Decay mechanisms and control methods for conservation of art works in museum conditions and surrounding postbyzantin church

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***Abstract*—Cultural heritage art works are exposed to weather and influence of various environmental parameters. Physicals, chemicals and biological factors interact with constitutive materials inducing changes both in its compositional and structural characteristics. A certain aspect of matter transformation is due to the metabolic activity connected with the growth of living organisms. The purpose of this paper is to analyse in depth the icons and wood materials (of both icos and church structures) in the collection of Medieval Art Museum of Korça and the famous Church of Theotokos (14th Century) in Maligrad Isle, Prespa. The survey was considering 60 icons and for all of them is done the categorization of icons according the panel construction, insect identification and the disinfection process of icons with the thermal treating in Thermo Lignum apparatus. The microscope observation revealed presence of *Anobium punctatum* in the icon collection, while other insects and fungi presence has been recorded in the Church of Theotokos. The method applied for the disinfection of icons is the Thermal treating in Thermo Lignium, which efficiently eliminates all kinds of insects at 55°C. The icons were treated at 55°C for 9 hours, while the positive effect clearly evidenced.**

Keyword - Medieval art, Art works, Biodegradation, Deterioration, Conservation

I. INTRODUCTION

In the current innovative approaches it is well established that diagnostics is at the basis of scientific conservation treatment [1]. This paper presents an integrated approach considering different diagnostics, treatment and preservation tools focused on medieval icons before and after its conservation. This multi-technique approach has been used to identify the materials and technique of icons preservation at the Medieval Art in Korça, to detect previous lacking and additions as well as the nature and extent of the alterations present. The intention of this approach was to provide key information to the conservator for the development of an appropriate conservation treatment. The diagnostics after conservation provided further information on materials thanks to the removal of the biodegradation and deterioration components on the wood material and painting surface, and allowed to evaluate the accuracy of the conservation treatment itself. This case study highlights the importance of a non-invasive diagnostics approach for artefact comprehension and for the evaluation of a conservation intervention. The study results are hoped to contribute to the literature regarding scientific examinations of medieval icons.

The conservation and restoration of art works in Albania has been considered as an interdisciplinary approach [1, 2, 3]. The particularities of post byzantine churches has been highlighted, while the importance of mural frescoes and other artworks is seriously threaten by the influence of environment and biological factors [2, 4]. The scientific research on bio-deterioration of works of art is known for over several decades, while in the last decades the surveys and proposals for adequate conservation techniques of monuments have significantly advanced [5]. It was demonstrated that the preference of microorganism for some category of substrate is related to their susceptibility [6, 3, 7, 8, 9]. During the past decade studies reveal that in post byzantine churches of Albania fungal attacks appear when improper conditions of maintenance, humidity variation exist and other environmental factors for the churches [4, 6]. Similar surveys confirmed the same results [10, 11, 12].

The National Museum of Medieval Art is one of the most important cultural institutions in Albania. It has a wealthy fund with about 6500 icons and about 1500 other objects in metal, stone, textiles and paper. This collection is one of the greatest not only in Albania but it can be considered one of the biggest also in Balkans. From the first centuries of medieval times in the museum are preserved objects that come mainly from large centres of Apollonia, Butrint, Durres. The most prominent representative of this post-Byzantine period in Albania is Onufri, along with his son Nikollë and Onufër Cypriot. These three are the most prominent representatives of the Berat School. The icons of the 16th and 17th centuries are numerous in number (421 works) and represent a variety of stylistic features. Of particular interest is also a large group of 125 icons available from the museum and coming from Vithkuq village of Korca and a group of 55 icons that come from the Erseka area and belong to the middle of the seventeenth century, (Saint Mary on the throne, Johan Baptist). Unlike the other icons of this period, they are back to XVI century models and the Cretan -Venetian style. The icons of the Albanian painters of the XVIII century belong to the school of Korça and show influences from Athos' painting and from the western art. But a very important place in the museum's collection is the iconic icons (246 works) that have the ateliers of two Athanas brothers and Constantine Zografi, the most important and productive of the time. On the works of the painters Zografi are observed features from the baroque style. From this period there are also a few icons found that belong to the school of Crete. There are thousands of icons that decorate the monuments of the XIX century. From the microscopic examination of the wooden material to the icons in the museum, it was found that the most used wood types in the construction of the wooden support of the icons were Walnut 63%, Pine 14%, Bosnian pine 14%, Fir 6%, Oriental Plane 3%.

This study has considered around 60 icons. For all of them is done the categorization of icons according the panel construction, icon deformation and deterioration, insect identification and the disinfection process of icons with the thermal treating in Thermo Lignum chamber.

II. MATERIAL AND METHODS

A. Examination of icon wood structure

The survey considered icons painted as separate pieces and icons incorporated on iconostases. The smallest icons are composed by a single plank. Their dimensions vary from 35 to 50 cm width 29.5 to 45 cm. Their thickness is 17 to 30 mm. In Albania, the single plank icons were commonly used. The dimensions of single plank icon vary from 45-70 cm width and 25-50 mm thickness. Larger icons are composed by two or more planks. In the two planks icon the width of the planks are usually similar. However in many cases we face icons with different plank width. It is thought that such a support choice was made by the painter conditioned by the composition nature of his painting. The methods that are used most often for the connection of the planks to form the wood panel can be divided into four main groups: (i) Glue connections; (ii) Groove and tongue connections; (iii) Butt join with doels connections and (iv) - Butterfly shaped wooden cleat connections. Crossbeams have the main function of maintaining the support continuity as well as insuring the planarity of the surface. In order to balance the deformations and strengthen the connection between the boards, the crossbar is mounted on the back of the wooden support of the icon.

B. Examination of icon deformation and deterioration

The most frequent damages to the wooden support are fractures and cracks in the direction of the grain, separation between the planks in the case of composite panels, breaking in the painting canvas or between the panel and the canvas, cracking from the bend, bow, crooks, twist. From this survey were considered 60 icons in the medieval museum of Korça, these structural damages have been observed: (i) Higroscopic cup; (ii) Cracking from the bend; (iii) Local breaks of panel parts; (iv) Surface checking and (v)Internal checking.

C. Biological and mycological examination

Samples for biological nd mycological analysis were obtained from 5 different locations in Church of Theotokos (14th Century) in Maligrad Isle, Prespa of in south eastern Albania. They were collected from mural frescoes and wood materials which were either partly or fully damaged in different locations of church structures. About sixty samples from canvas, dyes and wooden frames with visual changes were taken by sterile cotton swab for further mycological analysis. Samples were inoculated on malt streptomycin agar (MSA) medium (malt extract agar with 500 mg streptomycin per liter) in three replications. The inoculated plates were incubated at 25°C and fungal growth was daily observed during ten days and submitted to the routine laboratory procedure to obtain pure fungal culture. Reisolations were done successively, to the selective nutrient media: potato dextrose agar (PDA), Czapek's agar (CzA) and malt extract agar (MA) using standard mycological methods. Reisolated cultures were also incubated at 25°C. Identification of obtained isolates to species level was done by macroscopic and microscopic examination. Microscopic preparates were dyed with lacto phenol or fuchsin acid, observed by light microscopy and determined by appropriate keys [13, 14, 15].

For the identification of insect, initially these icons were taken and passed through the dissection process for 9 hours and after this process we took samples for analysis and identification of the insect that affected these icons, in the microscope. The chosen icons were those of: (i) IN/914 (Shen Kolli); (ii) IN/ 3634 (Shen Joan Ungjillori); (iii) IN/4170 (Shen Gjergji); (iv) IN/5094 (Krishti jetedhenes); (v) IN/4025 (Zona e engjejve); (vi) IN/4116 (Shen Joan Pagezori); (vii) IN/2688 (Hyjelindesja glikofilus); (viii) IN/6283 (Krishti i fronezuar, Gjykatesi i drejte) and (ix) IN/ 3472 (E tereshejta vrefokrausa)

The frass pellets samples of the insects were taken from the galleries created by insects and extracted in the form of wood dust, in mm size. The material was placed on the glass lamela to be observed and analyzed in the stereomicroscope, while this one and identified fungy are presented in Figure 2. Lamellas are carefully observed, fixing in the photo the relevant elements needed to determine the type of insect according to the identification key.

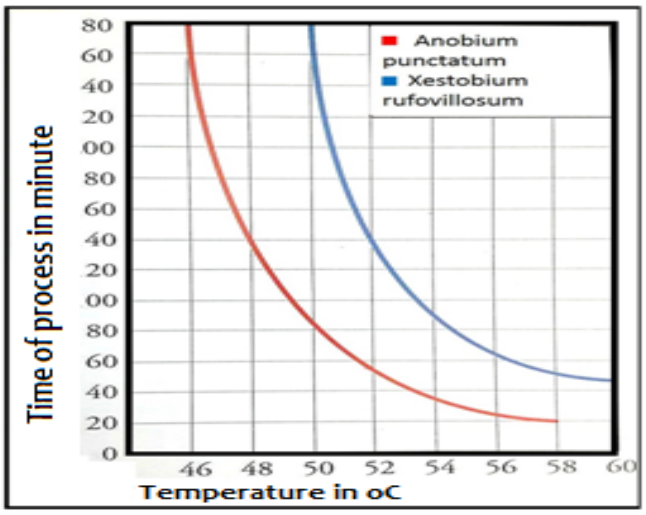

Fig. 1. The Keylwerth Diagram showing the effect of high temperature exposure on insect abundance

Fig. 2. Some of the considered icons during the survey

D. Disinfection method with Thermo Lignium

Heating is an effective way to eliminate insect pests from the panel of pictures. Relatively short exposures are needed to assure efficacy, so the utility of heat is relatively quick compare to other methods and the universal susceptibility of insects [16]. The method applied to the disinfection of icons at the Korca Medieval Museum is the high temperature treating of icons. It is one of the most effective methods of insect spread control because it does not pose a risk to the health of restorers, because the technique of this method relies on the handling of high temperature icons without chemicals or gasses. Thermo Lignum heat process, incorporating controls on relative humidity variation, was evaluated as a possible practical option [17. It also does not pose a risk for the icon support, as long as it is subject to strict relative humidity of the air and ambient temperature, it is the most productive method of icons treatment. Thermo Lignium chamber is the used chamber for this purpose and efficiently eliminates all kinds of insects at a temperature of 55°C. The extent and duration of the heating process plays an important role in this process [18]. The panels are heated to a minimum temperature of 55°C for a period of 60 minutes, causing insects and larvae to die. For a long time this method is not considered suitable for the treatment of icons, the cause is that air heating reduces relative air humidity, this changes the level of wood moisture, resulting in contraction of the icons.

III. Results and Discussion

The precondition complex factors that cause the presence of biological invasion and oscillation values are presented in Figure 3.

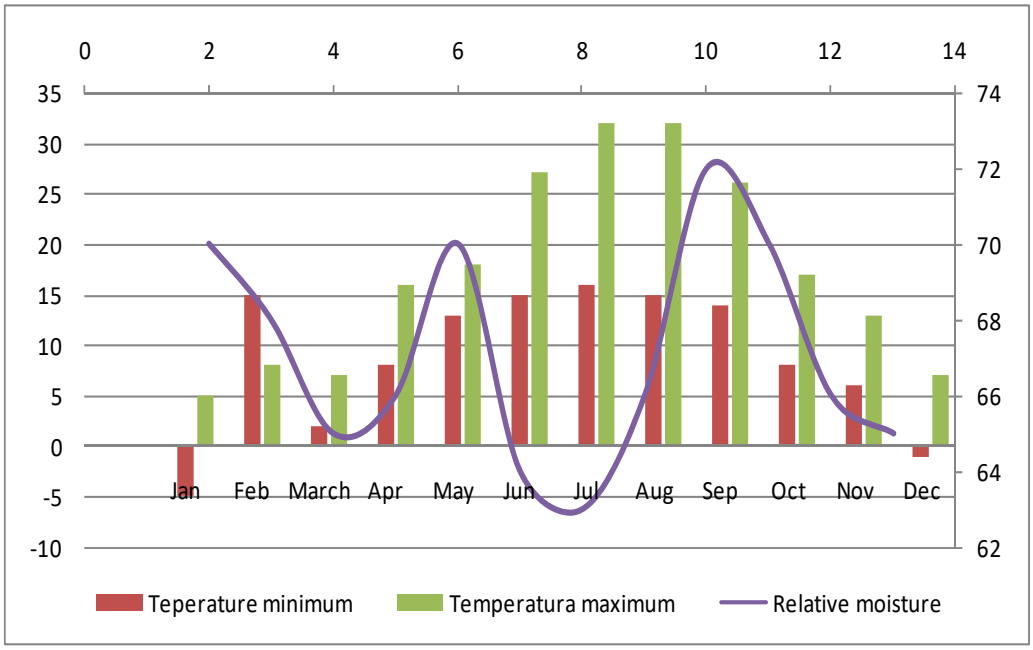

Fig. 3. The oscillation of main physical factors in the considered area

A considerable diversity of biological components including insects fungal species was obtained from all investigated icons and wooden frames, where 10 taxa were isolated and identified in total, representing 9 genera. The fungal species were more abundant on mural frescoes, while in wooden materials they were considerably less present (Figure 4). The data shows a difference in species presence, where the most affected structures were identified in case of Church of Theotokos, while in the other ones they were considerably less abundant. Based on the Identification table of the insect, the wood dusts (insect frass pellet) results in the shape of micro oval pellets that is characteristic of the common furniture beetle (*Anobium punctatum*).

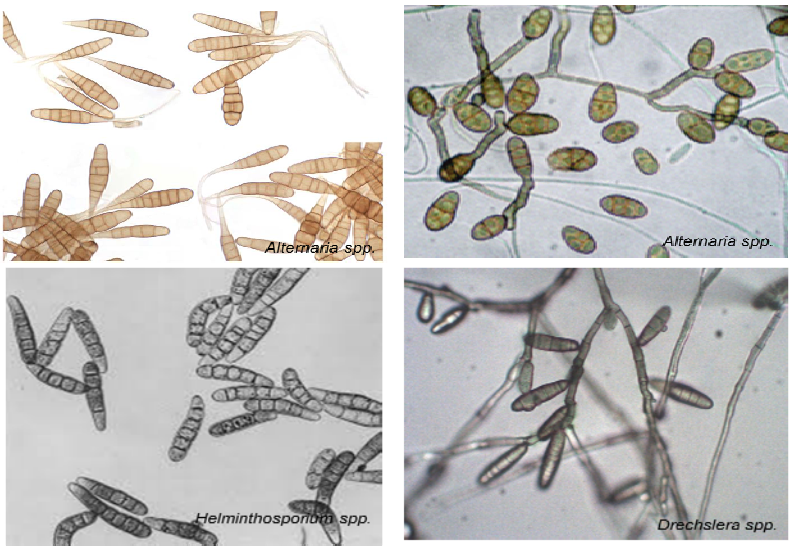

Fig. 4. Selected fungal species isolated from damaged frescoes and wooden frames [6]

The adult insect grows up to 5 mm, it is long in brown colour. The larva is 5-7 mm long, with a white colour and an arch shape. The adult insect appears from May until September and it has a lifespan of 3-4 weeks. It generates 20 to 30 eggs in checking or on the wood surface roughness, or on the walls of the old galleries. The appearance of larvae occurs after 4-5 weeks and their development takes place inside the wood. The nymphility of the nymph is 2-3 weeks, while the extension of the full cycle of development is 1-4 years according to the climatic conditions.

Contractions cause stress on the wooden support of the icon and cracking on the painting layers. Therefore, in order for these failures not to occur, it is necessary that all system parameters be regularly regulated and monitored by the restorer.

The technology is based on the Keylwerth Diagram (Figure 1), which determines the reciprocal relationship between the vapour pressure and the relative humidity, also determines the reciprocal relationship between relative humidity and wood humidity. In the Korça Museum icons inside the chamber are initially ventilated gradually with hot wet air for a period of 4 hours, then for a period of 1 hour the icons are warmed to 55°C, the time when the effective insect and larvae killing is made. At the end of the one-hour period starts the process of gradual cooling for a period of 4 hours. A microprocessor regulates relative humidity and ensures that there will be no changes in the moisture content of the wooden panel of the icon. This assures the restorer that he will not face different reaction to the support and damage the painting layers.

IV. Conclusion

Using a range of analytical and conservation approaches made possible to identify the original materials and methods of construction of the icon in the museum and in situ conditions at the south eastern Albania. The interpretation of these findings was only possible in combination with research into the history of the production and use of icons and previous conservation practices. The survey has also helped establish a likely of theory to practice considering previous interventions.

From observations carried out in the framework of this study resulted that the types of structural construction of the wood panel can be divided into 4 large groups: (i) Single board without crossbeam icon; (ii) Two boards with nailed crossbeams Icon; (iii) Two boards with sliding crossbeams Icons and (iv) Two boards with sliding and nailed crossbeams Icons.

Use of method applied for the disinfection of icons is the Thermal treating in Thermo Lignium, proven efficiently eliminates all kinds of insects at 55°C. We recommend that icons consisting of high wax amounts are recommended to be subjected to a cleaning prior to disinfection in order to lower the amount of wax because the high wax contents make the wood heat up to its interior difficult, thus making it difficult to insect death.

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