



# CROSSIDIUM SQUAMIFERUM COLLECTED IN VOLUBILIS ARCHEOLOGICAL SITE IN MOROCCO

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## Abstract

*Crossidium squamiferum* (Viv) belongs to the Pottiaceae family. It was collected as part of our scientific explorations which aim to identify vascular and non-vascular plants at the Volubilis site. This work aims to describe this species in its archaeological environment. It is installed in the joints between the bricks on the ancient walls of the site contributing to the deterioration of the contact surface with the substrate. Indeed, around the plant, the soil is born. *Crossidium squamiferum* is a particularly rare orophyte species. The genus *Crossidium* to which it is affiliated is represented in Morocco by 4 species: *Crossidium aberrans*; *Crossidium crassinervium*; *Crossidium laevipilum*; *Crossidium squamiferum* (Viv.) and a subspecies: *Crossidium squamiferum* var. *pottioideum* (De Not.) Mönk. The genus is distributed in all the countries of the Mediterranean basin.

**Key words:** Bryophytes, *Crossidium squamiferum*, Volubilis, Morocco.

## Introduction

Investigations were carried out at the archaeological site of Volubilis to establish the specific richness of vascular and non-vascular plants. During our explorations, we met a bryophyte that aroused our interest especially that it belongs to the genus *Crossidium* and that this genus includes in the world only about 11 species (Cano *et al.*, 1993) and in Morocco, only 4 species (Ros *et al.*, 1999).

*Crossidium squamiferum* is a species that has not been the subject of any detailed study in Morocco. Our work aims to document it with a morphological description and to underline by observations its contribution to the deterioration of the substrate in the archaeological site of Volubilis.

## Materials and Methods

### The archaeological site of Volubilis

It is located about thirty kilometers north of the city of Meknes in Morocco (Fig. 1). It occupies in the Saiss plain, on a plateau of around 390 m above sea level, a total area of 42 hectares at the foot of the Zerhoun massif. Volubilis probably takes its name from the Amazigh (Berber) term Walili, which designates oleander, an

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abundant plant in the region. The archaeological remains of this site bear witness to several civilizations. Volubilis is born in the 3<sup>rd</sup> century BC. A.D., under Carthaginian influence. In the 2<sup>nd</sup> century B.C. AD, the city is part of the Mauritanian kingdom which will be annexed for two centuries to the Roman Empire before being abandoned in the third century. In the 7<sup>th</sup> century, the city became Muslim and Idris, founder of the first Moroccan dynasty settled there. From the 12<sup>th</sup> century, the site of Volubilis then fell into oblivion. It was not until the first archaeological excavations in 1915 that the remains of the site were brought to light. From 1920, the legal protection of Volubilis worked in favor of its preservation. In 1997, the site was included in the UNESCO World Heritage List as an exceptionally well-preserved example of a large colonial Roman city, located at the edge of the empire.

The Climate of Volubilis is Mediterranean with annual precipitation of almost 770 mm and an average of the minimum temperatures of the coldest month of 5.3°C, the bioclimate is sub-humid in temperate winters according to the bioclimatic scale of (Emberger, 1955).

The sample was taken in the southern quarter characterized by so-called insulae dwellings, dating from the 1<sup>st</sup> century, comprising several rooms which are

organized on either side of a central corridor (Fig. 3).

**The substrate**

The building stone used to support *Crossidium squamiferum* corresponds to a yellowish beige calcarenite or molasse. With a low hardness and therefore an easy size, this rock has been widely used throughout the site. The main constituent minerals of this material are calcite (86% on average; up to 95% in some samples) and quartz (5 to 21%). Micaceous (muscovite) and clay minerals (illite, smectite, kaolinite) are also present in traces. The porosity varying from 15 to 26% (Dessandier *et al.*, 2008), promotes plant colonization of the rock.

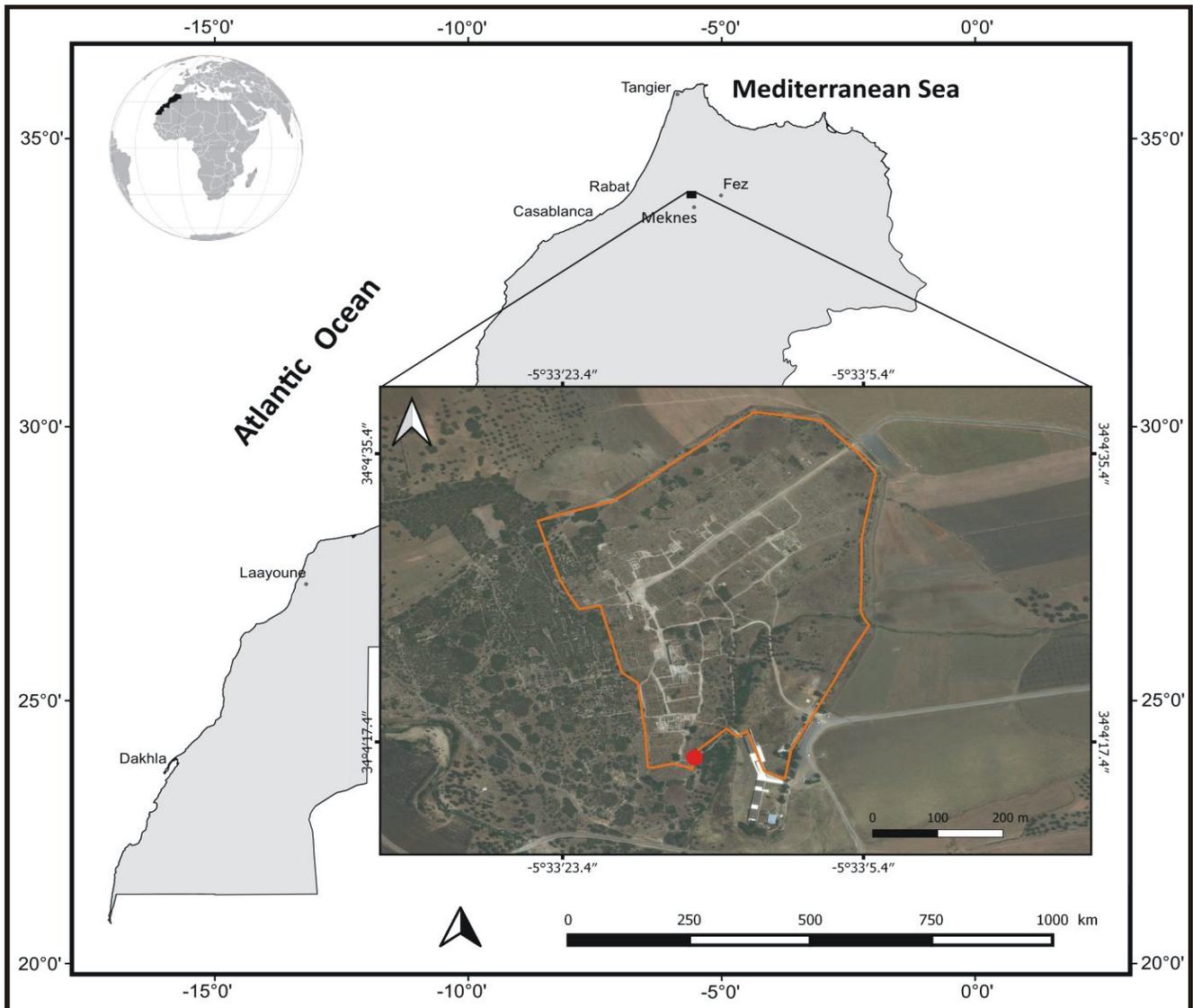
**Method**

As part of our scientific explorations that aim to identify vascular and non-vascular plants in the archaeological site of Volubilis, we observed a bryophyte emerging from the crevices of the boulders. Plant samples

were taken to the laboratory for identification. For this, macroscopic and microscopic observations of the gametophyte and the sporophyte were made and illustrated with photos. The determination of the species was based essentially on the documents of (Augier, 1966), (Casas *et al.*, 2006) and (Casas *et al.*, 2009).

**Results and Discussion**

The archaeological site of Volubilis is overgrown with vegetation which contributes dangerously to its biodeterioration. Among these plants, a bryophyte was observed between the stones and identified *Crossidium squamiferum*. It is a species that belongs to the family Pottiaceae, genus *Crossidium*. It includes several synonyms (Ros *et al.*, 2013) and (Ros *et al.*, 1999). These synonyms are: *Barbula grisea*; *Barbula membranifolia*, *Barbula membranifolia* f.brevisetata; *Barbula membranifolia* var.grisea; *Barbula membranifolia* var.



**Fig. 1:** Geographical location of the archaeological site of Volubilis specifying the place of sampling.

laevipila; *Barbula squamifera*; *Crossidium chloronotos*; *Crossidium griseum*; *Crossidium squamigerum*; *Desmatodon griseus*; *Tortula chloronotos*; *Tortula membranifolia*; *Tortulasquamifera*; *Tortula squamigera* var. *pottioidea*.

*Crossidium squamiferum* was observed in the GPS coordinates, 34°4'16"N and 5°33'15"W on a section of wall (Fig. 2). The site of Volubilis is cis on a plateau which rises to almost 390 m high below the Djebel Zerhoun. It is therefore an area well exposed to the sun especially during the summer season.

#### Description of *Crossidium squamiferum* observed in Volubilis

*Crossidium squamiferum* is a very small moss that does not exceed 15 mm in height. It forms compact, dense and spherical bearings. It is green to yellowish-green in color. *Crossidium squamiferum* is usually collected from rocks in dry places in mountainous areas (Augier, 1966); we found it emerging from the joints between the bricks on the ancient walls of Volubilis (Walili).

The primary stem is erect, very short reaching 10 mm, simple or sometimes branched with a large part sunk into the ground.

The leaves are 4 mm long, slightly spread when wet and nested against the stem when dry (Fig. 4, Photo E). The shape of the leaves is triangular, oval, with a flat blade at the margin, these leaves are suddenly narrowed into a long hyaline hair, this hair measures 3 times the length of the leaf, it is weakly denticulated (Fig. 4, Photo F).

The limbus is unistrified (Fig. 4, Photo K). (Fig. 4, Photo K). The majority of the limb (3/4) is made up of small, opaque, square and rounded cells (Fig. 4, Photo G), the cells of the lower half of the limbus and the marginal



Fig. 2: *Crossidium squamiferum* sampling area.

cells are rectangular, more or less elongated and colored hyaline (Fig. 4, Photo J).

The rib is strong, broad at the base, excurrent in a long hyaline hair weakly denticulated and carrying chlorophyllian filaments on the ventral face (Fig. 4, Photo I). The sporophyte is acrocarp with a small capsule of 2 to 2.5 mm, brownish, cylindrical, erect and curved (Fig. 4, Photo O). The operculum has a long, beaked beak. The silk is smooth, short (8 mm), erect and slightly dextrorated with a brown color.

#### The distribution of the genus *Crossidium* in the Mediterranean region

The genus *Crossidium* is distributed in all countries of the Mediterranean region where it is represented by 7 species and two subspecies (Ros *et al.*, 2013).

- *Crossidium aberrans* Holz. and E.B. Bartram: Canary Islands, Algeria, Egypt, Spain, France, Italy, Jordan, Morocco, Syria.

- *Crossidium crassinervium* (De Not.) Jur: Bulgaria, Balears, Canary Islands, Crete, Cyprus, Algeria, Egypt, Spain, France, Greece, Italy, Jordan, Libya, Morocco, Madiera, Montenegro, Malta, Portugal, Serbia, Sicily, Syria, Tunisia, Turkey.

- *Crossidium davidai* Catches: Canary Islands.

- *Crossidium geheebii* (Broth.) Broth: Canary Islands, Egypt, Italy.

- *Crossidium laevipilum* Thér. and Trab: Balears, Algeria, Egypt, Spain, Jordan, Morocco, Tunisia.

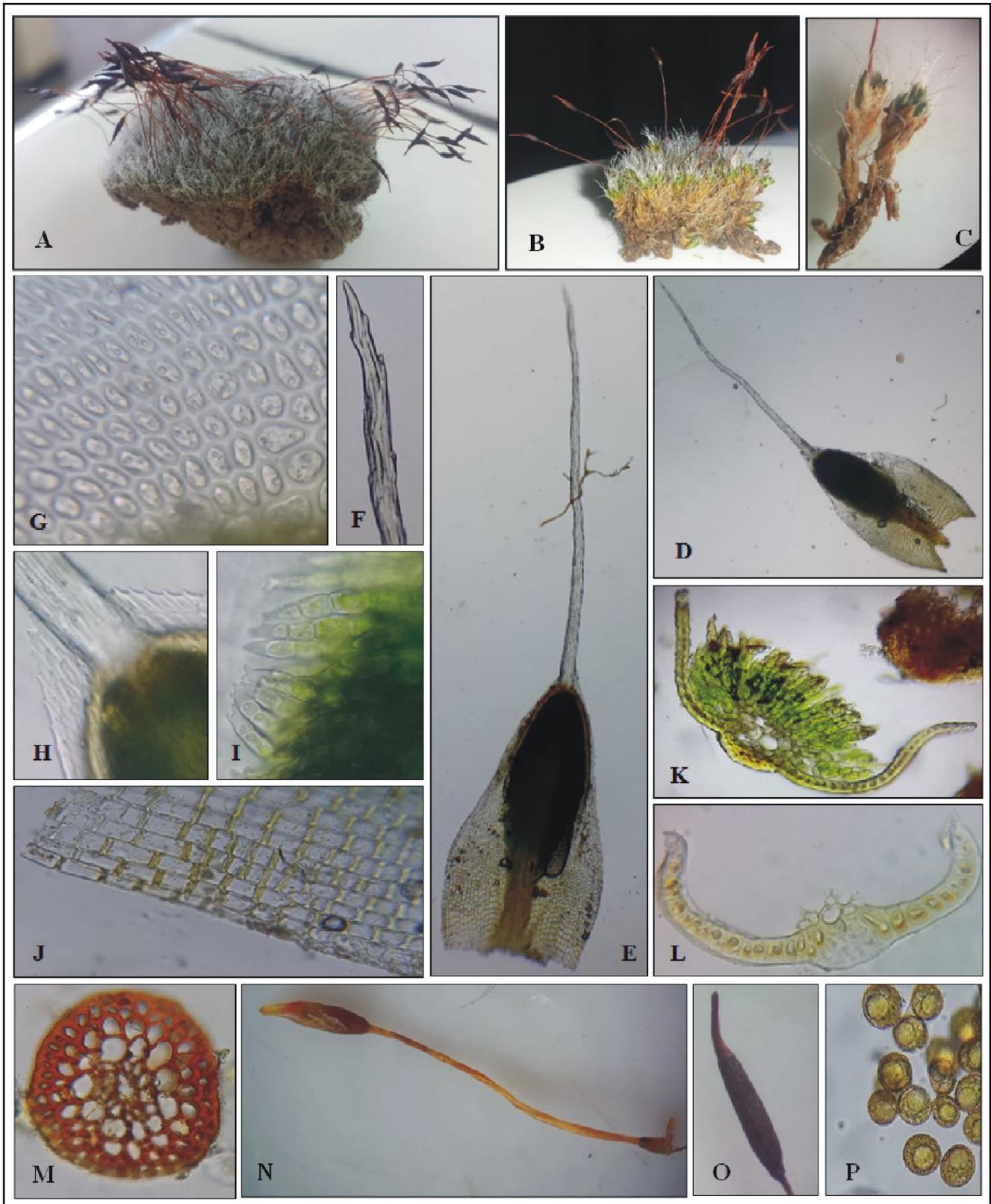
- *Crossidium laxefilamentosum* W.Freyet Kürschner: Egypt Serbia, Sicily, Tunisia, Turkey.

- *Crossidium squamiferum* (Viv.) Jur: Albania, Bosnia-Herzegovina, Balears, Canary Islands, Corsica, Crete, Algeria, Egypt, Spain, France, Greece, Croatia, Libya, Morocco, Montenegro, Macedonia, Portugal, Serbia, Sicily, Slovenia, Tunisia.

- *Crossidiumvar squamiferum*: Bulgaria, Spain, France, Greece, Italy, Jordan, Lebanon, Serbia, Sicily, Syria, Turkey.



Fig. 3: *Crossidium squamiferum* in situ in the joints between the bricks of the ancient walls in Volubilis.



**Fig. 4:** Macroscopic and microscopic views of *Crossidium squamiferum*. (A: Plant in the dry state; B: Plant in the wet state; C: Leafy stem (X20); D, E: leaf (X100); F: Hyaline hair (X400); G: Cells of the middle of the limbus (X 400); H: Top of the leaf (X400); I: Chlorophyll filaments on the rib, ventral side (X 400); J: Basal part of the leaf (X400); K and L: Cross section of the leaf at different levels (X400); M: Cross section of the silk (X400); N: Sporophyte (X4); O: Capsule (X40); P: Spores (X400).

• *Crossidium* var. *Pottioideum* (De Not.) Mönk: Bulgaria, Algeria, Egypt, Spain, France, Greece, Jordan, Lebanon, Libya, Morocco, Syria, Tunisia, Turkey.

According to a synthetic study by (Ros *et al.*, 1999), *Crossidium squamiferum* was observed on African territory, in Algeria, Chad, Egypt, Libya, Morocco and Tunisia. In Morocco, it has been observed by (Jelenc, 1955) and (Jelenc, 1967), (Braun-blanquet, 1954), (Delgadillo, 1975) and (Ros *et al.*, 1987).

In Morocco, the genus *Crossidium* is represented by 4 species: *Crossidium aberrans* Holz. E.B. Bartram; *Crossidium crassinervium* (De Not.) Jur; *Crossidium laevipilum* Thér. and Trab; *Crossidium squamiferum* (Viv.) Jur and a subspecies: *Crossidium squamiferum* var. *pottioideum* (De Not.) Mönk (Ros *et al.*, 2013).

Among the species of the genus, *Crossidium* reported in Morocco, *Crossidium squamiferum* (Viv) Jur. It is an orophyte moss particularly rare on Moroccan territory and mainly linked to old sunny walls and limestone rocks calcaire (Augier, 1966). This moss was collected in Volubilis and Jbel Ayachi (explorations underway in this latter site, located in the High Atlas); it is considered a newly observed species in these two regions.

In the bryological flora of England and Ireland inventoried and classified by (Smith, 2004), there is no mention of the genus *Crossidium*, it is the genus *Pseudocrossidium* which is described there. The genus *Crossidium* had a narrow ecological range, it is a taxon of xerophilic origin (IGNATOV *et al.*, 2010), which originally developed in the Mediterranean region. Recent work has shown that this xerophilia also applies to extreme cold conditions because this taxon can go to the south of Siberia thus marking its climatic border in Eurasia (Sandanov *et al.*, 2018). The species is absent from Australian territory even if the climatic conditions are favorable (Sandanov *et al.*, 2018), probably because of the geographical barriers which hinder the dissemination of spores.

In our site, *Crossidium squamiferum* adapts to the dryness of the environment during the summer season by taking a shape in a ball or compact pads and is embedded in the cracks and joints between the bricks of the ancient walls. Its propagation slowly contributes to the deterioration of the substrate where a soil draft is formed around and under the stands.

### Conclusion

The genus *Crossidium* is represented worldwide by 11 species. In Morocco, only 4 species are reported, all considered as rare or very rare species with very narrow distribution areas on Moroccan territory.

The identification of *Crossidium squamiferum*

carried out based on morphological and anatomical descriptions should be supplemented, for more reliability, by genetic and molecular investigations. Carrying out phylogenetic studies on the genus *Crossidium* is an undertaking which would have great scientific contribution.

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