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Analysis of the biodeteriogenic vascular flora at the Royal Palace of Portici in southern Italy

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ABSTRACT

A study was carried out on the biodeteriogenic vascular flora at the Royal Palace of Portici in southern Italy. In all, 160 species were found on the building, which represents approximately 35.5% of the flora found in the whole grounds (449 taxa). Ecological analysis of the plant population highlighted the decisive role of xeric climatic conditions, the lack of substrate, use of the site, and ordinary and restorative maintenance work. Therophytes (48.8%) broadly prevail over other biological forms. Most of the taxa censused (38.8%) may be considered ubiquitous and hence found at the same time on different types of substrate. Measured against the Hazard Index (HI), 62.5% of the species detected may be considered low-hazard (HI 0–3), 31.9% medium-hazard (HI 4–6), and 5.6% very hazardous (HI 7–10). *Ailanthus altissima* (Mill.) Swingle (HI 10), *Ficus carica* L. (HI 10), and *Quercus ilex* L. subsp. *ilex* (HI 9) were the species that had the most impact of the architectural structures in question.

1. Introduction

Biodeterioration can be defined as "any undesirable change in the properties of a material caused by the vital activities of organisms" (Hueck, 1965, 1968). This definition distinguishes biodeterioration from fields of study such as corrosion and wear of materials that relate to undesirable changes in the properties of a material brought about by chemical, mechanical, and physical influences. Obviously, many building materials are more or less bioreceptive (Guillitte, 1995) and hence subject to biological deterioration. The agents that cause biodeterioration vary according to the bioreceptivity of the building materials and the environment concerned.

Vascular plants, often associated with bryophyta, lichens, algae, and fungi, are the biodeteriogens causing most damage, such as cracks, collapse, and detachment of materials mainly due to biophysical and biochemical processes. The biophysical decay is mainly due to the growth and radial thickening of the roots of plants inside the stone, which results in increasing pressure on surrounding areas of the masonry. Root growth tends to occur in pre-existing fissures or cracks on stone surfaces and in zones of least resistance (e.g., mortar between stones), thereby increasing the size of the fissures and cracks and decreasing the cohesion between stones (Gill and Bolt, 1955; Mishra et al., 1995b). Biochemical deterioration resulting from assimilatory processes, where the organism uses the stone surface as a source of nutrition, is probably more easily understood than deterioration resulting from dissimilatory processes, where the organism produces a variety of metabolites that react chemically with the stone surface (Mortland et al., 1956; Caneva and Altieri, 1988). The acidity of root tips is maintained by a layer of H^+ ions that can be exchanged with nutritive metal cations in the solution following the lyotropic series (Williams and Coleman, 1950; Keller and Frederickson, 1952; Caneva and Altieri, 1988; Caneva and Roccardi, 1991; Jain et al., 1993; Mishra et al., 1995b). In addition, carbon dioxide, produced through respiration, changes into carbonic acid [H_2CO_3] in an aqueous environment. The carbonic acid reacts with calcium carbonate [$CaCO_3$] and magnesium [$MgCO_3$] insoluble present in limestone, marble, and plaster, forming calcium bicarbonate [$Ca(HCO_3)_2$] and magnesium [$Mg(HCO_3)_2$] soluble (Caneva et al., 1991c; Mishra et al., 1995a; Pinna and Salvadori, 2005).

The colonization of buildings by plants is often similar to the colonization of newly exposed rock in nature. Plants exploit and help to create microenvironments suitable for plant growth, and, if left undisturbed, a succession takes place of plants of increasing diversity and size (Allsopp et al., 2004). Vascular plant colonization is essentially conditioned by the adaptability of the species and the efficiency of their mode of reproduction (Lisci and Pacini, 1993; Lisci et al., 2003).

Abbreviations: HI, Hazard Index; PORUN, *Herbarium Porticense*; MDS, Monthly Drought Stress; MCS, Monthly Cold Stress; SDS, Summer Drought Stress; WCS, Winter Cold Stress; YDS, Yearly Drought Stress; YCS, Yearly Cold Stress; P, plant life form; I, invasiveness and vigour; R, root system.

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The problem of deterioration of cultural heritage is particularly significant in countries such as Italy that are rich in these assets. Indeed, according to UNESCO (United Nations Educational, Scientific and Cultural Organization) data, Italy possesses two-thirds of the world's cultural heritage.

In Italy, biodeterioration studies have been traditionally concerned bacteria, fungi, algae, lichens, and bryophytes. Only in relatively recent times has the presence of vascular plants on monuments and archaeological sites been examined (Hruska Dell'Uomo, 1979; Caneva, 1985; Caneva and De Marco, 1986; Catizone, 1990; Caneva and Roccardi, 1991; Caneva et al., 1991a,b, 1993, 1995, 2002; Raimondo et al., 1991; Celesti-Grapow et al., 1993–1994, 2001; Caneva and Galotta, 1994; Signorini, 1995, 1996; Poli Marchese et al., 1997; Ceschin and Caneva, 2002; Corbetta et al., 2002; Ceschin et al., 2003, 2006; Celesti-Grapow and Blasi, 2004; Lattanzi and Tilia, 2004; Altieri and Fabrini, 2005; Gueli et al., 2005; Spampinato et al., 2005; Stagno and Poli Marchese, 2005; Guglielmo et al., 2006; Distefano et al., 2009). Some studies have also investigated the damages to hypogeal archaeological monuments caused by growth of tree roots (Caneva, 1989; Caneva et al., 2004, 2006, 2009).

Studies concerning the vascular flora of Campania have focused mostly on the assessment of naturalness and biodiversity levels of more or less extensive areas. However, to our knowledge there are no floral studies applied to the conservation of monuments and archaeological sites. Such surveys, designed to detect the species that most contribute to the deterioration of historic buildings, are particularly valuable due to the importance of the historical, archaeological, and architectural heritage of Campania. The only bibliographic data concerning this subject consist of short notes by Ciarallo and D'Amora (1990) and Miravalle (1990), and a multiregional work by Celesti-Grapow and Blasi (2004).

To fill this gap, we analyzed the vascular flora biodeteriogens of the 18th-century Royal Palace of Portici, one of the most important Bourbon buildings in Italy. Such knowledge is critical to the choice of appropriate preventive and eradication methods of these species.

2. Study site: the Royal Palace of Portici

2.1. Geographic situation and conservation status

The Royal Palace covers an area of about 17,400 m^2 and is located at sea level on the boundary between two densely populated urban areas, Portici and Ercolano. The entire site is therefore at the heart of the Bay of Naples to the southwest of Mt. Vesuvius and falls in an urbanized area that is subject to ever-increasing human pressure (Fig. 1).

Due to the lack of periodic maintenance and the location of the building in an environment conducive to the development of organisms such as algae, lichens, bryophytes, fungi, and vascular plants (Fig. 2), the problems of biodeterioration have assumed particular importance.

2.2. Historical background

The Royal Palace was built between 1738 and 1743 for of the Bourbon King Charles III. Work on the palace was first directed by Antonio Medrano, who was replaced by Antonio Canevari in 1741. The whole complex was built in an area where there were already some noble residences that, once purchased, became the architectural basis for the new palace. The completion of the Bourbon residence in Portici was followed by the establishment of many other noble villas in the Vesuvian area, which became known as the "Golden Mile."

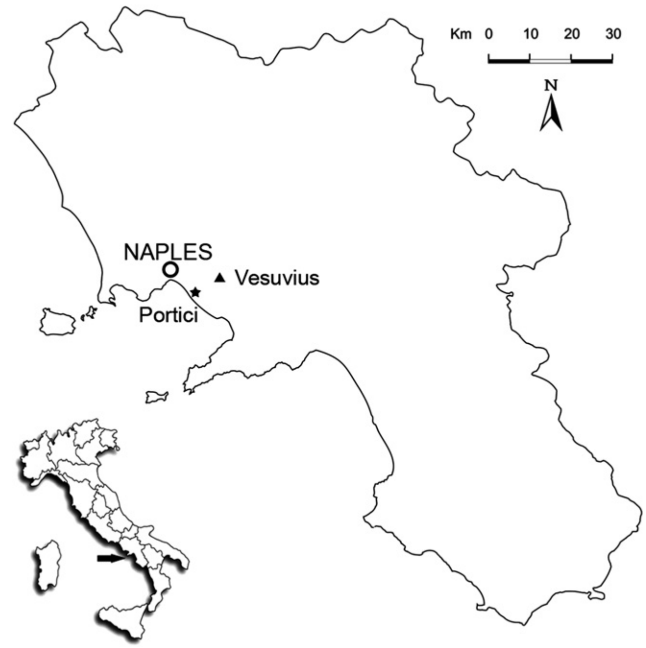

Fig. 1. Location of the study area in Campania (southern Italy).

The current structure of the Royal Palace is the result of historical events and major structural changes over time. After several vicissitudes, from 1861 onwards the royal estate became part of the heritage of the king of Italy, Vittorio Emanuele II, and in 1871 it was purchased by the Naples provincial authority and assigned to "Regia Scuola Superiore di Agricoltura," now the Faculty of Agriculture of the University of Naples Federico II.

At present the palace is comprised of two wings connected by buildings forming a bridge over Via Università (once known as "Strada delle Calabrie") delimiting a large octagonal courtyard. The seaward side has two large ramps; attached to the rear are the historical gardens, part of which has been assigned since 1872 to the Botanical Gardens.

2.3. Climate

The main climatic characteristics of the Royal Palace of Portici were obtained by processing meteorological data from the Naples Hydrographic Service (30 m a.s.l.) for the period 1969–1999 (Min. Lav. Pubb. – Serv. Idr., 1969–1984; Pres. Cons. Min. – Serv. Tec. Naz., 1985–1999). These observations provided the basis for the diagrams of Walter and Lieth (1960–1967) and Mitrakos (1980), reported in Figs. 3 and 4, respectively.

The first graph shows a Mediterranean climate with a summer drought lasting from June to August. Given the proximity of the Tyrrhenian Sea and the modest elevations reached by the site of Portici, snowfall is rare and practically negligible in defining the climate of the area.

Consistent with the climate trend described above is the Mitrakos diagram (1980). It shows the presence of moderate winter cold stress that lasts, to a limited extent, until April, and acute hot stress during the summer months.

2.4. Substrates

The main building materials of the architectural structures of the Royal Palace, and hence the growth substrates for biodeteriogen species, are listed in Table 1. It should be pointed out that plants, with a few exceptions, do not grow directly on the substrate, but on