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A Brief Overview of the Studies on Fungal Deterioration of Monuments in Turkey

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Abstract

Cultural heritages are at risk of biodeterioration caused by diverse populations of microorganisms such as fungi, bacteria, algae, lichens and cyanobacteria. For example, stone monuments may be discolored and degraded by growth and activity of microorganisms. Especially fungal communities cause aesthetic and structural damage. The fungal deterioration of stone monuments in many countries has become a serious threat for their existence. A brief overview of work on fungal deteriorations on stone monuments in Turkey, including recent studies resulting from molecular biology, is presented and fungal species causing degradation are discussed.

Keywords: Stone, Monuments, Fungi, Deterioration, Turkey

Türkiye'de Tarihi Eserlerdeki Fungal Bozunmalara Kısa Bir Bakış

Hacer BAKIR SERT*

Öz

Tarihi eserler; mantarlar, bakteriler, algler, likenler ve siyanobakteriler gibi mikroorganizma populasyonlarının neden olduğu biyobozunma riski altındadır. Özellikle mikromantarlar, taş anıtlar üzerinde renk değişikliğine, kabarmaya, çukurluklara ve kırılmalara neden olur. Tarihi eserlerdeki fungal bozunma birçok ülkede ciddi bir tehdit haline gelmiştir. Bu çalışmada, Türkiye'de tarihi eserlerde meydana gelen mikrofungal bozunmalar üzerine kısa bir genel bakış sunulmuştur.

***Anahtar Kelimeler*:** Taş, Tarihi eserler, Mikromantarlar, Bozunma, Türkiye

1. Introduction

Biodeterioration can be defined as a process that causes chemical, mechanical, physical and aesthetic alterations and damages to antique monuments. Cultural heritages are at risk of biodeterioration caused by diverse populations of microorganisms such as; fungi, bacteria, algae, lichens and cyanobacteria (Figure 1-3). In particular fungi play an important role in the alteration and weathering of rock. They exist in nearly every advisable habitat where organic carbon is available: in water and the sea, in soil, litter, in dung, in living plants and decaying remains of plants and animals [3], in marble and other calcareous rock types in nature and on monuments [15, 20, 21, 23].
A recent research has evidenced that especially a very slow-growing group of black fungi and yeast-like fungi plays an important role in the deterioration of marbles and other rocks [2, 22].
Black microcolonial fungi (MCF) and black yeasts are among the most stress-resistant eukaryotic organisms known on earth [4] (MCF form black, clump-like colonies consisting of isodiametrically dividing cells on rock surfaces, in cracks, pores and fissures of the rock and in

micropits, created by their own deteriorative activity [17]. Their morphology is interpreted as response to multiple stress factors: keeping the surface-volume ratio optimal decreases the loss of water and minimizes the colony surface with direct exposure to sun light and other physical and chemical stressors [4, 17].

Black fungi (Dematiaceae) are colonizers of bare rock surfaces in hot deserts of Arizona [12] and in semi-arid climatic regions such as the Mediterranean [4] but are also part of the cryptoendolithic community of the Antarctica [8]. Rock inhabiting fungi have something in common in that they form cauliflower-like microcolonies on and in rock, they have very thick, multilayered cell walls and are incrusted with melanins giving them a dark, blackish brown appearance. On the whole, meristematic morphology is interpreted as a response to multiple stress factors (oligotrophic nutrient conditions, elevated temperatures, UV-radiation, osmotic stress) supporting temperature tolerance and decreasing the rate and speed of desiccation by keeping the volume–surface ratio optimal [23]. The combined influence of these stress factors exerts a high selective pressure on the microbial community and as a consequence black yeast and meristematic fungi are rarely found in complex microbial populations but solitary or in spatial association with comparably stress resistant organisms such as lichens and cyanobacteria in very special habitats [13].

Figure 1. Biodeteriorations on a column in Efes Antique city

Figure 2. a-d. Biodeteriorations on diverse monuments in Seleukeia Antique city

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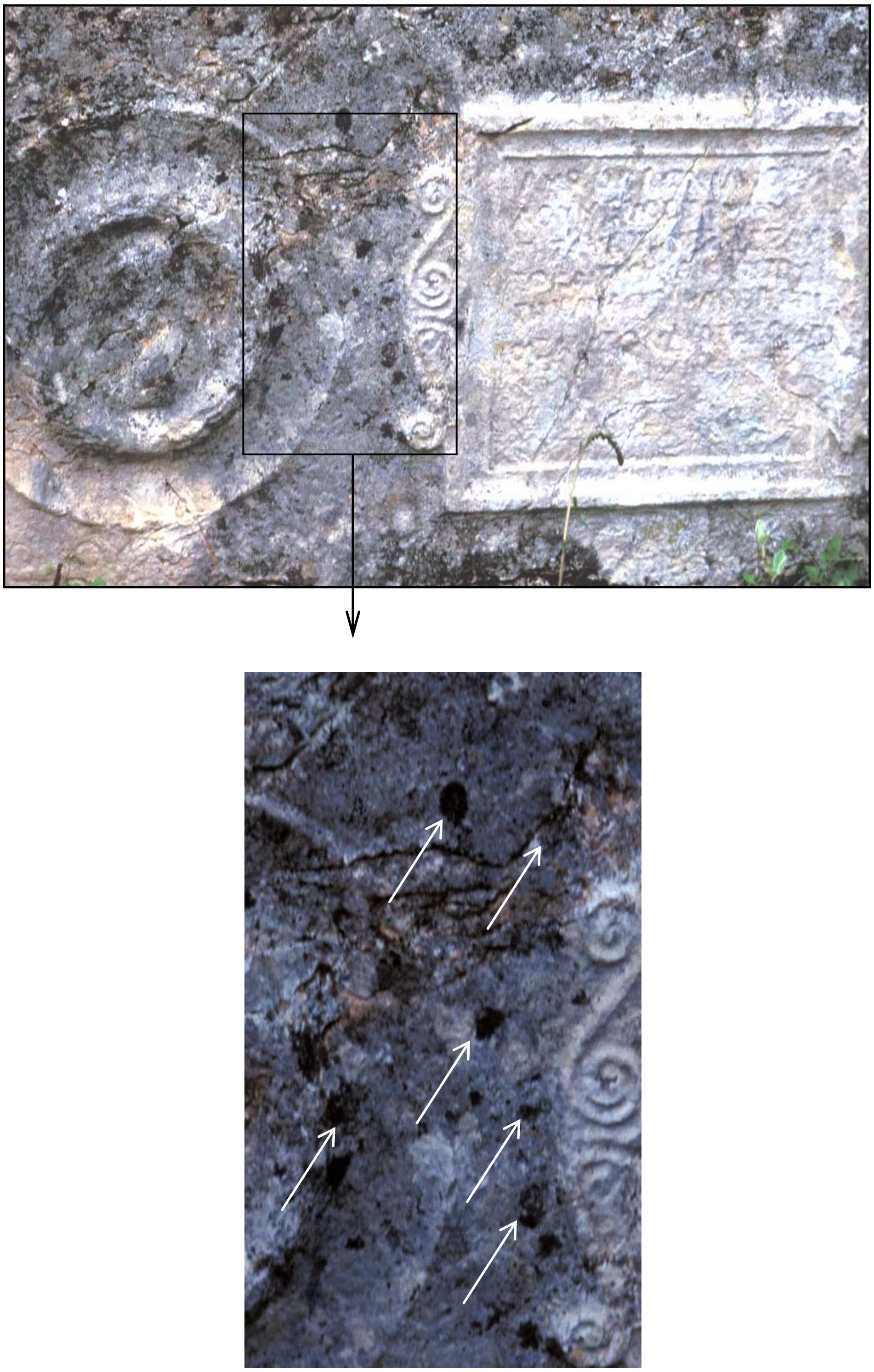

Figure 3. Black fungal colonies on monuments in Trabenna antique city.

2. Materials and Methods

The diagnosis of black microcolonial fungi using morphological characters is quite problematic. Therefore, species identification is performed by molecular genetic methods. Sample collection, isolation, morphological characterization and molecular characterization are carried out according to [9-11] and [17]. The Internal Transcribed Spacers (ITS regions), which are nested in the nuclear rDNA repeat, have been selected to investigate the fungal diversity of fungi on monuments [6, 18]. The ITS regions possess a high variation between taxonomically distinct fungal species and even within the species [14].

3. Results and Discussion

Fungi were first considered to be agents of carbonate deterioration by Krumbein [7]. The mechanical action of fungal growth affects building materials such as brick and concrete [5] and marble, limestone and sandstone [15]. Their deteriorating effect is due to mechanical and chemical actions as penetration of materials with deep-reaching deteriorating effects, such as swelling and deflation as physical effects, constant microvibrations through micromotility and acid production [22]. Fungi also play a major role in the color change of rock surfaces [16] demonstrated that there is a direct correlation between orange pigmentation (patination) of granite and sandstone and rock inhabiting fungi. In relatively few cases the epilithic fungal communities on marble, limestone, sandstone and other rock surfaces were completely inventoried. Still relatively few species have been described and characterized phylogenetically.

On historical monuments, there are two important fungal groups that can live in different environmental conditions. *Hyphomycetes*, including *Alternaria*, *Cladosporium*, *Epicoccum*, *Aureobasidium* and *Phoma* species, live in temperate and humid climates [14]. Black yeasts and black micro-colonial fungi live mostly in arid and semi-arid environments. The species of *Hortaea*, *Sarcinomyces*, *Coniosporium*, *Capnobotryella*, *Exophiala* and *Trimmatostroma* form small black colonies in stone and stone and often occur in close relationship with lichens [13, 14].

Various studies have been carried out in many countries of the world on black microcolonial fungi [1, 5, 9-11, 14, 18, 19, 22]. In addition to these studies, studies are being conducted on black microfungi in Turkey. The ancient cities of Side, Perge, Aspendos, Seleukeia, Ephesus, Teos, Phokaia, Olympos and Trebenna were examined on fungal degradation. It was observed that microfungal corrosion was very high especially in Side, Perge and Phokaia due to their high humidity and salinity due to being at the seaside. Additionally, although they are not at the seaside in the ancient cities of Seleukeia and Ephesos, microfungal degradation is quite high.

Many black microcolonial fungi have been isolated from the stone monuments located in Turkey and different countries (Figures 4-5). According to the results of these studies *Coniosporium*, *Phaeococcomyces*, and *Sarcinomyces* are well-known rock-inhabiting microfungal genera [1, 9-11, 18]. Also *Capnobotryella*, *Exophiala*, *Mycocalicium*, *Trimmatostroma*, *Phaeotheca*, *Phaeosclera* are isolated mostly [1, 9-11, 14, 18, 19].

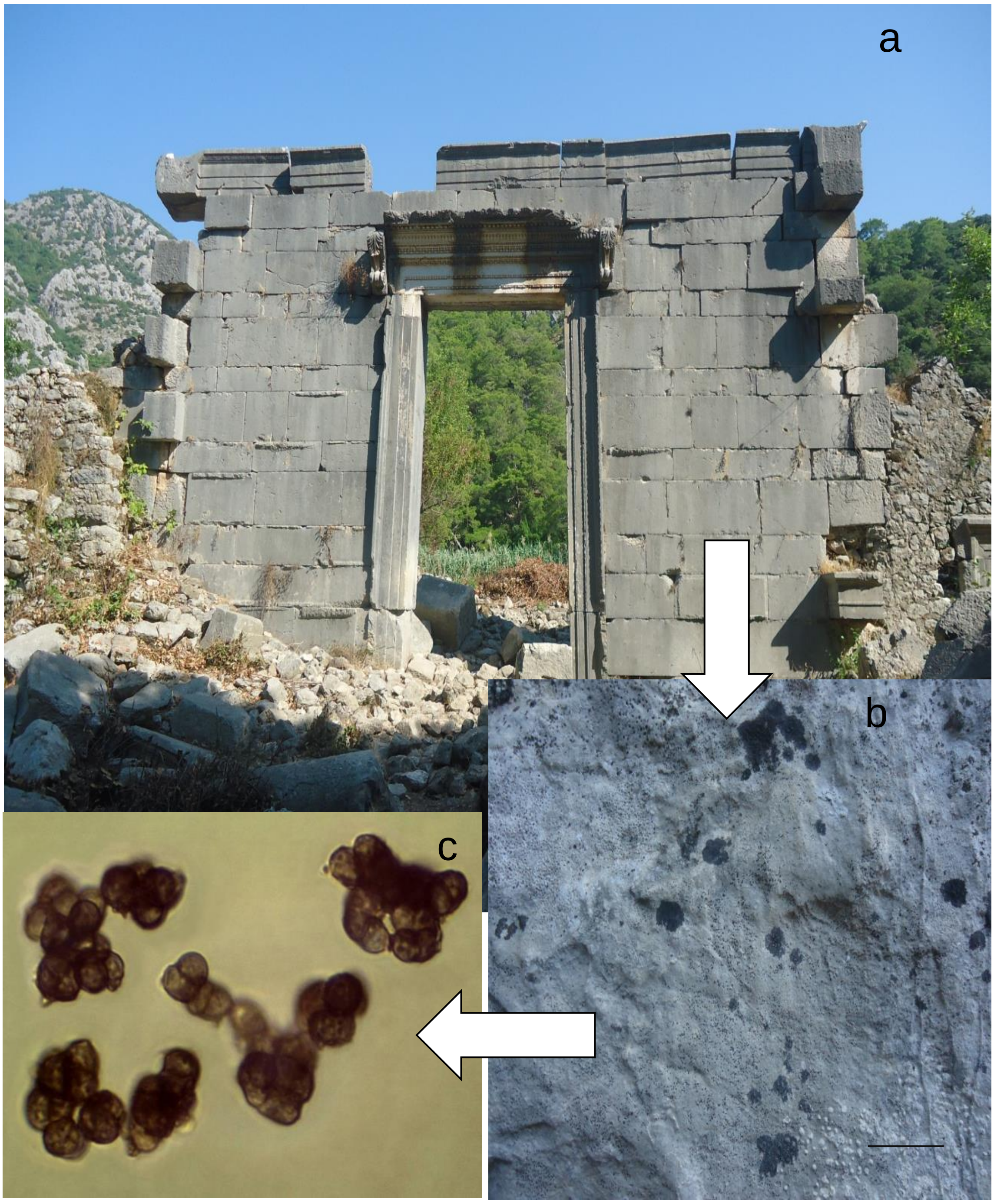

Figure 4.a. Roma temple in Termessos antique city **b.** *Capnobotryella renispora* on Roma temple (Bar; 1cm) **c.** Conidia of *Capnobotryella renispora* (x 3000)

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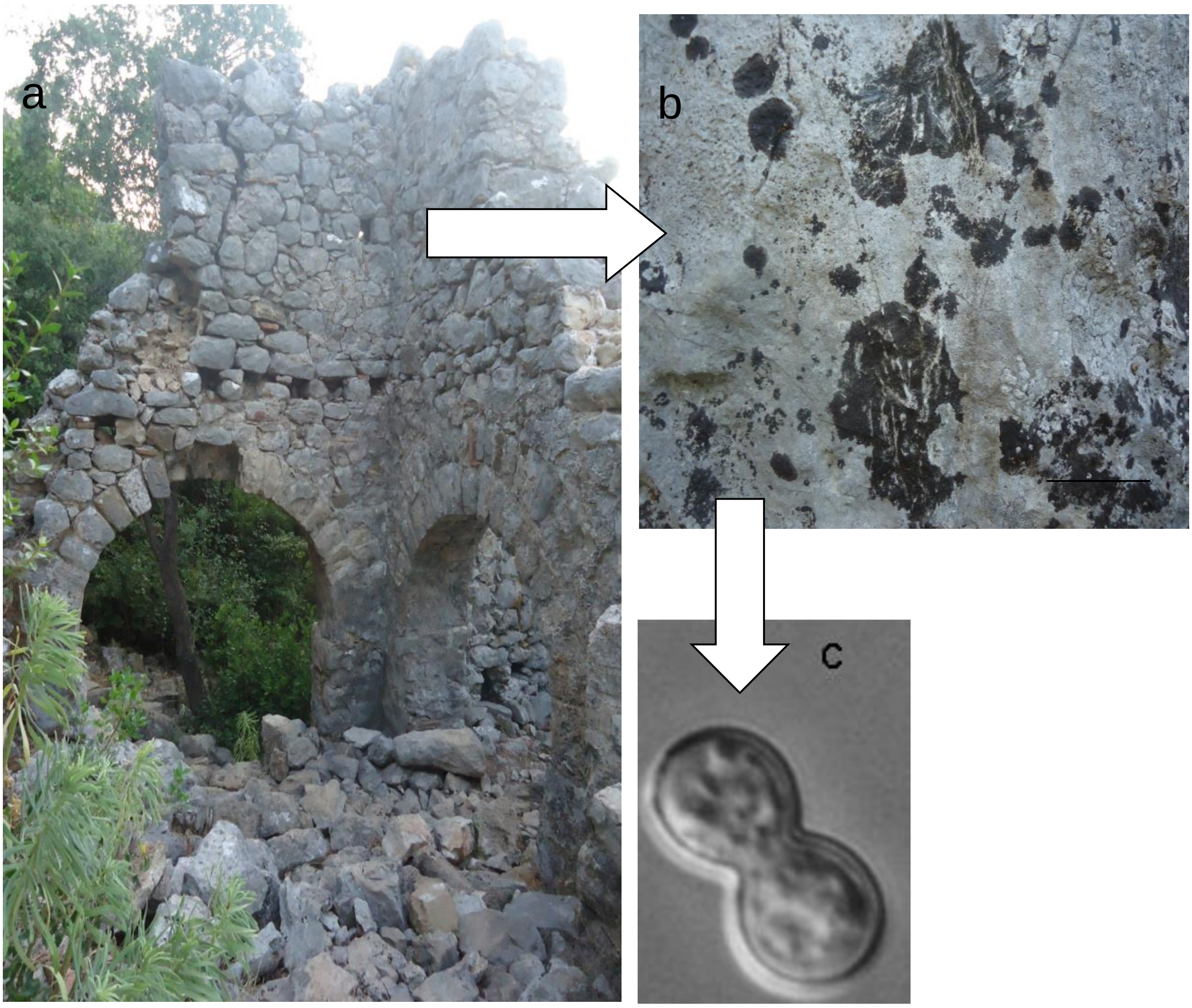

Figure 5. a. Ceneviz castle (Olympos antique city) **b.** *Sarcinomyces petricola* on monument (Bar; 1cm) **c.** A conidium of *S. petricola* (x3000)

Fungi play a very important role in the decay of our cultural heritage. It is necessary to identify the species of fungi that cause corrosion on historical monuments by increasing these studies which are still in the beginning level in our country. Then, not only chemical but also biological control methods should be developed so that historical monuments can be transferred to future generations intact

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