Agrobiodiversity for Improving Nutrition, Health and Life Quality

Research Article

OPEN ACCESS

Cultural extension of *Ginkgo biloba* L. in Slovakia

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Article Details:
Received: 2021-07-11
Accepted: 2021-08-27
Available online: 2021-11-30

DOI: https://doi.org/10.15414/ainhlq.2021.0025

Ginkgo biloba L. is the oldest species of tree on our planet. It is a dioecious species characterized by exceptional resistance to climate change and natural influences, which predetermines it as a suitable species for urban planting. Not to be overlooked is the ginkgo benefit in terms of the medical effects of leaf metabolites. Due to its aesthetic value ginkgo is becoming popular in family gardens. The aim of our research was the evidence and description of ginkgo trees in Slovakia. The study presents the completion of data on the cultural distribution of this tree. We confirmed the occurrence on more than one hundred localities (103 localities). Some previously registered localities (18) were not found, or trees were felled for various reasons (5). We evaluated the basic dendrometric and growth parameters of the oldest ginkgo trees (aged 242 – 111 years), found in 35 localities of Slovakia. The presented research results bring several new information concerning the tree gender determination, tree habitus, phenological rhythm of development and others. Morphologically interesting solitary trees, including trees with shoots known as lignotubers or "basal chichi" (locality Hajná Nová Ves), or the occurrence of fruits on the leaves, referred to as cv. Ohatsuki (Lučenec) are described and documented by photos.

Keywords: maidenhair tree, locality, occurrence, Slovak Republic

Introduction

Ginkgo biloba L. is a dioecious species endemic to China (Li et al., 2009). It is a famous living fossil and is the only known extant representative of *Ginkgophyta* (He et al., 2015; Šmarda et al., 2016). It contains several different biologically active compounds which play a role in defense mechanisms against insects, bacteria and fungi (Singh et al., 2008). The leaves of ginkgo are a rich source of compounds with antioxidant activity (van Beek, 2000) and are commonly used as phytomedicines in the treatment of atherosclerosis and cerebrovascular insufficiency (Kleijnen and Knipschild, 1992; Xie et al., 2003) depression, memory loss, headaches, and vertigo (Diamont et al., 2000). A recent study of extracts from the leaves of *Ginkgo biloba* L. from some Slovakian localities showed that these extracts can be used as antimicrobial and antioxidant additives due to their significant antioxidant and antimicrobial activity which was sample-specific (Ražná et al., 2020).

In Slovakia, *Ginkgo biloba* L. is relatively little known, although in historical parks and gardens it grows in several places, from plantings from the late 18th and 19th centuries (e. g. Bratislava, Topoľčianky, Nová Ves nad Žitavou, Beladice, Lučenec, Betliar, Jasov, Košice,

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ISSN 2585-8246

Humenné, etc.) (Tokár, 1968; Tokár, 1970; Ražná et al., 2014). Current horticultural practice confirms that ginkgo belongs to a small group of species capable of resisting urban exhaustion, salinization, and water scarcity (Raček et al., 2009, 2010, 2011), and at the same time, with its aesthetic value, effectively beautifies the urban environment. From the horticultural point of view, ginkgo is becoming more and more popular, and its coloured and shaped cultivars are gaining more and more space in family gardens (Tomaško, 2004; Hrubík et al., 2011).

We began research into the cultural distribution and occurrence of *Ginkgo biloba* L. in 2007. We focused first on the districts of Nitra and Zlaté Moravce, and later the entire Nitra self-governing region. The most suitable conditions for research were provided by fruit trees in the State Forest Park in Topoľčianky, the Arborétum Mlyňany of the Slovak Academy of Sciences, historical parks in Nová Ves nad Žitavou, Beladice, and trees planted in the Nitra City Park in Sihoť. Later, we extended the research to the districts of Topoľčany, Trnava, Levice, Nové Zámky and Komárno. Intensive field research continued in 2010–2011 in other districts of Slovakia (former districts of the West and Central Slovakia regions). We presented a summary of the acquired knowledge and more comprehensive research in two monographs (Ražná et al., 2014; Ražná and Hrubík, 2016). The mentioned publications contain a comprehensive overview of the determined taxation values, complete biological data, horticultural values, and an evaluation of the health status of ginkgo trees that grow in Slovakia. The publication also includes a complete list of trees growing in historical parks, street plantings (mostly as tree lines and alley plantings), and other objects of public (and accessible private) greenery in towns and villages in Slovakia. In addition to the results of field research, considerable attention was paid to a genomic screening of polymorphism using molecular markers, as well as antioxidant and antimicrobial parameters of selected individuals of ginkgo (Ražná et al., 2019; Ražná et al., 2020).

The impetus for concluding and completing the research on the cultural distribution of *Ginkgo biloba* in Slovakia was, on the one hand, the processing of scientific knowledge acquired so far, but especially the commitment to conclude current and interesting issues of spreading one of the rare cultural trees – *Ginkgo biloba* in Slovakia. The first findings on the distribution of ginkgo in Slovakia were obtained as early as 1965–1975, as part of cooperation on extensive and comprehensive research in the Arborétum Mlyňany – Institute of Dendrobiology of the Slovak Academy of Sciences. When selecting research sites, we therefore, accepted the published results of the cultural distribution of foreign trees in Slovakia (including *Ginkgo biloba*), (Benčať, 1982). It contains a total of 80 sites (75 historic parks, 5 other greenery). From the available literature, internet sources, other sources, as well as from our own findings, we supplemented and evaluated the ginkgo trees in other (new) localities. For the purposes of this publication, we selected a list of the oldest trees of *Ginkgo biloba*, growing in Slovakia. The locality contains the name and registration number of the historical park and garden (P – 44), district – according to the current territorial division of the territory (TO – Topoľčany), period of the foundation of the dendrological building in the relevant century (e. g. 19/1 – first half of the 19th century, with the designation of the years – 1850). For this purpose, we selected several figures of interesting solitary trees and conclusions based on our long-term research, concerning tree habitus and gender differentiation features.

Material and methodology

Biological material

In research of cultural extension of *Ginkgo biloba*, we followed methodologies and working procedures. As already mentioned, we have fully accepted the well-known and published list of identified localities (Benčať, 1982) (Figure 1), including other, new localities identified from other unpublished, internet sources, as well as information on previously registered or otherwise registered trees (e. g. state-protected trees, where old and memorial ginkgo trees were included). At each locality, which we personally evaluated, we surveyed the existing ginkgo trees, on which we obtained basic taxation data (trunk circumference, trunk diameter 1.3 m above the ground; tree height, crown width, health status, horticultural value – according to the 5-point scale, in the case of larger trees, we also determined the circumference of the trunk at the ground) (Hrubík et al., 2011) and made an up – to – date photo documentation of the trees at a specific locality.

When determining the main dendrometric dimensions of ginkgo trees, we used a specialized textile band, which measures, on one side of the band, in units of cm, and on the other side of the band, are measured units converted to the values of the average. During the field research, we used this textile band to measure the circumference of the tree trunk, thus also obtaining the measured value of the trunk diameter. We measured

ISSN 2585-8246

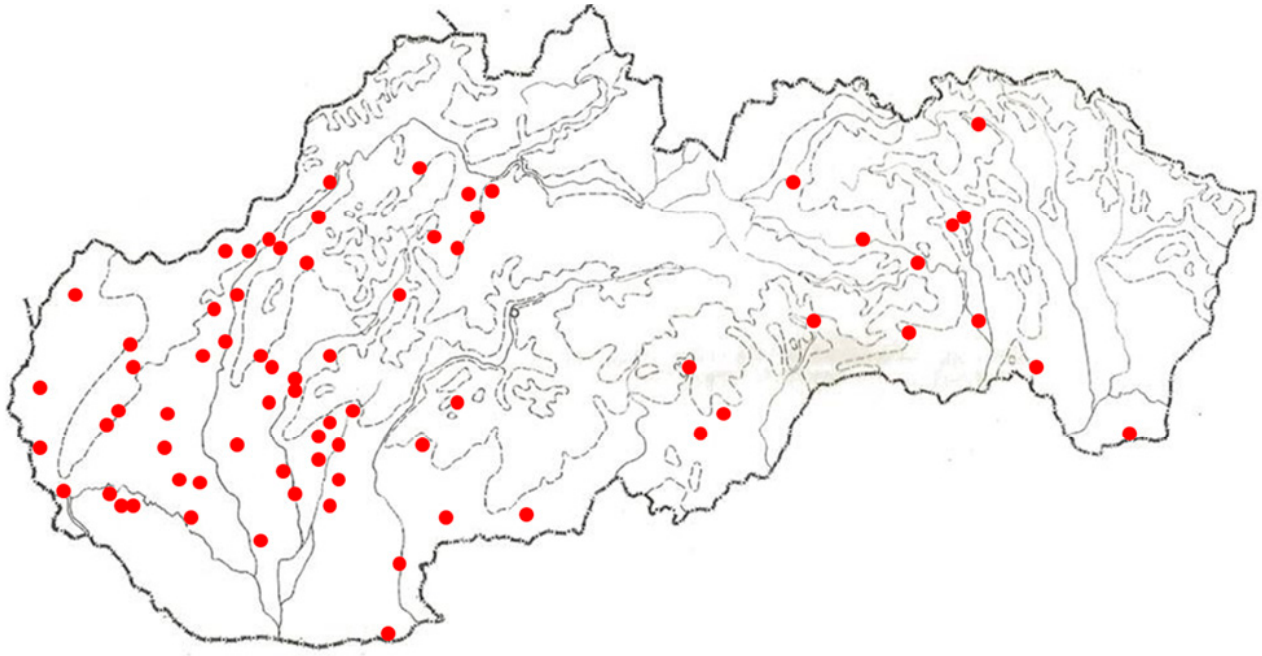

Figure 1 Localities of occurrence of *Ginkgo biloba* L. identified by Benčať (1982)

the height of the tree with a SUUNTO altimeter; we estimated the width of the crown by a step in two intersecting directions according to the shape of the crown (however, most of them were solitary trees with a regular crown). We identified the sex of the trees. The blossoms are dioecious, male and female blossoms occurring separately on two different trees. There are some additional tree gender differentiation features as crown habitual marks, and the angle of protruding lateral branches.

Determining the age of *Ginkgo biloba* L. trees was, in our experience, the most problematic. For some trees, especially younger (juvenile) individuals, the data of the tree age or year of planting are relatively accurate (a value must be added to this data, it is 5–10 years from the cultivation of seedlings from seed in the nursery until the planting of seedlings in a specific location). In addition, we used the Pressler drill (number of annual rings on a dendrometric borehole) to determine the age, but the evaluation of the obtained results was time and money consuming (we obtained a total of 25 boreholes), so we did not continue in this approach. However, we used a mathematical formula $V = \left(5/[\pi \times RL]\right) \times d$, where d is the diameter of the trunk (in cm) and RL is the width of the annual ring (in cm) (Kolařík, 2005).

Another way of determining the age of trees works with information about the period of origin, respectively the establishment of a specific historical park (dendrological building), the most often it is the 18th and 19th to 20th centuries (1901–2000). Determining the age of trees according to the circumference of the trunk (d 1.3 m) is another option, but the most accurate is the year of planting of a particular tree.

Research area

All obtained data on individual trees were processed in a tabular overview by locality, including data on a specific historical park or object of other greenery. The tabular overview includes findings on the tree gender (male – m; and female – f), juvenile age (until the period of occurrence of seeds, or male and female generative organs), and the occurrence of seed propagation (seedlings under fruiting female trees). For completeness, we present a table of localities of cultural extension of *Ginkgo biloba* in Slovakia according to Benčať (1982).

Description of a model tree, *Ginkgo biloba* L.

Ginkgo is a long-lived deciduous tree. It can reach more than a thousand years old. Depending on the growing conditions, mature trees reach a height from 20 to 40 m. The crown is somewhat ovoid to obovoid, tending to be asymmetric, primary branches ascending at ca. 45° from trunk (Flora of North America). In males' trees, it is usually slimmer, in females' ones bushier (Figure 2). Ginkgo trees produce two types of shoots: long shoots with widely spaced leaves that subtend axillary buds; and short shoots with clustered leaves that lack both internodes and axillary buds. Under stressful growing

Table 1 Localities of cultural extension of *Ginkgo biloba* L. in Slovakia according to Benčať (1982)

District	Localities	Registration number of localities
Bardejov	Bardejov spa	P-328
Bratislava-city	Bratislava	P-103, 105,108,110
	Častá – Červený Kameň	P-424
	Malacky	SG
Bratislava-city surroundings	Modra	P-90
	Stupava	P-96
	Tomášov	P-100
	Hubice	P-192
Dunajská Streda	Sládkovičovo	P-145
	Tomášikovo	P-148
Komárno	Kravany nad Dunajom	P-189
Košice	Jasov	P-396
	Košice	P-382, 388, 390, 392
	Bohunice	P-149
Levice	Horné Semerovce	P-158
	Pohronský Ruskov	SG
Lučenec	Lučenec – Ipeľské brickfield	SG
	Nenince	P-276
	Abramová	SG
	Martin	P-228
Martin	Mošovce	P-231
	Necpaly	P-230
	Turčianska Štiavnička	P-225
	Báb	P-133
	Beladice	P-124
	Ivanka pri Nitre	SG
	Mlyňany Arborétum	P-129
Nitra	Nová Ves nad Žitavou	P-135
	Sľažany	P-118
	Šurianky	P-114
	Telince	SG
	Topoľčianky	P-115
	Komjatice	P-166
Nové Zámky	Obid	SG
	Palárikovo	P-174
	Trávnica	P-169
Poprad	Kežmarok	SG
Považská Bystrica	Klobušice	P-217
	Horenická Hôrka – Medné	P-205
Prešov	Malý Šariš	P-348
	Župčany	P-347
Prievidza	Prievidza	SG
	Bojnice	park by the castle

ISSN 2585-8246

Table 1 Localities of cultural extension of *Ginkgo biloba* L. in Slovakia according to Benčať (1982)

District	Localities	Registration number of localities
Rimavská Sobota	Hnúšťa	SG
	Rimavská Sobota	P-292
	Veľký Blh	P-286
Rožňava	Betliar	P-407
Senica nad Myjavou	Cerová-Lieskové	P-30
	Gbely	P-28
Spišská Nová Ves	Bystrany	P-357
	Jaklovce	P-359
Topoľčany	Hajná Nová Ves	P-44
	Horné Obdokovce	P-50
	Janova Ves	P-42
	Oponice	P-52
Trebišov	Kovarce	P-48
	Kazimír	P-416
	Pribeník	P-418
Trenčín	Adamovské Kochanovce	P-8
	Částkovce	P-21
	Kočovce	P-17
	Motešice	P-13
	Trenčín	P-7, SG
	Záblatie	P-4
	Zemianske Podhradie	P-12
Trnava	Piešťany	P-58
	Rakovice	P-66
	Smolenice	P-70
	Trnava	P-78, SG
	Voderady	P-84
Žiar nad Hronom	Banská Štiavnica	P-246
Žilina	Rajecké Teplice	P-223

Note: SG – surrounding greenery, that is, the tree is in a territory other than a historic park or garden

conditions, Ginkgo can produce secondary trunks at or just below ground level. These secondary stems originate from root-like, positively geotropic shoots known as lignotubers or "basal chichi" (van Beek, 2000) (Figure 3). The bark is smooth, gray, relatively quickly turns into a brown-gray bark, which is cracked in longitudinal irregular plates (Figure 4c).

Buds are brown, globose, scales imbricate, margins scarious (Flora of North America) (Figure 4e). Leaves are 30–60 × 40–100 mm fan-shaped (with long stalks) with dichotomously branched veins (Figure 4a). They are flat, firm, leathery, light green, golden yellow in autumn before falling (Figure 4d). It blooms in May (Figure 4b). The flowers are dioecious, growing only on shortened shoots (Pagan and Randuška. 1988). Microsporophylls occur in small, conelike clusters (are pendulous). In females' trees, an upright 25–40 mm long stalk grows in the armpits of scales or leaves, which is widened at the end. Ovules occur in pairs at the ends of a short stalk. The ovule is surrounded by a cup-shaped cushion called a collar. Seeds obovoid to ellipsoid, yellow to orange, 2.3–2.7 × 1.9–2.3 cm, mostly 1.1–1.2 times longer than broad, glaucous, rugose, with an apical scar, maturing in a single season, usually 1 per peduncle, occasionally polyembryonic, outer coat foul-smelling; peduncles orange, glaucous, ridged, 3–9.5 cm, collar broadly elliptic, 7.2–8.6 mm broad (Vreštiak and Osvald, 1994; Klečková, 2010;

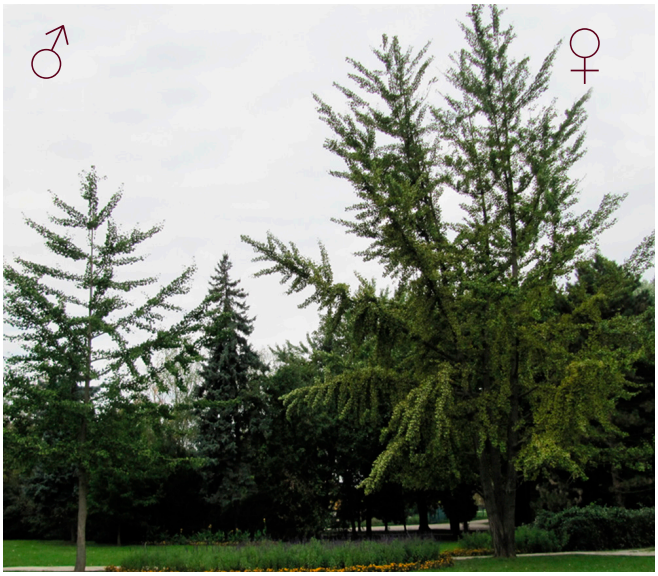

Figure 2 Male (left) and female (right) tree of ginkgo grown in city park in Nitra
Photo by Pavel Hrubík

Figure 3 Shoots known as lignotubers or "basal chichi". Ginkgo grows in historical park near the manor house, Hajná Nová Ves
Photo by Pavel Hrubík

Zvolen (3 pregenerative individual trees). In other localities we recorded from 1 to 2 trees. The total number of localities (towns and villages) with the occurrence of *Ginkgo biloba* was 103. In addition, we

Figure 4 Fan-shaped leaves with dichotomously branched veins (a), scaly stamens in short spikes on male tree (b), bark (c), golden-yellow leaves in autumn (d), buds (e)
Photos by Pavel Hrubík

Figure 5 Fruits on female tree (a), seeds (b) and seed of irregular shape with stalks
Photos by Pavel Hrubík

Flora of North America). Figure 5a shows fruits on the female tree, seeds after removal of the flesh (Figure 5b), and irregular shape of seeds from the ginkgo grown in Lučenec.

Ginkgo seeds are dormant when they fall from the tree because the embryo is not fully developed, being only about 4 to 5 mm in length. If seeds are collected shortly after dispersal, are cleaned, and placed in a warm greenhouse, the embryo will grow to its full size, 10 to 12 mm in length and germinate within eight to ten weeks. Ginkgo shows a long juvenile period, typically not reaching sexual maturity until 20 to 30 years of age (van Beek, 2000). The foul odour associated with mature seeds is result of the presence of butanoic and hexanoic acids (Zhou and Wang, 2020).

Results and discussion

Main dendrometric values of ginkgo trees

In Slovakia, we found the occurrence and cultural distribution of *Ginkgo biloba* in 103 localities (Table 2). The total number of trees reached 292 individuals (including new plantings in Bratislava – Košická street, tree line of 29 trees in the middle dividing grass strip, *Ginkgo biloba* cv. Fastigiata; group plantings at the level crossing with Bajkalská street, 30 pieces; in Senica – 25 trees in a two-sided alley on Hurbanova street, of which 4 in the tree line on Hviezdoslavova street, in Žilina above the shopping center, *Ginkgo biloba* (cv. Fastigiata – 5 pregenerative individuals). Some *Ginkgo biloba* trees were felled (despite protests from the civil public) at the site of the programmed construction of a hotel in Trenčín (one male tree in 2008); for hygienic and safety reasons (Košice, Rázusova street; Rimavská Sobota, Hviezdoslavova street no. 25); technical damage to the adjacent building (Košice, campus of the University of Veterinary Medicine and Pharmacy); tree damaged and destroyed during lawn mowing (Kežmarok, Gymnázium P.O. Hviezdoslava); a total of 5 Ginkgo trees.

The most numerous localities (apart from the already mentioned pregenerative individuals in tree lines and alley plantings) were recorded in the Mlyňany Arborétum SAS, 17 trees (of which one is a male tree, three females, fruiting trees, 13 pregenerative trees); In Bratislava, 14 trees (of which 5 in the Botanical Garden of the Charles University in Prague, 2 in Petržalka, Janko Kráľ Park; 2 on Dunajská Street in the courtyard of the fitness centre), the tree line on Košická Street is mentioned separately; 9 trees in Košice (of which 5 trees in the premises of the L. Pasteur University Hospital; 7 trees in Piešťany (3 Parks on the Island, 4 Parks at the Secondary Vocational Horticultural School), 5 trees in Palárikovo (3 males and 2 females trees, 3 trees in Nitra (of which 2 trees – male and female tree, planted in 1963 in the Nitra City Park in Sihoť); more cultivars and pregenerative individuals are still growing in the Botanical Garden of the Slovak University of Agriculture, which were not included in the research. In Topoľčianky we register 4 trees (of which one male and 3 female trees); in Nová Ves nad Žitavou 4 trees (female trees); we recorded 3 trees in the following localities: Bojnice (male individuals); Topoľčany (one female tree, 2 pregenerative individuals); Trenčín (2 female and 1 male tree); Trnava (2 male, 1 female tree); Banská Štiavnica (2 male and 1 female tree);

Table 2 Characteristics of *Ginkgo biloba* L. trees in Slovakia. The data come from the research period in 2014–2016

Locality	Trunk circumference (cm)	Trunk diameter (cm)	Tree height (m)	Crown width (m)	Gender (♂, ♀)	Age
Abramová (SG), TR	238	76	14	18 × 14	♀	121
Arborétum Mlyňany SAV, (P-129), 1892, ZM (11)	92	29,3	16	10 × 4	♂	47
Arborétum Mlyňany SAV, (P-129), 1964, ZM (1)	30	9,6	10	3 × 3	juv.	15
Arborétum Mlyňany SAV, (P-129), 1964, ZM (10)	18	6,0	7	3 × 3	♀	10
Arborétum Mlyňany SAV, (P-129), 1964, ZM (12)	60	19,2	11	5 × 6	juv.	31
Arborétum Mlyňany SAV, (P-129), 1964, ZM (13)	88	28,2	14	8 × 8	juv.	38
Arborétum Mlyňany SAV, (P-129), 1964, ZM (14)	90	28,8	16	8 × 8	juv.	44
Arborétum Mlyňany SAV, (P-129), 1964, ZM (15)	53	16,9	14	4 × 4	juv.	26
Arborétum Mlyňany SAV, (P-129), 1964, ZM (16)	43	13,7	14	3 × 3	juv.	22
Arborétum Mlyňany SAV, (P-129), 1964, ZM (2)	17	5,4	6	3 × 3	juv.	12
Arborétum Mlyňany SAV, (P-129), 1964, ZM (3)	23	7,4	8	3 × 3	juv.	9
Arborétum Mlyňany SAV, (P-129), 1964, ZM (4)	82	26,2	16	6 × 6	♀	41
Arborétum Mlyňany SAV, (P-129), 1964, ZM (5)	31	9,9	8	5 × 6	juv.	16
Arborétum Mlyňany SAV, (P-129), 1964, ZM (6)	64	20,4	10	5 × 5	juv.	32
Arborétum Mlyňany SAV, (P-129), 1964, ZM (8)	66	20,7	12	6 × 8	juv.	33
Arborétum Mlyňany SAV, (P-129), 1964, ZM (9)	70	22,4	12	8 × 10	♀	36
Arborétum Mlyňany SAV, (P-129), KD, ZM	18	5,8	5	2 × 2	juv.	9
Arborétum Mlyňany SAV, (P-129), 1964. ZM (17)	49	15,7	12	3 × 3	juv.	24
Báb (P-133), NR	187	59,7	16	10 × 12	♂	95
Bánovce nad Bebravou, City park, BN	101	32,3	16	12 × 6	♂	51
Banská Štiavnica (P-246), Botanical garden, ZH	178	56,8	20	3 × 8	♀	90
Banská Štiavnica (P-246), Botanical garden, ZH	191	69,9	18	12 × 10	♂	111
Banská Štiavnica (P-246), Botanical garden, ZH	112	36,0	16	8 × 10	♂	57
Beladice (P-124), ZM	259	82,5	18	16 × 16	♂	131
Beladice (P-124), ZM	237	75,2	20	16 × 16	♀	119
Betliar (P-407), RV	233	74,3	19	19 × 14	♂	118
Betliar (P-407), RV	12	4,0	3	1,5 × 1,5	juv.	6

ISSN 2585-8246

First continuation of table 1

Locality	Trunk circumference (cm)	Trunk diameter (cm)	Tree height (m)	Crown width (m)	Gender (♂, ♀)	Age
Bojnice (P-1, 2, 3), PD	276	87,9	21	10 × 10	♂	140
Bojnice (P-1, 2, 3), PD	218	69,5	16	10 × 10	♂	110
Bojnice (P-1, 2, 3), PD, 415 cm	290	92,4	26	12 × 12	♂	147
Bratislava (P-103), Botanical garden UK, BA	168	53,5	14	15 × 15	♀	85
Bratislava (P-103), Botanical garden UK, BA	222	70,7	16	8 × 8	♀	112
Bratislava (P-103), Botanical garden UK, BA	141	45,0	14	14 × 14	♀	72
Bratislava (P-103), Botanical garden UK, BA	125	37,0	12	6 × 5	♀	58
Bratislava (P-103), Botanical garden UK, BA	118	37,2	17	15 × 15	♀	53
Bratislava (P-105), Mountain park, BA	42	13,4	8	5 × 3	juv.	21
Bratislava (P-108), PKO, statue of D. Jurkoviča, BA	105	33,5	14	8 × 8	♂	53
Bratislava, Bohúňova St. 4, BA	114	36,4	18	6 × 6	♀	58
Bratislava, Dunajská St., BA, 168 cm	124	39,5	14	7 × 6	♀	63
Bratislava, Dunajská St., BA, park near FITNES	60	19,0	8	4 × 3	♂	30
Bratislava, Godrova St. 8, BA	215	65,0	16	12 × 12	♀	103
Bratislava, Košická St., alley, BA, 2008, 29 pcs.	18-35	5,5-11,0	4-5	2 × 2	juv.	18
Bratislava, At the Habán mill, BA	29	9,3	6	2 × 2	juv.	15
Bratislava, J. Kráľ Gardens, 18/2-1751, BA	165	52,5	16	14 × 13	♀	83
Bratislava, J. Kráľ Gardens, BA, 540 cm	467	148,8	20	28 × 24	♀	236
Bratislava, Slovanet Ltd., group planting. Bajkal St.	17-21(30 ks)	5-7	3-5-6	1 × 2	juv.	10
Brezová pod Bradlom, PS, SE	168	53,6	16	15 × 15	♂	65
Brusno Spa (P-242)	9	2,9	3,5	1 × 2	juv.	10
Budimír, at the chapel, (P-378), KE	155	49,4	22	7 × 7	♂	79
Bystrany (P-357), SN	179	57,0	22	8 × 8	♀	91
Bystrany (P-357), SN	57	18,2	3	3 × 3	♀	29
Cerová-Lieskové (P-30), SE	183	58,3	26	12 × 14	♂	93
Častá (Červený Kameň), PK, 447/142,4 cm	375	122,2	14	12 × 14	♀	194
Častkovce (P-21), NM	172	54,5	19	12 × 8	♀	87
Červený Hrádok, ZM, 1964	26	8,3	9	2 × 2	juv.	13
Dubnica nad Váhom, IL	123	39,3	18	8 × 8	♂	62
Fiľakovo,(P-272) City park	191	60,9	18	14 × 14	♂	97
Fiľakovo, (P-272) City park	173	55,2	20	16 × 8	♂	114
Fričovce (P-345), PO	171	54,5	16	6 × 5	♂	87
Galanta (P-146), GA	285	90,5	20	18 × 20	♂	144

Second continuation of table 1

Locality	Trunk circumference (cm)	Trunk diameter (cm)	Tree height (m)	Crown width (m)	Gender (♂, ♀)	Age
Gbely, Art School	80	25,5	8	4 × 4	juv.	41
Hájna Nová Ves (P-44), TO	478	152,4	22	30 × 30	♀	242
Hnúšťa (SG), RS, 320 cm	263	83,8	26	12 × 15	♂	133
Hokovce – historical park	166	52,8	16	14 × 12	♀	84
Hokovce – historical park	35	11	8	8 × 4	juv.	18
Hokovce – historical park	36	12	8	8 × 6	juv.	18
Hokovce, private garden	220	70,1	25	12 × 14	♂	111
Horenická Hôrka-Medné (P-205), PU	345	110,2	25	20 × 20	♀	175
Horné Obdokovce (P-50), TO	192	61,2	25	12 × 12	♂	97
Horné Semerovce (P-158), LV	325	103,7	19	14 × 10	♂	165
Hubice, historical park	184	58,7	18	16 × 12	♂	93
Humenné (P-340), HE,	275	87,6	22	15 × 20	♀	139
Jaklovce (P-359), GL, 230 cm	203	64,7	21	8 × 8	♀	103
Janova Ves (P-42), TO	373	111,2	22	20 × 20	♂	197
Jasov, monastery garden (P-396), KE	220	70,2	14	14 × 14	♂	112
Kalinovo, park PS	61	19,5	12	3 × 3	juv.	31
Kazimír (P-416),TV, 260 cm, double	229;170	73;54,2	17	22 × 20	♀	116
Klobušice (P-217), IL	212	67,5	22	15 × 15	♀	107
Klobušice (P-217), IL	179	57,0	22	14 × 14	♂	91
Klobušice (P-217), historical park	165	52,6	13	10 × 5	♀	84
Kočovce (P-17), NM	206	65,6	25	10 × 10	♀	104
Komárno (P-187), KN	76	24,2	12	10 × 12	♀	38
Komjatice (P-166), NZ, 365 cm	327	104,2	25	22 × 22	♀	165
Košice (P-382), Botanical garden UPJŠ, KE	69	22,0	12	5 × 4	juv.	35
Košice (P-388), Park J. A. Komenského, KE	312	99,7	20	20 × 20	♂	158
Košice (P-390), FN, KE Rastislavova St. (1)	197	62,7	22	14 × 16	♀	100
Košice (P-390), FN, KE Rastislavova St. (2)	131	41,8	19	4 × 0,5	♀	66
Košice (P-390), FN, KE, Rastislavova St., (4)	121	38,5	12	11 × 19	♀	61
Košice (P-390), FN, KE, Rastislavova St. (3)	151	48,1	18	10 × 12	♂	46
Košice (P-390), FN, KE, Rastislavova St. (5)	133	42,5	11	10 × 9	♀	68
Košice, Masarykova St. 3, ZŠ	381	121,7	27	24 × 12	♂	193
Košice, Town square MMM, KE	15.5	5.0	5	2 × 2	juv.	8
Kovarce (P-48), TO	167	53.2	19	12 × 12	♂	85

ISSN 2585-8246

Third continuation of table 1

Locality	Trunk circumference (cm)	Trunk diameter (cm)	Tree height (m)	Crown width (m)	Gender (♂, ♀)	Age
Krakovany, Park in the courtyard of the company, PN	40	12.8	7	3 × 3	juv.	20
Kravany nad Dunajom (P-189), KN	189	60.5	16	13 × 14	♂	96
Lučenec (SG), Ipeľské tehelne Ltd., LC, cv. ´Ohatsuki´	267	85.1	22	16 × 16	♀!!	135
Lučenec, City park, LC	40	12.0	12	8 × 8	♂	19
Malacky (SG), MA	16	5.3	5	3 × 3	juv.	10
Malacky (SG), MA	18	6.0	7	3 × 1	juv.	10
Malacky, private garden (SG), MA	59	18.8	12	7 × 7	♀	20
Malinovo,(P-99) SC	38	12.5	8	4 × 4	♂	20
Malý Šariš (P-348), PO	285;315	91;100.7	20	20 × 20	♂	160
Martin (P-228), MT	180	57.0	18	14 × 10	♂	91
Michalovce, park in front of the bank VÚB, MI	190	60.5	17	10 × 16	♂	96
Modra (P-90), PK	193	61.5	14	6 × 6	♀	98
Mošovce (P-231), TR	125	39.8	12	15 × 14	♂	63
Motešice (P-13), TN	110	35.0	15	12 × 10	♂	56
Necpaly (P-230), MT	195	62.2	27	8 × 8	♀	99
Nedožery-Brezany,168/120	48	15.3	10	5 × 4	juv.	24
Nenince (P-276), VK, 240 cm	195	62.0	16	8 × 8	♂	99
Nitra, Ďurčanského St. 12	60	19.2	5	6 × 6	juv.	31
Nitra, Faculty of Natur. Sci.UKF, NR	25	8.0	6	3 × 3	juv.	13
Nitra, Kupecká ulica, alley	6 pcs.	-	4 – 5	2 × 2; 3 × 3	juv.	10
Nitra, Nitra city park, 1963, NR, triple trunk (234 cm/74,5 cm)	120;119;96	38.2;30.7	18	18 × 18	♀	60
Nitra, Nitra city park, 1963. NR	81	26.0	12	14 × 12	♂	41
Nitra, Penzión LU×	15	4.8	6	3 × 3	juv.	10
Nitra, rest. MALIBU	107	34.2	15	9 × 9	♀	54
Nitra, Špitálska St.1, NR	102	32.5	12	9 × 9	♂	52
Nová Dubnica, TN	21;33	6.7;10.8	3.5;4.5	1 × 1;2 × 2	juv.	17
Nová Ves nad Žitavou (P-135), NR (1)	228	72.7	16	18 × 18	♀	116
Nová Ves nad Žitavou (P-135), NR (2)	277	88.3	17	18 × 18	♀	140
Nová Ves nad Žitavou (P-135), NR (4)	172	54.8	20	2 × 9	♀	87
Nová Ves nad Žitavou (P-135), NR	202	64.4	22	16 × 16	♀	102
Nový Život-Tonkovce, (P-191), DS	97	31.0	15	3 × 3	♂	49
Oponice (P-52), TO	185	59.0	13	10 × 8	♂	94
Palárikovo (P-174), NZ (4)	247	78.6	20	14 × 14	♂	125
Palárikovo (P-174), NZ (1)	316	101.0	20	19 × 19	♂	160
Palárikovo (P-174), NZ (2)	62	19.7	10	6 × 7	♀	31
Palárikovo (P-174), NZ (3)	60	19.2	12	7 × 5	♀	31
Palárikovo (P-174), NZ (5)	100	31.9	10	0 × 9	♂	51
Piešťany (SG), private garden, PN	280	89.2	25	20 × 20	♂	142

Fourth continuation of table 1

Locality	Trunk circumference (cm)	Trunk diameter (cm)	Tree height (m)	Crown width (m)	Gender (♂, ♀)	Age
Piešťany (P-58), Spa park near bath "Eva", PN	152	48.5	16	12 × 10	♂	97
Piešťany (P-58), Spa park, PN	202	64.9	23	16 × 14	♀	120
Piešťany (P-58), Spa park near outdoor bath, PN	186	59.3	25	16 × 14	♀	120
Piešťany, Park at High school, (118) PN	76;71;27	24.3;22.7; 8	15	6 × 6	juv.	37
Piešťany, Park at high school,(116) PN	82	26.2	15	8 × 8	juv.	41
Piešťany, Park at high school,PN	35	11.2;12;12.8	10	4 × 4	juv.	17
Pohronský Ruskov (SG), LV, 300 cm	261	83.2	14	23 × 20	♂	132
Považ. Bystrica, at the cinema MIER	48	15.5	4	4 × 4	juv.	50
Prešov, Art Garden, PO	265	84.5	18	15 × 15	♂	134
Pribeník (P-418),TV	330	105.5	25	16 × 22	♂	168
Prievidza (SG), PD	128	40.8	15	8 × 8	♀	65
Rajecké Teplice (P-223), Spa park, ZA	15	5.0	3	0,5 × 0,5	juv.	8
Rakovice (P-66), PN	237	75.5	20	18 × 15	♀	120
Rimavská Sobota (P-292), RS	126	40.2	16	12 × 12	♀	64
Rimavská Sobota, Športová St. č.4, RS	135	43.0	10	8 × 8	♀	68
Rimavská Sobota, Športová St. č.4, RS	155	49.5	18	6 × 10	♂	79
Ružomberok, Military hospital.	120;57	38.2;18.2	14;7	8 × 8	♂	95
Senica (SG), SE, alley-25 ks	7-10-12	4.8-9.8	3-6	2 × 2	juv.	8-16
Senica, Hviezdoslavova St., 4 pcs, row of trees SE	26-31	8.4-9.8	7	2 × 2	juv.	16
Senné (SG), private garden, 1964, VK	42	13.5	12	3 × 4	juv.	22
Sereď, private garden	59	18.8	12	7 × 7	juv.	30
Slanec, Park around PS and KG, KE, 362 cm	278	88.5	18	16 × 14	♂	141
Sľažany (P-118), ZM,	118	37.7	16	10 × 8	♂	60
Slovenské Pravno, PS	3	1.0	1	0,5 × 0,5	juv.	10
Spišská Belá, KK	198	63.0	16	8 × 9	♂	100
Stupava (P-96), MA	195	62.2	20	12 × 14	♂	99
Súdovce (SG), KA	302	96.5	14	12 × 10	♂	153
Šamorín, private garden	169	53.8	14	12 × 12	♂	40
Šišov (P-34), BN	160	51.0	28	8 × 8	♂	81
Šurianky (P-114), NR, 120 cm	87	27.8	12	6 × 0	♂	44
Tomášikovo (P-148), GA, 430 cm	315	100.4	25	16 × 16	♀	162
Tomášov (P-100), 362 cm	290	90.7	20	20 × 19	♂	144
Topoľčany (P-40), TO	110	35.0	17	6 × 6	♀	56
Topoľčianky (P-115), ZM (1)	225	71.7	20	16 × 16	♀	114
Topoľčianky (P-115), ZM (2)	305	97.5	12	14 × 14	♂	155
Topoľčianky (P-115), ZM (3)	261	83.2	18	16 × 16	♀	132
Topoľčianky (P-115), ZM (4)	92	29.3	12	6 × 6	♀	47
Tovarníky, (P-40), hist. park ObÚ	157	50	18	3 × 4	♀	79

ISSN 2585-8246

Fifth continuation of table 1

Locality	Trunk circumference (cm)	Trunk diameter (cm)	Tree height (m)	Crown width (m)	Gender (♂, ♀)	Age
Trávnica (P-169), NZ	239	76.2	22	10 × 8	♀	121
Trenčianske Teplice – Spa park (35 cm)	19	6.2	4	0,5 × 1	juv.	10
Trenčianske Teplice – Spa park (54 cm)	31	9.5	6	5 × 5	juv.	15
Trenčianske Teplice – Spa park (95 cm)	64	20.4	12	8 × 8	juv.	32
Trenčín (P-7), TN	290	92.7	16	10 × 10	♀	147
Trenčín (P-7), TN	365	116.7	16	12 × 12	♂	185
Trenčín (P-7), TN	210	67.0	17	10 × 10	♀	106
Trnava (P-78), TT	136	43.3	16	14 × 12	♂	72
Trnava (P-78), TT	116	36.9	14	6 × 6	♂	69
Trnava, (SG), Kalinčiakova St. 17, TT	151	48.2	12	16 × 14	♀	77
Turčianska Štiavnička (P-225), MT	233	74.2	24	9 × 9	♀	118
Veľký Blh (P-286), RS	190	60.5	14	0 × 14	♀	96
Vištuk, Park OÚ, PK	22	7.0	5	5 × 3	juv.	11
Voderady (P-84) historical park, TT	292	93	18	18 × 18	♂	148
Voderady (P-84), TT, 480 cm	213	68.0	16	15 × 15	♂	108
Vráble, private garden	110	35.0	16	10 × 10	♂	40
Záblatie (P-4),TN	178	56.7	15	10 × 12	♀	90
Zemianske Podhradie (P-12), NM	219	70.0	24	16 × 14	♂	111
Zvolen, at the factory Bučina	51	16.3	12	2 × 2	juv.	26
Zvolen, at the factory Bučina	45	14.0	10	2 × 2	juv.	22
Zvolen, at the factory Bučina	25	8.0	6	2 × 1	juv.	13
Želiezovce (P-162), LV	195	62.0	16	15 × 10	♂	98
Žilina, at the Department Store MIRAGE, 5 pcs ZA	25-29	8.0-9.3	4-5-6	1 × 1	juv.	13
Župčany (P-347), PO	136	43.3	16	9 × 10	♂	69

Notes: P-44 – registration number of the historical park and garden, TO – Topoľčany – district – according to the current territorial division, 19/1 – first half of the 19th century, with the designation of the years – 1850 of foundation of the dendrological building, SG – surrounding greenery, that is, the tree is in a territory other than a historical park or garden, PS – primary school, KG – kindergarten, juv. – an individual in juvenile growth

recorded 20 localities where no trees were found, but previously were identified by Benčať (1992) or these are private and religious buildings, unavailable at the time of our research.

We included 45 ginkgo trees that reached their maximum dimensions. The group of trees with a trunk circumference of more than 400 cm included individuals in Hájná Nová Ves – 477 cm; Bratislava – Petržalka, Sady J. Kráľa 467 cm. More numerous was the group of trees with trunk circumference over 300 cm (13 trees) and over 200 cm (33 trees).

Some new findings on the cultivation and growth of *Ginkgo biloba*

The number of localities with the intentional introduction of *Ginkgo biloba* in Slovakia cannot be complete, because in recent years, at the beginning of the 21st century, other new plantings were added in various categories of urban greenery, but also in private gardens and parks.

During our research, we occasionally recorded the nesting of birds (garden turtle, gray crow, common magpie) on the trees of the two-lobed ginkgo. We found nesting cavities on tree trunks and skeletal branches, which cut down woodpeckers in soft wood (even healthy trees), or in the cracks of tree bark we found collected seeds of yew (*Taxus baccata* L.). We first discovered the natural rejuvenation and occurrence of ginkgo seedlings in Trenčín (2007), and later in Palárikovo (2011); Nitra – Nitra City Park (2011); Tomášikovo (2011), Bratislava – Botanical Garden (2011), Godrova St. no. 8 (2014); Košice – park around

L. Pasteur Hospital (2014); Nová Ves nad Žitavou (2014). The best conditions for seed germination are in the fallen and accumulated leaves under the tree. The natural seed propagation (Figure 6) and occurrence of seedlings of foreign wood can be considered as the peak phase in the process of introduction, and in the case of ginkgo it was rare and rare.

When assessing the horticultural value and health of *Ginkgo biloba* trees, we did not find any major differences from typical habitual features (except for deformation and suppression of tree crowns, in a group or under the crowns of other surrounding trees), so we rated the trees with the highest number of points (5th grade). We did not record the occurrence of animal pests (especially leaf-eating, sucking, and wood-destroying insect pests) or fungal diseases on ginkgo trees during this research, and we also evaluated them at the highest level 5. The only disadvantage that will probably limit the cultivation of trees in our conditions is the unpleasant smell (after rotting meat) of ripening and falling fruit from female individuals. There have already been cases of tree felling for hygienic and safety reasons if the fruit pollutes busy streets, but especially pedestrian sidewalks, and there is a risk of slipping and possible fall of pedestrians. As a precautionary measure, we recommend covering the sidewalks under the fruiting trees, making structures covered with foil or tarpaulin with a tendency to the fruiting trees, permanent removal of deciduous fruit from the sidewalks, especially in parks, front gardens, and street plantings.

Figure 6 Natural seed propagation under the ginkgo tree
Photo by Pavel Hrubík

Figure 7 Large fruits observed on female ginkgo tree grown in the city park in Nitra
Photo by Pavel Hrubík

During our field research, we also recorded certain morphological differences (habitual features on trees –

Figure 8 Distinctive golden-yellow colour of leaves in autumn in the locality Bratislava – Gardens of J. Kráľ
Photo by Pavel Hrubík

ISSN 2585-8246

Figure 9 The variability of fruits stalks
Photo by Pavel Hrubík

branching and shape of the crown; angle of protrusion and growth of lateral branches from the main trunk; leaf fall time; tree sex differences). Large fruits on long stems, we recorded on trees in Kočovce, Rimavská Sobota, Nová Ves nad Žitavou, Topoľčianky, Nitra, Bratislava – Botanical Garden (Figure 7). Distinctive golden-yellow colour of leaves in autumn in localities Kočovce, Nová Ves nad Žitavou, Topoľčianky, Trenčín, Bratislava – Gardens of J. Kráľ in Petržalka, Dunajská

Figure 10 Epicormic sprout on the ginkgo tree trunk
Photo by Pavel Hrubík

Figure 11 Root stalks growing on the trunk of a felled ginkgo tree in Trenčín
Photo by Pavel Hrubík

street (Figure 8). A special peculiarity was the autumn in 2014, when during our research on September, October, and mid-November, the ginkgo trees kept the green leaves in the entire crown of the tree. At the same time, there are also differences between localities

Figure 12 A lateral branch formed after mechanical damage to the ginkgo strain in the locality Trávnica
Photo by Pavel Hrubík

ISSN 2585-8246

Figure 13 Heavily branched ginkgo tree with trunk circumference 478 cm in the locality Hajná Nová Ves. The oldest tree of *Ginkgo biloba* in Slovakia
Photo by Pavel Hrubík

in Slovakia from one year to another. The prevailing finding was that the leaves on the male trees fall off earlier than on the female fruiting trees (preservation of the leaves during fruit ripening is also more logical). In 2014, this did not manifest itself in Nitra – Nitra City Park, because in mid-November, the leaves on the female tree were fallen, while on the neighboring male tree, all the leaves remained golden-yellow on the tree.

The size of the leaves is very variable, sometimes the length of the leaf stalk is extreme (6.2–7.6 cm in Kočovce) (Figure 9), the leaves are deeply lobed, large, fleshy, they are on the stem and roots samplings of the trees (Figure 10), (15.5 × 13.5 cm, leaf lobe depth up to 8 cm, leaf size 12 × 14.8, 11 × 13.5 cm, length of samplings 100–150–180 cm, more than 220 pieces of root stalks around the trunk circumference of a felled tree in Trenčín).

The occurrence of samplings on the stems and roots of *Ginkgo biloba* trees is extremely strong. This was most pronounced in Trenčín, after the felling of a male tree on the construction site of the future hotel in 2008. The following spring, we found massive 100–150–180 long shoots on the trunk of the tree, more than 220 pieces around the entire circumference of the trunk. The leaves

Figure 14 Ginkgo tree in Janova Ves with unique branching and trunk circumference 373 cm
Photo by Pavel Hrubík

ISSN 2585-8246

Figure 15 Observation of the occurrence of fruits on the leaves, referred to as cv. Ohatsuki of ginkgo growing in Lučenec Photos by Pavel Hrubík and Katarína Ražná

on the samplings were large, fleshy, deeply lobed; bark on young shoots cinnamon brown, with pronounced brown lenticules, shoots 1–2 years old (Figure 11). Stump youth also occurred on felled trees in Košice; on the sawed branches and on the trunk of the *Ginkgo biloba* in Horné Semerovce (the budding shoots were also on the cut pieces of the trunk lying on the ground under the tree). It also regenerates branches broken by the wind, snow, or the weight of ripening fruits (Topoľčianky). It does not tolerate shading, limiting the growth of the crown by climbing trees (*Hedera helix* L. – Arborétum Mlyňany, Piešťany, Senné).

Also important is the rapid healing of wounds after mechanical damage to the trunk and branches, sawing of branches in the crown of the tree, sawing of the dry terminal top of the tree (then a beautiful, fan-shaped crown and top of the side branches – Trávnica); very good and fast is "hardening" after trimming thinner branches and healing larger wounds on the tree trunk (Figure 12).

In terms of the vertical distribution of *Ginkgo biloba* in Slovakia, we consider the highest-lying locality *Ginkgo biloba*, trees growing in the Botanical Garden of the Secondary Vocational Forestry School in Banská Štiavnica (three trees, one of them fruiting, female tree); the lowest localities included the ginkgo trees in Kravany pri Dunaji, Komárno, Pribeník, and Kazimír.

It is worth mentioning some of the particularly special trees, specific to twin habits, trunk dimensions, and fruits on leaves (Figures 13–15).

In the end, we present a list of the oldest trees of *Ginkgo biloba* in Slovakia (Table 3). The data on trees dimensions and age come from the period of our research in 2016.

On the importance of recognizing genetic diversity of *Ginkgo biloba* populations pointed out several studies focused on applying different molecular markers as genomic microsatellites (Yan et al., 2006; Yan et al., 2009; Li et al., 2009; Xie et al., 2013), RAPD (Fan et al., 2004; Li et al., 2013; Mei et al., 2014), ISSR (Mei et al., 2014), RFLP (Shen et al., 2005) and microsatellites (Xu et al., 2015) markers based on chloroplast DNA and microRNA-based markers (Ražná et al., 2020). Attention is also paid to the gender differentiation of ginkgo trees at the molecular level (Jiang et al., 2003; Liao et al., 2009; Milewicz and Sawicki, 2013).

In order to establish a molecular base to understand the evolution of ginkgo and to resolve the ambiguous phylogenetic relationship of ginkgo among the gymnosperm, several studies have been performed (Brenner et al., 2005; Lin et al., 2011; Lin et al., 2012; Šmarda et al., 2016).

Whereas ginkgo leaves contain a quantity of medicinally valuable compounds, extensive studies are carried on the identification and characterization of genes and molecules connected to these biosynthetic processes (Tekeľová et al., 2006; Zittlau, 2007; Wang et al., 2010; Han et al., 2015; He et al., 2015; Wang et al., 2015).

The genetic background of ginkgo resistance to a wide spectrum of biotic and abiotic stress conditions was also analysed (Mohanta, 2012). *In vitro* approaches of ginkgo micropropagation are known from the literature (Tommasi and Scaramuzzi, 2004; Mantovani et al., 2013).

ISSN 2585-8246

Table 3 The oldest *Ginkgo biloba* L. trees in Slovakia (2016)

Locality	Trunk circumference (cm)	Trunk diameter (cm)	The height of the tree (m)	Crown width (m)	Gender (M, F)	Age
Hajná Nová Ves (P-44), TO, 19/1-1850	478	152.4	22	30 × 30	F	242
Bratislava, J. Kráľ Gardens, BA, (P-110), 18/2 -1751	467	148.8	20	28 × 24	F	236
Janova Ves (P-42), TO,19/2-1851	373	111.2	22	20 × 20	M	197
Košice, Masarykova St.3, PS, KE, 19/1-1850	381	121.7	27	24 × 12	M	193
Častá (Červený Kameň) (P-424, PK,18/2-1771	375	122.2	14	12 × 14	F	194
Pribeník (P-418), TV, 19/1-1850	330	105.5	25	16 × 22	M	168
Komjatice (P-166), NZ, 18/2-1751 (365 cm)	327	104.2	25	22 × 22	F	165
Horné Semerovce (P-158), LV, 20/1-1950	325	103.7	19	14 × 10	M	165
Tomášikovo (P-148), GA, 8/2-1751, (430 cm)	315	100.4	25	16 × 16	F	162
Palárikovo (P-174), NZ, 19/1- 1850	316	101.0	20	19 × 19	M	160
Malý Šariš (P-348, PO, 19/1 - 1850	315;285	100.7;91.0	20	20 × 20	M	160
Horenická Hôrka-Medné (P-205, PU, 19/2-1851	345	110.2	25	20 × 20	F	175
Košice, Park J. A. Komenský (P-388),KE	312	99.7	20	20 × 20	M	158
Voderady (P-84), TT, 19/2-1851 (480 cm)	292	93.0	18	18 × 18	M	148
Súdovce, KA, 20/1 – 1950	302	96.5	14	12 × 10	M	153
Topoľčianky (P-115). ZM, 18/2 - 1751	305	97.5	12	14 × 14	M	155
Bojnice (P-1; 2; 3), PD, 19/1-1850, (415 cm)	290	92.4	26	12 × 12	M	147
Tomášov (P-100), SC, 18/2-1751 (362 cm)	290	90.7	20	20 × 19	M	144
Galanta (P-146), GA, 19/2-1851	285	90.5	20	18 × 20	M	144
Piešťany, PN, 19/1-1850 (SG)	280	89.2	25	20 × 20	M	142
Slanec, PS, KG, KE, 19/1-1850 (362 cm)	278	88.5	18	16 × 14	M	141
Nová Ves nad Žitavou (P-135), NR, 19/1-1850	277	88.3	18	22 × 24	F	140
Bojnice, PD, 19/1-1850	276	87.9	21	10 × 10	M	140
Humenné (P-340), HN, 18/2	275	87.6	22	15 × 20	F	139
Lučenec, Ipeľské tehelne, (SG), LC, cv.´Ohatsuki´	267	85.1	22	16 × 16	F	135
Topoľčianky (P-115), ZM, 18/2-1751 (293 cm)	261	83.2	18	16 × 16	F	132
Pohronský Ruskov (SG), LV, 20/1-1950 (300 cm)	261	83.2	14	23 × 20	M	132

Continuation of table 3

Locality	Trunk circumference (cm)	Trunk diameter (cm)	The height of the tree (m)	Crown width (m)	Gender (M, F)	Age
Beladice (P-124), ZM, 19/2-1851	259	82.5	18	16 × 16	M	131
Hnúšťa (SG), RS, 20/1-1950 (320 cm)	263	83.8	26	12 × 15	M	133
Palárikovo (P-174), NZ, 19/1 - 1850	247	78.6	20	14 × 14	M	125
Trávnica (P-174), NZ, 18/2- 1751	239	76.2	22	10 × 8	F	121
Rakovice (P-66), PN, 19/2 - 1851	237	75.5	20	18 × 15	F	120
Beladice (P-124), ZM, r. – 130 r.	237	75.2	20	16 × 16	F	130
Abramová (SG), TR, 18/2-1751	238	76.0	14	18 × 14	F	121
Betliar (P-407), RV, 19/1 - 1850	233	74.3	19	19 × 14	M	118
Trenčín (P-7), TN, 19/1 - 1850	365	116.7	16	12 × 12	M	185
Turčianska Štiavnička (P-225). MT, 18/2-1751	233	74.2	24	9 × 9	F	118
Kazimír (P-416), TV, 19/1-1850 (260 cm)	229;170	73.0;54.2	17	22 × 20	F	116
Nová Ves nad Žitavou (P-135), NR, 19/1-1850	228	72.7	16	23 × 20	F	115
Topoľčianky (P-115), ZM, 18/2-1751	225	71.7	20	16 × 16	F	113
Trenčín (P-7), TN, 19/1-1850	290	92.7	16	10 × 10	F	147
Prešov, Garden of Art (SG)	265	84.5	18	15 × 15	M	134
Jasov, Monastery Garden	220	70.2	14	14 × 14	M	112
Hokovce, private garden	220	70.1	25	12 × 14	M	180
Bratislava, Bot. garden	222	70.7	16	8 × 8	F	112

Notes: P-44 – registration number of the historical park and garden, TO - Topoľčany – district – according to the current territorial division, 19/1 – first half of the 19th century, with the designation of the years – 1850 of foundation of the dendrological building, SG – surrounding greenery, that is, the tree is in a territory other than a historical park or garden, PS – primary school, KG – kindergarten

During our long-term research of *Ginkgo biloba* and its cultural distribution in Slovakia, we verified or confirmed the knowledge about the growth, cultivation, use of fruits and seeds of this rare foreign tree.

Ginkgo biloba is a dioecious tree. Determining and differentiating the sex of trees is difficult, until the time of flowering and fruiting trees, is practically impossible. Several published findings concerning the gender differentiation, morphological and physiological features are known (Benčasť, 1982; Pagan and Randuška, 1988; Tomaško, 2004; Benčať, 2009; van Beek, 2000; Begovic, 2011; Kwant, 2011; Zhang et al., 2015). However, based on our long-term research and experiences obtained from three dendrological expeditions in the Democratic People's Republic of Korea (1983 and 1985) and China (1998), we have also come to conflicting views and experiences:

- The male and female trees occur in a ratio 1 : 1. Based on our research and practical experience, we cannot confirm this, and we observed that males predominate in the population.
- Habitus of the tree: male tree – side branches protruding at an acute angle from the main trunk; female tree – horizontally – horizontally projecting lateral branches from the trunk of the tree (almost at right angles). To our knowledge, it is exactly the opposite. The male tree has branches protruding horizontally (almost at right angles). The female tree has branches protruding from the main trunk at an acute angle.
- Number of grooves (ribs) per seed: seeds from which male trees grow have 3 ribs; those producing female tree – 2 ribs. To our knowledge, this phenomenon has the opposite character. The seeds from which male trees grow have 2 ribs on the seed (these are in absolute predominance); the ones producing female tree has 3 ribs per seed (a rare occurrence).

- The male trees bloom 2–3 weeks earlier than female ones. Due to the distances between the research localities of ginkgo trees, we did not perform regular phenological monitoring, so we cannot confirm the previous thesis, but we can agree with the data.
- Gender differentiation of *Ginkgo biloba* trees can be determined by the depth of cuts on the leaf blade: male trees have a deep cut on the leaf blade; female trees have a shallow notch at the leaves, up to entire leaves. We cannot confirm this thesis with certainty, moreover, the variability of the leaves on the one tree is very great.
- Fallen leaves in autumn: male trees tend to fall earlier; female trees have a later date of leaf fall. We can agree with this thesis, but in 2014, in Nitra City Park, the leaves of the male tree were kept two weeks longer (and fell later, while the female tree had been without leaves for a long time).

Conclusions

The final analysis of the research results on the cultigenous area of *Ginkgo biloba* in Slovakia confirmed the occurrence of this rare tree in more than one hundred localities (103 localities). No trees were found in the 18 previously registered localities of the occurrence of ginkgo, 5 trees were felled for various reasons (hygienic, safety, other reasons). The number of trees in solitary plantings (or in groups of three trees) reached 203 trees. 89 trees were planted in tree lines and alley plantings (especially in the city streets). There were 73 male trees, 65 female and 154 pregenerative individuals, a total of 292 trees of *Ginkgo biloba*. The number of ginkgo trees decreases in the following row: Bratislava – 42 trees; Senica – 27; Zlaté Moravce – 26; Nitra – 10; Košice – 9; Piešťany – 9; Topoľčany – 8; Žilina. 7; Nové Zámky – 7; in other districts (32) only 1–3 trees grow; we did not detect *Ginkgo biloba* trees in 31 districts. We evaluated the basic dendrometric and growth parameters of the oldest ginkgo trees, found in Slovakia. We evaluated 42 trees (aged 242 – 111 years) in 35 localities.

Conflict of interests

Authors declare no conflict of interests.

Ethical statement

This article does not contain any studies that would require an ethical statement.

Acknowledgements

We would like to thank our families for their support and patience. We thank the assoc. prof. Ľuba Ďurišová, Ph.D. for consulting the terminology.

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ISSN 2585-8246