Xilological analysis: a contribution to the history of the "Gallerie" of Castel Gandolfo (Rome)

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ABSTRACT

The ancient trees in parks, gardens and avenues are the historical evidences of an aesthetic choice of the trends and inspirations of the designers. They also represent a valuable source of information on events that occurred during their existence. Xylological analysis conducted on the trunk sections make it possible to determine the age of the trees, thereby estimation of the plantation period was possible with a sharp precision as well as to identify growth anomalies which could mark specific events, such as climatic, biological or antropic incidents, occurred over time. Even though, the trees could be dead, their stump could be found which is a valuable research tool despite the absence of written records.

The aim of this study is to determine the age and origin of the *Quercus ilex* L. trees by analysing the annual rings identified on the sectioned disks.

Four stumps of *Quercus ilex* L. were obtained from the "Gallerie" (avenues) leading to the Pope's historical residence at Castel Gandolfo and were sectioned from the basal region.

The annual rings from the sections reveal that all the trees are the same age and are placing their first years of life in the mid-nineteenth century. The characteristic features of the annual rings also reveal that the trees are of asexual origin.

In conclusion, this study proves that xylological analysis is an interesting approach for accurate understanding of historical events in the urban systems and for reading evolutionary processes of the green component which undoubtedly have an "environmental" value as well as decorative, historical and artistic ones.

Keywords: Quercus ilex L.; xilology; radial growth; avenue; Castel Gandolfo.

1. INTRODUCTION

The ancient trees in parks, gardens and avenues are the historical evidences of an aesthetic choice of the trends and inspirations of the designers. In addition to the ornamental, historical and artistic value urban trees have an active function improving quality of the urban environment. The urban forest can mitigate the climate of cities [1]. This is a common experience to people who attended forests and urban parks, especially in the summer months and they provide to Carbon dioxide sequestration [2].

They also represent a valuable source of information on events that occurred during their existence.

The "Galleria di sopra" and the "Galleria di sotto" are historical avenues in the town of Castel Gandolfo (Roma, Italy) and they connect Castel Gandolfo to Albano town. These avenues determine a way around the complex of the Villa Barberini, the Pope's historical residence at Castel Gandolfo (Fig. 1).

They are due to the prince Maffeo Barberini, ascended to the papal throne under the name of Urbano VIII in 1623. The Gallerie follow ancient tracks of Roman roads.

These avenues were lined with large holm oaks (*Quercus ilex* L.), and their crowns were joined in a tree canopy for "*ameno passeggio riparato dal sole a mezzo di grossi alberi*" (a pleasant promenade sheltered from the sun by big trees) [3].

Actually the avenues are 2995 m long, and *Quercus ilex* L. is the predominant species.

Quercus ilex L. is the main characteristic species of Mediterranean woodland. It is a mesomediterranean and a oromediterranean tree where termic condition are favourable [4] [5]. It can survive to severe drought but growth is reduced [6] [7]. The vessel distribution in xylem is typical of diffuse porous wood. Rings boundaries are detectable, even if sometimes with difficulty: dating difficulties have limited the number of dendrochronological investigations [8] [9].

In the avenues area, criticalities have been detected due to phytosanitary problems and to

irregular and heterogeneous distribution of trees size classes, caused by cuttings for the safety.

The Provincial Administration of Rome is the owner of these areas and it has promoted a study about these historical avenues which are of great interest from landscape and historical significance.

So the Administration financed a management plan to establish maintenance and care of the trees, to ensure their preservation, and safety of avenues users and inhabitants. The preliminary study was complex and involved many techniques and scientific skills [10].

The aim of this study is to determine the age and origin of the *Quercus ilex* L. trees by analysing the annual rings identified on the sectioned disks. This report contains the contribution of xilological analysis to better understanding the history of the avenues.

2. MATERIALS AND METHODS

Four stumps of *Quercus ilex* L. were obtained from the "*Gallerie*" (avenues) and were sectioned from the basal region. The trees were felled for safety or phytosanitary purposes at different time.

Xilological analysis are designed to estimate the age and growth abnormalities that may be witnesses to particular climate or biological events occurring over time. The disks surface was cut and polished with cutter aid.

Observations were conducted at a monocular that allows a magnification of 8 times. The growth rings were identified along radial directions from the bark to the pit. Sometime the rings were not always easily identifiable, so the ring boundaries were marked so that subsequent widths measurements were not overly costly in terms of time.

Measurements of growth rings widths were performed using a stereomicroscope with a magnification of 6, 16 and 40 times. Most appropriate magnification was chosen. Each single tree curve was visually compared and synchronization attempts were been tested with statistical methods.

3. RESULTS AND DISCUSSION

Basal disks are not always regular (Fig. 2). The presence of basal buttresses determines a taper which induces to differences of ring thickness and anatomical anomalies. Furthermore, the tree basal zone was affected by injuries because urban environment. The consequences are removal of xylem, scar tissue, biodeterioration, and sometimes insect tunnels even large (Fig. 3).

Basal disks are optimal, therefore, to estimate the age of the trees, but have many drawbacks for the rings analysis. For ecological, biological reasons and even for operational simplicity sections or cores at breast height are preferred [11]. According to recent studies it seems possible to use samples taken at stump height for dendroclimatic studies in order to obtain ring chronological sequence of maximum length [12].

Disks characteristics are shown in the table I.

Age determination is usually carried out by counting the annual rings formed on a cross section of the trunk, near the collar. This area is not always readily identifiable or samplable, so the growth rings were detected on the sections taken near ground. This age is a cambial age. The age is estimated as the age reached from the inner ring at considered height.

To estimate the tree age, a number of years must be added as a correction factor. The years number is proportional to the section height, to the growth rate of the species, to the particular conditions of the tree.

Since the determination is made on basal disks, the age of the tree does not differ much from the rings number found.

The trees are dated between 135 and 153 years old (Tab.I). There is a difference between the older and younger of 18 years. These trees are almost contemporary. In fact, sampling may have been unequal height from collar. So they place their first years of life in the mid-nineteenth century.

In a natural holm oak coppice in Corsica similar age was found for natural mortality of old trees [13].

The question concerning the stand origin has been analysed with different approaches (historical, lanscaped, artistic, urban planning, xilocronological, environmental and socioeconomic approach) because the "historical" places can not be separated from the "environmental" place [14]. These avenues have undergone changes of use from path for a "pleasant walks" sheltered by

large trees to a road subject to increasing traffic flows. The need for roadway enlargement and modifications induced by urban growth have greatly changed over time the dimensional and topographic trees distribution, the aesthetic features of the remaining holm oaks and the species composition of some avenue part (in Galleria di sopra, *Ligustrum* sp. trees have replaced the holm oaks, too large for the size of the road).

Therefore, the trees distribution shows that a predetermined alignment is no longer present, as described in documents and graphic representations of the Barberini archive preserved in the Vatican Library. Xilological analysis was conducted to interpret the green component origin of Gallerie.

Rings widths were measured under a steromicroscope on the disks. The curves describe the ring width on the basal disks (Fig. 4).

Generally rings widths are large and they show that the environment is favorable to the *Q. ilex* L. growing even in older age (Tab. II).

The ring chronologies show a strongly individualized trend. So the synchronization statistic parameter reliability is poor. For this reason, a mean curve representative of the general behavior in this context was not built up.

It must be stressed that the interventions on the tree crowns (topping, pruning, etc.) have influence on the growth rings, with possible width reduction in relation to the photosynthetic canopy eliminated amount. Indeed, the maintenance activities over time have focused on removing branches or large trees. Unfortunately, operations were performed in a state of emergency to allow the use of the area in safety for people and property. During the roadway enlargement for the passage of buses and trucks, pruning specific interventions were implemented for the raising of the crown and the removal of dead branches.

Therefore, trees management was characterized by different operating modes for intensity and location. The variability among trees was observed in all stage of growth. Thus, trees rings growth, which is characterized by great individuality, likely can be related to these anthropogenic interventions, because they do not synchronize the growth such as climate can do.

In addition, table III and figure 5 show that the rings around the pit are large.

It can therefore reasonably assume that trees are originated from shoots that have emerged over time, because natural selection or cultivation purposes.

Broadleaves can reproduce vegetatively. This capability is used in the hardwood forests that take the name of coppice. This kind of forest regeneration allows an early production of shoot and so a fast land cover. The new shoots are taking advantage of a large root system that support fastly growth. So every stump can power many shoots. Over time, the competition makes a natural selection on the stump and the number of shoots decreases. This selection is carried out by forest managers to maintain a reasonable number of shoots in relation to the stump size. In some cases, for example, when conversions are made from coppice to high forests, only one shoot is left. By the time it takes on the shape of high forest trees. The growth rates of a tree born of seed can be differentiate from a coppice shoot. The tree rings width is small in stem originating from seed, and they remain small particularly when growth up under forest cover.

Also Galleries inspection has provided additional elements: there are very large stumps indeed. Individuals morphologically similar to those studied are noted on stumps. Selection has consolidated a single young shoot. Moreover, the stumps have produced vigorous shoots, after phytosanitary cutting.

4. CONCLUSIONS

In conclusion, this study proves that xylological analysis is an interesting approach for accurate understanding of historical events in the urban systems and for reading evolutionary processes of the green component which undoubtedly have an "environmental" value as well as decorative, historical and artistic ones.

The annual rings from the analysed sections reveal that all the trees are the same age and are placing their first years of life in the mid-nineteenth century.

The characteristic features of the annual rings also reveal that the trees are of asexual origin. So they are shoots that have emerged over time, because natural selection or cultivation purposes.

The survey makes necessary to emphasize another aspect of the results. To understand the dynamics of this urban ecosystem, extensive surveys over time are needed.

Claiming that the evidence determined today can be considered definitive is an illusion in a period of change, including climate. Like the restoration of works of art, the management of Gallerie must be monitored for effectiveness and responsiveness over time.

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Fig 1. The historical avenues (Galleria di sopra and Galleria di sotto) around Villa Barberini.

Fig 2. a) Disk n. 1 from tree "Cet 4" in Galleria di Sopra; b) Disk n. 2 from tree "Cet 3" in Galleria di Sopra; c) Disk n. 3 from tree "Cet 1" in Galleria di Sotto; d) Disk n. 4 from tree "Cet 2" in Galleria di Sotto.

Fig. 3. The basal zone was affected by injuries because urban environment. a) Sapwood affected by rot fungi; b) Scar tissue and xylem biodeterioration; c) Ring and radial shake d) Insects large tunnels.

Fig. 4. The curves describe the radial growth (1/100 mm) year by year on the basal disks.

Fig.5. Widths (1/100 mm) of the first 30 growth rings of each sections (from pit), divided into blocks of 10 rings. The rings around the pit are large.

Table I. Disk dimensional characteristics. The ring number is the estimated age of the trees.

Table II. Growth rings characteristics of the sequences from pit to bark.

Table III. Growth rings characteristics of the first 30 growth rings of the section (from pit), divided into10 rings blocks.