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Wood anatomy of ivy-hosting black alder (*Alnus glutinosa* Gaertn.)

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Abstract: The study aims at investigating the impact of ivy (*Hedera helix* L.) on the growth and on some wood anatomical characteristics of black alder trees. Ivy-hosting and non-hosting black alder have a similar wood anatomy in terms of qualitative properties. However, in ivy-hosting trees tangential and radial diameter of vessels are narrower ($p < 0.001$), and inter-vessel pits are smaller ($p < 0.01$), whereas vessel frequency is higher ($p < 0.05$) than those of non-hosting ones. The average maximum ray height is greater ($p < 0.05$), and ray number mm^{-1} is lower ($p < 0.001$) than those of non-hosting individuals. In addition, the last ten years' average radial growth has decreased 39.5% compared to that of non-hosting black alder.

Additional key words: ivy impact, host tree, secondary xylem

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Introduction

Hedera helix L., commonly called as English ivy, is a woody species climbing to vertical surfaces such as suitable trees, cliffs, and walls (Chamberlain 1972; Metcalfe 2005). It is an aggressive plant competing with grasses, herbs and trees in its habitat (Morisawa 1999; Okerman 2000), and actually smothers most seedlings, breaks host tree's branches, and accelerates tree death (Wyman 1969). It can impact the forest floor, the shrub layer and the canopy of a forest (Simon 2004). Therefore, it is considered *H. helix* can be a problem in certain areas of its native zone, particularly in disturbed habitats (Morisawa 1999; Okerman 2000).

Due to negative effects on light penetration, *H. helix* can be a fatal threat for a host tree, canopy of which is entirely occupied by it (Thomas 1980; Reichard

2000). However, on the base of Arthur Arnold's unpublished experiment, Metcalfe (2005) reported no effect of *H. helix* on the height and cubic content of oak trees. Similarly, Tremolieres et al. (1988) pointed out that any significant effect of it does not occur on radial growth of host tree. Moreover, Nola (1997) rejected the hypothesis that *H. helix* has an unfavourable effect on radial growth of *Fagus sylvatica* L.

Alnus glutinosa is a well-known species in terms of its wood anatomy (Greguss 1959; Brazier & Franklin 1961; Jacquot et al. 1973; Schweingruber 1990; Merev 1998; Richter & Dallwitz 2000; Schock et al. 2004). However, literature is lacking on wood anatomy of ivy-hosting trees. Therefore, the present study aims at defining wood anatomical features of host *Alnus glutinosa*, the entire canopy of which is invaded by *H. helix*, and at comparing them with those of non-host tree.

Materials and Methods

The sample trees were selected on a flood plain near to the Kocanaz River in Bartın, Turkey (Fig. 1). The floodplain has alluvial soil, which is rich in nutrients, and the level of underground water is high. The experimental design was based on the comparison of two groups of ivy-hosting and non hosting individuals. Comparison of growth pattern was performed on 10 individuals per group, whereas analysis on wood anatomical characteristics was only based on wood from two groups of 3 trees. In the selection, almost even-aged trees were considered to eliminate length-on-age influences. To determine the last 10 years' radial growth, 20 increment cores (5.15 mm in diameter) were taken from all of them. For anatomical investigation, wood specimens with 12 mm in diameter were obtained from the trees, the diameters of which were from 20 to 28 cm at breast height, and wood anatomical measurements were performed on the growth rings of the year 2006. The breast height diameters ($D_{1.30}$) and the ages of the sample trees are presented in Table 1.

The wood specimens boiled were softened in a solution consisting of equal parts of water, glycerine and ethyl alcohol. For light microscopy, permanent slides of wood sections (15 μm thick) and macerated wood materials were prepared in accordance with general laboratory techniques (Yaltirik 1971; Meriv 1998).

Twenty-five measurements were performed for the each of the following: vessel lumen diameter, vessel element length, and vessel number per group, inter-vessel pit size, mean maximal ray height, fibre

length, and the lumen diameter and wall thickness of fibre. Vessel number mm^{-2} , and ray number mm^{-1} were determined by counting at 10 different points of transverse and tangential sections, respectively. The last 10 years' growth-ring widths (from 1998 to 2007) were measured at a precision of 0.01 mm using a VIAS Time-Table, and they were plotted as both the raw and cumulative values of mean tree-ring widths (Figs. 2 and 3, respectively). With the SPSS 10.0 program, the mean and standard deviation of each quantitative feature were computed, and for equality of means, Student's t-test was used.

Results

Followings are the qualitative features on wood anatomy of ivy-hosting *A. glutinosa*:

- Growth rings: The boundaries distinct owing to thick-walled and radially flattened latewood fibres at the end of growth ring.
- Vessels: Wood diffuse-porous, vessels in radial multiples of 4 or more common, solitary vessel outline angular, scalariform perforation plates with 10 up to more than 20 bars, intervessel pits opposite, vessel-ray pits with distinct borders; similar to intervessel pits in size and shape.
- Fibres: With simple to minutely bordered pits; thin- to thick-walled.
- Axial parenchyma: Apotracheal-diffuse, four (3–4) to eight (5–8) cells per parenchyma strand.
- Rays: Exclusively uniseriate, all ray cells procumbent, aggregate rays present.

Any effect of *H. helix* does not occur on qualitative wood anatomy of *A. glutinosa* in the study. However, the radial growth and some quantitative anatomical features are affected by *H. helix* at different significant levels. In host *A. glutinosa*, vessel diameters (both tangential and radial) are narrower, and inter-vessel pits are smaller, whilst vessel number mm^{-2} is higher than those of control trees. Mean maximal ray height is greater, whilst ray number mm^{-1} is lower than those of non-host trees. In terms of each of vessel element length, vessel number per group, fibre length, and the lumen diameter and wall thickness of fibres, the differences between host and non-host trees are not statistically significant.

The average of growth ring widths formed in the last 10 years was 1.96 mm and 3.25 mm for host- and



Fig. 1. The site of sample trees (41°32'13 N lat.; 32°20'34 E long. and 20 m alt.)

Table 1. The breast height diameters and the ages of the sample trees

No	Host <i>A. glutinosa</i>										Non-Host <i>A. glutinosa</i>									
	1*	2	3	4*	5	6	7	8	9*	10	1*	2*	3*	4	5	6	7	8	9	10
$D_{1.30}$	25	24	22	27	23	20	25	22	24	26	24	28	26	22	23	24	22	21	24	21
Age	30	29	26	32	27	24	30	25	31	32	25	26	24	20	19	24	22	18	23	20

$D_{1.30}$ = the diameter of breast height of sample trees (cm), * The sample trees used for anatomical investigation

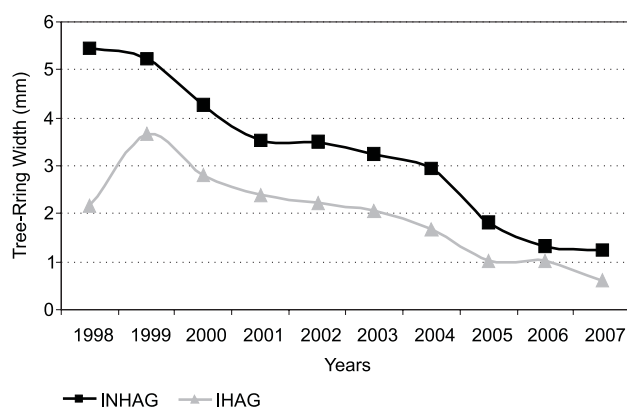


Fig. 2. Mean raw growth ring widths from 1998 to 2007, IHAG: ivy-hosting *A. glutinosa* INHAG: non-hosting *A. glutinosa*

non-host *A. glutinosa*, respectively. Due to the occurrence of *H. helix*, the average decrease in diameter is totally 2.6 cm (39.5%) along the last 10 years.

Table 2 shows the quantitative wood anatomical data of ivy-hosting and non-hosting *A. glutinosa*, and Figures 2 and 3 present the raw and cumulative values of the last 10 years' average growth ring widths, respectively. Figure 4 shows wood anatomical micrographs.

Table 2. Quantitative anatomical data of host and non-host *A. glutinosa*

	Host <i>A. glutinosa</i>		Non-host <i>A. glutinosa</i>		T-test Coefficient
	M	SD	M	SD	
TVD	47.5	8.0	54.5 ⁺	7.8	-5.4***
RVD	58.7	14.0	74.9 ⁺	13.6	-7.2***
VF	142.0	28.6	121.1 ⁺	17.9	2.4*
VEL	738.0	120.4	728.0	106.1	0.3 ^{ns}
VGR	1.84	1.16	1.98	1.65	-0.8 ^{ns}
IVPD	5.45	0.42	5.78	0.36	-3.3**
RHmax	667.3	96.1	621.3	50.4	2.3*
RNmm	14.3	1.6	16.0	1.6	-4.0***
FL	1.27	0.14	1.26	0.1	0.4 ^{ns}
FLW	16.2	2.2	16.7	3.7	-0.7 ^{ns}
FWT	4.44	1.14	4.08	0.8	1.2 ^{ns}
GRW	1.96	0.92	3.25	1.48	-2.3*

* = significant at the 0.05 level, ** = significant at the 0.01 level, *** = significant at the 0.001 level, ns = non-significant, + = these control values were also used in our TUBITAK project (TOVAG 1070886)

Abbreviations: TVD: Tangential vessel diameter (μm) – RVD: Radial vessel diameter (μm) – VF: Vessel frequency (vessel number mm^{-2}) – VEL: Vessel element length – VGR: Vessel grouping index (number of vessels per group) – IVPD: Intervessel pit diameter (μm) – RHmax: maximal height of multiseriate ray (μm) – RNmm: Ray number mm^{-1} – FL: Fibre length (mm) – FLW: Fibre lumen width (μm) – FWT: Fibre wall thickness (μm) – GRW: Growth ring width (mm) – M: Mean – SD: Standard deviation

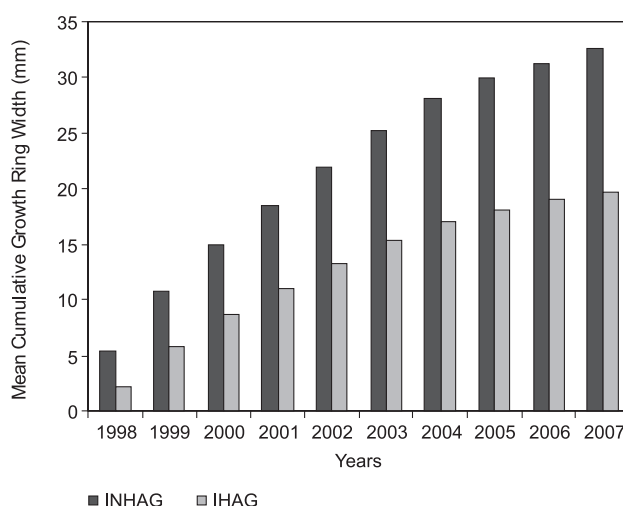


Fig. 3. Mean cumulative growth ring widths from 1998 to 2007, IHAG: ivy-hosting *A. glutinosa* INHAG: non-hosting *A. glutinosa*

Discussion

There are different opinions on the response of host tree invaded by *H. helix*. First, according to common concept, it has been regarded as a potential problem for host tree (Okerman 2000; Simon 2004). Second, it is a cooperative species having a positive impact on host tree (Tremolieres et al. 1988). Moreover, Nola (1997) pointed out no radial growth reduction in ivy-hosting *Fagus sylvatica* L., and the author emphasized the distinctive increase of its radial growth, in some cases, in that study. However, Yaman (2009) reported that *H. helix* causes radial growth reduction on host *Platanus orientalis*, and he also stated that it has an effect on the oriental plane's quantitative wood anatomical features. In response to the high-level invasion of *H. helix* on the canopy of *A. glutinosa*, similar results occur in the current study. As shown in Table 2, vessel diameter, vessel frequency, intervessel pit diameter, maximal ray height, ray number mm^{-1} , and growth ring width in host trees are significantly different from those of non-host trees. The decreasing trend in the either curves of Figure 2 is due to the age-related variation on stem cross-section from 1998 to 2007. However, as a result of high-level invasion of the canopy by ivy, the mean growth ring width of each year in the period studied is narrower in host tree group than that of control group (Fig. 2).

It appears that radial growth reduction and variations of some quantitative wood anatomical features in host *A. glutinosa* are a result of the negative effects of *H. helix* in the last phase of invasion. It tends to climb to host trunk and branches, especially those of deciduous trees such as *P. orientalis* and *A. glutinosa* in floodplains. Thomas (1980) stated that host tree's increasingly open crown allows it to grow even more

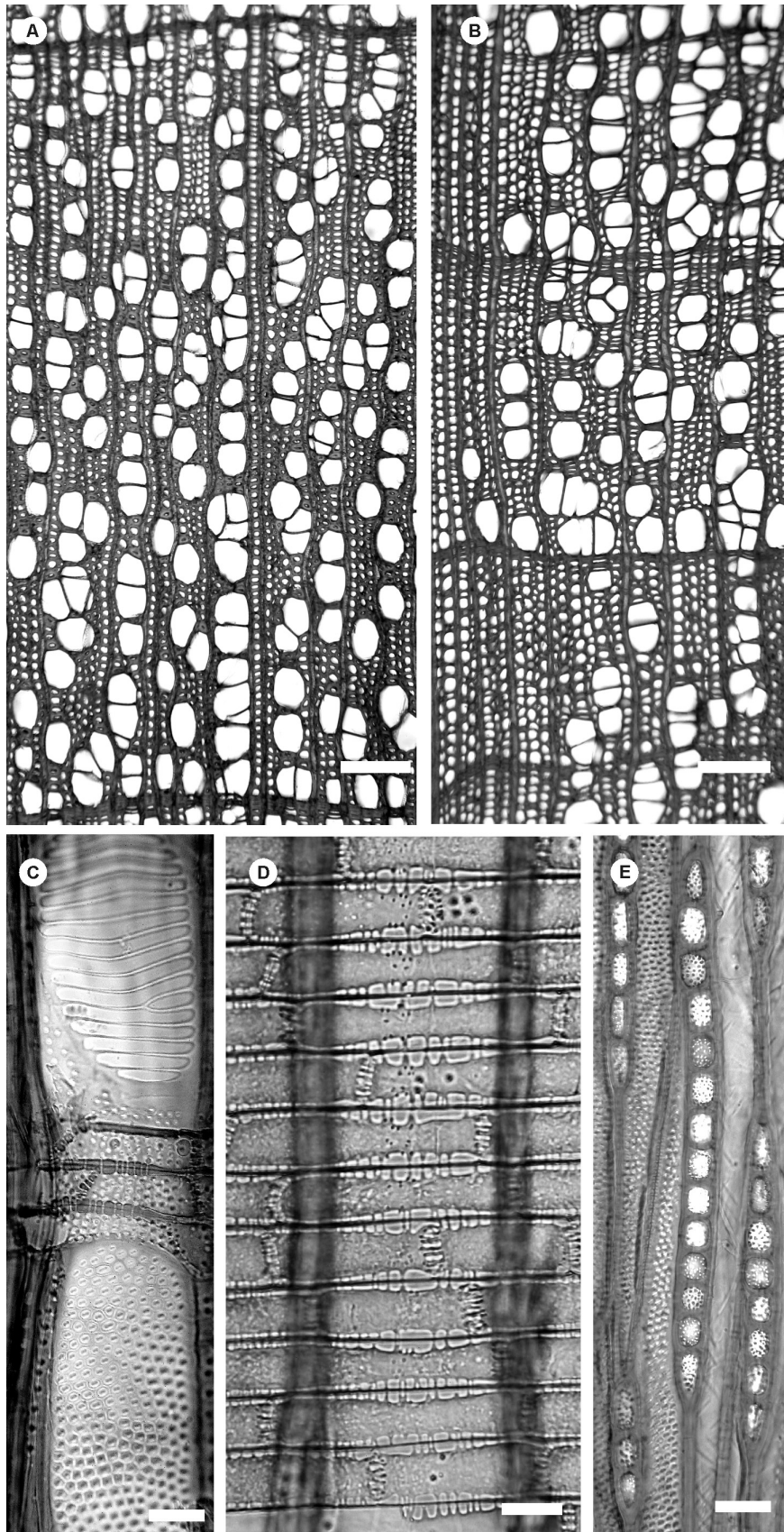


Fig. 4. A and B: Growth rings and vessels (TS); – C: Scalariform perforation, vessel-ray pits, intervessel pits (RLS); – D: ray parenchyma (RLS); – E: Uniseriate rays (TLS). Scale Bar (1 cm line): 150 μm for A, 120 μm for B, 30 μm for C, 20 μm for D, 30 μm for E. (Notes: – 1: the micrographs A and D were also presented in our TUBITAK project (TOVAG 1070886) – 2: Only A belongs to non-host tree, others to host tree)

due to dying back of host branches. While *H. helix* is invading the canopy, the light penetration to the foliage of host tree is reduced (Thomas 1980; Reichard 2000). Dense ivy cover on trunk and branches causes problems in normal contact of lenticels with air (Simon 2004). Furthermore, even though it has a fertilizer effect for host tree (Tremolieres et al. 1998), the fast-growing ivy competes with host tree for water and nutrients (Simon 2004).

In the current study, as distinct from the statements of Tremolieres et al. (1988) and Nola (1997), the radial growth of *A. glutinosa* appears to be affected by *H. helix*. The clear result in radial growth reduction can be due to the selection of entirely invaded host individuals as sample trees (Yaman 2009). Up to certain point of invasion, host tree cooperates with *H. helix* due to a fertilizer effect of more rapidly decomposing litter in the presence of ivy leaves (Tremolieres et al. 1988), but *H. helix* turns to “death-trap” by shutting out light penetration to the host tree’s foliage in the last phase of invasion.

References

- Brazier J.D., Franklin G.L. 1961. Identification of hardwoods. A microscope key. Forest Products Research Bulletin No. 46, 96 p.
- Chamberlain D.F. 1972. *Hedera* L. In: Flora of Turkey and the East Aegean Islands. Davis P.H. (ed.). University Press, Edinburgh, pp. 538–539.
- Greguss P. 1959. Holzanatomie der Europäischen Laubbölzer und Sträucher. Akadémiai Kiadó, Budapest, 335 p.
- Jacquot C., Trenard Y., Dirol D. 1973. Atlas d’anatomie des bois des Angiospermes (Essences feuillues). Centre Technique du Bois, Paris, 175 p.
- Merev N. 1998. Wood anatomy of native Angiospermae taxa in Eastern Black Sea Region I-A. Karadeniz Technical University-Forestry Faculty Press, Trabzon, 396 p.
- Metcalf DJ. 2005. *Hedera helix* L. Journal of Ecology 93: 632–648.
- Morisawa T. 1999. Weed Notes: *Hedera helix* L. The Nature Conservancy Wildland Invasive Species Team. Available from <http://tncweeds.ucdavis.edu>. Accessed 2007 the March 13th.
- Nola P. 1997. Interactions between *Fagus sylvatica* L. and *Hedera helix* L.: a dendroecological approach. Dendrochronologia 15: 23–37.
- Okerman A. 2000. Combating the “Ivy Desert”: The invasion of *Hedera helix* (English Ivy) in the Pacific Northwest United States. Restoration and Reclamation Review 6 (4). Available from <http://horticulture.cfans.umn.edu/vd/h5015/rrr.htm>. Accessed 2007 the March 3rd.
- Reichard S. 2000. *Hedera helix* L. In: Invasive Plants of California’s Wildlands. Bossard C.C., Randall J.M., Hoshovsky M.C. (eds.). University of CA Press, Berkeley, pp. 212–216.
- Richter H.G., Dallwitz M.J. 2000. Commercial timbers: descriptions, illustrations, identifications, and information retrieval. Available from <http://delta-intkey.com>. Accessed 2006 the April 16th.
- Schock W., Heller I., Schweingruber F.H., Kienast F. 2004. Wood anatomy of central European species. Available from <http://www.woodanatomy.ch>. Accessed 2009 the April 15th.
- Schweingruber F.H. 1990. Anatomy of European woods. Verlag Paul Haupt Berne and Stuttgart Publishers, 800 p.
- Simon B. 2004. English ivy – *Hedera helix*. King County Noxious Weed Control Program – Weed Bulletin. 4 p.
- Thomas L.K. 1980. The impact of three exotic plant species on a Potomac Island. National Park Service Scientific Monograph Series no. 13., Washington DC, 179 p.
- Tremolieres M., Carbiener R., Exinger A., Turlot J.C. 1988. An example of non-competitive interaction between lignous – the climbing ivy (*Hedera helix*) in the alluvial forest. Acta Oecologica 9: 187–209.
- Wyman D. 1969. Shrubs and vines for American gardens. Revised Ed. Macmillan Publishing Company, New York, 640 p.
- Yaltirik F. 1971. Taxonomical study on the macro- and micro- morphological characteristics of indigenous maples (*Acer* L.) in Turkey. Istanbul University Press, Istanbul, 232 p.
- Yaman B. 2009. Comparative wood anatomy of ivy-hosting and non-hosting oriental plane (*Platanus orientalis* L.). Plant Biosystems 143: 252–257.