Dendrochronologia 74 (2022) 125960

Contents lists available at ScienceDirect

Dendrochronologia

journal homepage: www.elsevier.com/locate/dendro

Dendrochronological analysis of the Stradivari's harp

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ARTICLE INFO

Keywords:
Dendrochronology
Stradivari
Amati
Violin-maker
Musical instruments
Resonant wood

ABSTRACT

Stradivari's apprenticeship is still not completely understood today. Tradition has it that he was a pupil of Nicola Amati, the great violin maker who preceded him in musical instruments production in the city of Cremona. However, no documents proving Stradivari's presence in Nicola Amati's workshop can be found. In this paper, we present a dendrochronological analysis of Stradivari's harp, the only surviving portable diatonic harp, now in the possession of the Museum of the Conservatorio San Pietro a Majella, Naples. The harp bears the inscription "*Ant:° Stradivarivs Cremonen.^{s} F. 1681*" engraved on the column. Dendrochronological analysis of the soundboard revealed high correlation values ($T_{BP} > 16$) between the tree ring sequence of the harp and that from a Nicola Amati cello made in 1679, suggesting that the wood of the two soundboards comes from the same tree trunk. The dendrochronological analysis of the harp offers new evidence of Stradivari's possible apprenticeship and has stimulated reflection on the wood trade for making musical instruments during the golden age of Italian classical violin making (16th–18th centuries).

1. Introduction

Antonio Stradivari (ca. 1644–1737) has been commonly thought to have been a pupil of Nicola Amati (1596–1684), but until now, no reliable documentary evidence to support this belief can be found (Hill et al., 1909). At the beginning of the 16th century, Andrea Amati's family was well established as violin makers. Nicola Amati belonged to the third generation of the family and his workshop in Cremona was very important, attracting pupils from other regions of Italy and beyond. Written documents are available that list Amati's pupils, but the name Stradivari is not among them (Farga, 1942). It has been suggested that this absence could be explained by the fact that Stradivari was a fellow Cremonese or from the surrounding villages, and therefore, did not need to stay at Amati's house while studying in his workshop (Hill et al., 1909). Currently, the only evidence of a possible link between the two violinmakers can be found in one of Stradivari's early instruments, the 'Serdet' violin, whose label bears the inscription, "*Antonius Stradivarius Cremonensis Alumnus Nicolaij Amati, Faciebat Anno 1666*" (Beare et al., 2013).

For a long time, however, the relevance and authenticity of that label have been questioned (Beare, 1987), and it has been thought that the inscription might have been inserted only to accredit the quality of a violin made by a young maker who was still almost unknown. While it was customary for apprentices to recognise their masters by naming them on the labels of their first instruments, Stradivari did not have this habit. The "Serdet" violin was the only instrument that followed this practice and already from 1667, in the early years of his activity, Stradivari adopted the standard label "*Antonius Stradivarius Cremonensis Faciebat Anno xxxx*" with very rare exceptions as in the case of the harp (Beare et al., 2013).

This work aimed to analyse the soundboard of the Stradivari harp through dendrochronology, to characterise the constructive features of the harp's soundboard, and to verify any possible cross-matching with other musical instruments. Furthermore, some aspects of the wood trade for musical instruments in the classic period of Cremonese violin making (16th–18th century) will be addressed and discussed.

2. Material and methods

2.1. The harp

The portable diatonic harp (Fig. 1), housed in the Museum of the Conservatorio San Pietro a Majella, Naples, is attributed to Stradivari (Gregori, 2018) and bears the inscription "*Ant:° Stradivarius Cremonen.^{s} F. 1681*" on the column (Sisto, 2010). This small harp is a "*unicum*" among the approximately 550 surviving instruments of the Cremonese

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https://doi.org/10.1016/j.dendro.2022.125960
Received 10 February 2022; Received in revised form 5 April 2022; Accepted 4 May 2022
Available online 6 May 2022

Fig. 1. The Stradivari harp. Top right, the connection of the strings to the soundboard. Centre right, the mask (partially visible) carved at the base of the column where the vertical white line indicates the junction of a small fragment of wood, with only eight tree rings growing in the opposite direction. Below, the inscription on the column bearing Stradivari's name.

craftsman and is now the symbol of the Conservatory (with repertory number 5.34). The entire structure is made of maple (*Acer* sp.) except for the soundboard, which is made of spruce (*Picea abies* Karst.) with four resonance holes in the shape of small hearts (Fig. 2). The harp dimensions are 45 cm for the neck, 75 cm is the soundbox length, and 93 cm for the column. The 27 strings extend over the entire length of the instrument from the neck to the centre of the soundboard. On the upper part of the joint between the soundbox and the neck, a mermaid carrying a putto has been carved while on the other side of the neck a mermaid (without her head) resides, and on the lower part of the column, a mask was sculpted (Fig. 1). According to some writers (Sisto, 2010), the artistic decoration is attributed to Giacomo Bertesi (1643–1710), the most talented sculptor of Cremona and a contemporary of Stradivari. Previous owners of the harp (Beare, 1993) include Marquis Carlo del Negro of Genoa, the noble family of Spinola (also from Genoa), and the ballerina Amina Boschetti. In 1881, it was donated to the Conservatory by Francesco Florimo, composer and friend of Vincenzo Bellini, librarian of the Conservatory of San Pietro a Majella (the Real Collegio di Musica).

2.2. Dendrochronological analysis

The dendrochronological analysis considered the soundboard of the harp (Bernabei and Čufar, 2018), which is the only part of the instrument made of spruce. The presence of the strings in the centre of the soundboard (Fig. 2) caused the tree ring measurement to be more challenging than usual as the movements of the measuring devices (see below) were hampered by the strings. The difficulties caused by the strings were such that it is not clear whether the soundboard was made in one or more pieces even after careful observation. The reduced width of the harp, which at its widest part reaches a length of about 14 cm, and the tensile forces in the centre of the soundboard caused by the strings suggested that the soundboard consists of a single piece of wood. On the contrary, the same decreasing trend in the widths of tree rings on both sides of the soundboard, which are visible to the naked eye, suggests that two sides were joined in the centre, both with the direction of the tree rings growth facing to the right (Fig. 2).

Considering the above-mentioned difficulties, the sampling of tree ring width was focused separately on the right side, the central portion, and the left side of the soundboard. Tree ring measurements were carried out by using the Video Time Table (VTT), an instrument that combines a portable measuring device and a digital, high-resolution video camera. The VTT allowed non-invasive measurements of the tree rings to be made in situ and to immediately verify the quality of the sampling (Bernabei et al., 2010). The growth rings of the central portion were sampled using a high-resolution camera, which made it possible to bypass the barrier formed by the neck and strings. The consequent parallax and focus problems were overcome by taking many photographs from different angles.

The measurements on the photographs were made with the CooRecorder program (Maxwell and Larsson, 2021; Cybis, Sweden). The dendrochronological data were acquired with the PAST4 program (Knibbe, 2008) and graphically processed and analysed with the PAST4 and 5 programs (SCIEM, Austria). The degrees of similarity, i.e. the correlation, among tree ring curves were assessed using t-tests (T_{BP} – Baillie and Pilcher, 1973; T_{HO} – Hollstein, 1980), the Gleichläufigkeit

Fig. 2. Left, right and central portion of the harp soundboard (detail). One of the four heart-shaped resonance holes is visible on the right.

(Eckstein and Bauch, 1969), and a visual comparison of the TRW series. Considering the variability of t-values in relation to the software employed (Sander and Levanic, 1996), it was decided to adopt the values calculated by the PAST4 programme in this study.

3. Results

The sampling procedure allowed the construction of three tree ring series corresponding to the left side, the central portion, and the right side (LX, CX, and RX, respectively) of the soundboard. Observations made with the high-resolution VTT camera confirmed that the direction of tree ring growth is towards the right, except for a small fragment (wing) of wood, with eight tree rings in the opposite direction that were found in the lower right side and probably added by Stradivari to obtain sufficient width for the soundboard (Fig. 1).

The comparison of the three growth-ring sequences among them and with numerous reference chronologies valid for European spruce (Bernabei and Bontadi, 2011), did not lead to any significant results. They were then matched with an extensive dendrochronological database of stringed instruments (Topham, 2003). As a result, a strong correlation between the RX series of the harp and the bass side of the soundboard of a cello made by Nicola Amati in 1679 was found (T_{BP} 10.9, T_{HO} 13.00, Glk 84.00***).

Further comparison with the other harp series (LX and CX) provided statistical tests for the resulting mean series of 157 tree rings, raised to T_{BP} 16.20 and T_{HO} 15.10, Glk 78.00*** with an overlap of 133 rings (Fig. 3). Dendrochronological analysis dated the last tree ring of the harp soundboard to 1624 CE as *terminus post quem*.

4. Discussion

4.1. Dendrochronological dating

Formerly, the harp had already been analysed from a dendrochronological point of view by Corona (1987) who divided the measurements on the soundboard into two parts as he assumed that the board was built in two portions as in violins. As mentioned above, determining the number of parts on the soundboard of this instrument is very difficult and even we would not have succeeded without the use of digital equipment that did not yet exist at the time of Corona's work.

In light of our results, it can now be stated that the harp was built using a single board, apart from the small wing of only eight rings on the lower right side that was probably cut away from the upper part of the board during processing to achieve the intended shape of the soundboard (Fig. 1). This finding is consistent with the structural stresses caused by the strings in the middle section of the board in which a joint could have caused discontinuity and/or fragility over time, leading to eventual soundboard breakage.

A statistical comparison between the harp and the bass series of the Amati cello shows a T_{BP} value equal to 16.20 and a T_{HO} equal to 15.10. Formerly, the threshold of $T_{BP} > 10$ was chosen to identify wood from the same tree trunk in oak species (Hillam, 1998; Hillam and Groves, 1996) with varying applications, including those in field of musical instruments (Topham and McCormick, 1998). Although this arbitrary value cannot be accepted uncritically, it is consistent with the value proposed in several other studies on dendrochronological dating of musical instruments (Topham and McCormick, 2000; Bernabei et al., 2010; Beuting, 2011; Lauw et al., 2021).

In our case, T_{BP} values of 16.20 in addition to the visual comparison (Fig. 3) remove any doubt that the soundboard of the Stradivari harp and the Nicola Amati cello were made using wood from the same tree trunk. Other cases of significant cross-matching between the soundboards of instruments made by the two violin makers can be found although the correlations are not as strong as the one in our study. For instance, the Stradivari violin named "Spanish", which is dated 1687, shows high correlation values with an Amati violin dated 1664 (Student's t 12.9, ring overlap 150; Topham, unpublished data). To understand how wood from the same trunk could have been used by different luthiers, a better understanding of how the trade of wood for musical instruments might have been organised in the past is needed.

4.2. Timber trade for musical instruments

The wood used for musical instruments must meet specific requirements. The predominant species for soundboard construction is spruce (Cherubini, 2021; Cherubini et al., 2022). Wood must have regular and narrow rings, no deviation of the grain, and an attractive appearance. The natural distribution of European spruce covers the forests of central and Northern Europe, from the Alps to the Carpathians via the Balkans, and does not extend westwards beyond the Alps. In the past as today, wood for musical instruments was often sourced from sites renowned for production of "resonance" spruce. The most popular sites for such spruce are those spanning from Trentino to Cadore (Friuli Venezia Giulia), Carnia and as far as Slovenia. Other important areas are the forests of Bavaria, Tyrol, Switzerland, some areas of Eastern Europe, and as far as Poland, Romania, and Southern Russia (Corona, 1998).

Such a limited natural distribution of "resonant" spruce contrasts with its widespread use by violin makers throughout Europe and beyond, and examples of the use of spruce in regions far from its natural range are numerous. Portuguese and Spanish luthiers used wood from the Alps for their instruments (Lauw et al., 2021; Topham, 2002; Ratcliff, 2014) as did Neapolitan luthiers (Bernabei and Bontadi, 2021). Evidently, resonant spruce had to be imported to regions where it did not grow naturally, probably through a specific trade.

The existence of a specific field of trade devoted to wood for musical instruments can also be traced in the analysis of documentary sources. From ancient accounting books, notarial acts and purchase or sales notes, we know that in the 17th century Italy, widespread distribution network for musical instrument materials, including wood, ivory, and mother-of-pearl, existed (Polato, 1985; Sisto, 2010). Families of luthiers, such as Welz, Haym, Nier, or Enzensperger, who immigrated to Italy from Füssen, Germany, specialised in this kind of trade (Sisto, 2016;

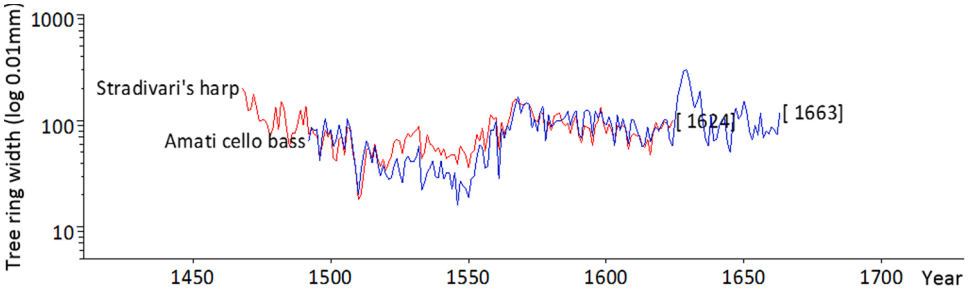

Fig. 3. Visual comparison between the tree ring series of the Stradivari harp and the cello of Nicola Amati (T_{BP} 16.20, T_{HO} 15.10, Glk 78.00***). The harp was made in 1681 and the cello in 1679. The slight upward shift of the harp curve in the period 1520–1560 is only due to photographic sampling (see Section 2.2).

Sisto, 2010). In this supply chain, it is likely that the violinmakers themselves, especially the well-established ones, such as Nicola Amati, would have been able to supply suitable timber to their colleagues, at least in their own city and surrounding areas. To underline the commercial nature of the violin makers, it should be mentioned that in Venice in which production activities were organised in guilds, the violin makers belonged to the guild of "marzeri", a category of sellers of the most varied goods that was socially very close to the merchant class (Polato, 1985). Thus, it cannot be excluded that not only musical instruments but also the materials for their construction were among the goods on sale (Polato, 1985). Therefore, it is likely that the two famous luthiers bought spruce wood from the same supplier who sold them wood from the same log, but it is equally possible that they shared wood as a result of a commercial relationship or through an apprenticeship.

4.3. *Stradivari's apprenticeship*

At the end of this study, it can be said that the mystery of Stradivari's apprenticeship still remains unsolved. However, some simple deductions can be made. No violin maker can start without a master, and Stradivari must have had one at least at the beginning of his career. Although no documentary proof exists, it can be speculated that if he was born in Cremona or nearby, who better than Nicola Amati, who was the most famous and talented violin maker of the time, lived in the same city, and already had a flourishing activity there, could have been his master? This thinking has been handed down by tradition as it was written by Stradivari in the "Serdet" violin and is now suggested by the dendrochronological analysis of the harp.

5. Conclusions

The Stradivari harp was analysed using dendrochronology. The examination revealed that the soundboard was made from a single piece of spruce and dated to 1624, *terminus post quem*, which confirms Stradivari as the possible author. The wood came from the same tree trunk from which the bass side of the soundboard of a cello attributed to Nicola Amati was also constructed. This result has given rise to some reflections on the timber trade for musical instruments in the past, which was most likely entrusted to specialist traders, and has added new evidence on Stradivari's possible apprenticeship with Nicola Amati.

Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgements

We gratefully acknowledge John Topham for providing the dendrochronological data of the Amati cello. We also thank John Topham, Derek McCormick, Bruce Carlson and Renato Meucci for their helpful comments and suggestions during the research and the writing of the manuscript.

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