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THE BUILDING AND RENOVATION HISTORY OF VILNIUS AND KAUNAS CHURCHES: DENDROCHRONOLOGICAL DATING AND HISTORICAL SOURCES

Summary. We present the application of dendrochronological dating of the renovation and construction works of churches in the Kaunas and Vilnius regions of Lithuania. The model for the estimation of the missing rings of Scots pine was used in Lithuania for the first time. We have assessed 18 timber cross-sections from nine churches, which were used for the constructions from the second half of the 17th to 19th c. The oldest wood samples were dated from St. Michael's Church in Vilnius (1668±4) and St. George, the Martyr, (Bernardine) Church in Kaunas (1693±3). The aim of this study was to compare the results of the investigation of timber samples from 9 churches with archival sources and literature data and to reveal the renovation history of the buildings. The study of written historical sources has revealed a lack of recorded building and reconstruction phases of the churches. This fact was later confirmed by the results of dendrochronological dating. The dating of the timber revealed undocumented reconstruction dates in Zapyškis church (1791±3), St. George, the Martyr, (Bernardine) Church in Kaunas (1711±4), St. Anne Church in Skaruliai (1693±3) and Vilnius Cathedral (1814±4).

Keywords: tree rings, dating, Scots pine, Lithuania, sapwood, the architecture of Kaunas and Vilnius regions, the history of Lithuanian architecture.

INTRODUCTION

Dendrochronology (in Greek *dendron* – tree, *khronos* – time, *logos* – science) is a multidisciplinary science of dating tree rings. It includes investigations in biology, climatology, ecology, geology, hydrology, volcanology, forestry, archaeology as well as the history of architecture and arts. In the strictest sense – a subfield of dendrochronology, which uses tree rings for dating of wooden material¹. The science is based on the fact that trees during each growing season form a tree ring, which width, density, size of vessels and other characteristics record the natural environmental processes². A. E. Douglass (1867–1962) is considered to be a father of dendrochronology³. Douglass, an American astronomer, was the first researcher to use crossdating⁴. By investigating sunspots, A. E. Douglass was searching for solar intensity records in tree rings. Later he demonstrated that the trees are

recording cycles driven by different climatic parameters⁵. The main principle of dendrochronology is crossdating, which states that variation in tree-ring widths are triggered by environmental factors limiting the growth. This provides exact calendar years for every tree ring in a sample. The principle of replication indicates that averaging across many samples enables to remove the individual tree variability⁶.

The 1960s saw an extensive application of dendrochronology in the dating of buildings and art pieces in Europe⁷. The majority of timber used for building and boards for painting in Europe is made of English oak (*Quercus robur* L.)⁸. Oak trees are long-lived, the tree rings are easily measured and show the high similarity over the vast geographical region making the English oak especially preferred species in dendrochronology⁹. On the contrary, Scots pine (*Pinus sylvestris* L.) and Norway spruce (*Picea abies* L.) Karsten) are the most common timber species in

Lithuania¹⁰. This was explained by intense Baltic timber trade to Western Europe¹¹. In spite of the long-life span of pines¹², missing rings and lower similarity between sites¹³ makes this species more challenging in dendrochronology. The dating of spruce is problematic in the Baltic States because of the highly individual growing patterns¹⁴.

The tree-ring dating in Lithuania during the Soviet times was impeded by the lack of reliable master chronologies used to date the timber of unknown age¹⁵. Therefore, the chronologies from Poland, Latvia and Estonia were used for the first dating works in Lithuania. For the dating of pine, the following chronologies were used: Dannenstern House (Latvia, M. Zunde)¹⁶, Polpinus-5 (Poland, A. Zielski)¹⁷, Polpinus (Poland, A. Zielski)¹⁸, Polskane (Poland, A. Zielski)¹⁹, Kujawpom (Poland, A. Zielski and M. Krąpiec)²⁰ and Estonian chronology (A. Läänelaid and D. Eckstein)²¹. The dating of oak in Lithuania was almost limited by East Pomerania (Poland, T. Wazny) and Baltic1 (United Kingdom, Hillam and Tyers) chronologies²². Currently compiled pine chronologies in Lithuania cover the last 500–1000 years: Litpinus 1 chronology spans from 1487 to 2002 (A. Vitas)²³ and the Vilnius Lower Castle chronology from 1010 to 2009 (R. Pukienė)²⁴. Therefore, they provide a high potential proxy for dating and climate reconstruction in Lithuania.

The wood of pine is formed of heartwood and sapwood. The heartwood is located in the inner part of the stem and is darker, drier and more resistant to deterioration. The sapwood is the outer portion of the stem. It contains living cells and reserve materials²⁵. Sapwood has higher moisture contents than heartwood, is softer and more prone to decay because it contains few toxic compounds²⁶.

However, very often the outer part or entire sapwood rings are missing in the historical timber samples due to deterioration of wood or artificially removed because of weaker sapwood. This does not allow to establish a precise date of felling. Then, a reliable dating encompasses the estimation of missing sapwood rings by statistical approximation of the number of missing rings between the heartwood/sapwood boundary and the supposed outermost ring²⁷.

The simple technique has been to add the average number of sapwood rings for the species altogether with estimated confidence interval calculated from the distribution of sapwood rings²⁸. In case when all sapwood rings are missing and also the last heartwood ring is not preserved or determinable, the reconstruction of the date of felling is not possible. Then, “terminus post quem” – “limit after which” is used, i.e. the latest measured ring with certainty²⁹.

The earlier investigations have shown that the number of sapwood rings of English oak is almost stable in the Baltic region³⁰. However, Scots pine is characterized by high and variable number of sapwood rings³¹, which depend on the cambial age of a tree.

The aim of this study was to assess the potential of sapwood rings estimation model for the dating of pine timber from churches located in the Kaunas and Vilnius regions of Lithuania.

METHODS

Scots pine timber (cross-sections) were taken from historical buildings in the Soviet period³². The investigated objects – churches and monasteries located in the Kaunas (St. Francis Xavier (Jesuits) Church, Kaunas St. Cross (Carmelite) Church, St. George, the Martyr, (Bernardine) Church, St. Anne Skaruliai Church, Zapyškis Church, City Hall) and the Vilnius regions (St. Catherine Church and Benedictines Convent, St. Michael's Church and Cathedral Basilica) of Lithuania.

The surface of timber disks was sanded with progressively finer grades of sand paper (40 to 400 grit). The tree-ring widths were measured to the nearest 0.01 mm. Cross-sections were measured in at least two radii. For this purpose, LINTAB tree-ring measuring table and TSAPWin 0.30 computer program (F. Rinn Engineering Office and Distribution, Heidelberg) were used. The cross-dating of the samples was performed by visual comparison of the tree-ring graphs³³ and statistically using TSAPWin 0.30.

In 2015–2016, more than 1000 living pine trees from 102 research plots were assessed for the estimation of sapwood rings³⁴. The trees were cored in different regions of Lithuania from 1969 to 2017.

The investigation has demonstrated that the link between the number of sapwood rings and age of the tree as well as the relationship between the number of sapwood rings and heartwood rings could be well approximated ($R^2 = 0.92$) using a polynomial formula. Using the regression model it is easy to calculate that a pine containing 50 heartwood rings will have 54, 100 years – 69, 150 years – 73 sapwood rings, on average, respectively.

$y = -0,0023x^2 + 0,6456x + 27,326$, where y is a number of sapwood rings and x – a number of heartwood rings.

In this study, we have studied the timber samples containing a part of pith, when the sapwood estimation rule could be applied. The samples in which the sapwood was completely removed or deteriorated will be not presented in this study.

RESULTS

Researchers in Lithuania investigating the pieces of art and architecture very often encounter with the lack of reliable historical sources. This is because many written sources were lost during various historical devastation events: wars, disturbances and occupations. The remaining sources were dispersed not only among different Lithuanian institutes, but are also stored in archives in Poland, Russia, Belarus, Germany, France, etc. In fact, there are no objects of art-architectural heritage in Lithuania having such a large and detailed documentation as in the Western and Central European countries. Therefore, Lithuanian art historians and architects often should trust the formal analysis method and attribution application, i.e. analysis of style, materials and ornaments, but not the written historical sources. The facts from the written sources would provide conditions for more precise dating of art pieces as well as the dates of building, reconstruction or repair works. Hence, the attribution results in the formal analysis of styles are determined by professional experience, which does not protect from mistakes. In addition, this does not allow to perform a precise and objective dating. Therefore, the dendrochronological dating of the wooden constructions of historical

buildings may complement the historical knowledge and architectural investigations.

We have investigated the timber from 9 Gothic and Baroque churches and monasteries and the Kaunas City Hall, which was an Orthodox church in the 19th century (Table 1). The obtained results considering the estimation of missing sapwood rings have specified the data from earlier publications³⁵.

THE CHURCHES OF KAUNAS REGION

The Gothic style church in Zapyškis was built ca 1502–1517, when Jonas Sapiega kept the holdings, but the foundation was obtained only in 1578 by the act of Paweł Sapieha³⁶. Historical sources mention several renovations of the church. The repairs were performed before 1666 as well as in 1698, 1763 and after 1829, 1864 and 1869³⁷. The important fact is that some Gothic forms of the church were changed into Baroque style in 1744 and 1763³⁸. However, the samples taken from wooden constructions and their dendrochronological dating showed that another repair in the church had taken place after 1791±3 (Table 1).

Another Gothic-style church is the St. George, the Martyr, (Bernardine) church in Kaunas, which was built in several stages and was repeatedly badly affected by fires. The Bernardines arrived in Kaunas in 1468³⁹. Iwaszka Wiażewicz, the elder of Kaunas benefited the building of wooden monastery and St. George Church. It was started to build on the land site in 1471, which was given by Stanisław Sędziwojewicz, palace marshal of the Grand Duchy of Lithuania and the elder of Gardinas⁴⁰. The sacristy was bricked until 1487 and later (after 1492) the building of the church has started. The sacristy was later connected to the church. Both buildings were finished not later than 1502. The vaults of the naves collapsed during the fire in 1624. The reconstruction works were started in 1630. New lower vaults and pillars were bricked. The church suffered again in 1668. In 1670, a new roof was covered and a Baroque turret was built on a roof of a presbytery. In 1744, a new main entrance was built and the tambour with portal was bricked in the middle of the northern façade. In 1747, an old tambour in

Table 1. A list of investigated objects, samples and the results of dendrochronological dating.

Object	Inv. No	No of rings*	Heart-wood rings*	Sap-wood rings*	Last ring**	Estimated sapwood*	Estimated date***
St. Francis Xavier (Jesuits) church, Kaunas	3333	78	39	39	1731	49	1741±1
St. Francis Xavier (Jesuits) church, Kaunas	3334	66	31	35	1732	45	1742±1
St. Francis Xavier (Jesuits) church, Kaunas	3335	121	71	50	1731	62	1743±6
St. Francis Xavier (Jesuits) church, Kaunas	3338	106	56	50	1818	56	1824±3
City Hall, Kaunas	126	94	56	38	1815	56	1833±3
City Hall, Kaunas	128	132	98	34	1751	69	1786±5
City Hall, Kaunas	129	94	54	40	1814	56	1830±3
Zapyškis church	3365	71	41	30	1771	50	1791±3
St. Cross (Carmelite) church, Kaunas	3342	86	40	46	1880	50	1884±1
St. George, the Martyr, (Bernardine) church, Kaunas	3322	76	62	14	1666	59	1711±4
St. Anne church, Skaruliai	3364	80	48	32	1672	53	1693±3
St. Catherine church, Vilnius	3355	133	93	40	1790	68	1818±5
Benedictines convent, Vilnius	3302	180	132	48	1723	74	1749±5
St. Michael's church, Vilnius	3294	95	61	34	1644	58	1668±4
Cathedral, Vilnius	3325	115	64	51	1788	59	1796±4
Cathedral, Vilnius	3391	106	52	54	1788	55	1789±3
Cathedral, Vilnius	3386	88	44	44	1759	51	1766±3
Cathedral, Vilnius	3388	100	65	35	1789	60	1814±4

* - years, ** - date, *** the estimated date is provided altogether with the standard error ($p \leq 0.05$).

the western façade was demolished. In 1812, the church was transformed into the food warehouse and in 1818, partly renovated⁴¹. However, the dendrochronological dating suggests that another restoration took place in ca 1711±4 (Table 1). This date is surprising for us, because the Great Northern War was fought in 1700–1721. The entire land was devastated, many religious buildings have suffered. In addition, there is no evidence in the archives of Lithuanian churches about any marked repair works during this time.

Under similar circumstances, the St. Anne church in Skaruliai was built. The documents testify that the church in Skaruliai was built according to the model of Jerusalem church by Andrzej Skorulski, Kaunas marszałek, in 1606⁴². The sources affirm that the church was finished in 1620–1622⁴³. However, a crucifix was already exposed in 1606⁴⁴, which means that the church was already finished. After the fire in 1656, the church repairs probably took longer than expected⁴⁵. In 1819–1820, the roofs, tower and

vaults were renovated⁴⁶. The dendrochronological dating indicated that the wood for the renovation of the Skaruliai Church was felled in 1693±3 (Table 1).

The building of the Baroque-style St. Francis Xavier (Jesuits) church in Kaunas was started in 1666. However, it was destroyed by fire in 1668. The later church was built almost 3 decades. In 1698, the new walls and sacristy were erected. The main building works were completed in 1720⁴⁷, the church was consecrated in 1722 and the towers were finished until 1725⁴⁸. In 1732, a fire has devastated the church: the roof, vaults and tower collapsed⁴⁹. The archival sources mention that the church was restored in 1746–1751⁵⁰. However, the received dendrochronological dates (1741±1, 1742±1 and 1743±6) suggest that the reconstruction activities have started earlier, in 1741–1743 (Table 1). Some reconstruction activities continued until 1759⁵¹. However, the dendrochronological dating does not prove this. Another sample evidences that the wood for this building was cut ca 1824±3 (Table 1). We know from historical sources that Kaunas Jesuits Church and Monastery

were transferred for Orthodox Confession in the same year. In 1825, they have renovated the building and adapted it for their own needs: a part of wooden constructions was changed, a roof was recovered, the interior was rearranged and the floor was paved with stone plates. After the renovation, an orthodox church was established in the building (Nevsky Sobor from 1843). The Church was transferred to Catholics only after the World War I⁵².

The Kaunas Jesuits church was not the only in Kaunas, which was taken from the Catholics and transferred to the Orthodox confession. Kaunas St. Cross (Carmelite) church was built in 1685–1700, but was returned to the Carmelites only in 1772⁵³. The Carmelites renovated the building in 1772–1773. However, the church suffered considerably during the war in 1812⁵⁴. The chapels were renovated and gables were bricked in 1830⁵⁵. The church and monastery was closed by the tsarist authorities in 1845⁵⁶. A project of the arrangement of the building to infantry regimental warehouse was approved in 1880. Therefore, all the interiors were destroyed: six Baroque altars were withdrawn altogether with the organ' choir, pulpit; new openings for doors and windows were cut out⁵⁷. The church was again returned to the Catholics in 1881. The renovation works were performed by Bishop Aleksander Kazimierz Bereśniewicz and canon Franciszek Butkiewicz⁵⁸. From the archival documents it is known that new altars, organ' choir, pulpit were built as well as new doors and windows were cut out in 1885–1895⁵⁹. This date is confirmed by the results of dendrochronological dating, which indicates that the wood was cut in 1884±1 (Table 1). In this instance, we also learn about the certain building technologies, which testify that the wood has been dried for about one year before its usage.

The City Hall in Kaunas was also tailored to the needs of the tsarist authorities. Until that time, this building was reconstructed many times. In 1771–1780, the building was reconstructed according to the project of architect Johan Mateker. The western part was re-erected. The building was heightened, new cornices were bricked and pilasters decorated by Corinthian capital. The Gothic tower was separated into five condignations from the external view and the sixth condignation was built as well as a

porch on the southern side – a balcony supported by columns. The interior was altered. A staircase was built in an old vestibule. A new vestibule was re-covered by vaults, cellars were filled, and their vaults were destroyed⁶⁰. The timber dating suggests that these works took longer, because the timber for these reconstructions was felled ca 1786±5 (Table 1). Therefore, the date of these large reconstruction works may be extended until 1786–1787. In 1824, an Orthodox Church was established in the City Hall and later it was used as an artillery ammunition warehouse⁶¹. In 1836–1837, the new roofs were covered and the ceilings renovated. In 1838, the former warehouse was adapted for the temporary tsar residence. At that time, a vestibule on the second floor was set up as well as the banquet and servant rooms, etc. The timber for these reconstructions was felled in 1830±3 and 1833±3 (Table 1).

THE CHURCHES AND MONASTERIES OF VILNIUS REGION

The St. Michael's church in Vilnius and Bernardine convent were benefited in 1594. The building of the church took several decades and the building was expanded several times. The embossed date (1625) on the gable is not very precise date of the building completion. The first service in the church was held only in 1627 and the church was consecrated in 1629. The Church devastated and suffered from fire during the war with the Czar Aleksey (1655 onwards). The restoration was started just after the Russian army retreat, although nuns have returned to the convent in 1663. The historical sources mention that the restoration works of the convent and church took place in 1662–1674⁶². This is also supported by dendrochronological dating (1668±4).

The Vilnius Benedictine convent, which belonged to the Kulm congregation, was found in ca 1620⁶³. The first wooden St. Catherine church was built in 1632 and the first masonry church – in 1650. During the war with Moscow in the mid-seventeenth century (1654–1660), the church was badly damaged and the restoration took place until 1703, when it was consecrated⁶⁴, however, already in 1737, the church burned during the great fire in Vilnius⁶⁵. The church was reconstructed in 1741–1746 according

to the project of architect Johan Christoph Glau-bitz (?–1767)⁶⁶. A new façade, towers and entrance were built in 1848. Towers were covered with tin and metal crosses were mounted⁶⁷. The old wooden altars were demolished and masonry altars were built in 1752–1759⁶⁸. The interior decorations (altar and sculptures) were created by sculptor Johann Hedel (worked in Vilnius from 1740s to 1764)⁶⁹ and his brother Joseph Hedel (worked in Vilnius in 1740s–1760s)⁷⁰. The last interior installation works, under the supervision of the monastery senior Anna Franciszka Wołłowiczówna (1760–1791)⁷¹. In 1812, the hospital was established in the convent and the church was used as a pharmaceutical store. The nuns returned back only in April of 1813 and the restoration works lasted until 1820⁷². The timber sample 3302 was felled in 1749±5. This corresponds to the restoration works of St. Catherine church in 1741–1746 and later interior renovations. Another sample dated to 1818±5 represents the restoration works of the convent at the beginning of the 19th c.

A study of Vladas Drėma, art and architecture historian, comprehensively presents the reconstructions of the most important church in Lithuania – Vilnius Cathedral Basilica in 1782–1801⁷³. According to the data of Vladas Drėma, the biggest part of timber was used in 1785–1789⁷⁴. The roof was already covered in the aforementioned years⁷⁵; other beams were felled and used in 1789⁷⁶. In 1796, the timber was used for the stairs⁷⁷. Dendrochronological investigations revealed that the timbers for cathedral constructions were cut in 1766±3, 1789±3 and 1796±4 (Table 1). In addition, the restoration works in the Cathedral were also performed in 1814±4.

FINAL STATEMENTS

Our investigations have shown that dendrochronological dating allows to look more deeply into the history of a building. In this case, it allows to define more precisely the reconstruction and renovation dates, which may be not mentioned in the remaining archival sources. The dating of the timber revealed not documented reconstruction dates in Zapyškis church (1791±3), St. George, the Martyr, (Bernardine) Church in Kaunas (1711±4), St. Anne

Church in Skaruliai (1693±3) and Vilnius Cathedral (1814±4).

However, it should be pointed out that the dating potential of the wooden constructions of historical buildings is not fully utilized. Not all of the timber accumulated from churches during the Soviet period was analysed. The lack of reliable long-term pine and oak chronologies in Lithuania impeded the research at this time. For example, the timber from Kintai Church (Klaipėda district) is not dated as well as a part of material from the old town of Klaipėda. The pine timber from the rostwerk constructions of Trakai Castle fore-work was analysed in 2015⁷⁸.

The investigation of the wooden sacral buildings in Lithuanian has great potential. For example, Algė Jankevičienė, the researcher of Lithuanian wooden architecture, calculated that 43 wooden churches built in the 18th c. have survived. A half of the wooden churches were built in 1795–1918⁷⁹. While the total number of wooden cemetery chapels and belfries in Lithuania is unknown⁸⁰. The building dates, especially, of the rural chapels in small cemeteries are mostly unknown. They are supposed, according to the negligible archival sources. For example, a cemetery chapel in Kurmaičiai (Joniškis district) was mentioned for the first time in the deceased register of the Joniškis parish in December of 1792. In the same year, a feast day was indicted after the bull of Pope Pius VI. However, the precise building date of this chapel is unknown⁸¹. Hence, the interdisciplinary research by dendrochronologists and architecture historians has great potential. The research of wooden buildings and wooden construction of masonry churches will not only specify the construction dates, but also specify the periodization history of Lithuanian architecture because the majority of sacral buildings in Lithuania has incomplete historical documentation. Therefore, the architectural historians usually date them based on the stylistic analysis. Such studies could be carried out not only in the sacral buildings, which we have analysed, but also in the city halls, estates and old living houses. Complex and more comprehensive investigations of historical buildings allow to draw conclusions about some building technological aspects, for example, to establish the tentative region of timber

provenance, to evaluate the species of the used wood and to answer the question how long the timber was dried before its application in the constructions.

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- ⁷⁰ Ibid., 122–123.
- ⁷¹ Ibid., 219.
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IŠ KAUNO IR VILNIAUS BAŽNYČIŲ STATYBOS IR REMONTŲ ISTORIJOS: DENDROCHRONOLOGINIS DATAVIMAS IR ARCHYVINIAI ŠALTINIAI

Santrauka

Straipsnyje pristatomi Kauno ir Vilniaus regiono bažnyčių medienos dendrochronologijos datavimo rezultatai. Pirmą kartą Lietuvoje panaudotas naujai sukurtas trūkstamų paprastosios pušies balanų rėvių rekonstrukcijos metodas. Tyrimui naudojome 18 medienos nuopjovų iš devynių bažnyčių. Datavimo rezultatai parodė, kad medienos konstrukcijos buvo naudojamos nuo XVII a. antrosios pusės iki XIX a. Seniausia datuota mediena iš Šv. Mykolo bažnyčios Vilniuje (1668±4) ir Šv. Jurgio Kankinio (bernardinų) bažnyčios Kaune (1693±3). Šio straipsnio tikslas – palyginti medienos pavyzdžių iš devynių bažnyčių tyrimo rezultatus su archyvinių šaltinių ir literatūros duomenimis bei atskleisti pastatų remontų istoriją. Istorinių šaltinių ir literatūros analizė parodė informacijos stygių apie kai kurių bažnyčių statybos ir rekonstrukcijos laikotarpius. Šį faktą patvirtino dendrochronologijos datavimo duomenys. Medienos datavimo rezultatai atskleidė iki šiol nežinomas rekonstrukcijos ir remonto datas Zapyškio bažnyčioje (1791±3), Šv. Jurgio bažnyčioje Kaune (1711±4), Šv. Onos bažnyčioje Skaruliuose (1693±3) ir Vilniaus katedroje (1814±4).

Reikšminiai žodžiai: medžių rievės, datavimas, paprastoji pušis, balana, Kauno ir Vilniaus regiono architektūra, Lietuvos architektūros istorija.

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