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MODIFICATIONS IN *GINKGO BILOBA* L. IN RESPONSE TO ENVIRONMENTAL POLLUTION

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ABSTRACT

Ginkgo biloba L. (maidenhair tree) was studied in polluted and relatively clean habitats of West Tennessee. In spite of its known resistance to smog and automobile exhaust fumes, it exhibited a decrease in leaf length, leaf width, and petiole length in polluted habitats. Furthermore, there was a definite trend towards lower stomatal density along the pollution gradient in selected habitats.

INTRODUCTION

Ginkgo biloba L. (maidenhair tree) is a dioecious deciduous gymnosperm, growing to 30 meters high. It is a native of China where the tree has been cultivated for centuries. It was introduced in the United States of America around the end of the 18th century and it is considered to be resistant to automobile exhaust and smog. Furthermore, it is quite free from pathogenic organisms. Its fruit is the source of gingkolic acid–an antibiotic active against Tubercle bacilli (Lewis and Lewis, 1976). It is because of its known resistance to air pollution that this plant species was selected to determine its cuticular and gross morphological responses to environmental pollution in selected habitats of West Tennessee, where it is cultivated for ornamental purposes. Air pollutants enter the leaves through tiny stomatal pores (Majernik and Mansfield, 1970; Bonte, De Cormis, and Louguet, 1977) and then attack chloroplasts causing chlorosis, necrosis, glazing, etc. (Crittenden and Read, 1978; Reinert and Henderson, 1980). Cuticular studies on several species of angiosperms (Salisbury, 1927; Au, 1969; Sharma and Butler, 1973; Sharma and Mann, 1984) confirm the usefulness of plants in general and their cuticular complex in particular as bioindicators of environmental contamination. The present study deals with a unique gymnosperm taxon.

MATERIALS AND METHODS

Four populations comprising twelve samples of the taxon were collected in West Tennessee (Table 1). The population from Memphis represented a heavily polluted habitat of urban, industrialized Memphis, which has a human population of more than 800,000. The plant samples from Memphis were affected by a wide variety of aerial pollution typical of a metropolitan, industrialized city. Union City, a small town in northwest Tennessee represented another habitat where the plant samples experienced air pollution from a local paving complex and a meat-packing plant. Close proximity of the plant population sampled to the industrial complex meant direct exposure to aerial pollution. Reelfoot Lake is a rural area in northwest Tennessee and had practically no visible source of local aerial pollution except some vehicular traffic. Martin, another small rural community of 8,000 has no industry and

Table 1. Pollution gradients of *Ginkgo biloba* populations.

Pop.	Locality*	Pollution level**	Source of Pollution	Number of Samples
A	Martin	+	vehicular traffic	3
B	Reelfoot Lake	+	vehicular traffic	3
C	Union City	++	vehicular traffic, industry, meat pkg plt.	3
D	Memphis	+++++	vehicular traffic, heavy industry, jet airport, etc.	3

*In Tennessee, USA

**+, lowest; +++++, highest

the plant samples were collected from sites typical of the area. No instrument for measuring pollution level or type was used, although apparent sources of pollution were noted and taken into consideration while collecting and interpreting data. Each sample was collected from similar microhabitats to minimize variation caused by other environmental parameters. Gross morphological data were collected from ten mature leaves in each sample. Cuticular slides were made for the adaxial and abaxial leaf surfaces (Williams, 1973). The data were collected from 10 microscope fields (40× objective and 10× oculars) selected at random from each slide. Stomatal density, trichomes, and epidermal wall undulations were studied for each population. The data were analyzed (Table 2).

Table 2. Statistical analysis of morphological and cuticular patterns* of populations of *Ginkgo biloba*.

Trait	Pop. A	Pop. B	Pop. C	Pop. D
Leaf length (cm)	7.1±0.7	7.3±0.5	6.8±0.6	6.4±0.6
Leaf width (cm)	7.6±0.7	7.7±0.6	6.3±0.7	6.0±0.6
Petiole length (cm)	4.8±0.8	5.1±0.8	4.8±1.4	4.2±0.6
Stomatal density**	U=0	U=0	U=0	U=0
	L=6.3±0.3	L=5.5±0.4	L=1.3±0.1	L=1.6±0.2
Epidermal wall	U=3.6±1.5	U=3.6±1.8	U=3.4±1.0	U=1.8±0.6
undulations (n)	L=3.5±2.0	L=3.2±1.6	L=3.9±1.3	L=3.7±1.7

*The values represent means of 10 measurements ± standard deviation.

U=adaxial leaf surface; L=abaxial leaf surface.

**Mean stomatal density=stomata of the leaf surface observed through a 40× objective and 10× oculars (field area=0.152 mm²)

Results and Discussion

Statistical analysis of the morphological and cuticular data (Table 2) indicates that the leaf length in *Ginkgo biloba* ranged from 6.4 cm in Memphis to 7.3 cm in the Reelfoot Lake area population. Similarly, the lowest measurement of 6.0 cm for leaf width was found in plants from Memphis, while the highest reading of 7.7 cm was in plant samples of the Reelfoot Lake area. Average petiole length was 4.2 cm in Memphis plants while the Reelfoot Lake plants had the longest petioles (mean $\overline{x}$ 5.1 cm). Cuticular data, derived from the abaxial leaf surface, revealed that the highest mean stomatal density value of 6.3/unit area (0.152mm²) was in leaves of the Martin area population A, and the Reelfoot Lake area population B had the high stomatal density value (mean $\overline{x}$ 5.5), while the lowest values for the stomatal density were found in plants of the polluted habitats of Memphis (population D) and Union City (population C). No stomata were found on the adaxial leaf surfaces of *Ginkgo biloba* sampled for the study. Furthermore, there were no trichomes on the adaxial or abaxial leaf surfaces. Epidermal wall undulations seemed to show no significant variation among the four populations sampled.

It seems obvious from the data that environmental pollution adversely affected the growth of maidenhair tree leaves as evident from the decrease in leaf length, leaf width, and petiole length in plant populations D and C of Memphis and Union City respectively. However, there was no visible macroscopic damage to the leaves of the polluted habitats of Memphis and Union City—thus suggesting the relative resistance of the taxon to the aerial contaminants of the area. The low density of stomata in the leaves of Memphis and Union City plant populations (populations D and C respectively) suggests that stress of environmental pollution induced this defensive response in these two populations. The physiological implications of this response mean that the amounts of gaseous pollutants entering the leaves through stomata is reduced and hence the plant is able to survive in contaminated habitats. The relatively less polluted habitats of Reelfoot Lake (population B) and Martin (population A) had high densities of stomata. The response may be of ecotypic or even evolutionary significance. Furthermore, the absence of trichomes on the leaves of the maidenhair tree and the insignificant variation in the undulations of epidermal walls in the polluted as well as relatively less polluted habitats may be suggestive of unique resistance of this plant species to air pollution, since most plant species studied (Sharma and Tyree, 1973; Sharma, Chandler, Salemi, 1980) exhibited definite modifications in trichome density and epidermal wall undulations under an environmental stress of this nature.

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