Phyton (Austria) Special issue: "Plant Physiology"	**Vol. 39**	Fasc. 3	(113)-(116)	30. 11. 1999

Tree-Ring Investigations in Oak and Ash from Different Sites in Slovenia

By

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K e y w o r d s : *Quercus robur*, *Quercus petraea*, *Fraxinus excelsior*, tree-ring chronologies, Slovenia.

S u m m a r y

ČUFAR K. & LEVANIČ T. 1999. Tree-ring investigations in oak and ash from different sites in Slovenia. - Phyton (Horn, Austria) 39 (3): (113) - (116).

To develop Slovenian tree-ring chronologies, ring width patterns were analysed of *Quercus robur* L. (pedunculate oak), *Q. petraea* Liebl. (sessile oak), and *Fraxinus excelsior* L. (European ash) from seven typical stands in the Ljubljana Moor and six locations in Central, W, S, and NE Slovenia. The wood was analysed by standard dendrochronological procedures. Cross-dating of the tree-ring series of young, fast-growing lowland oaks was generally not possible. However, slower-growing older pedunculate oak, sessile oak, and ash were able to be cross-dated within each sampled stand. Tree-ring series of slower-growing, old oaks from different locations in Slovenia were also able to be crossdated.

I n t r o d u c t i o n

Oak, *Quercus robur* L. (pedunculate oak) and *Q. petraea* Liebl. (sessile oak), is among the most investigated tree species in European dendrochronology and has yielded some of the longest continuous chronologies in the world (BAILLIE 1995). Oaks in Central and NW Europe show spatially coherent climate dependant patterns which made it possible to compare archaeological series from more distant regions and bridge gaps in regional dating chronologies (KELLY & al. 1989). Oaks south of the Alps such as in Slovenia have not been yet thoroughly investigated,

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and reports on cross-dating of oak chronologies over large regions are rare (GRYNAEUS 1996).

In Slovenia oak chronologies are needed for archaeological dating as well as for dendroecology and dendroclimatology. First investigations of trees, as well as of historic and archaeological wood (ČUFAR & al. 1997) indicate that it is often difficult to cross-date oak tree-ring series. This is mostly due to strict local factors, like ground water level, affecting tree growth (LEVANIČ 1993). Similar observations were made for ash (*Fraxinus excelsior* L.).

The objectives of the present study are to compare tree-ring series of oak and ash from eight systematically selected sites in the Ljubljana Moor and from additional six locations in Central, S, W and NE Slovenia and by their cross-matching obtain information on ecological factors affecting tree growth.

Materials and Methods

A selection of eight sites in the Ljubljana Moor (1 - 8, Fig. 1) include a typical variety of stand conditions. From each of site five oak and five ash trees were selected. *Q. robur* predominates on moist and *Q. petraea* on dry sites. All trees were dominant or co-dominant ones with a median DBH of 40 cm. To compare regional consistency of tree-ring patterns additional six sites including 48 adult oaks were selected (Fig. 1).

The wood was mainly taken by coring at breast height of standing trees. The tree-ring widths were measured and analysed using the LINTAB measuring device, TSAP/X programme and standard dendrochronological procedures (RINN 1989).

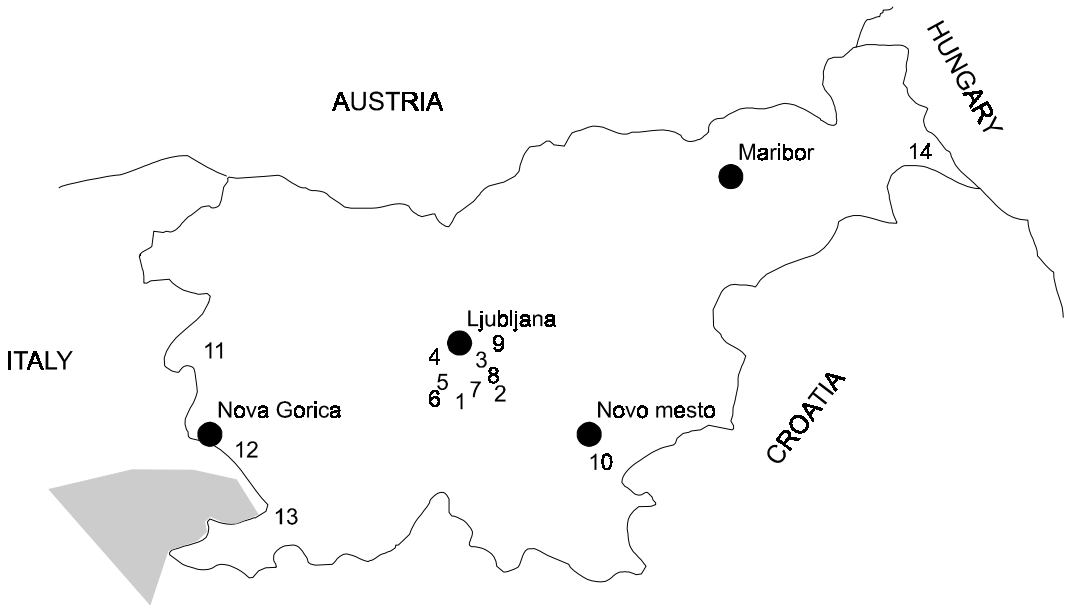

Fig. 1. Sampling areas: (1) Prevalje, (2) Sv. Rupert, (3) Babna Gorica, (4) Kostanjevica, (5) Brdo pri Bevkah, (6) Blatna Brezovica, (7) Lipe, (8) Kozlarjeva Gošča, (9) the surroundings of Ljubljana, (10) Vrh pri Ljubnu, (11) Plave, (12) Panovec, (13) Lipica, and (14) Polana.

Cluster analysis made by SPSS version 8 was used to assess the similarity between the Ljubljana Moor sites. The input data were mean ring-widths for the last 40 years. The squared

Euclidean distances were chosen to calculate the distances between sites. Ward's method was used to form the clusters on the basis of a smallest increase in the overall sum of the squared within-cluster distances.

Results and Discussion

Based on cluster analysis, the eight sites in the Ljubljana Moor were divided in three types (Table 1). Type III represents a group of typical lowland sites (7, 8 - Fig. 1) with swamp conditions. Moisture availability for the trees does not directly depend on precipitation, but it is in connection with the ground water system affected by the river Ljubljanica. Type I represents a group of more or less dry sites (1, 2) located at the edge of the Ljubljana Moor. Water supply of trees seems to depend greatly on precipitation. Type II sites (3, 4, 5, 6) are located on the hills scattered in the Ljubljana moor and are slightly more fresh than type I sites.

Table 1. Site types as defined by cluster analysis with characteristics of trees and tree-ring series. **(* Minimum, Average, Maximum).**

	Site Type		
	I	II	III
Site Number (see Fig. 1)	1, 2	3, 4, 5, 6	7, 8
DBH* (cm)	40 46 54	33 52 81	26 43 73
Length of Series* (Years)	45 89 114	32 75 137	22 36 57
Mean Ring Width (mm)	2.88	3.81	6.28
Median Ring Width (mm)	2.42	3.38	5.27
Cross-Dated Series (%)	100	85	8

The growth characteristics of the trees from the eight sites varied considerably (Table 1). The trees of type I were oldest and had the most narrow tree-rings, and those of type III were youngest with the largest ring width. By calculating t_{BP} and »Gleichläufigkeit« all tree-ring series from type I and most from type II could be successfully cross-dated. In case of type III trees cross-matching between tree-ring series was in most cases not possible. For type III trees it was also impossible to determine signature years indicating a site specific common event affecting tree growth. Analysis of ash essentially confirmed the results obtained for oaks.

Cross-dated tree-ring series from sites 1-6 were joined to chronologies of pedunculate oak, sessile oak, and ash, respectively. Statistically significant similarities were determined for both oak species (t_{BP} = 7.1), for pedunculate oak and ash (t_{BP}=5.8), as well as for sessile oak and ash (t_{BP}=5.3).

Finally site chronologies of oak were joined to three master chronologies, sites 1, 2, 3, 4, 5, 6, and 9 for Central, site 10 for South, and sites 12 and 13 for Western Slovenia (Fig. 1).They all covered the period of 1900 - 1996. The Central and the South cross-matched with t_{BP}=7.1 and the Central and the West with t_{BP}=4.6. This indicates that there exists a common regional factor affecting tree

growth and that a construction of a regional oak chronology might be possible. The trees from **the** NE Slovenia (site 14, Fig. 1) showed characteristics of type III trees from the Ljubljana Moor. LEVANIČ 1993 revealed that their growth was mainly affected by the ground water level.

Conclusions

Living Slovenian oaks from lowland sites are often relatively young, fast growing trees. Their growth is mainly affected by individual and local factors. The ring patterns of trees aged less than 50 years, with average tree-ring widths exceeding 5 mm, usually do not match with those from other locations, nor with those from the same location.

Despite their different ecological characteristics, pedunculate and sessile oak may dendrochronologically be regarded as one species. It may be even possible to cross-date oak and ash from the same site.

Cross-dating of tree-ring series of older, slower growing oaks from dryer stands is more likely. Their ring patterns show weak but significant similarity between distant locations in Slovenia.

The greatest obstacles for the future development of Slovenian oak tree-ring chronologies are the scarcity of older, slow growing trees and the abundance of young, fast growing trees which can usually not be employed for cross-dating.

Acknowledgements

The work was funded by the Ministry of Science and Technology of the Republic of Slovenia, Project J4-7434.

References

BAILLIE M.G.L. 1995. A slice through time. - B.T. Batsford Ltd., London.

ČUFAR K., LEVANIČ T., VELUŠČEK A. & KROMER B. 1997. First chronologies of the Eneolithic pile dwellings from the Ljubljana moor, Slovenia. - Dendrochronologia 15, **39-50**.

GRYNAEUS A. 1996. Progress of dendrochronological research in Hungary. - Dendrochronologia 14: 223 - 226.

KELLY P.M., MUNRO M.A.R., HUGHES M.K. & GODESS C.M. 1989. Climate and signature years in west European oaks.- Nature 340: 57-59.

LEVANIČ T. 1993. Vpliv melioracij na debelinsko rast in prirastek črne jelše, ozkolistenga jesena in doba v Prekmurju. (Effects of hydromelioration on diameter growth and increment of black alder, ash and oak in Slovene Prekmurje.) - Zbornik gozdarstva in lesarstva 42: 7-65.

RINN F. 1989. TSAP - Time series analysis programme, Version 2.3. Reference Manual.