

Communication

# *Berkeleya Transfretana* sp. Nov., a New Marine Diatom from Ceuta (North Africa)

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**Abstract:** The diatom *Berkeleya transfretana* is described as a new species from samples collected at Playa Punta Saucíño, an intertidal coastal area in Ceuta, North Africa. Its main features are the comparatively small size in relation to other *Berkeleya* species and the very fine and dense striae pattern (more than 40 striae per 10 µm). The new species is here described under light and scanning electron microscopy and compared to related taxa. The benthos of these rocky beaches are interesting spots of biodiversity still to be explored.

**Keywords:** Bacillariophyta; taxonomy; new species; Strait of Gibraltar; Mediterranean; marine benthos



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## 1. Introduction

Diatoms are one of the most diversified groups of microalgae, with >200,000 estimated species [1], occurring in a wide variety of aquatic ecosystems. Some genera form colonies by means of characteristic structures such as macroscopic mucilage tubes. One genus, *Berkeleya* Greville, was first described as a macroalga due to its macroscopic habit and its resemblance to filamentous brown algae. This genus was described for the first time by Greville [2] for a group of pennate diatoms living within mucilage tubes attached to macroalgae or macrophytes [3,4]. The high variability of tube structures was initially used as a taxonomic character. However Grunow [5] restricted its use to the definition of varieties. Ever since, frustular ultrastructure has been regarded as the most important diagnostic feature for this genus.

In its modern sense, *Berkeleya* cells are either solitary or form mucilage tubes or films. Valves are linear to linear-lanceolate, with bluntly rounded or slightly capitate poles. Striae are uniseriate, consisting of simple poroids closed by hymens. External raphe endings are straight or slightly deflected towards the secondary side. The mature cingulum consists of at least five open bands, each of which bears two rows of round or oval poroids. The plastid is unique, consisting of two girdle-appressed plates connected by a narrow isthmus [6]. According to Guiry & Guiry [7], there are 45 species names of *Berkeleya* at present, as well as 58 infraspecific names, but only 13 of them are currently accepted taxonomically. In spite of the ecological importance of these colonial forms, they have been scarcely studied [8]. Among the studies carried out, the taxonomic works of Cox [3,9,10] in England, Mizuno [11,12] in Japan, Lobban [4,13–15] in North Atlantic waters and Houpt [16] in Europe are of particular relevance. More recently, Hamsher and Saunders (2014) found an unexpected genetic diversity and extensive cohabitation among lines of the *Berkeleya rutilans* (Trentepohl ex Roth) Grunow complex [17].

In a preliminary account of the diatom flora of Ceuta (North Africa) [18], it came to our attention that an unknown *Berkeleya* population, which is here described, is a new species.

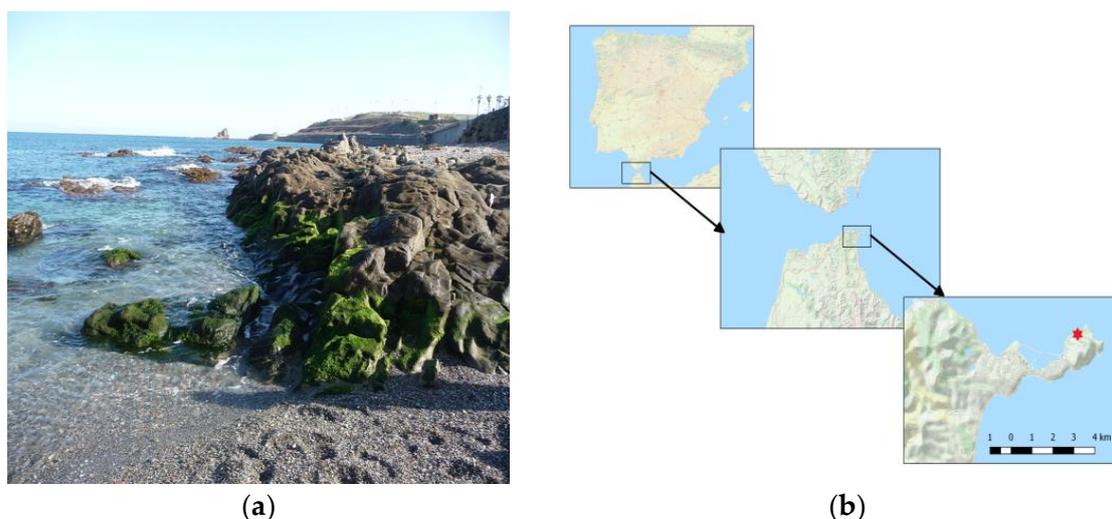
## 2. Materials and Methods

### 2.1. Study Site

The Autonomous City of Ceuta is a Spanish enclave located in North Africa, on the southern coast of the Strait of Gibraltar. The peninsula where it is located has a surface area of 20 km<sup>2</sup> and a perimeter of 28 km. The coast is composed of heterogeneous environments conditioned by its natural configuration, as well as by the intense port activity. At least 70% of Ceuta's coast is a natural hard bottom [19]. The coast of Ceuta is located in the Atlantic-Mediterranean interface, which causes important environmental and biogeographic gradients [20]. The very irregular underwater topography of this coast determines a great diversity in habitat types. The surface waters that enter from the Atlantic have an important influence, especially in the northern part of this coast [21].

### 2.2. Methodology

The material analyzed in this study was collected in November 2016 in Playa Punta Sauciño, a beach in the northern coast of the peninsula (Figure 1). Water parameters were measured in the field with COLEMETER portable digital probes to measure conductivity, total dissolved solids, pH and water temperature. Water chemical variables (ammonium, nitrites, nitrates, carbonate hardness and phosphates) were also determined in situ with a VISOCOLOR ECO reagent kit (Altmann Analytik GmbH & Co. KG). A sample of epilithon was collected from intermareal rocks with a toothbrush, and preserved using formaldehyde (4% v/v). A suspension of clean frustules was obtained in the laboratory by oxidation of organic matter with hydrogen peroxide (30% v/v) and heated to 70–90 °C to accelerate the reaction. Some drops of hydrochloric acid (3 M) were added to remove calcium carbonate inclusions. Light microscopy (LM) slides were mounted using a synthetic resin with a high optical refractive index (Naphrax<sup>®</sup>). The identification and counting of the diatom species were carried out at 1000× magnification using a DIC-light microscope (LM) Olympus BX60, equipped with an OPTIKA camera. A subsample was analyzed by scanning electron microscopy (SEM) at the Electron Microscopy Unit (University of Jaen, Spain), by placing a drop of the cleaned sample on a conductive metal structure and allowing it to dry at room temperature. The samples were subsequently coated with a 10 nm thick gold layer using a modular high vacuum metallization system (QUORUM Q150T ES). SEM images were obtained using a MERLIN (Carl Zeiss) microscope operating at 20 kV. Images were processed with GIMP software [22].



**Figure 1.** Type locality of *B. transfretana* (a) Playa Punta Sauciño in Ceuta, N. Africa; (b) location of the study site (red star).

### 3. Results and Discussion

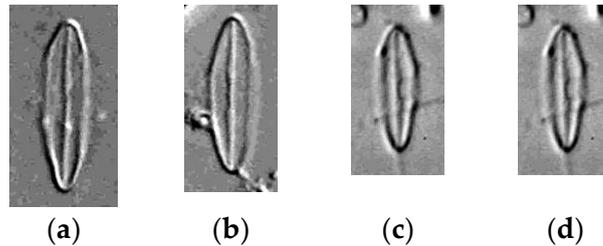
Phylum Bacillariophyta

Class Bacillariophyceae

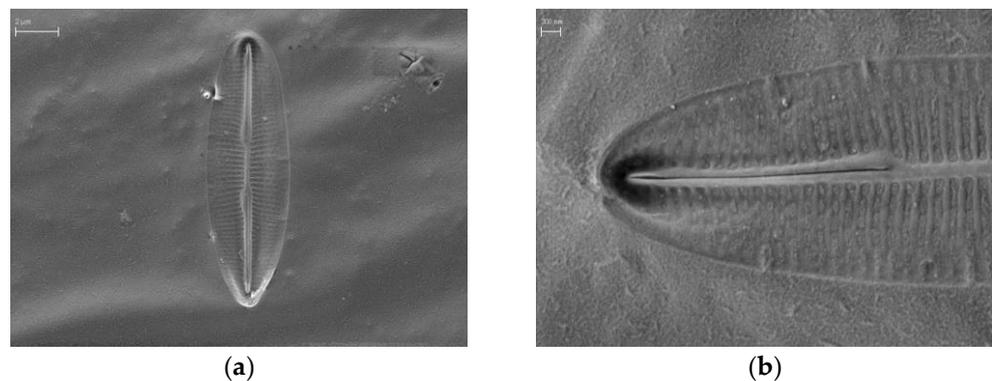
Order Naviculales

Family Berkeleyaceae

*Berkeleya transfretana* sp. nov. (Figures 2 and 3)



**Figure 2.** *Berkeleya transfretana*. LM. Individuals from the type population (valve views).



**Figure 3.** *Berkeleya transfretana*. Scanning electron microscopy (SEM). Individuals from the type population (valve views). (a) Whole valve, internal view; (b) detail of the apex, showing the striation pattern and one raphe branch.

Type: SPAIN. Ceuta (N. Africa): Playa Punta Sauciño (35.90304° N, 5.29289° W). coll. S. Blanco, 15-11-2016 (holotype LEB! DIATOMEA-28).

Etymology: from the Latin adjective *transfretanus -a -um*, literally meaning “on the other side of a strait”. The name refers to the occurrence of this new species in the Strait of Gibraltar.

Description: lanceolate valves, hyaline and inconspicuous under LM, with obtusely rounded apices, median length 10.41  $\mu\text{m}$  [10.13–14.73], median width 3.06  $\mu\text{m}$  [2.73–3.94], axial area very narrow, central area absent (Figure 2). Under SEM, only internal valve views were obtained (Figure 3). Raphe branches are slightly bent and the external central endings are 2–3  $\mu\text{m}$  far from each other; apical endings terminate slightly below apices in a deep perivalvar depression. Striae moderately radiate at center, becoming convergent towards apices, ca. 40 in 10  $\mu\text{m}$ , formed by transapically elongated, ellipsoid areolae, about 100 in 10  $\mu\text{m}$ .

Differential diagnosis: among the *Berkeleya* taxa with comparable morphometric data (particularly valve length and width, and stria density), only *B. fennica* Juhlin-Dannfelt shows a similar shape, but with a different length-to-width ratio (>4.3 vs. <4 in *B. transfretana*), with an internal ultrastructure of valves also different (*cfr.* Álvarez-Blanco & Blanco [23], figs 77: 2, 3). The valves in *B. insularis* Takano are narrow-elliptical, with a much lower stria and areola densities (up to 30 and 40 in 10  $\mu\text{m}$ ). Other commonly reported *Berkeleya* species are compared in Table 1.

**Table 1.** Diagnostic features of *B. transfretana* and similar species.

	Length (µm)	Width (µm)	Striae in 10 µm	Habitat
<i>B. fennica</i> Juhlin-Dannfelt	13–24	3–4	30–35	Freshwater
<i>B. rutilans</i> (Trentepohl ex Roth) Grunow	18–35	4–6	27	Brackish
<i>B. micans</i> (Lyngbye) Grunow	70–130	8–10	27	Marine
<i>B. fragilis</i> Greville	40–90	4–6	40	Marine
<i>B. hyalina</i> (Round & Brooks) Cox	30–50	5	>40	Marine
<i>B. transfretana</i> sp. nov.	12–14	3–4	>40	Brackish

Ecology: the type locality was characterized by the presence of very high nutrient concentrations (0.7 mg/L of phosphates, 0.5 mg/L of nitrates and 0.3 mg/L of ammonium) and a comparatively low conductivity (7590 µS/cm), with a turbidity of 9390 ppm (total dissolved solids) and a pH of 7.3. *Berkeleya transfretana* was scarce in the material analyzed, accounting for 5.3% of individuals occurring in the sample. Accompanying species include *Navicula perminuta* Grunow (14.6%), *Nitzschia inconspicua* Grunow (13.9%) and *Pteroncola inane* (Giffen) Round (12.6%), which reveals a community typical of transitional (freshwater-marine) waters. No other *Berkeleya* taxa were recorded in the type locality.

Comments: the new species can be readily ascribed to the genus *Berkeleya* on the basis of its ultrastructural features, namely the lateral central raphe slits and the uniseriate striae, consisting of rows of simple poroids. Ecologically similar *Berkeleya* species (e.g. *B. fennica* and *B. micans*) have been already recorded in western Mediterranean benthic (epilithic) intermareal communities [23]. This is the first finding of a new diatom taxon from Ceuta (after the description of *Cocconeis nigricans* var. *denudata* by Kützing [24] some 177 years ago) and the first phycological study of the region after the review by Blanco et al. [18] who found 268 different diatom taxa in 35 sampling sites (both freshwater and marine). In general, cosmopolite and generalist species were found, with a scarce degree of endemism, but eight new species for the African flora and four for the Spanish flora were found.

The lack of similar studies in this biogeographically important area prevents any comparative analysis, although the finding of floristic novelties such as *B. transfretana* make the Northern coast of Africa worthy of further taxonomic investigations.

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