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CORRELATION BETWEEN AGE AND BASAL DIAMETER OF *FRAXINUS ORNUS* L. IN THREE ECOLOGICALLY CONTRASTING HABITATS*

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Manna ash (*Fraxinus ornus* L.) is a typical deciduous tree of South European distribution reaching the northern border of its range in the Carpathian Basin. The correlation between age and basal diameter of this tree was analysed in three ecologically contrasting habitats, as follows. (1) Successional habitat. Abandoned farmland with scattered occurrence of manna ash as a colonising tree of the area. (2) Austrian pine plantation, where manna ash often forms a spontaneous subordinate tree or shrub layer. (3) *Cotino-Quercetum pubescentis*, the natural vegetation on south facing calcareous hillslopes in Hungary, where *Quercus pubescens* Willd. and *Fraxinus ornus* codominate in the low canopy. At each sampling site 21 individuals were selected with an even distribution within circumference categories ranging from 6 cm to 60 cm. Circumference measurements were made at the base of the tree-trunks, then either the tree was felled and a 1 cm thick disk was cut off from the trunk, or cores were taken by a driller. Linear regression analysis was applied to test the correlation between age and diameter.

Average age for the measured individuals was 19.76 years in the successional habitat, 37.76 years in the pine plantation and 33.67 years in the *Cotino-Quercetum pubescentis* community. Significant correlation ($p < 0.001$) appeared between basal diameter and age (year-ring count) in the successional habitat and the pine plantation with regression coefficients $r = 0.7406$ and $r = 0.9181$, respectively. In case of the *Cotino-Quercetum pubescentis* community age and basal diameter varied almost independently ($r = 0.2712$). Taking slope angles of regression equations into account, trees grow 72% faster in average in the successional habitat than in the pine plantation. In conclusion the basal diameter of the trunk was found to be a good predictor of tree age where populations develop under a relatively uniform light regime. However, the highly heterogeneous aerial and soil environments in the species' typical natural habitat cause an uncoupling of age and trunk diameter.

Key words: basal diameter, *Fraxinus ornus*, manna ash, plasticity, tree age, year-ring counts

* The authors dedicate this paper to Professor Gábor Fekete for his 70th birthday.

INTRODUCTION

Manna ash (*Fraxinus ornus* L.) is a typical deciduous tree of South European distribution with special importance in the vegetation of the East Mediterranean Basin (Horvat et al. 1974). Its area ranges from eastern Spain to the southern coastal area of Turkey and from Sicily and Peloponnesos to the Carpathian Basin (Kárpáti 1970, Meusel et al. 1978). Beyond this range it is known as naturalized tree from Barcelona and Burgos (Spain) regions (Baonza et al. 1995), from south France, from Crimea and from some other localities between the latitudes 45° and 50°. Recently its rapid invasion in the Hérault River system (France) was analysed by Thébaud and Debussche (1991).

Hungarian populations of manna ash are at the northern border of the distribution range, though its northernmost, sporadic occurrences are found in Slovakia (Bertová et al. 1984). In spite of the peripheral position regarding the area of the species it is widespread in Transdanubia (Hungary) (Szabó 1939) and occurs in several community types from the xerotherm rock grasslands to the more humid beech forests. Selected examples for coenological behaviour of manna ash are shown in Table 1, whereas a complete list of Hungarian community types with this species is given by Soó (1966). The morphological variability of the Hungarian populations is also notable (Kárpáti 1958).

The considerable plasticity of this species is obvious from the records above, but its growth rate and biomass production can be very different under various circumstances. Our interest in this paper is focused on the correlation between age and thickness of individual trees and its variation among manna ash populations growing on ecologically contrasting habitats.

MATERIALS AND METHODS

Three study sites were selected in the Buda Hills and its surroundings:

1. Successional habitat. Abandoned farmland, mainly covered by grassland vegetation with scattered occurrence of *Fraxinus ornus* as a colonising tree of the area. Additional woody species are: *Rosa canina* L., *Crataegus monogyna* Jacq., *Cornus sanguinea* L. and *Ailanthus altissima* (Mill.) Swingle. In this situation manna ash individuals are standing far from each other, thus exposed to full sun. Locality: Nyakas Hill, near the village Tök; altitude: 280–290 m a.s.l.; slope: 5–7°, facing east-southeast.

2. Pine plantation. In the middle of the 20th century many of the overgrazed hillslopes throughout the Hungarian Mountain Range were afforested with *Pinus nigra*, an introduced tree in Hungary. On the area consisting our study site afforestation was carried out in the early fifties. Nowadays the average height of these stands is 14–16 m, with a density of 0.16 pine individuals/square metre. In these pine forests *Fraxinus ornus* often forms a spontaneous subordinate tree or shrub layer (see Table 1), with a poorly developed low diversity herb layer (Borhidi 1956, Csontos et al. 1996). *Fraxinus* individuals are subjected considerable shade under the closed canopy of *Pinus nigra* (in an overcast summer day only 10% of the incoming diffuse radiation reaches the pine plantation floor), and this habitat is more humid than the other two. Worth for mentioning that in the Balkan Peninsula *Pinus nigra* and *Fraxinus ornus* naturally form mixed-

Table 1

Coenological behaviour of *Fraxinus ornus* in selected community types in Hungary. A–D = combined scale for abundance and dominance; K = constancy value; A = tree layer; B = shrub layer; C = herb layer; * = frequency value

Community type	A-D	K	Remark	Reference
Fageto-Ornetum hungaricum	2–4	V		Zólyomi 1958
Orneto-(Lithospermo-) Quercetum praeillyrico-matricum	2	V		Zólyomi 1958
Cotino-Quercetum pubescentis balatonicum	1–4	V		Zólyomi 1958
Orno-Quercetum pubescenti-cerris pannonicum	+–4	V	both in layer A and B	Debreczy 1968
Querceto-Lithospermetum cult. consoc. Pinus nigra	+–3	V	fewer in layer A	Borhidi 1956
Orno-Quercetum pubescentis Mecsekense	+–3	V		Horváth 1972
Mahalebeto-Quercetum pubescentis calcareum	+–3	V		Zólyomi 1958
Corno-Quercetum	+–3	V	fewer in layer B	Horánszky 1964
Cotino-Quercetum pubescentis Mecsekense	+–2	V		Horváth 1972
Ceraso-Quercetum	+–2	V	K = IV in layer B	Horánszky 1964
Orno-Quercetum	+–3	IV	K = V in layer B	Horánszky 1964
Querceto-Lithospermetum	+–2	IV	both in layer A and B	Fekete 1956
Festuco-Brometum erecti archimatricum	+–1	IV	in layer C	Tamás 1997
Quercetum petraeae-cerris	1–2	IV	in layer B only	Penksza et al. 1996
Genisto pilosae-Quercetum	+–2	III	fewer in layer B	Horánszky 1964
Helleboro dumetorum-Carpinetum	+–2	III	in layer B	Borhidi 1984

Community type	A-D	K	Remark	Reference
Vicio (oroboidi)-Fagetum	+–2	III	in layer B	Borhidi 1984
Seseleo leucospermi-Festucetum pallentis brometosum pannonici	+–1	III	in layer C	Mészáros-Draskovits 1967
Querco-Carpinetum Tilietosum argenteae	+–1	III	occasionally in layers B and C	Horváth 1972
Potentillo albae-Quercetum (petraeae-cerris) pannonicum	+–1	III	in layer B only	Zólyomi 1958
Fagetum silvaticae Mecsekense	+–1	III		Horváth 1972
Mercuriali-Tilietum	2	II	in layer B	Isépy 1968
Querco (petraeae)-Carpinetum pannonicum	+–1	II	in layer B	Fekete 1965
Quercetum petraeae-cerris pannonicum	+–1	II	in layer B	Fekete 1965
Festucetum glaucae cult. consoc. Pinus nigra	+–1	II	in layer B	Borhidi 1956
Dictamno-Tilietum cordatae	+–1	II	in layer B	Fekete 1965
Caricetum humilis cult. consoc. Pinus nigra	+–1	II	in layer B	Borhidi 1956
Cleistogeno-Festucetum rupicolae festucetosum rupicolae	+	II	in layer C	Penksza et al. 1995
Deschampsio-(Luzulo-) Fagetum Mecsekense	+	II	with reduced rate in layer B and C	Horváth 1972
Corno-Quercetum Matricum	+	II	in layer A only	Fekete 1965
Aceri (campestri)-Quercetum petraeae-roboris	+	II	in layer B	Fekete 1965
Mercuriali-Tilietum Ruscetosum aculeati Mecsekense	2	I		Horváth 1972
Asplenio rutae-murariae-Melicetum ciliatae	+	I	in layer C	Penksza et al. 1995
Querco petraeae-Carpinetum	+	I	A and B layers	Horánszky 1964
Luzulo-Quercetum	+	I	A and B layers	Horánszky 1964

canopy stands (Fekete 1959, Horvat et al. 1974). Locality: Zsíros Hill, Buda Hills; altitude: 360–380 m a.s.l.; slope: 30–35°, facing north.

3. *Cotino-Quercetum pubescentis*. This community is the natural vegetation on south facing, calcareous hillslopes in Hungary. Here *Quercus pubescens* and *Fraxinus ornus* codominate forming a tree canopy with 40–70% cover. Detailed phytosociological description of this vegetation type is given by Zólyomi (1958). Manna ash individuals receive much more sunshine than under the pine stand, however, they are somewhat shaded by neighbouring *Quercus* and *Fraxinus* trees. Water shortage may prevail more often than the other two sites, because considerable surface run off due to the slopes with rock outcrops. Locality: Ördög-orom, Buda Hills; altitude: 260–280 m a.s.l.; slope: 20–40°, facing east-southeast.

At each sampling site 21 manna ash individuals were selected with an even distribution within prefixed circumference categories ranging from 6 cm to 60 cm. Trees with larger circumference than 60 cm were rare in the studied habitats. Circumference measurements were made at the base of the tree-trunks, but conical parts caused by the branching main roots were omitted. Diameter at brest height – traditionally measured by foresters – was not appropriate in this case, because several individuals branched more close to the soil surface. After measuring the circumference the tree was normally felled and a 1 cm thick disk was cut off from the point where the circumference was measured. Disks were labelled then transported to the laboratory and the year-rings were counted by the aid of appropriate microscope. In case of the thickest individuals the cores were taken by a driller. Because of uncertainty due to year-ring anomalies (Lorimer et al. 1999), counts were repeated three times for disks and twice for cores in different directions, then the average value was calculated for each tree. Disks were considered completely circular for calculating diameter values, then diameter data were plotted against year-ring counts (i.e. age of manna ash individuals). Linear regression analysis was applied to test the correlation between age and diameter (Sváb 1981).

RESULTS AND DISCUSSION

Basic data for basal diameters and year-ring counts are shown in Table 2. Average ages of the measured individuals were 19.76 years for the successional habitat, 37.76 years in the pine plantation and 33.67 years in the *Cotino-Quercetum pubescentis* community. The relatively low average age obtained for the successional habitat – considering that the same circumference categories were filled up at every site – highlight the higher growth rate of manna ash individuals at this habitat.

Significant correlation appeared, at $p < 0.001$ level, between basal diameter and age (year-ring count) in the successional habitat and the pine plantation (Figs 1 and 2). The highest regression coefficient ($r = 0.9181$) was found in pine plantation, probably as a result of the uniform conditions prevailing for manna ash growth under the *Pinus nigra* canopy (Fig. 2). In the successional habitat the data were somewhat more scattered, but the correlation coefficient was still high enough for significance ($r = 0.7406$). At this site there were several examples when a thin tree was older than other individuals found in one or two circumference classes higher (Fig. 1). Presumably, this size and age plasticity can be interpreted as a buffer mechanism against spatial and temporal variability in habitat conditions (Grime

Table 2

Basal diameter and year-ring counts data of *Fraxinus ornus* individuals from three ecologically contrasting habitats

Nr.	Circumference class (cm)	Successional habitat (Nyakas Hill)		Pine plantation (Zsíros Hill)		*Cotino-Quercetum pubescentis* (Ördög-orom)	
		Diameter (cm)	Year-ring counts	Diameter (cm)	Year-ring counts	Diameter (cm)	Year-ring counts
1	6–8	2.55	10	2.23	19	1.91	19
2	8–10	3.02	15	2.86	19	2.86	31
3	10–12	3.66	18	3.50	21	3.66	33
4	12–14	4.30	16	3.98	26	3.98	37
5	14–16	4.93	19	4.93	34	4.93	27
6	16–18	5.57	13	5.09	30	5.25	35
7	18–20	6.21	15	6.37	34	6.21	29
8	20–25	7.00	20	7.80	41	7.00	45
9		7.80	24	7.96	39	7.96	39
10	25–30	9.23	20	9.23	32	8.12	30
11		9.55	21	9.39	42	8.44	40
12	30–35	9.87	20	10.35	40	10.66	32
13		10.50	20	10.82	41	11.14	36
14	35–40	12.25	19	11.78	42	11.78	20
15		12.57	25	12.41	49	12.41	26
16	40–45	13.05	26	13.69	45	13.21	49
17		14.16	17	13.85	47	13.53	26
18	45–50	14.64	24	14.96	49	15.28	36
19		14.80	22	15.28	49	15.92	46
20	50–60	16.55	22	16.55	45	16.55	37
21		16.87	29	17.35	49	18.94	34

et al. 1986). Since the solitary individuals of the studied successional habitat are subjected to a very uniform aerial environment, soil properties can be the main factors responsible for the mosaic-like local habitat differences.

Though the fate of a certain individual at the successional habitat can vary in a wide range, however at the population level this habitat offers much better conditions for growth of *Fraxinus ornus*, than the pine plantation does. Taking slope angles of regression equations into account, trees grow 72% faster in average in the successional habitat than in the pine plantation.

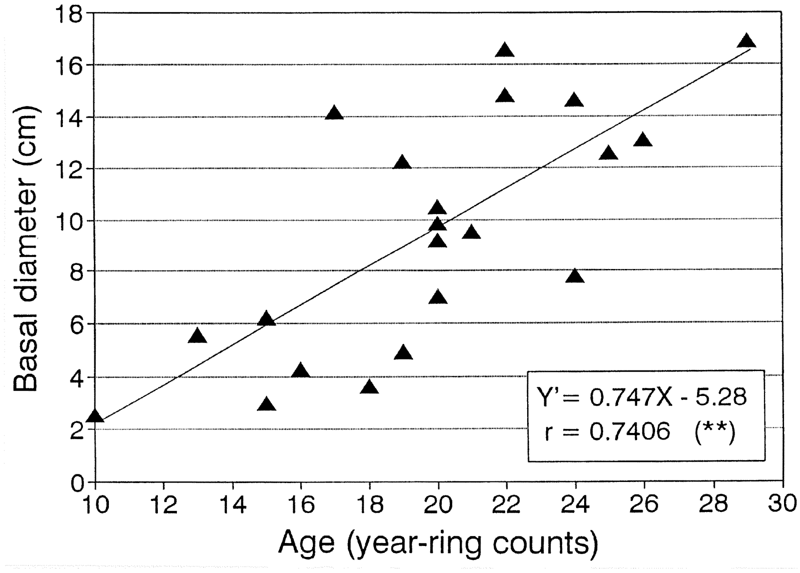

Fig. 1. Correlation between age and basal diameter of *Fraxinus ornus* individuals in a successional habitat (Nyakas Hill); ** = significant at $p < 0.001$ level

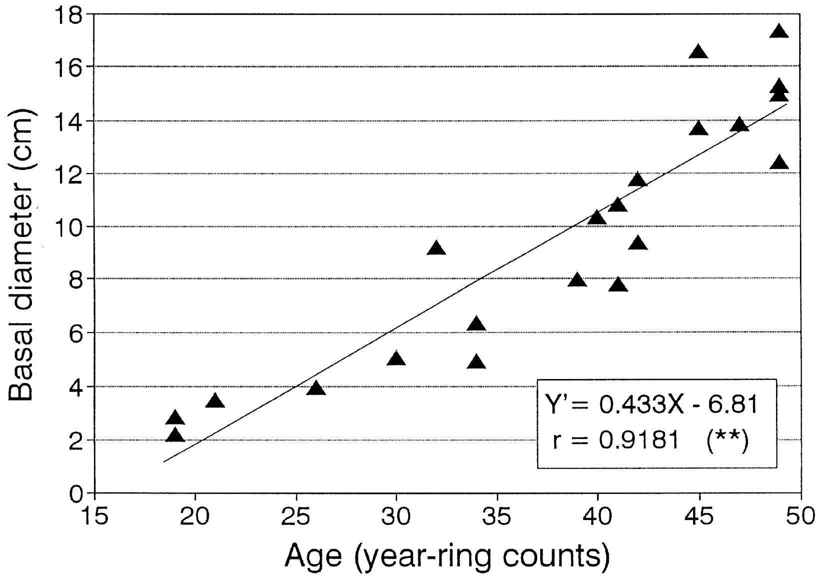

Fig. 2. Correlation between age and basal diameter of *Fraxinus ornus* individuals in a pine plantation (Zsíros Hill); ** = significant at $p < 0.001$ level

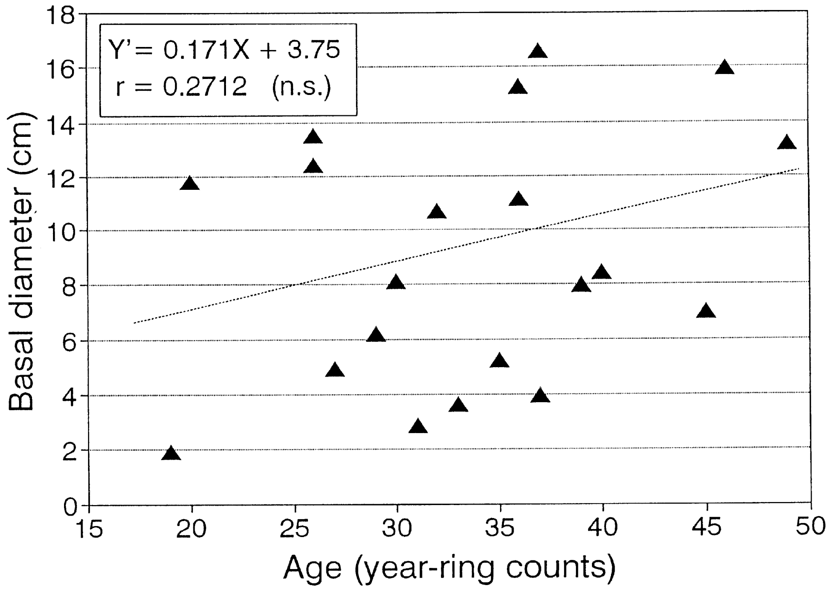

Fig. 3. Correlation between age and basal diameter of *Fraxinus ornus* individuals in a *Cotino-Quercetum pubescentis* community (Ördög-orom); n.s. = not significant

In case of the *Cotino-Quercetum pubescentis* community – what is considered as natural habitat of *Fraxinus ornus* – surprisingly the age and the basal diameter varied almost independently (r = 0.2712) (Fig. 3). In this habitat sometimes 10 or even 20 years differences occurred between individuals belonging the same circumference class, or from the other side 3–4-fold differences appeared in basal diameter of even-aged trees. Beside this, the average growing rate of manna ash (slope angle of the regression equation) was the lowest in this habitat.

These findings reflect to the highest variability of habitat conditions and to low productivity in general in the *Cotino-Quercetum pubescentis* community. Here the quality of a local habitat to what a certain individual meets is highly unpredictable because of the heterogeneity by both the aerial environment and soil properties. Undoubtedly, a considerable rate of morphological plasticity must characterize *Fraxinus ornus, making it capable to maintain high density and to become dominant tree of a plant community in such extreme and chronically unproductive habitat like the studied one. It is assumed that certain physiological plasticity also contribute* to the success of manna ash in surviving under very different conditions.

CONCLUSIONS

For *Fraxinus ornus* growing in ecologically contrasting habitats the basal diameter of the trunk was found to be a good predictor of tree age where populations develop under a relatively uniform light regime, *i.e.* in a successional sun habitat (colonised grassland) or in the deep shade of a *Pinus nigra* plantation. However, the highly heterogeneous aerial and soil environments in the species' typical natural habitat (*Cotino-Quercetum pubescentis* scrub woodland) cause an uncoupling of age and trunk diameter. In addition, diameter growth is fastest in the least abiotically limited successional sun habitat.

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