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Evaluation of bacterial diversity on historical silk velvet textiles from the Museum of King John III's Palace at Wilanów, Poland

Iwona Brzozowska^a, Albert Bogdanowicz^a, Paweł Szczęsny^{a, c}, Urszula Zielenkiewicz^{a, **}, Agnieszka Laudy^{b, *}

^a Institute of Biochemistry and Biophysics, Polish Academy of Sciences, Warsaw, Poland

^b Museum of King John's III Palace at Wilanów, Laboratory of Environmental Analysis, Warsaw, Poland

^c Faculty of Biology, University of Warsaw, Warsaw, Poland

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ABSTRACT

Understanding the diversity and the role of microorganisms residing on an art object is important for its conservation and future preservation. This study reports the first application of a culture-independent NGS approach to identify the total community present on biodeteriorated historical artistic textiles. The samples were taken from five Royal Apartments decorated with Genoa type silk velours and different conservation procedures were applied to their fragments. Sequencing of 16S rRNA amplicons revealed overall high similarity in microbial biodiversity. Interestingly, conservation procedures had little effect on the structure of the microbial population. Similarly, airflow did not appear to influence the biodiversity of microorganisms on the silks, as neighbouring rooms did not exhibit greater similarity in the structure of the population of bacteria, in comparison to remote ones. The high biodiversity found on silks is likely to represent the complex history of the velvets, not the immediate past. Therefore, further studies, relying on techniques for analysis of living microbes, are needed to elucidate the sophisticated process of biodeterioration of museum objects.

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1. Introduction

The unique artworks made of silk decorate five rooms in the oldest part of Wilanów Palace, the precious Baroque royal residence in Warsaw. With their characteristic delicate material, superb dyeing and interesting textures they became the research material for this study as objects of unique historical and cultural value.

The history of the Palace in Wilanów began in 1677, when a village became the property of king John Sobieski III. The building comprised elements of a nobility house, an Italian garden villa and a French palace in the style of Louis XIV. In 1730, considerable changes in the residence were made and genuine suede decorations were placed on walls. The Wilanów property was not destroyed during World War II and under the land reform the whole land and buildings became the property of the state.

Any works of art are exposed to the physical, chemical and biological factors that cause their aesthetical changes. Object aging, oxidization or reduction of chemical components are caused by the processes spread out in time which turn historical materials into a source of carbon, nitrogen and other nutrients, thus making them prone to microorganisms (Mitchell and McNamara, 2010; Kraková et al., 2012). In the indoor environments these components are hard to access and scarce and only microorganisms with specific metabolic properties can colonize surfaces of museum objects. Long exposure to biological impacts that are harmful to collections may largely heighten the risk of loss of value in a process referred to as biodeterioration. The main factors responsible for the proliferation of microorganisms on art objects are their chemical nature and the environmental conditions, especially the availability of nutrients, light intensity and favorable humidity (Saiz-Jiménez, 1993; Pavlogiorgatos, 2003; Camuffo et al., 2004; Corgnati et al., 2009).

Baroque artworks that command special attention are old silks of unique historical and cultural value, which decorate the walls of five Royal Apartments (Fig. 1A) in Wilanów Palace. Silk, as a chemical substance, being an insoluble and fairly decomposition-

* Corresponding author.

** Corresponding author.

E-mail addresses: iwonab@ibb.waw.pl (I. Brzozowska), albertbogdanowicz@ibb.waw.pl (A. Bogdanowicz), szczesny@ibb.waw.pl (P. Szczęsny), ulazet@ibb.waw.pl (U. Zielenkiewicz), aludy@muzeum-wilanow.pl (A. Laudy).

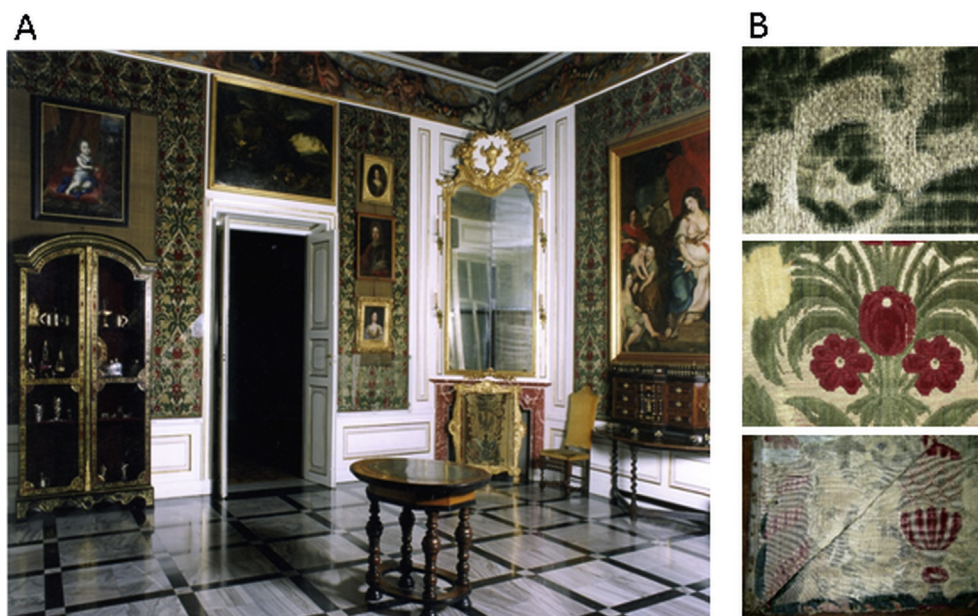


Fig. 1. Genoa velvets in Wilanów Palace Museum. A. Queen's Antechamber interior. B. Sections of a patterned velvets. Photos: Department of Research Documentation of the Wilanów Palace Museum.

resistant protein, is less susceptible than other natural fibers to microbial invasion but may also undergo biodegradation (Peacock, 1996; Seves, 1998). However, there are a number of factors (apart from storage and presentation conditions) that affect the way and pace fibres and fabrics decay. These factors include thread thickness, type of ground used before dying, dyes applied etc. But the most important is the natural durability of the fibre, which is a result of its individual features: origin, composition and structure. The silk velvet textiles in the royal chambers are characterised by a unique formula of pattern arrangements: plain fabric with solid color weave is placed centrally and surrounded by borders of elaborate design. All velvet fabrics, with the exception of those in the Dutch Cabinet, have characteristic silver ribbon woven into the ground (the King's Bedroom), or silver ribbon gilded on both sides, like in the Queen's Bedroom, the King's Antechamber or the Queen's Antechamber. Recent research showed that the ribbon is corroded, cracking or crumbling in a number of places (Czaja-Szewczak and Przygońska, 2009). Colours probably closest to the original ones can now be found only in fabric sections shielded from direct sunlight or other discolouring impacts.

The silk textiles are mounted on wooden canvas-covered looms and have decorated the Palace walls permanently for almost 300 years. They never suffered severely from fierce harmful environmental circumstances though they have been exposed to a variety of adverse ambient impacts, from significant fluctuations of relative humidity and temperature to intense changes of exposure to ultraviolet and infrared radiation. An important factor is also the fact that in these spaces erstwhile residents spent a daily, family life and their routine activities could have become a risk factor. Frequent changes in the Palace's indoor microclimate cause silk threads to tauten and contract, and consequently weaken them physically. Processes of silk fiber aging were accelerated by dust and dirt stuck between the silk fibers and air pollution contributing to the acidification of fabrics. Collectively, all these factors caused the deterioration of the delicate silk threads (Fig. 1B).

For decades, investigations concerning microbial populations on art objects were carried out mainly basing on classical cultivation studies and have involved the characterization of physiological

properties of the isolates. As a result, the enormously important role of microbes in art object degradation processes has been recognized (Urzi et al., 2003; Florian, 2007). However, the well-known cultivability bias (estimated fraction of detected species could be as low as less than 1% (Hugenholtz et al., 1998; Donachie et al., 2007) causes serious underestimation of real microbial diversity. As for other environments molecular techniques have been applied in cultural heritage asset biodiversity studies (Schabereiter-Gurtner et al., 2001; González and Saiz-Jiménez, 2005; May et al., 2008). Particularly, nucleic acid fingerprinting techniques have been successfully employed with the DGGE method practiced most often (Möhlenhoff et al., 2001; Schabereiter-Gurtner et al., 2001; Michaelsen et al., 2006; Santos et al., 2009).

Very few in-depth studies dedicated to microbial deterioration of historical textiles have been conducted (Szostak-Kotowa, 2004). Mostly, they have been specific investigations carried out with the use of physical and chemical methods characterizing the extent of fabric degradation caused by microbial activity (Degano and Colombini, 2009; Kavkler et al., 2011; Margariti et al., 2011). Special attention has been devoted to archeological textiles - ancient remnants of funeral clothes (Pangallo et al., 2009; Škrilin et al., 2011; Piñar et al., 2013). However, these investigations were performed using cultivation methodology.

Nowadays, the need to determine the microbial communities inhabiting particular museum environments is widely understood. The diversity of microorganisms residing on an art object, their quantity and metabolic potential are of great importance for its conservation and future preservation. As has been exemplified by the history of Lascaux Cave Paleolithic paintings conservation, application of potent antimicrobial treatment would lead to the creation of modified ecological niche better suited to the development of certain microorganisms eventually more harmful (Dupont et al., 2007; Bastian and Alabouvette, 2009; Bastian et al., 2010).

In this study the analysis of fungi which are documented as the more critical in degradation of majority of art objects (Sterflinger, 2010; Sterflinger and Piñar, 2013; Kwiatkowska et al., 2016) was intentionally omitted. Particular analyses on viable fungi in the

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