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Aegean Trees and Timbers: Dendrochronological Survey of the Island of Symi

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Received: 15 October 2020; Accepted: 25 November 2020; Published: 27 November 2020



Abstract: The current study presents the results of the first dendrochronological survey performed over the East Aegean island of Symi. **Research Highlights:** Dendrochronological research of the East Aegean region is of paramount importance since dendrochronological data from the region, and especially the islands, are still limited. **Background and Objectives:** The main aim of the study is to explore the dendrochronological potential of the island, focusing on the dating of historical wood and buildings as well as dendroprovenancing. **Materials and Methods:** A total of 57 wood samples were collected from historical timber from windmills and architectural elements, including doors and warehouse planks, while 68 cores were collected from the three dominant tree species of the island—*Cupressus sempervirens*, *Pinus brutia*, and *Quercus ithaburensis* subsp. *macrolepis*—in an attempt to develop local reference chronologies that could be useful in dating historical timber. **Results:** Of the historical timber, at least nine different species have been detected, with conifers representing the majority of the collected material. In total, 56% of the dendroarchaeological samples, belonging to four different species, were dated absolutely. According to cross-dating and dendroprovenancing results, *Pinus nigra*, *Cedrus* sp., and *Quercus* sp. represent timber imported from present-day Turkey while the fir samples collected from the windmills originate from Central Europe. The use of local timber is also highly probable although it could not be confirmed by the reference chronologies developed for the three dominant tree species of the island. **Conclusions:** The results of the study reveal the dendrochronological potential of the island from both dendroarchaeological and dendroecological perspectives. The finding that most of the wood was imported mainly from Turkey highlights the importance of timber trade with the Turkish mainland during the mid-18th and 19th centuries. Chronologies developed from living trees could be used in future studies for dating historical material while further research would increase our understanding of past timber trade and the island's history.

Keywords: dendroarchaeology; tree-rings; cypress; Turkish pine; valonia oak; conifers; timber; trade

1. Introduction

A dendrochronological survey of the Aegean islands is of paramount importance since, up to now and according to our current knowledge, dendrochronological data from the region are limited to Crete [1–6], Samos [7,8], and Euboea [9,10]. The majority of these studies focus on living trees and the environmental and/or climatic factors that drive their growth trend and survival [1–5,7–9]. Only two of these studies deal with dendroarchaeological studies of historical buildings from the Venetian and Ottoman periods [6,10]. There are plenty of reasons why the inland part of Greece has been overlooked compared to the mainland with regard to living trees. The main reason is the lower suitability of tree species for dendrochronology and the expected limited availability of older trees, compared to the

higher mountains of continental Greece, as trees of lower altitudes are more exposed and prone to human activities, and therefore they rarely reach really old ages. Nonetheless, the presence of old trees on the Aegean islands cannot be ruled out, especially on islands where species such as *Cupressus sempervirens*, *Pinus brutia* and *Quercus ithaburensis* subsp. *macrolepis* are still present. In terms of historical timber, dendrochronology has been mainly limited to northern Greece [11,12] where the available timber was more abundant and easier to handle. Nonetheless, recent studies highlight the potential of several historical buildings such as monasteries, churches, and mansions, where timber is available in Southern Greece and the islands [13].

The current study presents the results of the first dendrochronological survey performed on the island of Symi, an East Aegean island. We initiated our dendrochronological survey after a request to date a group of standing windmills located on a hill to the east of Ano Symi (Figure 1). Our first visits to the island revealed its dendrochronological potential not only from a dendroarchaeological perspective, but also for dendroecological and future climate reconstruction studies, due to the presence of old-looking forest stands and woodlands. The main objective of our study was to perform the first dendrochronological survey of the island, focusing on dating of historical timber and dendroprovenancing. To identify and date locally sourced timber which may have been utilized in local buildings and carpentry, cores from living trees were collected to develop local tree-ring chronologies. Such local chronologies are essential for the ongoing development of an eastern Mediterranean master chronology since the only continuous tree-ring chronology available for the region going back to 1089 AD has been developed from material originating from only Turkey and mainland Greece [14]. However, the material used for that master chronology contains also wood imported from the Balkans [15]. Therefore, the development of local chronologies from any part of the eastern Aegean region could prove beneficial for different disciplines and regional projects.

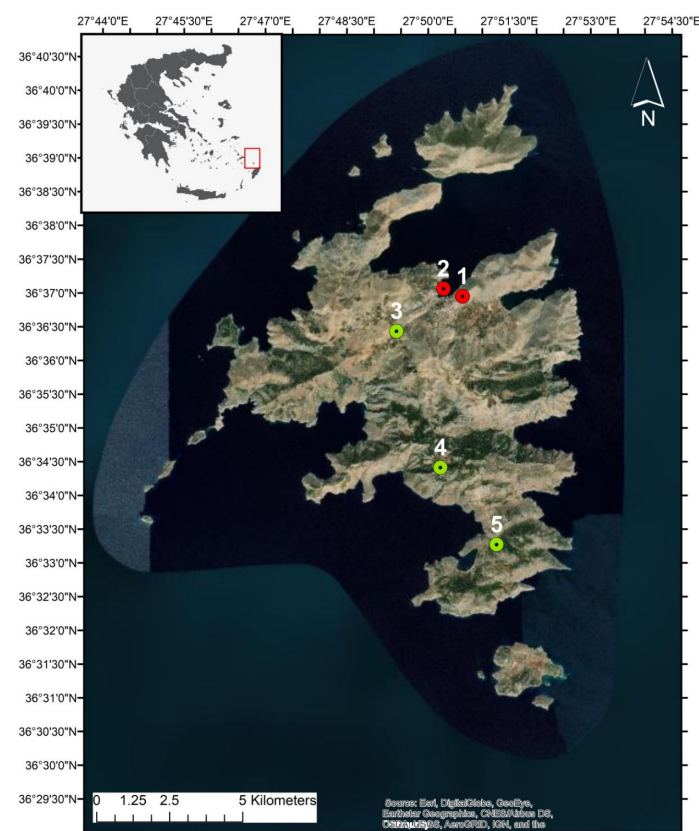


Figure 1. Location of the study area and the different study sites where samples were collected from historical timber (red dots) and living trees (green dots): (1) windmills, (2) doors and imported timber, (3) valonia oak woodland, (4) Cypress forest, and (5) Turkish pine forest.

2. Materials and Methods

2.1. Study Area, Study Sites, Study Material, and Sample Collection

Symi is a Greek island, geographically belonging to the Dodecanese island chain, located about 41 kilometres N-NW of Rhodes, while the nearest mainland is made up of the Datça and Bozburun peninsulas of Muğla province of Turkey. The island is mostly mountainous and rocky, and its highest elevation (Vigla peak) is 616 m. The Municipality of Symi covers the neighbouring uninhabited offshore islets with a total land area of 65,754 km² [16]. The climate of the island is semi-arid Mediterranean, with short, mild and wet winters, followed by long, hot and dry summers [17]. The economy of Symi was traditionally based on shipbuilding and sponge industries [18] and the island was particularly prosperous during the 19th century thanks to these two activities (Zographos, pers. com.). The island remained under the Ottoman rule from 1522 until 1912, but it was allowed to retain many of its privileges. Nowadays, the main source of income for the island is tourism, and the presence of tourists who regularly visit the islands is of particular interest from an anthropological point of view [19].

The vegetation of the island mainly consists of phrygana communities (low evergreen, shrub formation), remnants of pre-existing conifer woodlands dominated by cypress (*Cupressus sempervirens* L.) and Turkish pine (*Pinus brutia* Ten.), as well as sclerophyllous and deciduous forests [17]. Although Symi is one of the few islands where natural stands of Cypress can still be found [20], it is believed that cypress forests were wider in size in the past while, according to locals, most of the cypress trees today are younger than the end of the Ottoman period (1912 AD). In several parts of the island, especially in the north, valonia oak (*Quercus ithaburensis* subsp. *macrolepis* (Kotschy) Hedge and Yalt.) woodlands can be seen. Although Symi is not mentioned in the distributional and phytogeographical study of the taxon [21], both the areas where valonia oak woodlands are present and the understory vegetation are very similar to those described by Vrahnakis et al. [22]. Nevertheless, it is unclear whether these open woodlands are remnants of the once-existing wider natural forests or emerged as a result of large-scale cultivation, livestock grazing, and acorn production.

2.1.1. Historical Timber

1. The standing windmills

The first study site was a group of six standing windmills located within a private land on a hill to the east of Ano Symi (Figure 2). The owner of this land, the architect in charge of the ongoing renovation project as well as the Ephorate of Antiquities of Dodecanese responsible for Symi, wanted to know the age of these windmills. According to the architect, local timber was used in the construction of these six windmills. Historical photos from the 19th century suggest that only two of them functioned as windmills at the time. Furthermore, the roof construction of a few of them suggests that they were used as a shelter for local shepherds.

We visited the study site in autumn 2018. After a visual inspection of the windmills, a total of 39 samples were collected from four of them (described as no. 1, no. 2, no. 4 and no. 5). In two others, there was no access to wooden elements. The majority of the samples were collected from roof beams (41%) while 35.9% were taken from floorboards. Some of the wood seemed to have been reused. In total, 23.1% of the samples were taken from different parts of the preserved doors. Since the interior sections of all of the windmills would be either restored or disassembled, we were allowed to collect samples by cutting cross-sections with a hand saw. Only in two cases were samples from the roof beams taken in the form of a core with the use of a modified electric drill.

2. Doors and imported warehouse planks

In addition to the windmills, we also examined loose timber preserved in a storehouse on the island (Figure 1). These timbers belonged to a total of three different wooden doors (Figure 2) found in different buildings of the island, but with no further information concerning their origin or their

architectural context. All of the 14 samples collected from Symi's doors were in the form of wood strips. We also examined four warehouse planks, probably imported from Turkey according to the local architect, in order to date them and confirm their origin. From each one of them we collected one sample in the form of slices.



Figure 2. Historical timber examined in the current study: (a) one of the examined doors; (b) one of the standing windmills on a hill to the east of Ano Symi; (c) its interior.

2.1.2. Cores from Living Trees

To develop local reference chronologies that could be used for dating historical timber of local origin, we collected cores from the three dominant tree species of the island: namely cypress, Turkish pine and valonia oak at three distinct sites (Figure 1). Cypress forms rather dense forest stands in the central part of the island where trees of different age classes, where an almost total absence of shrub layer, low natural regeneration, and scattered presence of pine trees can be observed. Turkish pine also forms dense forests, especially on the southern part of the island. Most trees seem to belong to the same age class while some older dominant trees are also present. Natural regeneration is poor while shrub layer is loose, mostly covered with *Pistacia lentiscus* L. and *Cistus* spp. Valonia oak forms open woodlands in old agricultural terraces and livestock land. In these formations *Quercus coccifera* L. and *Pistacia terebinthus* L. are also present in the tree layer while *Asphodelus* sp. represents the most common herbaceous species.

Two cores per tree were taken for the two conifer species while for valonia oak one core per tree was extracted. A total of 68 cores were collected from 40 trees (Table 1). Sampling was performed manually with the use of a 5 mm increment borer while for the hardwood oak increment borer was adjusted to Smartsocket (Technoforest Co. Ltd., Tokyo, Japan) attached to the impact wrench Makita DTW1001RTJ.

Table 1. General characteristics of the three study sites from where cores from living trees were collected.

Species	Latitude	Longitude	Elevation	Aspect	No. of Sampled Trees (No. of Cores)
<i>Cupressus sempervirens</i>	36.573567°	27.837136°	460	N-NE	14 (28)
<i>Quercus ithaburensis</i> subsp. <i>macrolepis</i>	36.607239°	27.823600°	280	E	12 (12)
<i>Pinus brutia</i>	36.554545°	27.854378°	95	NW	14 (28)

Coordinates are given in decimal degrees.

2.2. Samples Preparation, Measurements, and Statistical Analysis

In the laboratory, all 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. Before tree-ring width measurements, we performed wood identification of historical timber. Identification was based on observation under a biological microscope by comparing wood structures against reference material from known tree species [23–26]. For samples and species suitable for dendrochronology, tree-ring widths were measured to 0.01 mm using Time Series Analysis and Presentation software (TSAP-Win) [27] and a LINTAB (Rinntech Inc. Heidelberg, Germany) measuring table.

After grouping the samples into species, we tried to synchronize samples of each group and to develop mean chronologies. “Floating” chronologies from historical timber were cross-dated and synchronized with regional and supra-regional reference chronologies [28]. Cross-dating was performed with the use of TSAPWin and its results were evaluated based on the following parameters: (I) Gleichlaueufigkeit (Glc), a measure of how well the growth of two trees parallel each other in an overlapping set of years; (II) t-value Baillie-Pilcher (TVBP) [29] and t-value Hollstein (TVH) [30], t-values that are sensitive to extreme values, such as marker years; (III) Cross-Dating Index (CDI), which combines I and II [27]. The common interval expressed by the number of overlapping years (OVLs) was also considered. In addition to TSAP, we used the packages “dplR” and “tidyverse” in the R statistical software package [31] for visualization of the results and further statistical analysis. Series from living trees were used to develop reference chronologies per species. For dating historical timber, we used both mean chronologies without detrending and mean chronologies after detrending in order to remove the age-related trends in ring-width series. For mean chronologies without detrending, the period of analysis for cypress and oaks was restricted to the last 60 years and to the last 70 years for pines so as to: (I) have sufficient sample depth and (II) avoid juvenile wood. Juvenile wood is formed during the first 20–30 years of a tree’s life. Since this is the phase of growth when young trees are becoming established and struggling to reach the canopy, the tree-ring pattern can be irregular and reflect mainly tree-specific variation [32,33]. As a consequence, short tree-ring series of juvenile wood generally do not match very well between different trees and are more difficult to date as they do not contain a strong environmental/climate signal, which is the basis for a significant match [34]. For detrending we selected the approach in which ring-width series are fitted with a negative exponential curve. This commonly used method tends to preserve high-frequency variation of a shorter duration than the length of the individual series (interannual and interdecadal variation) while removing longer-term low-frequency trends [35].

3. Results

3.1. Tree Species Identification for Historical Timber

3.1.1. The Standing Windmills

Timber from windmills revealed at least nine different species: six conifers, representing the majority of the samples (79.5%) and at least three angiosperms. Most samples (25.6%) are high and

mid-altitude pine (*Pinus* sp.). They were used mainly for floor planks, but also for door planks and beams. The pine samples could be either Scots pine (*Pinus sylvestris* L.) or Black pine (*P. nigra* J.F. Arnold), since the two species cannot be distinguished by their wood anatomy [24]. Nonetheless, the results of dendroprovenancing (see Section 3.2.1) suggest that they are most probably Black pine. The second most common species (23.1%) was fir (*Abies* sp.), used for doors and floorboards, while cedar (*Cedrus* sp.) (17.9%) was also used for different types of beams. Two samples are spruce (*Picea abies* (L.) H. Karst.), and another two are low-altitude pine, most probably Turkish pine (*Pinus brutia*), which is also prevalent on the island. Angiosperms were all found in the roof structures, but most of them remain unidentified. None of them were useful for dendrochronology due to the very short tree-ring series (fewer than 5–10 rings)

3.1.2. Doors and Imported Warehouse Planks

All of the 14 samples collected from the doors are conifers, with high-altitude pine—probably Black pine—representing 57.1% and cedar 42.9%, while the four warehouse planks being made of deciduous oaks.

3.2. Dendrochronological Dating and Dendroprovenancing

Twenty-eight (56%) of the 50 dendroarchaeological samples useful for dendrochronology were dated absolutely. These samples were grouped into three different conifer species and deciduous oaks. The rest of the samples could not be dated, due to either the short length of developed chronologies per species or the low replication of tree-ring series or the lack of proper master chronologies.

3.2.1. Black Pine (*Pinus nigra*)

We were able to date 12 (66.7%) of the Black pine samples, eight of which were taken from different elements of the windmills while the rest were from local doors. The synchronized samples created a mean chronology covering 234 years (Figure 3, Table 2). The developed chronology (SYMIPN01) was cross-dated against several pine chronologies. The best results were obtained against Turkish Black pine chronologies, with several of them giving 1898 AD as the last year. The best cross-dating results [36] are presented in Table 3. The visualization of cross-matching is presented in Figure 3.

The synchronization of the developed chronology with ten Black pine chronologies from Turkey helps to determine the provenance of the timber and consolidates the wood identification results.

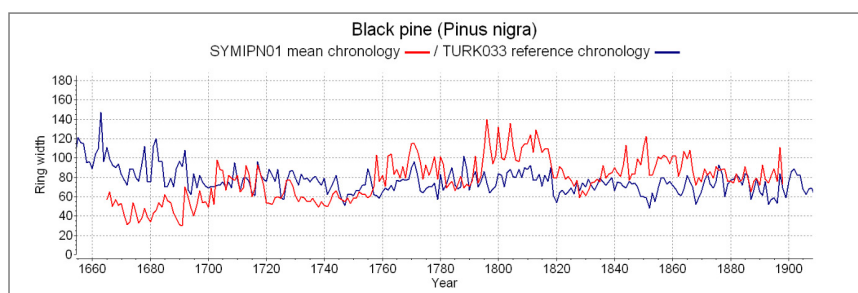


Figure 3. Visual cross-matching of the Black pine chronology (SYMIPN01, in red) with the *Pinus nigra* chronology from the area around Alanya and Cevizli in Turkey (TURK033, in blue) [36]. Only the overlapping period of the two chronologies is presented here.

Table 2. Mean chronologies per species for historical timber from Symi.

Species	Number of Series	Average No. of Rings Per Series	Total No. of Years	Years AD
Black pine	12	77.1	234	1665–1898
Cedar	4	92.3	159	1721–1879
Deciduous oak	4	140.5	320	1532–1851
Fir	7	61.1	127	1746–1872

Table 3. Cross-dating results of the developed chronologies 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 = Gleichlaufigkeit, a measure of how well the growth of two trees corresponds to each other in an overlapping set of years.

Species	Developed Chronology	Reference Chronology Code	Region	Years AD of the Reference Chronology (No. of Years)	TVBP/TVH	CDI	Glk	No. of Overlapping Years
Black pine	SYMIPN01	TURK033 [36]	Around Alanya-Cevizli (Turkey)	1597–1995 (429)	5.5/5.3	33	62 ***	234
Fir	SYMIAA02	0526102m [37]	South Germany	877–1963 (1087)	4.3/5.3	34	72 ***	127
Cedar	SYMICL03	ElmalıRa [38]	Hüseyin Kuyusu (Turkey)	1449–2000 (552)	4.9/4.4	32	66 ***	159
Deciduous oak	SYMIQS04	BEK0001m [39]	Bekedemirköy (Turkey)	1089–1875 (787)	9.2/9.5	71	71 ***	320

***: statistical significance of Glk at 99.9%.

3.2.2. Fir (*Abies alba*)

Seven of the ten fir samples, collected from the windmills, were dated. The seven synchronized samples helped us create a mean chronology covering 127 years (Figure 4, Table 2). The developed chronology (SYMIAA02) was cross-dated against several fir chronologies, both from Europe and Turkey. The best results were obtained against *Abies alba* Mill. chronology from South Germany [37], with the last year going back to 1872 AD (Table 3). Fir timber found in the windmills seems to originate from the Alps.

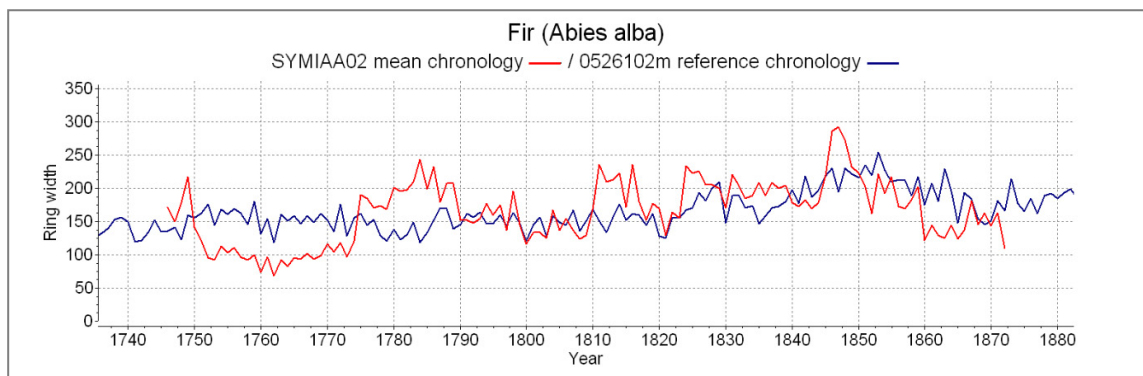


Figure 4. Visual cross-matching of the fir chronology (SYMIAA02, in red) with the revised version of the South German *Abies alba* chronology (0526102m, in blue) [37]. Only the overlapping period of the two chronologies is presented here.

3.2.3. Cedar (*Cedrus libani*)

Five of the 13 cedar samples (38.5%), with four of them originating from different parts of Symi's doors and one from the windmill, were synchronized for developing the mean floating chronology SYMICL03, consisting of 159 years. This chronology was dated against several cedar chronologies, most of them originating from Turkey, and the best cross-dating results were obtained against a *Cedrus libani* A. Rich. chronology [38] from Turkey (Figure 5). The last year of the developed chronology is 1879 AD. The Turkish provenance of the timber was determined based on synchronization with several different Turkish chronologies.

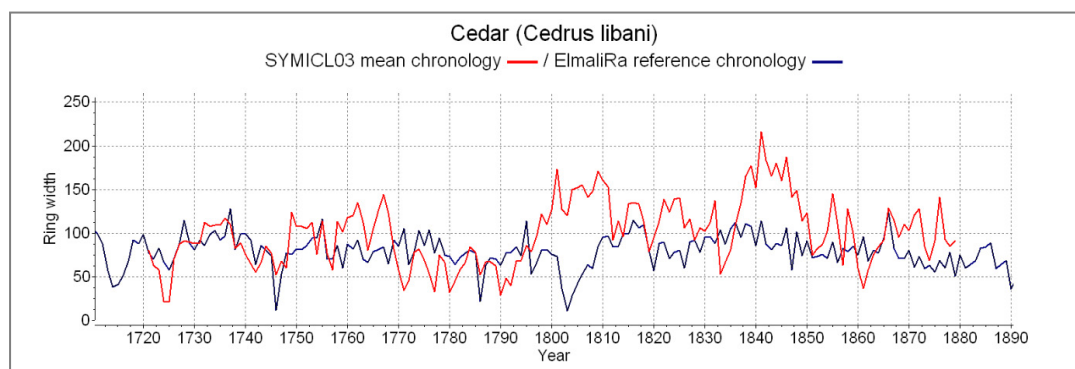


Figure 5. Visual cross-matching of the cedar chronology (SYMICL03, in red) with the *Cedrus libani* chronology from Turkey (ElmalıRa, in blue) [38]. Only the overlapping period of the two chronologies is presented here.

3.2.4. Deciduous Oak (*Quercus* sp.)

All of the four oak planks examined were synchronized into a mean chronology of 320 years (SYMIQS04) (Table 2) and dated against a Turkish deciduous oak chronology from Bekedemirköy [39], yielding 1851 AD as the last year (Table 3, Figure 6). The oak timber originates from Turkey.

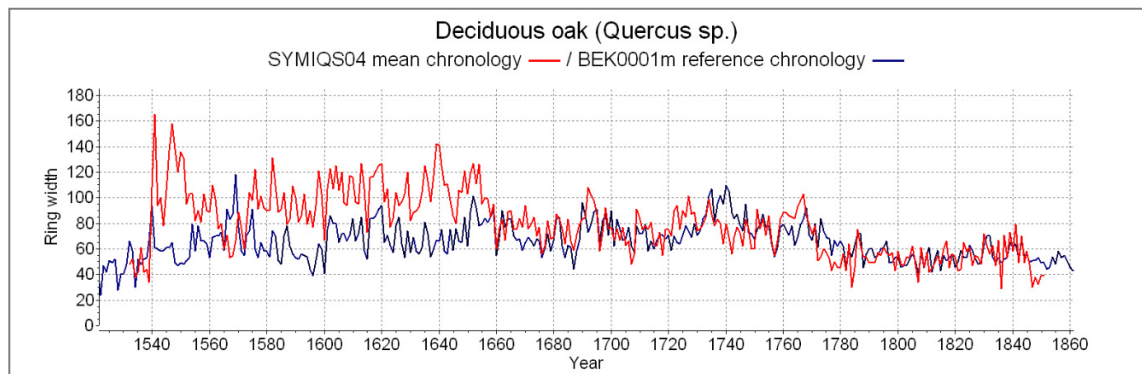


Figure 6. Visual cross-matching of the oak chronology (SYMIQS04, in red) with deciduous oak chronology from Bekedemirköy in Turkey (BEK0001m, in blue) [39]. Only the overlapping period of the two chronologies is presented here.

3.2.5. Dating of Historical Timber

None of the dated samples collected from the historical material the bark, or the waney edge, i.e., the edge of timber underneath the bark [40], were preserved. Therefore, all results show the *post quem* dating.

From Windmill no. 1, four samples were taken from the beams of the partially collapsed roof, one of which, a Black pine sample, was successfully dated, giving the year 1730 AD. This date could be close to the time of construction of the stone structure. It is also possible that the timber was reused when the function of the windmill changed.

Ten samples were collected from Windmill no. 2. Five of them, corresponding to *P. nigra*, were successfully dated. Two samples represent the mid-18th century (1752, 1761). Both the result of our dendrochronological analysis and observations made in situ suggest that the timber was reused during the last reconstruction of the windmill. Three other samples are dated to the end of the 19th century, which most probably belong to the timber introduced during the last reconstruction.

From Windmill no. 4, we collected three samples, all of which came from the door. One plank from this windmill was dated, giving 1803 AD as the last year.

In the last visited windmill (no. 5) we collected a total of 16 samples, eight of which were successfully dated. Four fir planks found on the second floor of the building are all of different age, but fall within the 19th century, while a Black pine plank was dated to the mid-18th century (1748). One beam recognized in situ as an original element of the windmill was dated to 1827 AD. The dating results of the three planks from the door indicate that the door was constructed around the mid-19th century.

Eight of the fifteen samples taken from loose timber preserved in a storehouse on the island, representing a total of three different wooden doors, were all dated to the second half of the 19th century. The dating results of the four warehouse oak planks are 1651, 1710, 1770, and 1851 AD. Nevertheless, they should all be considered at least 6 to 30 years younger [11,41–43] as there is no sapwood preserved in any of these samples (Figure 7).



Figure 7. Two of the examined warehouse oak planks with narrow rings but no presence of sapwood rings.

3.3. Developed Chronologies from Living Trees

From the cores collected from living trees we created a mean chronology for each one of the three dominant tree species of the island (Figure S4 in Supplementary Materials). The development of mean chronology for cypress was based on cores collected from seven trees (Figure S1 in Supplementary Materials), since the rest of the samples could not be synchronized due to the presence of several false rings or intraannual density fluctuations that are more evident closer to the pith, a common characteristic in low-altitude cypress trees [5,6,44]. For these trees, even an estimation of age can be erroneous. Turkish pine seems to form the oldest stands on the island, followed by cypress, while valonia oaks are less than 100 years old in most of the cases (Table 4, Supplementary Materials). Based on detrended mean chronologies (Figure S5 in Supplementary Materials), it could be said that the annual growth of cypress seems to be the smoothest one while in oaks abrupt fluctuations in growth can be observed over the years.

Table 4. Descriptive statistics of the chronologies developed per dominant tree species. The mean diameter at breast height (dbh) is reported together with the minimum and maximum values of the sampled trees. Standard deviation (std dev) is provided for the mean series intercorrelation.

Species	Number of Dated Series	dbh (cm)	Average No. of Rings Per Series	Average Age	Mean Series Intercorrelation (std dev)
<i>Cupressus sempervirens</i>	7	45.1 (34.1–59.9)	78.1	90 (64–145)	0.369 (0.09)
<i>Quercus ithaburensis</i> subsp. <i>macrolepis</i>	12	43.4 (33.1–72.9)	69.1	75 (43–106)	0.425 (0.09)
<i>Pinus brutia</i>	14	56.1 (43.3–77.1)	112.6	119 (92–167)	0.552 (0.08)

The developed *P. brutia* chronology was used to date our historical timber samples collected from the windmills and identified as low-altitude pines, but cross-dating results were not satisfactory. The same applies for the cypress sample collected from a roof beam in one of the windmills.

4. Discussion

Symi is an island which, despite its relatively smaller size, has quite extensive forests and woodlands. Cypress and Turkish pine woodlands still cover a significant portion of the island, especially its central and southern parts. Both the age structure and vegetation of these forests confirm that they are natural [20,45], with the presence of several trees—especially in pine forests—being older than 100 years old, a fact that is not typical for such small islands where the limited presence of local trees usually leads to their overexploitation. In general, the forests in the southern part of Symi seem to be somehow protected by the Panormitis Monastery located in close vicinity. This may also explain why these forests have remained rather untouched at least during the last 150 years.

The presence of valonia oak, although it was not mentioned in the national distributional and phytogeographical study of the taxon [5], is confirmed in several areas of the island, especially in the northern part where it forms woodlands similar to those described by Vrahnakis et al. [22]. Valonia oak woodlands have been extensively used for livestock grazing [22], especially for grazing pigs [21], and are considered as important silvopastoral systems in several regions throughout Greece. Even though in most cases throughout their distribution valonia oak woodlands are abandoned and degraded as a result of inappropriate management [22], in Symi livestock grazing is still active and it is difficult to decide whether these woodlands and stands are natural or a result of cultivation. Our dendrochronological results suggest that oaks are slightly younger than the two conifers.

In both Turkish pine and valonia oak chronologies, 1989 and 1990 were the years with extremely low annual growth, demonstrating one of the most recent drastic drought events over the Mediterranean and southern Europe [46,47] and the potential usefulness of the developed chronologies for future dendroclimatological studies.

As for historical timber, our results suggest that during the 19th century, at a time of economic prosperity based on sponge-fishing, timber trade was also flourishing on Symi, not only with the neighboring mainland, but also with Central Europe. In all of the examined building elements, imported timber originating from Turkey represented the majority of the wood type. This should not be surprising, bearing in mind the distance of the island from the Turkish coast. Cedar and Black pine were used in different doors of the island and also found as basic elements both in the roof structures and floor planks/coverings of the windmills. They are both woods of high quality, and are durable and easy to process [48,49]. *Cedrus libani* has been historically used for building temples, palaces, and boats [50], while during the 19th century it was also used in the construction of traditional rural settlements and agricultural farms [48]. *Pinus nigra*, highly suitable for indoor flooring, was also extensively used for making doors, paneling, staircases, furniture, etc. [49]. The third species, representing timber imported from Turkey and used for warehouse planks, is *Quercus* spp. Deciduous oaks are one of the most commonly approached tree types in dendroarchaeology not only because they are ideal for dendrochronology, but also because they have been widely used in different types of constructions since prehistoric times, thanks to the mechanical properties of their wood [51] being stronger, harder, and much more durable than other commonly used species in constructions [52].

In the windmills, apart from the Turkish originated timber, fir probably originating from the Alps was also identified. *Abies alba* has been one of the most preferred tree species for the construction of buildings since the antiquity [52] due to its good cleavability and durability, especially under humid conditions [53]. Silver fir timber was especially popular during the 19th century [54,55], and it has been already suggested that timber trade existed between the Aegean Islands that were then part of the Ottoman Empire and Central Europe [6]. In the case of the Symi windmills, similar to other historical buildings in Greece, silver fir was used mainly for making floor planks [6,13]. With the rest of our identified species—namely *Cupressus sempervirens*, *Pinus brutia*, and *Picea abies*—cross-dating against existing reference chronologies was not successful, which hampers our understanding of the origin of these timbers. Cypress and Turkish pine most probably correspond to local timber, but the chronologies developed from living trees within the scope of the current study do not cover the period

of interest for the building elements under study. Therefore, an extension of the developed local chronologies into the past could be useful for dating local timber.

Due to the absence of bark, or wane edge, we could not calculate the cutting years of the historical timber with annual precision. Nevertheless, cutting dates and non-cutting dates are not necessarily exclusive since other criteria, such as bark, beetle galleries, patinated surfaces, etc., may give the near-cutting dates [56]. In our case, such criteria were not present and it was impossible to understand how many rings were missing from the outside portion of the specimen. Even the warehouse oak planks originating from Turkey, in which we can estimate the number of missing rings to the bark thanks to the specific number of rings in sapwood, may vary from 6 to 30 years [11,41–43]. The origin of timber suggests that we should probably calculate 26 ± 8 or 27 ± 9 sapwood rings [11].

Some of the timber from windmills that dated back to the mid-18th century may be contemporary with the construction of the stone structure. The vast majority of the dated samples indicate a shift in the functions of the windmills in relation to the changing socio-economic context of the island during the 19th century.

Our study shows that even small Aegean islands can provide crucial dendrochronological information. In the case of Symi, imported timber, mostly from Turkey, and to a lesser extent from Central Europe, was the main choice of wood despite the availability of easily accessible local timber useful for construction during the mid-18th and 19th centuries. This situation can be explained by both the limited resources of the island and visible intention to protect forest resources in the southern part of the island which belongs to the property of the monastery. The off-shore chain of the Dodecanese islands has been closely linked with the Turkish mainland commercially and the local people of Symi took an advantage of this opportunity to secure their timber supplies.

5. Conclusions

The results of the study reveal the dendrochronological potential of the Symi island from both dendroarchaeological and dendroecological perspectives. The examined historical timber mostly represents timber imported from Turkey, highlighting the importance of timber trade with the neighboring mainland during the mid-18th and 19th centuries. During the same period, timber was also imported from Central Europe, while the use of local timber cannot be confirmed, which is because the developed chronologies from the three dominant tree species of the island do not cover the period of interest. The extension of local chronologies into the past will contribute to dating historical timber while the already developed chronologies can be useful for future dendroclimatological studies in the region.

Supplementary Materials: The following are available online at <http://www.mdpi.com/1999-4907/11/12/1266/s1>, Figure S1. Tree-ring series of *Cupressus sempervirens* trees from Symi. Figure S2. Tree-ring series of *Quercus ithaburens* subsp. *macrolepis* trees from Symi. Figure S3. Tree-ring series of *Pinus brutia* trees from Symi. Figure S4. Mean chronologies without detrending developed for the three dominant tree species from Symi for the time period with sufficient replication and without juvenile wood. The sample depth is also shown: (a) *Cupressus sempervirens*; (b) *Quercus ithaburens* subsp. *macrolepis*; (c) *Pinus brutia*. Figure S5. Mean chronologies developed for the three dominant tree species from Symi after detrending. The sample depth is also shown: (a) *Cupressus sempervirens*; (b) *Quercus ithaburens* subsp. *macrolepis*; (c) *Pinus brutia*.

Author Contributions: Conceptualization, A.C., B.G.-N. and T.W.; methodology, A.C., B.G.-N. and T.W.; software, A.C.; validation, A.C. and T.W.; formal analysis, A.C.; investigation, A.C.; resources, A.C.; data curation, A.C.; writing—original draft preparation, A.C.; writing—review and editing, A.C., B.G.-N., Y.Ö. and T.W.; visualization, A.C. and B.G.-N.; supervision, T.W.; project administration, T.W.; funding acquisition, T.W. All authors have read and agreed to the published version of the manuscript.

Funding: This research was founded by the National Science Center, Poland, project nr 2016/22/A/HS3/00285.

Acknowledgments: The authors would like to thank the architect Dimitris Zographos for bringing our attention to the potential of Symi for dendrochronological research and for providing access to the historical timber of the island. Special thanks to Maria Rosario Conceição for her participation in our field work.

Conflicts of Interest: The authors declare no conflict of interest.

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