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KRONOLOGIJA JELKE (*Abies alba* Mill.) ZA OBMOČJE POHORJA

THE CHRONOLOGY OF THE SILVER FIR (*Abies alba* Mill.) FROM POHORJE, SLOVENIA

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IZVLEČEK

Opravljene so bile dendrokronološke raziskave jelke (*Abies alba* Mill.) z Lovrenškega Pohorja. Analize širin branik so bile opravljene na kolutih 25 zdravih, odraslih, vladajočih in sovladajočih jelk in na izvrtkih lesa iz dveh starih kmečkih stavb iz istega vzorčnega območja. Iz kronologije dreves za obdobje od 1785 do 1996 in kronologij objektov za obdobje od 1713 do 1887 je bila sestavljena 284 let dolga pohorska jelova kronologija. Ta se kljub oddaljenosti in fitogeografskim razlikam statistično značilno ujema z doslej najdaljšo slovensko dinarsko jelovo kronologijo. Obe kronologiji skupaj predstavljata dobro osnovo za datiranje jelovine iz celotne Slovenije za obdobje 1712-1996.

ABSTRACT

Dendrochronological investigations were made in the the silver fir (*Abies alba* Mill.) from Lovrenc, Pohorje, Slovenia. Tree-ring analyses were made in discs of 25 healthy, adult, dominant or codominant silver firs and in cores from the roof construction of two older rustic buildings from the same region. Based on chronologies of trees and buildings covering the periods 1785-1996 and 1713-1887, was constructed a 284 years long silver fir chronology for Pohorje. It showed a statistically significant similarity with the Slovene Dinaric silver fir chronology, despite distances between the two regions and great difference in phytogeographical conditions. Both chronologies are expected to be a good base to construct a regional Slovene silver fir chronology for dating fir from the period 1712-1996 in whole of Slovenia.

LEVANIČ T., ČUFAR K. 1998. The chronology of the silver fir (*Abies alba* Mill.) from Pohorje, Slovenia = Kronologija jelke (*Abies alba* Mill.) za območje Pohorja. *Zbornik gozdarstva in lesarstva*, 55: 135-149.

CONTENTS / KAZALO

1 INTRODUCTION / UVOD

Tree-ring width variation of the silver fir (*Abies alba* Mill.) in Slovenia was until now dendrochronologically investigated only in the Dinaric region, located in the south west, between Ljubljana and Trieste. Based on several local chronologies (LEVANIČ / ČUFAR 1995a,b) a Dinaric silver fir chronology covering the period of 1716 - 1996 was constructed (LEVANIČ 1996, LEVANIČ / ČUFAR 1997). It proved to be useful for dating constructions from the Dinaric region (LEVANIČ et al. 1997, ČUFAR / LEVANIČ 1998), but we had no information on the possibilities of using it for dating constructions made of silver fir from other locations in Slovenia with different climatic and soil conditions.
Besides the Dinaric region, the Pohorje mountain ridge is an important source of this tree species. Pohorje located near Maribor, approx. 150 km to the NE of the Dinaric region, basically represents the main subalpine range in Slovenia. Its northern slopes border to the Drava River which later joins the Danube River. The region is heavily wooded. The predominating tree species are the Norway spruce (*Picea abies* (L.) Karst.) and the silver fir. The two regions belong to different phytogeographic areas with different climate, soils, and forest stands. The climate of Pohorje is continental and often influenced by a higher elevation, whereas in the Dinaric region it is characterised by the transition of the Mediterranean to a moderate continental climate. Typical silver fir forest stands in the Dinaric region belong to Abieti Fagetum dinaricum on carbonate bedrock, and on Pohorje to Bazzanio-Abietetum and Dryopterido-Abietetum on crystalline bedrock.

1.1 OBJECTIVE OF THE STUDY / CILJI ŠTUDIJE

The objective of this study was to construct a silver fir chronology for Pohorje, to compare tree-ring patterns from the Pohorje and from the Dinaric regions, to evaluate the possibility of constructing a chronology valid for the entire Slovenia, and to compare the Pohorje chronology with some European silver fir chronologies.

2 MATERIAL AND METHODS / MATERIAL IN METODE

The sampling area was located on Recenjak, Lovrenc Pohorje, latitude 46°32'30'', longitude 15°22', and 500-600 m above sea level. The wood was taken from freshly cut trees and from the roof constructions of buildings. The trees and the buildings were both located in the forests and the farm of Kasjak.
The test trees were 25 healthy, adult, dominant or codominant silver firs, with DBH approx. 55 cm and height above 30 m. The trees were felled between 1995 and 1997. After felling, the stem discs were taken at 4 m above ground. To prolong the chronology of the trees, cores were taken from the roof constructions of two rustic buildings, an old house and a barn. For

this, borers constructed by T. BARTHOLIN were used. According to information of the owner, the old house was thought to have been built 300 years ago, but a later reconstruction of the roof was likely. The barn was supposed to have been built in 1830 and reconstructed in 1888 as indicated by the number 1888 carved on the roof.

The tree-ring widths were smoothed and measured using a LINTAB measuring device developed by F. RINN and an Olympus stereo microscope S2 11. The ring widths were plotted and cross-dated using a TSAP/X programme and the individual series were averaged to 3 chronologies one each for the trees and both buildings.

The "Gleichläufigkeit" coefficient was calculated in accordance with HUBER (1943) and ECKSTEIN / BAUCH (1969). t-values (t_{BP}) were calculated in accordance with BAILLIE / PILCHER (1973), and the cross date index (CDI) in accordance with RINN (1989). The pointer years were calculated as *per* SCHWEINGRUBER et al. (1990). All calculations were made with the TSAP/X programme.

3 RESULTS AND DISCUSSION / REZULTATI IN DISKUSIJA

3.1 CONSTRUCTION OF THE POHORJE SILVER FIR CHRONOLOGY / SESTAVLJANJE POHORSKE JELOVE KRONOLOGIJE

The tree-ring series of 21 trees were used to construct a chronology covering the period of 1785 and 1996. It was particularly well replicated for 1850 to 1996. Fig. 1 shows the length of the tree-ring series of individual trees.

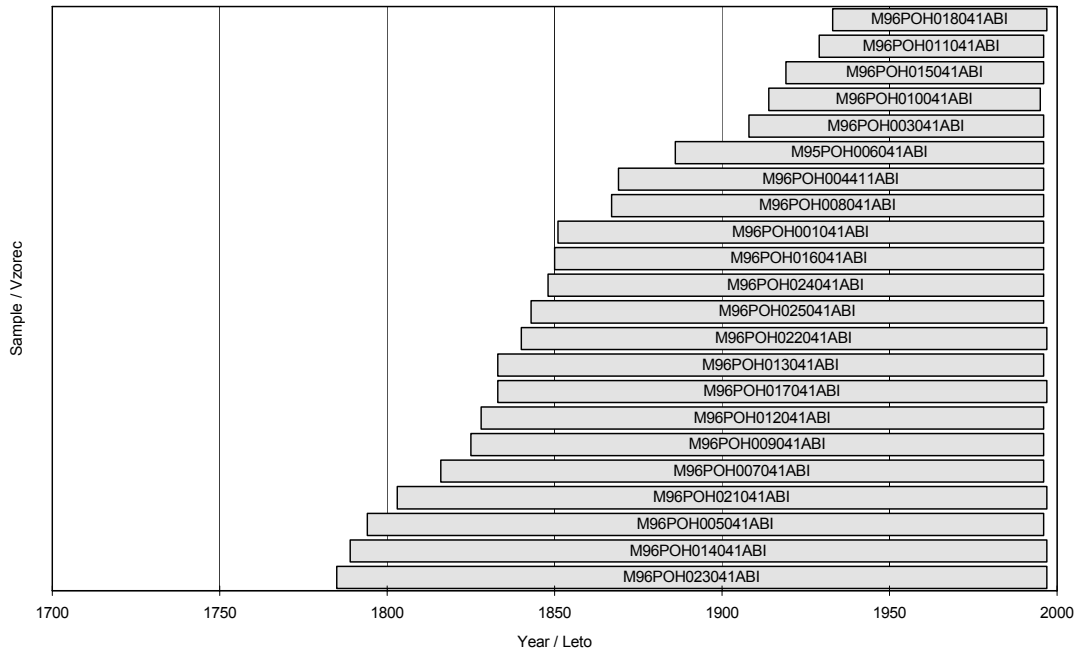

Figure 1. - Block diagram showing the years spanned by the tree-ring series of individual trees.

Slika 1.- Blok diagram z obdobjem, ki ga premoščajo zaporedja širin branik posameznih testnih dreves.

For the old Kasjak house 9 of 10 samples were cross-dated, and a chronology from 1713 to1852 was constructed. Three elements containing the outer ring below the bark were dated 1852, indicating that the last considerable reconstruction of the roof took place after the end of the growing period of 1952, most probably early in 1953.

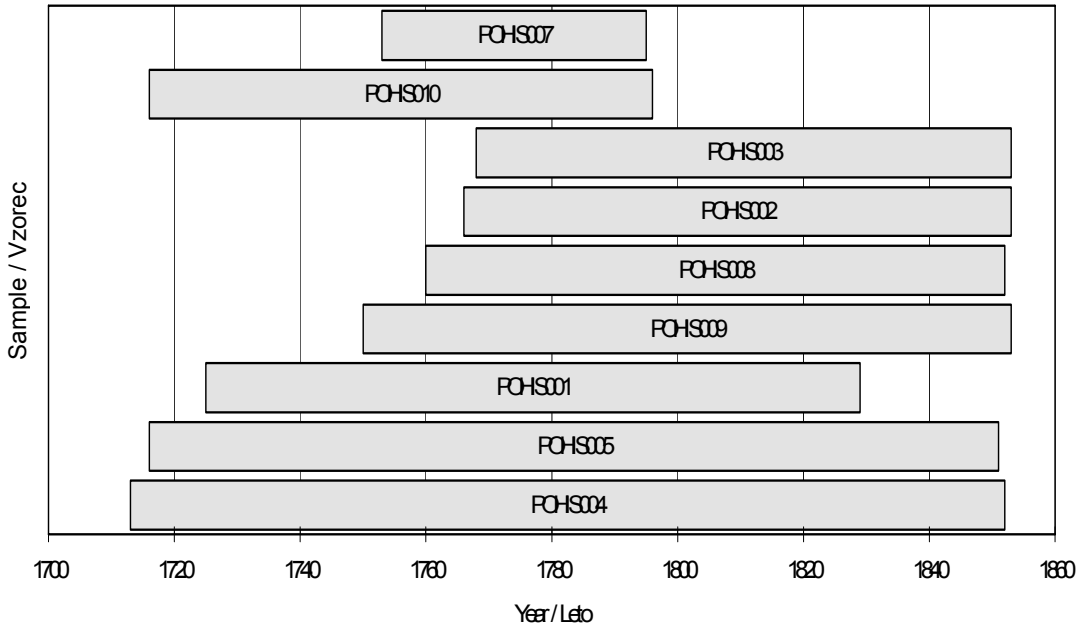

Figure 2. - Block diagram showing the years spanned by the tree-ring series of individual cores from the old Kasjak house.
Slika 2.- Blok diagram z obdobjem, ki ga premoščajo zaporedja širin branik posameznih izvrtkov iz stare Kasjakove hiše.

Six samples were taken from the barn. All of them were cross-dated and the chronology from 1745 to 1887 was constructed. Two elements containing the outer ring were dated 1887. Based on this date and information on wood-working practices in the 19th century, we may suppose that the trees were felled in winter 1987/88, and the barn was built in 1888; thus the dating of the building based on the carved inscription “1888” was confirmed.
In all cases the tree-ring patterns of individual trees and cores from the construction elements showed great similarity between each other. This was confirmed both visually and by significant statistical parameters.

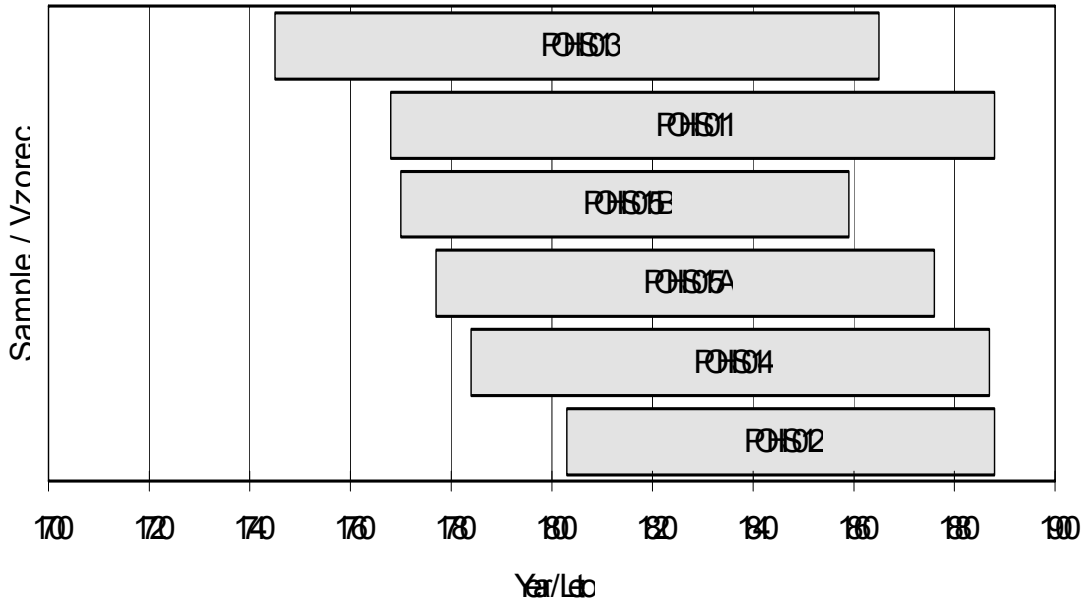

Figure 3. - Block diagram showing the years spanned by the tree-ring series of cores from the Kasjak barn.

Slika 3.- Blok diagram z obdobjem, ki ga premoščajo zaporedja širin branik posameznih izvrtkov iz Kasjakovega skednja.

For each of both historic buildings, the tree-ring series of cores were averaged and the chronologies constructed. Chronology from the trees and two chronologies from the historic buildings were finally joined into a 284 long silver fir chronology of Pohorje spanning the period of 1713-1996 (Figure 4). The chronology and its replication is presented in Fig. 5 and its description in Table 1.

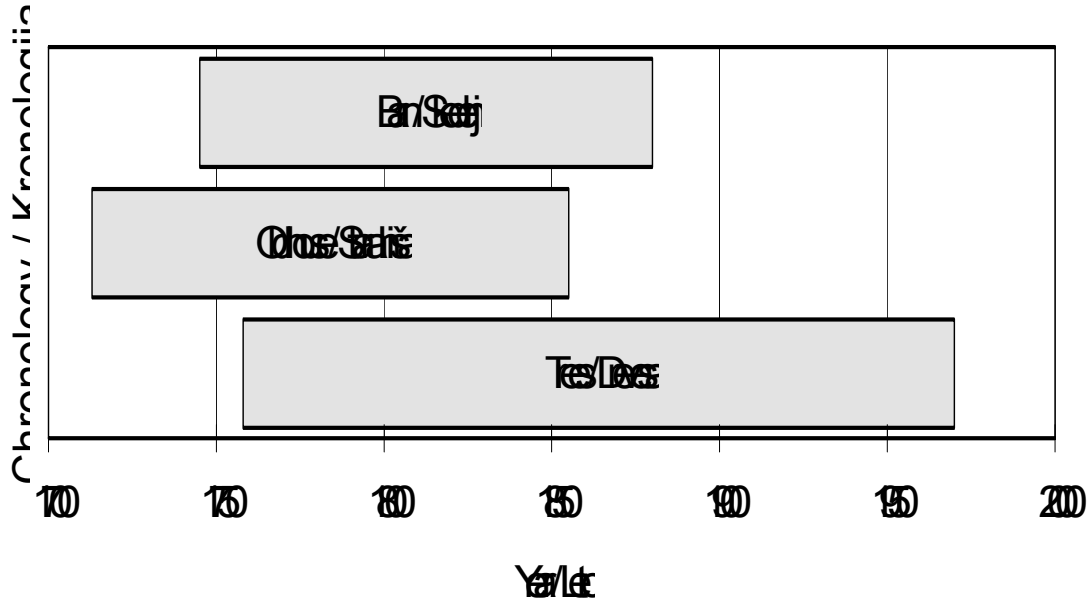

Figure 4. Block diagram showing the years spanned by the chronologies of trees, old house and barn.

Slika 4.- Blok diagram z obdobjem, ki ga premoščajo kronologije dreves, stare Kasjakove hiše in Kasjakovega skednja.

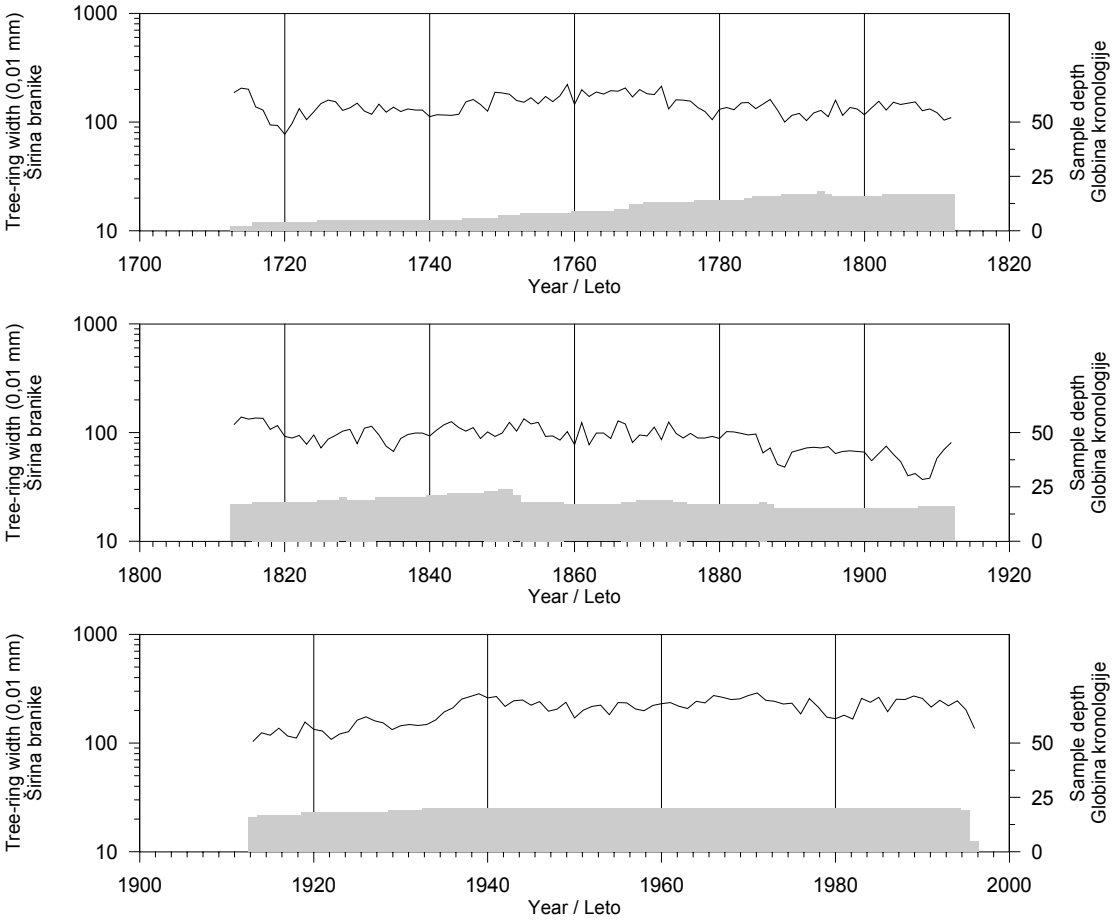

Figure 5.- The Pohorje silver fir chronology. The curve represents the chronology and the area the number of samples (= sample depth).

Slika 5.- Pohorska jelova kronologija. Krivulja predstavlja kronologijo in površina pod njo število vzorcev (= globina kronologije).

Table 1 - Statistical parameters for nonstandardised Pohorje silver fir chronology.

Tabela 1.- Statistični kazalniki nestandardizirane Pohorske jelove kronologije.

Time span	Obdobje	1713 - 1996
Length (years)	Dolžina (let)	284
Mean tree-ring width (mm)	Povprečna širina branike (mm)	1.43
Minimum tree-ring width (mm)	Najožja branika (mm)	0.37
Maximum tree-ring width (mm)	Najširša branika (mm)	2.89
Standard deviation (mm)	Standardna deviacija (mm)	0.576

Mean sensitivity	Srednja stopnja občutljivosti	13 %
Relative mean sensitivity	Relativna sred. stop. občutlj.	16 %
Autocorrelation (1)	Avtokorelacija (1)	0,91
Variance	Varianca	0.3321

For the best replicated part of the chronology between 1773 and 1996, based on 13 or more tree-ring series, pointer years and intervals were calculated. We present only those showing a simultaneous response of 90-100 % firs (Table 2).

Table 2.- List of positive and negative pointer years and the pointer interval for the Pohorje silver fir chronology.
Tabela 2.- Seznam pozitivnih in negativnih značilnih let in intervalov za pohorsko jelovo kronologijo.

Negative / negativna	1773, 1830, 1847, 1856, 1862, 1868, 1872, 1886, 1896, 1906, 1917, 1920, 1942, 1950, 1954, 1957, 1972, 1976, 1979, 1986, 1991
Positive / pozitivna	1774, 1780, 1804, 1831, 1836, 1853, 1861, 1866, 1873, 1890, 1903, 1910, 1925, 1943, 1949, 1955, 1964, 1966, 1977, 1983, 1987
Pointer interval / značilni interval	1796 (+) 1797 (-) 1798 (+)

3.2 COMPARISON OF THE POHORJE CHRONOLOGY WITH THE SLOVENE DINARIC AND FOUR EUROPEAN SILVER FIR CHRONOLOGIES / PRIMERJAVA DOBLJENE KRONOLOGIJE S SLOVENSKO DINARSKO IN ŠTIRIMI EVROPSKIMI JELOVIMI KRONOLOGIJAMI

The Pohorje chronology was compared with the Dinaric silver fir chronology and the four European ones listed in Table 3.

Table 3.- Comparison of the Pohorje chronology with the Slovene Dinaric and four European silver fir chronologies
Tabela 3.- Primerjava pohorske kronologije s slovensko dinarsko in štirimi evropskimi jelovimi kronologijami

Chronology / Kronologija	**Country / Država**	**t_{BP}**	**GLK %**	**CDI**	**Author / Avtor**
Dinaric	Slovenia	9.8	71	398	LEVANIČ 1996
South German,	Germany	5.5	70	244	BECKER / GIERTZ-

stand 1993					SIEBENLIST 1970, SPURK / FRIEDRICH - personal communication
Bavarian Forest	Germany	5.4	215	68	ECKSTEIN / SASS 1988
Abetone	Italy	4.1	108	64	SCHWEINGRUBER, ITRDB
Bannwald	Switzerland	/	/	/	SCHWEINGRUBER, ITRDB

t_{BP} - t-value after Baillie-Pilcher, GLK - "Gleichläufigkeit", CDI - Cross Date Index
t_{BP} - t-vrednost Baillie-Pilcher, GLK - koeficient časovne skladnosti, CDI - indeks navzkrižnega datiranja
/ - values nonsignificant, vrednosti neznačilne

The most significant values were obtained in both Slovene chronologies. Besides the values shown in Table 3, they have the following common negative pointer years 1872,1917, 1942, 1979, and the positive ones 1861, 1866, 1873, 1910, 1925, 1943, 1987.
The high similarity indicates that the growth of silver fir is, despite distance and differences between sampling areas, influenced by factors common to the whole of Slovenia. We think that both the Dinaric and Pohorje chronologies may represent a basis to construct a Slovene silver fir chronology valid in the entire region.

The similarity of the Pohorje chronology with the European ones was significant in all cases with, one exception from Bannwald, Switzerland. This is in accordance with BECKER (1978), FELIKSIK (1993), and KYNCL / KYNCL (1996) who were observing similarity between tree-ring patterns of silver fir at several European sites.

The comparison of Slovene chronologies with European ones presented in Table 4 shows that the Pohorje chronology correlates better with both German ones and that the Dinaric chronology correlates better with the Italian one. The results are in accordance with the opinion of foresters, who observed that Pohorje is among the areas in Slovenia showing the most pronounced Central European characteristics (ROBIČ, personal communication).
This information is also important for the future dating of tree species like the Norway spruce and oaks (*Quercus petraea* Liebl. and *Quercus robur* (L.)) that show great variability of tree-ring patterns within Slovenia and do not show any similarity with the neighbouring countries.

Table 4.- Parameters for comparison of two Slovene chronologies with three European ones. For information on chronologies see Table 3.
Tabela 4.- Primerjava obeh slovenskih kronologij s tremi Evropskimi. Podatki o kronologijah so v tabeli 3.

	Pohorje		Dinaric	
	t_{BP}	GLK %	t_{BP}	GLK %
South German	5.5	70	4.4	59
Bavarian Forest	5.4	68	5.0	66
Abetone	4.1	64	6.2	62

4 CONCLUSIONS / ZAKLJUČKI

- Silver fir growing in two separate and different areas of Slovenia, the Pohorje and the Dinaric region, shows great similarity between tree-ring patterns.
- The Pohorje chronology was proved to be statistically similar with two German and one Italian one, but showed no similarity with the Swiss one.
- Comparison of the two Slovene chronologies with three European ones showed that the Pohorje chronology correlates better with both German ones and that the Dinaric chronology correlates better with the Italian one.

5 SUMMARY

Dendrochronological investigations were made in the silver fir (*Abies alba* Mill.) from Lovrenc, Pohorje, in the NE Slovenia. Tree-ring analyses were made in discs of 25 healthy, adult, dominant or codominant silver firs and in cores from roof construction of two older, rustic buildings from the same region, using a LINTAB measuring device and a TSAP/X programme. We constructed a chronology of trees spanning the period of 1785-1996. The chronology of the old house spanned the period of 1713-1852 and the chronology of barn 1745-1887. We demonstrated that the last considerable reconstruction of the house roof took place after the end of the growing period of 1852. Dating of the cores containing the outer ring 1887 confirmed dating based on the carved inscription “1888”. The three chronologies were joined into a 284 years long silver fir chronology for Pohorje spanning the period of 1713-1996.

It was compared with the Slovene silver fir chronology of the Dinaric region. Despite distance and great differences between the two regions, we confirmed a similarity of both with a t_{BP}=9.8, GLK=71% and CDI=398. The chronologies have 21 common negative, 21 positive signature years, and one common signature interval. They are a good basis for constructing a regional Slovene silver fir chronology for dating in the whole of Slovenia.

Two Slovene chronologies were compared with the following European ones: South German, stand 1993 (BECKER / GIERTZ-SIEBENLIST 1970; SPURK / FRIEDRICH, personal communication), Bavarian Forest - Germany (ECKSTEIN / SASS 1988), Abetone - Italy (SCHWEINGRUBER, ITRDB), Bannwald - Switzerland (SCHWEINGRUBER, ITRDB). Both

Slovene chronologies proved to be statistically similar with the two German and one Italian chronology, but showed no similarity with the Swiss one. The Pohorje chronology correlates better with both German ones and the Dinaric chronology correlates better with the Italian one.

6 POVZETEK

Rastni vzorec jelke (*Abies alba* Mill.) je bil v Sloveniji v zadnjih letih podrobno preiskan (LEVANIČ / ČUFAR 1995 a, b), vendar so bile vse dosedanje raziskave omejene na jelko iz Dinarske regije. Sestavljena je bila 279 let dolga regionalna dinarska jelova kronologija, ki temelji na lesu dreves iz več kot 10 rastišč (LEVANIČ 1996, LEVANIČ / ČUFAR 1997). Pokriva obdobje od leta 1716 do 1994 in je med drugim zelo uporabna za datiranje lesa iz zgodovinskih objektov (LEVANIČ et al. 1997, ČUFAR / LEVANIČ 1998). Ugotovljeno je bilo da se statistično značilno ujema z v Evropi najbolj znano južnonemško jelovo kronologijo.
Da bi preverili domet dinarske kronologije v Sloveniji smo se odločili, da bomo raziskali rastni vzorec jelke s Pohorja in ga primerjali s tistim iz dinarske regije. Jelka iz rastišč na Pohorju ima velik gospodarski pomen. Rastne razmere na Pohorju se močno razlikujejo od tistih v Dinarski regiji, saj območji pripadata različnima geografskima in fitogeografskima območjema z različno klimo in tlemi. Jelka v obeh območjih raste tudi v različnih gozdnih združbah.
Cilj pričujoče raziskave je bil sestaviti čim daljšo kronologijo jelke z območja Pohorja, jo primerjati z Dinarsko kronologijo, oceniti možnost za sestavo jelove kronologije za celotno območje Slovenije in pohorsko kronologijo primerjati z nekaterimi evropskimi jelovimi kronologijami.
Les za raziskave smo odvzeli iz dreves in starih stavb na Kasjakovi domačiji s pripadajočimi gozdovi. Domačija se nahaja na Recenjaku na območju Lovrenškega Pohorja. Za raziskave smo odvzeli les 25 zdravih vladajočih in sovladajočih jelk, ki so bile odkazane za posek v letih 1995 do 1997. Iz posekanih dreves smo odvzeli kolute na višini 4 m. Za podaljšanje kronologije dreves smo odvzeli še izvrtke jelovine iz stropnih oz. strešnih konstrukcij dveh stavb, stare hiše in skednja. Hiša je po pričevanjih stara okoli 300 let, vendar je bila v preteklosti verjetno večkrat popravljena. Skedenj so domnevno postavili leta 1888, o čemer priča vrezana letnica. Vzorce lesa smo odvzeli s svedrom premera 16 mm, ki ga je skonstruiral T. BARTHOLIN.
Merjenje širin branik smo opravili na gladko obdelanih vzorcih lesa s pomočjo merilne mizice LINTAB proizvajalca F. RINN-a in stereo mikroskopa Olympus S2 11. Širine branik smo izmerili na 0.01 mm natančno. Zajem in obdelava podatkov je potekala s pomočjo IBM - kompatibilnega osebnega računalnika in programa TSAP/X avtorja F. RINNA. Zaporedja širin branik smo grafično prikazali v odvisnosti od časa, jih med seboj sinhronizirali ter izračunali povprečja za posamezno drevo, rastišče in stavbo. Ker je bil za vsako drevo znan natančen čas poseka, smo lahko zaporedja širin branik dreves takoj po merjenju datirali. Zaporedja

širin branik obeh stavb smo najprej medsebojno sinhronizrali, sestavili kronologiji objektov in ju datirali s pomočjo kronologije dreves.

Proučena drevesa, so bila zelo stara, saj je najstarejše imelo na višini 4 m 228 branik. Za kronologijo smo lahko uporabili zaporedja širin branik 21 dreves. Sestavljena kronologija je bila dolga 212 let in je pokrivala obdobje od 1785 do 1996. Pokritost je bila posebno dobra v obobju 1850 do 1996. Del kronologije pred letom 1850 smo želeli izboljšati in podaljšati s kronologijama stavb (Slika 1).

Iz stare hiše smo odvzeli 10 izvrtkov in sestavili kronologijo za obdobje 1713-1852 (Slika 2). Rezultati kažejo, da je bila obsežna prenova stropne in strešne konstrukcije opravljena po zaključku vegetacijske dobe 1852, najverjetneje spomladi 1853.

Iz skednja smo odvzeli 5 izvrtkov in sestavili kronologijo, ki premošča obdobje 1745-1887 (Slika 3). Več vzorcev, ki so vsebovali zadnjo braniko pod skorjo, smo datirali v leto 1887. Ta datum kaže, da so les posekali pozimi 1887 / 1888, skedenj pa najverjetneje postavili spomladi 1888. S tem smo potrdili datiranje na osnovi vrezane letnice “1888”. Visoko značilne vrednosti koeficientov datiranja kažejo, da je bil les za obe stavbi posekan v gozdovih okoli kmetije, od koder smo izbrali tudi raziskana drevesa.

Kronologije dreves in obeh stab smo združili v kronologijo dolžine 284 let za obdobje 1713 do 1996. Imenovali smo jo pohorska jelova kronologija (Slika 5, Tabela 1, Tabela 2).

Preverili smo ujemanje pohorske in dinarske kronologije. Statistični kazalniki ujemanja so bili: t_{BP} 9,8; koeficient časovne skladnosti 71% in indeks navzkrižnega datiranja 398 (Tabela 3).

Vsi kazalniki kažejo na visoko značilno ujemanje obeh kronologij, kljub dokajšni oddaljenosti in različnim rastiščnim razmeram v obeh območjih.

Pohorska kronologija je bila statistično značilno podobna jelovim kronologijam iz južne Nemčije, Bavarskega gozda in Abetone-ja v Italiji (Tabela 3). Primerjava obeh slovenskih kronologij s tremi evropskimi je pokazala, da se rastni vzorci Pohorske jelke bolje ujemajo z nemškima kronologijama, rastni vzroci Dinarske jelke pa z italijansko kronologijo (Tabela 4). Pohorska in dinarska kronologija skupaj predstavljata dobro osnovo za sestavo regionalne kronologije za datiranje na celotnem območju Slovenije.

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