

Acta Biologica Plantarum Agriensis 8(1): 3–16 (2020)
ISSN 2061-6716 (Print), 2063-6725 (Online)
<http://abpa.ektf.hu/>

DOI:10.21406/abpa.2020.8.1.3
Research article

THE BRYOPHYTE DIVERSITY OF CENTRAL PARK (ARCHBISHOP'S GARDEN) OF EGER TOWN (HUNGARY)

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Abstract: The objective of the present work was the evaluation of the bryophyte diversity of the central park of Eger town. Altogether 59 taxa (4 liverworts and 55 mosses) were recorded. Nearly half of the identified species (49%) belong to three families: Orthotrichaceae, Pottiaceae, and Brachytheciaceae. *Brachythecium glareosum*, *Cirriphyllum piliferum*, *Eucladium verticillatum*, *Orthotrichum obtusifolium* and *Orthotrichum pumilum* are rated near threatened (NT) according to the Hungarian Red List. Some of the taxa found in Eger were not known from other central east european urban parks (*Ctenidium molluscum*, *Hygroamblystegium tenax*, *Pohlia melanodon*, *Cirriphyllum crassinervium*, *Hypnum cupressiforme* var. *lacunosum*, *Orthotrichum stramineum* and *Orthotrichum striatum*). There are remarkable differences between central park of Eger and other Central and Eastern European parks regarding species composition and the percentage of species in each of the life strategy categories.

Keywords: downtown, urban area, Sørensen index, comparison

INTRODUCTION

There is growing recognition of urban areas as hosts for innovative ways to conserve and promote biodiversity. Parks, as one specific type of urban green space, constitute particularly important biodiversity hotspots in the cityscape (Nielsen *et al.* 2014).

In Central and Eastern Europe several publications address the bryophyte flora or diversity of parks and gardens in urban areas, for example Warsaw, Łódź and other Polish cities (Fudali 2006, Wolski *et al.* 2012), Lviv (Mamchur *et al.* 2018), Bucharest (Gomoiu and Ștefănuț 2008), Velký Krtíš (Mišíková *et al.* 2007), Sofia (Gospodinov *et al.* 2018) and Bratislava (Godovičová and Mišíková

2017). The aim of this study was the examination of the bryophyte diversity of the central park of Eger town.

Knowledge about the bryophytes of anthropogenic habitats in Hungary is limited, and the following papers focus mostly on the description of floristic data: Budapest city (Szepesfalvi 1940, 1941, 1942) Barcs (Szűcs *et al.* 2014), the towns of Sopron (Szűcs 2015) and Gödöllő (Király *et al.* 2019). The bryophyte flora of Almásfüzitő (Szűcs *et al.* 2017a), Balaton village (Zsólyom and Szűcs 2018), and of the manor park of Martonvásár village (Nagy *et al.* 2016) are well documented in Hungary. However, there are no publications aiming at completeness with respect to the bryophyte diversity of parks of downtown areas in Hungary.

MATERIALS AND METHODS

Site details descriptions include data in the following order in the Appendix: habitat, GPS-coordinates, date of collection. Based on the Central European Flora Mapping System (Király *et al.* 2003), each collection point belongs to the 8188.1 square. The nomenclature follows Király (2009) for vascular plants, Söderström *et al.* (2016) for liverworts, and Hill *et al.* (2006) for mosses. In order to characterise the conservation and indicator status of taxa the Hungarian Red List was used (Papp *et al.* 2010). We used the Sørensen index (Sørensen 1948) for the comparison of the species composition of different localities. Collected specimens are deposited at the Cryptogamic Herbarium of the Department of Botany and Plant Physiology at the Eszterházy Károly University, Eger (EGR).

Study area

The town of Eger belongs to the Eger-Bükkalja micro-region, which is a colline area at an elevation of 126 to 420 m above sea level, slightly sloping to the south-east. The settlement is situated on the terraced valley of the Eger Creek, and to a smaller extent it covers the hillside accompanying the valley of the Tárkány Creek (Sugár 1983).

It is a region with a moderately warm to moderately dry climate. The average annual temperature is 9.0–10.0 °C at the highest points. The average annual precipitation is approximately 600 mm,

of which 340–380 mm is produced during the vegetation period. The likelihood of rainfall is the highest in early summer and late autumn (Dövényi 2010, Sugár 1983).

The dominance of the North-West winds is evident in every season, which is particularly characteristic during the summer months. In terms of wind flow speed, Eger is classified into the moderately windy areas of Hungary, which is also indicated by the relatively high frequency of wind silences (Dövényi 2010, Sugár 1983). The Eger Creek forms the boundary of the park in the north-east. The groundwater of the Eger valley has particularly hard water rich in sodium-calcium-hydrogencarbonate and sulfate (Sugár 1983).

The historical descriptions from the 15th and 16th century refer to this part of our town as a rich forested area where the wildlife park was located which was probably established by a bishop of Eger from the Renaissance. The former wildlife park was much larger than today's Archbishop's Garden. It included the area of today's Thermal bath, the present Archbishop's Garden, and also the Csákó district, which extends to the present railway station.

In the park there is an ornamental garden, on the left side of the creek there is a flower garden up to the mills, and between the mills and today's Csákány street there is a vegetable garden which together formed the old bishop's garden. The episcopal ornamental garden was established during the time of Ferenc Barkóczy (1710–1765), in the style of French gardens. In 1769 Bishop Károly Eszterházy (1725–1799) initiated the construction of a stone fence and ornate baroque gates to replace the old wooden fence. The oldest trees in the park are sycamore trees, estimated to be between 300 and 400 years old. Lajos Szmrecsányi (1851–1943) opened the gates of the 14-hectare Archbishop's Garden to the citizens of the town in 1919, and since then the area has been under significant human influence. (Herzegné Székely 2010). As for the park's maintenance, lawn mowing and leaf collection is performed regularly.

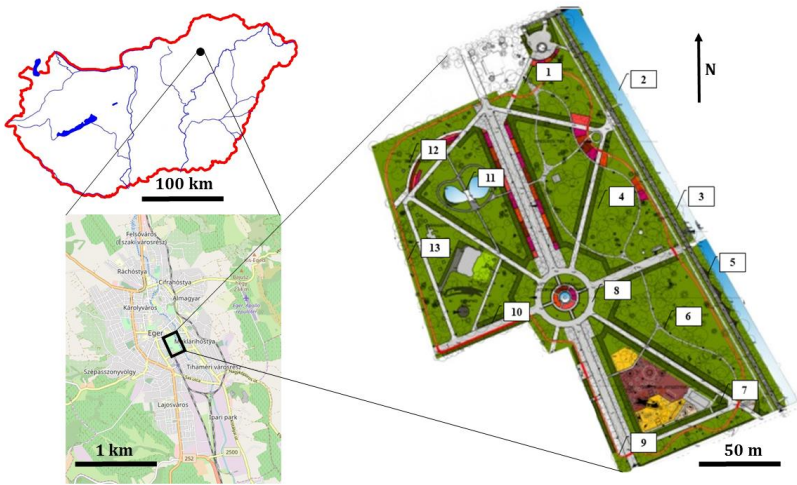


Figure 1. The situation of Eger town, and the map and collecting points of the central park of Eger.

RESULTS AND DISCUSSION

List of species

Numbers refer to sites (*Figure 1*) listed in the Appendix. The substrates given after a colon refer to all listed sites.

Marchantiophyta

Frullania dilatata (L.) Dumort. – LC – 1: bark of *Fraxinus*

Marchantia polymorpha subsp. *ruderalis* Bischl. & Boisselier – LC
– 3: rock in stream water

Pellia endiviifolia (Dicks.) Dumort. – LC - 2: rock in stream water

Radula complanata (L.) Dumort. – LC – 1: bark of *Sophora japonica*; 6, 7: bark of *Acer negundo*; 5: bark of *Ailanthus altissima*

Bryophyta

Amblystegium serpens (Hedw.) Schimp. – LC – 1: artificial stone; 3: wall of the stream; 4, 5: soil; 7, 12: concrete and mown lawn

Atrichum undulatum (Hedw.) P. Beauv. – LC – 7, 9: shaded soil

- Barbula unguiculata*** Hedw. – LC – 1, 3, 13: shaded soil
- Brachytheciastrum velutinum*** (Hedw.) Ignatov & Huttenen – LC – 12: concrete
- Brachythecium glareosum*** (Bruch ex Spruce) Schimp. – NT – 3: wall of the stream bank
- Brachythecium rutabulum*** (Hedw.) Schimp. – LC – 1, 9: soil; 4, 5, 6: mown lawn; 10: stone fence; 11: artificial stone; 12: concrete; 13: andesit stone wall
- Brachythecium salebrosum*** (F. Weber et D. Mohr) Schimp. – LC – 5: bark of *Ailanthus altissima*
- Bryoerythrophyllum recurvirostrum*** (Hedw.) P. C. Chen – LC-att – 3: wall of the stream bank
- Bryum argenteum*** Hedw. – LC – 1, 8, 11: artificial stone; 3: wall of the stream; 7, 8, 12: concrete; 10: stone fence
- Bryum caespiticium*** Hedw. – LC – 1: concrete
- Bryum capillare*** Hedw. – LC – 3: soil bank
- Bryum moravicum*** Podp. – LC – 3: wall of stream bank, bark of *Tilia platyphyllos*; 13: andesit stone wall; 5: bark of *Ailanthus altissima*
- Calliergonella cuspidata*** (Hedw.) Loeske – LC – 11: artificial stone; 13: andesite stone wall
- Ceratodon purpureus*** (Hedw.) Brid. – LC – 3: wall of the stream bank; 7, 8, 12: concrete; 8, 10: soil
- Cirriphyllum crassinervium*** (Taylor) Loeske & M. Fleisch – LC – 3: wall of stream bank
- Cirriphyllum piliferum*** (Hedw.) Grout – NT – 1: soil
- Cratoneuron filicinum*** (Hedw.) Spruce – LC – 2: rock in stream water
- Ctenidium molluscum*** (Hedw.) Mitt. – LC – 5: rubble
- Didymodon rigidulus*** Hedw. – LC-att – 7, 8: concrete; 10: stone fence
- Eucladium verticillatum*** (With.) Bruch & Schimp. – NT – 2: artificial stone in thermal water
- Fissidens taxifolius*** Hedw. – LC – 5, 7, 9: shaded soil
- Grimmia pulvinata*** (Hedw.) Sm. – LC – 1, 8: artificial stone; 7, 12: concrete; 13: andesite stone
- Homalia trichomanoides*** (Hedw.) Brid. – LC-att – 5: rubble
- Homalothecium lutescens*** (Hedw.) H. Rob. – LC – 4, 6: soil
- Homalothecium sericeum*** (Hedw.) Schimp. LC – 3: wall of the stream bank, 13: andesite stone wall

- Homomallium incurvatum** (Schrad. ex Brid.) Loeske – LC – 3: wall of the stream bank
- Hygroamblystegium tenax** (Hedw.) Jenn. – LC – 2: rock in stream
- Hygroamblystegium varium** (Hedw.) Mönk. – LC-att – 11: wet soil on lake shore
- Hypnum cupressiforme** Hedw.- LC – 1: artificial stone, bark of *Fraxinus*, and *Sophora japonica* 3: wall of the stream bank; 4, 5, 6, 7: soil; 13: andesite stone
- Hypnum cupressiforme** var. **lacunosum** Brid. – LC – 3: wall of the stream bank
- Leskea polycarpa** Ehrh. ex Hedw. – LC – 1: bark of *Sophora japonica*; 3, 4, 5, 6: bark of *Acer negundo*; 5: bark of *Tilia platyphyllos*
- Leucodon sciuroides** (Hedw.) Schwägr. – LC – 1: bark of *Fraxinus*
- Orthotrichum affine** Schrad. ex Brid. – LC – 1: bark of *Fraxinus*; and *Sophora japonica*; 4, 6: bark of *Acer negundo*; 5: bark of *Tilia platyphyllos* and *Ailanthus altissima*
- Orthotrichum anomalum** Hedw. – LC – 1: artificial stone; 3: wall of the stream bank; 13: andesite stone wall
- Orthotrichum cupulatum** Hoffm. ex Brid. – LC-att – 1: artificial stone; 3: wall of the stream bank
- Orthotrichum diaphanum** Schrad. ex Brid. – LC – 1, 4, 6: bark of *Acer negundo*
- Orthotrichum obtusifolium** Brid. – NT – 1: bark of *Fraxinus*; 4, 6: bark of *Acer negundo*; 10: bark of *Sophoria japonica*
- Orthotrichum pallens** Bruch ex Brid. – LC – 5, 7: bark of *Tilia platyphyllos*; 10: bark of *Sophoria japonica*
- Orthotrichum pumilum** Sw. ex anon. – NT – 10: stone fence
- Orthotrichum speciosum** Nees – LC-att – 5, 7: bark of *Tilia platyphyllos*
- Orthotrichum stramineum** Hornsch. ex Brid. – LC – 5, 7: bark of *Tilia platyphyllos*; 10: bark of *Sophoria japonica*
- Orthotrichum striatum** Hedw. – LC-att – 5, 7: bark of *Tilia platyphyllos*
- Oxyrrhynchium hians** (Hedw.) Loeske – LC – 1, 4, 5, 6, 7, 8, 12: soil
- Plagiomnium cuspidatum** (Hedw.) T. J. Kop. – LC – 3, 7, 9: soil
- Plagiomnium undulatum** (Hedw.) T. J. Kop. – LC – 7, 9: soil
- Platygyrium repens** (Brid.) Schimp. – LC – 5: artificial stone; 7, 8: concrete
- Pohlia melanodon** (Brid.) A.J. Shaw – LC – 3: soil of stream bank

Pylaisia polyantha (Hedw.) Schimp. – LC – 1: bark of *Fraxinus*; 4, 6: bark of *Acer negundo*

Schistidium crassipilum H. H. Blom – LC – 1: artificial stone; 3: wall of the stream bank

Sciuro-hypnum populeum (Hedw.) Ignatov & Huttunen – LC – 3: wall of the stream bank

Syntrichia papillosa (Wilson) Jur. – LC-att – 1: bark of *Fraxinus*

Syntrichia ruralis (Hedw.) F. Weber & D. Mohr – LC – 3: wall of the stream bank

Syntrichia virescens (De Not.) Ochyra – LC-att – 1: bark of *Fraxinus*; 3: wall of the stream bank; 10: stone fence

Tortula muralis Hedw. – LC – 1, 8, 11: artificial stone; 7, 8, 12: concrete

Tortula truncata (Hedw.) Mitt. – LC – 7: soil

Bryophyte diversity

Altogether 59 bryophytes were detected in the central park of Eger, which include 4 liverworts (7%) and 55 mosses (93%). The liverwort species belong to 4 families and 4 genera, while the mosses belong to 16 families and 32 genera (*Figure 2*).

Nearly half of the species (49.15%) belong to the 3 families Orthotrichaceae (10 taxa), Brachytheciaceae (10 taxa) and Pottiaceae (9 taxa).

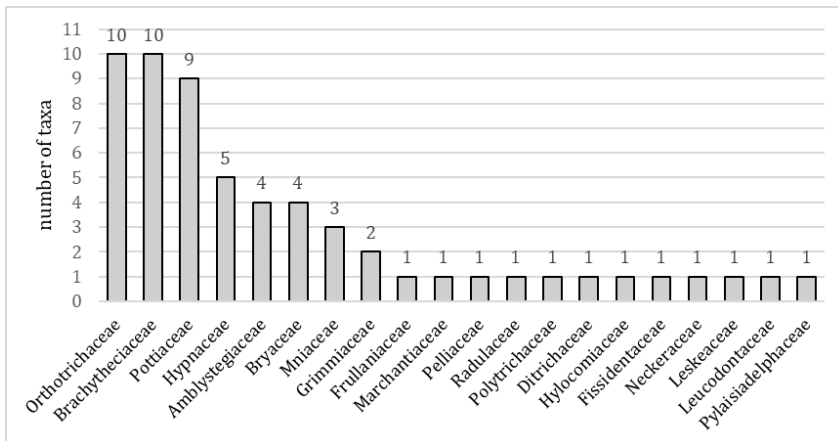


Figure 2. Distribution of bryophyte species found in the central park of the Eger town among families (Taxonomy follows Goffinet and Shaw 2009 and Söderström *et al.* 2016).

Many of the common mosses of the central park of Eger, including *Amblystegium serpens*, *Barbula unguiculata*, *Brachythecium rutabulum*, *B. salebrosum*, *Bryum argenteum*, *Ceratodon purpureus*, *Fissidens taxifolius*, *Grimmia pulvinata*, *Hypnum cupressiforme*, *Leskea polycarpa*, *Leucodon sciuroides*, *Orthotrichum affine*, *O. anomalum*, *O. diaphanum*, *O. pumilum*, *Oxyrrhynchium hians*, *Plagiomnium undulatum*, *Platygyrium repens*, *Pylaisia polyantha*, *Syntrichia ruralis* and *Tortula muralis* have also been found in some other parks of Central East European settlements (Fudali 2006, Wolski *et al.* 2012, Mamchur *et al.* 2018, Gomoiu and Ștefănuț 2008, Mišíková *et al.* 2007, Gospodinov *et al.* 2018 and Godovičová and Mišíková 2017).

Atrichum undulatum and *Homalia trichomanoides* occur in some Central East European parks (Fudali 2006, Mamchur *et al.* 2018) and *Eucladium verticillatum* was detected in the forest park of Lviv city (Mamchur *et al.* 2018). These three species are not known from other hungarian settlements (Szűcs *et al.* 2017a, Zsólyom and Szűcs 2018).

There are a few taxa in Eger, which are not known in the Central East European urban parks (Fudali 2006, Wolski *et al.* 2012, Mamchur *et al.* 2018, Gomoiu and Ștefănuț 2008, Mišíková *et al.* 2007, Gospodinov *et al.* 2018 and Godovičová and Mišíková 2017), for example *Ctenidium molluscum*, *Hygroamblystegium tenax*, *Pohlia melanodon*, *Cirriphyllum crassinervium*, *Hypnum cupressiforme* var. *lacunosum*, *Orthotrichum stramineum* and *O. striatum*.

Table 1 shows the values of the Sørensen index, which are derived from a comparison of moss species in the region, in Central and Eastern European parks, and the central park of Eger. The values of parks in Central and Eastern Europe are similar in this respect, there is no notable difference between the calculated data (0.415–0.590). Compared to the park of Eger, the discrepancy is most pronounced in the case of the Teaching Garden, Łódź (0.415). The Botanical Garden or EKV is situated closest to the central park of Eger and shows the greatest similarity in species composition (highest Sørensen index of 0.590).

Table 1. Comparison of the area, the distance of localities from Eger, the altitude, the number of taxa and Sørensen index of central east european parks with central park of Eger town.

Name of locality	area (hectare)	distance from Central park of Eger (km)	alt (meter a.s.l.)	number of taxa	Sørensen index
Central Park of Eger (present study)	14	0	155-165	59	1
Botanical Garden of EKU, Eger (Hungary) (Szűcs <i>et al.</i> 2017b)	1	1.3	230	46	0.590
Mátraai Sanatorium, Mátraháza (Hungary) (Szűcs <i>et al.</i> 2018)	14	30.4	650-700	65	0.564
Horka forest park, Velky Krtís, (Slovakia) (Mišíková <i>et al.</i> 2007)	1500	83	210	37	0.541
Vrana Park, Sofia (Bulgaria) (Gospodinov <i>et al.</i> 2018)	99.3	623	560	68	0.488
Pohulyanka forest park, Lviv, (Ukraine) (Mamchur <i>et al.</i> 2018)	129	343	340-370	108	0.455
Exp. and Teaching Garden, Łódź, (Poland) (Wolski <i>et al.</i> 2012)	1	435	225	42	0.415

Conservation status

Five taxa belong to the near threatened (NT) category according to the Hungarian Red List (Papp *et al.* 2010): *Brachythecium glareosum*, *Cirriphyllum piliferum*, *Eucladium verticillatum*, *Orthotrichum obtusifolium* and *Orthotrichum pumilum*. Another eight species belong to least concern attention (LC-att), viz. *Bryoerythrophyllum recurvirostrum*, *Didymodon rigidulus*, *Homalia trichomanoides*, *Hygroamblystegium varium*, *Orthotrichum cupulatum*, *Orthotrichum striatum*, *Syntrichia papillosa*, and *Syntrichia virescens*.

Some indicator mosses (species which by their presence indicate a higher conservation value of the habitat) also occur in the park, for example *Cirriphyllum piliferum*, *Eucladium verticillatum*, *Homalia trichomanoides*, *Hygroamblystegium varium*,

Orthotrichum cupulatum, *O. obtusifolium*, *O. pumilum*, *O. speciosum*, *O. striatum*, and *Syntrichia papillosa*.

Life strategies

There is a remarkable difference between central park of Eger and other local or regional habitats (*Table 1*) concerning the percentage of species in each of the life strategy categories (Dierßen 2001).

Central park of Eger is more abundant in colonists and pioneer colonists, and less abundant in long-lived shuttle, perennial, and competitive perennial species, compared to the other habitats. None of the bryophytes in the Central park of Eger belong to the ephemeral colonist and fugitive categories (*Figure 3*).

A possible explanation for the above phenomenon is that abundant bare soil surface is available for the bryophytes, but disturbed substrates are very rare in the studied area.

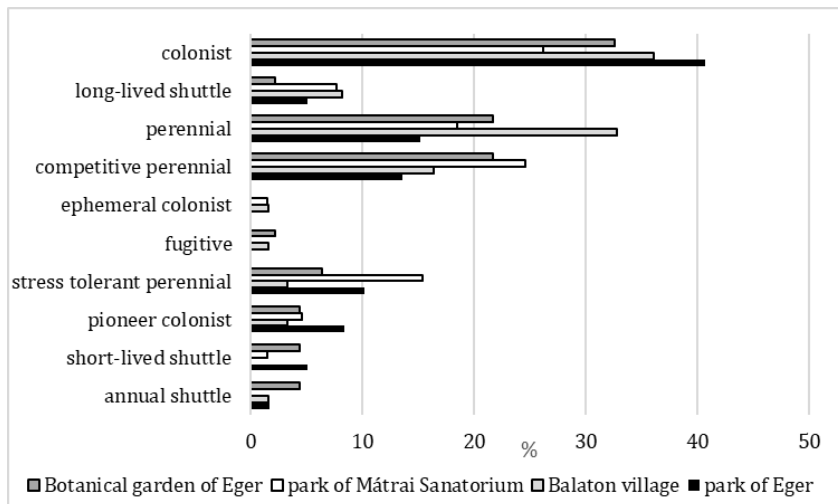


Figure 3. Comparison of the life strategies of bryophytes in Botanical Garden of Eger (Szűcs *et al.* 2017b), park of Mátrai Sanatorium (Mátraháza) (Szűcs *et al.* 2018), Balaton village (Zsólyom and Szűcs 2018) and central park of Eger (present study).

CONCLUSIONS

The central park of Eger has a remarkable bryophyte diversity, which is of comparable magnitude to local, regional places and central east european urban parks in accordance with its size. The high number of indicator mosses shows a high level of conservation value of the park.

The rich bryophyte flora partly can be explained by the history of the different habitats, the abundance of old and varied deciduous trees and the proximity of Eger creek and the municipal thermal spa.

Acknowledgement – The authors would like to express their gratitude to Peter Erzberger and Andrea Sass-Gyarmati for their useful comments. The authors would like to thank Tamás Pócs for the identification of *Eucladium verticillatum*. The first author's research was supported by the grant EFOP-3.6.1-16-2016-00001 ("Complex improvement of research capacities and services at Eszterházy Károly University"). Special thanks to András Vojtkó and András Schmotzer for their help with literature.

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(submitted: 10.12.2019, accepted: 27.04.2020)

APPENDIX

Site details

1. soil, artificial stone, bark of trees (04.12.2018, 01.08.2019, 02.03.2020)
N47°53'53" E20°22'46"
2. rock in stream water (14.06.2019) N47°53'52" E20°22'52"
3. wall of the stream bank, soil (14.06.2019, 03.07.2019) N47°53'49" E20°22'54"
4. mown lawn, soil (13.03.2019., 03.07.2019) N47°53'50" E20°22'50"
5. mown lawn, soil, bark of trees (13.03.2019) N47°53'47" E20°22'56"
6. bark of trees, soil, mown lawn (17.04.2019) N47°53'46" E20°22'54"
7. mown lawn, bark of trees, concrete (11.03.2019) N47°53'41" E20°22'54"
8. artificial stone, soil, concrete (11.03.2019) N47°53'45" E20°22'50"
9. soil (11.03.2019) N47°53'40" E20°22'52"
10. stone fence, soil (11.03.2019) N47°53'44" E20°22'44"
11. artificial lake (14.06.2019) N47°53'49" E20°22'45"
12. mown lawn, concrete, soil (13.03.2019) N47°53'51" E20°22'40"
13. artificial stone wall (14.04.2019, 14.06.2019) N47°53'48" E20°22'44"