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Fungal spore content of the atmosphere of the Cave of Nerja (southern Spain): Diversity and origin

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ABSTRACT

Fungal spores are of great interest in aerobiology and allergy due to their high incidence in both outdoor and indoor environments and their widely recognized ability to cause respiratory diseases and other pathologies. In this work, we study the spore content of the atmosphere of the Cave of Nerja, a karstic cavity and an important tourist attraction situated on the eastern coast of Malaga (southern Spain), which receives more than half a million visitors every year. This study was carried out over an uninterrupted period of 4 years (2002–2005) with the aid of two Hirst-type volumetric pollen traps (Lanzoni VPPS 2000) situated in different halls of the cave. In the atmosphere of the Cave of Nerja, 72 different spore types were detected during the studied period and daily mean concentrations of up to 282,195 spores/m^3 were reached. Thirty-five of the spore types detected are included within Ascomycota and Basidiomycota (19 and 16 types, respectively). Of the remaining spore types, 32 were categorized within the group of so-called imperfect fungi, while Oomycota and Myxomycota were represented by 2 and 3 spore types, respectively. *Aspergillus*/*Penicillium* was the most abundant spore type with a yearly mean percentage that represented 50% of the total, followed by *Cladosporium*. Finally, the origin of the fungal spores found inside the cave is discussed on the basis of the indoor/outdoor concentrations and the seasonal behaviour observed.

1. Introduction

Large karstic caves have always aroused the curiosity of both scientists and the general public, so many have become tourist attractions visited by large numbers of people each year. Moreover, during recent years, the study of fungal allergens associated with allergies has become a matter of great importance (Kurup et al., 2002). Many indoor studies have been carried out in Spain and throughout the world in different buildings, such as hospitals (Sautour et al., 2009), homes (Basilico et al., 2007; Crawford et al., 2009), offices (Baxter et al., 2005; Law et al., 2001), schools (Meklin et al., 2003; Scheff et al., 2000), factories (Awad et al., 2010), farms (Miao et al., 2010), stables (Beck et al., 2007), markets (Arya and Arya, 2007), museums (Camuffo et al., 1999; Niesler et al., 2010), wineries (Li and LaMondia, 2010), churches (Aira et al., 2007), etc. However, after an exhaustive search of the literature, there seem to be few works that address the study of biological airborne particles inside natural cavities. Although some references were found such as Bastian et al. (2010), Borda and Borda (2006), Borda et al. (2009), Groth et al. (1999), Jurado et al. (2009), Koilraj et al. (1999), and Mulec et al. (2002), most studies used viable methods and counting of colony forming units (CFUs), usually over a short period of time, which means that the results of our study at Nerja, which involved a non-viable uninterrupted sampling over 4 years, cannot be compared with similar studies.

The aerobiological study was carried out inside the Cave of Nerja, situated near the village of the same name, southern Spain. This coastal town, (21 m above sea level), is located 65 km east of the capital of the province, Malaga, on the border with the province of Granada.

The surrounding area of the Cave of Nerja is situated in the thermo-Mediterranean belt (Rivas-Martínez, 1981) and is characterized by mild frost-free winters. The rainfall is unevenly distributed throughout the year, the highest levels occurring in early autumn and late winter–early spring. This leads to a prolonged drought that causes a large water deficit in the soil from June to October, which is further accentuated by the high temperatures reached during the summer.

The cave was formed by the dissolution of the calcium–magnesium carbonate of the dolomitic rocks that comprise the mountain range of Almijara. It is situated 158 m above sea level and 800 m from it. It is thought that the genesis of the cave started in the Pliocene although the greatest lithogenic activity took place during the Middle Pliocene (Carrasco, 1993). Although the Cave of Nerja was re-discovered in 1959, evidence (archaeological remains and examples of rock art) indicate that it was inhabited by members of an uninterrupted succession of prehistoric cultures from the beginning of the Upper Palaeolithic (20,000 B.C.) to the Bronze Age (1800 B.C.) (Sanchidrian, 1994). Nowadays, the surroundings of the cave have been developed into a tourist complex that receives over 500,000 visitors a year. This natural

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