

The red alga *Bonnemaisonia clavata*, an addition to the marine flora of the Port-Cros National Park (Provence, France, Mediterranean Sea)

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Abstract. The red alga *Bonnemaisonia clavata* has rarely been reported in the Mediterranean Sea, perhaps because its very close resemblance to *B. asparagoides*. A relatively dense stand of *B. clavata*, with female and male individuals bearing cystocarps and androphores, respectively, has been observed at La Gabinière Island (Port-Cros Archipelago, Port-Cros National Park, Provence, France) in April 2024.

Keywords: *Bonnemaisonia clavata*, Macroalgae, Port-Cros National Park.

Résumé. L'algue rouge *Bonnemaisonia clavata* : une addition à la flore marine du Parc national de Port-Cros (Provence, France, Méditerranée). L'algue rouge *Bonnemaisonia clavata* n'a été que rarement signalée en Méditerranée, peut-être en raison de confusion avec une espèce voisine, *B. asparagoides*. Une population relativement dense de *B. clavata* a été observée à La Gabinière (archipel de Port-Cros, Parc national de Port-Cros, Provence, France) en avril 2024. Les spécimens femelles et mâles portaient des cystocarpes et des androphores, respectivement.

Mots-clés : *Bonnemaisonia clavata*, Macroalgues, Parc national de Port-Cros.

Introduction

The Port-Cros National Park (PCNP) was established in 1963. It was then limited to the Port-Cros Archipelago (eastern Provence, France). Subsequently, in the 2010s, it was extended to include a larger area, including Porquerolles Island and the Port-Cros Archipelago (core areas), the marine area from La Garde to Ramatuelle (Adjacent Marine Area) and the mainland terrestrial area of five municipalities (La Garde, Carqueiranne, Hyères, La Croix-Valmer and Ramatuelle) which have voluntarily joined the Port-Cros National Park and signed its Charter (Barcelo and Boudouresque, 2012; Boudouresque *et al.*, 2020, 2021). The marine core area and the Adjacent Marine Area cover approximately 120 000 ha and extend over 63 km as the crow flies, from east to west.

The marine and brackish flora of the PCNP has been recorded by tens of authors, since the 19th century, first summarized by Belsher *et al.* (1976), and recently updated by Boudouresque *et al.* (2022a). The number of reported macrophyte taxa amounted to 502:

73 green algae, 316 red algae, 104 brown algae and 9 Magnoliophyta and other taxa (Boudouresque *et al.*, 2022a).

The most widespread and common species of the red alga genus *Bonnemaisonia*, in Europe, is *B. asparagoides* (Woodward) C. Agardh. It occurs in the Mediterranean and in the eastern Atlantic, from Iceland to Portugal (Rodríguez-Prieto *et al.*, 2013, Cormaci *et al.*, 2020; Guiry, 2020). In the PCNP, it has been reported from Giens Peninsula and the Port-Cros Archipelago (Boudouresque *et al.*, 2022a).

A second species of *Bonnemaisonia* has been described by Hamel (1930), *B. clavata* Hamel. It occurs in the Mediterranean and the eastern Atlantic, from Azores to Morocco (Gallardo *et al.*, 1985; Benhissoune *et al.*, 2002; Neto *et al.*, 2022; Guiry, 2023), and seems to be less common than *B. asparagoides*. It has not been previously reported from the PCNP area. We discovered it by chance, while researching an introduced species, *Lophocladia trichocladus* (C. Agardh) F. Schmitz, in April 2024 (Boudouresque *et al.*, 2022b).

A third species of *Bonnemaisonia*, *B. hamifera* Hariot occurs in Europe. It is native to Japan and was probably introduced to Europe at the end of the 19th century. It occurs in the Mediterranean, mostly under its sporogene phase (named 'tetrasporophyte' by traditionalist botanists), known as *Trailiella intricata* (Hariot, 1891; Verlaque *et al.*, 2015; Guiry, 2024; see Boudouresque, 2015 for 'sporogene').

Material and methods

The study material was collected at 15 m depth on subvertical reefs, Calanque Sombre (northern shore of La Gabinière Island), Port-Cros Archipelago (Provence), on April 4th, 2024. Individuals, pink to purple in colour (**Fig. 1**), were growing isolated or forming small patches, a dozen or more centimetres wide, between 5 and 30 m depth.

Voucher specimens are housed at HCOM herbarium (Aix-Marseille University, OSU Pytheas, Oceanomed, Plateforme macrophytes) under HCOM TT 0310.



Figure 1. Individuals of *Bonnemaisonia clavata* (pink in colour, centre of the photo) at La Gabinière Island, 15 m depth. Photo © Marie Borrighione.

Results

Collected specimens were gametogenes (referred to as 'gametophytes' by traditionalist botanists) with either cystocarps (female gametogenes) or androphores (male gametogenes) (see Boudouresque, 2015 for 'gametogene').

Observations confirmed the suite of features distinguishing *B. clavata* from *B. asparagoides* (Hamel, 1930; Feldmann, 1939; Coppejans, 1981; Salvador *et al.*, 2008), e.g.: **(i)** dioecious, i.e. distinct female and male gametogenes (*vs.* monoecious). **(ii)** Cystocarps ovoid with a relatively long pedicel (*vs.* spherical with a short pedicel) (**Fig. 2 and 3**). **(iii)** Androphores very long, up to 1 mm (*vs.* less than 100 μ m) (**Fig. 4 and 5**).

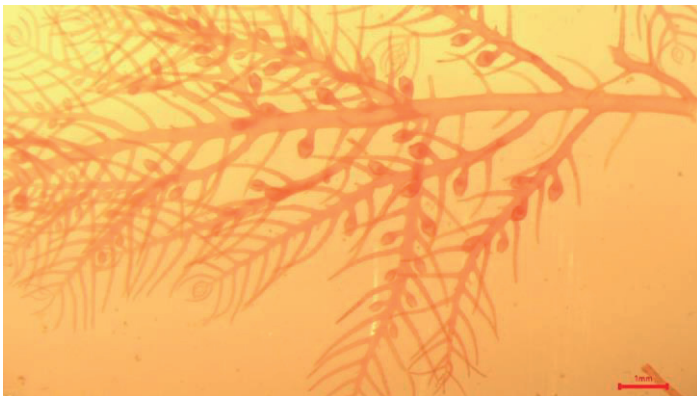


Figure 2. A female gametogene of *Bonnemaisonia clavata* from La Gabinière Island with cystocarps. Scale bar: 1 mm. Photo © Marie Borrighione.

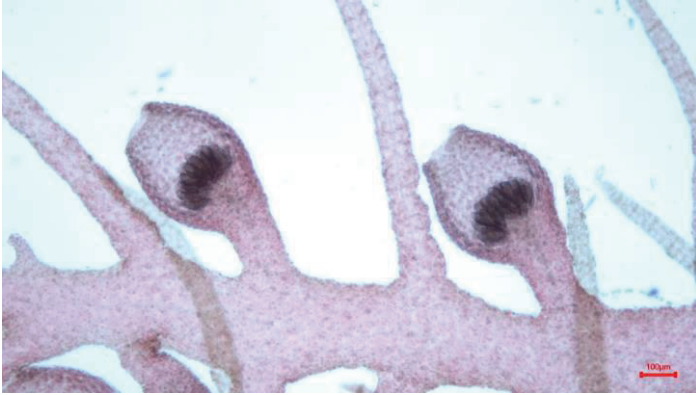


Figure 3. A female gametogene of *Bonnemaisonia clavata* from La Gabinière Island with two cystocarps. Scale bar: 100 μm . Photo © Marie Borriiglione.

However, in contrast to the description by Coppejans (1981), who ascribed, between ramuli and the axis, an angle of $45\text{-}60^\circ$ in *B. asparagoides* and $80\text{-}100^\circ$ in *B. clavata*, this angle is closer to 45° than to 90° in our specimens (**Fig. 2 and 5**).



Figure 4. A male gametogene of *Bonnemaisonia clavata* from La Gabinière Island with androphores. Scale bar: 1 mm. Photo © Marie Borriiglione.

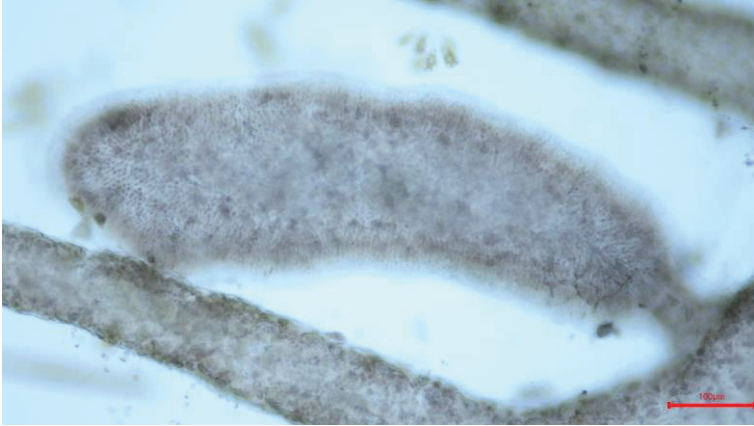


Figure 5. A male gametogene of *Bonnemaisonia 39lavate* from La Gabinière Island with an androphore. Scale bar: 100 μ m. Photo © Marie Borriiglione.

Discussion and conclusion

In the Mediterranean Sea, *Bonnemaisonia 39lavate* has been reported from a very few localities (Table 1). It is probably more common, but, in the absence of sexual organs, misidentification with *B. asparagoides* is possible (Salvador *et al.*, 2008). We might expect that some records of *B. 39lavate* have been erroneously reported as *B. asparagoides*, and that some sequences ascribed to *B. asparagoides* in Gene Bank actually refer to *B. 39lavate*.

Table 1. Records of *Bonnemaisonia 39lavate* in the Mediterranean Sea. Countries are arranged clockwise from Spain. C = cystocarps, A = androphores.

Country	Locality or region	Depth and months	Sexual reproduction	Reference
Spain	Murcia	20-25 m, May	C, A	Pérez-Ruzafa and Honrubia (1984), Pérez-Ruzafa (1985)
	Alicante	8 m, May-June	C	Salvador <i>et al.</i> (2008)
	Tossa	10 m, April	A	Ballesteros I Sagarra (1984)
	Palamós	17-25 m, May	C, A	Salvador <i>et al.</i> (2008)
	Majorca	June	C, A	Salvador <i>et al.</i> (2008)

Country	Locality or region	Depth and months	Sexual reproduction	Reference
France	Banyuls-sur-Mer	20-30 m, June	A	Feldmann (1939)
	Marseille		A	Derbès and Solier (1856); Hamel (1930)
	La Gabinière Island (Hyères)	15 m, April	C, A	This work
	Calvi (Corsica)	20-25 m, April	C, A	Coppejans (1981)
Italy	Sardinia			Furnari <i>et al.</i> (2003)
	Aeolian Islands	25 m, May		Cormaci <i>et al.</i> (1992)
Greece	North Aegean			Athanasiadis (1987); Tsiamis and Panayotidis (2019)
Turkey	Antalya			Okudan and Aysel (2005)
Tunisia	Tabarka	14 m, April		Boudouresque (1973), Ben Maiz <i>et al.</i> (1987)
Algeria	Algiers	10 m and deep habitats, April and May	C, A	Mazoyer and Feldmann (1937), Feldmann (1939), Feldmann and Feldmann (1939)

The occurrence of cystocarps and androphores, which allows *B. clavata* to be easily distinguished from *B. asparagoides*, between April and June, is very brief (a few weeks), which may explain why harvests of *B. clavata* were possibly referred to as *B. asparagoides*, perhaps by default.

Obviously, the marine flora of the PCNP is still underestimated, with many taxa still to be reported, as exemplified by *B. clavata* (this article) and *Laurenciella* cf. *marilzae* (Tritz *et al.*, 2024). However, this flora is not as rich as suggested according to the idealized vision of 'greens' and naïve ecologists. It should be stressed that species diversity (how many species?), often idolized by 'greens' and naïve

ecologists, taxonomic lobbies, the general public and managers, is a very poor indicator of biodiversity. The concept of biodiversity is actually very different from, and much broader than, species richness (Sala and Knowlton, 2006; Lyashevskaya and Farnsworth, 2012; Boudouresque, 2014; Boudouresque *et al.*, 2017; Pavé, 2019; Bianchi *et al.*, 2022). Contrary to the beliefs of the 1950s, disturbances do not reduce the number of species, but generally increase them, as suggested by the Intermediate Disturbance Hypothesis (IDH) (Lubchenco and Menge, 1978; Hastwell and Huston, 2001; Boudouresque *et al.*, 2023; Canessa *et al.*, 2023). As a result, the relatively low gamma species diversity of the PCNP should not be considered as a negative, but rather as a positive quality index.

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