Insights into the species diversity of the genus Sargassum (Phaeophyceae) in the Mediterranean Sea, with a focus on a previously unnoticed taxon from Algeria

<table>
<thead>
<tr>
<th>Name</th>
<th>Institution</th>
</tr>
</thead>
<tbody>
<tr>
<td>AOUSSI MOUNIA</td>
<td>Laboratoire Bioressources Marines, Université Badji-Mokhtar, BP 12, El-Hadjar, 23000 An-naba</td>
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<td>Laboratoire d’Océanographie Biologique et Environnement Marin (LOBEM), Faculté des Sciences Biologiques (FSB), Université des Sciences et de la Technologie Houari-Boumédiène, BP 32 El-Alia, 16111 Bab Ezzouar, Algiers</td>
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<tr>
<td>BOUDOURESQUE CHARLES</td>
<td>Aix-Marseille University, University of Toulon, CNRS, IRD, Mediterranean Institute of Oceanography (MIO), Campus of Luminy, 13288 Marseille</td>
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<td>BLANFUNÉ AURELIE</td>
<td>Aix-Marseille University, University of Toulon, CNRS, IRD, Mediterranean Institute of Oceanography (MIO), Campus of Luminy, 13288 Marseille</td>
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<td>DERBAL FARID</td>
<td>Laboratoire Bioressources Marines, Université Badji-Mokhtar, BP 12, El-Hadjar, 23000 An-naba</td>
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<td>FRIHI HOCINE</td>
<td>Laboratoire Bioressources Marines, Université Badji-Mokhtar, BP 12, El-Hadjar, 23000 An-naba</td>
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<tr>
<td>PERRET-BOUDOURESQUE MICHELE</td>
<td>Aix-Marseille University, University of Toulon, CNRS, IRD, Mediterranean Institute of Oceanography (MIO), Campus of Luminy, 13288 Marseille</td>
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<tr>
<td>REBZANI-ZAHAF CHAFIKA</td>
<td>Laboratoire d’Océanographie Biologique et Environnement Marin</td>
</tr>
</tbody>
</table>

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Insights into the species diversity of the genus Sargassum (Phaeophyceae) in the Mediterranean Sea, with a focus on a previously unnoticed taxon from Algeria

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Abstract

Nine species of the genus Sargassum (Phaeophyceae; kingdom Stramenopiles) are currently accepted in the Mediterranean Sea: S. acinarium, S. desfontainii, S. flavidulum, S. furcatum, S. hornechuchii, S. muticum, S. ramentaceum, S. trichocarpum and S. vulgare. Sargassum desfontainii and S. furcatum are Atlantic-Mediterranean species. Sargassum hornechuchii, S. ramentaceum and S. trichocarpum are endemic to the Mediterranean. The presence of the Atlantic S. flavidulum in the Mediterranean is at least in part based upon a misidentification and therefore requires confirmation. Near Algiers and Annaba (Algeria), a Sargassum taxon sharing most characters with S. flavidulum was collected. This taxon, referred to as the Algerian Sargassum sp., is described and illustrated. Its distribution and ecology in Algeria are presented. This taxon differs from S. flavidulum in having costate, small-sized, unbranched leaves and small-sized receptacles, branched in all directions and lacking a branched sterile pedicel at the base. In the absence of genetic data, and a study of the type material of S. flavidulum, sp., syntype localities: West Indies (Antilles) and Biarritz, a description of a new taxon would be premature.

Keywords: Algeria, Mediterranean Sea, Phaeophyceae, Sargassum flavidulum, Sargassum spp.

Introduction

The genus Sargassum C. Agardh is one of the most species-rich genera among the Fucales (Phaeophyceae, kingdom Stramenopiles; for taxonomic treatment see references in Boudouresque, 2015), with 354 taxa (species and infraspecific taxa) currently accepted (Guiry & Guiry, 2017). Most Sargassum taxa are tropical and subtropical. In the Mediterranean Sea, nine species of Sargassum have been reported (Table 1): Sargassum acinarium (Linnæus) Setchell, S. desfontainii (Turner) C. Agardh, S. flavidulum Kützing, S. furcatum Kützing, S. hornechuchii C. Agardh, S. muticum (Yendo) Fensholt, S. ramentaceum Zarmouh & Nizamuddin, S. trichocarpum J. Agardh and S. vulgare C. Agardh (Ribera et al., 1992; Cormaci et al., 2012). Sargassum salicifolium (J. Agardh) J. Agardh sensu lato and infraspecific taxa of S. vulgare (see e.g. Span, 2005), which are of uncertain taxonomic status (Ribera et al., 1992), are not taken into consideration here. Sargassum hornechuchii, S. ramentaceum and S. trichocarpum have only been recorded in the Mediterranean Sea (Guiry & Guiry, 2017) and are putatively endemic to this area. Sargassum species can form extensive marine forests that are major components of the underwater seascapes and coastal ecosystems (Komatsu & Murakami, 1994; Yatsuya et al., 2007; Komatsu et al., 2014; Boudouresque et al., 2016). In some regions, Sargassum species are undergoing a very severe decline due to overgrazing by herbivores (a cascading effect of overfishing), invasive species such as the herbivorous teleosts Siganus spp., habitat destruction, trawling and net fishing, eutrophication and an increase in water turbidity (Thibaut et al., 2005; Airoldi & Beck, 2007; Tsiamis et al., 2013; Bianchi et al., 2014; Vergès et al., 2014; Thibaut et al., 2015, 2016; Gatti et al., 2017). In Algeria, four species have been listed, namely S. acinarium, S. hornechuchii, S. trichocarpum and S. vulgare (Perret-Boudouresque & Seridi, 1989; Ribera et al., 1992). Here, we report on a species belonging to Sargassum, occurring in Algeria (southwestern Mediterranean Sea), which does not correspond to any of the nine species reported from the Mediterranean Sea. We also highlight the likely underestimation of the Sargassum diversity in the Mediterranean Sea.
Material and Methods

Specimens belonging to the study species (hereafter the study species) were observed in shallow reef habitats, 0-0.5 m depth, compared with the collection of Mediterranean species deposited in the HCOM and with the following specimens of genuine S. flavifolium deposited in the herbarium of the Muséum National d’Histoire Naturelle, Paris, PC:

- PC0527409, Biarritz, June 1830, coll. Heribaud;
- PC0539255, PC0539256 and PC0458533, Guéthary [France, NE Atlantic Ocean], 1 July 1921, coll. C. Sauvageau;
- PC0527408, Guéthary [France, NE Atlantic Ocean], 25 July 1923, coll. C. Sauvageau;
- PC0458529, Herbier J. Feldmann, between Guéthary and Bidart [France, NE Atlantic Ocean], 15 August 1927;

Table 1. Distribution of currently accepted taxa (according to Guiry & Guiry, 2017) of the genus *Sargassum* in the Mediterranean Sea and Black Sea (data from Ribera et al., 1992; and updated as by Ben Maiz et al., 1987; Zarmouh & Nizamuddin, 1991; González García & Conde, 1992; Ribera et al., 1996; Curiel et al., 1998; Flores Moya & Conde 1998; Benhissoune et al., 2002; Cormaci et al., 2012; Verlaque et al., 2015; Guiry & Guiry, 2017). +: present; -: not recorded. Sp: continental Spain; Bl: Balearic Islands (Spain); Fr: continental France; CS: Corsica (France) and Sardinia (Italy); WS: Western Italy; SI: Sicily (Italy) and adjacent islands; Ad: Adriatic Sea, including Albania; Gr: Greece; BS: Black Sea and Azov Sea; Tu: Turkey (Sea of Marmara and Mediterranean coast); LS: Levant states (Lebanon, Syria and Israel); Eg: Egypt; Li: Libya; Tu: Tunisia; Ag: Algeria; Mo: Morocco (including Spanish territories, e.g. Chafarinas islands).

<table>
<thead>
<tr>
<th>Taxon</th>
<th>Sp</th>
<th>BI</th>
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</thead>
<tbody>
<tr>
<td><em>Sargassum acinarium</em> (Linnaeus) Setchell</td>
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<td><em>Sargassum desfontainii</em> (Turner) C. Agardh</td>
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<td><em>Sargassum flavifolium</em> Kützing</td>
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<td><em>Sargassum furcatum</em> Kützing</td>
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<td><em>Sargassum hornechuchii</em> C. Agardh</td>
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<td><em>Sargassum muticum</em> (Yendo) Fensholt</td>
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<td><em>Sargassum ramentaceum</em> Zarmouh &amp; Nizamuddin</td>
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<tr>
<td><em>Sargassum trichocarpum</em> J. Agardh</td>
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<tr>
<td><em>Sargassum vulgaris</em> C. Agardh</td>
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</table>

* Based upon a misidentification; see text. \(^{a}\) Only drift material of *S. muticum* has been found. \(^{b}\) In the framework of the study of the marine benthos of El Dabaa (Egypt) (Campos-Villaça et al., 1995; Thélin et al., 1985), an unidentified species of *Sargassum* was collected; the specimens have subsequently been referred to as *S. ramentaceum* (Marc Verlaque, unpublished data). \(^{c}\) Only observed once, in the plume of warm water from a thermal power plant (Verlaque, 1977); this power plant only operates intermittently today, so that the species may be no longer present.

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• PC0458530, Pointe Sainte Barbe, Saint Jean de Luz [France, NE Atlantic Ocean], 16 July 1927, coll. J. Feldmann;
• PC0458531, between Guéthary and Bidart [France, NE Atlantic Ocean], 21 July 1927, coll. J. Feldmann;
• PC0458532 and PC0458534, Pointe Sainte Barbe, Saint Jean de Luz [France, NE Atlantic Ocean], 1st August 1927, coll. J. Feldmann;

Results and Discussion

The studied specimens of the Algerian Sargassum sp. (Table 2) were collected over a time period of 30 cm long and 6 cm long respectively; leaves (foliaceous branches) with a very short (< 1 mm) petiole; they are lanceolate, up to 35 mm long and 3-4 mm wide (Fig. 1), unbranched, with a midrib, an acute extremity and numerous marginal acute teeth. At the base of the leaf gas vesicles (aerocysts) and receptacles can be found; gas vesicles spherical, 2-4 mm in diameter, at the end of a slender pedicel 1-3 mm long, rarely surmounted with a sterile pedicel at the base of the receptacles (present in S. ramentaceum) and some receptacles can show either an air vesicle or a muriculate, warty and sometimes bifurcate at the extremity; some receptacles can show either an air vesicle or a short, up to 3-6 mm long, with branches cylindrical, in one plane. Small leaves and gas vesicles can be inserted sometimes between the fertile parts (‘zygocarpic receptacle’), a feature not mentioned in the descriptions of S. flavifolium. On the basis of the latter character, the Algerian specimens would be referred to the sectio Zygocarpiceae (J. Agardh) Sertchell of the genus Sargassum and subgenus Sargassum (see Mattio & Payri, 2011, for infrageneric delineation of Sargassum taxa). However, a few zygocarpic receptacles were observed in some herbarium specimens of S. flavifolium collected by Camille Sauvageau at Guéthary (Bay of Biscay, France) (Figs 6-8) and housed at PC (PC0539255, PC0539256). A similar zygocarpic receptacle was also drawn by Gruet (1983) from a specimen of S. flavifolium collected in Arcachon Bay (Bay of Biscay, France).

Sargassum flavifolium, has long been known from the Bay of Biscay (European Atlantic Ocean) (Kützing, 1861; Sauvageau, 1897; Hamel, 1931-1939; Parriaud, 1959; Gruet, 1983; Casasas Pascual, 1989; Gómez García et al., 2004; Dízerbo & Herpe, 2007; Cires Rodríguez & Cuesta Moliner 2010). It has also been recorded in Andalusia and Extremadura (Atlantic Spain) (Bárbara et al., 2012; Gallardo et al., 2016), Atlantic Morocco (Benissoue et al., 2002) and in the Canary Islands (Borgesen, 1926; Sangil et al., 2015; Gallardo et al., 2016). In the Mediterranean Sea, S. flavifolium was first reported from Corsica (Verlaque & Boudouresque, 1981; Boudouresque & Perret-Boudouresque, 1987). The species has also been mentioned from different Mediterranean regions: Provence, France (Verlaque & Boudouresque, 1981; Thibault et al., 2016), Italy (Giaccone, 1969; Giaccone et al., 1985), Greece (Tsekos et al., 1982) and Tunisia (Ben Maiz et al., 1987). However, it has never been recorded in Algeria (see e.g. Perret-Boudouresque & Seridi, 1989; Ould-Ahmed et al., 2013). Outside the European and African NE Atlantic Ocean, and possibly (see below) the Mediterranean Sea, S. flavifolium has been reported (as Sargassum flavifolium – sic) from the Saudi Arabian coast of the Persian Gulf (Abdel-Kareem, 2009); in the absence of an accurate description of the collected specimens, this record requires confirmation. The identity of the West Indies specimens mentioned in the protologue requires further investigation.

Mediterranean records of S. flavifolium are questionable. A re-examination of specimen HF.1184 from Corsica (Lavezzi Islands), recorded and described by Verlaque & Boudouresque (1981) and housed at the HCOM herbarium, shows that it actually belongs to S. vulgaris. For the other Mediterranean records of S. flavifolium (Giaccone, 1969; Tsekos et al., 1982; Giaccone et al., 1985; Ben Maiz et al., 1987), no description is available. The presence of S. flavifolium in the Mediterranean Sea therefore requires confirmation.

All in all, S. flavifolium would appear to be a north-eastern Atlantic species, known from the Bay of Biscay to the Canary Islands. Along the Algerian coast, a previously unrecorded species of the Sargassum, mor-
Table 2. Morphological and reproductive characters of the Mediterranean species of the genus *Sargassum* (according to Hamel 1931-1939; Gómez Garreta *et al.*, 2001; Cormaci *et al.*, 2012), and of the Algeria *Sargassum* sp. When details come from other authors, this is mentioned in a footnote. Leaves are often named 'foliaceous branches' (e.g. by Gómez Garreta *et al.*, 2001; Cormaci *et al.*, 2012).

<table>
<thead>
<tr>
<th>Characters</th>
<th><em>S. alcinorium</em></th>
<th><em>S. desfontaini</em></th>
<th><em>S. fragile</em></th>
<th><em>S. furcata</em></th>
<th><em>S. hornschuchii</em></th>
<th><em>S. munitum</em></th>
<th><em>S. ramentaceum</em></th>
<th><em>S. trichocarpum</em></th>
<th><em>S. vulgaris</em></th>
<th>Algerian <em>Sargassum</em> sp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Basionym</td>
<td><em>Fucus aciculatus</em></td>
<td><em>Fucus desfontaini</em> Turner</td>
<td>-</td>
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<td>-</td>
<td><em>Sargassum</em></td>
<td>-</td>
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</tr>
<tr>
<td>Type locality</td>
<td><em>Italia &amp; Oceano australinum</em></td>
<td>Canary Islands</td>
<td>Biarritz (Bay of Biscay)</td>
<td>St Thomas Virgin Islands</td>
<td>'In mari Adriatico prope Paraees Istriae'</td>
<td>Izumo, Wakayama Prefecture, Japan</td>
<td>Guillia- ana-Benghaza, Libya</td>
<td>'E. Gaidibus' (today: Cádiz, Spain)</td>
<td>(Ad littor Oceani Atlantici; ex India Occiden- tal)</td>
<td>-</td>
</tr>
<tr>
<td>Size (height in cm)</td>
<td>Up to 100</td>
<td>Up to 100</td>
<td>Up to 50</td>
<td>Up to 35</td>
<td>Up to 50</td>
<td>Up to 200, sometimes more</td>
<td>Up to 91</td>
<td>Up to 50</td>
<td>Up to 70</td>
<td>Up to 30 (Fig. 1)</td>
</tr>
<tr>
<td>Main axis (above the basal disc)</td>
<td>Several centimetres long</td>
<td>(13)-8(15)</td>
<td>main axes, cylindrical, 0.5-4.7 cm long, 2-4(7) mm in diameter, verrucose</td>
<td>1-2 cm long, smooth or with scars</td>
<td>Numerous short axes, smooth*</td>
<td>2-3 cm long, cylindrical, verrucose</td>
<td>Single axis, up to 2 cm long, 2-3 mm in diameter, smooth*</td>
<td>Up to 6.0 cm long, compressed, up to 6 mm in cross section, with smooth apex</td>
<td>Up to 3.5 cm*</td>
<td>2-4 cm long</td>
</tr>
<tr>
<td>Primary branches</td>
<td>Well-developed, cylindrical, rough-muricate</td>
<td>Cylindrical, 1-2 mm in diameter, up to 50 cm long, smooth</td>
<td>Well-developed, cylindrical, smooth or rarely spinose</td>
<td>5-7 cm long, muricate</td>
<td>10-50 cm long, flattened or winged near the base</td>
<td>Cylindrical, up to 6 cm long, 3-4 mm in diameter</td>
<td>Cylindrical, smooth, rarely muricate</td>
<td>Well-developed, cylindrical, 2 mm in diameter, smooth or muricate in the young parts</td>
<td>Up to 30 cm long, cylindrical and smooth</td>
<td></td>
</tr>
<tr>
<td>Leaves: present or absent</td>
<td>present</td>
<td>present</td>
<td>present</td>
<td>present</td>
<td>present</td>
<td>present</td>
<td>present</td>
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<td>present</td>
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<td>Leaf middle: present or absent</td>
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<td>present</td>
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<tr>
<td>Leaf size (length x width)</td>
<td>30-80 mm x 3-8 mm</td>
<td>-</td>
<td>30-70 mm x 2-6 mm</td>
<td>15-50 mm x 2-5 mm</td>
<td>40-80 mm x 3-15 mm</td>
<td>30 mm x 3-4 mm in basal parts, much smaller in upper parts</td>
<td>Up to 100 mm x 3 mm</td>
<td>30-50 mm x 2-4(10) mm</td>
<td>15-40 mm x 2-4 mm</td>
<td>30-35 mm x 3-4 mm</td>
</tr>
<tr>
<td>Leaf shape</td>
<td>Acute, with serrated margin</td>
<td>-</td>
<td>Acute, with wavy and toothed margin</td>
<td>Branched up to 4 times, with or without teeth</td>
<td>With or without very small teeth</td>
<td>Lanceolate, without teeth or slightly toothed</td>
<td>Sessile, linear, narrow, lanceolate, strongly serrate-dentate</td>
<td>Wavy or toothed margin</td>
<td>Lanceolate, serrate or slightly wavy margins</td>
<td>Lanceolate, acute, with toothed margins and a short petiole</td>
</tr>
<tr>
<td>Gas vesicles (aerocysts)</td>
<td>Spherical, 4-6 mm in diameter, pedicel 3-5 mm long, without mucron*</td>
<td>Spherical, oblong, 2-6 mm in diameter, with a mucron</td>
<td>Spherical, 4-6 mm in diameter, pedicel 3-5 mm long, sometimes with a mucron</td>
<td>Spherical, 3-4 mm in diameter, pedicel 1-2 mm long, without a mucron</td>
<td>Spherical, 3 mm in diameter, short pedicel, sometimes with a short mucron</td>
<td>Spherical, without mucron, up to 6 mm in diameter, pedicel compressed and spinose, up to 7 mm long</td>
<td>Spherical or slightly elongated, 4-5 mm in diameter, pedicel 3-5 mm long, with mucron*</td>
<td>Spherical, 3-5 mm in diameter, with a short pedicel and without mucron</td>
<td>Spherical, 2-4 mm in diameter, a slender pedicel 1-3 mm long, sometimes with a short mucron</td>
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<tr>
<td>Receptacles with or without (i.e. sessile) a sterile pedicel</td>
<td>with a pedicel</td>
<td>with a pedicel</td>
<td>without pedicel</td>
<td>with a branched pedicel</td>
<td>with a short pedicel</td>
<td>with a branched pedicel</td>
<td>without pedicel (or a very short pedicel)</td>
<td>with a cylindrical, branched pedicel</td>
<td>without (or with a very short) sterile pedicel</td>
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continued
### Characters

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<thead>
<tr>
<th>Characters</th>
<th>S. acinarium</th>
<th>S. desfontainesii</th>
<th>S. flava</th>
<th>S. furcatum</th>
<th>S. hornschuchii</th>
<th>S. maticum</th>
<th>S. ramunculosemum</th>
<th>S. trichocarpum</th>
<th>S. vulgare</th>
<th>Algerian Sargassum sp.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Shape of the receptacles</td>
<td>Fertile branch up to 50 mm, receptacles cylindrical, 10-20 mm long, un-branched or branched once</td>
<td>Fertile branch up to 27 mm, branched, bearing up to 12 receptacles, receptacles alternately branched in one plane, 3-8 mm long, non muriculate</td>
<td>Receptacles alternately branched up to 50 mm, receptacles flattened or triangular in section, with toothed margin</td>
<td>Fertile branch up to 50 mm, receptacles cylindrical, 10-12 mm long, 1-2 mm in diameter</td>
<td>Receptacles simple or branched, cylindrical, verrucose, submoniliiform, up to 6 mm long, 1-2 mm in diameter</td>
<td>Receptacles not-branched, cylindrical, 10-20 mm long and 1 mm in diameter</td>
<td>Receptacles branched, 3-10 mm long, fusiform</td>
<td>Receptacles branched in all directions, thicker, some branches developing small leaves and gas vesicles, cylindrical, muriculate, 3-6 mm long</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

| Male vs female receptacles | Data missing | Receptacles with both male and female conceptacles more irregular than only male receptacles | Plants monoecious | Data missing | Plants monoecious | Plants monoecious | Data missing | Plants dioecious (rarely monoecious) | Plants monoecious |

| Conceptacles | Data missing | Female conceptacles larger than male ones | Conceptacles unisexual | Data missing | Conceptacles unisexual, more rarely hermaphroditic | Unisexual male and female conceptacles present within a given receptacle | Unisexual | Conceptacles unisexual | Conceptacles unisexual or hermaphrodites |

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Figs 1-4: Pressed specimen H8320 of the Algerian Sargassum sp., collected by L.N. Sellam at El Marsa, Algiers, 27 June 2015. Fig. 1. Habit; bar = 1 cm. Fig. 2. Upper part of a fertile branch (arrow heads = receptacles); bar = 1 cm. Fig. 3. Detail of the arrangement of gas vesicles (aerocysts) and receptacles on a branch; bar = 5 mm. Fig. 4. Detail of a composite receptacle with fertile branches and gas vesicles (arrow head = terminal mucron); bar = 5 mm.
phologically close to *S. flavifolium* but presenting some unequivocal differences, is widely distributed and not uncommon.

With a few exceptions (e.g. Garreta *et al.* 2001; Špan, 2005), the species diversity of the genus *Sargassum* in the Mediterranean Sea has been poorly studied, since the pioneering work of Hamel (1931-1939). In the southern and eastern Mediterranean Sea, there are only checklists that name taxa without proper taxonomic identification (i.e. description or illustrations) (e.g. Diannelidis *et al.*, 1977; Taşkin & Öztürk, 2013; Tsiamis *et al.*, 2013a, 2013b, 2014). In their Mediterranean Flora of Phaeophyceae, Cormaci *et al.* (2012) only reproduce previous descriptions and illustrations from Kützing (1849, 1861) and Hamel (1931-1939).

In fact, in the Mediterranean Sea, a warm-temperate sea, the species diversity of the genus *Sargassum*, a genus with warm affinities, might be expected to be far greater than as currently assessed.

Within the genus *Sargassum*, nearly 350 taxa are currently accepted worldwide (Guiry & Guiry, 2017). Yet most taxonomic characters are elusive, often overlapping

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*Fig. 5:* Illustrations of *Sargassum flavifolium* Kützing from Kützing (1861, plate 26), Biarritz, Bay of Biscay, France: a. Habit; b. Receptacle.

*Figs 6-8:* Pressed specimen PC0458534 of *S. flavifolium* collected by J. Feldmann at Saint Jean de Luz, Bay of Biscay, France, 1st August 1927, and deposited at the the Muséum National d’Histoire Naturelle, Paris; bar = 2 cm. Fig. 7. Details of gas vesicles; bar = 5 mm.

*Fig. 8:* Details of receptacles; bar = 5 mm.
among species, so that species delineation is a difficult, uncertain, and even scientifically hazardous task (Mattio & Payri, 2011). Genetic tools are therefore particularly welcome. On the basis of genetic studies, a reappraisal of the Sargassum taxonomy is now available in e.g. western and central Pacific islands, Korea, the Oman Sea, Australia and South Africa (Zhao et al., 2007; Mattio et al., 2008, 2009, 2010; Mattio & Payri, 2011; Nooromohammadi et al., 2011; Cho et al., 2012; Dixon et al., 2012, 2014; Dixon & Huisman, 2015; Mattio et al., 2015). Unfortunately, this is not yet the case for the Mediterranean.

What is the status of the studied Sargassum species from Algeria? (i) a species hitherto ignored or confused with another Mediterranean taxon; (ii) an Atlantic species extending its range area and entering the Mediterranean Sea through the Strait of Gibraltar; (iii) a recently introduced species? The Mediterranean Sea is the marine area that harbours the highest number of introduced species worldwide (Ribera & Boudouresque, 1995; Galil, 2000; Boudouresque & Verlaque, 2002; Galil, 2008; Boudouresque et al., 2011; Zenetos et al., 2012, 2017). A set of criteria can be used to consider whether or not a species is probably introduced (Ribera & Boudouresque, 1995; Boudouresque, 1999); these criteria are not met by the Algerian Sargassum sp. populations.

Before describing a new species, we must examine the type material of S. flavifolium and of the other Mediterranean taxa belonging to the genus Sargassum, which although inadequately known, are at present regarded as synonyms. We also need to check the relationships between the Algerian Sargassum sp., the Atlantic species and the other species of the sectio Zygocarpicae, including putative synonyms, using both genetic markers and morphological characters (see e.g. Tseng & Baoren, 1988; Ajsaka et al., 1995; Fuji et al., 2014)

As far as the geographical distribution of the nine Mediterranean Sargassum species is concerned, a variety of different origins exist. Sargassum flavifolium seems to be restricted to a range from the Bay of Biscay to the Canary Islands, while the protologue also includes material from the Antilles; it is the species of Sargassum acinarium reported furthest northwards in Europe (Gruet, 1983); Mediterranean localities (Table 1) could result from misidentifications (see above). Sargassum acinarium is known from the western (Caribbean) and eastern (tropical West Africa and Canary Islands) Atlantic Ocean, and from the Mediterranean (Ribera et al., 1992; Littler & Littler, 2000; Gómez Garreta et al., 2001; John et al., 2004). This range of distribution is consistent with the dissemination of drift specimens of Sargassum by transoceanic currents, such as the Gulf Stream. Sargassum desfontainesii is present occurs on both sides of the North Atlantic Ocean, including the Canary Islands and the Azores, and is present only a short distance into the western Mediterranean (Alboran Sea, close to the Strait of Gibraltar) (Taylor, 1976; Price et al., 1978; González García & Conde, 1992). Sargassum furcatum has a very similar pattern of distribution (Taylor, 1960; Flores-Moya & Conde, 1998; Benhissoune et al., 2002; Cruz-Reyes et al., 2003; Freitas Ferreira, 2011; Wynne, 2011). Sargassum hornschuchii, S. ramentaceum and S. trichoecarpum are assumed to be endemic to the Mediterranean (Hamel, 1931-1939; Ben Maiz et al., 1987; Perret-Boudouresque & Seridi, 1989; Zarmouh & Nizamuddin, 1991; Ribera et al., 1992; Gómez Garreta et al., 2001). Sargassum muticum is native to Japan and has been introduced, via oyster aquaculture, to north-western America, western Europe and the Mediterranean Sea (Critchley et al., 1983; Knoepfler-Peguy et al., 1985; Ribera & Boudouresque, 1995; Verlaque et al., 2007). Finally, S. vulgare seems to be a cosmopolitan species, reported on both sides of the Atlantic Ocean, in the Mediterranean Sea, the Indian Ocean, Polynesia, Japan, Taiwan and other Pacific Ocean areas (Taylor, 1960; Price et al., 1978; Ribera et al., 1992; Silva et al., 1996; Gómez Garreta et al., 2001; Tsudo & Walsh, 2013; Pang et al., 2016; Guiry & Guiry, 2017). True cosmopolitan species are often species originating from a given area of the world ocean, which have subsequently been transported by man and introduced into all the other areas of their current world range (see e.g. Carlton, 1996). Nevertheless, most of the so-called cosmopolitan species are actually complexes including several cryptic species (see e.g. Belton et al., 2014; Di Joux et al., 2014; Zanolla et al., 2014), and S. vulgare could be such a case.

Conclusions

Nine species of Sargassum are currently accepted in the Mediterranean Sea. This is probably an underestimation, as this genus, highly diversified in most warm and tropical seas, has been poorly studied in the Mediterranean, especially in the eastern and southern Mediterranean. Here, we have reported an undescribed species from Algeria that differs from the currently accepted taxa. Until further studies can be undertaken, including molecular analyses and thorough exploration of herbarium materials that contain early and poorly understood taxa (often regarded as synonyms), it seemed premature to formally describe it as a new species. Nevertheless, we thought it important not to delay drawing the attention of researchers to this plant), potentially present in other Mediterranean areas too. In addition, we have highlighted the possible underestimation of the diversity of the genus Sargassum in the Mediterranean, pending the achievement of the long-term objective of disentangling the taxonomy of the genus in the Mediterranean as a whole.

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