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Charles-François BOUDOURESQUE, Rachid SEMROUD, Aurélie BLANFUNÉ & Michèle PERRET-BOUDOURESQUE

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Sighting of *Saccorhiza polyschides* (Lightfoot) Batters (Phaeophyceae, Stramenopiles) in Algeria (Mediterranean Sea): an insight into range expansion routes

Charles-François BOUDOURESQUE
Aix-Marseille University and University of Toulon, MIO (Mediterranean Institue of Oceanography), CNRS, IRD, Campus of Luminy, F-13288 Marseilles (France)
charles.boudouresque@mio.osupytheas.fr (corresponding author)

Rachid SEMROUD
Marine Resources Conservation and Valorisation, National School of Marine Science and Coastal Management (ENSSMAL); BP 19, Bois des Cars-Campus Universitaire de Dély Ibrahim, 16320 Alger (Algeria)

Aurélie BLANFUNÉ
Aix-Marseille University and University of Toulon, MIO (Mediterranean Institue of Oceanography), CNRS, IRD, Campus of Luminy, F-13288 Marseilles (France)
aurelie.blanfune@mio.osupytheas.fr (corresponding author)

Michèle PERRET-BOUDOURESQUE
Aix-Marseille University and University of Toulon, MIO (Mediterranean Institue of Oceanography), CNRS, IRD, Campus of Luminy, F-13288 Marseilles (France)

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ABSTRACT
In the Mediterranean Sea, the north-east Atlantic seaweed *Saccorhiza polyschides* (Lightfoot) Batters is uncommon. The only permanent populations are located in the Alboran Sea near the Strait of Gibraltar and the Strait of Messina (Italy). In contrast, since the early 19th century, several sightings, on ship's hulls or in harbours, reflect the dispersal of propagules which failed to establish in the Mediterranean. Here we report a new sighting of *Saccorhiza polyschides*, near the port of Jijel, Algeria. This first new record in the Mediterranean for more than a century indicates that the dispersal of propagules continues today. In addition, because of its spectacular size and ease of its observation, it sheds light on the expansion routes of a species at the limit of their current range area.

KEY WORDS
Algeria, biogeography, Mediterranean Sea, range expansion, *Saccorhiza polyschides*.

RÉSUMÉ

Observation de Saccorhiza polyschides *(Lightfoot) Batters (Phaeophycées, Straménopiles) en Algérie (mer Méditerranée) : une illustration des voies d'expansion de l'aire de distribution.*

En Méditerranée, la macroalgue du nord-est de l'Atlantique *Saccorhiza polyschides* (Lightfoot) Batters n'est pas commune. Les seules populations permanentes sont celles de la mer d'Alboran, près du détroit de Gibraltar et du détroit de Messine (Italie). Depuis le début du XIXe siècle, plusieurs observations, sur des coques de bateaux ou dans des ports, traduisent la dispersion de propagules en Méditerranée ; l'espèce n'y a pas dépassé le stade d'adventice. L'observation de *Saccorhiza polyschides* près du port de Jijel (Algérie), la première nouvelle observation en Méditerranée depuis plus d'un siècle, montre que la dispersion de propagules en Méditerranée se poursuit de nos jours. De plus, grâce à sa taille et à la facilité de son observation, elle contribue à illustrer les voies d'expansion d'une espèce à la limite de son aire actuelle de distribution.

MOTS CLÉS
Algérie, biogéographie, mer Méditerranée, expansion d'aire, *Saccorhiza polyschides*.

INTRODUCTION

The brown alga *Saccorhiza polyschides* (Lightfoot) Batters (Phaeophyceae, Ochrophyta, kingdom Stramenopiles) (synonym of *Saccorhiza bulbosa* (Hudson) De la Pylaie) is a north-eastern Atlantic large seaweed, known from Norway to southern Morocco (Hamel 1931-1939; Gayral 1966; Norton & Burrows 1969; Ardré 1970; Norton 1977; Rueness 1977). It is a species with a short life-span: the longevity of the macroscopic sporogenic phase (2n) never exceeds one year; the gametogenic phase is microscopic and is dependent on the presence of encrusting corallines (Rhodobionta, kingdom Archaeplastida) to thrive (Feldmann 1934; Huvé 1958; Fredj & Giaccone 1995; see Boudouresque 2015, for the taxonomic treatment). Records from the Gulf of Guinea (Beauvois 1805) and Lanzarote (Canary Islands; Ballesteros *et al.* 1992) could correspond to casual populations stemming from individuals transported on ships' hulls, as is the case for most Mediterranean records (see opposite) (Norton & Burrow 1969; Price *et al.* 1978).

In the Mediterranean Sea, *S. polyschides* is extremely rare or almost non-existent, with the exception of certain areas of the Alboran Sea, close to the Strait of Gibraltar (Feldmann 1934; Norton 1977; Navarro & Gallardo 1989; Boudouresque *et al.* 1990; Ribera *et al.* 1992; Benhissoune *et al.* 2002). A permanent population is present in the Strait of Messina (Sicily and Calabria, Italy); it thrives mainly on the vertical faces of the blocks of harbour jetties, from sea level down to 2 m depth (Molinier & Picard 1953; Huvé 1958; Giaccone 1969; Fredj & Giaccone 1995). Mediterranean specimens are generally smaller than those of the Atlantic: less than 2 m vs up to 5 m (Feldmann 1934; Cormaci *et al.* 2012).

Saccorhiza polyschides has sometimes been observed in the Mediterranean (Table 1; Fig. 1). However, with the exception of the Alboran Sea and the Strait of Messina, no permanent populations have been recorded. It was observed on ship hulls, on harbour jetties or in the close vicinity of a harbour (Sauvageau 1918; Feldmann 1934). The populations were temporary: the following year, the species was no longer observed, a feature that is indicative of a failed introduction process (Feldmann 1934; Boudouresque *et al.* 1990; Ribera & Boudouresque 1995; Boudouresque & Verlaque 2012).

In Algeria, *Saccorhiza polyschides* has been never observed (Perret-Boudouresque & Seridi 1989; Ould-Ahmed *et al.* 2013). The record of Debray (1897) from Cherchell, 89 km west of Algiers, is erroneous (Table 1); Jean Feldmann, who examined the voucher specimens of the Debray herbarium, corrected the identification into *Phyllaria reniformis* (Lamouroux) Rostafinsky ex Bornet (now *Phyllariopsis brevipes* (C.Agardh) E.C.Henry & G.R.South) (Feldmann 1934; Perret-Boudouresque & Seridi 1989). It is worth noting that the Moroccan populations of Cabo Tres Forcas are located only 60 km away from Algeria (González-García 1994).

RESULTS

In 2014, Souhila Bounail, a student in aquaculture at the ENSSMAL (Algeria), observed a strange brown alga thrown by local artisanal fishers, while cleaning their fishing nets, onto the wharf of the small fishing harbour of El Aouana (formerly Cavallo, during the French colonization), *c.* 15 km west of Jijel (Fig. 2). The city of Jijel is located 330 km (by road) and 240 km (as the crow flies) east of Algiers. We easily identified the alga as *Saccorhiza polyschides*.

DISCUSSION

Fishers at El Aouana exploit a *c.* 10-15 km range east and west of the harbour. There is therefore little doubt that the alga came from this area. All fishers at El Aouana use fishing nets, not trawl, so that the alga probably hooked onto nets at a relatively shallow depth. The very fresh appearance of the seaweed suggests that it was not drift matter carried by the current coming from Gibraltar and the areas of the Alboran Sea where the species is present, more than 1000 km to the west of Jijel. It is worth noting that drift individuals of *S. polyschides* do not float. The possibility of spores being driven by currents from Cabo Tres Forcas (Morocco) or other intermediate (unknown) localities must also be considered.

A large part of the world's maritime traffic (*c.* 30%) passes through the Mediterranean Sea (Dobler 2002). The main

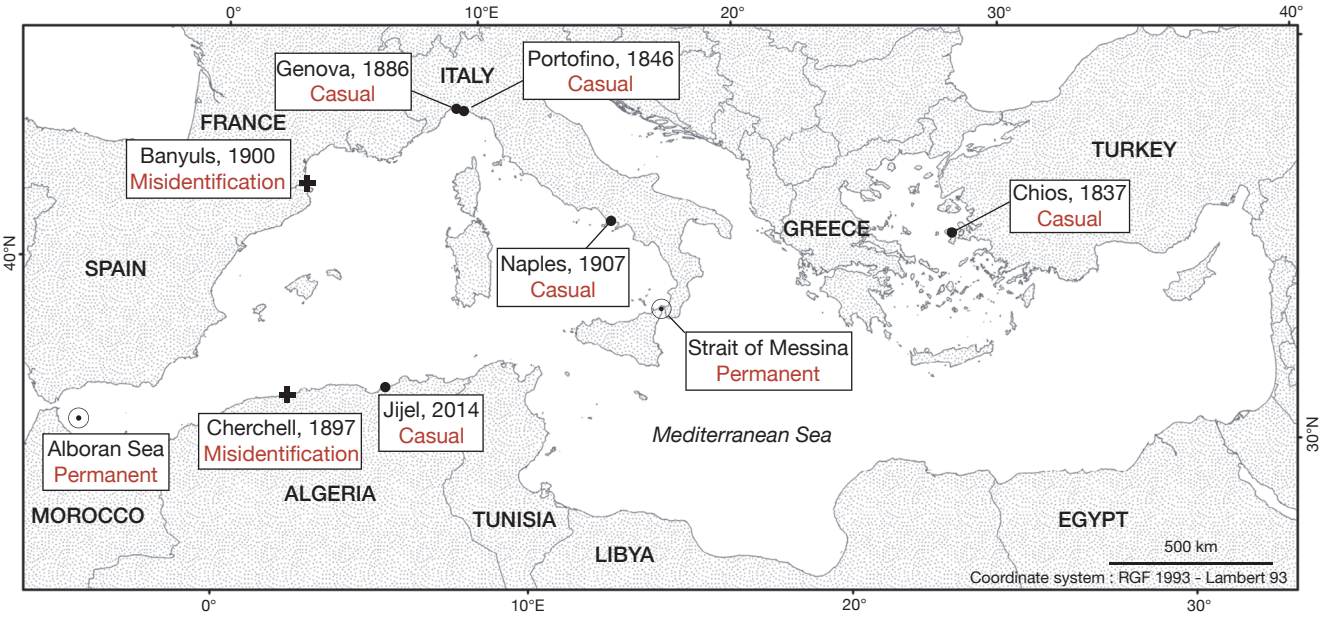

FIG. 1. — Mediterranean records of *Saccorhiza polyschides* (Lightfoot) Batters. The date is that of the sighting and, if unknown, that of the publication.

TABLE 1. — Mediterranean records of *Saccorhiza polyschides* (Lightfoot) Batters. Records from the Alboran Sea, close to the Straits of Gibraltar, are not reported.

Country	Site	Habitat and comments	References
France	Banyuls (Occitania)	Erroneous record, for Phyllariopsis brevipes (Sauvageau, 1918; Feldmann, 1934)	Chalon (1900)
Italy	Genoa (Genova) (Liguria)	Harbour, on a ship hull, collected by Baglietto (in Ardissone, 1886)	Ardissone (1886), Sauvageau (1918), Feldmann (1934)
	Portofino (Liguria)	Collected on shallow reefs in 1846 by Savignone (in Ardissone, 1886)	Ardissone (1886), Sauvageau (1918), Feldmann (1934)
	Naples (Napoli) (Campania)	On a ship hull, in the harbour, in May 1907	Nienburg *in* Funk (1927) & Funk (1955)
	Villa San Giovanni (Calabria)	Harbour jetties	Molinier & Picard (1953), Huvé (1958), Giaccone (1969)
	Messina (Sicily)	Harbour jetties	Huvé (1958), Giaccone (1969)
	Messina (Sicily)	On buoy chains, in the liner harbour	Falkenberg (1879), Feldmann (1934)
	Paradiso (Messina, Sicily)	On the chain of a buoy, 22 m depth	Furnari & Scammacca (1973)
Greece	Chios Island	Observed in 1837 by Chaubard & Bory de Saint-Vincent (1838). Whether it was dredged or found in the drift matter is unknown. Never observed again.	Chaubard & Bory de Saint-Vincent (1838), Sauvageau (1918), Feldmann (1934), Athanasiadis (1987), Tsiamis *et al.* (2013)
Algeria	Cherchell	Erroneous record, for Phyllariopsis breviceps (Feldmann, 1934)	Debray (1897)

Mediterranean route from Gibraltar to the Suez Canal runs along the Algerian coast (Katsanevakis *et al.* 2014; Grid-Arendal 2019). The port of Jijel, a middle-sized city (*c.* 150 000 inhabitants), is mainly used by car carriers and bulk cargo vessels. *Saccorhiza polyschides* can be attached to the hull of ships. A specimen could have detached itself from the hull of a ship in transit in the Jijel region. Another hypothesis is that an ephemeral population of *S. polyschides* may have settled in the vicinity of the port. We did not thoroughly explore the region of Jijel, to attempt to localize a possible source population of *S. polyschides*. However, such a large species, with characteristics that are so striking if compared with other species of the Mediterranean flora, living on relatively shallow hard substrates, could hardly pass unnoticed. We did not obtain any information regarding its presence after 2014. If a stable population did exist, it has since disappeared, as was the case in most of its other Mediterranean localities (Fig. 2).

The main interest of our sighting of *S. polyschides* near Jijel, and of the review of Mediterranean sightings we present (Table 1), is that they shed light on the routes and processes of the range expansion of a species. For most species, due to their small size and to the microscopic nature of their propagules, the flow of propagules, from the margin of their range area towards possible new quarters, is invisible. Failed colonization "attempts" therefore go unnoticed. A large species (several metres tall), dwelling in shallow waters and therefore

Fig. 2. — The specimen of *Saccorhiza polyschides* (Lightfoot) Batters collected in 2014 at El Aouana (formerly Cavallo), near Jijel, Algeria. Photo: Rachid Semroud.

impossible to miss, *S. polyschides* offers the opportunity to monitor the routes followed by propagules, together with failed "attempts" to establish into new quarters. Our review shows that: 1) "attempts" have been uneven over time, with the exception of the early 20th century (no sightings have been recorded in the 20th century); The cold 19th century, at the end of the Little Ice Age (Le Roy-Ladurie 2004; Gioda *et al.* 2004; Luterbacher *et al.* 2004; Le Roy-Ladurie 2005), was probably more favourable to the expansion of *S. polyschides*, a warm temperate affinities species (from Norway to Morocco; Hoek 1982), than the 20th and 21st centuries; yet, the flow of propagules, from the Atlantic and the Alboran Sea, to the Mediterranean, is still active, as evidenced by our sighting at Jijel; 2) beachheads have also been uneven. They depend upon the presence of *S. polyschides* on a ship's hull and on the route of a ship towards a port of call. There is therefore no logical pattern of expansion; it follows the "saltation dispersal – hopscotch jump model" rather than the "diffusion dispersal –

wave of advance model"; see e.g. López-Legentil *et al.* (2015), Boudouresque & Sempéré (2017), Petrocelli *et al.* (2018), Verlaque & Breton (2019). On the basis of genetic tools, the expansion of *Dictyota cyanoloma* Tronholm, De Clerck, A. Gomez-Garetta & Rull Lluch (Phaeophyceae), native to Australia, along the Mediterranean coasts, has been shown to match both the saltation (from harbour to harbour) and the diffusion models (Aragay *et al.* 2016); and 3) range expansion events can prove to be highly uncommon. Despite the major current of Atlantic water which enters the Mediterranean at Gibraltar and runs eastwards along the north African coast, only a handful of colonization events have been recorded in more than two centuries.

Fortuitous sightings of supposedly ordinary species may seem uninteresting and not worthy of publication. Yet, they can tell us about important processes in ecology. To understand the current state of the earth and its changes, we need baselines, which are often missing. Reporting these observations helps to shed light on future changes.

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