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# The introduced marine macroflora of Lebanon and its distribution on the Levantine coast

**G. BITAR[1], A.A. RAMOS-ESPLÁ[2], O. OCAÑA[3], Y.R. SGHAIER[4], A. FORCADA[5], C. VALLE[5], H. EL SHAER[6] and M. VERLAQUE[7]**

[1] Lebanese University, Faculty of Sciences, Hadath, Beirut, Lebanon
[2] Centro de Investigación Marina de Santa Pola (CIMAR), Universidad de Alicante, 03080 Alicante, Spain
[3] Departamento de Oceanografía Biológica y Biodiversidad, Fundación Museo del Mar, Muelle Cañonero Dato s.n, 51001 Ceuta, Spain
[4] Centre d'Activités Régionales pour les Aires Spécialement Protégées, Boulevard du leader Yasser Arafat, B.P.337 –1080 - Tunis Cedex - Tunisie
[5] Departamento de Ciencias del Mar y Biología Aplicada, Universidad de Alicante, Po Box 99, Edificio Ciencias V, Campus de San Vicente del Raspeig, E-03080, Alicante. Spain
[6] IUCN (International Union for Conservation of Nature), Regional Office for West Asia Sweifiyeh, Hasan Baker Al Azazi St. no 20 - Amman, Jordan
[7] Aix Marseille University, CNRS/INSU, Université de Toulon, IRD, Mediterranean Institute of Oceanography (MIO), UM 110, GIS Posidonie,13288 Marseille, France

Corresponding author: ghbitar@ul.edu.lb

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## Abstract

The marine macroflora introduced into Lebanon was studied through an analysis of historical data and field studies carried out since 1991. A total of 29 introduced species have been listed: 3 Chromobionta, 13 Rhodobionta, 12 Chlorobionta, and one Streptobionta. Among them, *Caulerpa taxifolia* var. *distichophylla*, *Spatoglossum variabile* and *Womersleyella setacea* are recorded for the first time from Lebanon while *Asparagopsis taxiformis, C. taxifolia* var. *distichophylla*, *Cladophora patentiramea*, *Codium arabicum*, *Codium parvulum, Galaxaura rugosa, Halophila stipulacea, Hypnea cornuta, Laurencia* cf. *chondrioides*, *Lophocladia lallemandii*, *Stypopodium schimperi*, *Ulva lactuca*, and *Womersleyella setacea* are potentially invasive species, and several of them already occupy extensive stretches of the Lebanese coast. The distribution of species on the Levantine coast, their dynamics, and the current status of their populations are discussed.

**Keywords**: Marine macroflora, introduced species, invasive species, Lessepsian species, Lebanon, Eastern Mediterranean.

## Introduction

With nearly 1000 marine introduced taxa identified (excluding microalgae), the Mediterranean Sea is one of the regions of the world most severely impacted by the introduction of species (Zenetos *et al.*, 2010, 2012). In 2017, the number of introduced marine macrophytes would be around 120-130 taxa (Verlaque *et al*., 2015; M. Verlaque, unpub. data). Among the major pathways of introduction, the Suez Canal ranks ahead. Since its opening in 1869, the flow of Lessepsian species, i.e. Indo-Pacific species introduced into the Mediterranean Sea via the Suez Canal, has never stopped (Nunes *et al.,* 2014).

Few studies have dealt with the marine flora of Lebanon. Basson *et al.* (1976) listed 190 taxa of macrophytes (including Cyanobacteria). In 1999, 18 taxa were added to the Lebanese marine flora, including 4 introduced Indo-Pacific species (Bitar, 1999). In 2000, the checklist of marine macrophytes (including Cyanobacteria) amounted to 243 taxa (Lakkis & Novel-Lakkis, 2000, 2007). Since then, the number has been steadily increasing (Abboud-Abi Saab *et al*., 2003; Bitar, 2010b; Belous & Kanaan, 2015; Kanaan *et al.,* 2015). The aim of our work was to draw up a list of exotic marine macrophytes introduced into Lebanon, and to discuss their distribution, their dynamics and the current status of their populations.

## Materials and Methods

The historical data (publications and technical reports) have been exhaustively looked for. Specimens corresponding to these data have not been re-studied; the same applies for the Lebanese herbaria deposited in Institutions. The field survey covers a 25 year-period and the whole Lebanese coast. Field data were collected by one of us (G.B.) from 1991 to 1999. In October 1999 and May-June 2000, two field surveys were conducted within the framework of the Franco-Lebanese research program CEDRE (Abboud-Abi Saab *et al*. 2003). In September 2005, a field survey was carried out for the EU projet Grundtvig (Bitar *et al.,* 2007). In 2012, 2013 and 2016, several Lebanese localities were prospected (Enfeh, Ras Chekaa, Batroun, El Madfoun, Byblos, Raoucheh, Saida, Tyre and Nakoura) within the framework of the interna-

tional MedMPAnet Program for the establishment of an effective Mediterranean network of marine protected areas (RAC/SPA - UNEP/MAP, 2014). Finally, a constant monitoring was provided by one of us (G.B.) to detect new introductions.

Surveys were carried out along the complete Lebanese coast (Fig. 1, Table 1), covering from the sea-surface, especially on vermetid reefs, down to 50 m depth, involving different methods (hydroplane transects, snorkelling and SCUBA diving). Only the large taxa (> 1-2 cm high) were considered. The species were identified in situ, on photographs or in the laboratory after hand sampling or scraping with chisel and hammer. The taxonomic nomenclature of species follows the Algaebase database (Guiry & Guiry, 2016).

For each species, the date, the locality, and the reference of the first record in Lebanon have been looked for, as well as its alien status and its possible origins, putative pathways of first introduction into the Mediterranean Sea and its establishment success in Lebanon according to the following nomenclature:

**Alien status**: Al = Alien; Cr = Cryptogenic; Qu = Questionable.

**Origins**: A = Atlantic; IP= Red Sea / Indo-Pacific.

**Pathways:** Categories / Subcategories according to the CBD (2014) classification: C/CAE = Corridor / Canal of Ancient Egyptians; C/SC = Corridor / Suez Canal; R/Aq = Release in nature / Aquarium species; T-C/A = Transport-Contaminant / Aquaculture; T-S/Sh = Transport-Stowaway / Ship hull fouling or ballast water.

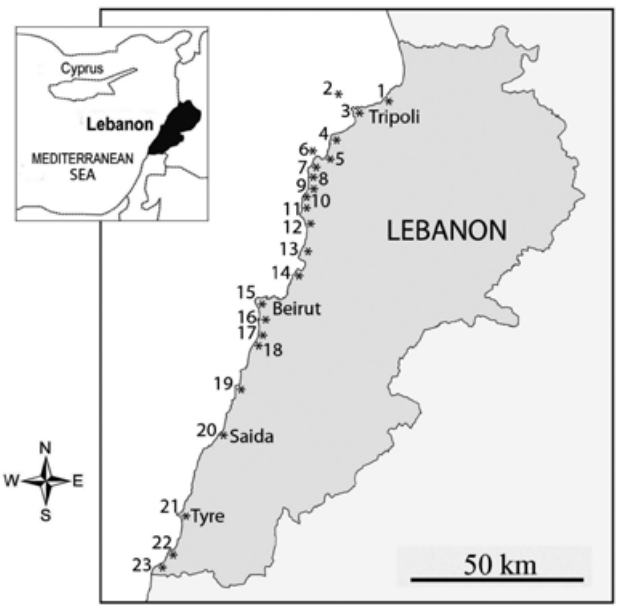


***Fig. 1:*** Study localities in Lebanon: 1. Aramane; 2. Ramkine Island; 3. Tripoli and El Mina; 4. Enfeh; 5. El Heri; 6. Ras Chekaa; 7. Hannouch; 8. Selaata; 9. Batroun; 10. Kfar Abida and El Madfoun; 11. Barbara; 12. Amchit and Byblos; 13. Tabarja; 14. Zouk Mkayel; 15. Beirut, El Manara and Raoucheh; 16. Ouzai; 17. Khalde; 18. Doha; 19. Saadiyat; 20. Saida; 21. Tyre and El Jamal; 22. El Baiada; 23. Nakoura.

**Establishment success in Lebanon**: E = established; Inv = invasive; C = casual; E? = establishment to precise by further investigation.

## Results

The analysis of historical data revealed a list of 26 taxa of marine macrophytes introduced to Lebanon (Hamel, 1930, 1931; Rayss, 1941, 1955; Lipkin, 1975; Basson *et al*., 1976; Bitar & Bitar-Kouli, 1995a,b; Bitar, 1999, 2008, 2010a,b, 2011, 2014; Bitar *et al.,* 2000, 2007; Lakkis & Novel-Lakkis, 2000, 2001; Bitar & Kouli-Bitar, 2001; Abboud-Abi Saab *et al*., 2003; Lakkis, 2013;Verlaque *et al.,* 2015). On the basis of the field surveys along the Lebanese coasts, this total was increased to 29 taxa, namely 3 brown algae (Chromobionta), 13 red algae (Rhodobionta), 12 green algae (Chlorobionta) and one seagrass (Streptobionta) (Table 1).

**Table 1.** Lebanese localities with coordinates.

| Localities | Latitudes (N) | Longitudes (E) |
|---|---|---|
| 1. Aramane | 34,4803 | 35,9094 |
| 2. Ramkine Island | 34,4894 | 35,7731 |
| 3. El Mina | 34,4572 | 35,8097 |
| Tripoli | 34,4450 | 35,8042 |
| 4. Enfeh | 34,3708 | 35,7303 |
| 5. El Heri | 34,3097 | 35,7094 |
| 6. Ras Chekaa | 34,3169 | 35,6803 |
| 7. Hannouch | 34,2925 | 35,6661 |
| 8. Selaata | 34,2692 | 35,6494 |
| 9. Batroun | 34,2664 | 35,6539 |
| 10. Kfar Abida | 34,2275 | 35,6531 |
| El Madfoun | 34,2111 | 35,6442 |
| 11. Barbara | 34,1978 | 35,6322 |
| 12. Amchit | 34,1475 | 35,6228 |
| Byblos | 34,1222 | 35,6378 |
| 13. Tabarja | 34,0325 | 35,6131 |
| 14. Zouk Mkayel | 33,9789 | 35,6042 |
| 15. Beirut | 33,9094 | 35,4942 |
| Manara | 33,9067 | 35,4772 |
| Raoucheh | 33,8883 | 35,4567 |
| 16. Ouzai | 33,8464 | 35,4717 |
| 17. Khalde | 33,7875 | 35,4647 |
| 18. Doha | 33,7622 | 35,4544 |
| 19. Saadiyat | 33,6950 | 35,4161 |
| 20. Saida | 33,5622 | 35,3628 |
| 21. Tyre | 33,2839 | 35,2006 |
| El Jamal | 33,2617 | 35,1983 |
| 22. El Baiada | 33,1661 | 35,1672 |
| 23. Nakoura | 33,1228 | 35,1300 |

**1. *Padina boergesenii* Allender & Kraft** (Fig. 2)

Described from the western Atlantic (Virgin Islands) and present in the Indian Ocean, this species was first found in the Mediterranean Sea in the 1960s along the South Levantine coast [Ramon & Friedmann, 1966, misidentified as *P. gymnospora* (Kützing) Vickers]. *Padina boergesenii* was identified in Syria in 1997 (Verlaque *et al.,* 2015).

In Lebanon, *P. boergesenii* was first found in May 1992 at Tripoli - El Mina (Bitar, 1999, as *Padina* sp.). Currently, *P. boergesenii* is present at numerous localities along the coast, from sea level down to 15 m depth, especially on vermetid reefs (Bitar, 2010b; present study).

The *Padina* sp. observed in August 2010 at Ramkine Island, between 4 and 5 m depth (Bitar, 2010b), might be either *P. boergesenii* or *P. tetrastromatica* Hauck, another Indo-Pacific species discovered in Syria (Mayhoub, 2004), and is not yet reported from Lebanon. *Padina boergesenii* is well established along the Levantine coasts.

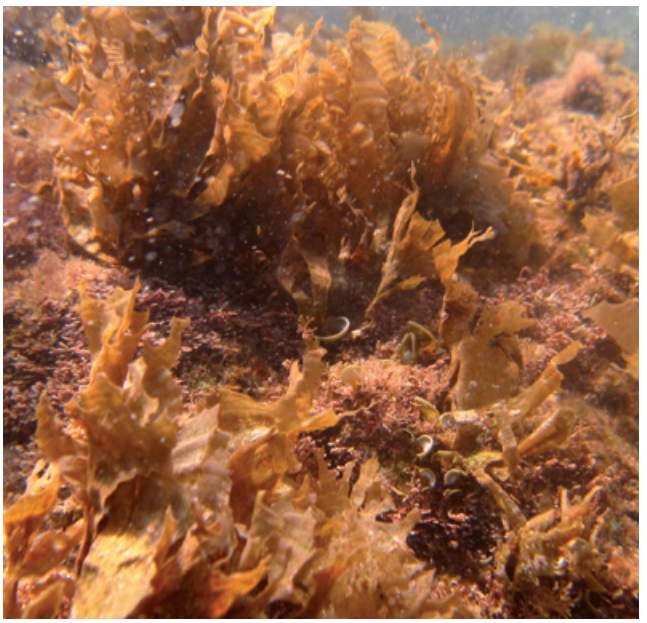

***Fig. 2:*** *Padina boergesenii,* Tyre, August 2013.

**2. *Spatoglossum variabile* Figari & De Notaris** (Fig. 3)

Described from the Red Sea, this species was first found in the Mediterranean Sea in 1944, in Egypt (Aleem, 1950). The exotic Dictyotale *Spatoglossum asperum* J. Agardh, regularly recorded from the South Levantine coast (Lundberg, 1980, 1989, 1996; Lundberg & Golani, 1995) is a probable misidentification of *S. variabile*, which was later recorded and illustrated from the same region [Einav, 2007, misidentified as *Spatoglossum solieri* (Chauvin *ex* Montagne) Kützing].

In Lebanon, *S. variabile* was first found in July 2009 at Tabarja. Subsequently, it was observed in June 2010 at Enfeh, and in June 2015 at Beirut and Raoucheh, where it constituted a subtidal belt close to the sea-surface. Lebanese specimens were well characterized by (i) the thallus complanate and subdichotomously to irregularly

***Fig. 3:*** *Spatoglossum variabile*, Raoucheh, June 2015.

branched in one plane, (ii) the growth from a flat terminal marginal row of apical cells, (iii) the segments cuneate with lateral margins entire, (iv) the apices obtuse, and (v) the scattered hair tufts arising from a pit within the thallus. This is the first time that this species has been recorded in Lebanon. This late discovery probably results from previous confusions with other Dictyotales. The species is probably well established in Lebanon.

**3. *Stypopodium schimperi* (Kützing) Verlaque & Boudouresque** (Fig. 4)

Described from the Red Sea, this species was probably first observed in the Mediterranean Sea in Syria in 1979 [Mayhoub, 1989, as *Stypopodium fuliginosum* (Martius) Kützing; Mayhoub & Billard, 1991, as *S. zon-*

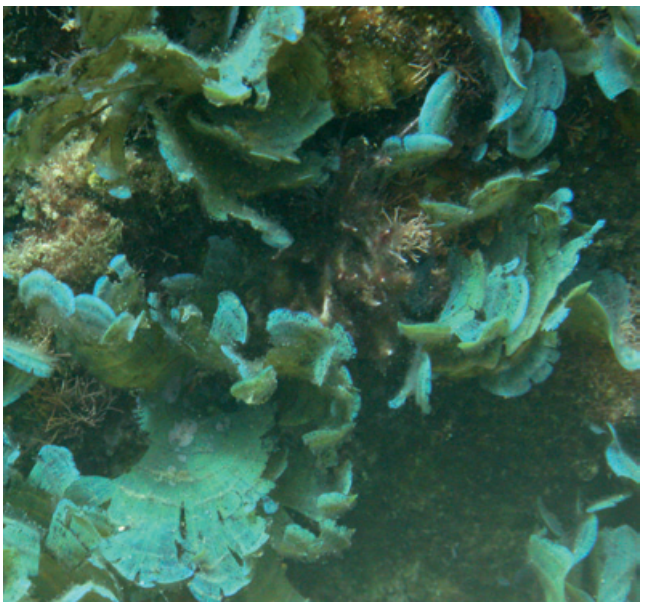

***Fig. 4:*** *Stypopodium schimperi*, Nakoura, March 2008.

*ale* (J.V. Lamouroux) Papenfuss; Verlaque & Boudouresque, 1991]. We found it in 1999 and 2003 at several Syrian localities where it was abundant from the sea surface down to 25 m depth (Bitar, 2010b). The species is also present and invasive in Haifa Bay and the surrounding area (Lundberg, 1996, as *S. zonale*; Hoffman, 2014a).

In Lebanon, *S. schimperi* was first found in May 1991 at Barbara and subsequently, in 1995, at Hannouch (Bitar, 1999; Bitar & Bitar-Kouli, 1995a, misidentified as *S. zonale*; Bitar *et al.,* 2000). Lakkis & Novel-Lakkis (2000, 2001) recorded *S. schimperi* from Tripoli to Beirut in 1996-1997. Since 2000, it has become very abundant along the whole Lebanese coast, from the sea surface down to 45 m depth, at the expense of native benthic assemblages (Bitar *et al*., 2000; Bitar, 2010b; RAC/SPA - UNEP/MAP, 2014). Kanaan *et al.* (2015) recorded the species from Tyre and Barbara. *Stypopodium schimperi* was the second invasive marine macrophyte to be identified in Lebanon, after *Ulva lactuca*.

**4. *Acanthophora nayadiformis* (Delile) Papenfuss** (Fig. 5)

Although described from both the Red Sea and the Mediterranean Sea (Alexandria) before the opening of the Suez Canal, the chronology of Mediterranean records suggests an introduction or the co-occurrence of introduced and native populations (Verlaque *et al.*, 2015). According to Aleem (1948), the first migration into the Mediterranean Sea could have taken place through the old intermittent canal, which was established by the Ancient Egyptians. However, modern introductions through the Suez Canal cannot be excluded (Verlaque *et al.*, 2015). In 1908, *A. nayadiformis* was recorded from Syria (Preda, 1908, as *A. delilei*).The species is also common along the South Levantine coast (Nemlich & Danin, 1964, as *A. delilei*; Lundberg, 1996).

In Lebanon, we first found *A. nayadiformis* in November 1991 at Tabarja (Bitar, 2010b). Currently, the species is common in shallow habitats, intertidal rock pools and on vermetid reefs (Lakkis & Novel-Lakkis, 2000, 2001, 2007, as *A. delilei*; Bitar, 2010b; Kanaan *et al.,* 2015).

**5. *Asparagopsis taxiformis is* (Delile) Trevisan de Saint-Léon** (Fig. 6)

Described from Alexandria, in 1813, before the opening of the Suez Canal, this taxon corresponds to a complex of species worldwide distributed in temperate and warm seas (Andreakis *et al.,* 2007). Among these cryptic species, two of them occur in the Mediterranean Sea: a taxon mainly distributed in the Atlantic Ocean and the eastern Mediterranean basin and an Indo-Pacific taxon, which is invasive in the western basin. In 1883, *A. taxiformis* was recorded from Syria (Ardissone, 1883). Gametophytes are rare along the South Levantine coast (Lundberg, 1996; Einav, 2007).

In Lebanon, the tetrasporophytic phase described as '*Falkenbergia hillenbrandii'* was first found in 1973 at Selaata, Barbara, Zouk Mkayel and Khalde (Basson *et al*., 1976), while gametophytes were only found in 1993 at Barbara and Batroun, near the sea-surface (Bitar *etal*., 2000). The species is common but not invasive on the whole Lebanese coast, down to 5 m depth (Lakkis & Novel-Lakkis, 2000, 2001; present study). Records of *Asparagopsis armata / Falkenbergia rufolanosa* from Batroun, El Manara, Tyre, Barbara and Beirut (Military Club) in 2014 (Kanaan *et al.,* 2015) are probably misidentifications of *A. taxiformis / F. hillenbrandii.* Molecular studies showed that the species occurring in Lebanon belongs to the taxon distributed in the Atlantic Ocean and the eastern Mediterranean basin (Andreakis *et al.,* 2007), so its alien status in the Mediterranean Sea requires confirmation (Cryptogenic taxon).

***Fig. 5:*** *Acanthophora nayadiformis*, Tyre, May 2016.

***Fig. 6:*** *Asparagopsis taxiformis*, Beirut, April 2008.

**6. *Chondria coerulescens* (J. Agardh) Falkenberg** (not illustrated)

Described from the northeastern Atlantic (Brittany, France), this taxon was widely recorded from the Mediterranean Sea, where introduced and possibly also native populations co-occur (Verlaque *et al.*, 2015).

In Lebanon, *C. coerulescens* was first found in 1973 (Basson *et al*., 1976). Subsequently, it was recorded from Batroun, Barbara and Zouk Mkayel in 1996-1997, in the intertidal and the upper subtidal zones (Lakkis & Novel-Lakkis, 2000). The alga is established in Lebanon, but its identity and the origin of Lebanese populations should be confirmed by molecular studies. Confusion with an unidentified Indo-Pacific taxon introduced through the Suez Canal cannot be excluded.

**7. *Galaxaura rugosa* (J. Ellis & Solander) J.V. Lamouroux** (Fig. 7)

Described from Jamaica and Bahamas and widespread in warm seas, this species was first recorded in the Mediterranean Sea from Syria (Mayhoub, 1990, as *G. lapidescens*). In Syria, we found *G. rugosa* in June 1999 at Lattakieh, in the Ras Ibn Hani region, in shallow habitats. We observed it again in the same locality in August 2000 and especially in May 2003 when it became invasive on rocky substrates, from the sea-surface down to 10-12m depth. Associated to *Stypopodium schimperi*, it replaced native species, especially *Halopteris scoparia* (Linnaeus) Sauvageau (Bitar, 2010b). In August 2003, several Syrian localities, from Tartous to Ras El Samra, were invaded by these two exotic species (Bitar *et al*., 2003). *Galaxaura rugosa* was found in 2003 in Haifa Bay, where it has become invasive since 2006 (Hoffman *et al.*, 2007; Hoffman & Dubinsky, 2010; Hoffman, 2014a).

In Lebanon, *G. rugosa* was first found in May 1995 at Kfar Abida, at 7 m depth, before to become invasive between 3 and 8 m depth in August 2007 (Bitar, 1999, as *Galaxaura* sp.; Bitar *et al.,* 2000; Bitar, 2010b). Subsequently, it was observed down to 35 m depth (RAC/SPA - UNEP/MAP, 2014). Kanaan *et al.* (2015) recorded the species from Batroun, El Manara, Saida, Tyre and Barbara in 2014. *Galaxaura rugosa* was the third invasive marine macrophyte to be identified in Lebanon after *Ulva lactuca* and *Stypopodium schimperi.*

***Fig. 7:*** *Galaxaura rugosa,* Batroun, May 2008.

**8. *Ganonema farinosum* (J.V. Lamouroux) K.C. Fan & Y.C. Wang** (Fig. 8)

Described from the Red Sea and widespread in warm seas, *G. farinosum* was collected for the first time in the Mediterranean Sea in Egypt (Alexandria), before the opening of the Suez Canal (see Hamel, 1931, as *Liagora farinosa*). However, the chronology of Mediterranean records suggests an introduction or the co-occurrence of introduced and native populations (Verlaque *et al.*, 2015). *Ganonema farinosum* was recorded, as *Liagora farinosa,* from the South Levantine coast (Nemlich & Danin, 1964) and from Syria (Mayhoub, 1976).

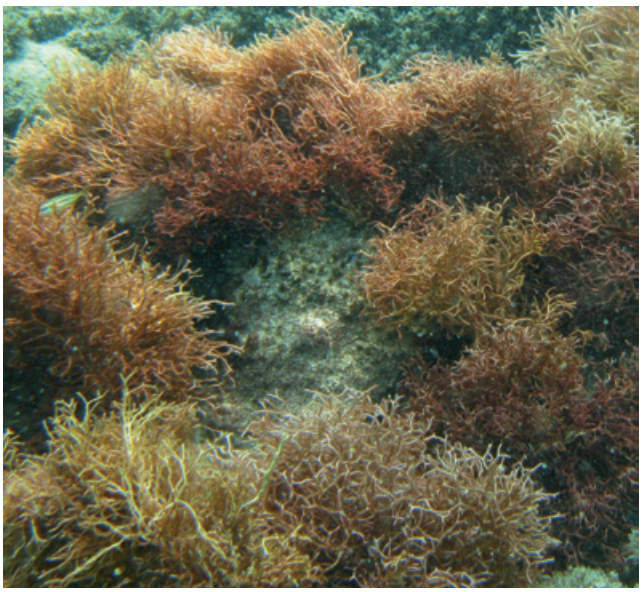

***Fig. 8:*** *Ganonema farinosum*, Barbara, June 2008.

In Lebanon, *G. farinosum* was first found in April 1993 at El Heri (Bitar *et al.,* 2000, as *L. farinosa*; Bitar, 2010b). Subsequently, it was observed in 1996-1997, forming a *G. farinosum* facies along the coast, mainly in shallow habitats (2-3 m depth) (Lakkis & Novel-Lakkis, 2000, 2001, 2007, as *Liagora farinosa*; present study). *Ganonema farinosum* is established in Lebanon.

**9. *Hypnea cornuta* (Kützing) J. Agardh** (Fig. 9)

The Mediterranean reports of *Hypnea* spp. must be considered with caution because of frequent confusions in taxonomic identifications (Verlaque *et al.,* 2015). Described from the eastern Atlantic (Guinea) and wide-

***Fig. 9:*** *Hypnea cornuta*, Tyre, May 2016.

spread in warm seas, *H. cornuta* was first collected in 1894 at Rodos Island, Greece [Reinbold, 1898; misidentified as *H. valentiae* (Turner) Montagne]. *Hypnea cornuta* was recorded from the South Levantine coast (Nemlich & Danin, 1964; Lundberg, 1996; Einav, 2007; Hoffman, 2014a) and from Syria [Mayhoub, 1976, misidentified as *H. hamulosa* (Esper) J.V. Lamouroux].

In Lebanon, *H. cornuta* was first found in 1973 (Basson *et al*., 1976, as *H. hamulosa*). Subsequently, it was recorded from Aramane, Selaata, Barbara and Zouk Mkayel in 1996-1997 (Lakkis & Novel-Lakkis, 2000, misidentified as *H. hamulosa;* Lakkis & Novel-Lakkis, 2001). We observed it in abundance in shallow pools of Vermetid reefs, especially at Beirut and at Tyre. *Hypnea cornuta* is established in Lebanon.

**10. *Hypnea spinella* (C. Agardh) Kützing**
(not illustrated)

Described from the Caribbean Sea and widespread in warm seas, *Hypnea spinella* was probably first found in the Mediterranean Sea in 1926 in Greece (Symi Island, Dodecanese) (Forti, 1928; misidentified as *H. nidifica* J. Agardh). The species is present along the South Levantine coast (Lundberg, 1996, as *H. cervicornis*; Hoffman, 2014a).

In Lebanon, we first found *H. spinella* in August 1998 at Beirut, off the American University, in shallow pools of Vermetid reefs and below their outer margins. Subsequently it was recorded from Aramane, Barbara and Zouk Mkayel in 1996-1997, in mediolittoral and infralittoral zones (Lakkis & Novel-Lakkis, 2000, as *H. cervicornis* J. Agardh). Subsequently, the species was identified at Enfeh, Ras Chekaa, Saida and Tyre in 2012-2013, on Vermetid reefs (RAC/SPA - UNEP/MAP, 2014). Kanaan *et al.* (2015) recorded the species from Batroun, Barbara and Nakoura in 2014. *Hypnea spinella* is established in Lebanon.

**11. *Hypnea valentiae* (Turner) Montagne** (Fig. 10)

Since its description from the Red Sea, *H. valentiae* has been reported worldwide in warm seas and in the Mediterranean Sea. However the first illustrated Mediterranean record dates only from 1996 in France (Verlaque *et al.,* 2015). In the eastern Mediterranean basin, it was first collected in the south-eastern Aegean Sea at Rodos Island, Greece (Tsiamis & Verlaque, 2011).

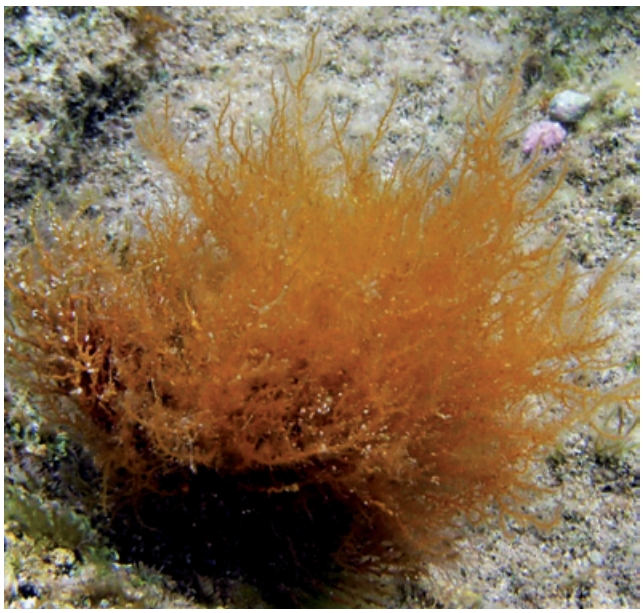

***Fig. 10:*** *Hypnea valentiae*, Lebanon, with the permission of Prof. Oksana Belous.

In Lebanon, *H. valentiae* was only found at Batroun in 2014, in the lower intertidal zone (Belous & Kanaan, 2015), but the description and the illustration (Fig. 3E) given by the authors do not allow to warrant the identification. The occurrence of this casual species in Lebanon should be confirmed by further studies.

**12. *Laurencia* cf. *chondrioides* Børgesen** (Fig. 11)

Described from the Caribbean Sea, *L. chondrioides* was first recorded in the Mediterranean Sea from the Balearic Islands, the Aeolian Islands and from Lachea Island (Boisset *et al.,* 1998). Subsequently, the species was reported throughout the Mediterranean Sea, without mention of any pullulation, until late October 2007, when Hoffman *et al.* (2014) discovered large quantities of a species of *Laurencia,* referred to as *L. chondrioides*, in the algal drift on the shore at Haifa.

In Lebanon, we found large quantities of this *Laurencia* in October 2009 at El Baiada and between Tyre and Nakoura. In December 2010, we identified Saadiyat as its northern limit of distribution. To date, it has never been observed between Beirut and Tripoli. In 2013, we confirmed the invasion at Saida and the Tyre – Nakoura region, where the species was abundant from the sea-surface down to 23 m depth (RAC/SPA - UNEP/MAP, 2014).

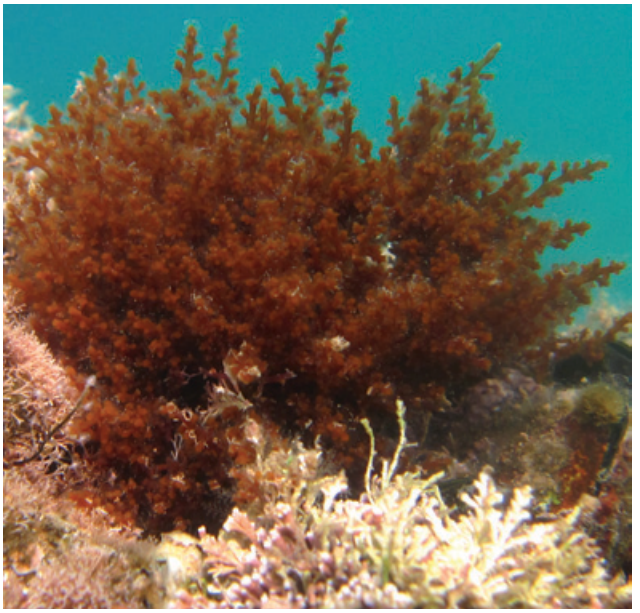

***Fig. 11:*** *Laurencia* cf. *chondrioides*, Saadiyat, April 2013.

Both its recent arrival and its invasive behaviour argue in favour of an introduction on the Levantine coasts. However, the natural presence of *L. chondrioides* in the Canary Islands, where many Mediterranean taxa are native, makes a recent introduction of the species into the Mediterranean Sea unlikely (Boisset *et al.*, 1998). Consequently, the origin and the identity of this invasive *Laurencia* should be confirmed by molecular study because the possibility of an introduction through the Suez Canal of another Indo-Pacific species must be considered.

This *Laurencia* was the fifth invasive marine macrophyte to be identified in Lebanon, after *Ulva lactuca, Stypopodium schimperi*, *Galaxaura rugosa* and *Codium parvulum*. At several Lebanese localities, it competes with the other invasive species.

### 13. *Lophocladia lallemandii* (Montagne) F. Schmitz
(Fig. 12)

Described from the Red Sea, this species was first recorded in the Mediterranean Sea from Greece (Piraeus) and from Libya (Petersen, 1918). In Syria, it was recorded by Mayhoub (1976).

*Lophocladia lallemandii* was first found in Lebanon in 1973 (Basson *etal.*, 1976). Subsequently, it was observed at Batroun and Barbara, in 1996-1997 (Lakkis & Novel-Lakkis, 2000, 2001). The species is qualified as 'dominant upper infralittoral species' (Lakkis & Novel-Lakkis, 2007; Lakkis, 2013). We found it in August 1993 drifting in the port of Barbara, at Amchit on Vermetid reefs in 2000, and at Ras Chekaa and Hannouch in 2012, in the infralittoral zone, from the sea-surface down to 25 m depth (Bitar, 2010b; RAC/SPA - UNEP/MAP, 2014). *Lophocladia lallemandii* is well established in Lebanon.

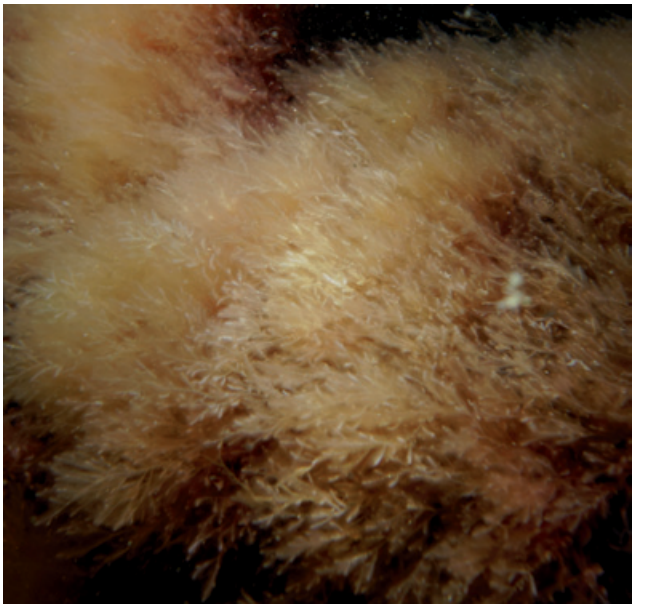

***Fig. 12:*** *Lophocladia lallemandii*, Lebanon, August 2015.

### 14. *Polysiphonia atlantica* Kapraun & J.N. Norris
(Fig. 13)

Described from the northeastern Atlantic (Ireland) and reported worldwide in temperate and warm seas, *P. atlantica* was first found in the Mediterranean Sea in 1969 in France (Verlaque *et al*., 2015). In the Eastern Mediterranean, it was recorded from Cyprus (Taşkin *et al*., 2008) and Greece (Tsiamis & Panayotidis 2016).

In Lebanon, *P. atlantica* was only found in 2014 at Batroun (Belous & Kanaan, 2015; Kanaan *et al.*, 2015). The occurrence of this casual species in Lebanon should be confirmed through further study.

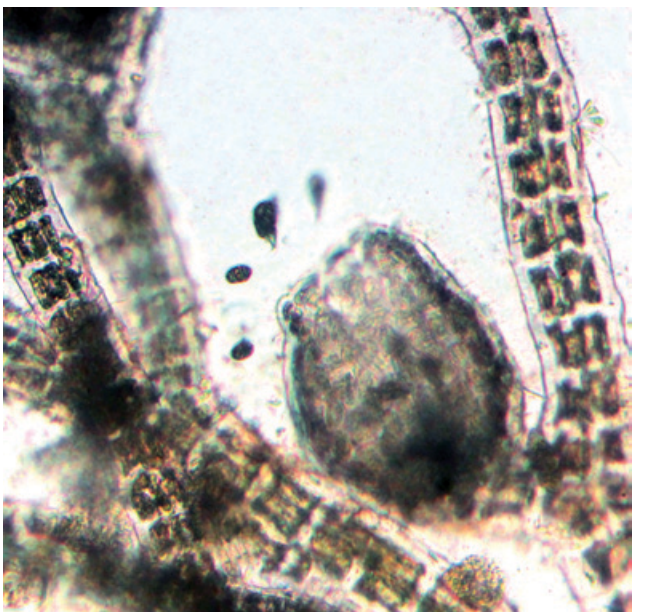

***Fig. 13:*** *Polysiphonia atlantica*, Lebanon, with the permission of Prof. Oksana Belous.

**15. *Sarconema filiforme* (Sonder) Kylin** (Fig. 14)

Described from Western Australia, this species of the Red Sea and the Indian Ocean was first found in the Mediterranean Sea in 1944 in Egypt (Aleem, 1948, as *Sarconema furcellatum*). Subsequently, it was recorded from the South Levantine coast (Rayss, 1963, as *S. filiforme* f. *gracillima*; Einav, 2007, misidentified as *Solieria filiformis*) and from Syria, in lower sciaphilic infralittoral assemblages (Mayhoub, 1976).

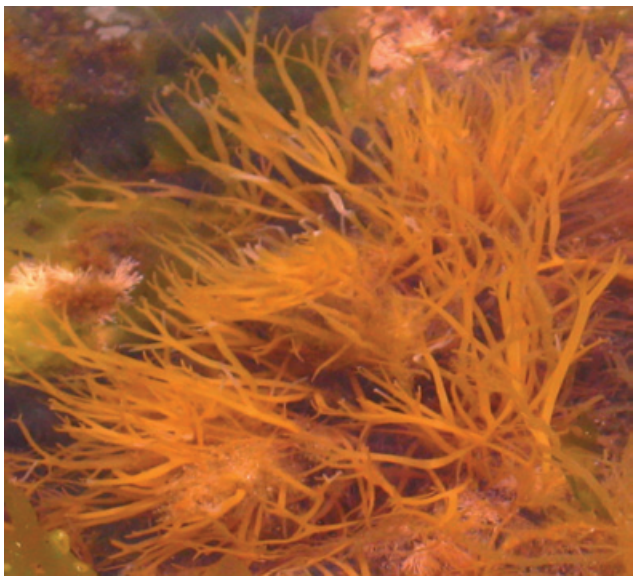

***Fig. 14:*** *Sarconema filiforme*, Beirut, June 2010.

In Lebanon, *S. filiforme* was first found in April 2001 at Beirut, in shallow pools of Vermetid reefs and between the sea-surface and 1m depth (Bitar, 2010b). *Sarconema filiforme* is established in Lebanon.

**16. *Womersleyella setacea* (Hollenberg) R. E. Norris** (Fig. 15)

Described from Hawaii and widespread in the Tropical Pacific and Atlantic Oceans, this species was first found in the Mediterranean Sea in 1986 in Italy (Livorno) (Verlaque *et al.*, 2015). Invasive in the western Mediterranean basin and the Adriatic Sea, *W. setacea* was recorded in the eastern Mediterranean basin from Cyprus (Taskin *et al.*, 2008) and Rodos Island, Greece (Zenetos *et al,* 2015).

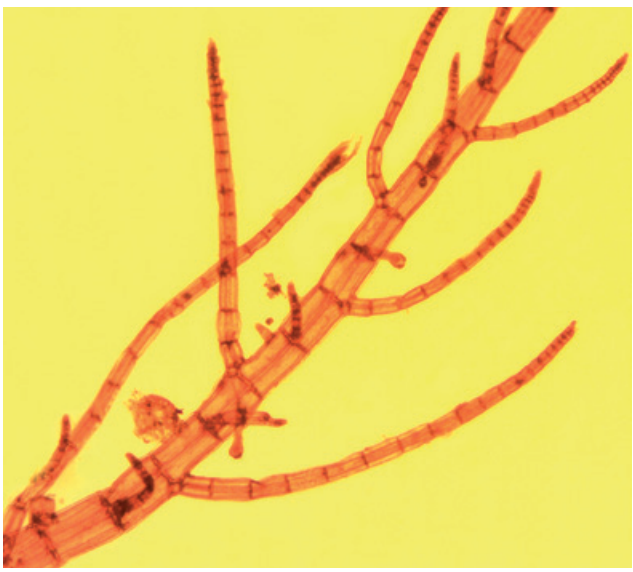

***Fig. 15:*** *Womersleyella setacea*, Batroun, October 2016.

In Lebanon, *W. setacea* was found in October 2016 at Batroun, between 40 and 50 m depth. Lebanese specimens were well characterized by (i) the thallus filamentous without percurrent axis, up to 100 µm in diameter, (ii) the four periaxial cells, and (iii) the rhizoids cut off from periaxial cells and forming terminally a multicellular disc. It is the first time that this highly invasive species has been recorded from Lebanon.

**17. *Bryopsis pennata* J.V. Lamouroux?** (Fig. 16)

Described from the Caribbean Sea (Lamouroux, 1809) and reported worldwide in warm seas, this species was first observed in the Mediterranean Sea in France (Feldmann, 1937). In the eastern Mediterranean Sea, *B. pennata* was recorded from Syria (Mayhoub, 1976), from Turkey (Cirik, 1978; Çinar *et al*., 2005), and from Greece (Tsiamis *et al.*, 2014).

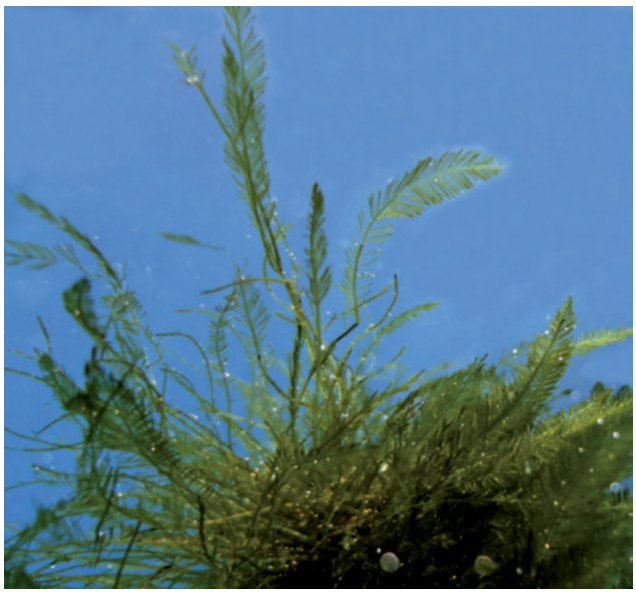

***Fig. 16:*** *Bryopsis pennata*, Kfar Abida, August 2012.

*Bryopsis pennata* has been excluded of the CIESM Atlas of exotic species of the Mediterranean Sea (Verlaque *et al.*, 2015). However, the Lebanese specimens agree well with descriptions and illustrations of Red Sea and Indo-Pacific algae attributed to *B. pennata*. *Bryopsis pennata* is morphologically very close to the Indo-Pacific species *B. indica* A. Gepp & E.S. Gepp. Consequently, the probability that the Lebanese alga be introduced is high, but its identity and origin should be tested through molecular studies.

In Lebanon, *B. pennata* was first recorded in 1973 from Khalde (Basson *et al*., 1976). Subsequently, it was found at Batroun and Barbarain 1996-1997 and 2014 (Lakkis & Novel-Lakkis, 2000, 2001; Belous & Kanaan, 2015).We first observed *B. pennata* in 1991 at Barbara,

and subsequently at Ramkine Island, Enfeh, El Heri, Kfar Abida, Tabarja, Beirut and El Baiada. *Bryopsis pennata* is well established in Lebanon.

**18. *Caulerpa chemnitzia* (Esper) J.V. Lamouroux** (Fig. 17)

Described from India and widespread in warm seas, this species was first recorded in the Mediterranean Sea from Tunisia (Hamel, 1926, misidentified as *C. racemosa*). *Caulerpa chemnitzia* was recorded from Syria (Mayhoub, 1976, as *C. racemosa*) and from the South Levantine coast (Lundberg, 1996 and Einav, 2007, as *C. racemosa*).

In Lebanon, *C. chemnitzia* was first recorded from Beirut (Hamel, 1931, misidentified as *C. racemosa*). Subsequently, the species was recorded from Aramane, Batroun, Barbara, Zouk Mkayel and Khalde in 1996-1997 (Lakkis

***Fig. 17:*** *Caulerpa chemnitzia*, Tripoli, September 2002.

& Novel-Lakkis, 2000, 2001, 2007, as *C. racemosa*). We found *C. chemnitzia* in 1993 and 2002, at Tripoli, in the area of El Mina and in the commercial port, between the sea-surface and 2m depth (Bitar, 1999, 2010b). Recently, it has disappeared from El Mina following the economic development of the area. Although uncommon, *C. chemnitzia* is established in Lebanon.

**19. *Caulerpa mexicana* Sonder *ex* Kützing** (Fig. 18)

Described from the Mexico Gulf and widespread in warm seas, this species was first found in the Mediterranean Sea in 1939 in Palestine and in Lebanon (Beirut) (Rayss, 1941, 1955, as *C. crassifolia*). Subsequently, it was recorded from Syria (Mayhoub, 1976) where we observed it in the shallow pools of Vermetid reefs of the Arwad Island (Bitar *et al*., 2003). The species is common on the South Levantine coast (Lundberg, 1996; Einav, 2007)

In Lebanon, we found an individual of *C. mexicana* in 1991 off the Riviera Hotel at El Manara (Beirut), on

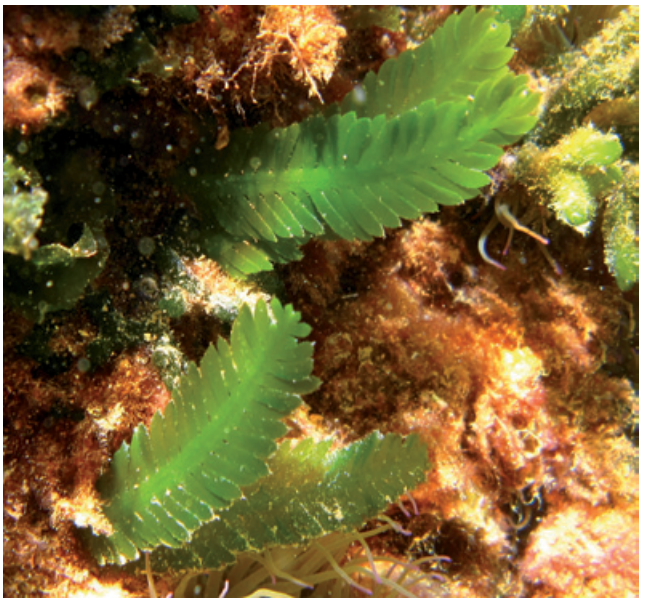

***Fig. 18:*** *Caulerpa mexicana*, Beirut, July 2016.

a sandy-rocky substrate, around 3 m depth. In 1992, it had disappeared and no other specimen was found (Bitar, 1999, 2010b). It was not until July 2016 that several small individuals were found off the American University of Beirut, in a large pool of the Vermetid reef, at 1m depth. The species was also reported as rare by Lakkis *et al.* (1996) and Lakkis & Novel-Lakkis (2001). Although uncommon, *C. mexicana* is established in Lebanon.

**20. *Caulerpa racemosa* (Forsskål) J. Agardh var. *lamourouxii* (Turner) Weber-van Bosse f. *requienii* (Montagne) Weber-van Bosse** (Fig. 19)

Described from the Red Sea, this species was first foundin the Mediterranean Sea in 1951 along the South

***Fig. 19:*** *Caulerpa racemosa* var. *lamourouxii* f. *requienii*, Batroun, September 2016.

Levantine coast (Rayss & Edelstein, 1960, as *C. feldmannii*). Subsequently, it was recorded from Syria (Huvé, 1957) where it has become common (Bitar *et al.*, 2003).

In Lebanon, our first observation dates from August 1991 at Beirut. From north to south, *C. racemosa* var. *lamourouxii* f. *requienii* was found in 1994, 1999, 2001 and 2016 at Ramkine Island, Tripoli, Hannouch, El Heri, Ras Chekaa, Selaata, Batroun, Beirut, Saadiyat and Saida. (Bitar *et al.*, 2000; Bitar, 2010b; present study). The taxon is established in Lebanon, without any detectable impact on benthic assemblages.

**21. *Caulerpa scalpelliformis* (R. Brown *ex* Turner) C. Agardh** (Fig. 20)

Described from South Australia and widespread in warm seas, this species was first found in the Mediterranean Sea in 1929 along the South Levantine coast (Carmin, 1934). In Syria, *C. scalpelliformis* was recorded by Mayhoub (1976), and we found it in 2003 off Arwad Island, at 34 m depth, and at the seaside resort of Lattakieh, around 30 m depth, on a soft bottom, associated with *Penicillus capitatus* Lamarck and *Caulerpa racemosa* var. *lamourouxii* f. *requienii* (Bitar *et al*., 2003). The species is common on the South Levantine coast (Lundberg, 1996).

***Fig. 20:*** *Caulerpa scalpelliformis*, Ras Chekaa, June 2012.

In Lebanon, *C. scalpelliformis* was first found at Beirut, close to the sea-surface, where it was abundant, and at 30 m depth (Hamel, 1930). Subsequently, the species was recorded from Batroun and Barbara in 1996-1997 (Lakkis *et al.*, 1996; Lakkis & Novel-Lakkis, 2000, 2001, 2007). We found two varieties of *C. scalpelliformis* (Bitar, 2010b):

- *C. scalpelliformis* var. *scalpelliformis* in 1994 at Hannouch, on a rocky substrate, at 1 m depth.
- *C. scalpelliformis* var. *intermedia* Weber-van Bosse in June 2000 at Khalde, in the Villamar Marina where it was well established (Bitar *et al.,* 2000), and in April 2001 at Batroun.

We observed *C. scalpelliformis* in September 2005 off Selaata, at around 30 m depth, on a muddy substrate (Bitar *et al*., 2007; Bitar, 2010b), and in June 2012 at Ras Chekaa, at 44 m depth on a muddy maerl assemblage associated with *Flabellia petiolata* (Turra) Nizamuddin (RAC/SPA - UNEP/MAP, 2014). The species is well established in Lebanon, without being invasive.

**22. *Caulerpa taxifolia* var. *distichophylla* (Sonder) Verlaque, Huisman & Procaccini** (Fig. 21)

Described from south-western Australia and recorded from Torres Strait and Central Polynesia, this Indo-Pacific species was first found in the Mediterranean Sea by one of us (G.B.) in August 2003 in Syria (RAC/SPA – UNEP/MAP, 2003, misidentified as a dwarf form of *C. mexicana*; Bitar, 2010b, as a dwarf form of *C. mexicana* or *C. taxifolia*). Subsequently, it was recorded from Turkey (Gulf of Iskenderun) (Cevik *et al.,* 2007, as *C. taxifolia*), Sicily (Jongma *et al.,* 2013), Cyprus (Çiçek *et al.,* 2013), Malta (Schembri *et al.*, 2015), and Rodos Island (Aplikioti *et al.,* 2016).

In Lebanon, *C. taxifolia* var. *distichophylla* was first found in October 2016 at El Madfoun and Byblos, between 16 and 48 m depth, where it constituted small patches (10-40 cm in diameter) on sand and gravels. Lebanese specimens were well characterized by (i) the thallus tiny with fronds, up to 3.5 mm broad and 10 cm high, bearing distichously arranged pinnules, and (ii) the pinnules closely adjacent, compressed, slightly upwardly curved, broadest just above the base, and tapering to a distinct spinous tip. *Caulerpa taxifolia* var. *distichophylla,* which is invasive in the Central Mediterranean basin (Sicily; Jongma *et al.*, 2013), is recorded for the first time from Lebanon.

***Fig. 21:*** *Caulerpa taxifolia* var. *distichophylla*, El Madfoun, October 2016.

**23. *Cladophora herpestica* (Montagne) Kützing** (Fig. 22)

Described from New Zealand and widespread in the Indo-Pacific Ocean, this species was first recorded in the Mediterranean Sea from Egypt (Aleem, 1948, as *Cladophoropsis zollingeri*). All the other Levantine records of *Cladophoropsis* spp. (Rayss, 1955; Mayhoub, 1976; Lundberg, 1996; Einav, 2007) have been attributed to *C. herpestica* (Verlaque *et al.,* 2015).

In Lebanon, *C. herpestica* was first found in 1973 at Barbara, Zouk Mkayel, Khalde and Doha (Basson *et al*., 1976, misidentified as *Cladophoropsis modonensis*).

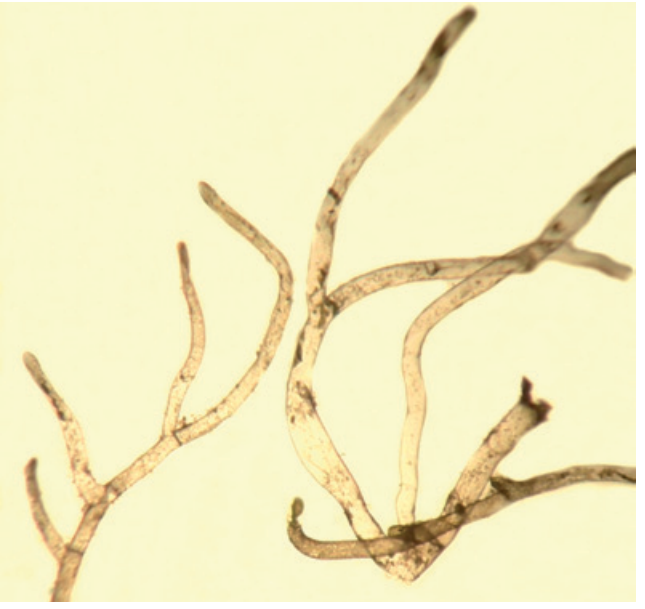

***Fig. 22:*** *Cladophora herpestica*, Tyre, May 2016.

Subsequently it was found at Aramane and Batroun in 1996-1997 (Lakkis & Novel-Lakkis, 2000). We observed *C. herpestica,* in October 1991 at Saadiyat and May 2016 at Tyre. *Cladophora herpestica* is well established on the outer margins of Vermetid reefs of the Lebanese coast.

**24. *Cladophora patentiramea* (Montagne) Kützing** (Fig. 23)

Described from Tahiti and widespread in the Indo-Pacific Ocean, this species was first found in the Mediterranean Sea in 1991 at Cyprus (Verlaque *et al.*, 2015).

In Lebanon, we found *C. patentiramea* at Selaata and Tyre in September 2005 (Bitar *etal.*, 2007). Subsequently, it was observed at several other localities, especially in May 2010 and May 2016 at El Jamal (Tyre), on extended surfaces sheltered by small islets, at 2-3 m depth. The species is very similar to several native species of *Cladophora*, so the identity and origin of Mediterranean populations should be tested through molecular studies. *Cladophora patentiramea* requires special attention because it was invasive on shallow sandy localities in Cyprus.

***Fig. 23:*** *Cladophora patentiramea*, Tyre, May 2016.

**25. *Codium arabicum* Kützing** (Fig. 24)

Described from the Red Sea and widespread in the Indo-Pacific Ocean, this species was first found in the Mediterranean Sea in 2007 at Haifa (Hoffman *et al.,* 2011). In Syria, it was found in April 2013 (Abbas, 2015). According to Hoffman (2014a), *C. arabicum* should be regarded and treated as an invasive species.

In Lebanon, we found some individuals of *C. arabicum* at Hannouch in August 2007. Subsequently, we found it on a cliff, between 1 and 4 m depth, at Ramkine

***Fig. 24:*** *Codium arabicum*, Enfeh, June 2012.

Island in August 2010, at Barbara in October 2011, close to the Sea Star Hotel, at 2 m depth, and at Enfehin June 2012 (Bitar, 2014; present study). Although uncommon, *C. arabicum* seems to be established in Lebanon.

**26. *Codium parvulum* (Bory *ex* Audouin) P.C. Silva** (Fig. 25)

Described from the Red Sea and present in the Indian Ocean, this species was first found in the Mediterranean Sea in 2004 at Haifa (Israel *et al.*, 2010). In Syria, it was found in April 2013 (Abbas, 2015).

In Lebanon, we first found *C. parvulum* at Nakour-

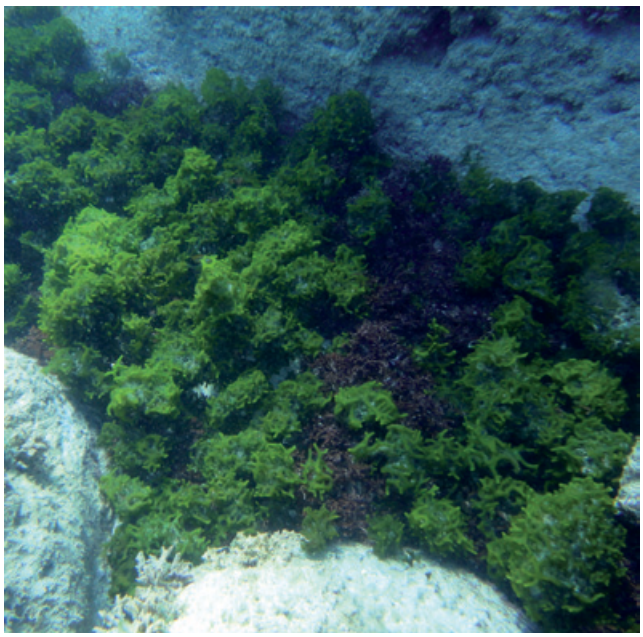

***Fig. 25:*** *Codium parvulum*, Kfar Abida, August 2012.

ain June 2008, where it occupied extensive areas at 30 m depth (Bitar, 2010b). Currently, *C. parvulum* is invasive along the whole Lebanese coast, between 1 and 35 m depth. *Codium parvulum* was the fourth invasive marine macrophyte to be identified in Lebanon, after *Ulva lactuca*, *Stypopodium schimperi* and *Galaxaura rugosa*.

**27. *Codium taylorii* P.C. Silva** (Fig. 26)

Described from Florida and widespread in the Atlantic and the Indian Oceans, *C. taylorii* was first recorded in the Mediterranean Sea from Palestine (Rayss, 1955; misidentified as *C. dichotomum*). In Syria, it was found in 1973 (Mayhoub, 1976, as *C. decorticatum*) and April 2013 (Abbas, 2015).

In Lebanon, we first found *C. taylorii* in September 2002 at Ouzai, on the breakwater close to Beirut Airport (Abboud-Abi Saab *et al*., 2003; Bitar *et al*., 2007, Bitar, 2010b). Currently, *C. taylorii* is well established along the whole Lebanese coast, without being invasive.

***Fig. 26:*** *Codium taylorii*, Hannouch, August 2012.

**28. *Ulva lactuca* Linnaeus** (Fig. 27)

All the European records of *U. lactuca* over the past 200 years correspond to another species referable as '*U. lactuca* auctores' (Verlaque *et al.,* 2015). The genuine *U. lactuca* is an alga widespread in warm seas and usually known as *U. fasciata* Delile (1813), a taxon described from the Mediterranean Sea (Egypt, Alexandria), before the opening of the Suez Canal. However, the chronology of Mediterranean records suggests multiple introductions via different vectors or co-occurrence of introduced and native populations (Verlaque *et al.*, 2015). *Ulva lactuca* was recorded along the whole Levantine coast (Mayhoub, 1976; Hoffman, 2014a; both as *U. fasciata*).

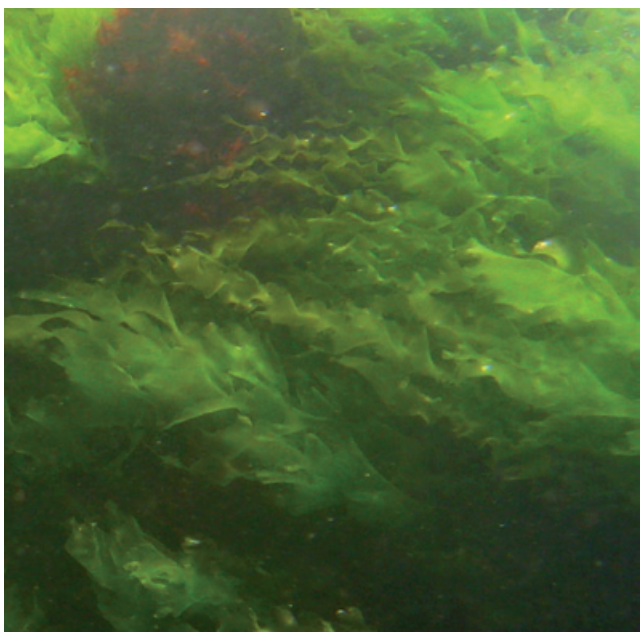

***Fig. 27:*** *Ulva lactuca*, Beirut, June 2010.

In Lebanon, we first found *U. lactuca* in April 1991 at Beirut (Bitar, 1999, as *U. fasciata*). Kanaan *et al.* (2015) recorded the species from Batroun, El Manara, Saida, Tyre and Barbara in 2014. The species is invasive along the whole Lebanese coast on Vermetid reefs and in shallow habitats. *Ulva lactuca* was the first invasive exotic marine macrophyte to be identified in Lebanon.

**29. *Halophila stipulacea* (Forsskål) Ascherson** (Fig. 28)

Described from the Red Sea and present in the Indian Ocean, *H. stipulacea* was first found in the Mediterranean Sea in 1894 at Rodos Island, Greece (Verlaque *et al*., 2015). In Syria, dense seagrass beds were observed at Ras El Bassit (Abboud-Abi Saab *et al*., 2003; Bitar *et al*., 2003, 2007). The species has not yet been detected along the South Levantine coast (Hoffman, 2014a).

In Lebanon, it was first collected in 1966, off Saida, by Dr J. H. Powell (Lipkin, 1975). We found it in July 1993 in the Beaulieu tourism complex at El Heri, at 2m depth, then in 1999 at Selaata (Bitar *et al.*, 2000; Bitar, 2010b). The species was also recorded from Aramane, Batroun, Barbara, Enfeh and Zouk Mkayel in 1996-1997 (Lakkis & Novel-Lakkis, 2000, 2001,2007; present study). *Halophila stipulacea* is mainly distributed in the northern part of Lebanon, between 1 and 40 m depth. No dense meadow shave been found in Lebanon.

***Fig. 28:*** *Halophila stipulacea*, Enfeh, October 1999.

## Discussion and conclusion

The analysis of historical and field data provided the basis for drawing up a list of 29 exotic macrophytes for the marine flora of Lebanon. The major origin and pathway of introduction are the Indo-Pacific Ocean and the Suez Canal, respectively (Table 1), namely the Lessepsian or Erythraean invasion. *Caulerpa taxifolia* var. *distichophylla, Spatoglossum variabile* and *Womersleyella setacea* are recorded for the first time from Lebanon. Among the invasive or potentially invasive species listed in the Mediterranean Sea (Verlaque *et al.*, 2015), thirteen occur in Lebanon: *Asparagopsis taxiformis, Caulerpa taxifolia* var. *distichophylla, Cladophora patentiramea, Codium arabicum, C. parvulum, Galaxaura rugosa, Halophila stipulacea, Hypnea cornuta, Laurencia* cf. *chondrioides, Lophocladia lallemandii, Stypopodium schimperi*, *Ulva lactuca* and *Womersleyella setacea*, and five of them, namely *Codium parvulum, Galaxaura rugosa, Laurencia* cf. *chondrioides, Stypopodium schimperi* and *Ulva lactuca*, already occupy extensive stretches of the coast, more or less replacing the native benthic assemblages.

*Neomeris annulata* Dickie and *Solieria dura* (Zanardini) F. Schmitz, two Indo-Pacific species respectively first recorded from Syria (Bitar *et al.,* 2005) and from the South Levantine coast (Rayss, 1963), have not yet been found in Lebanon contrary to what is stated in Verlaque *et al.* (2015). The identity and the origin of several exotic species, namely *Bryopsis pennata, Chondria coerulescens, Cladophora patentiramea, Hypnea valentiae, Laurencia* cf. *chondrioides* and *Polysiphonia atlantica*, should be confirmed by further studies (Questionable species). *Acanthophora nayadiformis, A. taxiformis, G. farinosum* and *U. lactuca* are considered to be cryptogenic (Table 2).

The total number of exotic macrophytes listed in the marine flora of Lebanon is probably under-estimated because, in addition to *Neomeris annulata* and *Solieria dura,* several other large exotic species recorded from the other Levantine countries have not yet been found in Lebanon, namely *Dichotomaria* cf. *obtusata* (J.Ellis & Solander) Lamarck, *Gracilaria arcuata* Zanardini, *Grateloupia turuturu* (identification to be confirmed by molecular studies), *Hypnea flagelliformis* Greville ex J. Agardh (misidentified as *H. spicifera*), *Padina boryana* Thivy, *Rhodymenia erythraea* Zanardini and *Sarconema scinaioides* Børgesen (Hoffman, 2014b; Hoffman *et al.*, 2015; Verlaque *et al.,* 2015; Arraj *et al.*, 2016), as well as *Palisada maris-rubri* (K.W. Nam & Saito) K.W. Nam, a species recorded from Rodos Island, Greece (Tsiamis & Gerakaris *in* Tsiamis *et al.,* 2015) and Tunisia (Boudouresque *et al.,* 2016). Likewise, we did not look for the small exotic species (< 1-2 cm high) such as *Acrochaetium* spp., *Antithamnionella elegans* (Berthold) J.H. Price & D.M. John, *Boodlea composita* (Harvey) F.Brand (record requiring confirmation), *Boodleopsis pusilla* (Collins) Taylor (Identification requiring confirmation), *Chondria pygmaea* Garbary & Vandermeulen, a common epiphytic species of *Halophila stipulacea, Derbesia boergesenii* (Iyengar & Ramanathan) Mayhoub, *Hypnea anastomosans* Papenfuss, Lipkin & P.C. Silva, *Hypoglossum caloglossoides* M.J.Wynne & Kraft, *Monosporus indicus* Børgesen (Einav, 1998, 2007; Verlaque *et al.,* 2015; Hoffman, 2014a, 2015; Hoffman & Wynne, 2015, 2016).

**Table 2.** List of exotic marine macrophytes of the Lebanese coast, with alien status, date, locality and reference of the first record in Lebanon, possible origins, putative pathways of the first introduction in the Mediterranean Sea and establishment success in Lebanon. **Alien status**: Al = Alien; Cr = Cryptogenic; Qu = Questionable. **Origins**: A = Atlantic; IP= Red Sea / Indo-Pacific. **Pathways:** Categories / Subcategories according to the CBI (2014) classification: C/CAE = Corridor / Canal of Ancient Egyptians; C/SC = Corridor / Suez Canal; R/Aq = Release in nature / Aquarium species; T-C/A = Transport-Contaminant / Aquaculture; T-S/Sh = Transport-Stowaway / Ship hull fouling or ballast water. **Establishment success in Lebanon**: E = established; Inv = invasive; C = casual; E? = establishment to precise by further investigation.

| SPECIES | STATUS | DATE | LOCALITY | SOURCE | ORIGINS | PATHWAYS | SUCCESS |
|---|---|---|---|---|---|---|---|
| **CHROMOBIONTA** | | | | | | | |
| ***Padina boergesenii*** Allender & Kraft | Al | 1992 | Tripoli | Bitar, 1999 | IP | C/SC | E |
| ***Spatoglossum variabile*** Figari & De Notaris | Al | 2009 | Tabarja | Present study | IP | C/SC | E |
| ***Stypopodium schimperi*** (Kützing) Verlaque & Boudouresque | Al | 1991 | Barbara | Bitar, 1999 | IP | C/SC | Inv |
| **RHODOBIONTA** | | | | | | | |
| ***Acanthophora nayadiformis*** (Delile) Papenfuss | Cr | 1991 | Tabarja | Bitar, 2010b | IP | C/CAE<br>C/SC<br>T-S/Sh | E |
| ***Asparagopsis taxiformis*** (Delile) Trevisan de Saint-Léon (Tetrasporophyte) | Cr | 1973 | Selaata, Barbara, Zouk Mkayel Khalde | Basson *et al.*, 1976 | A/IP? | C/CAE<br>C/SC<br>T-S/Sh | E |
| ***Asparagopsis taxiformis*** (Delile) Trevisan de Saint-Léon (Gametophyte) | Cr | 1993 | Barbara, Batroun | Bitar *etal*., 2000 | A/IP ? | C/CAE<br>C/SC<br>T-S/Sh | E |
| ***Chondria coerulescens*** (J. Agardh) Falkenberg* | Qu | 1973 | North Lebanon | Basson *etal*., 1976 | A | T-C/A | E |
| ***Galaxaura rugosa*** (J. Ellis & Solander) J.V. Lamouroux | Al | 1995 | Kfar Abida | Bitar *et al.*, 2000 | IP | C/SC | Inv |
| ***Ganonema farinosum*** (J.V. Lamouroux) K.C. Fan & Y.C. Wang | Cr | 1993 | El Heri | Bitar *et al.*, 2000, as *Liagora farinosa* | IP | C/SC<br>T-S/Sh | E |
| ***Hypnea cornuta*** (Kützing) J. Agardh | Al | 1973 | North Lebanon | Basson *etal*., 1976, as *H. hamulosa* | IP | C/SC<br>T-S/Sh | E |
| ***Hypnea spinella*** (C. Agardh) Kützing | Al | 1998 | Beirut, | Present study | A/IP | C/SC<br>T-S/Sh | E |
| ***Hypnea valentiae*** (Turner) Montagne* | Qu | 2014 | Batroun | Belous & Kanaan, 2015 | IP | C/SC<br>T-C/A | C |
| ***Laurencia* cf. *chondrioides*** Børgesen* | Qu | 2009 | El Baiada, Tyr, Nakoura | Present study | A | T-S/Sh | Inv |
| ***Lophocladia lallemandii*** (Montagne) F. Schmitz | Al | 1973 | North Lebanon | Basson *etal.*, 1976 | IP | C/SC<br>T-S/Sh | E |
| ***Polysiphonia atlantica*** Kapraun & J.N. Norris* | Qu | 2014 | Batroun | Bellous & Kanaan, 2015 | A/P | T-S/Sh | C |
| ***Sarconema filiforme*** (Sonder) Kylin | Al | 2001 | Beirut | Bitar, 2010b | IP | C/SC | E |
| ***Womersleyella setacea*** (Hollenberg) R.E.Norris | Al | 2016 | Batroun | Present study | IP | R/Aq<br>T-S/Sh | E? |
| **CHLOROBIONTA** | | | | | | | |
| ***Bryopsis pennata*** J.V. Lamouroux* | Qu | 1973 | Khalde | Basson *et al*., 1976 | IP | C/SC<br>T-S/Sh | E |
| ***Caulerpa chemnitzia*** (Esper) J.V. Lamouroux | Al | 1931 | Beirut | Hamel, 1931, as *C. racemosa*; | IP | C/SC | E |
| ***C. mexicana*** Sonder *ex* Kützing | Al | 1941 | Beirut | Rayss, 1941, as *C. crassifolia* | IP | C/SC | E |
| ***C. racemosa* var. *lamourouxii* f. *requienii*** (Montagne) Weber-van Bosse | Al | 1991 | Beirut | Present study | IP | C/SC | E |
| ***C. scalpelliformis*** (R.Brown ex Turner) C. Agardh | Al | 1930 | Beirut | Hamel, 1930 | IP | C/SC | E |
| ***Caulerpa taxifolia* var. *distichophylla*** (Sonder) Verlaque, Huisman & Procaccini | Al | 2016 | El Madfoun, Byblos | Present study | IP | R/Aq<br>T-S/Sh | E |
| ***Cladophora herpestica*** (Montagne) Kützing | Al | 1973 | Barbara, Zouk Mkayel, Khalde, Doha | Basson *et al*., 1976, as *Cladophoropsis modonensis* | IP | C/SC | E |
| ***Cladophora patentiramea*** (Montagne) Kützing* | Qu | 2005 | Selaata, Tyr | Bitar *etal.*, 2007 | IP | C/SC | E |
| ***Codium arabicum*** Kützing | Al | 2007 | Hannouch | Present study | IP | C/SC | E |
| ***C. parvulum*** (Bory *ex* Audouin) P.C.Silva | Al | 2008 | Nakoura | Bitar, 2010b | IP | C/SC | Inv |
| ***C. taylorii*** P.C. Silva | Al | 2002 | Ouzai, Beirut | Abboud-Abi Saab *et al.*, 2003 | IP/A | T-C/A<br>T-S/Sh | E |
| ***Ulva lactuca*** Linnaeus | Cr | 1991 | Beirut | Bitar, 1999, as *U. fasciata* | IP | C/CAE<br>T-S/Sh | Inv |
| **STREPTOBIONTA** | | | | | | | |
| ***Halophila stipulacea*** (Forsskål) Ascherson | Al | 1966 | Saida | Lipkin, 1975 | IP | C/SC | E |

* Identification requiring confirmation

Lastly, it is worth noting the absence of *Caulerpa cylindracea* Sonder, which is probably the most aggressive invasive species of the Mediterranean Sea. All these exotic species need to be looked for in Lebanon. On the other hand, the Lebanese record of *Solieria filiformis* (RAC/SPA - UNEP/MAP, 2014) is a misidentification of *Sarconema filiformis*.

As far as the ecological and economic impact is concerned, the introduction of species constitutes biological pollution and is one of major constituents of Global Change. In the eastern Mediterranean basin, the negative impact of the arrival of Indo-Pacific species is on the increase, and this phenomenon will likely be intensified with the doubling of the Suez Canal (Galil *et al.,* 2015). Consequently, the Mediterranean nations must be made fully aware and international collaboration must be developed between all stakeholders (national and international organisations, governmental and non-governmental organisations, research institutes, etc.) to attempt to slow down the phenomenon and mitigate the consequences.

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