CONSERVATION APPROACH DIVERSITY
TO ADDRESS THE DECORATIVE ELEMENTS IN THE GARDENS OF THE NATIONAL PALACE OF QUELUZ, LISBON, PORTUGAL

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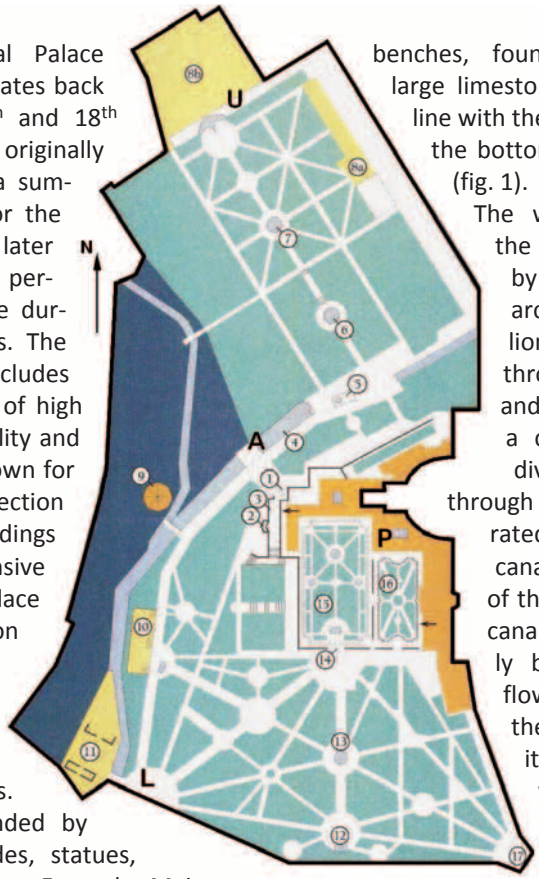
The National Palace of Queluz dates back to the 17th and 18th centuries. It was originally designed to be a summer residence for the royal family while later also serving as its permanent residence during some periods. The Baroque Palace includes several buildings of high architectonic quality and is particularly known for the intimate connection between the buildings and the extensive gardens. The Palace opens directly on to the two main formal gardens in French style: the Malta and the Hanging gardens. These are surrounded by various balustrades, statues, fountains and vases. From the Main Gate, various avenues open fan-like to traverse the large park to the south, decorated with statues, pedestals, benches, fountains and a large limestone cascade in line with the Main Gate at the bottom of the park (fig. 1).



The west wing of the Palace, built by the French architect Robillion, leads down through terraces and staircases to a creek affluent diverted to run through a highly decorated azulejo-lined canal in this part of the garden. This canal was purposely built to bring flowing water to the gardens and its walls lined with azulejo in the mid 18th century. Between the canal bordering path and the formal Hanging garden, there is a mini-maze and a herb garden. Across the canal,

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Fig. 1 - General layout of the Queluz Palace (in the centre of the map) and gardens. P: Palace buildings; A: Azulejos-lined canal; U, L: Upper and Lower collecting tanks, respectively.

an orange tree orchard a larger formal garden with flower beds and decorated with statues and fountains leads up to the most important marble fountain, the Neptune attributed to Gianlorenzo Bernini and Ercole Ferrata, installed during the early 20th century restoration of the gardens.

The Queluz Palace and gardens are listed as a national monument since 1910 and is one of the most visited historic gardens in Portugal. Further information on historical aspects of the Palace and its gardens can be found in the publications by Luz Afonso [1], and Ferro [2, 3].

The fifteen hectare grounds are decorated with some 91 marble statues and 35 marble busts, apart from 40 bases, 143 pedestals, 100 vases and 43 balustrades sections. Of these, some are carved some in marble but most in limestone. There are also 22 marble fountains and a large limestone cascade. Some of the fountains have lead figures decorating them and there are other 14 statues cast in lead attributed to the British artist John Cheere. Water is a central component in the layout of the gardens and the slope of the land, from north to south, served to shape the garden design by the positioning of the various fountains.

The climate in Queluz is temperate, with mild seasons. Rain falls mostly from November through

April with a total yearly average of around 850 mm. July and August are the hottest months, when temperature maxima may surpass 40° C. Winter temperatures may come close to 0ºC, but freezing events are very rare. The extensive presence of vegetation, in particular that of frondose trees, influences the local conditions creating different localised microclimates that have a significant influence in the development and extension of biocolonisation.

The paper presents a brief description of the problems presented by the decorative stone elements, both statues and fountains, and the approach taken during their intervention carried out under the World Monuments Fund-Portugal project as well as the maintenance recommendations suggested for their regular upkeep.

State of conservation of the stone elements

The stone ornaments are mostly carved in marble or limestones. Marbles are attributed an Italian provenance, probably from Carrara. The limestones are Portuguese and two main types are present: a very low porosity limestone quarried in the nearby region (Lioz stone) and a highly porous variety quarried near Coimbra (Ançã limestone). Limestones were preferentially used for the pedestals and balustrades that are distributed throughout the gardens. The compact variety, Lioz, is extremely resistant and in general is in good state of conservation. Biopitting, minor scaling, and rain erosion channels are characteristic erosion forms. The porous variety was mostly used for balustrades, and those balusters showing deterioration suffer powdering and scaling, particularly in areas next to cement patching.

The garden ornaments show typical deterioration as can be expected to occur in a garden environment. Extensive biocolonisation (fig. 2) is the major problem, with lichens being the most aggressive colonizers. There are several species, from foliose to crustose types, and ranging in colour from yellow to white, black, and green. A diffuse darkish biocolonisation is also present. During wet periods, the green algae are clearly visible, especially in sheltered areas that become dark during the dry and hot summers of Queluz. Colonisation has induced the heaviest losses in the sculptures, either directly by micropitting, or indirectly through poor cleaning practices frequently used to eliminate it in the past (fig. 3). The mostly rural environment does not favour the development of black crusts

Fig. 2, a, b. Aspects of the heavy biocolonisation in the stone sculptures.

and therefore their presence is rare and restricted to some minor sheltered zones.

Biopitting and other colonisation scars are commonly visible in the marble surfaces, and are especially noticeable when soft methods (biocides plus soft brushing) are used to eliminate colonisation (fig. 4). “Sugaring” disintegration of marble and rain erosion channels are also present but to a lesser degree. Fractures, fissures, and losses of stone fragments complete the list of the major deterioration patterns.

The fountains present a totally different scenario from that of the sculptures. Because of the complexity of the interior water circuit, these only can be addressed during a comprehensive restoration intervention. Therefore, they have undergone fewer interventions during their lifetime. The main problem is the biocolonization that develops consequently to the presence of water. This results in the development of both endolithic algae in the stone basin [4] as well as the growth of algae on the decorative elements in the areas where water runs over them. For example, the Neptune fountain underwent a thorough restoration in 1999 [5] and at the time, the figures decorating it were treated with a water repellent. This treatment enhanced localized bio-

Fig. 3, a, b. Appearance of sandblasted marble sculptures. Micropitting of biocolonisation shows borders smoothened by the cleaning method.

Fig. 4 a, b. Appearance of colonisation scars remaining after cleaning the marble sculpture surface using a soft method.

colonization along the water paths as shown in fig.5 a). This problem has been addressed in detail elsewhere [6].

Another important point is the pressure of the water spray in the fountains. Using the aforementioned example, the Triton figures spout water through conches they carry. Although initially the water spouted beyond the figure itself, as the tubing and nozzles become incrusted by calcareous deposits, the jet tends to fall short and dribbles over the figure increasing the development of algae (fig. 5b).

Past conservation intervention policies

Frequent maintenance of the sculptures was certainly a current practice in the early times of the gardens, especially during the times the royal family was present. A letter from 1820 [7] proves that cleaning operations were already being carried out prior to this date.

Early in the 20th century, the gardens underwent a major intervention. Many fountains were moved from one place to another in the gardens, while others, previously removed, were returned and reinstalled.

Reinstallation was not well planned and hastily carried out. Some were placed in areas where they still remain unconnected to the hydraulic system. Others suffered from poor installation leading to new problems as discussed below.

In the 1930s, after the big fire of 1933, the conservation actions followed a more coherent approach that considered buildings and gardens as a whole, with both parts requiring equal consideration and maintenance. Around 1948, some restoration actions were reported and, after a long period where no actions were recorded, documented interventions start in 1977.

These documented maintenance actions carried out on the decorative elements in the gardens lack a coherent approach, and the actions were mostly prompted to address the most urgent matters. The conservation methods applied were left to the discretion of the conservator-restorer or tradesperson resulting in some cases in the use of very aggressive cleaning methods, and in others, in poor quality work. Towards the end of the century, the lack of maintenance of the gardens proper led them to near destruction as plants grew wild, the boxwood hedges got diseased and sick trees were left to fall by themselves with consequent damage to any stone object nearby.

The World Monuments Fund-Portugal project, briefly presented below, served as the turning point of the described situation.

The World Monuments Fund-Portugal project

The recently completed seven-year-long project that addressed the conservation and restoration of the Palace

Fig. 5. ◄ a) Biocolonization develops first in the water paths that result from the application of a water repellent to the marble surface of a Triton in the Neptune fountain.

▼ b) Four years after the restoration, the hardness of the water reduced the spray to a dribble that fell over the shield, rather than spraying beyond it. Consequently, the shield is being overgrown by biological colonization.

gardens was divided into the following subprojects: the gardens proper; the azulejo-lined canal, the decorative stone elements, including fountains and the cascade; the lead statues; and the hydraulic system that feeds the fountains. As in previous projects, these tasks were shared between WMF-P and the Portuguese government. The latter, via the Ministry of Culture, took the responsibility for the restoration of the gardens proper and the installation of a new hydraulic system, while the former addressed the remaining subprojects.

Most of the stone statuary and smaller decorative elements such as vases and balustrades are concentrated in the formal gardens while other stone elements such as pedestals and benches are dispersed throughout the grounds. However, since the main problem is biocolonization, all of them could be approached in a uniform and systematic way. Not so the fountains that showed significant differences in their condition and required to be addressed individually. Some of them had to undergo extensive work that included partial dismounting, readjustments of some pieces, structural reinforcement and detailed conservation of the stone surfaces. The following sections present and discuss these interventions in more detail.

Statues and other decorative elements

The prevailing rural environment and the presence of many large trees enhances the development of biocolonisation that in some situations can reach extreme density resulting in complete visual obliteration of the stone surface. The degree of the biocolonisation cover and its developing rate vary from place to place in the garden according with the exposure to sunlight, proximity of the building, or other sheltering effects. Once cleaned, algae can reappear within a year and the foliose lichens may take about four years to develop.

Given the high variability in environmental conditions and the consequent colonization intensities, it became apparent that a highly practical conservation approach had to be designed for the site. In fact, the previously used approach: cleaning - recolonization - cleaning, proved to have a clearly nega-

tive effect in view of the drastic methods employed, such as grit blasting, that over time would lead to severe wearing away of the stone surfaces, more so than through the naturally induced erosion.
Furthermore, these focused interventions lead to situations where nearby standing sculptures were highly contrasting, i.e., treated vs. untreated, resulting in an aesthetically unacceptable presentation of these decorative elements. Apart from aesthetics, objects cleaned at very close intervals will inevitably erode faster, as clearly shown by many of the sculptures cleaned in the past have nearly lost important sculpted details.
The first task in the project was cataloguing all the stone elements, including their conservation history, to complement the existing partial data base. At the same time a detailed biocide testing programme was implemented that aimed to find an appropriate biocide treatment (product, concentration, and application method) [8]. This was required to overcome the previous practice where biocides concentrations could be as high as 5 % and the number of applications could reach 5 times. Not to mention the ubiquitous and nefarious use of sodium hypochlorite. The study was carried out with two biocides, Preventol R80 (a biocide based on a quaternary ammonium salt) and zinc chloride, in concentrations of 1.5, 2, and 3 %, and in 1 to 4 applications (at one week interval). The effectiveness of biocides was monitored by using a portable fluorimeter prototype [9].
The conclusions that resulted from the study and are listed here because of their importance in defining a practical conservation approach:
• A 1.5 % concentration of Preventol R80 is effective in removing moderately dense colonization by a single application;
• The biocide treated areas showed progressive losses of bioactivity during 6 to 9 months after application, thus suggesting that washing surfaces soon after treatment reduces the action of the biocide;
• Densely colonized areas with thick lichen cover require higher concentrations of biocide. A concentration of 3 % Preventol R80 proved to be adequate for these situations;
• Dead lichens fall off spontaneously and progressively, and the treated areas eventually reach a visual appearance well harmonised with the surrounding elements.
The WMF-P project started to develop a realistic conservation methodology that could be easily implemented, taking into account the relative scarce human resources available to the Palace. For this purpose, several practical workshops were carried out where the local personnel and conservation students could implement the chosen approach directly on selected objects. In total, 9 workshops were implemented during the course of the project with some 105 participants attending, some of them taking part in more than one workshop.
The rationale for this approach and the strategy adopted was based on a regular maintenance plan described in detail elsewhere [10, 11]. In brief, the approach is based on the use of low concentrations of Preventol R80 (in the order of 1.5 % v/v) when a maintenance intervention is considered, and of 3 %, for situations of extreme cover density. After brushing on the biocide solution, the object is left for several months without any additional action. In most cases, the dead colonization detaches spontaneously and the result is evident after 2 months (fig. 6). Brushing is not required to remove the dead colonisers, except for some stubborn cases. So far, the sculptures treated under this new approach show that recolonisation does not occur faster in comparison with more aggressive cleaning methods.
Recolonisation will reappear at rates varying from place to place. Some evaluation of this was carried out during the 7-year duration of the project [12]. A certain degree of recolonisation is acceptable for sculptures in gardens,

Fig. 6 a, b. Aspects of a marble sculpture before application of a biocide and spontaneous detachment of lichens two months after application..

since this contributes to a coherent aesthetic presentation of the site, and considering that these sculptures are mainly decorative elements. Therefore it is recommended that low concentrations of biocide should be applied whenever recolonisation departs from the incipient to moderate intensity levels. This criterion reduces the required applications to a minimum.

Marble vases

Marble vases have the specific function of holding plants. Putting the soil directly into them will result in a heavier soiling of the marble and therefore the following suggestions were given:

- The plants should be placed in an independent, plastic, pot that is kept in place in the marble vase by coarse gravel in the bottom and fine gravel above it.
- No soil should be put on top of this fine gravel to prevent weeds from growing in it.
- If a soil appearance is desired, then expanded clay should be used as it is soil-coloured.

The Canal dos Azulejos

The Canal dos Azulejos refers to the section of the creek that runs between two walls that are lined with azulejos, both on the inner side, corresponding to the first installation of typical blue azulejo panels representing diverse monuments from around the world, and later also on the outer walls. On the Palace side of the Canal, historically the walk by the canal had been shaded by mulberry trees, subsequently replaced by sycamores. The far side of the canal was lined by a box-bush hedge, but because of poor maintenance, trees started to grow as well on that side.

It is well known that tree roots threathen the stability of structures, and this occurred in the case of the canal, mostly on the side with the sycamores. But on both side, tree roots penetrated deep into the supporting walls and contributed to mechanically dislodge the azulejos on both sides. Therefore, the trees on both sides were felled in spring of 2009.

Fountains

Fountains vary in size, shape, style and complexity, as well as in the wealth of ornamentation. They range from simple shell-like fountains with a few water jets to large ones with an exposed water surface reaching one hundred square meters and having several overnatural size sculptures spouting water.

Some combine stone basins with sculptured elements in stone and lead as the Nereid fountain at the entrance of the Hanging garden.

Most fountains had inoperative spouts or had various structural problems. The hydraulic network that distributed and collected water from the fountains was

refurbished as part of the project. The water circuits within the fountains were inspected and repaired at the time the cleaning, restoration and conservation of the individual fountains was carried out under the supervision of the conservation-restoration team.

All the basins of the fountains were built with the dense Lioz limestone (porosity ~1 %). In general, the stone is in good condition and the most common problems are soiling, mostly of biological origin; fractures resulting from settling or structural imbalance; and open joints that needing repointing. The most difficult and time consuming task was the reduction of the dark grey color in heavily colonised staining and flood zones of the basin. This is produced by both epilithic and endolithic algae.

Studies carried out showed that the endolithic colonization in the Lioz limestone can be as deep as 0.5- mm [13]. After the application of a biocide, bru-shing was used to remove as much of the surface colonization as possible while also destroying the endolithic colonization. The greyish colour on the stone results from the inactive remains of the dead cells and their melanin. If necessary, a gentle microabrasion was used to attain a homogeneous light grey appearance. Any further attempt to eliminate it would be unjustified from a conservation point of view since in an operating fountain the process will re-start once the basin is again filled with water.

In the particular case of the Neptune fountain, thick roots of nearby trees had caused cracking of in the retaining basin. To address this, a reinforced concrete ring structure had to be constructed around it to strengthen the basin.

Some of the simple fountains are located along the paths of the main park. These walkways, made by compacting soil and gravel, suffered from erosion as the grounds are pitched: the Palace is on higher ground than the lower end of the garden where the limestone cascade is found. Decades of rain erosion and no maintenance produced a clear lowering of the ground level that is affecting the soil foundation of the fountain basins. This problem was not addressed during the restoration of the fountains (fig. 7) and needs to be integrated within the larger context of the walkways in the park. Recommendations on how to address this rather simple but urgent problem were left to the Palace authorities.

Circulating water

The water used in the fountains is supplied from two local wells and its chemical composition shows both a high hardness and high nitrogen content. Its very low phosphor content is a limiting factor for algae proliferation.

The hydraulic project served to install a recirculating circuit that feeds all fountains. The pumped water is collected in the upper tank from where it is distributed to the different fountains. The outcoming water from the fountains flows down to the lower collecting tank from where it is pumped back to the upper tank. There it is mixed with the incoming water (see fig.1).

To prevent algal proliferation, the following recommendations were made:

- Maintain tanks and fountains clean by removing any organic debris;
- Install aquatic plants with large leaves to reduce the light availability;
- Reduce the use of fertilisers and pesticides near the fountains;
- Do not introduce ornamental fishes since these would increase organic matter availability;
- Use barley straw, or its extracts, as a complementary action to limit algae proliferation.

The upper tank needs to be addressed especially because of its large dimensions (over 300 m2) and its role in the overall water distribution. It was suggested that it be covered with an opaque cover to reduce algal proliferation and to avoid the introduction of organic matter from the exterior.

Fig. 7. Small shell-like fountain showing the problem of soil erosion under it (▲), and the Neptune fountain with extensive cracking in the bottom of the basin from roots of nearby trees.

Conclusions

Decorative stone elements in a garden cannot be considered independently of their surroundings.

Statues and fountains are an integral part of the garden and require a similar approach as that taken for the plants. Historically, this was the case. As with the seasons plants were changed, so were many of the statues that were re-located in the gardens. Now, historical gardens can be considered as "frozen" because, as stated in the Charter of Venice [14] it is our responsibility "*to hand them on in the full richness of their authenticity*."

The conservation of the gardens must perforce include regular maintenance for the plants.

Water hardness is responsible for the heavy incrustations found in all of the fountains and the problems of water pressure at the nozzles of the fountains. Therefore, it was recommended that a water softening system be installed at the outlet of the supplying wells before the water enters the upper tank.

These recommendations are to be implemented by the Palace authorities as soon as possible.

Furthermore, it was suggested that a careful monitoring of the fountains conditions be made so as to obtain a better understanding of the development of biological communities under the new established system.

Following this idea, it was decided that the minimum intervention approach was the best. This approach has several advantages, such as:

• Minor biocolonisation serves to give the statues the aged appearance appropriate to a historic garden.

• It avoids the contrasting appearance between cleaned and untreated statues that had previously disrupted the garden equilibrium.

• It requires little work and a minimum of personnel to implement it.

• The cleaning is the consequence of a natural detachment of the organisms after their death.

This approach can be applied to statues

and decorative objects that are within easy reach in the gardens with the aim of achieve a uniform, aged appearance of all stone objects. One of the important points is that biocolonisation does not get eradicated instantly after application of the biocide. While the biocide may act very fast, the detachment of the organisms from the substrate takes months to occur.

This is perfectly acceptable for a garden environment under long term regular maintenance.

It is clear that this approach cannot be extended to the fountains, as they are intrinsically complex objects. Therefore, these need periodic "extraordinary" maintenance, where the fountain is drained, examined, its water circuit checked for problems, and basin and ornaments cleaned. The frequency of this periodic maintenance will depend on the regular maintenance that they undergo; the quality of the water used; and the overall functioning of the hydraulic system.

The seven-year long WMF-P project has served several purposes: firstly, to identify the key problems that caused the main deterioration of the various decorative elements; secondly, to develop a practical maintenance plan than can be systematically applied to all easily accessible stone elements in the garden; and finally, to address all fountains in the garden connected to the hydraulic system so that they are fully functional. Specific recommendations were prepared to facilitate the future maintenance of these various objects, since maintenance on a permanent basis is fundamental, as stressed in the 4th article of the Venice charter. ■

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C*urative Conservation Theme* Conservation Approach Diversity to Address the Decorative Elements in the Gardens of the National Palace of Queluz, Lisbon, Portugal.

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Résumé

Diverses approches de conservation des éléments décoratifs des jardins du Palais national de Queluz, Lisbonne, Portugal.

Le Palais national de Queluz a été construit entre le XVII^e^ et le XVIII^e^ siècle. Le Palais baroque comprend quelques constructions de grande qualité architecturale et est particulièrement connu pour la relation intime existant entre les bâtiments et les jardins contigus qui sont agrémentés d'une centaine de statues, bustes, socles et piédestaux, vases, balustrades, plus d'une vingtaine de fontaines en marbre et une grande cascade en calcaire. Une crique coupe le jardin et coule dans un canal richement décoré de faïences. Les jardins ont subi des transformations importantes au début du XX^e^ siècle. Beaucoup de fontaines ont été déplacées dans les jardins et d'autres ont été enlevées précautionneusement puis replacées. La remise en place précipitée a conduit à de mauvais placements et entraîné une non fonctionnalité de certaines d'entre elles, par exemple, quelques fontaines réinstallées ne sont pas connectées au réseau hydraulique. La maintenance et le soin apportés aux jardins et à leurs éléments décoratifs, ont manqué de coordination et les actions menées ont seulement concerné les problèmes les plus urgents. Les méthodes de conservation appliquées ont été laissées à la discrétion des restaurateurs ou des artisans, conduisant dans certains cas à l'utilisation de méthodes de nettoyage très agressives et dans d'autres à un travail de médiocre qualité. Les sculptures et les éléments de décoration sont répartis dans les jardins et situés pour beaucoup d'entre eux sous des arbres ou buissons denses où la plus forte humidité relative et les plus faibles expositions solaires sont attendues. La plupart des pierres sont dans un état de conservation satisfaisant, en particulier les marbres bien que quelques altérations puissent être notées. Quelques desquamations et fissures peuvent être observés, mais la dégradation majeure correspond à une érosion due aux précipitations et /ou l'activité biologique. Cet article décrit la multiplicité des approches utilisée pour les différents types d'éléments en pierre : ceux facilement atteignables comme les statues sur piédestal et balustrades, et les structures plus complexes comme les fontaines. Ont été mis en place pour les premiers, un système de maintenance régulière basé sur l'application de biocides et pour les seconds, une intervention systématique considérant les problèmes de structures, le système hydraulique et l'actuel traitement des éléments en pierre. Un programme de maintenance global a été élaboré à l'issue du projet de conservation actuel.

Jardins de pierres: conservation de la pierre dans les parcs, jardins et cimetières

Conservation of Stone in Parks, Gardens and Cemeteries

M. Stefanaggi and V. Vergès-Belmin, Eds.

IIC French section, Paris 2011