Dendrochronological dating of the Cherubini stringed instruments collection, Florence

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In 2009, the general catalogue of the Conservatory Cherubini Collection was produced. 49 stringed instruments of the collection, the most important nucleus of the Florentine and Tuscan violin-makers' school, were submitted to a dendrochronological investigation to obtain information regarding the instruments' construction dates and attribution. Sampling was carried out using a portable tree-ring measuring device, equipped with a high resolution digital camera. 37 stringed instruments were dated. The correlation values of the statistical cross-dating tests were generally very high. Apart from dating the instruments, the dendrochronological analyses permitted to determine which instruments had been made from wood of the same provenance and, in some cases, from the same tree trunk. The mean chronology built on the musical instrument series is 558 years long and dates from 1396 to 1953 AD. The master chronology is well replicated along its entire length and cross-dates well with all the other alpine Norway spruce chronologies and with the master curves of numerous other species.

Introduction

In 2008, the general catalogue of the stringed instruments of the Musical Instruments Department of the Accademia Gallery, Conservatory Cherubini collection, was produced.
The 49 stringed instruments of the collection were submitted to a series of scientific investigations in order to improve objectivity and standard of comparison in their description and to obtain information about dating and attribution.
In particular, the purposes of the dendrochronological study are:

- to date the stringed instruments by determining their *terminus post quem* date;
- to provide possible indications regarding the construction characteristics of the instruments.

The instruments

The Collection of musical instruments from the Conservatory « Luigi Cherubini » that, since 2001, has been conserved and exhibited at the Department of Musical Instruments of the Accademia Gallery of Florence, comprises about five hundred instruments, sixty of which belong to the violin family: violins, viole, controviolini. (bass-violins), celli and double basses.
The original nucleus of the Collection, which is not included in this study but will be the subject of future research work, consists of instruments from the private collections of the Grand Dukes of Tuscany, Medici and Lorena, including, in particular, some specimen still in existence that belonged to Prince Ferdinando de Medici (1663-1713), son of Cosimo III and contemporary of Antonio Stradivari. The Collection holds three instruments made by Stradivari, including the only one in the world to have survived completely intact in all its parts (Antonio Stradivari, tenor viola « Medicea », Cremona 1690; see Falletti et al., 2001).

To this first group, consisting of eleven instruments, another forty-nine were added (see Table 1 p. 9) between 1863 and 2001, either by donation or acquisition: twenty-four violins, fourteen viole, three celli, two double basses and six controviolini (instruments built at the beginning of the twentieth century by the violin-maker Valentino De Zorzi and playing an octave below the violin, which places them between viola and cello, both by tuning and size).
Although German and French violin-makers are also represented, the Collection mainly consists of Italian instruments made between the second half of the eighteenth and the first half of the twentieth centuries.
The nucleus attributed to Florentine and Tuscan violin-makers, of which this Collection includes the largest group presently known, stands out in particular (Rossi Rognoni, 2004). These constitute a special school that is still little known, with its own characteristic choice of materials (linings and purflings made of beech wood, whereby the black part of the purflings was sometimes made from tinted whalebone) and style (very high arching that recalls the German school; short and vertically-positioned f-holes that are rather distant one from another). The concentration of a representative number of instruments from this school in a single collection facilitates a series of wide-ranging investigations, aiming to determine both common and individual characteristics of these instruments (Rossi Rognoni, 2009). The Collection includes, in fact, at least one instrument each of all the principal violin-makers belonging to the golden era of the Tuscan school. Three violins are attributed to its most prominent representative, Giovanni Battista Gabbrielli (1716-1771), whose instruments had already attained international fame in Europe during the life of their maker. Of these, only one is signed and labelled (1988/008), whilst another, although it does not bear a label, exhibits its maker's brand (1988/009). While, for the third instrument (1988/237), its dendrochronological analysis can yield useful information regarding its likely attribution.
One viola bears a label of Bartolomeo Bimbi (1988/022), a violin-maker who worked in Siena and Florence during the second half of the eighteenth century, and whose importance amongst the Florentine violin-makers is confirmed not only by contemporary critics of his work, but also by the commission he received from the Court of the Grand Duke as controller of all the custom duties for musical instruments in the region of Tuscany (Rossi Rognoni, 2002).
Two instruments (1988/007 and 1988/026), a violin and a viola, both signed, are attributed to the workshop of Lorenzo and Tommaso Carcassi, both of whom had connections with the Lorenese Court, where they carried out restoration and maintenance work on almost all the stringed instruments of the Collection (Montanari, 1997).

The sampling device

The great part of the measurements was carried out by using the Video Time Table (VIAS, 2005), an instrument that combines a portable measuring device and a digital, high-resolution video camera (Fig. 1).
The device has the following advantages:

- the tree rings can be measured on site;
- the measurements are not invasive;
- the correctness of the measurements can be checked immediately.

The measuring device consists of four fundamental parts: a tripod, the optics, a three-axes movement device and an external unit for the movements control. The whole system is connected to a portable computer that elaborates the data. The

optics consist of a digital video camera with a focal distance of 20 cm, which avoids any direct contact with the wooden object (Fig. 1). The three-axes movement device allows movements with a precision of 1/8000 mm. The tree-ring series obtained can be visualized and elaborated with the PAST4 software of SCIEM (Scientific Engineering and Manufacture). The VTT's video control enables its user to save the most important images, a service that has proved to be very useful in those cases where doubts arose regarding the interpretation of a sequence.

Fig. 1 - The dendrochronological measuring device used in the study.
In some cases, dendrochronological analysis was possible through the instrument case.

The sampling procedure

Basically, four tree-ring series were obtained from the belly of each musical instrument: two each from the bass and treble sides, which were repeated at various parts of the belly in order to maximize the number of growth rings available and, at the same time, to avoid errors caused by possible distortions in the veining. The possibility of immediate comparisons between the dendrochronological series measured allowed the repetition of a measurement whenever anomalies were detected in the tendency of a ring curve.

The above-described sampling procedure was adapted to the characteristics of each instrument. In particular, the number of elements that make up the belly of each instrument was taken into consideration: one, two or more pieces. Consequently, the number of measurements was increased or reduced, accordingly.

The tree-ring measurements undertaken by the VTT were always accompanied by photographs of the wooden surface. These digital photographs permitted a constant comparison, on the monitor, between the wooden surface analysed and the dendrochronological series recorded.

Tree-species identification was carried out on the belly of the instruments, in a non-invasive manner, by Marco Fioravanti and Giovanni Signorini of the University of Florence, Italy.

Statistical tests

Statistical tests are usually of great help in dendrochronological dating. However, if used without the necessary discretion, they have serious deficits. In particular, they may give rise to the following errors (Sander and Levanic, 1996):

- wrong dates believed to be correct because they are associated with high, casual correlation values (type I errors);
- correct dates not accepted because they are associated with occasional low correlation values (type II errors).

In order to avoid this kind of problem, each tree-ring sequence was confronted visually and statistically with more than one reference chronology. Dates were considered reliable only after they had been confirmed by more than one reference chronology.

The statistical cross-dating tests used in this study are:

- t-values: adapted to time-series by Baillie and Pilcher (1973).
- Gleichläufigkeit (Glk): a measure of the year-to-year agreement of the ring-growth tendencies of two chronologies, expressed as a percentage of cases of agreement from one year to the next (Kaennel and Schweingruber, 1995).
- Statistical significance of Glk: can be at 95.0%, 99.0% or at 99.9% and has been indicated here as *, ** and ***, respectively.

Sequences that cross-matched with t-values >4, and with corresponding high values of Gleichläufigkeit and high statistical significance values in more than one reference chronology, were considered to be statistically reliable.

CATRAS and PAST4 computer programmes were used for visualizing the series and for carrying out statistical synchronization tests. Considering the variability of t-values in relation to the software employed (Sander and Levanic, 1996), and in order to keep the following tables uniform, it was decided to adopt the values calculated by the PAST4 programme in this study.

Results

A total of forty-nine instruments was dendrochronologically analysed, 192 chronologies were built and more than ten thousand year rings were measured. Where more than one measurement had been obtained from the same instrument belly, a comparison of the sequences always showed high correlation values (mean t-value >11). For this reason, a representative mean chronology was built for each instrument whose belly consisted of more than one piece (See Table 2 p.10). In the case of four instruments, no tree-ring measurement was possible, whereas in five cases only one belly piece was measurable, although the instrument's belly contained more than one piece. Here, the rings were not clearly visible because the varnish was not transparent enough, in addition to being obscured by the patina of many years.

Thirty-seven instruments (75%) were successfully dated (Fig. 2). The remaining eight (twelve minus the four unmeasured ones) were considered undatable because of an insufficient number of identifiable rings (<50), or because the statistical correlation values were not high enough (t-values <4). Generally, however, the correlation values of cross-dating individual instrument curves against the reference chronologies were high (mean t-value: 6.08 and Glk 69.27, with a statistical significance of 95% or higher; in twenty-eight cases as high as 99.9%). There were particularly high correlations with the Alpine chronologies of Siebenlist-Kerner (1984) and Hüsken and Schirmer (1993).

For each dated sample, a value Δt was calculated, which is defined as the difference between each instrument's label date and its *terminus post quem* date (See Table 3 p. 11).
The mean chronology built from the tree-ring series of the individual instruments, which was called Accademia Master Chronology (AMC01), consists of 558 year rings (Fig. 3) dating from 1396 to 1953, and it correlates very well with other Alpine Norway spruce reference chronologies. Furthermore, there is very good cross-matching with central European spruce reference chronologies (high t-values, usually above 5), but also with master chronologies from different species, such as silver fir (Abies alba Mill.) and larch (Larix decidua Mill.) See Table 4 p. 11.
Some instrument tree-ring series cross-match very well amongst themselves. In particular, the wood used by Gabbrielli, Bimbi, Carcassi and Guadagnini shows the highest correlation values, with mean t-values of 8.25.

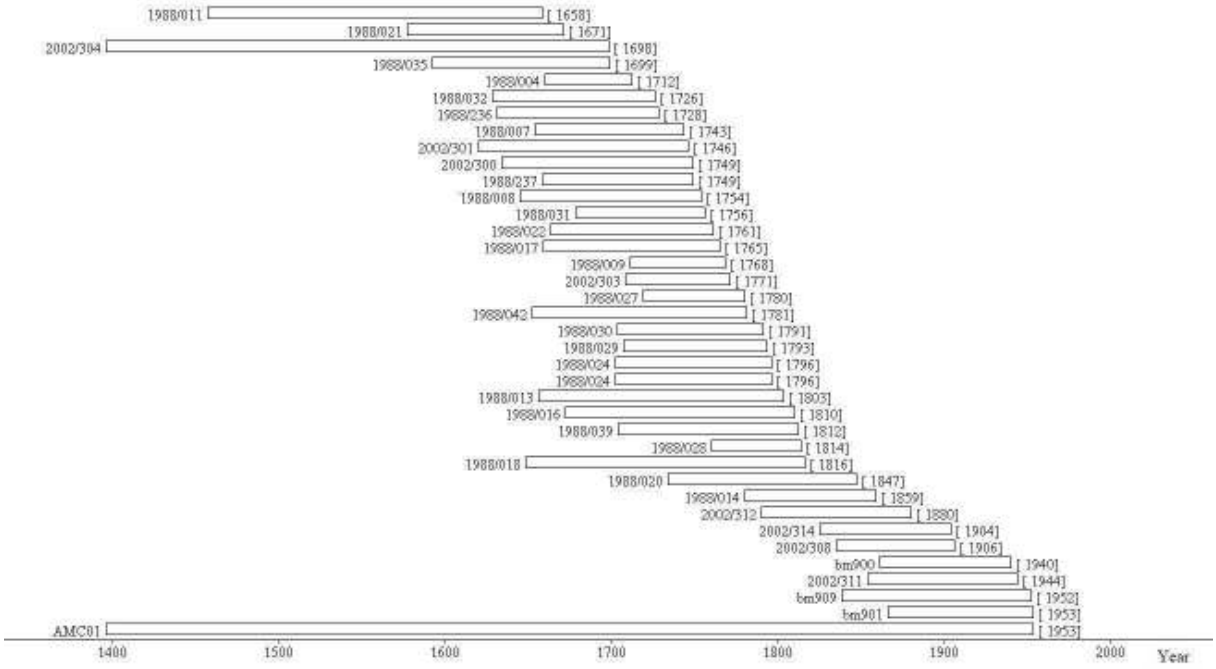

Fig. 2: Dendrochronological dates of the stringed instruments from the Cherubini Collection

Discussion

75% of the instruments were successfully dated, thereby determining the *terminus post quem* date of manufacture. Compared with similar research work of the past (Klein et al., 1986; Topham and McCormick, 1998; 2000), our percentage of success is somewhat higher. The reason for this probably lies in the homogeneity of the analysed wood, which mainly derives from central and northern Italy, thereby giving rise to high statistical values of synchronization between individual instrument ring-curves and the master chronologies. In this context, the works of Gabbrielli, Bimbi, Carcassi and Guadagnini must be mentioned, which are all very similar from a dendrochronological point of view, indicating the same provenance of the wood used for their manufacture. In particular, the wood used to make an instrument of uncertain attribution, inv. no. 1988/237, bears a strong affinity to the one signed by Giovanni

Battista Gabbrielli. This, together with similarities of style, removes all doubts regarding the making of this instrument by this famous violin-maker.
Finally, a t-value of 16.40 between the controviolini 1988/029 and 1988/030, both attributed to the violin-maker Valentino De Zorzi, as well as the significant visual comparison (Fig. 3), demonstrate the use of wood deriving from the same tree for the manufacture of two different instruments.

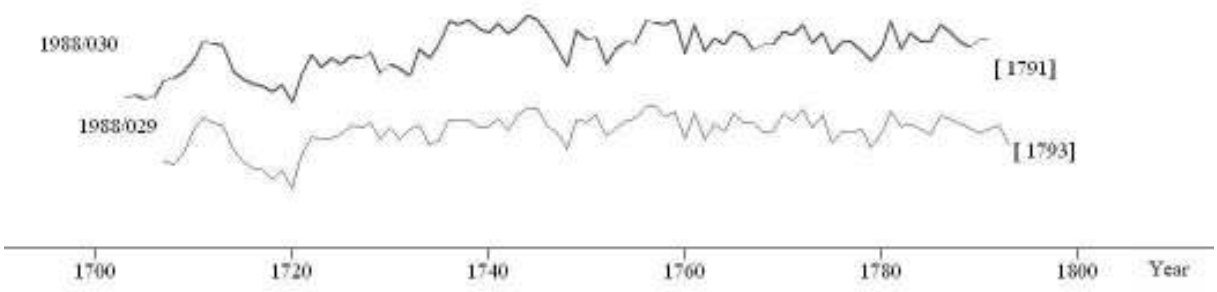

Fig. 3: Two tree-ring curves from controviolini 1988/029 and 1988/030, made by Valentino De Zorzi, stacked one above the other for visual comparison.

Generally, high statistical correlations between the AMC01 (See Table 4 p.11) and the Siebenlist-Kerner (1984) chronology in particular, indicate that a large part of the timber originates from the Eastern Alps. Apart from the statistical evidence, this is confirmed by the opinion of various authors (Henley, 1973; Harvey, 1995; Corona, 1998), who state that that particular region traditionally was one of the most important timber supply centres in Europe. Furthermore, the use of Norway spruce of Alpine provenance is documented amongst violin-makers of Nuremberg in Bavaria, another centre that is well-known for the production of resonance spruce wood (Klein et al., 1986), and even amongst British violin-makers (Topham and McCormick, 1998). Hence, when the timber is analysed from a geographical point of view, an Alpine provenance for the instruments of the Cherubini Conservatory would appear to be most likely. An even more precise geographical location has been proposed by Corona (1981) who, on the basis of dendrochronological considerations and evaluations, demonstrated that the wood of the Bimbi viola, which is also subject of this study, originates from the Val di Fiemme in the Trentino region, Italy. And Bimbi was one of those violin-makers who used wood with very similar ring patterns.
Some instruments have high correlation values also with other, more central European, reference chronologies, for example from Germany (Falkenstein, Bavaria) or Switzerland (Obersaxen). This is true particularly for more recently built instruments, from the nineteenth and twentieth centuries. The instruments with inventory numbers bm900, 2002/311, bm909 and bm901, for example, have higher t-values against the Bavarian chronology than against the Siebenlist-Kerner master chronology (mean t-value >5 and >3, respectively). In any case, the values of these statistical synchronization tests are not high enough to securely attribute the provenance of these instruments that, however, reach t-values that vary between 7.37 and 11.90 against the AMC01 master chronology.

Apart from being entirely consistent with the attributed date of manufacture, a comparison between the dendrochronological dates and the label dates on the instruments has permitted to find out something about the working methods of these violin-makers, of whom very little is known besides their surviving instruments. In fact, the interval between the youngest ring and the date of manufacture, called Δt (See Table 3 p. 11), depends on the amount of wood removed during the construction of the instrument, but it also includes the period of wood seasoning, and it gives an indication of how much time had passed after felling the tree before the wood was used. Furthermore, all modern violin-makers agree that, traditionally, only a few rings near the bark were removed during the manufacture of an instrument and that, if a piece of timber was larger than necessary, the inner (older) part was removed, not the outer one (Topham, 2003).
Hence, the value Δt can provide an indirect estimate of the seasoning time before manufacture, which is an important technical aspect for violin-makers.
Similarly to earlier findings from a study of seventy-two instruments attributed to Antonio Stradivari (Topham, 2003), in our study the value Δt varies between a minimum of two and a maximum of twenty-four rings for instruments built during the eighteenth century (See Table 3 p.11). For instruments made around the mid-nineteenth century, instead, there is a wider range of Δt, here between a minimum of thirteen and a maximum of 132 years. This tendency continues during the twentieth century, when the use of old wood, obtained from artefacts, became more frequent, as in the case of six controviolini of the Collection (with a minimum of 88 to a maximum of 184 years of difference between the dendrochronological date and the date of manufacture) and of a violin by Lapo Casini (72 years of difference).

Conclusions

This study is part of a wider range of research work. Right from the start, the dendrochronological investigations have been based on a continual exchange of data and information between researchers. The raw data of the dendrochronological series were shared equally, and the elaboration of the results was described and discussed, thereby determining a reliable *terminus post quem* date for each instrument. The interaction between musical instruments experts and dendrochronologists proved extremely fruitful and resulted in a more accurate interpretation of the acquired data from both disciplines.

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Table 1: List of analysed stringed instruments from the Collection of the Cherubini Conservatory, at the Department of Musical Instruments of the Accademia Gallery, Florence

Inv. no.	Instrument	Hypothesized date	Origin	Maker
1988/035	Cello	-	Rome	David Tecchler
1988/039	Cello	-	-	Anonymous, Tuscan school
bm909	Cello	1968	Rimini	Marino Capicchioni
1988/044	Double bass	1827	Livorno	Giuseppe Bracci
1988/042	Double bass	179?	Florence	Luigi Piattellini
1988/027	Controviolino	1901	Florence	Valentino De Zorzi
1988/028	Controviolino	1902	Florence	Valentino De Zorzi
1988/029	Controviolino	1904	Florence	Valentino De Zorzi
1988/030	Controviolino	1904	Florence	Valentino De Zorzi
1988/031	Controviolino	1908	Florence	Valentino De Zorzi
1988/032	Controviolino	1910	Florence	Valentino De Zorzi
1988/020	Bass-viola	1874	Arezzo	Lorenzo Arcangioli
1988/016	Viola	First half of the 19th century	Mirecourt	Anonymous
1988/017	Viola	-	Naples	Johannes Gagliano
1988/018	Viola	First half of the 19th century	Mirecourt	Anonymous
1988/021	Viola	First half of the 18th century	Central Italy	Anonymous
1988/022	Viola	1770	Florence	Bartolomeo Bimbi
1988/023	Viola	First half of the 20th century	Southern Italy	Anonymous
1988/024	Viola	1809	Perugia	Pietro Pallotta
1988/025	Viola	1915	Florence	Serafino Casini
1988/026	Viola	1786	Florence	Lorenzo and Tommaso Carcassi
2002/312	Viola	Early 20th century	Mirecourt	Anonymous
2002/313	Viola	1978	Florence	Luciano Sderci
2002/314	Viola	1919	Pieve di Cento (FE)	Gotti, Orsolo
bm901	Viola	1968	Florence	Iginio Sderci
1988/004	Violin	-	Naples	Nicolò, Ferdinando and Giuseppe Gagliano
1988/005	Violin	1719	Salzburg	Joannes Schorn
1988/006	Violin	1722	Salzburg	Andreas Ferdinand Mayr
1988/007	Violin	1767	Florence	Lorenzo and Tommaso Carcassi
1988/008	Violin	1764	Florence	Giovanni Battista Gabbrielli
1988/009	Violin	1770	-	Giovanni Battista Gabbrielli
1988/011	Violin	-	Pesaro	Del Coradel
1988/012	Violin	1784	Livorno	Antonio Gragnani
1988/013	Violin	1861	Turin	Antonio Guadagnini
1988/014	Violin	1886	Florence	Giuseppe Scarampella
1988/236	Violin	-	Mittenwald	school of Joan Carol Kloz
1988/237	Violin	-	-	attr. to Giovanni Battista Gabbrielli
2002/300	Violin	-	-	Tyrolean school
2002/301	Violin	-	-	German school
2002/302	Violin	Early 20th century.	Saxony	Anonymous
2002/303	Violin	-	Germany	Anonymous
2002/304	Violin	1830	Paris	François Breton
2002/305	Violin	1920	Milan	Leandro Bisiach
2002/306	Violin	1927	Florence	Josef Bargelli
2002/307	Violin	1926	Florence	Lapo Casini
2002/308	Violin	1978	Florence	Lapo Casini
2002/309	Violin	1982	Florence	Lapo Casini
2002/311	Violin	1977	Florence	Luciano Sderci
bm900	Violin	1967	Bologna	Ansaldo Poggi

Table 2: The belly: number of tree rings in each instrument's series, number of measured pieces for each belly, arrangement of the pieces (B being the bass side and T the treble side) related to the tree growth direction, Δt is the difference between each instrument's label date and its dendrochronological date

Inv. no.	Instrument	Tree rings	Measurements /pieces	Arrangement of pieces	Hypothesized date	Dendrochronol. date	Δt
1988/035	Cello	108	2/2	→←	-	1699	-
1988/039	Cello	109	2/2	→←	-	1812	-
bm909	Cello	115	2/2	→←	1968	1952	16
1988/042	Double bass	130	2/2	→←	179?	1781	14 (?)
1988/044	Double bass	209	1/8	-	1827	-	-
1988/027	Controviolino	62	2/4	– →← –	1901	1780	121
1988/028	Controviolino	55	1/2	→?	1902	1814	88
1988/029	Controviolino	87	2/2	←→	1904	1793	111
1988/030	Controviolino	89	2/4	– →← –	1904	1791	113
1988/031	Controviolino	79	2/2	→←	1908	1756	152
1988/032	Controviolino	99	2/2	→←	1910	1726	184
1988/020	Bass-viola	114	2/2	→←	1874	1847	27
1988/016	Viola	139	2/2	→←	First half of the 19th century	1810	-
1988/017	Viola	107	2/2	→←	-	1765	-
1988/018	Viola	169	1/1	B→T	First half of the 19th century	1816	-
1988/021	Viola	95	2/2	←←	First half of the 18th century	1671	>29
1988/022	Viola	99	2/2	→←	1770	1761	9
1988/023	Viola	-	0/2	→←	First half of the 20th century	-	-
1988/024	Viola	95	2/2	→←	1809	1796	13
1988/025	Viola	59	1/2	←←	1915	-	-
1988/026	Viola	-	0/?	?	1786	-	-
2002/312	Viola	91	2/2	→←	Early 20th century	1880	>20
2002/313	Viola	25	1/5	-	1978	-	-
2002/314	Viola	80	2/2	→←	1919	1904	15
bm901	Viola	88	2/2	→←	1968	1953	15
1988/004	Violin	53	2/2	→←	-	1712	-
1988/005	Violin	72	2/2	→←	1719	-	-
1988/006	Violin	52	2/2	→←	1722	-	-
1988/007	Violin	90	2/2	→←	1767	1743	24
1988/008	Violin	110	2/2	→←	1764	1754	10
1988/009	Violin	58	2/2	→←	1770	1768	2
1988/011	Violin	202	1/1	B→T	-	1658	-
1988/012	Violin	94	2/2	→←	1784	-	-
1988/013	Violin	148	1/1	B→T	1861	1803	58
1988/014	Violin	80	2/2	→←	1886	1859	27
1988/236	Violin	98	2/2	→←	-	1729	-
1988/237	Violin	92	2/2	→←	-	1749	-
2002/300	Violin	116	1/1	B→T	-	1749	-
2002/301	Violin	127	2/2	→←	-	1746	-
2002/302	Violin	136	2/2	→←	Early 20th century	-	-
2002/303	Violin	64	2/2	→←	-	1771	-
2002/304	Violin	303	1/1	B→T	1830	1698	132
2002/305	Violin	-	0/?	?	1920	-	-
2002/306	Violin	70	2/2	→←	1927	-	-
2002/307	Violin	82	2/2	→←	1926	-	-
2002/308	Violin	72	2/2	→←	1978	1906	72
2002/309	Violin	-	0/2	→←	1982	-	-
2002/311	Violin	91	2/2	→←	1977	1944	33
bm900	Violin	80	2/2	→←	1967	1940	27

Table 3: The mean difference between label date and *terminus post quem* date (Δt) for instruments produced in the course of three centuries

Century	Mean Δt (years)	Mean values (years)	Max. value (years)
18th	11.3	2	24
19th	51.4	13	132
20th	73.9	14	184

Table 4: Cross-matching the Accademia Master Chronology against some reference chronologies valid for the study area (Data downloaded from the International Tree-Ring Data-Bank, http://hurricane.ncdc.noaa.gov/pls/paleo/fm_createpages.treering)

Chronology author	Species	Site name	*t*-value	Glk
Siebenlist-Kerner	*Picea abies* Karst.	Ötztal	14.40	70.90***
Hüsken and Schirmer	*Larix decidua* Mill.	Fodara Vedla	9.36	63.50***
Schweingruber	*Picea abies* Karst.	Obersaxen	9.26	67.50***
Hüsken and Schirmer	*Picea abies* Karst.	Fodara Vedla	8.16	64.00***
Siebenlist-Kerner	*Larix decidua* Mill.	Ötztal	7.07	61.80***
Schweingruber	*Picea abies* Karst.	Cortina D'Ampezzo	6.98	64.80***
Bigler	*Picea abies* Karst.	Davos	6.48	65.00***
Becker	*Picea abies* Karst.	Bayerischer Wald	6.07	63.60***
Siebenlist-Kerner	*Pinus cembra* L.	Ötztal	5.63	57.50***
Hüsken and Schirmer	*Pinus cembra* L.	Fodara Vedla	5.17	58.00***
Becker	*Abies alba* Mill.	Bayerischer Wald	4.98	57.00**