittley and Neto 2005)   | Boat hulls or ballast water     | Pacific ocean  |  |
| <i>C. f. tomentosoides</i> (van Goor) P.C. Silva (1955)                      | 1993 (Neto 1997)                       | Introduced. Recorded for São Miguel, Corvo (Tittley and Neto 2005)  | Boat hulls or rafting           | Pacific ocean around Japan   |  |
| <i>Codium vermilara</i> (Olivi) Delle Chiaje, (1829)                         | 1993–1995 (Neto 1997)                  | Introduced. Recorded for São Miguel island  | Boat hulls or rafting           | Mainland Europe and North Africa   |  |
| Phaeophycota<br><i>Endarachne binghamiae</i> J. Agardh (1896)                | (Yoneshigue 1985)                      | Introduced. Faial, Pico, São Miguel and Terceira islands  | Hulls or rafting                | South Africa   | Tittley and Neto (1995) and Neto (1997)        |
| <i>Sphaerotrichia divaricata</i> (C. Agardh) Kylin (1940)                    | 1993–1995 (Neto 1997)                  | Introduced. São Miguel island   | Boat hulls or rafting           | Japan  |  |
| Porifera<br><i>Cinachyrella</i> cf. <i>alloclada</i> (Uliczka 1929)          | 1989 (Moss 1992)                       | Cryptogenic. Faial island   | Boat hulls                      | Caribbean sea  |  |
| Cnidaria<br><i>Tubularia crocea</i> (Agassiz 1862)                           | 1989 (Cornelius 1992)                  | Introduced. Recorded from Faial island  | Boat hulls                      | Amphiatlantic. Madeira was the previous northern limit (Wirtz and Debelius 2003) |  |
| <i>Tubularia indivisa</i> Linnaeus (1758)                                    | 1989 (Cornelius 1992)                  | Introduced. Recorded from Faial island  | Boat hulls                      | South Norway and North Sea (Wirtz and Debelius 2003)                             |  |
| <i>V. haleciovides</i> (Alder 1859)  | 1989 (Cornelius 1992)                  | Recorded from Faial island but probably not established   | Boat hulls                      |  |  |
| Annelida<br><i>Hydroides elegans</i> Haswell (1883)                          | Prior to 2000 (Morton and Briton 2000) | Introduced. Species present at all Azorean islands  | Boat hulls                      | Indo-Pacific   |  |
| <i>S. spallanzanii</i> (Gmelin 1791)   | 1954 (Chapman and Dales 1954)          | Cryptogenic. Chapman and Dales (1954) point out the fact of previous work not mentioning this species (Fauvel 1914 in Chapman and Dales 1954) and they found it only in Faial harbour | Boat hulls                      | Mediterranean (Wirtz and Debelius 2003)  | Morton and Briton (2000)                       |
| <i>Spirorbis marioni</i> Caullery and Mesnil (1897)                          | 1979 (Zibrowius and Bianchi 1981)      | Introduced. Reported for São Miguel and Faial island by Zibrowius and Bianchi (1981) and Knight-Jones et al. (1991)   | Boat hulls or rafting           | Eastern Pacific (Panama and Mexico)  | Morton et al. (1998), Morton and Briton (2000) |

Table 1 (Contd.)

| Taxon   | Year of first record                             | Status   | Possible vector of introduction   | Origin or distribution  | Other references  |
|---|--|--|---|---|---|
| Mollusca<br><i>E. turbinella</i><br>(Kiener 1836)     | 1998 (Ávila et al. 1998)                         | This species was confused with the Eastern Atlantic buccinid <i>P. dorbignyi</i> (Ávila 2005)  | Ballast water   | Western Atlantic  | Morton et al. (1998), Morton and Briton (2000)                        |
| <i>Hexaplex trunculus</i><br>(Linnaeus 1758)          | 1919 (Nobre 1930)                                | Introduced. Harbours in São Miguel and Faial island  | Ballast water   | Mediterranean Sea (Poppe and Goto 1991)   | Morton et al. (1998), Morton and Briton (2000) and Ávila (2000, 2005) |
| <i>Hiatella arctica</i><br>(Linnaeus 1767)            | 1969 (Nordsteck 1969)                            | Cryptogenic. Hayward and Ryland (1990) do not refer to it as introduced  | Unknown but not deliberate  | Arctic and boreal regions (MacAndrews 1856), now cosmopolitan (Barash and Danin 1987 in Poppe and Goto 1993)                    | Rodriguez and Sánchez (1997), Morton et al. (1998)                    |
| <i>P. dorbignyi</i><br>(Payraudeau 1826)              | 1998 (Ávila et al. 2000)                         | Introduced. Initially recorded for São Miguel island, in the vicinity of the main harbour, and in Ferraria and São Vicente Ferreira. Registered here for Faial and Pico islands as well (DOP Database) | Ballast water   | Portugal, Mediterranean and Morocco (Ávila 2005)  | Ávila (2003)  |
| <i>Ruditapes decussatus</i><br>(Linnaeus 1758)        | Probably beginning of 20th century (Morton 1967) | Introduced. São Jorge island. Introduction attempts in other islands [Terceira and Graciosa (Silva 2000); Pico and Faial (H. Martins personal communication)] were not successful                      | Deliberate introduction   | Great Britain or America (Morton 1967), probably Portugal. Dist.: SW England to Senegal and Mediterranean Poppe and Goto (1993) | Morton et al. (1998), Ávila (2000, 2005) and Ávila et al. (1998)      |
| <i>Pinctada radiata</i><br>(Linnaeus 1758)            | 1998 (Ávila et al. 1998)                         | Introduced. This is an Indo-Pacific species that has invaded the Mediterranean through the Suez Canal  | It was first found attached to a ball-float, nearby Faial and was also reported to Vila Franca do Campo (São Miguel island) (Ávila et al. 2000) | Indo-Pacific (Poppe and Goto 1991)  |   |
| <i>Truncatella subcylindrica</i><br>(Linnaeus 1758)   | 1980 (Frias Martins personal communication)      | Introduced. Recorded by Frias Martins (personal communication) for Terceira (1980, 2001) and Graciosa (1989) islands   | Unknown but not deliberate  | From the Channel coasts of Britain to the Mediterranean, the Black sea and the Canaries (Poppe and Goto 1991)                   | Ávila (2000)  |
| Arthropoda<br><i>Balanus eburneus</i><br>Gould (1841) | 1997 (Southward 1998)                            | Introduced. Recorded in Faial island   | Boat hulls or rafting   | East coast of North America (Southward 1998)  |   |
| <i>Balanus trigonus</i><br>Darwin (1854)              | 1887 (Gruvel 1920)                               | Introduced. Faial, Graciosa, São Jorge, Santa Maria, São Miguel and Terceira islands   | Boat hulls or rafting   | Pacific and Indian oceans. Introduced in the Atlantic in 1860s by ships (Zullo 1992)  | Baker (1967), Southward (1998)  |
| <i>C. maenas</i> (Linnaeus 1758)                      | 1857 (Drouët 1861)                               | Probably misidentified (Barrois 1888)  |   | Atlantic Europe   | Morton and Briton (2000)  |
| <i>Ligia italica</i><br>Fabricius (1798)              | 1887 (Barrois 1888)                              | Introduced   | Ballast water   | Mediterranean (Wirtz and Debelius 2003)   | Dollfus (1888), Nobre (1930) and Morton and Briton (2000)             |

Table 1 (Contd.)

| Taxon   | Year of first record                   | Status   | Possible vector of introduction          | Origin or distribution  | Other references                            |
|---|--|--|--|---|---|
| <i>Ligia oceanica</i> (Linnaeus 1767)               | Prior to 1998 (Morton et al. 1998)     | Introduced   | Ballast water                            | Western Atlantic  | Morton and Briton (2000)                    |
| <i>Pilumnus spinifer</i> (H. Milne Edwards 1834)    | Prior to 2000 (Morton and Briton 2000) | Cryptogenic  | Shipborne (Hayward and Ryland 1990)      | North Africa or Mediterranean                                     |   |
| <i>Plagusia depressa</i> (Fabricius 1775)           | 1901–1903 (Lenz and Strunk 1914)       | Cryptogenic  | Boat hull (Bouvier 1940)                 | Amphiatlantic   | Morton and Briton (2000)                    |
| <i>Sphaeroma serratum</i> (Fabricius 1787)          | 1990 (Hayward and Ryland 1990)         | Cryptogenic. Hayward and Ryland (1990) do not mention the natural range  | Boat hull                                | Mediterranean   | Morton and Briton (2000)                    |
| <i>Tanais dulongi</i> (Audouin 1826)                | Prior to 2000 (Morton and Briton 2000) | Cryptogenic. Hayward and Ryland (1990) do not mention the natural range  | Marine fouling (Hayward and Ryland 1990) | Western Europe, Mediterranean, North and South America, Australia | Morton et al. (1998), Hawkins et al. (2000) |
| <i>Tesseropora atlantica</i> Newman and Ross (1977) | 1965 (Southward 1998)                  | Cryptogenic. Recorded in São Jorge and in São Miguel islands. Considered as relict species in the area according to Southward (1998) | Boat hull                                | Bermuda   |   |
| Bryozoa   |  |  |  |   |   |
| <i>Bugula simplex</i> Ryland (1960)                 | Prior to 2000 (Morton and Briton 2000) | Cryptogenic  | Marine fouling (Hayward and Ryland 1990) | Southern Britain (Hayward and Ryland 1990)                        |   |
| <i>Bugula stolonifera</i> Hincks (1886)             | Prior to 2000 (Morton and Briton 2000) | Cryptogenic  |  | Southern Britain (Hayward and Ryland 1990)                        |   |
| <i>Bugula</i> cf. <i>dentata</i> (Lamouroux 1816)   | 1997                                   | Cryptogenic. Recorded for Faial and Pico islands where it is relatively frequent on infralittoral rocky surfaces                     |  | Australasia   | Tempera and de la Cuadra (unpublished data) |
| Phoronida   |  |  |  |   |   |
| <i>Phoronis hippocrepia</i> Wright (1856)           | 1991 (Wirtz and Martins 1993)          | Introduced. All Azores islands (DOP Database)  | Boat hulls or rafting                    | Widely distributed (Hayward and Ryland 1990)                      | Morton and Briton (2000)                    |
| <i>Phoronis psammophila</i> Cori (1889)             | Prior to 2000 (Morton and Briton 2000) | Cryptogenic  | Boat hulls or rafting                    | Brittany (France) (Hayward and Ryland 1990). Now cosmopolitan     |   |
| <i>Phoronopsis hamneri</i> Pixell (1912)            | Prior to 2000 (Morton and Briton 2000) | Cryptogenic  | Boat hulls or rafting                    |   |   |
| Ascidacea   |  |  |  |   |   |
| <i>Alloecarpa loculosa</i> Monniot C (1974)         | 1971 (Monniot C 1974)                  | Introduced (Monniot C 1974)  | Boats (Monniot C 1974)                   | South Africa and New Zealand (Monniot C 1974)                     | Monniot and Monniot (1983)                  |

Table 1 (Contd.)

| Taxon  | Year of first record  | Status  | Possible vector of introduction   | Origin or distribution  | Other references  |
|--|---|---|---|---|---|
| <i>Botryllus schlosseri</i><br>(Pallas 1766)         | Referred as “Botrylles” in 1971 by Monniot C (1974). Morton et al. (1998) refers as <i>B. schlosseri</i><br>1971 (Monniot F 1974) | Introduced (Morton and Britton 2000). Flores and Terceira islands (DOP database)  | Boat hulls or ballast water (Morton et al. 1998)  | Norway to Mediterranean (Hayward and Ryland 1990)                         |   |
| <i>Clavelina lepadiformis</i><br>(Muller 1776)       | 1971 (Monniot F 1974)   | Introduced. From São Miguel (Monniot F 1974) it dispersed to Horta harbour and neighbourhood (Wirtz and Martins 1993) and now all the Azores, except Corvo (DOP Database). Colonies are small and scattered | Attached to boat hulls (Monniot and Monniot 1983; Morton et al. 1998) or ballast water (Morton et al. 1998) | Norway to Adriatic (Hayward and Ryland 1990; Turon et al. 2003)           | Monniot C (1974), Wirtz and Martins (1993) and Morton and Britton (2000)  |
| <i>C. oblonga</i><br>Herdmann (1880)                 | 1971 (Monniot F 1974)   | Introduced. Only in Faial (Monniot F 1974) and Pico (DOP Database). Possibly São Jorge as well due to proximity to these islands  | Attached to yacht hulls (Wirtz 1995)  | Bermuda (Monniot F 1974), Caribbean (Wirtz 1995)                          | Monniot C (1974), Morton and Britton (2000) and Wirtz and Debelius (2003) |
| <i>Cystodytes dellechiaiei</i><br>(Della Valle 1877) | 1969 (Monniot 1971)   | Cryptogenic   |   | Cosmopolitan (López-legendil and Turon 2005)                              | Monniot F (1974), Morton et al. (1998) and Morton and Britton (2000)      |
| <i>D. corolla</i><br>F Monniot (1975)                | 1971 (Monniot F 1974)   | Introduced. From Horta’s harbour (Monniot F 1974) to all the Azores (DOP Database)  | Boat hulls (Monniot and Monniot 1983) or ballast water (Morton et al. 1998)                                 | Caribbean (Wirtz 1995), Brazil to Bermuda (Wirtz and Debelius 2003)       | Wirtz and Martins (1993), Morton and Britton (2000)                       |
| <i>Eudistoma angolatum</i><br>Michaelsen (1914)      | 1971 (Monniot F 1974)   | Cryptogenic   | Boat hulls or ballast water (Morton et al. 1998)  | South Africa to Senegal (Monniot F 1974), Madeira and Azores (Wirtz 1995) | Morton et al. (1998)  |
| <i>Molgula plana</i><br>Monniot C (1971)             | 1969 (Monniot 1971)   | Cryptogenic. Recorded only for the harbour of Ponta Delgada (Monniot C 1974)  | Boat hulls (Monniot and Monniot 1983)   | Eastern North Atlantic  |   |
| <i>Polyclinum aurantium</i><br>Milne-Edwards (1841)  | 1971 (Monniot F 1974)   | Introduced. Recorded only for the harbour of Ponta Delgada (Monniot F 1974)   | Accidental importation (Monniot F 1974)   | Europe (Monniot F 1974).  | Monniot and Monniot (1983)  |
| <i>Pyura tessellata</i><br>(Forbes 1948)             | 1969 (Monniot 1971)   | Introduced. Recorded only for Terceira island (Monniot and Monniot 1983)  | Boat hulls (Monniot and Monniot 1983)   | Norway to Senegal and Mediterranean (Monniot C 1974)                      |   |

to clarify the origin of several species (e.g., *Sabella spallanzanii* in Morton and Britton 2000).

The genus *Caulerpa*, mentioned by Lowe et al. (2000) as a particularly invasive taxon, is present in the Azores. Several healthy mats of *C. webbiana* have now been identified outside Horta harbour and deserve special attention in future studies.

The bivalve *Mytilus edulis* has been occasionally reported for the Azores. Ávila et al. (1998) reported small populations inside the harbour of Ponta Delgada (São Miguel island) but recent surveys did not find live specimens (Ávila 2005). Transient mussels were also found in Santo Cristo Lagoon, São Jorge island (Morton et al. 1998). This species arrives at the Azores with floating objects (e.g., adrift floats with ropes hanging on the water column). Shells found inside harbours may have been discarded after meals. No self-sustaining populations have ever been recorded and this species is not considered to have established.

Several species in the northern hemisphere display a northward expansion of their distribution area due to the increase of water temperature (Elliot 2003; Perry et al. 2005). For the Azores, this seems to be the case for the fish species *Canthigaster capistrata* according to Wirtz (2005). *Scorpaena canariensis* is a rare species in the Azores and Wirtz (2005) admits this as a possible case of a northward expansion. As no direct human vector seems to be applicable to these species, they were not considered as introduced.

Other coastal fish species, such as *Chaetodon sedentarius*, *Aluterus monoceros*, *Fistularia petimba* (Santos et al. 1997; Wirtz 2005; Afonso et al. unpublished data) and *Mycteroperca phenax* (Morato et al. 2004) occur occasionally in the Azores but no stable populations seem to have established. Apparently, the same is applicable to the hydroid *V. halecioides* which was recorded only once in the Azores, in Horta's marina at the island of Faial (Cornelius 1992). In this particular case, more surveying should be carried out.

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