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Diversity and Seasonal Dynamics of Airborne Fungi in Nerja Cave, Spain

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Abstract: Nerja Cave, Southern Spain, was revealed as an important biodiversity reservoir from which several novel species of *Aspergillus* were described. We carried out an aerobiological study in Nerja Cave to assess the origin of airborne fungi. This study quantified the fungi present in the air of ten representative halls covering the three sectors comprising the cave: Touristic Galleries, High Galleries, and New Galleries. Microclimatological monitoring allowed us to understand the dynamic of airborne fungi in two seasons of the year (winter and summer), corresponding to the strongest and the lowest cave ventilation, and to validate the influence that the transport of airborne fungi from outside may have on the cave itself. The data show that cold air enters in winter, as confirmed by the abundant presence of *Aspergillus* and *Penicillium* spores inside and outside the cave. In summer, the abundance of some fungi in the air of Nerja Cave, which are not detected outside, indicates a stagnation or low ventilation, and therefore, the concentration of fungal spores is maxima. The high occurrence of *Cladosporium* outside the cave and the scarce abundance inside support the cave stagnation in this season.

Keywords: aerobiology; airborne fungi; *Aspergillus*; *Penicillium*; *Parengyodontium*; entomopathogenic fungi

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1. Introduction

One of the most important topics in the conservation of caves with Paleolithic paintings is the assessment of the microbial communities inhabiting speleothems, rocks, water pools and air. A wide diversity of approaches on cave fungi can be found in the literature [1–6] and aerobiological studies were introduced as a management tool to control airborne fungi in caves with paintings [7–10].

Microclimate control and monitoring of gases (CO_2, CH_4, ^{222}Rn, etc.) are used to investigate cave aerodynamic and ventilation or stagnation periods [11–17]. These studies, in combination with aerobiology, can provide clues for controlling airborne fungi and dispersion patterns in the caves [18,19].

The microbiology of Nerja Cave, Southern Spain, was studied regarding the impact of lighting on the development of phototrophic communities [20–24], but scarcely from an aerobiological point of view. A preliminary study carried out by Del Rosal et al. [25] was focused on the survey of pathogenic bacteria and the genus *Aspergillus*, very abundant in the cave air in summer. Further studies by Docampo et al. [26,27] using nonviable Hirst-type volumetric pollen traps located near the entrance and at the end of the visited area found that *Aspergillus/Penicillium* were the most abundant spore types, representing 50% of the total, followed by *Cladosporium.* However, the morphology of the spores, studied