Abstract

Background

The algal flora of the western group of the Azores archipelago (Islands of Flores and Corvo) has attracted the interest of many researchers on numerous past occasions (such
as Drouet 1866, Trelease 1897, Gain 1914, Schmidt 1929, Schmidt 1931, Azevedo et al. 1990, Fralick and Hehre 1990, Neto and Azevedo 1990, Neto and Baldwin 1990, Neto 1996, Neto 1997, Neto 1999, Tittley and Neto 1996, Tittley and Neto 2000, Tittley and Neto 2005, Tittley and Neto 2006, Azevedo 1998, Azevedo 1999, Tittley et al. 1998, Dionísio et al. 2008, Neto et al. 2008). Despite this interest, the macroalgal flora of the Islands cannot be described as well-known with the published information reflecting limited collections performed in short-term visits by scientists. To overcome this, a thorough investigation, encompassing collections and presence data recording, has been undertaken for both the littoral and sublittoral regions, down to a depth of approximately 40 m, covering a relatively large area on both Islands (approximately 143 km² for Flores and 17 km² for Corvo).

This paper lists the resultant taxonomic records and provides information on species ecology and occurrence around both these Islands, thereby improving the knowledge of the Azorean macroalgal flora at both local and regional scales.

**New information**

For the Island of Flores, a total of 1687 specimens (including some taxa identified only to genus level) belonging to 196 taxa of macroalgae are registered, comprising 120 Rhodophyta, 35 Chlorophyta and 41 Ochrophyta (Phaeophyceae). Of these taxa, 128 were identified to species level (80 Rhodophyta, 22 Chlorophyta and 26 Ochrophyta), encompassing 37 new records for the Island (20 Rhodophyta, 6 Chlorophyta and 11 Ochrophyta); two Macaronesian endemics (*Laurencia viridis* Gil-Rodríguez & Haroun and *Millerella tinerfensis* (Seoane-Camba) S.M.Boo & J.M.Rico); six introduced (the Rhodophyta *Asparagopsis armata* Harvey, *Neoizziella divaricata* (C.K.Tseng) S.-M.Lin, S.-Y.Yang & Huisman and *Symphyocladia marchantioides* (Harvey) Falkenberg; the Chlorophyta *Codium fragile* subsp. *fragile* (Suringar) Hariot; and the Ochrophyta *Hydroclathrus tilesii* (Endlicher) Santianez & M.J.Wynne and *Papenfussiella kuromo* (Yendo) Inagaki); and 14 species of uncertain status (10 Rhodophyta, two Chlorophyta and two Ochrophyta).

For the Island of Corvo, a total of 390 specimens distributed in 56 taxa of macroalgae are registered, comprising 30 Rhodophyta, nine Chlorophyta and 17 Ochrophyta (Phaeophyceae). Whilst a number of taxa were identified only to the genus level, 43 were identified to species level (22 Rhodophyta, eight Chlorophyta and 13 Ochrophyta), comprising 22 new records for the Island (nine Rhodophyta, four Chlorophyta and nine Ochrophyta), two introduced species (the Rhodophyta *Asparagopsis armata* and the Chlorophyta *Codium fragile* subsp. *fragile* and seven species of uncertain status (five Rhodophyta and two Ochrophyta).

**Keywords**

Macroalgae, Azores, Corvo Island, Flores Island, new records, endemism, native, uncertain, introduced, occurrence data.
**Introduction**

The Azorean algal flora, considered cosmopolitan, with species shared with Macaronesia, North Africa, the Mediterranean Sea, Atlantic Europe and America (Tittley 2003, Tittley and Neto 2006, Wallenstein et al. 2009), is relatively rich when compared to that of other remote oceanic Islands (Neto et al. 2005, Tittley and Neto 2005, Wallenstein et al. 2009). Around 400 species of marine macroalgae have, to date, been recorded for the isolated mid-Atlantic Azores archipelago (Freitas et al. 2019). These authors, based on extensive analysis encompassing data on brachyurans, polychaetes, gastropods, echinoderms, coastal fishes and macroalgae, suggested that the Azores should be a biogeographical entity of its own and proposed a redefinition of the Lusitanian biogeographical province, in which they recognised four ecoregions: the South European Atlantic Shelf, the Saharan Upwelling, the Azores ecoregion and a new ecoregion herein named Webbnesia, which comprises the archipelagos of Madeira, Selvagens and the Canary Islands. In their paper comparing the Azorean algal flora to that of the new Webbnesia region, they reported that the Canary Islands, with 689 species of marine macroalgae, are by far the most diverse archipelago, followed by the Azores (405), Madeira (396) and Cabo Verde (333). The Selvagens are the least diverse one (295 species). It is worth mentioning that the published information reflects data from only a few of the nine Azorean Islands, since not all of them have been adequately investigated. In the Azores archipelago, São Miguel is by far the Island with the largest amount of research dedicated to the study of its algal flora. The total number of algal species is, at the moment, 260, a number that is likely to increase due to ongoing research by authors of the present paper. Most of the remaining Islands have received less attention. To overcome this and improve the understanding of the archipelago’s macroalgal flora, research has been conducted over the past three decades on all the Islands. Data on the Islands of Pico, Graciosa and Terceira is already available on the recently-published papers (Neto et al. 2020a, Neto et al. 2020b, Neto et al. 2020c). Table 1 summarises the currently-available information.

| Phylum         | Santa Maria | São Miguel | Terceira | Graciosa | São Jorge | Pico | Faial | Flores | Corvo |
|----------------|-------------|------------|----------|----------|-----------|------|-------|--------|-------|
| Rhodophyta     | 68          | 168        | 73       | 126      | 35        | 142  | 59    | 59     | 13    |
| Chlorophyta    | 20          | 39         | 24       | 31       | 17        | 41   | 16    | 16     | 2     |
| Ochrophyta     | 28          | 53         | 16       | 38       | 10        | 42   | 8     | 16     | 4     |
| Total          | 116         | 260        | 113      | 195      | 62        | 225  | 83    | 91     | 19    |

To provide a better understanding of the archipelago's seaweed flora, a long term research programme of study has been undertaken, mainly by local investigators into the marine macroalgae flora on several of the less studied Azorean Islands. The present paper presents both physical and occurrence data and information gathered from surveys
undertaken on Flores and Corvo Islands mainly by the Island Aquatic Research Group of the Azorean Biodiversity Centre of the University of the Azores (Link: https://ce3c.ciencias.ulisboa.pt/sub-team/island-aquatic-ecology), the BIOISLE, Biodiversity and Islands Research Group of CIBIO- Açores at the University of the Azores (Link: https://cibio.up.pt/research-groups-1/details/bioisle) and the OKEANOS Centre of the University of the Azores (Link: http://www.okeanos.uac.pt). In these surveys, particular attention was given to the small filamentous and thin sheet-like species that are often short-lived and fast-growing and usually very difficult to identify in the wild, without the aid of a microscope and specialised literature in the laboratory.

The present paper aims to provide a valuable marine biological tool for research on systematics, diversity and conservation, biological monitoring, climate change and ecology for academics, students, government, private organisations and the general public.

General description

Purpose: In this paper, we present taxonomic records of macroalgae recorded from the Islands of Flores and Corvo and provide general information on their occurrence and distribution. By doing this, we are contributing to address several biodiversity shortfalls (see Cardoso et al. 2011, 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 abundance and dynamics in space (Prestonian shortfall).

Project description

Title: Marine algal flora of Flores and Corvo Islands, Azores.

Personnel: Collections were made and occurrence data recorded over several years (1989 - 2018). Main collectors were Ana Cristina Costa, Ana I Neto, Andrea Z. Botelho, Carolina Arruda, Cláudia Hipólito, Cristiana Figueiredo, David Milla-Figueras, Heather Baldwin, Inês Neto, Joana Michael, José M. N. Azevedo, Ian Tittley, Manuela I. Parente, Marco Henrique, Maria Ana Dionísio, Maria Ventura, Nuno Vaz Álvaro, Patrícia Madeira, Pedro Cerqueira, Raul Neto, Rita Grilo, Rita Norberto, Robert Fletcher, Sandra Monteiro and William Farnham.

Preliminary in situ identifications were carried out by: Ana Cristina Costa, Ana I Neto, Andrea Z. Botelho, David Milla-Figueras, Heather Baldwin, Ian Tittley, Manuela I. Parente, Maria Ventura, Rita Grilo, Robert Fletcher and William Farnham.

Ana I. Neto, Andrea Z. Botelho, David Milla-Figueras, Ian Tittley, Manuela I. Parente, Robert Fletcher and William Farnham were responsible for the final species identification.
Voucher specimen management was mainly undertaken by Afonso Prestes, Ana I. Neto, Andrea Z. Botelho, David Milla-Figueras, Eunice Nogueira, Manuela I. Parente, Natália Cabral and Roberto Resendes.

**Study area description:** The Azores archipelago (38°43′49″N, 27°19′10″W, Fig. 1), comprising nine Islands and several islets, is spread over 500 km, in a WNW direction. The Islands emerged from what is called the Azores Plateau and are located above an active triple junction between three of the world's largest tectonic plates (the North American Plate, the Eurasian Plate and the African Plate, Hildenbrand et al. 2018). Flores and Corvo (in black in Fig. 1), the westernmost Islands of the archipelago, are located in the North American Plate, whereas the remaining Islands are located around the boundary that divides the Eurasian and African Plates (Hildenbrand et al. 2018).

The Islands of Flores and Corvo are sub-aerial domains of a large volcanic formation, mostly submarine, implanted on an oceanic crust and aged between 9.0 and 10.0 million years (Ma). Each of these Islands has unique geomorphological characteristics: Flores (39°31′27″N, -31°15′31″W, Fig. 2), of approximately 141 km², is composed of two units, the central massif located in the central plain and the coastal periphery; Corvo, its neighbour (39°43′37″N, -31°7′44″W, Fig. 3), of approximately 17 km², is a crater of a major Plinian eruption and the smallest Island of the Azores archipelago (Azevedo 1999). The climate, as in the remaining Islands, is characterised by regular and abundant rainfall, high levels of...
relative humidity and persistent winds, mainly during the winter and autumn seasons (Morton et al. 1998). Fog is common and almost permanent at the higher elevations.

Marine action is responsible for the predominance of erosive morphologies in the coastal areas of both Islands, examples of which on Flores (Neto et al. 2008) are: the valleys associated with fluvial erosion (Vales das Lajes and da Fazenda); the coastal or back cliffs (Fajãzinha - Ponta da Fajã); the large marine abrasion platforms (Fajãzinha - Fajã Grande); and the coastal platforms associated with landslides and collapses (Ponta da Fajã).

Owing to the lack of a continental shelf that characterises most volcanic Islands, coastal extension is restricted and deep waters occur within a few kilometres offshore. The tidal
range is small (< 2 m, Hidrogrográfico 1981) and coasts are subjected to swell and surge for most of the year.

The Islands’ coastline, approximately 72.209 km long on Flores and 19.045 km long on Corvo, is predominantly rocky, subject to strong maritime erosion and presents an irregular slope with extensive and high cliffs cut by waterfalls and streams, alternating with a complex system of bays, rocky beaches and natural terraces (Azevedo 1999). The bottom is mostly made up of irregular rocky bedrock, containing, in some places, pockets of sediment of coarse sand and gravel, alternating with places covered by blocks that rest on either the rocky bed or the sediment. Submerged or semi-submerged caves, arches and tunnels of small amplitude and reduced length are common. As depth increases, the slope decreases, although the bottom is still rocky and uneven. This feature is interrupted by valleys and other structures of smooth to rough relief. The sediment floor in the deepest areas is stable, generally composed of medium and/or coarse sand. From this floor arise small islets with normally vertical walls and low irregular crowns, marked by ridges and valleys (Neto et al. 2008). Along the coastline and islets, natural sheltered habitats (arches and semi-submerged caves, tide pools) create favourable conditions for the growth of juveniles and adults of coastal fish. The constant recycling of nutrients caused by the wave-exposed coasts of these Islands, provides suitable conditions for the occurrence of considerable diversity and abundance of macroinvertebrates and pelagic and benthic fish (Neto et al. 2008). At the foot of the cliffs, the rocky intertidal zone is, as elsewhere in the Azores, dominated by algal communities that form mosaic and/or horizontal bands relative to tide level and are made up of multispecific algal turfs (growth forms of either diminutive algae or diminutive forms of larger species) that carpet the rocks. In the intertidal, a distinct zonation pattern is evident. The higher zone, dominated by invertebrates (littorinids and chthamalid barnacles, Fig. 4), gives rise below to a mid-shore zone covered by algal turfs that create a dense, compact mat 20-30 mm in thickness, Fig. 5). The turf can be monospecific (of either Caulacanthus ustulatus (Turner) Kützing, Centrceras clavulatum (C. Agardh) Montagne or Gymnogongrus) or multispecific and composed by soft algae (e.g. Centrceras clavulatum, Ceramium and Chondracanthus) usually growing as epiphytes over articulate calcareous forms (e.g. Ellisolandia and Jania). The low-shore zone is mainly dominated by calcareous crusts (first/basal strata), covered by corticated macrophytes, for example, Ellisolandia elongata (J.Ellis & Solander) K.R.Hind & G.W.Saunders (Fig. 6) and Pterocladiella capillacea (S.G.Gmelin) Santelices & Hommersand (Fig. 7) and, in more exposed locations, Tenarea tortuosa (Esper) Me Lemoine (Neto et al. 2008). Seasonally and mainly in spring and summer, the introduced red alga Asparagopsis armata occurs often abundantly at this lower intertidal level. Important features and habitats at this shore level are rock pools, occurring in different shapes and sizes and often recreating a shallow subtidal habitat, which contains a rich diversity of marine life. A few shores consist of irregularly rounded boulders or cobbles between which coarse sand or gravel may be retained. Sandy shores are rare (Neto, pers. observ.). The rocky bottoms in the submerged zone are covered by more frondose macrophytes, such as Pterocladiella capillacea, Halopteris filicina (Grateloup) Kützing, Dictyota spp. or Zonaria tournefortii (J.V.Lamouroux) Montagne (Fig. 8). At this level, the edible barnacles Megabalanus azoricus (Pilsbry, 1916) and/or the limpets Patella aspera
Röding, 1798 are concentrated in the first few metres, while the slipper lobsters *Scyllarides latus* (Latreille, 1803) or the spiny lobsters *Palinurus elephas* (Fabricius, 1787) are found at greater depths. Several species of fish, such as the blue wrasse *Symphodus caeruleus* (Azevedo, 1999) or the ornate wrasse *Thalassoma pavo* (Linnaeus, 1758), are particularly frequent in shallow rocky areas, whereas other fish take shelter in crevices during the day, such as the morays, *Muraena helena* Linnaeus, 1758 or the forkbeards *Phycis phycis* (Linnaeus, 1766). Still other species roam amongst rocky reefs, such as the parrotfish *Sparisoma cretense* (Linnaeus, 1758), the salemas *Sarpa salpa* (Linnaeus, 1758) and the white sea bream *Diplodus sargus* (Linnaeus, 1758). In the numerous sea caves around Flores and Corvo, the dusky grouper *Epinephelus marginatus* (Lowe, 1834) occurs with an unknown frequency in most of the other Islands (Neto et al. 2008).
In 2007, both Flores and Corvo Islands were recognised by UNESCO as a Biosphere Reserve and thus integrated into the programme “The Man and the Biosphere”. The programme focuses on the ecological, social and economic dimensions of biodiversity loss and uses the World Network of Biosphere Reserves as a vehicle for knowledge sharing, research and monitoring, education and training and participatory decision-making with local communities. The proposed area for the Biosphere Reserve includes the entire emerged land area of the Islands and a surrounding marine zone, covering a total area of 58,619 hectares in Flores and 25,853 hectares in Corvo and incorporating an important diversity of habitats of regional, national and international importance, which includes, for example, areas integrated in the Natura 2000 Network. The inclusion of a vast marine area promotes explicitly, along with conservation, an integrated management practice between terrestrial, coastal and marine environments (Neto et al. 2008).

Figure 6. The calcareous frondose alga *Ellisolandia elongata* at the low intertidal level (by the Island Aquatic Ecology Subgroup of cE3c-ABG).

Figure 7. The red agarophyte *Pterocladiella capillacea*, a common species at the low intertidal level (by the Island Aquatic Ecology Subgroup of cE3c-ABG).
Design description: The algae referred to in this paper were collected during field surveys from both the littoral and sublittoral regions down to approximately 40 m on the Islands of Flores and Corvo. Each sampling location was visited several times. On each occasion, a careful and extensive survey was undertaken to provide good coverage of the area. Both presence recording and physical collections were made by walking over the shores or by SCUBA diving. The specimens collected were taken to the laboratory for identification and preservation and the resulting vouchers were deposited in the AZB Herbarium Ruy Telles Palhinha and the Molecular Systematics Laboratory at the Faculty of Sciences and Technology of the University of the Azores.

Funding: This study was mainly financed by the following projects/scientific expeditions:

- **Projects:**
  - IASTFC- “Impact Assessment Study for the construction of the Transport Infrastructures of the Islands of Flores and Corvo, Azores - natural environment”, funded by the Azores Regional Government - Regional Secretariat for Tourism and Environment / Regional Environment Directorate, 1990;
  - LFFC- “Littoral flora of the islands of Flores and Corvo: Inventory, ecology and biogeographic affinities”, Government of the Azores - Regional Secretariat for Tourism and Environment / Regional Environment Directorate (GRA-SRTA / DRA), 1995-1999;
  - Project Flores- Biosphere - “Application of Flores Island to a Biosphere Reserve”. Government of the Azores - Regional Secretariat for the Environment and the Sea (GRA-SRAM). 2007-2008;
  - Project MOST - “Application of a model of sustainable tourism to areas of Natura 2000 network in the Azores” (PTDC / AAC-AMB / 104714/2008). Foundation for Science and Technology and the Government of the Azores.
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Acores - Regional Secretariat for the Sea, Science and Technology, Regional Directorate for Sea Affairs (GRA / SRMCT-DRAM), 2010 - 2013;
◦ Project PIMA – “Elaboration of the implementation program of the Marine Strategy Framework Directive - Marine Invasion Program in the Azores” (3 /DRAM /2015). Government of the Azores - Regional Secretariat for the Sea, Science and Technology, Regional Directorate for Sea Affairs (GRA / SRMCT-DRAM), 2015;
◦ Project BALA – “Elaboration of the implementation program of the marine strategy framework directive - biodiversity of the coastal environments of the Azores” (2 /DRAM /2015). Government of the Azores - Regional Secretariat for the Sea, Science and Technology, Regional Directorate for Sea Affairs (GRA / SRMCT-DRAM), 2015;
◦ Project “ACORES-01-0145-FEDER-000072 - AZORES BIOPORTAL – PORBIOTA. Operational Programme Azores 2020 (85% ERDF and 15% regional funds);
• Scientific Expeditions and campaigns:
◦ “FLORES/89”, organised by the Biology Department of the University of the Azores, Flores Island, Azores, July 1989;
◦ “Earthwatch FLORES/95”, a joint organisation of the Marine Biology Section of the Biology Department of the University of the Azores and the Natural History Museum (London), co-funded by the Earthwatch International and developed under the project LFFC, July – August 1995;
◦ “FLORES & CORVO/99”, developed under the project LFFC, July 1999;
◦ “FLORES & CORVO/2007”, XIII Scientific Expedition of the Biology Department of the University of the Azores, Islands of Flores and Corvo, July 2007;
◦ “MOST”, under the project MOST, 2011-2013;
◦ “PIMA/BALA”, under the projects PIMA and BALA, 2015;
• Other funds:
◦ Portuguese National Funds, through FCT– Fundação para a Ciência e a Tecnologia, within the projects UID/BIA/00329/2013, 2015-2019, UID/BIA/00329/2020-2023 and UID/BIA/50027/2019 and POCI-01-0145-FEDER-006821;
◦ ERDF funds through the Operational Programme for Competitiveness Factors – COMPETE;
◦ Portuguese Regional Funds, through DRCT - Regional Directorate for Science and Technology, within several projects, 2019 and 2020 and SRMCT / DRAM - Regional Secretariat for the Sea, Science and Technology, Regional Directorate for Sea Affairs;
◦ CIRN/DB/UAc (Research Centre for Natural Resources, Universidade dos Açores, Departamento de Biologia);
◦ CIIMAR (Interdisciplinary Centre of Marine and Environmental Research, Porto, Portugal).
Sampling methods

Study extent: This study covers a relatively large area, of approximately 143 km² on Flores and 17 km² on Corvo, covering littoral and sublittoral levels down to approximately 40 m around the Islands (Tables 2, 3, Figs 2, 3).

Table 2.
Information and location of the sampling sites on Flores Island.

| Location No | Location ID | Municipality | Locality | Latitude / Longitude | Littoral zone |
|-------------|-------------|--------------|----------|----------------------|---------------|
| 1           | FLO_bris    | Baixa Rasa do Ilhéu |          | 39.495215; -31.274644 | Subtidal      |
| 2           | FLO_L_FGem  | Lajes | Fajã Grande | Entre-marés | 39.453485; -31.267758 | Intertidal    |
| 3           | FLO_L_FGprb | Lajes | Fajã Grande | Porto de Recreio | Baía | 39.460831; -31.261651 | Subtidal      |
| 4           | FLO_L_FGprem| Lajes | Fajã Grande | Porto de Recreio | Entre-marés | 39.459356; -31.261244 | Intertidal    |
| 5           | FLO_L_FGpvb | Lajes | Faja Grande | Porto Velho | Baía | 39.456795; -31.268607 | Subtidal      |
| 6           | FLO_L_FGpvb | Lajes | Faja Grande | Porto Velho | Baía | 39.458818; -31.264851 | Intertidal    |
| 7           | FLO_L_FGpve | Lajes | Fajã Grande | Porto Velho | Enseada | 39.459471; -31.264743 | Subtidal      |
| 8           | FLO_L_FGpve | Lajes | Faja Grande | Porto Velho | Entre-marés | 39.458818; -31.264851 | Intertidal    |
| 9           | FLO_L_Ls    | Lajes | Lajedo | | 39.392978; -31.259311 | Subtidal      |
| 10          | FLO_L_Lnt   | Lajes | Lajedo | Nascente termal | | 39.393021; -31.258356 | Intertidal    |
| 11          | FLO_L_Lapem | Lajes | Lajes | Atrás do Porto | Entre-marés | 39.377324; -31.169366 | Intertidal    |
| 12          | FLO_L_Laps  | Lajes | Lajes | Atrás do Porto | Subtidal | 39.372111; -31.17103 | Subtidal      |
| 13          | FLO_L_Lem   | Lajes | Lajes | Entre-marés | | 39.376978; -31.171336 | Intertidal    |
| Location No | Location ID | Municipality       | Locality                                      | Latitude / Longitude     | Littoral zone |
|-------------|------------|-------------------|----------------------------------------------|--------------------------|---------------|
| 14          | FLO_L_Flvs | Lajes             | Lajes | Fajã de Lopo Vaz                         | 39,372801; -31,208518    | Subtidal      |
| 15          | FLO_L_Fpls | Lajes             | Lajes | Fazenda | Porto da Lomba                      | 39,399797; -31,150731    | Subtidal      |
| 16          | FLO_L_Ms   | Lajes             | Lajes | Mosteiro                                | 39,413261; -31,260714    | Subtidal      |
| 17          | FLO_L_Lp   | Lajes             | Lajes | Porto                                   | 39,379015; -31,167686    | Subtidal      |
| 18          | FLO_SC_CAb | Santa Cruz        | Cedros | Alagoa | Baía                                | 39,474441; -31,144853    | Subtidal      |
| 19          | FLO_SC_CAem | Santa Cruz       | Cedros | Alagoa | Entre-marés                         | 39,474473; -31,148271    | Intertidal    |
| 20          | FLO_SC_PDapem | Santa Cruz    | Ponta Delgada | Atrás do Porto | Entre-marés | 39,519728; -31,206613    | Intertidal    |
| 21          | FLO_SC_PDaps | Santa Cruz       | Ponta Delgada | Atrás do Porto | Entre-marés | 39,519568; -31,206579    | Subtidal      |
| 22          | FLO_SC_PDpem | Santa Cruz       | Ponta Delgada | Porto | Entre-marés                         | 39,519473; -31,208125    | Intertidal    |
| 23          | FLO_SC_PDpes | Santa Cruz       | Ponta Delgada | Porto | Este                                 | 39,519017; -31,206235    | Subtidal      |
| 24          | FLO_SC_PDpos | Santa Cruz       | Ponta Delgada | Porto | Oeste                               | 39,520223; -31,205269    | Subtidal      |
| 25          | FLO_SC_PDFAs | Santa Cruz      | Farol de Albernaz                         | 39,520461; -31,238744    | Subtidal      |
| 26          | FLO_SC_SCaps | Santa Cruz       | Santa Cruz | Atrás do porto |                             | 39,452411; -31,125155    | Subtidal      |
| 27          | FLO_SC_SCapvem | Santa Cruz   | Santa Cruz | Atrás do porto velho |                       | 39,454593; -31,124608    | Intertidal    |
| 28          | FLO_SC_SCapvem | Santa Cruz   | Santa Cruz | Atrás do porto velho | Entre-marés | 39,454593; -31,124608    | Intertidal    |
| 29          | FLO_SC_Scbvs | Santa Cruz       | Santa Cruz | Baixa vermelha                           | 39,46859; -31,135821     | Subtidal      |
| 30          | FLO_SC_SCbpds | Santa Cruz     | Santa Cruz | Baixas de Ponta Delgada                 | 39,526318; -31,206453    | Subtidal      |
| Location No | Location ID     | Municipality | Locality                       | Latitude / Longitude | Littoral zone |
|-------------|----------------|--------------|--------------------------------|----------------------|---------------|
| 31          | FLO_SC_SCfs    | Santa Cruz   | Santa Cruz | Fazenda               | 39.469496; -31.139423 | Subtidal      |
| 32          | FLO_SC_SCiars  | Santa Cruz   | Santa Cruz | Ilhêu de Álvaro Rodrigues | 39.488436; -31.148651 | Subtidal      |
| 33          | FLO_SC_SCigs   | Santa Cruz   | Santa Cruz | Ilhêu do Garajau      | 39.48444; -31.145556  | Subtidal      |
| 34          | FLO_SC_SCias   | Santa Cruz   | Santa Cruz | Ilhêu dos Abrões       | 39.504518; -31.187712 | Subtidal      |
| 35          | FLO_SC_SCifs   | Santa Cruz   | Santa Cruz | Ilhêu Francisco        | 39.523814; -31.214148 | Subtidal      |
| 36          | FLO_SC_SCimvs  | Santa Cruz   | Santa Cruz | Ilhêu Maria Vaz        | 39.505833; -31.245   | Subtidal      |
| 37          | FLO_SC_Scipas  | Santa Cruz   | Santa Cruz | Ilhêu Pão de Açúcar    | 39.500367; -31.170582 | Subtidal      |
| 38          | FLO_SC_SCpiem  | Santa Cruz   | Santa Cruz | Piscinas | Entre-marés | 39.458842; -31.124608 | Intertidal |
| 39          | FLO_SC_SCpcs   | Santa Cruz   | Santa Cruz | Ponta da Caveira       | 39.424187; -31.145587 | Subtidal      |
| 40          | FLO_SC_Spis    | Santa Cruz   | Santa Cruz | Ponta do lhêu          | 39.509661; -31.19527  | Subtidal      |
| 41          | FLO_SC_SCpros  | Santa Cruz   | Santa Cruz | Ponta Ruiva | Oeste | 39.495572; -31.152406 | Subtidal      |
| 42          | FLO_SC_Spbbd   | Santa Cruz   | Santa Cruz | Porto da Baleia | Baía | Deep | 39.463387; -31.127258 | Subtidal      |
| 43          | FLO_SC_Spbbs1  | Santa Cruz   | Santa Cruz | Porto da Baleia | Baía | Shallow 1 | 39.463035; -31.128021 | Subtidal      |
| 44          | FLO_SC_Spbbs2  | Santa Cruz   | Santa Cruz | Porto da Baleia | Baía | Shallow 2 | 39.463731; -31.12752 | Subtidal      |
| 45          | FLO_SC_Spbbb   | Santa Cruz   | Santa Cruz | Porto da Baleia | Bóia flutuante | 39.463035; -31.128021 | Bóia          |
| 46          | FLO_SC_Spbem1  | Santa Cruz   | Santa Cruz | Porto da Baleia | Entre-marés 1 | 39.463518; -31.128256 | Intertidal |
| 47          | FLO_SC_Spbem2  | Santa Cruz   | Santa Cruz | Porto da Baleia | Entre-marés 2 | 39.463686; -31.128523 | Intertidal |
| Location No | Location ID | Municipality | Locality | Latitude / Longitude | Littoral zone |
|------------|-------------|--------------|----------|----------------------|--------------|
| 48         | FLO_SC_SCpvs | Santa Cruz | Santa Cruz | 39.454305; -31.12449 | Subtidal     |
| 1          | COR_VC_VCaaem | Vila do Corvo | Vila do Corvo | 39.670289; -31.115366 | Intertidal |
| 2          | COR_VC_VCms | Vila do Corvo | Vila do Corvo | 39.668742; -31.120615 | Subtidal |
| 3          | COR_VC_VCps | Vila do Corvo | Vila do Corvo | 39.669127; -31.113446 | Subtidal |
| 4          | COR_VC_VCps | Vila do Corvo | Vila do Corvo | 39.669127; -31.113446 | Subtidal |
| 5          | COR_VC_VCpas | Vila do Corvo | Vila do Corvo | 39.672838; -31.123437 | Subtidal |
| 6          | COR_VC_VCpem | Vila do Corvo | Vila do Corvo | 39.671968; -31.110846 | Intertidal |
| 7          | COR_VC_VCps | Vila do Corvo | Vila do Corvo | 39.672729; -31.109214 | Subtidal |
| 8          | COR_VC_VCpbem | Vila do Corvo | Vila do Corvo | 39.669523; -31.112739 | Intertidal |
| 9          | COR_VC_VCpbs | Vila do Corvo | Vila do Corvo | 39.668229; -31.112482 | Subtidal |

**Sampling description:** Intertidal collections were made during low tide by walking over the shores. Subtidal collections were made by SCUBA diving around the area. Sampling involved specimen collecting and species presence recording. For the former, at each location, samples were obtained by scraping from the surface one or two specimens of all the observed species and then placing them into labelled bags (Fig. 9). Species recording data was gathered by registering all species present in the sampled locations visited (Fig. 10).

**Quality control:** Each sampled taxon was identified by trained taxonomists and involved morphological and anatomical observations of whole specimens by eye and/or of
histological preparations under microscopes to determine the main diagnostic features of each species, as described in literature.

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

Species identification was usually based on a combination of morphological, anatomical and reproductive features. For small and simple thalli, this required observing the entire thallus with the unaided eye and/or using dissecting and compound microscopes. For larger and more complex algae, investigation of the thallus anatomy required histological procedures (longitudinal and transverse sections) or squashed preparations of mucilaginous thalli, sometimes after staining, to observe vegetative and reproductive structures and other diagnostic features.

The mixed nature of the Azorean algal flora with components from several geographical regions cause difficulties in species identification. Floras and keys for the North Atlantic, Tropical Atlantic and Western Mediterranean were used (e.g. Schmidt 1931, Taylor 1967, Taylor 1978, Levrin 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, Llorèns et al. 2012, Rodríguez-Prieto et al. 2013).

For more critical and taxonomically-difficult taxa, specimens were taken to the Natural History Museum (London) for comparison with collections there.

A reference collection was made for all collected specimens by assigning them a herbarium code number and depositing them at the AZB Herbarium Ruy Telhes Palhinha and the Molecular Systematics Laboratory, University of Azores. Depending on the species and on planned further research, 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); (ii) dried collections, either by pressing the algae (most species) as described by Gayral and Cosson (1986) or by letting them air dry (calcareous species); and (iii) silica gel collections for molecular studies.

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

Figure 10. doi

Quantitative recording of the presence and coverage of macroalgal species at the subtidal rocky habitat (by the Island Aquatic Ecology Subgroup of cE3c-ABG).

Geographic coverage

**Description:** Flores Island Description: Azores, Portugal (approximately 39°31'27"N, -31°15'31"W);

**Coordinates:** 39.524201 and 39.37521 Latitude; -31.258622 and -31.124496 Longitude.

**Corvo Island Description:** Azores, Portugal (approximately 39°43'37"N, -31°7'44"W).

**Coordinates:** 39.726829 and 39.669576 Latitude; -31.12899 and -31.082546 Longitude.

Taxonomic coverage

**Description:** All macroalgae were identified to genus or species level. For Flores, a total of 196 taxa were identified belonging to 24 orders and 54 families, distributed in the phyla Rhodophyta (14 orders and 33 families), Chlorophyta (three orders and nine families) and Ochrophyta (seven orders and 12 families). For Corvo, a total of 56 taxa were identified belonging to 16 orders and 29 families, distributed in the phyla Rhodophyta (seven orders
and 16 families), Chlorophyta (three orders and four families) and Ochrophyta (six orders and nine families).

Temporal coverage

Notes: The sampling was performed on several occasions between 1989 and 2018.

Collection data

Collection name: AZB | Marine macroalgae collection of Flores and Corvo Islands (Azores)-Expedition Flores/89; AZB | Marine macroalgae collection of Flores and Corvo Islands (Azores)-Expedition Earthwatch Flores/95; AZB | Marine macroalgae collection of Flores and Corvo Islands (Azores)-Expedition Flores & Corvo/99; Marine macroalgae collection of Flores and Corvo Islands (Azores)-Expedition Flores & Corvo/2007; AZB | Marine macroalgae collection of Flores and Corvo Islands (Azores)-Occasional sampling; AZB | Marine macroalgae collection of Flores and Corvo Islands (Azores)-Occasional sampling; Marine macroalgae occurrence of Flores and Corvo Islands (Azores)-Expedition Flores & Corvo/99; Marine macroalgae occurrence of Flores and Corvo Islands (Azores)-Project MOST; Marine macroalgae occurrence of Flores and Corvo Islands (Azores)-Campaign PIMA/BALA; Marine macroalgae occurrence of Flores and Corvo Islands (Azores)-Occasional sampling.

Collection identifier: 33967202-6b10-4182-99d2-621d594572cc; cd4c8ddd-49f7-4318-9b3d-c78aaec53c2d; 93772fb0-339a-4081-b742-a101ca66c019; a7ca4500-9608-44eb-9269-528a40264071; 1a7a0a41-5a5c-460c-815d-0c3503a5a2ea; cfc9d276-6d4e-4cc3-8f40-be9c3e5ba6e9; 434097ea-bac3-49ac-9f5a-3aa9b6c10503; db4e55cc-1401-4b1c-9343-fc2a3e27e473; 29ca7edc-3911-4c59-9722-c9aba69ca506; 153bd328-1e16-4e9e-8dc8-56994c25fb31.

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; AZB Herbarium Ruy Telles Palhinha, Faculty of Sciences and Technology of the University of the Azores; Expedition Flores & Corvo/2007 Macroalgae collection, 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; AZB Herbarium Ruy Telles Palhinha, Faculty of Sciences and Technology of the University of the Azores; Not applicable; Not applicable; Not applicable; Not applicable.

Specimen preservation method: All specimens were preserved as follows: 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.
Usage licence

Usage licence: Creative Commons Public Domain Waiver (CC-Zero)

Data resources

Data package title: Marine algal flora of Flores and Corvo Islands, Azores
Resource link: http://ipt.gbif.pt/ipt/resource?r=flores-corvo_seaweed_flora
Alternative identifiers: http://ipt.gbif.pt/ipt/resource?r=flores-corvo_seaweed_flora

Number of data sets: 1

Data set name: Marine algal flora of Flores and Corvo Islands, Azores

Character set: UTF-8

Download URL: http://ipt.gbif.pt/ipt/archive.do?r=flores-corvo_seaweed_flora

Data format: Darwin Core Archive

Data format version: 1.3

Description: This data paper presents physical and occurrence data from macroalgal surveys undertaken on Flores and Corvo Islands between 1989 and 2018 (Neto et al. 2020d). 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 90 records (eventID). The extension data table has 2077 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                                           |
|------------------|--------------------------------------------------------------|
| 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                                         |
| Field                          | Description                                                                 |
|-------------------------------|-----------------------------------------------------------------------------|
| 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                                                              |
| minimumDepthInMeters         | The minimum depth in metres where the specimen was found                    |
| maximumDepthInMeters         | The maximum depth in metres where the specimen was found                    |
| eventRemarks                 | Notes about the event                                                       |
| 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                                |
Additional information

This paper accommodates the 1687 specimens of macroalgae recorded from Flores Island in 196 taxa comprising 128 confirmed species and 68 taxa identified only to generic level. The confirmed species (Tables 4, 5) include 80 Rhodophyta, 22 Chlorophyta and 26 Ochrophyta (Phaeophyceae). Of these, 37 species are newly recorded for the Island (20 Rhodophyta, six Chlorophyta and 11 Ochrophyta). Most species are native, including the two Macaronesian endemics (*Laurencia viridis* and *Millerella tinerfensis*). Six species are introductions to the algal flora (*Asparagopsis armata*, *Neoizziella divaricata* and *Symphyocladia marchantioides*; the Chlorophyta *Codium fragile* subsp. *fragile*; and the Ochrophyta *Hydroclathrus tilesii* and *Papenfussiella kuromo*). Fourteen species are uncertain in status (10 Rhodophyta, two Chlorophyta and two Ochrophyta).

Many species were only sporadically recorded on Flores, but 19 were commonly found around the Island and occurred quite abundantly in some locations, namely: the Rhodophyta *Acrosorium ciliolatum* (Harvey) Kylin, *Asparagopsis armata*, A. *taxiformis* (Dellile) Trevisan, *Platoma cyclocolpum* (Montagne) F.Schmitz, *Plocamium cartilagineum* (Linnaeus) P.S.Dixon, *Pterocladiella capillacea* and *Sphaerococcus coronopifolius* Stackhouse; the Chlorophyta *Anadyomene stellata* (Wulfen) C.Agardh, *Cladophora prolifera* (Roth) Kützing, *Codium adhaerens* C.Agardh, *Microdictyon umbilicatum* (Velley) Zanardinian *Ulva rigida* C.Agardh; and the Ochrophyta *Cladostephus spongiosus* (Hudson) C.Agardh, *Colpomenia sinuosa* (Mertens ex Roth) Derbès & Solier in Castagne,
**Table 4.**
Macroalgal species recorded from Flores Island, with information on relative abundance, origin and status.

| Phylum        | Species (Accepted Name)                                                      | Number of records | Establishment Means | Occurrence Remarks |
|---------------|------------------------------------------------------------------------------|-------------------|---------------------|--------------------|
| Chlorophyta   | *Anadyomene stellata* (Wulfen) C.Agardh                                      | 13                | Uncertain           |                    |
| Chlorophyta   | *Bryopsis cupressina* J.V.Lamouroux                                          | 2                 | Native              | New record         |
| Chlorophyta   | *Bryopsis hypnoides* J.V.Lamouroux                                           | 4                 | Native              |                    |
| Chlorophyta   | *Bryopsis pennata* J.V.Lamouroux                                              | 1                 | Native              |                    |
| Chlorophyta   | *Bryopsis plumosa* (Hudson) C. Agardh                                        | 3                 | Native              |                    |
| Chlorophyta   | *Chaetomorpha aerea* (Dillwyn) Kützing                                       | 1                 | Native              |                    |
| Chlorophyta   | *Cladophora albida* (Nees) Kützing                                            | 3                 | Native              |                    |
| Chlorophyta   | *Cladophora coelothrix* Kützing                                              | 6                 | Native              |                    |
| Chlorophyta   | *Cladophora hutchinsiae* (Dillwyn) Kützing                                   | 2                 | Native              | New record         |
| Chlorophyta   | *Cladophora lehmanniana* (Lindenberg) Kützing                                | 5                 | Native              | New record         |
| Chlorophyta   | *Cladophora prolifera* (Roth) Kützing                                       | 20                | Native              |                    |
| Chlorophyta   | *Cladophoropsis membranacea* (Hofman Bang ex C.Agardh) Bærgesen              | 1                 | Uncertain           |                    |
| Chlorophyta   | *Codium adhaerens* C.Agardh                                                   | 18                | Native              |                    |
| Chlorophyta   | *Codium decorticatum* (Woodward) M.A.Howe                                    | 3                 | Native              | New record         |
| Chlorophyta   | *Codium fragile* subsp. *fragile* (Suringar) Hariot                           | 5                 | Introduced          | New record         |
| Chlorophyta   | *Derbesia marina* (Lyngbye) Solier                                            | 1                 | Native              |                    |
| Chlorophyta   | *Lychaete pellucida* (Hudson) M.J.Wynne                                      | 4                 | Native              | New record         |
| Chlorophyta   | *Microdictyon umbilicatum* (Velley) Zanardini                                | 31                | Native              |                    |
| Chlorophyta   | *Ulva clathrata* (Roth) C.Agardh                                             | 3                 | Native              |                    |
| Chlorophyta   | *Ulva intestinalis* Linnaeus                                                   | 8                 | Native              |                    |
| Chlorophyta   | *Ulva rigida* C.Agardh                                                        | 10                | Native              |                    |
| Chlorophyta   | *Valonia utricularis* (Roth) C.Agardh                                        | 3                 | Native              |                    |
| Ochrophyta    | *Ascothystum nodosum* (Linnaeus) Le Jolis                                     | 7                 | Native              |                    |
| Ochrophyta    | *Carpomitra costata* (Stackhouse) Batters                                    | 2                 | Native              |                    |
| Ochrophyta    | *Cladostephus spongiosus* (Hudson) C.Agardh                                  | 23                | Native              |                    |
| Phylum   | Species (Accepted Name)                                                                 | Number of records | Establishment Means | Occurrence | Remarks                        |
|---------|----------------------------------------------------------------------------------------|-------------------|---------------------|------------|--------------------------------|
| Ochrophyta | *Colpomenia sinuosa* (Mertens ex Roth) Derbès & Solier                               | 61                | Native              |            |                                |
| Ochrophyta | *Cutleria multifida* (Turner) Greville                                                | 4                 | Uncertain           |            |                                |
| Ochrophyta | *Cutleria multifida* (Turner) Grevill, phase *Aglaozonia parvula* (Greville) Zanardini | 2                 | Uncertain           | New record |                                |
| Ochrophyta | *Cystoseira foeniculacea* (Linnaeus) Greville                                        | 4                 | Native              |            |                                |
| Ochrophyta | *Cystoseira humilis* Schousboe ex Kützing                                              | 1                 | Native              |            |                                |
| Ochrophyta | *Dictyopteris polypondiioides* (A.P.De Candolle) J.V.Lamouroux                         | 2                 | Native              | New record |                                |
| Ochrophyta | *Dictyota barbarysiana* J.V.Lamouroux                                                  | 4                 | Native              |            |                                |
| Ochrophyta | *Dictyota cyanoloma* Tronholm, De Clerck, A.Gómez-Garreta & Rull Lluch                 | 1                 | Native              | New record |                                |
| Ochrophyta | *Dictyota dichotoma* (Hudson) J.V.Lamouroux                                           | 3                 | Native              |            |                                |
| Ochrophyta | *Halopteris filicina* (Gratetloup) Kützing                                            | 54                | Native              |            |                                |
| Ochrophyta | *Halopteris scoparia* (Linnaeus) Sauvageau                                            | 61                | Native              |            |                                |
| Ochrophyta | *Hydroclathrus tilesii* (Endlicher) Sántañez & M.J.Wynne                            | 1                 | Introduced          | New record |                                |
| Ochrophyta | *Leathesia marina* (Lyngbye) Decaisne                                                 | 6                 | Uncertain           |            |                                |
| Ochrophyta | *Lobophora variegata* (J.V.Lamouroux) Womersley ex E.C.Oliveira                     | 11                | Native              | New record |                                |
| Ochrophyta | *Myrionema strangulans* Greville                                                     | 1                 | Native              |            |                                |
| Ochrophyta | *Padina pavenica* (Linnaeus) Thivy                                                   | 85                | Native              |            |                                |
| Ochrophyta | *Papenfussiella kuroma* (Yendo) Inagaki                                                | 1                 | Introduced          | New record |                                |
| Ochrophyta | *Petrospongium berkeleyi* (Greville) Nägeli ex Kützing                                | 1                 | Native              | New record |                                |
| Ochrophyta | *Sargassum furcatum* Kützing                                                          | 5                 | Native              | New record |                                |
| Ochrophyta | *Sargassum vulgare* C.Agardh, nom. illeg.                                             | 5                 | Native              |            |                                |
| Ochrophyta | *Sphacecalaria cirosa* (Roth) C.Agardh                                               | 1                 | Native              | New record |                                |
| Ochrophyta | *Taonia atomaria* (Woodward) J.Agardh                                                 | 6                 | Native              | New record |                                |
| Ochrophyta | *Zanardinia typus* (Nardo) P.C.Silva                                                   | 15                | Native              | New record |                                |
| Ochrophyta | *Zonaria tournefortii* (J.V.Lamouroux) Montagne                                        | 96                | Native              |            |                                |
| Rhodophya | *Acrosorium ciliolatum* (Harvey) Kylin                                                | 35                | Native              |            |                                |
| Rhodophya | *Amphiroa beavoensis* J.V.Lamouroux                                                   | 1                 | Native              |            |                                |
| Rhodophya | *Amphiroa rigida* J.V.Lamouroux                                                       | 5                 | Native              |            |                                |
| Rhodophya | *Asparagopsis armata* Harvey                                                          | 58                | Introduced          |            |                                |
| Phylum     | Species (Accepted Name)                                                                 | Number of records | Establishment Means | Occurrence | Remarks         |
|------------|----------------------------------------------------------------------------------------|-------------------|---------------------|------------|-----------------|
| Rhodophya  | Asparagopsis armata Harvey, phase                                                      | 6                 | Introduced          |            |                 |
|            | Falkenbergia rufolanosa (Harvey) F.Schmit                                              |                   |                     |            |                 |
| Rhodophya  | Asparagopsis taxiformis (Delile) Trevisan                                               | 38                | Native              |            |                 |
| Rhodophya  | Bornetia secundiflora (J.Agardh) Thuret                                                 | 2                 | Native              |            |                 |
| Rhodophya  | Botryocladia botryoides (Wulffen) Feldmann                                            | 8                 | Native              |            | New record      |
| Rhodophya  | Callithamnion corymbosum (J.E.Smith) Lyngbye                                            | 3                 | Native              |            |                 |
| Rhodophya  | Callithamnion granulatum (Ducluzeau) C.Agardh                                          | 2                 | Native              |            | New record      |
| Rhodophya  | Caulacanthus ustulatus (Turner) Kützing                                                | 2                 | Uncertain           |            |                 |
| Rhodophya  | Centroceras clavulatum (C.Agardh) Montagne                                             | 14                | Native              |            |                 |
| Rhodophya  | Ceramium ciliatum (J.Ellis) Ducluzeau                                                 | 2                 | Native              |            |                 |
| Rhodophya  | Ceramium cimbricum H.E.Petersen                                                        | 3                 | Native              |            |                 |
| Rhodophya  | Ceramium derbesii Solier ex Kützing                                                    | 2                 | Native              |            |                 |
| Rhodophya  | Ceramium echionotum J.Agardh                                                           | 1                 | Native              |            | New record      |
| Rhodophya  | Ceramium gaditanum (Clemente) Cremades                                                 | 2                 | Uncertain           |            |                 |
| Rhodophya  | Ceramium virgatum Roth                                                                 | 3                 | Native              |            |                 |
| Rhodophya  | Ceratodictyon intricatum (C.Agardh) R.E.Norris                                         | 2                 | Native              |            |                 |
| Rhodophya  | Ceratodictyon scoparium (Montagne & Millardet) R.E.Norris                              | 1                 | Uncertain           |            | New record      |
| Rhodophya  | Chondracanthus acicularis (Roth) Fredericq                                             | 11                | Native              |            |                 |
| Rhodophya  | Chondracanthus teedei (Mertens ex Roth) Kützing                                        | 1                 | Native              |            | New record      |
| Rhodophya  | Chondria dasypylla (Woodward) C.Agardh                                                 | 6                 | Uncertain           |            |                 |
| Rhodophya  | Corallina ferreyrae E.Y.Dawson, Acleto & Foldvik                                      | 1                 | Native              |            | New record      |
| Rhodophya  | Corallina officinalis Linnaeus                                                         | 18                | Native              |            |                 |
| Rhodophya  | Cruoria pellita (Lyngbye) Fries                                                        | 1                 | Native              |            |                 |
| Rhodophya  | Cryptopleura ramosa (Hudson) L.Newton                                                  | 2                 | Native              |            | New record      |
| Rhodophya  | Ellisolandia elongata (J.Ellis & Solander) K.R.Hind & G.W.Saunders                     | 3                 | Native              |            |                 |
| Rhodophya  | Erythrocris montagnei (Derbès & Solier) P.C.Silva                                     | 2                 | Native              |            | New record      |
| Rhodophya  | Gelidium corneum (Hudson) J.V.Lamouroux                                                 | 10                | Native              |            |                 |
| Phylum     | Species (Accepted Name)                                                                 | Number of records | Establishment Means | OccurrenceRemarks |
|------------|----------------------------------------------------------------------------------------|-------------------|---------------------|-------------------|
| Rhodophya  | Gelidium microdon Kützing                                                              | 4                 | Native              |                   |
| Rhodophya  | Gelidium pusillum (Stackhouse) Le Jolis                                                | 12                | Native              |                   |
| Rhodophya  | Gelidium spinosum (S.G.Gmelin) P.C.Silva                                              | 11                | Native              |                   |
| Rhodophya  | Gigartina pistillata (S.G.Gmelin) Stackhouse                                           | 1                 | Native              |                   |
| Rhodophya  | Gracilariopsis longissima (S.G.Gmelin) Steentoft, L.M.Irvine & Farnham                | 2                 | Native              |                   |
| Rhodophya  | Grateloupiella filicina (J.V.Lamouroux)                                               | 10                | Native              |                   |
| Rhodophya  | Griffithsia corallinoides (Linnaeus) Trevisan                                          | 1                 | Uncertain           |                   |
| Rhodophya  | Griffithsia devoniensis Harvey                                                         | 1                 | Native              | New record        |
| Rhodophya  | Gymnogongrus crenulatus (Turner) J.Agardh                                               | 14                | Native              |                   |
| Rhodophya  | Gymnogongrus griffithsiae (Turner) C.Martius                                            | 3                 | Native              |                   |
| Rhodophya  | Gymnophyllum elegans (Schousboe ex C.Agardh) J.Agardh                                  | 2                 | Native              |                   |
| Rhodophya  | Halurus flosculosus (J.Ellis) Maggs & Hommersand                                       | 1                 | Native              |                   |
| Rhodophya  | Hypnea musciformis (Wulfen) J.V.Lamouroux                                              | 19                | Uncertain           |                   |
| Rhodophya  | Hypoglossum hypoglossoides (Stackhouse) Collins & Hervey                              | 9                 | Native              | New record        |
| Rhodophya  | Jania capillacea Harvey                                                                | 1                 | Native              | New record        |
| Rhodophya  | Jania crassa J.V.Lamouroux                                                             | 2                 | Native              | New record        |
| Rhodophya  | Jania longifurca Zanardini                                                             | 8                 | Uncertain           |                   |
| Rhodophya  | Jania rubens (Linnaeus) J.V.Lamouroux                                                  | 6                 | Native              |                   |
| Rhodophya  | Jania virgata (Zanardini) Montagne                                                     | 13                | Uncertain           |                   |
| Rhodophya  | Kallymenia reniformis (Turner) J.G.Agardh                                              | 1                 | Native              |                   |
| Rhodophya  | Laurencia obtusa (Huds.) J.V.Lamouroux                                                 | 8                 | Native              |                   |
| Rhodophya  | Laurencia viridis Gil-Rodríguez & Haroun                                               | 3                 | Macaronesian endemic | New record       |
| Rhodophya  | Laurencia maritzae (Gil-Rodríguez, Senties, Díaz-Larrea, Cassano & M.T.Fuji) Gil-Rodríguez, Senties, Díaz-Larrea, Cassano & M.T.Fuji | 4                 | Native              | New record        |
| Rhodophya  | Leptosiphonia fibrillosa (Agardh) A.M.Savoie & G.W.Saunders                            | 1                 | Native              |                   |
| Rhodophya  | Lomentaria articulata (Hudson) Lyngbye                                                 | 12                | Native              |                   |
| Rhodophya  | Mesophyllum expansum (Philippi) Cabioch & M.L.Mendoza                                  | 1                 | Native              | New record        |
| Phylum | Species (Accepted Name) | Number of records | Establishment Means | OccurrenceRemarks |
|--------|-------------------------|-------------------|---------------------|-------------------|
| Rhodophya | *Millerella tinerfensis* (Seoane-Camba) S.M.Boo & J.M.Rico | 3 | Macaronesian endemism | |
| Rhodophya | *Nemalion elminthoides* (Velley) Batters | 5 | Native | |
| Rhodophya | *Neoziziaella divaricata* (C.K.Tseng) S.-M.Lin, S.-Y.Yang & Huisman | 5 | Introduced | New record |
| Rhodophya | *Osmundea hybrida* (A.P.de Candolle) K.W.Nam | 4 | Native | |
| Rhodophya | *Osmundea pinnatifida* (Hudson) Stackhouse | 10 | Native | |
| Rhodophya | *Peyssonnelia squamaria* (S.G.Gmelin) Decaisne ex J.Agardh | 6 | Native | |
| Rhodophya | *Phyllophora crispa* (Hudson) P.S.Dixon | 3 | Native | |
| Rhodophya | *Pliatoma cyclocolpum* (Montagne) F.Schmitz | 42 | Native | New record |
| Rhodophya | *Plocamium cartilagineum* (Linnaeus) P.S.Dixon | 23 | Native | |
| Rhodophya | *Polysiphonia opaca* (C.Agardh) Moris & De Notaris | 2 | Native | |
| Rhodophya | *Polysiphonia stricta* (Mertens ex Dillwyn) Greville | 1 | Native | |
| Rhodophya | *Pterocladiella capillacea* (S.G.Gmelin) Santelices & Hommersand | 42 | Native | |
| Rhodophya | *Rhodymenia holmesii* Ardissone | 14 | Native | |
| Rhodophya | *Schimmelmanna schousboei* (J.Agardh) J.Agardh | 1 | Native | |
| Rhodophya | *Schizymenia apoda* (J.Agardh) J.Agardh | 1 | Native | New record |
| Rhodophya | *Schottera nicaeensis* (J.V.Lamouroux ex Duby) Guiry & Hollenberg | 2 | Uncertain | |
| Rhodophya | *Sphaerococcus coronopifolius* Stackhouse | 20 | Native | |
| Rhodophya | *Spyridia filamentosata* (Wulfen) Harvey | 3 | Native | |
| Rhodophya | *Stenogramma interruptum* (C.Agardh) Montagne | 1 | Native | |
| Rhodophya | *Symphyocladia marchantioides* (Harvey) Falkenberg | 1 | Introduced | |
| Rhodophya | *Taenioma nanum* (Kützing) Papenfuss | 1 | Native | New record |
| Rhodophya | *Tenarea tortuosa* (Esper) Me.Lemoine | 1 | Native | |
| Rhodophya | *Vertebrata fruticulosa* (Wulfen) Kuntze | 2 | Native | |
| Rhodophya | *Vertebrata fucoides* (Hudson) Kuntze | 2 | Uncertain | |
| Rhodophya | *Vertebrata thuyoides* (Harvey) Kuntze | 1 | Native | New record |
For the Island of Corvo, this paper accommodates the 390 specimens of macroalgae recorded in 56 taxa comprising 43 confirmed species and 13 taxa identified only to genus level. The confirmed species (Tables 6, 7) include 22 Rhodophyta, eight Chlorophyta and 13 Ochrophyta (Phaeophyceae). Of these, 22 species are newly recorded to the Island (nine Rhodophyta, four Chlorophyta and nine Ochrophyta). Most species are native, two represent introductions to the algal flora of the Azores (the Rhodophyta *Asparagopsis armata* and the Chlorophyta *Codium fragile* subsp. *fragile*) and seven have an uncertain status (five Rhodophyta and two Ochrophyta).

Table 5.
Summary of the macroalgal flora of Flores Island, with information on the species origins and status.

| Phylum       | Order | Family | Specimens | Total taxa | Total species | Native | Introduced | Uncertain | Macaronesian endemism | New record |
|--------------|-------|--------|-----------|------------|---------------|--------|------------|-----------|------------------------|------------|
| Rhodophyta   | 14    | 33     | 789       | 120        | 80            | 65     | 3          | 10        | 2                      | 20         |
| Chlorophyta  | 3     | 9      | 216       | 35         | 22            | 19     | 1          | 2         | 6                      |            |
| Ochrophyta   | 7     | 12     | 682       | 41         | 26            | 22     | 2          | 2         | 11                     |            |
| Total        | 24    | 54     | 1687      | 196        | 128           | 106    | 6          | 14        | 2                      | 37         |

Table 6.
Macroalgal species recorded from Corvo Island, with information on relative abundance, origin and status.

| Phylum       | Species (Accepted Name)                          | Number of records | Establishment Means | Occurrence | Remarks               |
|--------------|------------------------------------------------|-------------------|---------------------|------------|-----------------------|
| Chlorophyta  | Chaetomorpha linum (O.F.Müller) Kützing         | 1                 | Native              |            |                       |
| Chlorophyta  | Cladophora coelothrix Kützing                   | 1                 | Native              |            |                       |
| Chlorophyta  | Cladophora hutchinsiae (Dillwyn) Kützing        | 1                 | Native              |            | New record            |
| Chlorophyta  | Cladophora laetevirens (Dillwyn) Kützing        | 1                 | Uncertain           |            |                       |
| Chlorophyta  | Cladophora prolifera (Roth) Kützing             | 2                 | Native              |            |                       |
| Chlorophyta  | Codium fragile subsp. fragile (Suringar) Hariot | 2                 | Introduced          |            |                       |
| Chlorophyta  | Microdictyon umbilicatum (Velley) Zanardini     | 29                | Native              | New record |                       |
| Chlorophyta  | Valonia utricularis (Roth) C.Agardh             | 1                 | Native              | New record |                       |
| Ochrophyta   | Carpomitra costata (Stackhouse) Batters         | 1                 | Native              | New record |                       |
| Ochrophyta   | Cladostephus spongiosus (Hudson) C.Agardh       | 1                 | Native              | New record |                       |
| Phylum        | Species (Accepted Name)                                                                 | Number of records | Establishment Means | Occurrence Remarks |
|--------------|----------------------------------------------------------------------------------------|-------------------|---------------------|--------------------|
| Ochrophyta   | *Colpomenia sinuosa* (Mertens ex Roth) Derbès & Solier                                | 18                | Native              |                    |
| Ochrophyta   | *Cutleria multifida* (Turner) Greville                                                 | 3                 | Uncertain           | New record         |
| Ochrophyta   | *Dictyopteris polypodioides* (A.P.De Candolle) J.V.Lamouroux                           | 3                 | Native              | New record         |
| Ochrophyta   | *Halopteris filicina* (Grateloup) Kützing                                              | 31                | Native              |                    |
| Ochrophyta   | *Halopteris scoparia* (Linnaeus) Sauvageau                                             | 15                | Native              |                    |
| Ochrophyta   | *Leathesia marina* (Lyngbye) Decaisne                                                 | 1                 | Uncertain           | New record         |
| Ochrophyta   | *Lobophora variegata* (J.V.Lamouroux) Womersley ex E.C.Oliveira                       | 8                 | Native              | New record         |
| Ochrophyta   | *Padina pavonica* (Linnaeus) Thivy                                                    | 32                | Native              |                    |
| Ochrophyta   | *Sargassum furcatum* Kützing                                                           | 2                 | Native              | New record         |
| Ochrophyta   | *Taonia atomaria* (Woodward) J.Agardh                                                  | 5                 | Native              | New record         |
| Ochrophyta   | *Zonaria tournefortii* (J.V.Lamouroux) Montagne                                       | 33                | Native              |                    |
| Rhodophyta   | *Acrosorium ciliolatum* (Harvey) Kylin                                                 | 28                | Native              | New record         |
| Rhodophyta   | *Asparagopsis armata* Harvey                                                           | 23                | Introduced          |                    |
| Rhodophyta   | *Asparagopsis armata* Harvey, phase *Falkenbergia rufolanosa* (Harvey) F.Schmitz     | 1                 | Introduced          |                    |
| Rhodophyta   | *Asparagopsis taxiformis* (Dellile) Trevisan                                          | 13                | Native              | New record         |
| Rhodophyta   | *Carradoriella denudata* (Dillwyn) A.M.Savoie & G.W.Saunders                           | 1                 | Uncertain           |                    |
| Rhodophyta   | *Caulacanthus ustulatus* (Mertens ex Turner) Kützing                                  | 1                 | Uncertain           | New record         |
| Rhodophyta   | *Chondracanthus acicularis* (Roth) Fredericq                                         | 2                 | Native              |                    |
| Rhodophyta   | *Chondria capillaris* (Hudson) M.J.Wynne                                             | 1                 | Native              |                    |
| Rhodophyta   | *Corallina officinalis* Linnaeus                                                       | 3                 | Native              |                    |
| Rhodophyta   | *Erythrodermis trailii* (Holmes ex Batters) Guiry & Garbary                           | 1                 | Uncertain           |                    |
| Rhodophyta   | *Gelidium pusillum* (Stackhouse) Le Jolis                                              | 2                 | Native              |                    |
| Rhodophyta   | *Gigartina pustillata* (S.G.Gmelin) Stackhouse                                        | 1                 | Native              |                    |
| Rhodophyta   | *Gymnogongrus crenulatus* (Turner) J.Agardh                                           | 1                 | Native              | New record         |
| Rhodophyta   | *Gymnogongrus griffithsiae* (Turner) C.Martius                                        | 5                 | Native              | New record         |
| Phylum | Species (Accepted Name)                                      | Number of records | Establishment Means | OccurrenceRemarks |
|--------|-------------------------------------------------------------|-------------------|---------------------|-------------------|
| Rhodophyta | Jania virgata (Zanardini) Montagne                          | 8                 | Uncertain           | New record        |
| Rhodophyta | Nemalion elminthoides (Velley) Batters                      | 1                 | Native              |                   |
| Rhodophyta | Osmundea pinnatifida (Hudson) Stackhouse                    | 2                 | Native              |                   |
| Rhodophyta | Plocamium cartilagineum (Linnaeus) P.S.Dixon                | 4                 | Native              | New record        |
| Rhodophyta | Pterocladiella capillacea (S.G.Gmelin) Santelices & Hommersand | 6                 | Native              |                   |
| Rhodophyta | Schottera nicaeensis (J.V.Lamouroux ex Duby) Guiry & Hollenberg | 1                 | Uncertain           |                   |
| Rhodophyta | Sphaerococcus coronopifolius Stackhouse                     | 3                 | Native              | New record        |
| Rhodophyta | Spyridia filamentosa (Wulfen) Harvey                        | 2                 | Native              | New record        |
| Rhodophyta | Vertebra fruticulosa (Wulfen) Kuntze                        | 1                 | Native              |                   |

Table 7. Summary of the macroalgal flora of Corvo Island, with information on the species origins and status.

| Phylum | Order | Family | Specimens Number | Total taxa | Total species | Native | Introduced | Uncertain | New record |
|--------|-------|--------|------------------|------------|---------------|--------|------------|-----------|------------|
| Rhodophyta | 7     | 16     | 136              | 30         | 22            | 16     | 1          | 5         | 9          |
| Chlorophyta | 3     | 4      | 42               | 9          | 8             | 7      | 1          | 0         | 4          |
| Ochrophyta | 6     | 9      | 212              | 17         | 13            | 11     | 0          | 2         | 9          |
| Total   | 16    | 29     | 390              | 56         | 43            | 34     | 2          | 7         | 22         |

Nine species were commonly found, some abundantly in some locations, namely: the Rhodophyta Acrosorium ciliolatum, Asparagopsis armata, A. taxiformis; the Chlorophyta Microdictyon umbilicatum; and the Ochrophyta Colpomenia sinuosa, Halopteris filicina, H. scoparia, Padina pavonica and Zonaria tournefortii.

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: Conceptualization; Methodology; Research (field and laboratory work); Resources; Data Curation; Formal analysis and interpretation; Paper writing
• MIP: Research (field and laboratory work); Data Curation; Formal analysis and interpretation; Paper writing
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• RF: Methodology; Research (field work and laboratory work); Data Curation
• WF: Methodology; Research (field work and laboratory work); Data Curation
• ACC: Research (field and laboratory work); Resources; Data Curation
• AZB: Research (field and laboratory work); Data Curation
• SM: Research (field and laboratory work); Data Curation
• RR: Resources; Data Curation
• PA: Resources
• ACLP: Investigation (laboratory work); Resources; Paper writing
• NVA: Research (field work); Maps elaboration
• DM-F: Research (field and laboratory work); Data Curation
• RMAN: Data Curation; Formal analysis and interpretation; Paper writing
• JMNA: Research (field work and laboratory work); 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-FLOR+COR-id_15074_normalized.csv[1]

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-FLOR+COR-id_15074_normalized.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 solve this situation.

Download file (35.03 kb)