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# Aeromycological study in the Cathedral of Santiago de Compostela (Spain)

M.J. Aira[a], V. Jato[b], A.M. Stchigel[c], F.J. Rodríguez-Rajo[b,*], E. Piontelli[d]

[a]*Department of Botany, Faculty of Pharmacy, University of Santiago de Compostela, Campus South, Santiago de Compostela, Spain*
[b]*Department of Plant Biology and Soil Sciences, Sciences Faculty Ourense, University of Vigo, Campus As Lagoas, Spain*
[c]*Microbiology Unit, Medicine and Health Sciences Faculty, Rovira y Virgili University, Tarragona, Spain*
[d]*Mycology Chair, Medicine School, Valparaíso University, Valparaíso, Chile*

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**Abstract**

A study of airborne fungi was carried out in the architectural complex of the Cathedral of Santiago de Compostela (Spain) during 2002, by using viable volumetric sampling methods. This resulted in a total of 35 identified taxa, of which the most abundant were: *Alternaria*, *Aspergillus*, *Cladosporium* and *Penicillium*. Sampling was completed with data from the outdoor atmosphere and swab samples in specific places.

In general there were no statistically significant indoor/outdoor differences and in both cases the highest CFU m-3 were obtained during the spring-summer. Similar relatively low numbers of the same fungi were likewise detected at different points in the Cathedral nave, while up to nearly 6500 CFU m-3 were recorded in the Corticela Chapel. The study of intradiurnal levels carried out in the Cathedral nave reveals greater abundance of fungal concentrations at 13:00 h, the moment of massive influx of visitors in the Cathedral, with 406 CFU m-3 compared to the 380 CFU m-3 sampled at 9:00 h and the 350 CFU m-3 at 21:00 h. The whole investigation is the first study of the atmospheric fungal content of the Cathedral of Santiago de Compostela.


*Keywords:* Aerobiology; Biodeterioration; Fungal spores; Santiago of Compostela Cathedral; Volumetric sampling

## 1. Introduction

Different microorganisms such as fungi, algae and bacteria may have a negative effect on the preservation of artistic-historical heritage, especially when microclimatic conditions favour their development. Numerous museum complexes therefore employ systematic temperature and humidity monitoring, with the aim to prevent or slow down their growth (De Nuntiis et al., 2004).

Some authors also report interaction between microscopic fungi and arthropods on the surface of wall paintings, which increases their alteration (Hoffland et al., 2004). These biological agents affect not only the aesthetical appearance but also the structure of materials. Contributing to their preservation therefore is the main goal of studies of the mycobiota carried out in heritage buildings.

Studies on biodeterioration deal with different topics and substrates. There is great diversity in relation to the subjects of such studies since they encompass any type of work of art (Guglielminetti et al., 1994; Gorbushina and Palinska, 1999; Pitzurra et al., 1999; Maggi et al., 2000), as well as the materials of the buildings (Caretta and Piontelli, 1998; Petushkova and Kandyba, 1999). However, despite the interest of this type of study, those related to fungal biodeterioration are not very common; in the case of the Cathedral of Santiago de Compostela, no previous studies have been conducted.

The main objective of this study was therefore to ascertain the mycobiota atmospheric content of the city's most important architectural complex, which forms part of its World Heritage as pointed out by UNESCO, to identify the agents causing the proliferation of these

*Corresponding author. Tel.: +34 988387054; fax: +34 988387001.
*E-mail address:* javirajo@uvigo.es (F.J. Rodríguez-Rajo).

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microorganisms and its favouring factors. This will pave the way for a proposal regarding any necessary conservation work to the building, which is showing some evidence of alteration caused by fungi in certain areas.

Indirectly, this type of study may have public health applications, since the calculation of atmospheric fungal content and the identification of certain human pathogens can show whether an atmosphere is healthy or not and point to potential allergy risks (Terr, 2004). In this regard, fungi such as *Stachybotrys* are a usual component of the mycobiota inside buildings with water-damaged walls (Terr, 2001).

## 2. Material and methods

This study was carried out during the year 2002 in the main monumental complex of Santiago de Compostela (Spain), made up of the Cathedral and Museum.

Atmospheric spore samples were collected by using two viable volumetric sampling systems. These are a six-stage Andersen sampler (A) and a single-stage Burkard portable air sampler for agar plates (BPC) including 1 sampling plate. The sampling lasted 10 min been the collectors placed 1 m above ground level. The results were expressed in CFU m-3 and the positive-hole correction in both samplers was applied (Mehta et al., 1996). Random swab samples were also collected, to identify the fungal types present on certain works of artistic value or "areas" showing fungal growth. The entire methodology used in the study was explained in detail by Aira et al. (2005). The preparation of culture media was conducted following the instructions of Hoog et al. (2000).

With the aim to ascertain the fungal quantity and diversity throughout the year, sampling was carried out every four weeks at five points in the Cathedral nave, four at the extremes (identified as Point 1: Quintana, Point 2: Azabacheria, Point 3: Portico and Point 4: Platerias) and one at the centre (Point 5: Nave centre) of the Latin-cross ground plan. Sampling was also carried out outside the Cathedral (Point 6: Outdoors) as a reference (Fig. 1). Friday was chosen as a representative day of the Cathedral's normal activity, i.e. without a massive influx of visitors that could affect atmospheric fungal content. At each sampling time and location, single samples were taken using the BPC and commercial Sabouraud agar amended with chloramphenicol to control bacteria.

To evaluate efficiency of Sabouraud agar culture media in comparison with malt extract agar (MEA) and oatmeal agar (OA), sampling was carried out in the central area of the nave (Point 5: Nave centre) under the same conditions as the previous ones, with the exception that the Sabouraud was replaced by MEA and oat agar (OA).

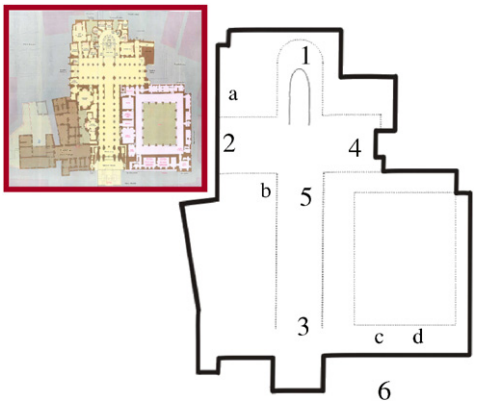


Fig. 1. Sampling site points in the nave Cathedral (1—Quintana, 2—Azabachería, 3—Pórtico, 4—Platerias, 5—Nave Centre, 6—Outdoors) and seasonal sampling site points (a—Corticela Chapel, b—Santísimo Chapel, c—Library Museum room, d—Goya Museum room).

The influence of the high quantity of people visiting the Cathedral on Sundays was studied, since religious services may be attended by more than 5000 people. To evaluate whether this variable influences fungal content, every fourth Sunday, air in the centre of the Nave (Point 5) and outdoors was sampled onto Sabouraud agar using the BPC. The samples were conducted when low numbers of visitors are in the Cathedral (09.00 h), in the moment of the high influx of visitors (13.00 h) and in an hour of the day with medium people presence (21.00 h), so as to assess its impact on the data obtained.

Other seasonal samplings (Spring: April 21, Summer: August 11, Autumn: November 3 and Winter: December 29, January 27, February 1st) was carried out (Fig. 1) inside the Cathedral chapels (Point a: Corticela and Point b: Santísimo) and inside the Museum's exhibition rooms (Point c: Library and Point d: Goya), where possible alterations produced by fungi were detected, to determine the particular atmospheric fungal content in each area. In this case both volumetric sampling systems were used, with Sabouraud agar as before as culture medium. Finally, swabbing was used to obtain samples directly from the walls inside of the Chapel of Corticela and the Chapel of Santísimo, the sides of the "Pórtico de la Gloria" (which is located in the Cathedral nave) and from different artistic pieces on display inside the Museum's exhibition rooms Library and Goya.

The culture plates obtained were incubated at 25 °C during 7 d, after which the colonies were counted and isolated. Simultaneously, in all of the samples, temperature and humidity was measured using a weatherlink meteorological station; days with rainfall were also recorded due to the possible influence on the outdoor atmosphere's fungal content.

Finally, we applied Scheffé's test to study the homogeneity of the populations under study (Wassertheil-Smoller, 2004), which would enabled us to identify the presence of differences in the quantity of mycobiota content between the sampling points. Spearman's correlation test was used to find a possible relationship between the fungal levels and meteorological factors (temperature and humidity) or visitors affluence.

## 3. Results

### 3.1. Quantitative data

The total number of colony forming units in all of the samples taken in the Cathedral nave (38,137 CFU) was higher than that of outdoor air (20,509 CFU). However, despite this apparent predominance of fungi inside the Cathedral (Table 1), when applying Scheffé's test no general significant differences ($p<0.05$) were revealed when comparing each sampling point inside the nave with the outside.

In general, the results obtained throughout the year inside the nave of the Cathedral show that the maximum concentration is recorded during spring and summer months (with the exception of sampling in April), decreasing considerably in the first 3 months of the year. The

Table 1
Mean of CFU and range of counts for each sampling point in the nave of the Cathedral

| | Point 1 Quintana | Point 2 Azabachería | Point 3 Pórtico | Point 4 Platerías | Point 5 Nave center | Outdoors |
|---|---|---|---|---|---|---|
| Range | 135–560 | 145–615 | 70–610 | 85–570 | 105–560 | 55–540 |
| Mean | 327 | 350 | 388 | 339 | 357 | 309 |