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**Occurrence of the invasive brown seaweed *Rugulopteryx okamurae* (E.Y.Dawson)  
I.K.Hwang, W.J.Lee & H.S.Kim (Dictyotales, Phaeophyta) in Morocco (Mediterranean  
Sea)**

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## ABSTRACT

*Rugulopteryx okamurae*, a brown alga native to the temperate western Pacific Ocean, was discovered for the first time in the Mediterranean Sea in 2002, in the Thau Lagoon (France). A new population of *R. okamurae* was discovered in Belyounech Beach with the observation of some specimens fixed near the harbour of Tanger (Strait of Gibraltar-Morocco). As well as, the remarkable record of this alga stranded in M'diq beach (Alboran Sea-Morocco). Since its introduction *R. okamurae* has established in the Thau Lagoon (France), self-sustaining populations without displaying an invasive behaviour. On the contrary, the newly discovered population in Morocco would be classified as invasive. This new record gives the range extension of this invasive alga, from the southwest of Alboran Sea to the southwestern limit of Gibraltar.

The presence of this invasive seaweed in the area may affect the native alga, seagrass and native fauna including fish community negatively.

**KEY WORDS:** *Rugulopteryx okamurae*, invasive species, brown alga, Strait of Gibraltar, Alboran Sea, Morocco.

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## 1. Introduction

Nonindigenous Invasive Species (NIS) is a global phenomenon with potentially serious consequences for ecological, economic, and social systems (Carlton, 2000; IUCN, 2009). Economically, invasive marine species have been responsible for the collapse of fisheries and losses in aquaculture, tourism, and marine infrastructure (Bax et al., 2003). Invaders may also have substantial ecological impacts by modifying the habitat they invade, displacing native species, and altering food webs and community structure (Jones et al., 2010). Species invasions are considered one of the greatest threats to native biodiversity and resource values of the world's oceans (Rilov and Crooks, 2009; Molnar et al., 2008).

The brown seaweed *Rugulopteryx okamurae* (E.Y.Dawson) I.K.Hwang, W.J.Lee and H.S.Kim (2009) is a species native to the warm temperate western Pacific Ocean (Philippines, Taiwan, China, Korea and Japan) and to the western coast of northern America (Agatsuma et al., 2005). This species is characterized by a dichotomously branched thallus with a medulla one cell thick centrally and two to three cells thick near the margins (Womersley, 1987; De Clerck et al., 2006; Hwang et al., 2009). *Rugulopteryx okamurae* was recorded from the Mediterranean Sea in the Thau

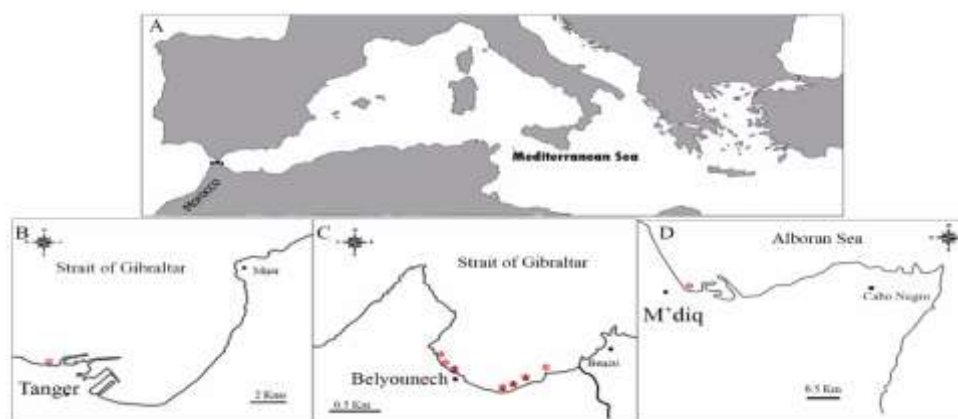
Lagoon, France (Verlaque et al., 2009). Recently, Altamirano et al. (2017) reported the proliferation of *Rugulopteryx okamurae* in Tarifa and Ceuta littorals as the first appointment of this species in Spain, and the second for the Mediterranean.

In August 2017, a population of the brown seaweed *Rugulopteryx okamurae* was discovered in Belyounech Beach, Strait of Gibraltar (Morocco) by the first author. Belyounech Beach is located in the marine part of the Jbel Moussa Site of Biological and Ecological Interest (SIBE). The characteristics of species were the same as reported by Verlaque et al. (2009). Few months later, a massive stranding of this brown alga was observed in M'diq beach (Alboran Sea) with the observation of some specimens fixed in the rocky near the harbour of Tanger (Strait of Gibraltar).

This paper reports the first record of *Rugulopteryx okamurae* from Moroccan and third record of Mediterranean Sea.

## 2. Results

Sampling was carried out in October 2017 in Belyounech beach between 35°54' 44.35''N; 5°22' 56.55'' W and 35°54' 46.87''N; 5°23' 56.27''W. This locality is characterized by sandy beach with rocky areas (Figure 1C).



**Figure.1.** (A) Geographical position of the study area within the Mediterranean Sea; (B) locality of observation of *R. okamurae* in Tanger; (C) Illustration of the sampling area in Belyounech; (D) locality of stranding of *R. okamurae* in M'diq. Asterix : stations where *R. okamurae* was found.

The specimens were collected by hand free diving between 1 - 5 meters' in the rocky area (Figure 2). The samples were fixed in formalin solution at 5% in seawater, placed in plastic bags

and transported to the laboratory. Underwater photography of fixed alga *Rugulopteryx okamurae* was done with an action camera, and in the laboratory, photography of collected materiel was done with numeric camera.



**Figure.2.** *Rugulopteryx okamurae*. In situ habitat of a population from Belyounech Beach.

Material was sectioned manually with a Scalpel. The sample was studied under the light microscope, and the photos were made using a camera linked with a software Leica Application Suite (LAS, version 5.4.0).

Voucher specimens of the examined species were preserved in formalin at the Laboratory of Fisheries of the National Institute of Fisheries Research- Tanger (Morocco).

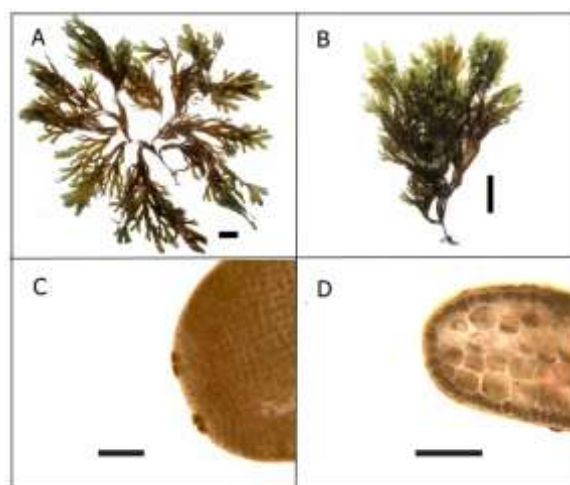
In February 2018, a remarkable stranding of *R. okamurae* was observed in M'diq beach, 35° 40'59" N and 5°19'8" W (Figure 1B and Figure 4) and in March 2018 some specimens fixed on the rocky in intertidal area were observed near the harbour of Tanger, 35°47'25" N and 5°48'50" W (Figure 1D).



**Figure.4.** Stranding of *Rugulopteryx okamurae* in M'diq beach.

**2.1. Brief description**

Thalli are erect up to 14 cm in diameter and branched dichotomously (Figure 3A), attached by means of numerous rhizoids (re). Fronds are expanding into a compressed flabellum, up to 10 cm in high (Figure 3B); apices are obtuse (Figure 3C). Colour *in situ* is yellow-brown. The medulla of thallus (lower parts) is composed of four to five layers of polygonal cells (Figure 3D).



**Figure.3.** (A-B) Habit of a broad specimen (A. Scale Bar = 1 cm; B. Scale Bar = 2 cm); (C) Detail of an apical portion of thallus with two apical cells (Scale Bar = 100 µm); (D) Transverse section of

thallus, detail of the basal portion (Scale Bar= 100 µm).

### 3. Discussion

The favourable environmental conditions, especially the marine temperature, enabled a successful establishment of a population of *Rugulopteryx okamuræ* in Belyouch Beach (Strait of Gibraltar). Indeed, the monthly SST data about Gibraltar area provided by the NCEP/NCAR Re-analysis 1 (Kalnay et al., 1996) is varying between 25 °C in August to +/-20 °C in October 2017 and characterising a temperate water, ideal environmental conditions not only for *R. okamuræ* but for all *Rugulopteryx* species (see Verlaque et al., 2009).

Belyounech Beach is located in the marine part of the Jbel Moussa Site of Biological and Ecological Interest (SIBE), and the site shelters a variety of habitats of conservation interest (UNEP/MAP, 2015).

Today, we don't know if these habitats can be affected negatively or not by the presence of *R. okamuræ*. Indeed, this alga has been upholstering the rocky bottom (Figure.2), especially which is located in the central area of the Belyounech beach and the propagation in the area may be turned into a pest that is affecting the rest of native alga, seagrass and native fauna including protected species present in the area as *Patella ferruginea*, *Corallium rubrum* (red coral) and *Astroides calycularis* (orange coral which is endemic to the western Mediterranean Sea).

*Rugulopteryx okamuræ* contains feeding inhibitory substances that can reduce the intensity of predation (Tokuda et al., 1994). This character may be harmful especially for some gastropods and echinoderm species which feed on alga.

Furthermore, this invasive brown seaweed may affect, also, the community of native fish. Recently, some fishermen of the harbour of Tarifa / Algeciras (Spain) have claimed the fall of their catches by the abundant presence of this seaweed in the fishing area (Monplamar, 2017).

*R. okamuræ* invasion may modify intertidal and subtidal communities and the impacts can occur across all trophic levels. The impact assessments

cannot keep up with rates of introduction and spread it to new locations. The presence of some specimens fixed in the intertidal area close to harbour of Tanger and the massive stranding record in M'diq beach suggests that a potential population may be established from the southwest of Alboran Sea till the southwestern limit of Gibraltar, and maybe it continues to spread. The entrance route of this species is still unknown, did this species come from the Red Sea or Atlantic Ocean? Indeed, previous records of this algae (from France and Spain) and this record were given from the western Mediterranean Sea.

Further research is needed to assess its possible invasive characters and their impact on native communities.

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