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Discovering the Unknown History of the Utilization of *Pinus heldreichii* in Wooden Structures by Means of Dendroarchaeology: A Case Study from Metsovo (Northern Greece)

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Abstract: (1) Background: *Pinus heldreichii* is a long-living tree subalpine species commonly used for climate reconstruction. Nevertheless, its potential for dendroarchaeology and dating of historical timber remains unknown. In Metsovo and in the surrounding area of Pindus National Park (Northern Greece) it is commonly used for the construction of buildings and wooden objects and artifacts. (2) Methods: We examined timber found in historical buildings within the study area and we tried to date it using local reference chronologies of Bosnian and Black pines. (3) Results: Bosnian pine chronologies can be used to date timber from historical buildings, while they can also be used as reference chronologies against Black pines, giving very high cross-dating values. Therefore, and since the macroscopic identification of the two species' timber is impossible, the analysis of wood anatomy is necessary to distinguish the two species in the case of historical wood. (4) Conclusions: The current paper presents the first application of dendroarchaeology for Bosnian pine and highlights the potential of the species in studying cultural heritage and the human past.

Keywords: Bosnian pine; Black pine; cultural heritage; architecture; historical buildings; pindus national Park

1. Introduction

Among different regions, different tree species are used as construction material in historical buildings and artifacts [1]. The selection of tree species used for wooden constructions depends mostly on their availability and the characteristics that make them suitable for specific purposes [2]. For instance, in the Mediterranean region, different softwoods are most used such as pine (*Pinus* spp.), fir (*Abies* spp.), juniper (*Juniperus* spp.), cedar (*Cedrus* spp.), larch (*Larix decidua*), Norway spruce (*Picea abies*) and cypress (*Cupressus sempervirens*) [1,3–8], while deciduous oak (*Quercus* spp.) and chestnut (*Castanea sativa*) are also frequently present [1,3,8,9].

Oaks are in most cases used for timber reinforcements of masonry, beams in the roof and floor construction, and in timber-framed walls, while different kinds of conifers are preferred for planks, floorboards, shutters, and doors, although they can also be found as part of the main load-bearing system (roofs, floors, walls), depending on availability and accessibility of forest resources [6,7,9]. In most of the examined historical buildings in Greece, both local and imported timber can be found [6,7,9–11], as has been documented for other sparsely wooded areas of the Mediterranean region [8,12], making the existence and selection of the proper regional and supraregional reference chronologies [13,14] and dendroprovenancing [15–17] indispensable steps for the secure dating and the holistic study of a historical building.

For southern Europe, multi-centennial long chronologies exist for several species, including Bosnian pine (*Pinus heldreichii* Christ) [1]. Bosnian pine is a Tertiary relict species [18,19], endemic to the high mountains of south-western Bulgaria, northern Greece, Albania, Montenegro, Bosnia and Herzegovina, Kosovo, and the southern Italian Apennines (Monte Pollino) [20,21]. Bosnian pine forms very old stands, including the oldest scientifically dated tree in Europe [22,23]. Due to its longevity, the species has been widely used for climate reconstruction, e.g., [24–37], while up to our knowledge there are no studies using those long-developed chronologies for dating historical timber. Given its very resinous and resistant to decay and decomposition wood [34] and its suitability as a timber species for general construction, housing, carving, cooperage, dairying, and storage of goods [21,27,38], the lack of dendroarchaeological studies may be possibly attributed to its limited distribution and the non-exploration of the historical timber within or around the distribution area of the species. The potential use of long Bosnian pine chronologies for dendroarchaeology and dating of historical timber has been recently highlighted [39].

The current study presents the results of the first dendroarchaeological survey in Metsovo and in other Vlach villages founded or expanded between the fifteenth and seventeenth centuries over the northern Pindus [39] (Figure 1), with the aim to explore the use of Bosnian pine in wooden structures and artifacts and to estimate its potential application for dating of historical timber. Our first exploration of historical timber in the study area, together with interviews with the locals, suggests the wide use of Bosnian pine, although other pine species and deciduous oaks (*Quercus* spp.) are also present. The natural distribution of pine species within the broader study area suggests that the second pine species used corresponds most probably to Black pine (*Pinus nigra* J.F. Arnold). In the current study, we present the first results obtained from samples collected from the Monastery of St. Nicholas, one of the most important monasteries in a short distance from the town of Metsovo (Figure 2). The main objective of our study was to perform the first dendroarchaeological survey of the broader area, focusing on the dating of Bosnian pine timber and dendroprovenancing. To identify and date locally sourced timber, we used local Bosnian and Black pine tree-ring chronologies developed from living trees.

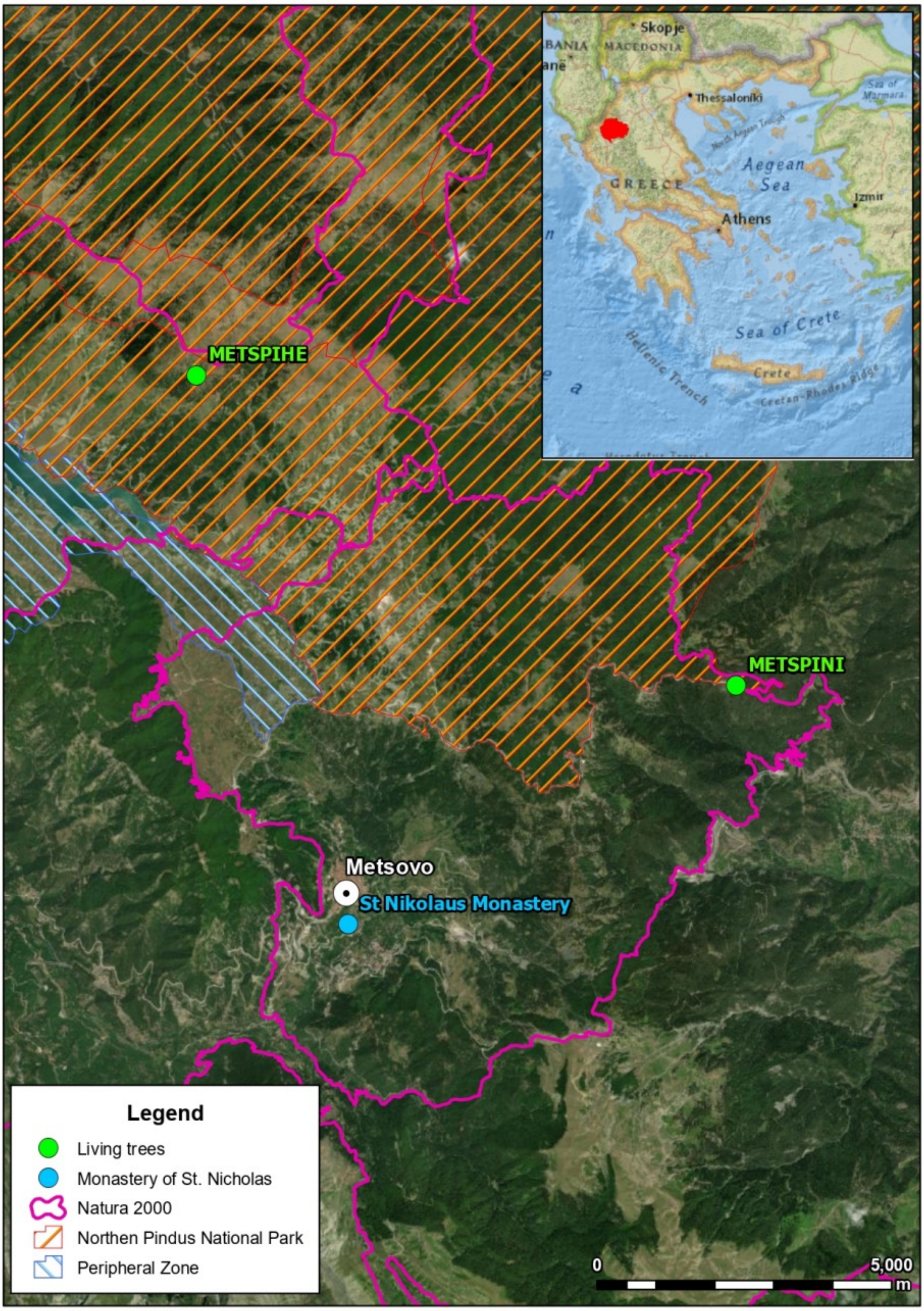


Figure 1. Location of the broader study area within the borders of the Northern Pindus National Park and the different study sites where samples were collected from historical timber (blue dot) and living trees (green dots): (1) METSPIHE: Bosnian pine forest, (2) METSPINI: Black pine forest.

Figure 2. Monastery of St. Nicholas, located SW of Metsovo; (**a**) general position, (**b–d**) views from the Monastery complex, (**e**) Monastery's auxiliary building from where samples were collected.

2. Materials and Methods

2.1. Study Area, Study Sites, and Sample Collection

The study area is located within the borders of the Northern Pindus National Park (Northwestern Greece), the largest terrestrial National Park in Greece, covering an area of approximately 2000 km^2. A great part of the National Park is included in the Natura 2000 European network of protected areas (Figure 1). *Pinus heldreichii* forests represent the dominant forest type at altitudes of 1.600 m–2.000 m, while *Pinus nigra* is the dominant tree species of Pindus at the altitudinal zone of 1.000 m–1.600 m, representing one of the priority habitats of the National Park. In the same zone, beech (*Fagus sylvatica* L.) forests and mixed forests with beech and Hybrid fir (*Abies borisii-regis* Mattf.) or Black pine can be found [40].

The study area comprises Metsovo and the surrounding villages and forests. Metosovo is a well-known and large village/small town in Epirus, located at the altitude of 1156 m, in the mountains of Pindus in northern Greece, between Ioannina to the west and Meteora to the east. Metsovo is the largest center of Vlach life in Greece. The area of Metsovo is of great interest in terms of cultural heritage and architecture, with the presence of many historical and traditional buildings, many of which wood represents a basic building material, widely used in the construction of the roof, ceiling, floor, masonry reinforcements, etc., while there is a long tradition on timber related to traditional crafting.

2.1.1. Historical Timber

The initial exploration of historical timber in the study area suggests the use of Bosnian pine in several historical buildings including the Monastery of St. Nicholas, the Monastery of Panagia, and the church of Agia Paraskevi located in the center of the village square, the church of Agios Georgios, etc. In each building at least two visits should be performed: one for initial exploration and documentation of available timber and a second one for sampling after the required permission from the Ephorate of Antiquities of Ioannina is issued. In the current study, as above-mentioned, we present the first results from the implementation of preliminary dendrochronological sampling in the Monastery of St. Nicholas, since the evaluation of the achieved results is important before designing further sampling. The Monastery of St. Nicholas, together with Panagia Monastery, are two important fortress monasteries in short distance from Metsovo. In contrast to most the Monasteries, usually located in remote and physically protected mountainous areas, St. Nicholas is built low, towards the river (Figure 2a), in the middle of the route Metsovo—Anilio. It is not known precisely when the Monastery was built [41], but is mentioned as a prominent monastery back to 1380 AD. The catholicon of the monastery was destroyed in 1453 by the Turks, but it was rebuilt in 1700, thanks to the privileges given by the sultan Ahmed IV to Metsovo. By 1925, the monastery was abandoned by its monks, while today the Ecclesiastical Committee of Agia Paraskevi is responsible for its maintenance and use, together with a permanent guardian that lives there throughout the year. The monastery constitutes an important touristic attraction but also an important site to visit for the locals. The last renovation of the monastery, financed by the Averof–Tositsas Foundation, took place in 1960 and 1984 [42].

In this framework of the preliminary dendrochronological examination of the Monastery, we collected a total of 21 samples from the auxiliary building (Figure 2e) and the basement where a big timber wine barrel is stored (Figure 3d). The barrel itself will be further examined in terms of species used and its potential for dendrochronology (in prep.). Within the scope of the current study the majority of the samples (13 pieces, 62%), were collected from floor beams (Figure 3a), vertical elements supporting the floor beams (Figure 3b) and cantilever beams at the lower level, supporting the floor beams with extra timbers (Figure 3c), in the form of cores (Figure 4), with the use of a modified electric drill. After removal of the samples, the holes were properly plugged, in order not to be visible and to affect the aesthetic of the building. The rest samples (8 pieces, 38%), were collected from a pile of discarded timber inside the basement. Most of them were probably old planks, removed for safety reasons. In this case, samples were collected in the form of slices, with the use of a hand saw (Figure 4).

Figure 3. (**a**) Floor beams next to firewood, at the corridor driving to the basement in the auxiliary building; (**b**) vertical elements supporting the floor beams on the horizontal beam placed at the lower level; (**c**) cantilever beams at the lower level, supporting the floor beams with extra timbers (**d**) old wine barrel stored at the basement of the auxiliary building.

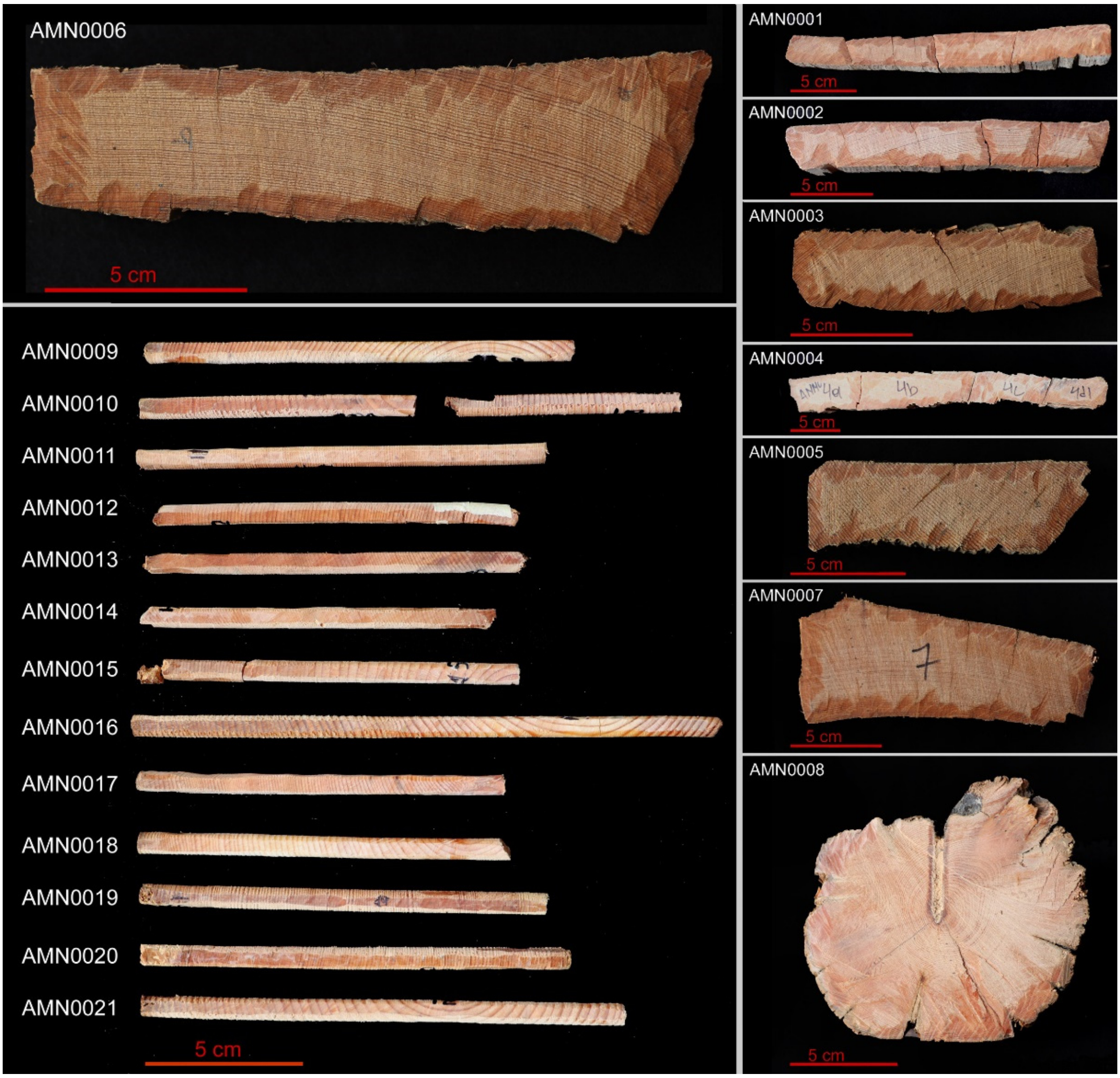


Figure 4. Samples collected in the Monastery's auxiliary building.

2.1.2. Cores from Living Trees for the Development of Local Reference Chronologies

In order to detect the possible local origin of the timber used, we developed local reference chronologies for the two pine species: *Pinus heldreichii* and *P. nigra*. For the first species, we used the chronology developed from the summit called Mavrovouni located 9 km N–NW of Metsovo, comprising cores from 51 trees [39]. For *P. nigra* we collected cores from 20 dominant trees from a Black pine forest, located ~9 km E-NE of Metsovo (Figure 1, Table 1). Sampling was performed with the use of increment borers long enough to obtain a complete radius of the trunk to reach the pith, adjusted to Smartsocket (Technoforest Co. Ltd., Tokyo, Japan) attached to the impact wrench Makita DTW1001RTJ.

Table 1. General characteristics of the two sites from where cores from living trees were collected for the development of the local reference chronologies.

Species	Latitude	Longitude	Elevation (m)	Mean Diameter of Sampled Trees (cm)	No. of Sampled Trees
Pinus heldreichii	39.847637°	21.148649°	1650–2000	130.5	51
Pinus nigra	39.804248°	21.257544°	1530	86.2	20

Coordinates are given in decimal degrees.

2.2. Samples Preparation, Wood Identification, Measurements, and Statistical Analysis

Samples, both from historical timber and living trees, were properly prepared with the use of either progressively finer grade abrasive paper or razor blades, so as to have tree-rings and xylem cells clearly visible under magnification. For historical timber and due to the fact that the macroscopic identification of the two-pine species' timber is impossible a microscopic identification of wood has been performed. Identification was based on the observation of cross, tangential, and radial sections under a biological microscope by comparing wood structures against reference material [43–46]. Subsequently, tree-ring widths were measured to 0.01 mm using Time Series Analysis and Presentation software (TSAP-Win) [47] and a LINTAB (Rinntech Inc. Heidelberg, Germany) measuring table.

After distinguishing the samples into the two pine species, we made attempts to synchronize samples of each species and to develop mean chronologies for both groups. "Floating" chronologies from historical timber were cross-dated and synchronized with the newly developed local reference chronologies, plus the available reference chronologies from the broader area. All samples were visually and statistically cross-dated using TSAPWin and the parameters described in [7]; namely (I) Gleichlaeufigkeit (Glk); (II) t-value Baillie-Pilcher (TVBP) [48] and t-value Hollstein (TVH) [49]; (III) Cross-Dating Index (CDI) [47]; and a number of overlapping years (OVLs). Visualization of the results was performed using TSAP and DENDRO for Windows [50].

3. Results

3.1. Tree Species Identification for Historical Timber

The two species found in the Monastery's auxiliary building—Bosnian pine and Black pine were distinguished based on wood anatomy analysis. The crucial difference between the two species is visible in the radial section. The characteristic features of Black pine are cross-fields with one to two fenestriform large pits and ray tracheids with clearly visible dentate walls (Figure 5), while Bosnian pine has pinoid pits in its cross-fields and ray tracheid with smooth or slightly dentate walls (Figure 6) [51]. The number of rays per 1 mm^2 and the height of the rays (both features observed in the tangential section) is also slightly different. Bosnian pine has a higher number of rays per 1 mm^2. The height of its rays varies from 1 to 30 cells, while in Black pine the height of rays can reach a maximum of 15 cells [52].

Results of wood identification suggest that both Bosnian and Black pine were almost equally used for the construction of the Monastery, during the three identified periods (see next paragraphs). Bosnian pine seems to have been preferred for the floor beams (Figure 3a), Black pine for the cantilever beams (Figure 3b), and for the vertical elements that support the floor beams on beams placed on the lower level (Figure 3c) both species have been used. Although both pine species were present in the pile of discarded timber, Black pine was the only species used for planks that were most probably removed during previous restorations.

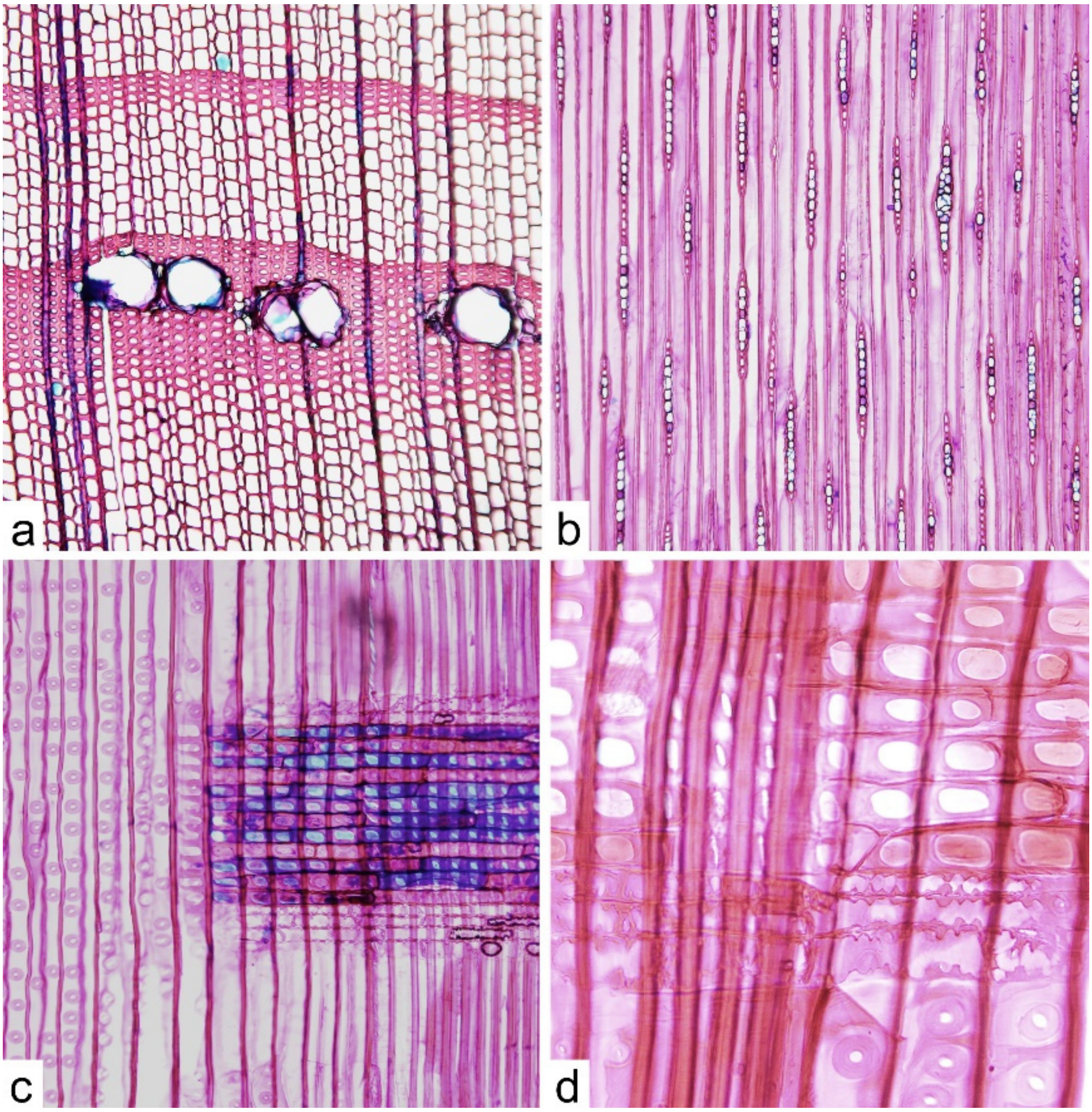


Figure 5. Black pine—*Pinus nigra*, sample no. ANM0007. Microscopic slides: (**a**) cross-section in which the well-defined growth rings and the quite rapid transition from early to latewood are visible, moreover, resin canals located in the latewood are visible; (**b**) tangential section—uniseriate and fusiform rays are visible; (**c**) radial section—heterogeneous ray is visible; (**d**) radial section—fragment of heterogeneous ray with window-like pits in cross fields is visible.

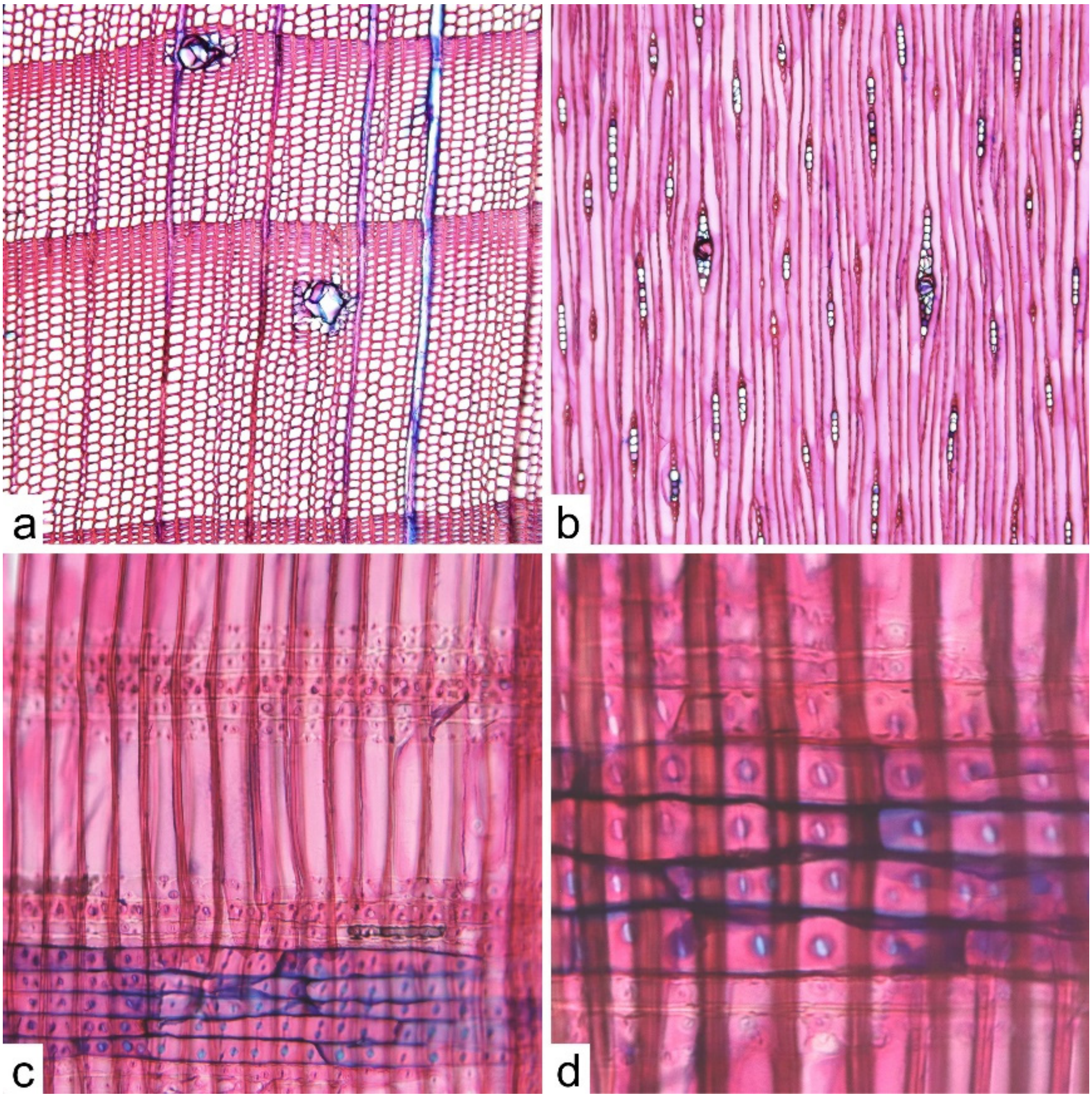


Figure 6. Bosnian pine—*Pinus heldreichii*, sample no. ANM0008. Microscopic slides: (**a**) cross-section in which the well-defined growth rings and the gradual transition from early to latewood are visible, moreover, two resin canals are visible; (**b**) tangential section—uniseriate and fusiform rays are visible; (**c**) radial section—two heterogeneous rays are visible; (**d**) radial section—heterogeneous ray with pinoid cross-field pits (1 to 2 pits per cross-field) is visible.

3.2. Development and Use of Local Reference Chronologies in Dendroarchaeology

From the cores collected from living trees we created a mean reference chronology per species. The length of the developed chronology for Bosnian pines is 611 years, after removing the first years where the sample depth was not sufficient. It covers the period 1408–2018. For Black pine 19 of the 20 sampled trees were used for the development of the reference chronology (Table 2), since one had rather individual tree-ring patter. The Black pine reference chronology is 344 years-long, expanding from 1677 to 2020. The two chronologies were successfully used to date the historical timber collected from the Monastery of St. Nicholas (see Section 3.3).

Table 2. Descriptive statistics of the reference chronologies developed for the two pine species. The average age per species is reported together with the minimum and maximum values of the sampled trees. Standard deviation (std dev) is provided for the mean series intercorrelation.

Developed Reference Chronology	Species	Number of Dated Series	Average Age	Mean Series Intercorrelation (std dev)
MAVRO01m	*Pinus heldreichii*	51	405 (126–735)	0.589 (0.08)
MAL0001m	*Pinus nigra*	19	292 (189–344)	0.584 (0.08)

3.3. Dendrochronological Dating of Historical Timber

Eighteen (86%) of the 21 samples collected from the auxiliary building of the Monastery were synchronized and absolutely dated. The samples were divided into three different groups based on the species and the period covered. All Black pine samples were dated, while for Bosnian pine three samples remained undated. The mean series length of the three undated Bosnian pines was 60 rings, while for the dated ones it was more than double (127 rings).

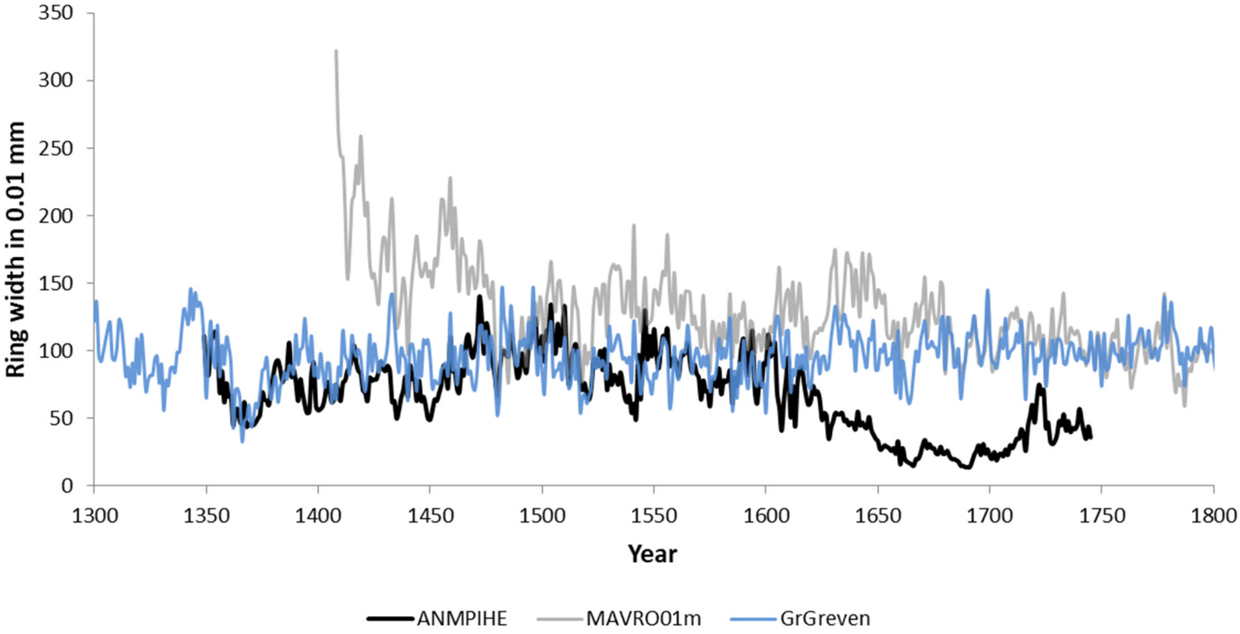
The seven synchronized Bosnian pine samples, collected all except one from standing elements, created a long mean chronology covering 397 years (Table 3). The developed chronology (ANMPIHE) was cross dated against our Bosnian pine chronology from the study area (MAVRO01m), yielding 1745 AD as the last year (Figure 7a, Table 4). Very high t-values were also obtained against Bosnian pine chronologies from elsewhere in Greece [35,53], but also against Albania [29] and Mt Pollino in Italy [54,55]. The same ending year is also given against our newly developed Black pine chronology (MAL0001m) from the study area, although with rather low t-values (Table 4). Statistical cross-dating suggests that timber originates from the broader study area.

Table 3. Mean chronologies developed for the two pine species from historical timber from the Monastery of St. Nicholas.

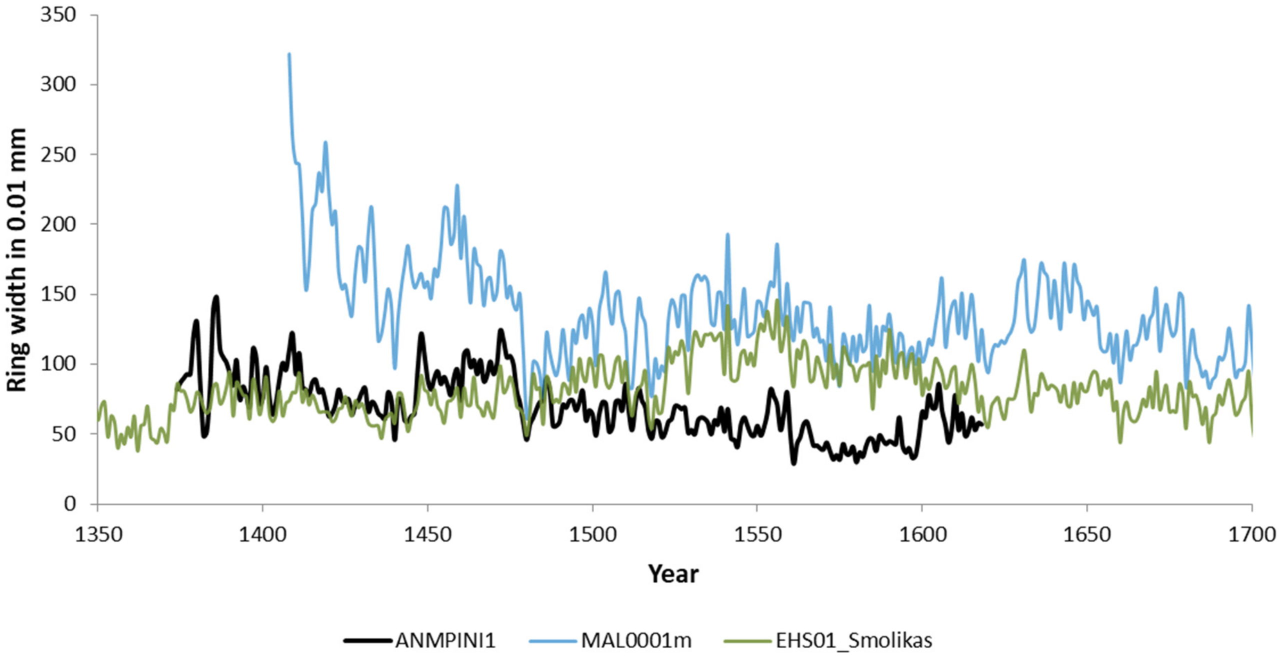
Developed Mean Chronology	Species	Number of Series	Average No. of Rings Per Series	Total No. of Years	Years AD
ANMPIHE	*Pinus heldreichii*	7	127	397	1349–1745
ANMPINI1	*Pinus nigra*	8	128.4	245	1374–1618
ANMPINI2	*Pinus nigra*	3	123.7	181	1677–1857

Black pine samples were divided into two groups. The first group comprises eight samples collected both from standing elements and discarded timber. The synchronized samples created a mean chronology covering 245 years (ANMPINI1) (Table 3). In this case our developed Black pine chronology could not be used as a reference chronology since it was not long enough, but very high t-values were obtained against Bosnian pine chronologies from the study area and elsewhere, all giving 1618 AD as the last preserved ring (Figure 7b,Table 4).

The second Black pine floating chronology, consisted of three samples represented timbers of unknown origin and covering a 181-year-long period (ANMPINI2) (Table 3), was cross-dated both against local Black pine chronology and chronology from Mt Taygetos in Southern Greece [56] (Figure 7c, Table 4). The same ending year, namely 1857 AD, was obtained against Bosnian pine chronologies from the broader study area. Therefore, for Black pine it can be supported that the timber originates most probably from Greece, but the exact location remains unclear.

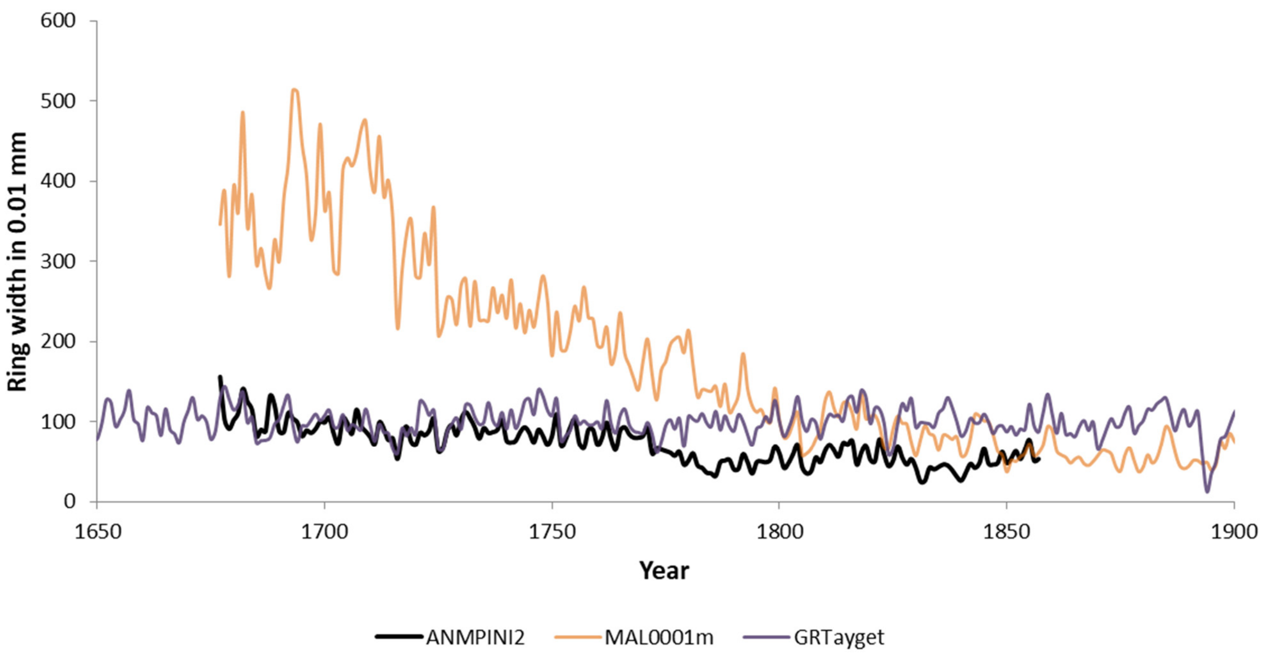


(a)



(b)

Figure 7. *Cont.*



(**c**)

Figure 7. Visual cross-matching of the newly developed mean chronologies (in black) and the reference chronologies with different colors. Only the overlapping period of the reference chronologies is presented. (**a**) Bosnian pine chronology (ANMPIHE) with Bosnian pine chronology from the study area (MAVRO01m) and Grevena (GrGreven) [53]; (**b**) Black pine chronology (ANMPINI1) with Bosnian pine chronology from the study area (MAVRO01m) and Mt Smolikas (EHS01_Smolikas) [35]; (**c**) Black pine chronology (ANMPINI2) with Black pine chronology from the study area (MAL0001m) and Mt Taygetos (GRTayget) [56].

Table 4. Cross-dating results of the three developed pine chronologies (PIHE for *Pinus heldreichii* and PINI for *Pinus nigra*) against the reference chronologies providing the best results. t-value Baillie-Pilcher (TVBP) and t-value Hollstein (TVH) are t-values sensitive to extreme values, such as marker years. CDI = cross-dating index; Glk = Gleichlaeufigkeit, a measure of how well the growth of two trees corresponds to each other in an overlapping set of years.

Developed Mean Chronology	Reference Chronology		Years AD of the Reference Chronology (No. of Years)	TVBP/TVH	CDI	Glk	No. of Overlapping Years
	Code (Species)	Region					
ANMPIHE	MAVRO01m [39] (PIHE)	Mavrovouni summit, located 9 km N–NW of Metsovo (Greece)	1408–2018 (611)	9.8/11.0	68	69 ***	338
	GrGreven [53] (PIHE)	Grevena forests (Greece)	1243–2002 (760)	11.8/12.7	82	67 ***	397
	EHS01 [35] (PIHE)	Mt Smolikas (Greece)	575–2015 (1441)	10.9/12.0	78	68 ***	397
	Albania2 [29] (PIHE)	Fushe Lura (Albania)	617–2008 (1392)	9.2/9.6	63	67 ***	397
	POLPIHE [54] (PIHE)	Mt Pollino (Italy)	1148–1974 (827)	8.6/8.3	56	66 ***	397
	MAL0001m (PINI)	Black pine forest ~9 km E-NE of Metsovo (Greece)	1677–2020 (344)	3.6/3.5	13	65 **	255
ANMPINI1	MAVRO01m [39] (PIHE)	Mavrovouni summit, located 9 km N–NW of Metsovo (Greece)	1408–2018 (611)	9.5/9.0	59	67 ***	211
	EHS01 [34] (PIHE)	Mt Smolikas (Greece)	575–2015 (1441)	10.9/9.7	67	66 ***	245
ANMPINI2	MAL0001m (PINI)	Black pine forest ~9 km E-NE of Metsovo (Greece)	1677–2020 (344)	7.4/6.5	44	63 ***	181
	GRTayget [56] (PINI)	Taygetos forest, Peloponnese (Greece)	1657–1999 (343)	9.1/7.7	55	65 ***	181

: statistical significance of Glk (99.9%; ** 99.0%).

3.4. First Dating Results for the Monastery of St. Nicholas

Although this is not a complete dendrochronological survey of the Monastery's available timber, since only the auxiliary building has been studied, some first conclusions can already be reached. The examined timber reveals three different phases of the building history (Figure 8). The first one can be extracted by the ending dates of the standing elements, covering the period from the end of the 15th century to the early beginning of the 17th century (outermost rings dated from 1498 to 1602 AD). During this period Bosnian pine was used as floor beams, while both pines were used for vertical timbers supporting the floor on beams at lower level. Black pine timber from the mid-16th to early 17th century (outermost rings dated from 1526 to 1618 AD) was also found as discarded timber left inside the basement, suggesting that some restoration works took place in the complex during this period. The discarded wood is not necessarily related to the auxiliary building—the elements could be removed from other buildings belonging to the Monastery complex e.g., from the church. The second phase is supported by two samples collected from the pile of loose timber: 1745 for the Bosnian pine sample and 1773 for the Black pine sample. These dates may be in accordance with historical archives supporting that after 1700 AD the temple of the church was renovated and the icons that were found in its interior belong to the 17th and 18th century. Since we cannot assume that these timbers are related with the above-mentioned renovation, additional sampling from the church and other structures that belong to the monastery, is needed. The last phase, accentuated by the Black pine loose timber is the early-mid 19th century (1826, 1857), most probably representing a more recent restoration intervention. Since in none of the collected samples the bark, or the waney edge, i.e., the edge of timber underneath the bark [57], were present all results should be treated as *terimus post quem* dating.

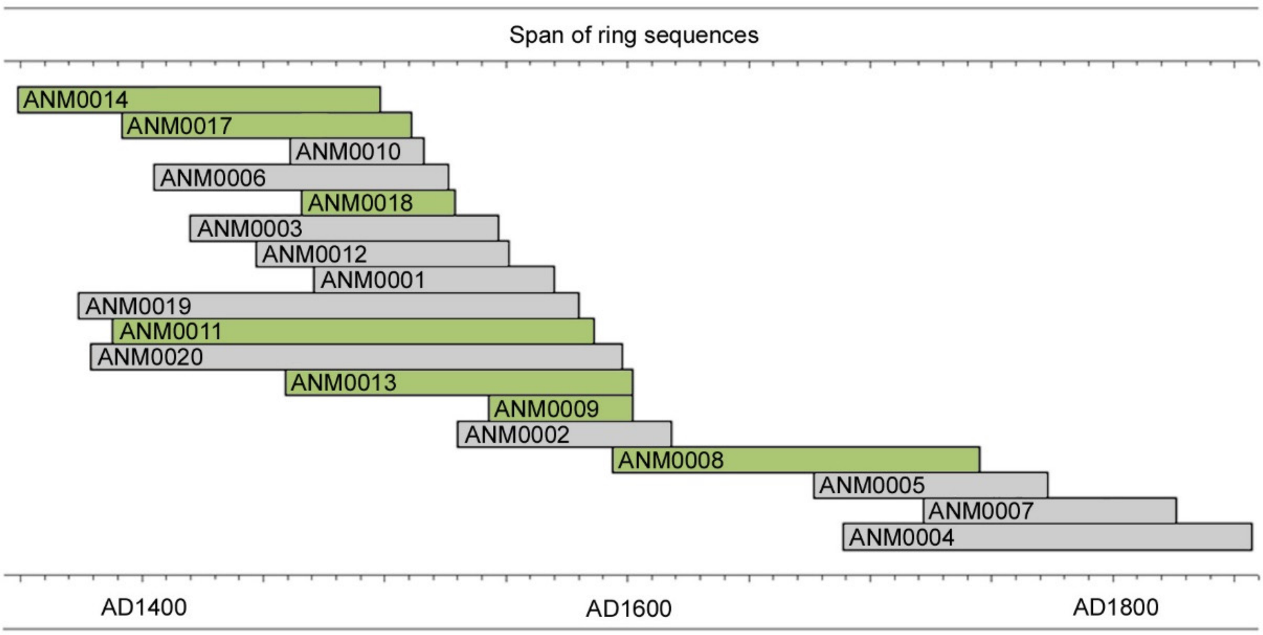


Figure 8. Chronological span of dated pine timbers (Bosnian pine in green, Black pine in gray) from the Monastery of St. Nicholas. Graph was prepared in DENDRO for Windows [50].

Two of the three undated Bosnian pine samples collected from the floor beams, could possibly represent re-used timbers, but the length of these samples did not allow their synchronization and dating.

4. Discussion

Dating of historical buildings is of great importance when studying cultural heritage and human past [58]. Dendrochronology is an excellent tool for dating and reconstructing the history of buildings, despite existing limitations that should be taken into account both by the practitioners and the end users of the dating results [2]. Proper sampling may overcome most of limitations. It can give valuable results when it is studied and correlated with historical research and documentation, based also on observations on site too, concerning architectural and constructional data. The position and mainly the structural role and architectural features of the timbers that are sampled are of great importance for the assessment and the interpretation of the results for the dating of the buildings. Despite the great advances in dendrochronological studies, such studies are not equally distributed [1]. There are still areas with great dendroarchaeological potential remaining almost unexplored. This seems to be the case for Metsovo and the broader area of Pindus and Epirus, despite the pioneer dendrochronological studies performed by Kuniholm and Striker [53,55]. Results of the current study highlight the dendroarchaeological potential of the area, together with the importance of Bosnian pine timber in studying historical buildings.

Bosnian pine turned out to be wood commonly used in areas with forest stands of this species. Trees that grow slowly and regularly in high mountain conditions reach the age of several hundred years and even smaller structural elements have a sufficient number of tree-rings [59] to achieve successful dating. Bosnian pine was proved to be a valuable species in dating historical buildings, but caution is needed in terms of wood identification, given the fact that it co-exists with Black pine and the macroscopic identification of the two species is impossible when dealing with historical wood. Study of the wood anatomical features under microscope on radial thin sections is required to safely distinguish the two species.

As previously stated [1], there is a number of multi-centennial long Bosnian pine chronologies that can be used in dendroarchaeology for Southern Europe. Nevertheless, given the high correlations that are observed even between Bosnian pine populations located far away from each other [55] the use of regional and supra-regional reference tree-ring chronologies should be treated with caution in terms of dendroprovenancing [17,60]. This is also supported by our results with the very high statistical correlations of the developed Bosnian pine chronology from historical timber not only against Bosnian pine chronologies from Greece, but also against Albania [29] and Italy [54,55]. There are though several approaches that can be performed in order to improve results of dendroprovenancing including stable carbon or strontium isotopes, DNA analyses, etc., e.g., [2,17,61] depending, among others, on the species under study. The high correlation between the Bosnian pine chronologies will definitely increase the effectiveness of dendrochronological dating thanks to the high percentage of dated elements. Dating results are supported by various chronologies across the whole range of species distribution.

Similar to Bosnian pine, the exact origin of Black pine timber remains unclear, although cross-dating results suggest that they could both represent local timber and the high correlations with populations from elsewhere in Greece could be attributed to strong teleconnections. This is further supported by the fact that reference chronologies of one species can be used to date timber belonging to the second species, which significantly increases the potential of dendroarchaeology. Mixed conifer chronologies are commonly used in dendroarchaeology, especially in the geographical regions where *Pinus sylvestris* and *Pinus nigra* grow together because distinguishing between the wood of both species is not possible on the base of microscopic wood anatomy. High correlation values between different conifer species were also observed and used for successful dendrochronological dating e.g., [62].

Regarding the dating and history reconstruction of the Monastery of St. Nicholas, three different phases have been detected with both Bosnian and Black pine having been used during the period from the end of the 15th century to the early beginning of the 17th century, but also in restorations that took place during the 18th century. In the last recorded restoration phase by the early-mid 19th-century Black pine timber was used. The origin of all used timbers seems to be local, with the exception of the Black pine timber used in the more recent restoration whose origin remains unclear. The use of local timber is expected given the availability of forests and available timber in the broader area of Northern Pindus National Park.

Concerning the chronologies developed from living Bosnian and Black pine trees they were proved to be useful for the dating of historical wood in the study area. Apart from their dendroarchaeological interest, the developed chronologies are of great importance also in terms of the climate of the region and of nature conservation since they confirm the presence of multi-centuries old pine stands requiring special protection, given the multiple benefits they offer to local biodiversity, including the offer of suitable habitats for several species groups such as hole-nesting birds, arboreal mammals, bryophytes, lichens and fungi [63]. Meanwhile, they may provide valuable information concerning the social fabric, the anthropogenic activity of the area, concerning traditional professions and crafts of the past, related to timber (logging, wood processing, and treatment, resin collection, woodcarving, barrel making, etc.), and the presence of natural disturbances such as forest fires [39], since mature trees of both species can withstand surface fires [20,64–68].

Our study highlights the dendrochronological potential of the study area and confirms the usefulness of Bosnian pine timber in dating historical wood, opening new horizons to the implementation of future dendroarchaeological surveys both in Northern Pindus, in Epirus, in West Macedonia, and elsewhere within the natural distribution of the species.

5. Conclusions

For the first time, buildings made of *Pinus heldreichii* wood became the subject of dendroarchaeological studies. The results of our study confirm the high potential of Bosnian pine for dendroarchaeology and dating of historical timber. Metsovo and the broader area of Northern Pindus and Epirus, have great potential with numerous historical buildings and artifacts, disposing of timber with a high number of preserved rings adequate for dendroarchaeological studies. Although Bosnian and Black pine are the two most frequently used species, other species also useful for dendrochronology, including deciduous oaks, are also present. Future dendrochronological surveys of the area are expected to increase the dataset of dated timber for Greece and provide important insights to the built and natural environment and the cultural heritage of the region.

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