Marine algal flora of Formigas Islets, Azores

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Abstract

Background

The oldest reference to marine life in Formigas Islets (oriental group of the Azores archipelago) goes back to the 16th century. Nevertheless, their macroalgal flora is poorly known, the published information mainly resulting from occasional collections of sporadic visitors. To overcome this and contribute to the knowledge of Azorean macroalgal flora at both local and regional scales, a thorough investigation was conducted in 1990 and 1991 under two expeditions promoted by the Marine Biology Research Group of the Department of Biology, University of the Azores. Collections and presence data recordings were undertaken at the littoral and sublittoral levels down to approximately 40 m, in an area of approximately 0.04 km². This paper lists the taxonomic records and provides information regarding each species' ecology and occurrence on the Islets' littoral.
New information

A total of 320 specimens are registered (including taxa identified only at generic level) belonging to 90 taxa of macroalgae, from which 70 were diagnosed at species level. The confirmed species comprise 39 Rhodophyta, 12 Chlorophyta and 19 Ochrophyta (Phaeophyceae), distributed in 22 orders (13 Rhodophyta, 3 Chlorophyta and 6 Ochrophyta) and 37 families (24 Rhodophyta, 6 Chlorophyta and 7 Ochrophyta). Sixty-one species represent new records for the Islets, from which Botryocladia macaronesica Afonso-Carrillo, Sobrino, Tittley & Neto and Laurencia viridis Gil-Rodriguez & Haroun are Macaronesian endemisms. Most species are native to the Azores, but six have an uncertain origin and four are introduced (the Rhodophyta Asparagopsis armata Harvey; Laurencia dendroidea J.Agardh; Neoizziella divaricata (C.K.Tseng) S.-M.Lin, S.-Y.Yang & Huisman and the Ochrophyta Hydroclathrus tilesii (Endlicher) Santiañez & M.J.Wynne).

Keywords

Macroalgae, new records, Azores, Formigas Islets, endemism, native, introduced, uncertain, occurrence data.

Introduction

The Formigas Islets are located about 31 km NE of Santa Maria Island and 55 km SE of São Miguel Island (oriental group of Azorean archipelago, approximately 37°16′35″N, 24°46′54″W). They are arranged in a N-S direction, over a total length of about 165 m and a width of 80 m. Together with the submersed bank of Dollabarat, they form the Nature Reserve of Formigas Bank (DLR n° 11/88/ A).

The oldest reference to life in Formigas Islets consists of descriptions of its marine fauna in the 16th century manuscript "Saudades da terra", written by the naturalist clergyman Gaspar Frutuoso. Subsequently, these Islets were occasionally studied in sporadic visits by researchers, the first reference to the marine macroalgae being that of Piccone (1889). After that, several expeditions were made in order to study of the fauna and flora of the Islets, which resulted in a few publications (see revision in Azevedo et al. 1991). An important finding was the first Azorean record of the brown alga Laminaria ochroleuca Bachelot de la Pylaie (made by Ardré et al. 1973). Despite these efforts, the algal flora of these Islets remained poorly known until the nineties, when a thorough investigation conducted by the Marine Biology Research Group of the Department of Biology, University of the Azores, took place. This research group went to the Islets in 1990 and 1991 and undertook collections and presence data recordings at the littoral and sublittoral levels down to about 40 m, over an area of approximately 0.04 km².
General description

Purpose: This paper, aimed at contributing to a better understanding of the seaweed flora of the Azores archipelago, lists the macroalgae recorded on surveys undertaken on the Formigas Islets (Azores, eastern group) and presents general information for each taxon’s occurrence on the Islets’ littoral, thus addressing several biodiversity shortfalls (see Hortal et al. 2015), namely the need to catalogue the Azorean macroalgae (Linnean shortfall) and improve the current information on their local and regional geographic distribution (Wallacean shortfall), as well as on species abundances and dynamics in space (Prestonian shortfall). It is intended as a resource for academics, students, government, private organisations and the general public and also as a practical basis for biological studies, such as systematics, diversity and conservation, biological monitoring, climate change and ecology.

Project description

Title: Marine algal (seaweed) flora of Formigas Islets, Azores

Personnel: Sampling took place in the summers of 1990 and 1991 under the coordination of Ana I. Neto. Main collectors were Ana I. Neto, Bruno Brum, Carlos Rodrigues, Heather Baldwin, João Brum, José M. N. Azevedo, José Pedro Viegas and Luís Resendes. Ana I. Neto and Heather Baldwin were responsible for the species identification.

Voucher specimen management was mainly undertaken by Afonso Prestes, Ana I. Neto, Eunice Nogueira, Natália Cabral and Roberto Resendes.

Study area description: Located in the eastern group of the Azores archipelago, the Formigas Islets (37°16’35”N, 24°46’54”W, Fig. 1) are approximately 32 km NE of Santa Maria Island and 55 km SE of São Miguel Island, thus being the most isolated Islets of the Azores. Consequently, they are relatively protected from human action and function as a breeding and nursing ground for many marine species occurring in the Azorean waters (Costa et al. 1994). The Islets, together with the submersed bank of Dollabarat, form the Formigas Bank, located between the parallels 37°14’N and 37°17’N and the meridians 24°43’W and 24°47’W, occupying an area about 11 km long and 5 km wide (Azevedo et al. 1991) and designated as a Nature Reserve in 1988 (DLR n° 11/88/ A).

The Formigas Islets are located in the NW part of the bank. With a N-S arrangement, they have a total length of about 165 m and width of 80 m, with an area of compact rocks in the southern part and one of large blocks in the North (Fig. 2). The highest block (Formigão) is 11 m high. In the South region, there is a lighthouse, from which there are two small anchorages (Azevedo et al. 1991).
As in the remaining archipelago, the climate is temperate oceanic with persistent winds, regular and abundant rainfall and high levels of relative humidity, mainly during winter and autumn (Morton et al. 1998). The tidal range is small (< 2 m, see Hidrográfico 1981) and
the Islets are surrounded by deep waters. Intertidal space is limited and permanently subjected to the action of the waves, which does not allow the establishment of terrestrial fauna and flora (Costa et al. 1994), but the marine biota is rich. Most seaweeds and invertebrates that characterise the exposed Azorean coasts can be found there; the great clarity of the waters allows the algal communities to extend to great depths. This profusion of algae provides shelter and food for many animals and supports a complex food web (Costa et al. 1994).

The intertidal zone is narrow and mostly dominated by animals (e.g. gastropods, chthamalid barnacles and decapods) and algal turfs (mostly composed by various species of *Ceramium* spp. and *Gymnogongrus* spp.) (Fig. 3), that are typically found in most of the Islands. The many channels that cross the rocky platforms are dominated by luxuriant forms of the brown algae *Cystoseira* spp., *Treptacantha abies-marina* (Fig. 4) and *Sargassum* spp. At the low intertidal, the algal turfs give rise to erect forms of algae, for example, *Elisolandia elongata* (Fig. 5). Subtidally, the rocky walls and rocky platforms are covered with erect, corticated macrophytes, for example, *Dictyota* spp. and *Plocamium cartilagineum* (Fig. 6). At and below 40 m depth, the leathery brown algae *Laminaria ochroleuca* can form some monospecific patches (Neto, pers. observ.).
Figure 4. *Treptacantha abies-marina* in an intertidal channel (by the Island Aquatic Ecology Subgroup of cE3c-ABG).

Figure 5. Low intertidal showing multi-specific algal turf and *Elisolandia elongata* (by the Island Aquatic Ecology Subgroup of cE3c-ABG).
Design description: The macroalgae, referred to in this paper, were collected during field studies at littoral and sublittoral levels down to approximately 40 m on the Formigas Islets, over an area of 0.04 km² (Table 1, Fig. 2). Intertidal collections were undertaken at low tide by walking over the shore. Subtidal collections were undertaken by scuba diving. Each sampling location was visited several times. On each occasion, a careful survey was made to allow a good coverage of the area. Whenever an unknown species was found, it was collected, given an individual registration number and vouchers deposited at the AZB Herbarium Ruy Telles Palhinha, at the Faculty of Sciences and Technology of the University of the Azores.

| Location N0 | Location ID | Municipality | Locality                      | Latitude / Longitude       | geodeticDatum | Littoral zone |
|-------------|-------------|--------------|-------------------------------|-----------------------------|---------------|---------------|
| 1           | FOR_FOR_PNI | Formigas     | Ponta norte do ilhéu          | 37.272261, -24.780546       | WGS294        | Intertidal    |
| 3           | FOR_FOR_AVI1| Formigas     | À volta do ilhéu 1            | 37.270887, -24.779604       | WGS84         | Subtidal      |

Figure 6. Frondose macrophytes (*Dictyota* spp. and *Plocamium cartilagineum*) at the subtidal level (by the Island Aquatic Ecology Subgroup of cE3c-ABG).
| Location N0 | Location ID | Municipality | Locality | Latitude / Longitude | geodeticDatum | Littoral zone |
|------------|-------------|--------------|----------|----------------------|---------------|--------------|
|            | FOR_FOR_AV12 | Formigas     | À volta do ilhéu 2 | 37.271983, -24.779321 | WGS84         | Subtidal     |
|            | FOR_FOR_AV13 | Formigas     | À volta do ilhéu 3 | 37.27011, -24.780593 | WGS84         | Intertidal   |
|            | FOR_FOR_AV2  | Formigas     | No intertidal do ilhéu | 37.270904, -24.780187 | WGS84         | Intertidal   |
|            | FOR_FOR_AV3  | Formigas     | No intertidal do ilhéu | 37.271014, -24.779862 | WGS84         | Subtidal     |
|            | FOR_FOR_LAI  | Formigas     | Lado oeste do ilhéu | 37.270836, -24.781069 | WGS84         | Subtidal     |
|            | FOR_FOR_LOIb | Formigas     | Lado oeste do ilhéu | 37.270025, -24.781135 | WGS84         | Subtidal     |

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- Expedition SANTA MARIA and FORMIGAS/90, Departamento de Biologia da Universidade dos Açores, Ilha de Santa Maria e Ilhéus das Formigas, Açores, June 1990;
- Expedition FORMIGAS/91, Secção de Biologia Marinha do Departamento de Biologia da Universidade dos Açores, Ilhéus das Formigas, July 1991;
- Project “ACORES-01-0145-FEDER-000072 - AZORES BIoPORTAL – PORBIOTA. Operational Programme Azores 2020 (85% ERDF and 15% regional funds);
- Portuguese National Funds, through FCT – Fundação para a Ciência e a Tecnologia, within the projects UID/BIA/00329/2019 and UID/BIA/00329/2020-2023;
- CIRN/DB/UAc (Research Centre for Natural Resources, Universidade dos Açores, Departamento de Biologia).

**Sampling methods**

**Study extent:** Collections were made at littoral and sublittoral levels down to about 40 m around Formigas Islets over a total area of approximately 0.04 km² (Fig. 2).

**Sampling description:** Intertidal collections were made at low tide by walking over the shore. Subtidal collections were made by scuba diving. In each sampling location, one or two specimens of all different species found were scraped into labelled bags (Fig. 7). Complementary data, such as shore level (high, mid, low), orientation and type of substrate (bedrock, boulders, mixed), habitat (tide pool, open rock, gully, crevice) were also recorded.
Quality control: Each sampled taxon was investigated by trained taxonomists with the help of keys and floras. This involved morphological and anatomical examination by eye or under the dissecting and compound microscopes of an entire specimen or slide preparation. In difficult cases, specimens were sent to experts for identification.

Step description: In the laboratory, the specimens were sorted and studied following standard procedures used in macroalgae identification.

Species identification was based on morphological and anatomical characters and reproductive structures. For small and simple thalli, this required the observation of the entire thallus with the naked eye and/or using dissecting and compound microscopes. For larger and more complex algae, the investigation of thallus anatomy required histological work to obtain longitudinal and transverse sections needed for the observation of cells, reproductive structures and other diagnostic characters.

Due to the mixed nature of the Azorean macroalgal flora, relevant floras from the Atlantic and western Mediterranean were used for the species identification (e.g. Schmidt 1931, Taylor 1967, Taylor 1978, Levring 1974, Dixon and Irvine 1977, Lawson and John 1982, Irvine 1983, Gayral and Cosson 1986, Fletcher 1987, Afonso-Carrillo and Sansón 1989, Burrows 1991, Boudouresque et al. 1992, Cabioc'h et al. 1992, Maggs and Hommersand 1993, Irvine and Chamberlain 1994, Brodie et al. 2007, Lloréns et al. 2012, Rodríguez-Prieto et al. 2013).

For more critical and taxonomically-difficult taxa, specimens were taken to the herbarium of the Natural History Museum (London) for comparison with collections there.
A reference collection was made for all specimens collected by giving them a herbarium code number and depositing them at the AZB Herbarium Ruy Telles Palhinha, University of Azores. Depending on the species and on further research planned, different types of collections were made, namely (i) liquid collections using 5% buffered formaldehyde seawater and then replacing it by the fixing agent Kew (Bridsen and Forman 1999) and (ii) dried collections, either by pressing the algae (most species) following the method described by Gayral and Cosson (1986).

Nomenclatural and taxonomic status used here follow Algaebase (Guiry and Guiry 2020). The database was organised on FileMaker Pro.

**Geographic coverage**

**Description:** Formigas Islets, Azores, Macaronesia, Portugal (approximately 37°16′35″N, 24°46′54″W).

**Coordinates:** 37.269 and 37.276 Latitude; -24.783 and -24.778 Longitude.

**Taxonomic coverage**

**Description:** All macroalgae were identified to genus or species level. In total, 90 taxa were identified comprising 71 confirmed species, belonging to 22 orders and 37 families, distributed by the phyla Rhodophyta (13 orders and 24 families), Chlorophyta (3 orders and 6 families) and Ochrophyta (6 orders and 7 families) (see Tables 2, 3).

| Phylum       | Species (Accepted Name)                        | Number of records | Establishment Means | Occurrence Remarks |
|--------------|------------------------------------------------|-------------------|---------------------|--------------------|
| Rhodophyta   | Amphiroa beauvoisii J.V.Lamouroux              | 1                 | Native              | New record         |
| Rhodophyta   | Asparagopsis armata Harvey                    | 12                | Introduced          | New record         |
| Rhodophyta   | Bornetia secundiflora (J.Agardh) Thuret       | 4                 | Native              | New record         |
| Rhodophyta   | Botryocladia macaronesica Afonso-Carrillo, Sobrino, Titley & Neto | 2 | Macaronesian endemic | New record         |
| Rhodophyta   | Callithamnion corymbosum (J.E.Smith) Lyngbye  | 1                 | Native              | New record         |
| Rhodophyta   | Callithamnion tetragonum (Withering) S.F.Gray | 1                 | Native              | New record         |
| Rhodophyta   | Centroceras clavulatum (C.Agardh) Montagne    | 1                 | Native              | New record         |

Table 2. Macroalgae species from Formigas Islets, with information on their relative abundance, origin and status.
| Phylum   | Species (Accepted Name)                                      | Number of records | Establishment Means | Occurrence Remarks |
|----------|------------------------------------------------------------|-------------------|---------------------|--------------------|
| Rhodophyta | Ceramium ciliatum (J.Ellis) Ducluzeau                      | 2                 | Native              | New record         |
| Rhodophyta | Ceramium deslongchampsi Chauvin ex Duby                   | 4                 | Native              | New record         |
| Rhodophyta | Ceramium diaphanum (Lightfoot) Roth                        | 4                 | Native              | New record         |
| Rhodophyta | Ceramium gaditanum (Clemente) Cremades                    | 8                 | Uncertain           | New record         |
| Rhodophyta | Chondria capillaris (Hudson) M.J.Wynne                    | 1                 | Native              | New record         |
| Rhodophyta | Chondria dasypylla (Woodward) C.Agardh                    | 4                 | Uncertain           | New record         |
| Rhodophyta | Cryptopleura ramosa (Hudson) L.Newton                     | 12                | Native              | New record         |
| Rhodophyta | Dasysa ocellata (Grateloup) Harvey                         | 3                 | Native              | New record         |
| Rhodophyta | Digenea simplex (Wulffen) C.Agardh                        | 4                 | Native              |                    |
| Rhodophyta | Dudresnaya verticillata (Withering) Le Jolis              | 1                 | Native              | New record         |
| Rhodophyta | Gelidium spinosum (S.G.Gmelin) P.C.Silva                  | 1                 | Native              | New record         |
| Rhodophyta | Gymnogongrus crenulatus (Turner) J.Agardh                  | 3                 | Native              | New record         |
| Rhodophyta | Gymnogongrus griffithsiae (Turner) C.Martius               | 2                 | Native              | New record         |
| Rhodophyta | Halurus equisetifolius (Lightfoot) Kützing                 | 1                 | Native              |                    |
| Rhodophyta | Haraldiophyllum bonnemaisonii (Kylin) A.D.Zinova          | 2                 | Native              | New record         |
| Rhodophyta | Itonoa marginifera (J.Agardh) Masuda & Guiry             | 1                 | Native              | New record         |
| Rhodophyta | Laurencia dendroidea J.Agardh                              | 6                 | Introduced          | New record         |
| Rhodophyta | Laurencia viridis Gil-Rodriguez & Haroun                  | 3                 | Macaronesian endemism | New record |
| Rhodophyta | Leptosiphonia brodiei (Dillwyn) A.M.Savoie & G.W.Saunders | 1                 | Uncertain           | New record         |
| Rhodophyta | Lophosphonia obscura (C.Agardh) Falkenberg                 | 1                 | Native              | New record         |
| Rhodophyta | Meredithia microphylla (J.G.Arardh) J.G.Agardh             | 8                 | Native              | New record         |
| Rhodophyta | Nemalion elminthoides (Velley) Batters                    | 6                 | Native              | New record         |
| Rhodophyta | Neoizziella divaricata (C.K.Tseng) S.-M.Lin, S.-Y.Yang & Huisman | 2                 | Introduced          | New record         |
| Rhodophyta | Peyssonnelia squamaria (S.G.Gmelin) Decaisne ex J.Agardh  | 1                 | Native              | New record         |
| Phylum     | Species (Accepted Name)                                                                 | Number of records | Establishment Means | Occurrence Remarks |
|------------|----------------------------------------------------------------------------------------|-------------------|---------------------|--------------------|
| Rhodophyta | *Platoma cyclocolpum* (Montagne) F.Schmitz                                             | 4                 | Native              | New record         |
| Rhodophyta | *Plocamium cartilagineum* (Linnaeus) P.S.Dixon                                          | 11                | Native              | New record         |
| Rhodophyta | *Polysiphonia atlantica* Kapraun & J.N.Norris                                          | 2                 | Native              | New record         |
| Rhodophyta | *Pterocladia capillacea* (S.G.Gmelin) Santelices & Hommersand                           | 9                 | Native              | New record         |
| Rhodophyta | *Pyropia leucosticta* (Thuret) Neefus & J.Brodie                                       | 1                 | Native              | New record         |
| Rhodophyta | *Rhodymenia holmesii* Ardissonne                                                        | 3                 | Native              | New record         |
| Rhodophyta | *Scinaia furcellata* (Turner) J.Agardh                                                 | 7                 | Native              | New record         |
| Rhodophyta | *Vertebrata fucoidea* (Hudson) Kuntze                                                  | 1                 | Uncertain           | New record         |
| Chlorophyta| *Bryopsis cupressina* J.V.Lamouroux                                                     | 2                 | Native              | New record         |
| Chlorophyta| *Bryopsis hypnoides* J.V.Lamouroux                                                      | 2                 | Native              | New record         |
| Chlorophyta| *Chaetomorpha linum* (O.F.Müller) Kützing                                               | 4                 | Native              | New record         |
| Chlorophyta| *Cladophora albida* (Nees) Kützing                                                      | 2                 | Native              | New record         |
| Chlorophyta| *Cladophora coelothrix* Kützing                                                         | 1                 | Native              | New record         |
| Chlorophyta| *Cladophora laetevirens* (Dillwyn) Kützing                                              | 4                 | Uncertain           | New record         |
| Chlorophyta| *Codium adhaerens* C.Agardh                                                            | 1                 | Native              | New record         |
| Chlorophyta| *Phyllodictyon anastomosans* (Harvey) Kraft & M.J.Wynne                                | 1                 | Native              |                    |
| Chlorophyta| *Ulva compressa* Linnaeus                                                               | 1                 | Native              | New record         |
| Chlorophyta| *Ulva linza* Linnaeus                                                                   | 2                 | Native              | New record         |
| Chlorophyta| *Ulva rigida* C.Agardh                                                                  | 6                 | Native              | New record         |
| Chlorophyta| *Valonia utricularis* (Roth) C.Agardh                                                  | 3                 | Native              | New record         |
| Ochrophyta | *Canistrocarpus cervicornis* (Kützing) J.C.De Paula & De Clerck                          | 1                 | Native              | New record         |
| Ochrophyta | *Carpomita costata* (Stackhouse) Batters                                               | 6                 | Native              |                    |
| Ochrophyta | *Colpomenia sinuosa* (Mertens ex Roth) Derbès & Solier                                  | 7                 | Native              | New record         |
| Ochrophyta | *Cystoseira compressa* (Esper) Gerloff & Nizamuddin                                    | 8                 | Native              | New record         |
| Ochrophyta | *Cystoseira humilis* Schousboe ex Kützing                                              | 1                 | Native              | New record         |
| Ochrophyta | *Dictyopteris polypodioides* (DC.) J.V.Lamouroux                                       | 2                 | Native              |                    |
| Phylum     | Species (Accepted Name)                  | Number of records | Establishment Means | Occurrence Remarks |
|------------|-----------------------------------------|-------------------|---------------------|--------------------|
| Ochrophyta | *Dictyota bartayresiana* J.V.Lamouroux  | 9                 | Native              | New record         |
| Ochrophyta | *Dictyota dichotoma* (Hudson) J.V.Lamouroux | 8                 | Native              | New record         |
| Ochrophyta | *Dictyota dichotoma var. intricata* (C.Agardh) Greville | 5                 | Native              | New record         |
| Ochrophyta | *Ectocarpus siliculosus* (Dillwyn) Lyngberg | 6                 | Uncertain           | New record         |
| Ochrophyta | *Halopteris filicina* (Grateloup) Kützing | 7                 | Native              |                    |
| Ochrophyta | *Halopteris scoparia* (Linnaeus) Sauvageau | 3                 | Native              | New record         |
| Ochrophyta | *Hydroclathrus tilesii* (Endlicher) Santiañez & M.J.Wynne | 1                 | Introduced          | New record         |
| Ochrophyta | *Laminaria ochroleuca* Bachelot de la Pylaie | 7                 | Native              |                    |
| Ochrophyta | *Padina pavonica* (Linnaeus) Thivy       | 2                 | Native              | New record         |
| Ochrophyta | *Sargassum cymosum* C.Agardh              | 4                 | Native              | New record         |
| Ochrophyta | *Sargassum furcatum* Kützing              | 6                 | Native              | New record         |
| Ochrophyta | *Treptacantha abies-marina* (S.G.Gmelin) Kützing | 9                 | Native              |                    |
| Ochrophyta | *Zonaria tournefortii* (J.V.Lamouroux) Montagne | 13                | Native              |                    |

Table 3.
Main taxonomic figures with information on the species origin and status.

| Phylum     | Order | Family | Specimens Number | Total taxa | Total species | Native | Introduced | Uncertain | Macaronesian endemicism | New record |
|------------|-------|--------|------------------|------------|---------------|--------|------------|-----------|------------------------|------------|
| Rhodophyta | 13    | 24     | 169              | 54         | 39            | 30     | 3          | 4         | 2                      | 37         |
| Chlorophyta | 3     | 6      | 33               | 14         | 12            | 11     | 1          |           | 1                      | 11         |
| Ochrophyta  | 6     | 7      | 118              | 22         | 19            | 17     | 1          | 1         | 1                      | 13         |
| Total       | 22    | 37     | 320              | 90         | 70            | 58     | 4          | 6         | 2                      | 61         |

Taxa included:

| Rank | Scientific Name | Common Name |
|------|-----------------|-------------|
| phylum | Rhodophyta | Red algae |
| phylum | Chlorophyta | Green algae |
| phylum | Ochrophyta | Brown algae |
Temporal coverage

Data range: 1990-7-07 - 1990-7-14; 1991-7-05 - 1990-7-12.

Notes: The sampling was performed in the summers of 1990 and 1991.

Collection data

Collection name: AZB | Marine macroalgae collection of Formigas Islets - Expedition SANTA MARIA and FORMIGAS/90; AZB | Marine macroalgae collection of Formigas Islets - Expedition FORMIGAS/91.

Collection identifier: de350d60-48c0-409c-a71f-0ae4df753fde; 2d4aad32-17f3-426e-92f1-3d8654fc781e.

Parent collection identifier: AZB Herbarium Ruy Telles Palhinha, Faculty of Sciences and Technology of the University of the Azores; AZB Herbarium Ruy Telles Palhinha, Faculty of Sciences and Technology of the University of the Azores.

Specimen preservation method: Air-dry, Dried and pressed; Liquid (Formalin; fixing agent Kew), Silica

Curatorial unit: AZB Herbarium Ruy Telles Palhinha, Faculty of Sciences and Technology of the University of the Azores.

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Data resources

Data package title: Marine algal (seaweed) flora of Formigas Islets, Azores

Resource link: http://ipt.gbif.pt/ipt/resource?r=formigas_seaweed_flora

Alternative identifiers: https://www.gbif.org/dataset/22c0c715-b2a8-4c01-9719-13f79be07fdc

Number of data sets: 1

Data set name: Marine algal (seaweed) flora of Formigas Islets, Azores

Download URL: http://ipt.gbif.pt/ipt/resource?r=formigas_seaweed_flora

Data format: Darwin Core Archive

Data format version: version 1.7
Description: This data paper presents data from macroalgae surveys developed in Formigas Islets in 1990 and 1991 (Neto et al. 2020). The dataset submitted to GBIF is structured as a sample event dataset, with two tables: event (as core) and occurrences. The data in this sampling event resource have been published as a Darwin Core Archive (DwCA), which is a standardised format for sharing biodiversity data as a set of one or more data tables. The core data table contains eight records (eventID). The extension data table has 320 occurrences. An extension record supplies extra information about a core record. The number of records in each extension data table is illustrated in the IPT link. This IPT archives the data and thus serves as the data repository. The data and resource metadata are available for downloading in the downloads section.

| Column label                        | Column description                                                                 |
|-------------------------------------|------------------------------------------------------------------------------------|
| Table of Sampling Events            | Table with sampling events data (beginning of table)                               |
| eventID                             | Identifier of the event, unique for the dataset                                     |
| country                             | Country of the sampling site                                                       |
| countryCode                        | Code of the country where the event occurred                                        |
| stateProvince                       | Name of the region                                                                 |
| island                              | Name of the island                                                                  |
| municipality                        | Name of the municipality                                                            |
| locality                            | Name of the locality                                                                |
| locationID                          | Identifier of the location                                                          |
| decimalLatitude                     | The geographic latitude of the sampling site                                         |
| decimalLongitude                    | The geographic longitude of the sampling site                                        |
| geodeticDatum                       | The spatial reference system upon which the geographic coordinates are based         |
| coordinateUncertaintyInMetres       | The horizontal distance (in metres) from the given decimalLatitude and decimalLongitude describing the smallest circle containing the whole of the Location |
| eventDate                           | Time interval when the event occurred                                               |
| year                                | The year of the event                                                               |
| samplingProtocol                    | Sampling method used during an event                                                |
| locationRemarks                     | Zonation level                                                                     |
| minimumDepthInMetres                | The minimum depth in metres where the specimen was found                             |
| maximumDepthInMetres                | The maximum depth in metres where the specimen was found                             |
| eventRemarks                        | Notes about the event                                                               |
| Table of Species Occurrence         | Table with species occurrence data (beginning of new table)                        |
| Field                  | Description                                                                                                                                 |
|-----------------------|--------------------------------------------------------------------------------------------------------------------------------------------|
| occurrenceID          | Identifier of the record, coded as a global unique identifier                                                                              |
| institutionID         | The identifier for the institution having custody of the object or information referred to in the record                                 |
| institutionCode       | The acronym of the institution having custody of the object or information referred to in the record                                       |
| collectionID          | An identifier of the collection to which the record belongs                                                                                 |
| collectionCode        | The name of the collection from which the record was derived                                                                               |
| datasetName           | The name identifying the dataset from which the record was derived                                                                         |
| eventID               | Identifier of the event, unique for the dataset                                                                                             |
| kingdom               | Kingdom name                                                                                                                               |
| phylum                | Phylum name                                                                                                                                  |
| class                 | Class name                                                                                                                                    |
| order                 | Order name                                                                                                                                     |
| family                | Family name                                                                                                                                    |
| genus                 | Genus name                                                                                                                                     |
| specificEpithet       | The name of the first or species epithet of the scientificName                                                                              |
| infraspecificEpithet  | The name of the lowest or terminal infraspecific epithet of the scientificName, excluding any rank designation                                 |
| acceptedNameUsage     | The specimen accepted name, with authorship                                                                                                  |
| previousIdentifications | Previous name of the specimen, with authorship                                                                                              |
| scientificName        | The name without authorship applied on the first identification of the specimen                                                             |
| basisOfRecord         | The specific nature of the data record                                                                                                       |
| habitat               | Description of the habitat where the specimen was found                                                                                     |
| recordedBy            | Person(s) responsible for sampling                                                                                                            |
| catalogNumber         | Identifying code for a unique sample lot in a biological collection                                                                           |
| identifiedBy          | Person(s) responsible for taxa identification                                                                                                 |
| type                  | The nature of the resource                                                                                                                   |
| preparations          | The preservation method used for the specimen                                                                                                 |
| establishmentMeans    | The establishment status of the organism in the study region                                                                                |
| occurrenceRemarks     | New record status assignment                                                                                                                  |
| licence               | Reference to the licence under which the record is published                                                                                |
Additional information

This paper is based on the 320 specimens of macroalgae collected from the Formigas Islets. Ninety taxa are listed (54 Rhodophyta, 14 Chlorophyta and 22 Ochrophyta) of which 70 are confirmed species and 20 taxa are identified only to genus level. The confirmed species (Tables 2, 3) include 39 Rhodophyta, 12 Chlorophyta and 19 Ochrophyta (Phaeophyceae) distributed by 22 orders (13 Rhodophyta, 3 Chlorophyta and 6 Ochrophyta) and 37 families (24 Rhodophyta, 6 Chlorophyta and 7 Ochrophyta). Sixty-one of the confirmed species are newly-recorded to the islets (37 Rhodophyta, 11 Chlorophyta and 13 Ochrophyta), as the invasive Asparagopsis armata (Fig. 8). Most species are native (58), including the Macaronesian endemisms Botryocladia macaronesica Afonso-Carrillo, Sobrino, Tittley & Neto and Laurencia viridis Gil-Rodriguez & Haroun. Four species represent introductions to the algal flora (the Rhodophyta Asparagopsis armata Harvey, Laurencia dendroidea J.Agardh, Neoizziella divaricata (C.K.Tseng) S.-M.Lin, S.-Y.Yang & Huisman and the Ochrophyta Hydroclathrus tilesii (Endlicher) Santiañez & M.J.Wynne) and six have an uncertain status.

Many species were only sporadically observed on the Islets, but seven were commonly found, namely: the Rhodophyta Asparagopsis armata Harvey, Cryptopleura ramosa (Hudson) L.Newton, Plocamium cartilagineum (Linnaeus) P.S.Dixon and Pterocladiella
capillacea (S.G.Gmelin) Santelices & Hommersand; and the Ochrophyta Dictyota bartayresiana J.V.Lamouroux, Treptacantha abies-marina (S.G.Gmelin) Kützing and Zonaria tournefortii (J.V.Lamouroux) Montagne.

A mismatch regarding the GBIF backbone taxonomy of some of the macroalgae species names was identified as detailed in Suppl. material 1.

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Author contributions

- AIN: Conceptualisation; Methodology; Investigation (field and laboratory work); Resources; Data Curation; Formal analysis and interpretation; Paper writing
- ACLP: Investigation (laboratory work); Resources; Paper writing
- JMNA: Investigation (fieldwork); Formal analysis and interpretation; Paper writing
- RR: Resources; Data Curation
- NVA: Maps elaboration; Paper writing
- RMAN: Data Curation; Formal analysis and interpretation; Paper writing
- IM: Data Curation; Formal analysis and interpretation; Paper writing

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Supplementary material

Suppl. material 1: DP-FOR-id_14155_normalized-redz.csv [do]

Authors: Ana I. Neto  
Data type: Macroalgae taxonomic mismatching  
Brief description: GBIF does not have the more actualised nomenclature for some of the macroalgae species names. Therefore, the matching tools of its platform were applied to the species list, as required by Pensoft's data auditor, to identify the problematic taxonomic situations. The resulting file (DP-FOR_id_14155_normalized-redz.csv) is included here, since the names will not be immediately updated in the GBIF Taxonomic Backbone. A request was already sent to GBIF helpdesk to resolve this situation.

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