Cryptogamie, Bryologie, 2017, 38 (2): 153-170
© 2017 Adac. Tous droits réservés

The bryophyte flora of the village of Almásfüzitő, a former industrial settlement in NW-Hungary

Péter SZŰCS[a], Erika PÉNZES-KÓNYA[a] & Tamás HOFMANN[b]*

[a]*Eszterházy Károly University, Institute of Biology, Department of Botany and Plant Physiology, H-3300 Eger, Leányka Str. 6, Hungary*

[b]*University of Sopron, Institute of Chemistry, H-9400 Sopron, Bajcsy-Zsilinszky Str. 5, Hungary*

Abstract – The objective of the present work was the evaluation of the bryophyte flora diversity of the Hungarian village Almásfüzitő and the adjacent industrial zone. The investigated area was divided into 6 sections depending on the human influence. Altogether 82 taxa (3 liverworts and 79 mosses) were recorded. The low proportion of liverwort species could be primarily explained by the moderately dry climate of the region, and by the fact that the village of Almásfüzitő does not have any historical districts, and old buildings, thus the proportion of new artificial surfaces is relatively high. The bryophyte flora of Almásfüzitő shows the greatest similarity with that of nearby Middle-European metropolises (Linz, Bratislava and Vienna), which was primarily explained by the presence of common and frequent species.

Abandoned alumina factory / Central Europe / Danube / urban bryophytes / semi-natural habitats

INTRODUCTION

Bryofloristical and ecological investigations carried out in inhabited areas usually focus on the urban areas of large cities. During the last decades, the bryophyte flora of several European metropolises have been studied, including Belgrade (Grdović & Stevanović, 2006; Sabovljević & Grdović, 2009), Berlin (Schaepe, 1986; Benkert *et al.*, 1995), Bratislava (Janovicová *et al.*, 2003), Brussels (Vanderpoorten, 1997), Bucharest (Gomoiu & Ştefãnuţ, 2008), Cologne (Sabovljević & Sabovljević, 2009), Katowice (Fojcik & Stebel, 1999, 2014), Linz (Zechmeister *et al.*, 2002), Lisbon (Sérgio, 1981), Ljubjana (Skudnik *et al.*, 2013), Madrid (Mazimpaka *et al.*, 1988), Plovdiv (Hristeva *et al.*, 2011), Praha (Soldán, 1982; Váňa, 2004), Rome (Carcano, 1989), Salzburg (Gruber, 2001), Sofia (Ganeva, 2004), Szczecin (Fudali, 1994, 1996), Wrocław (Fudali, 2012), and Vienna (Hohenwallner, 2000; Zechmeister, 2009).

Compared to these results, far less data have been published on the bryophyte flora diversity of smaller Middle-European cities and settlements: Czech Republic (Vondráček, 1997; Vincenecová, 1998; Hradílek & Koval, 2012; Vejmelková, 2014), Germany (Stingl, 1985; Müller, 1993; Schrader, 1994; Koperski,

* Corresponding author: szucs.peter@uni-eszterhazy.hu

doi/10.7872/cryb/v38.iss2.2017.153

1998; Solga, 1998; Frahm, 2006; Isermann 2007), Poland (Filipiak & Sieradzki, 1996; Żarnowiec, 1996; Fudali, 1998, Wolski *et al.*, 2012), Slovakia (Mišíková *et al.*, 2007; Mišíková & Kubinská, 2010; Mišíková & Cibulková, 2012; Mišíková, 2013; Kolbek *et al.*, 2015). The results on the urban bryophyte flora distribution of (small) South-European cities are more abundant in the scientific literature compared to Middle-Europe: Italy (Cortini-Pedrotti, 1989; Aleffi, 1991; Lo Giudice, 1992; Aleffi & Taruschio, 1996; Lo Giudice *et al.*, 1997; Pokorny *et al.*, 2006), and Spain (Esteve Chueca *et al.*, 1976, 1977; Fiol, 1983; Ballesteros Segura & Ron, 1985; Vicente *et al.*, 1986; Viera & Ron, 1986; Lara & Mazimpaka, 1989, Heras & Soria, 1990; Lara *et al.*, 1991; Mazimpaka *et al.*, 1993; Ayuso *et al.*, 1995; Soria & Ron, 1990, 1995; Rams *et al.*, 2000).

There are only a few publications on the bryophytes of the inhabited areas of Hungary and these works focus only on the documentation of floristic data. The majority of this research was conducted at Budapest (Szepesfalvi, 1940, 1941, 1942) and Almásfüzitő (Szűcs & Lóth, 2008; Szűcs, 2015a) yet, there are also data on other small settlements like Dunaalmás and Neszmély (Szűcs, 2007), Barcs (Szűcs *et al.*, 2014) as well as on the city of Sopron (Szűcs, 2015b).

The main objective of the present article was the presentation of the bryophyte flora diversity of the village of Almásfüzitő and the comparison of these results with those of other major European cities, as well as to know the effects of anthropogenic impacts on the bryophyte diversity in different parts of the village.

MATERIALS AND METHODS

Studied area

The village of Almásfüzitő occupies an area of 8.2 km^2 and is located in northwestern Hungary, in the so called Komarom-Esztergom (Small Plain) region, on the bank of the Danube River and has about 3,000 inhabitants (Fig. 1). The village comprises two settlements (Nagykolónia and Kiskolónia) and lies at 105-115 m a.s.l. (above sea level). The region is covered by slightly basic Neogenic silt, sand deposits, fluvial sand and wind-carried sand (Dövényi, 2010). The climate is moderately warm and dry; the mean annual temperature varies from 9.8°C to 10.2°C and the annual precipitation from 550 mm to 580 mm (Dövényi, 2010). The nearest main watercourse is the Danube River. The village has two gravel-pit lakes and at the riverside of the Danube one dead channel and one oxbow lake which result a more humid microclimate at these habitats. In the middle of the 20th century, considerable alumina production facilities were set up near the village and with the upswing of alumina production a new housing estate was also built in the western part of the village. Over 12 million tons of red mud (by-product of alumina production) were stored in the depositories of Almásfüzitő, covering an area of about 200 ha. The alumina factory was closed down in 1997, and the red mud depositories were recultivated about 20 years ago (Nagy, 2014).

Sampling

The field work was carried out between 2006 and 2014. Random sampling was performed in different habitats and microhabitats within the administrative borders of the village including the housing estate, traffic, recreation, garden,

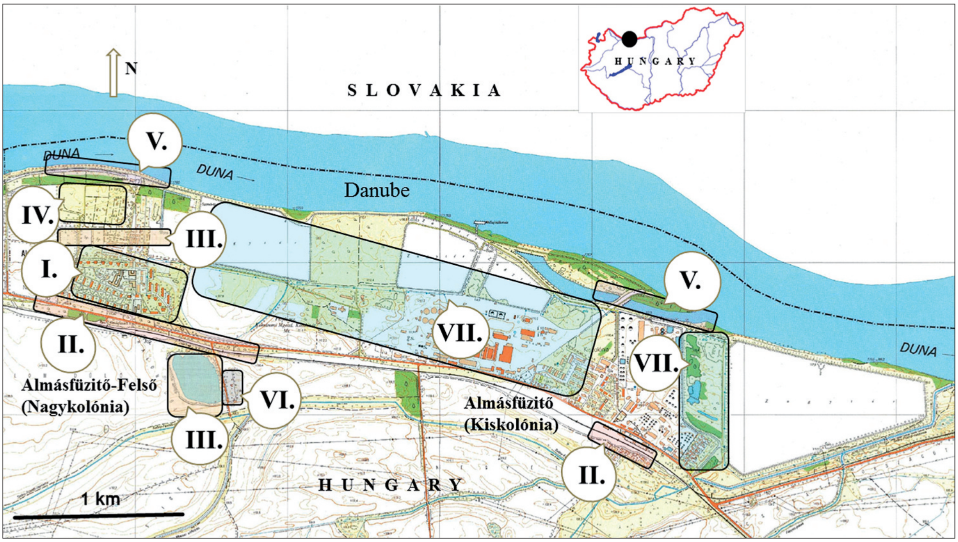

Fig. 1. Map of Almásfüzitő village and the investigated areas. I: Housing estate area; II: Traffic areas; III: Recreation areas; IV: Garden area; V: Riverside areas; VI: Cemetery; VII: Industrial areas. Map of Hungary with indication of the studied area is inserted in the upper right corner.

riverside, cemetery and industrial areas (Fig. 1). The list and details of the sampling plots are included in Appendix I (See Supplementary Material 1, doi/10.7872/cryb/v38.iss2.2017.Suppl.Mat.1).

The housing estate area is that part of the village which is most significantly under human impact. The next specific microhabitats and substrates were here surveyed: mown lawn, bare soil surface, exposited and shaded soil, humicolous and burned soil, tree bark, concrete, artificial stone, dry calcareous rock, asphalt roofing felt, decayed planks and plastic floor mats. The traffic areas involve the highway and railway tracks, touching the southern part of the village. The mentioned railway tracks are among the busiest in Hungary. Specific microhabitats and substrates in these zones were: concrete, exposed and bare soil, and tree bark. Recreation areas of the village involve a turf covered football pitch, a concrete covered sports field, a holiday park and fishing lake which was a former gravel pit lake. Specific microhabitats and substrates were: mown lawn, wet soil, concrete, artificial stone, exposed and shaded soil, and tree bark. The garden area stretches between the Danube River and the housing estate. Small gardens and wooden houses as well as narrow cart roads and alleys are characteristic of this zone. The riverside areas involve the local riverside of the Danube, the Prépost peninsula, one dead channel and one oxbow lake. The specific microhabitats and substrates of these zones were: wet calcareous rock, riverbed sediment sludge, wet soil, bare and sandy soil, concrete, shaded soil, floating and decayed wood, and tree bark. The local cemetery, which belongs to the village, was treated as an individual zone and was therefore not included either in any of the above mentioned zones. The specific microhabitats and substrates of the cemetery were: artificial stone, concrete, mown lawn, and exposed soil. The industrial areas can be characterised by spontaneously growing secondary vegetation, industrial buildings, pipelines, utility roads, railway tracks, and the recultivated red mud depositories found in the area of the abandoned alumina factory. This part of the village was subjected to a heavy anthropogenic load for several years. With the closing down of the plant, industrial activities as well as human activity have completely disappeared. The following specific microhabitats and substrates were explored in this area: concrete, artificial stone, mown lawn, sunny soil, gravelly and burned soil, tree bark, rubber liners and glass-wool.

The work of During *et al.* (1979) was used for the evaluation of the life strategies of bryophytes comparing the most represented life-strategies in the industrial and non-industrial areas of Almásfüzitő. The last ones include housing estate area, traffic areas, recreation areas, garden area, riverside areas, and cemetery, indicated in Fig. 1.

Nomenclature follows the classification of Király (2009) for vascular plants, Ros *et al.* (2007) for liverworts and Ros *et al.* (2013) for mosses. Specimens were deposited in the bryophyte herbarium of the Eszterházy Károly University in Eger (EGR).

RESULTS AND DISCUSSION

The bryophytes found in the studied area are listed below indicating species names, life strategy (given in brackets), numbers of the sampling plots and the substrates where they were found on. Species marked with an asterisk are identified as indicators in the investigated area.

List of taxa

Hepaticae

Marchantia polymorpha L. (colonist) – 3, 7: sandy soil
Pellia endiviifolia (Dicks.) Dumort. (colonist) – 7, 40: sandy, shaded soil
Radula complanata (L.) Dumort. (long-lived shuttle) – 5: trunk of *Acer negundo* L.

Musci

Abietinella abietina (Hedw.) M. Fleisch. (perennial) – 1, 5, 8: sandy, exposed soil
**Aloina aloides* (Koch *ex* Schultz) Kindb. (colonist) – 20: sandy and gravelly soil
**Aloina rigida* (Hedw.) Limpr. (colonist) – 1, 8: bare and clayey soil
Amblystegium serpens (Hedw.) Schimp. (perennial) – 3: shaded wall, 4: trunk of *Populus nigra* L.; 6: shaded decayed wood; 7: shaded soil; 18: shaded and decayed planks; 23: artificial stone; 32: tree base of *Populus* x *euramericana* (Dode) Guinier; 38: trunk of *Populus tremula* L.
Barbula convoluta Hedw. (colonist) – 1, 5, 22, 28, 32: exposed soil; 21: concrete; 37: sunny soil
Barbula unguiculata Hedw. (colonist) – 1, 2, 4, 5, 7, 9, 11, 12, 13, 14, 17, 18, 19, 20, 22, 26, 32, 33, 35, 37, 41, 46: exposed soil; 23: artificial stone
Brachytheciastrum velutinum (Hedw.) Ignatov & Huttunen (perennial) – 1, 32, 33: shaded soil; 3: calcareous stone; 38: stump of *Populus tremula*
Brachythecium albicans (Hedw.) Schimp. (perennial) – 1, 8, 23, 34, 35, 37: exposed soil; 10: sunny asphalt roofing felt; 23, 42: exposed artificial stone
Brachythecium glareosum (Bruch *ex* Spruce) Schimp. (competitive perennial) – 1, 5: bare and exposed soil; 24: concrete; 42: artificial stone

Brachythecium rivulare Schimp. (competitive perennial) – 6: wet, calcareous stone
Brachythecium rutabulum (Hedw.) Schimp. (competitive perennial) – 1, 7, 11, 24, 32, 33, 34, 35, 37, 46: soil; 10: sunny asphalt roofing felt; 17, 36: concrete; 36: exposed glass-wool; 23, 42: artificial stone
Brachythecium salebrosum (Hoffm. *ex* F. Weber & D. Mohr) Schimp. (competitive perennial) – 4: root of *Populus nigra*
**Brachythecium tommasinii* (Sendtn. *ex* Boulay) Ignatov & Huttunen (perennial) – 23: artificial stone; 26: exposed concrete
Bryum argenteum Hedw. (colonist) – 1, 2, 3, 5, 9, 18, 20, 32: soil; 14, 15, 36, 43: exposed concrete, 23: artificial stone; 36: glass-wool; 36: rubber liners
Calliergonella cuspidata (Hedw.) Loeske (competitive perennial) – 14, 24: shaded soil
Campyliadelphus chrysophyllus (Brid.) R.S. Chopra (perennial) – 6, 7: wet, exposed soil
Ceratodon purpureus (Hedw.) Brid. (colonist) – 1, 11, 28, 32, 34, 37, 39: exposed soil; 1: bark of *Betula pendula* Roth and *Robinia pseudoacacia* L.; 3: bark of *Sophora japonica* L.; 5, 26, 30, 36: exposed concrete; 10: sunny asphalt roofing felt; 35: trunk of *Populus nigra*; 36: exposed rubber liners; 42: sunny artificial stone
**Cinclidotus fontinaloides* (Hedw.) P. Beauv. (colonist) – 6: wet, exposed limestone
Cinclidotus riparius (Host *ex* Brid.) Arn. (colonist) – 6: wet, exposed limestone
Cirriphyllum crassinervium (Taylor) Loeske & M. Fleisch. (perennial) – 5, 28: exposed concrete; 23: artificial stone, 35: exposed soil
**Cirriphyllum piliferum* (Hedw.) Grout (competitive perennial) – 5: wet soil
Cratoneuron filicinum (Hedw.) Spruce (competitive perennial) – 4: shaded limestone and bark of *Populus nigra*; 6: limestone; 12: shaded artificial stone; 31: shaded concrete
Dicranella staphylina H. Whitehouse (ephemeral colonist) – 24: sandy, bare soil
Dicranella varia (Hedw.) Schimp. (ephemeral colonist) – 7, 8, 40: wet soil
Didymodon insulanus (De Not.) M.O. Hill (colonist) – 4, 7, 24: disturbed, bare and sandy soil
**Didymodon tophaceus* (Brid.) Lisa (colonist) – 23: wet, sandy soil
Drepanocladus aduncus (Hedw.) Warnst. (perennial) – 6: riverbed sediment sludge; 14, 20, 29: wet soil
Encalypta streptocarpa Hedw. (perennial) – 7: wet soil
Encalypta vulgaris Hedw. (long-lived shuttle) – 11: exposed soil
Eurhynchium angustirete (Broth.) T.J. Kop. (perennial) – 19, 24: shaded soil
Fissidens crassipes Wilson *ex* Bruch & Schimp. (long-lived shuttle) – 6: wet limestone
Fissidens taxifolius Hedw. (colonist) – 17, 24: shaded and humicolous soil
Funaria hygromertica Hedw. (fugitive) – 1, 2, 5, 32: burn and exposed soil
Grimmia pulvinata (Hedw.) Sm. (colonist) – 3: limestone wall; 3, 5, 14, 15, 21, 25, 26, 31, 36, 37, 41, 43: exposed concrete, 12, 23: artifical stone
Hedwigia ciliata (Hedw.) P. Beauv. (long-lived shuttle) – 10: sunny asphalt roofing felt; 24: bark of *Robinia pseudoacacia*
Homalothecium lutescens (Hedw.) H. Rob. (perennial) – 1, 2, 5, 8, 13, 14, 23, 33: exposed soil; 11, 31, 36, 41: concrete; 36: sunny rubber liners; 42: artificial stone
Homalothecium sericeum (Hedw.) Schimp. (perennial) – 3: sunny limestone
Homomallium incurvatum (Schrad. *ex* Brid.) Loeske (colonist) – 11: exposed concrete

**Hygroamblystegium fluviatile* (Hedw.) Loeske (perennial) – 6: wet and exposed limestone

Hypnum cupressiforme Hedw. (stress tolerant perennial) – 1: tree base of *Betula pendula*; 3: shaded wall; 4: tree base of *Populus nigra*; 5: trunk of *Populus* x *euramericana*; 11, 23: exposed soil; 23: sunny artificial stone; 26: concrete; 27: exposed plastic artificial floor mats; 36: sunny rubber liners; 38: tree base of *Populus tremula*

Hypnum cupressiforme var. *lacunosum* Brid. (stress tolerant perennial) – 10: sunny asphalt roofing felt

Leptodyctium riparium (Hedw.) Warnst. (perennial) – 4, 6: floating trunks and wet limestone; 18: decayed *Populus* wood; 18, 39, 40: wet soil

Leskea polycarpa Hedw. (perennial) – 1: trunk of *Robinia pseudoacacia*; 4, 6, 32: trunk of *Populus nigra*; 17: concrete; 38: trunk of *Populus tremula*; 44: trunk of *Populus* x *euramericana*

**Nyholmiella obtusifolia* (Brid.) Holmen & Warncke (pioneer colonist) – 1, 14: trunk of *Populus* x *euramericana*

Orthotrichum affine Schrad. *ex* Brid. (colonist) – 31: branches of *Sambucus nigra* L.

Orthotrichum anomalum Hedw. (colonist) – 3: sunny limestone wall; 6: exposed limestone; 15, 17, 21, 26, 30, 37, 43; concrete; 23: sunny artificial stone

**Orthotrichum cupulatum* Hoffm. *ex* Brid. (colonist) – 3: sunny limestone wall, 23: sunny artificial stone

Orthotrichum diaphanum Schrad. *ex* Brid. (colonist) – 1: trunk of *Populus alba* L. and *Populus* x *euramericana*; 3: branch of *Sophora japonica*; 5, 10, 12, 44: trunk of *Populus* x *euramericana*; 4: bark of *Populus nigra*; 23: artificial stone, 31: branch of *Sambucus nigra*; 32, 35: trunk of *Populus nigra*; 45: bark of *Koelreuteria paniculata* Laxm.

Orthotrichum pallens Bruch *ex* Brid. (pioneer colonist) – 38: trunk of *Populus tremula,* 45: branch of *Koelreuteria paniculata*

**Orthotrichum pumilum* Sw. *ex anon.* (colonist) – 1: trunk of *Robinia pseudoacacia*; 24: shaded concrete; 45: branch of *Koelreuteria paniculata*

Orthotrichum stramineum Hornsch. *ex* Brid. (colonist) – 31: branch of *Sambucus nigra*; 45: trunk of *Koelreuteria paniculata*

**Orthotrichum striatum* Hedw. (short-lived shuttle) – 5: trunk of *Populus;* 45: branches of *Koelreuteria paniculata*

Oxyrrhynchium hians (Hedw.) Loeske (pioneer colonist) – 1, 2, 5, 8, 14, 18, 19, 23, 24, 33, 39, 40: shaded soil

Physcomitrella patens (Hedw.) Bruch & Schimp. (annual shuttle) – 6: riverbed sediment sludge

Physcomitrium pyriforme (Hedw.) Bruch & Schimp. (annual shuttle) – 6: riverbed sediment sludge; 17: wet soil

Plagiomnium cuspidatum (Hedw.) T.J. Kop. (competitive perennial) – 5, 8, 14, 46: humicolous soil

Plagiomnium undulatum (Hedw.) T.J. Kop. (competitive perennial) – 24, 27: wet soil

Platygyrium repens (Brid.) Schimp. (stress tolerant perennial) – 32: trunk of *Populus nigra*

Pohlia lutescens (Limpr.) H. Lindb. (colonist) – 6: riverbed sediment sludge

Pseudoleskeella nervosa (Brid.) Nyholm (stress tolerant perennial) – 1: bark of *Populus alba*

Pseudoscleropodium purum (Hedw.) M. Fleisch. (perennial) – 14, 19, 24, 35: exposed soil

**Pterygoneurum ovatum* (Hedw.) Dixon (annual shuttle) – 1, 3, 22: bare and exposed soil

Ptychostomum capillare (Hedw.) Holyoak & N. Pedersen (colonist) – 1: stump of *Populus alba* and *Betula pendula*; 31: exposed concrete

Ptychostomum imbricatulum (Müll. Hal.) Holyoak & N. Pedersen (colonist) – 1, 2, 5, 24, 25, 28, 32, 33, 34, 35, 37, 46: sunny soil; 23: artificial stone; 36: exposed glass-wool; 43: concrete

Ptychostomum moravicum (Podp.) Ros & Mazimpaka (colonist) – 3: shaded limestone; 5: trunk of *Populus* x *euramericana*; 1, 13: trunk of *Robinia pseudoacacia*

Pylaisia polyantha (Hedw.) Schimp. (stress tolerant perennial) – 1: trunk of *Populus alba*; 38: trunk of *Populus* x *euramericana*

**Rhynchostegium murale* (Hedw.) Schimp. (perennial) – 3: exposed artificial stone; 6: sunny limestone, 41: concrete

Schistidium crassipilum H.H. Blom (colonist) – 3, 5, 11, 15, 24, 26, 30, 31, 36, 41: exposed concrete; 12, 23: sunny artificial stone

Sciuro-hypnum populeum (Hedw.) Ignatov & Huttunen (perennial) – 1: base of *Populus alba*; 13: shaded and decayed plank

Syntrichia latifolia (Bruch *ex* Hartm.) Huebener (colonist) – 4: limestone and bark of *Populus nigra*

**Syntrichia papillosa* (Wilson) Jur. (colonist) – 5: bark of *Ulmus laevis* Pall.

Syntrichia ruralis (Hedw.) F. Weber & D. Mohr (colonist) – 1, 2, 11: sunny soil, 3, 4: exposed limestone; 10: sunny asphalt roofing felt 4: tree base of *Populus nigra*; 14, 15, 20, 26, 30, 31, 43: sunny concrete

Syntrichia virescens (De Not.) Ochyra (colonist) – 4: trunk of *Populus nigra*; 5, 44: trunk of *Populus* x *euramericana*

Tortella inclinata (R. Hedw.) Limpr. (colonist) – 8, 19, 35, 39, 41: bare and sandy soil

Tortula acaulon (With.) R.H. Zander (annual shuttle) – 1, 2, 18: exposed and bare soil

**Tortula lindbergii* Broth. (annual shuttle) – 1, 11: bare and exposed soil

Tortula muralis Hedw. (colonist) – 3, 23: artificial stone; 5, 14, 15, 21, 31, 33, 36, 41, 43: exposed concrete; 32: limestone

Weissia condensa (Voit) Lindb. (colonist) – 14: sunny and sandy soil

Weissia longifolia Mitt. (short-lived shuttle) – 1, 5: exposed and humicolous soil

Bryophyte diversity

Altogether 82 taxa were recorded, which include 3 liverworts (4%) and 79 mosses (96%). The liverwort species belonged to 3 families and 3 genera, while the 79 mosses belonged to 17 families and 47 genera (Fig. 2). More than half of the species (54%) belong to 3 families (*Brachyteciaceae, Orthotrichaceae, Pottiaceae*).

The high proportion of acrocarpous mosses (especially those belonging to *Pottiaceae*) is characteristic primarily in Mediterranean cities (e. g. Soria & Ron, 1995; Rams *et al.*, 2000; Pokorny *et al.*, 2006).

In the case of the pleurocarpous mosses the high number of *Brachytheciaceae* species was primarily explained by the great diversity of substrates and habitats, while the high proportion and diversity of lime containing substrates (artificial stone, limestone wall, concrete) and woody plants account for the outstanding number of *Orthotrichaceae* species.

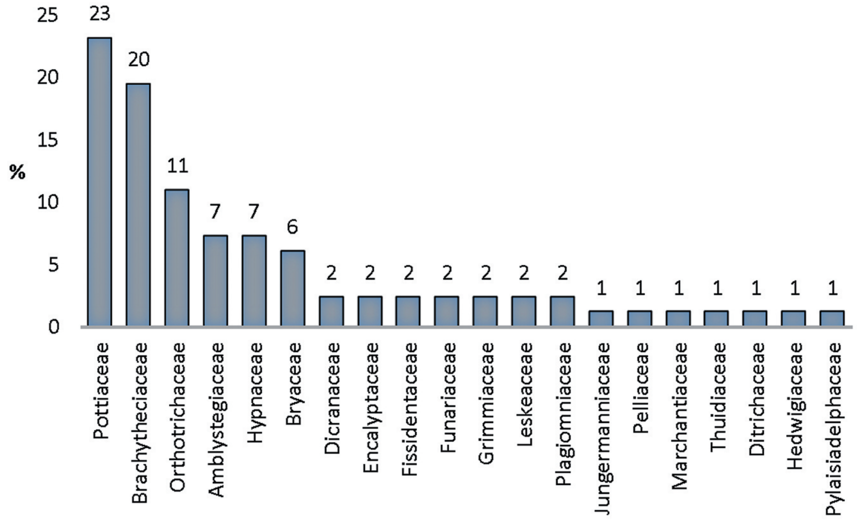

Fig. 2. Percentage distribution of bryophyte species between families, based on the sample collections at the village of Almásfüzitő.

A lot of the common bryophytes of the village, including *Amblystegium serpens*, *Barbula convoluta*, *B. unguiculata*, *Brachytheciastrum velutinum*, *Brachythecium rutabulum*, *B. salebrosum*, *Bryum argenteum*, *Calliergonella cuspidata*, *Ceratodon purpureus*, *Encalypta streptocarpa*, *Fissidens taxifolius*, *Funaria hygrometrica*, *Grimmia pulvinata*, *Homalothecium sericeum*, *Hypnum cupressiforme*, *Orthotrichum affine, O. anomalum, O. diaphanum*, *Oxyrrhynchium hians*, *Plagiomnium undulatum*, *Ptychostomum imbricatulum, Rhynchostegium murale*, *Tortula acaulon* and *Tortula muralis* also occur in some other central European cities (Gruber, 2001; Zechmeister *et al.*, 2002; Janovicová *et al.*, 2003; Frahm, 2006; Sabovljević & Grdović, 2009; Sabovljević & Sabovljević, 2009; Zechmeister 2009; Skudnik *et al.*, 2013; Fojcik & Stebel, 2014). The following taxa are characteristic and frequent in both Central European and South European cities: *Amblystegium serpens*, *Barbula unguiculata*, *Bryum argenteum*, *Funaria hygrometrica*, *Grimmia pulvinata*, *Homalothecium sericeum*, *Hypnum cupressiforme*, *Orthotrichum affine, O. diaphanum*, *O. anomalum, Oxyrrhynchium hians*, *Tortula acaulon* and *T. muralis* (Heras & Soria, 1990; Lo Giudice *et al.*, 1997; Pokorny *et al.*, 2006).

The taxa *Pellia endiviifolia*, *Ptychostomum capillare*, *Syntrichia papillosa*, *S. virescens* have been recorded only in some Central-European countries up till now, however they were indicated in the bryophyte flora of the cities of Trento, Enna and Vitoria (Pokorny *et al.*, 2006; Mazimpaka & Lara, 1997; Heras & Soria, 1990).

Ninety-three % of the species identified in the investigated territory can also be found in the bryophyte flora of Bratislava and Vienna. The values for other cities are as follows: Belgrade 74%, Cologne 63%, Enna 35%, Katowice 64%, Linz 94%, Ljubljana 56%, Marianka 41%, Rolandseck 67%, Salzburg 87%, Trento 64%, Vitoria 39%. The results showed that the bryophyte flora of Almásfüzitő most closely resembled that of Bratislava, Linz, and Vienna and to a lesser extent that of Salzburg and Belgrade (Table 1). Similarities can primarily be explained by the presence of frequent and common species.

Table 1. Occurrence of detected species in central and south European settlements and percentage of similitude with Almásfüzitő bryophyte flora. Data were obtained from the next literature references. – Belgrade: Sabovljević & Grdović (2009); Bratislava: Janovicová *et al.* (2003), Cologne: Sabovljević & Sabovljević (2009); Enna: Lo Giudice *et al.* (1997); Katowice: Fojcik & Stebel (2014); Linz: Zechmeister *et al.* (2002); Ljubljana: Skudnik *et al.* (2013); Marianka: Mišíková (2013), Rolandseck: Frahm (2006); Salzburg: Gruber (2001); Trento: Pokorny *et al.* (2006); Vienna: Zechmeister (2009); Vitoria: Heras & Soria (1990)

Taxa name/cities	*Belgrade*	*Bratislava*	*Cologne*	*Enna*	*Katowice*	*Linz*	*Ljubljana*	*Marianka*	*Rolandseck*	*Salzburg*	*Trento*	*Vienna*	*Vitoria*
Hepaticae													
Marchantia polymorpha L.	x	x	x	–	–	x	x	x	x	x	x	x	–
Pellia endiviifolia (Dicks.) Dumort.	x	x	–	x	–	x	–	x	x	x	x	x	x
Radula complanata (L.) Dumort.	x	x	–	–	–	x	x	x	x	x	x	x	–
Musci													
Abietinella abietina (Hedw.) M. Fleisch.	–	x	x	–	x	x	x	–	–	x	–	x	–
Aloina aloides (Koch *ex* Schultz) Kindb.	x	–	–	–	–	–	–	–	–	–	–	–	x
A. rigida (Hedw.) Limpr.	x	x	–	x	x	x	–	–	–	x	–	x	–
Amblystegium serpens (Hedw.) Schimp.	x	x	x	x	x	x	x	x	x	x	x	x	x
Barbula convoluta Hedw.	x	x	x	x	x	x	x	x	x	x	–	x	x
B. unguiculata Hedw.	x	x	x	x	x	x	x	x	x	x	x	x	x
Brachytheciastrum velutinum (Hedw.) Ignatov & Huttunen	x	x	x	x	x	x	x	x	x	x	x	x	–
Brachythecium albicans (Hedw.) Schimp.	x	x	x	–	x	x	x	x	x	–	–	x	–
B. glareosum (Bruch *ex* Spruce) Schimp.	x	x	–	–	–	x	–	–	–	x	–	x	–
B. rivulare Schimp.	x	x	x	–	x	x	–	–	x	x	x	x	–
B. rutabulum (Hedw.) Schimp.	x	x	x	–	x	x	x	x	x	x	x	x	x
B. salebrosum (Hoffm. *ex* F. Weber & D. Mohr) Schimp.	x	x	x	–	x	x	x	x	x	x	x	x	–
B. tommasinii (Sendtn. *ex* Boulay) Ignatov & Huttunen	–	x	–	–	–	x	–	–	–	x	x	–	–
Bryum argenteum Hedw.	x	x	x	x	x	x	x	x	x	x	x	x	x
Campyliadelphus chrysophyllus (Brid.) R.S. Chopra	x	x	–	–	–	–	–	–	–	x	x	x	–
Calliergonella cuspidata (Hedw.) Loeske	x	x	x	–	x	x	x	–	x	x	x	x	–
Ceratodon purpureus (Hedw.) Brid.	x	x	x	–	x	x	x	x	x	x	x	x	x
Cinclidotus fontinaloides (Hedw.) P. Beauv.	–	x	x	–	–	x	–	–	x	x	–	x	–
C. riparius (Host *ex* Brid.) Arn.	–	x	x	–	–	x	–	–	x	x	x	x	–
Cirriphyllum crassinervium (Taylor) Loeske & M.Fleisch.	–	x	–	–	–	x	–	–	x	x	x	x	x

Taxa name/cities	*Belgrade*	*Bratislava*	*Cologne*	*Enna*	*Katowice*	*Linz*	*Ljubljana*	*Marianka*	*Rolandseck*	*Salzburg*	*Trento*	*Vienna*	*Vitoria*
C. piliferum (Hedw.) Grout	x	x	–	–	x	x	x	x	x	x	–	x	–
Cratoneuron filicinum (Hedw.) Spruce	x	x	–	x	–	x	–	–	x	x	x	x	x
Dicranella staphylina H. Whitehouse	–	x	–	–	x	x	–	x	x	–	–	–	–
D. varia (Hedw.) Schimp.	x	x	x	–	x	x	x	–	–	x	x	x	x
Didymodon insulanus (De Not.) M.O. Hill	x	–	x	x	–	–	–	–	x	–	–	–	x
D. tophaceus (Brid.) Lisa	x	–	–	x	x	x	–	–	–	–	x	x	–
Drepanocladus aduncus (Hedw.) Warnst.	–	x	x	–	x	x	–	–	–	x	–	x	–
Encalypta streptocarpa Hedw.	x	x	x	–	x	x	x	–	x	x	x	x	–
E. vulgaris Hedw.	x	x	x	–	–	x	x	–	x	x	–	x	–
Eurhynchium angustirete (Broth.) T.J. Kop.	–	x	–	–	x	x	–	x	–	x	–	x	–
Fissidens crassipes Wilson *ex* Bruch & Schimp.	–	x	x	x	–	x	–	–	x	x	x	x	–
F. taxifolius Hedw.	x	x	x	–	x	x	x	x	x	x	x	x	x
Funaria hygromertica Hedw.	x	x	x	x	x	x	x	x	x	x	x	x	x
Grimmia pulvinata (Hedw.) Sm.	x	x	x	x	x	x	x	x	x	x	x	x	x
Hedwigia ciliata (Hedw.) P. Beauv.	–	x	–	–	–	x	–	–	x	x	x	–	–
Homalothecium lutescens (Hedw.) H. Rob.	x	x	–	–	–	x	–	–	–	x	–	x	x
H. sericeum (Hedw.) Schimp.	x	x	x	x	x	x	x	–	x	x	x	x	x
Homomallium incurvatum (Schrad. *ex* Brid.)	x	x	–	–	–	x	–	–	–	x	–	x	–
Hygroamblystegium fluviatile (Hedw.) Loeske	–	x	–	–	–	x	–	–	–	x	x	x	–
Hypnum cupressiforme Hedw.	x	x	x	x	x	x	x	x	x	x	x	x	x
H. cupressiforme var. *lacunosum* Brid.	x	–	x	–	–	x	x	–	x	x	–	x	–
Leskea polycarpa Hedw.	x	x	x	–	x	x	x	–	x	x	x	x	–
Leptodyctium riparium (Hedw.) Warnst.	–	x	x	–	–	x	–	–	x	x	x	x	–
Nyholmiella obtusifolia (Brid.) Holmen & Warncke	–	x	–	–	x	x	–	–	–	x	x	x	–
Orthotrichum affine Schrad. *ex* Brid.	x	x	x	x	x	x	x	x	x	x	x	x	x
O. anomalum Hedw.	x	x	x	x	x	x	x	x	x	x	x	x	x
O. cupulatum Hoffm. *ex* Brid.	x	x	–	–	x	x	x	–	x	x	x	–	–
O. diaphanum Schrad. *ex* Brid.	x	x	x	x	x	x	x	x	x	x	x	x	x
O. pallens Bruch *ex* Brid.	–	x	–	–	–	x	–	–	–	x	–	x	x
O. pumilum Sw. *ex* anon	x	x	x	–	x	x	–	–	–	x	–	x	–
O. stramineum Hornsch. *ex* Brid.	x	x	–	x	x	x	–	–	x	x	–	x	–
O. striatum Hedw.	x	x	–	x	x	x	–	–	–	x	x	x	–
Oxyrrhynchium hians (Hedw.) Loeske	x	x	x	x	x	x	x	x	x	x	x	x	x

Taxa name/cities	*Belgrade*	*Bratislava*	*Cologne*	*Enna*	*Katowice*	*Linz*	*Ljubljana*	*Marianka*	*Rolandseck*	*Salzburg*	*Trento*	*Vienna*	*Vitoria*
Physcomitrella patens (Hedw.) Bruch & Schimp.	x	x	x	–	x	x	x	–	x	–	–	x	–
Physcomitrium pyriforme (Hedw.) Bruch & Schimp.	x	x	x	–	x	x	–	–	–	x	x	x	–
Plagiomnium cuspidatum (Hedw.) T.J. Kop.	x	x	x	–	x	x	x	x	–	x	x	x	–
P. undulatum (Hedw.) T.J. Kop.	x	x	x	–	x	x	x	x	x	x	x	x	x
Platygyrium repens (Brid.) Schimp.	–	x	–	–	x	x	x	–	x	x	x	x	–
Pohlia lutescens (Limpr.) H. Lindb.	–	–	–	–	–	x	–	–	–	–	–	x	–
Pseudoleskeella nervosa (Brid.) Nyholm	x	x	–	–	–	–	–	–	–	x	x	x	–
Pseudoscleropodium purum (Hedw.) M. Fleisch.	–	x	x	–	x	x	x	–	x	x	–	x	–
Pterygoneurum ovatum (Hedw.) Dixon	–	x	–	–	–	x	–	–	–	–	–	x	–
Ptychostomum capillare (Hedw.) Holyoak & N.Pedersen	x	x	x	x	–	x	x	x	x	–	x	x	x
P. imbricatulum (Müll. Hal.) Holyoak & N. Pedersen	x	x	x	x	x	x	x	x	x	x	–	x	–
P. moravicum (Podp.) Ros & Mazimpaka	x	x	x	–	–	–	x	x	x	–	x	x	–
Pylaisia polyantha (Hedw.) Schimp.	x	x	x	–	x	x	–	–	–	x	x	x	–
Rhynchostegium murale (Hedw.) Schimp.	x	x	x	–	x	x	x	x	x	x	x	x	–
Schistidium crassipilum H.H. Blom	x	–	–	–	–	–	–	x	–	x	x	x	–
Sciuro-hypnum populeum (Hedw.) Ignatov & Huttunen	x	x	x	–	x	x	–	x	x	x	x	x	–
Syntrichia latifolia (Bruch *ex* Hartm.) Huebener	–	–	x	x	x	x	–	–	x	–	–	x	–
S. papillosa (Wilson) Jur.	x	x	x	x	–	x	x	–	–	x	x	x	x
S. ruralis (Hedw.) F. Weber & D. Mohr	x	x	x	–	x	x	x	x	–	x	–	x	–
S. virescens (De Not.) Ochyra	x	x	x	x	x	x	–	–	x	x	x	x	x
Tortella inclinata (R. Hedw.) Limpr.	x	x	–	–	x	x	–	–	–	x	–	x	–
Tortula acaulon (With.) R.H. Zander	x	x	x	x	x	x	x	x	x	x	x	x	x
T. lindbergii Broth.	x	x	–	–	–	x	x	–	–	x	–	x	x
T. muralis Hedw.	x	x	x	x	x	x	x	x	x	x	x	x	x
Weissia condensa (Voit) Lindb.	–	x	–	–	–	x	–	–	–	x	–	x	x
W. longifolia Mitt.	–	x	–	–	–	x	–	–	x	x	–	x	–
Percentage of similitude with Almásfüzitő (%)	**74**	**93**	**63**	**35**	**64**	**94**	**56**	**41**	**67**	**87**	**64**	**93**	**39**

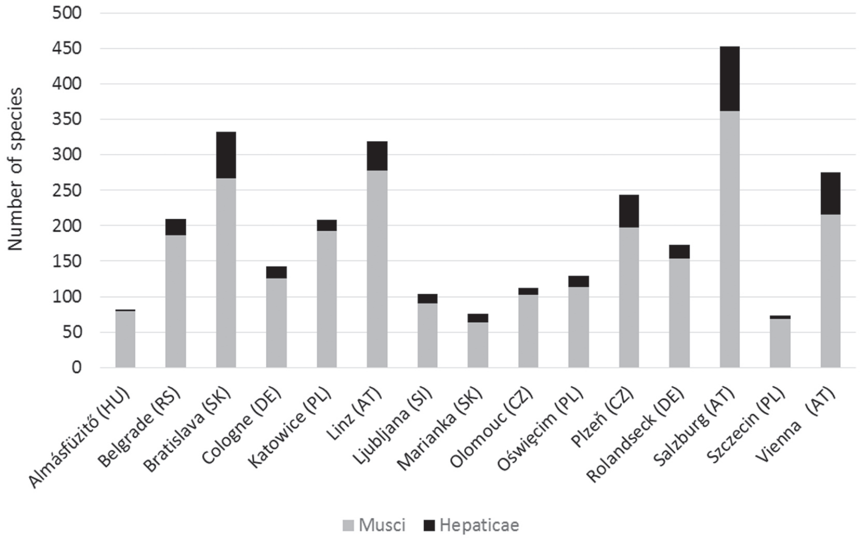

Fig. 3. Number of Musci and Hepaticae species reported from several central European settlements with indication of the country by the standardized two-letter country code (ISO 3166-1 alpha-2). Data were obtained from the next literature references.- Almásfüzitő (HU) (this work); Belgrade (RS): Sabovljević & Grdović (2009); Bratislava (SK): Janovicová *et al.* (2003); Cologne (DE): Sabovljević & Sabovljević (2009); Katowice (PL): Fojcik & Stebel (2014); Linz (AT): Zechmeister *et al.* (2002); Ljubljana (SI): Skudnik *et al.* (2013); Marianka (SK): Mišíková (2013); Olomouc (CZ): Hradílek (unpublished data); Oświęcim (PL): Żarnowiec (1996); Plzeň (CZ): Vondráček (1997); Rolandseck (DE): Frahm (2006); Salzburg (AT): Gruber (2001); Szczecin (PL): Fudali (1994); Vienna (AT): Zechmeister (2009).

The common geographical feature of Bratislava, Linz, Vienna and Almásfüzitő is the presence of the Danube River, which explains the presence of the species related to river beds (e.g. *Brachythecium rivulare*, *Cinclidotus fontinaloides, C. riparius, Hygroamblystegium fluviatile*) in all of these locations (Zechmeister *et al.*, 2002; Janovicová *et al.*, 2003; Zechmeister, 2009).

Katowice and Trento showed the same percentage values, yet they significantly differed in species. It must be noted that in the village of Marianka, which is located only 100 km from the investigated area, only 41% of the species found at Almásfüzitő were indicated. The bryophyte flora diversity of Vitoria and Enna in southern Europe differs markedly from that of Almásfüzitő.

Many of the taxa have been recorded only at certain locations in Middle Europe: *Aloina aloides*: Belgrade, *Pohlia lutescens*: Linz and Vienna, *Pterygoneurum ovatum*: Bratislava, Linz and Vienna (Zechmeister *et al.*, 2002; Janovicová *et al.*, 2003; Sabovljević & Grdović, 2009; Zechmeister, 2009).

The low proportion of liverworts in the investigated area is uncommon compared to most Central European cities and locations (Fig. 3). However, this phenomenon is very characteristic of many Mediterranean cities: Ávila (Vicente *et al.*, 1986), Murcia (Rams *et al.*, 2000), Palma de Mallorca (Fiol, 1983) and Rome (Carcano, 1989) have not yet been reported on the presence of liverworts, while only one taxon was recorded in Madrid (Mazimpaka *et al.*, 1988) and Salamanca (Ayuso *et al.*, 1995), two taxa in Toledo (Ballesteros Segura & Ron, 1985), three taxa in Jesi (Aleffi, 1991) and four taxa in Treia (Aleffi & Taruschio, 1996) and Vitoria (Heras

& Soria, 1990). The low proportion of liverwort species can be primarily explained by the moderately dry climate of the region, and by the fact that Almásfüzitő lacks historical districts and old buildings. Thus the proportion of new artificial surfaces (less than 60 years of age) is relatively high.

The bryophyte flora of the anthropogenic and close-to-natural habitats of Dunaalmás and Neszmély (villages about 10 km away from Almásfüzitő) and their surroundings was already explored (Szűcs, 2007). These data provide basis for the comparison of the flora of Almásfüzitő with the vegetation of areas under lesser human impact. Out of the 82 taxa found at the investigated area, only 63 had been recorded earlier in the neighbouring regions.

Conservation status

Twelve taxa (about 15% of those recorded) belong to the near threatened (NT) category according to the Hungarian Red List (Papp *et al.*, 2010): *Aloina aloides, A. rigida, Brachythecium glareosum, Cinclidotus fontinaloides, Cirriphyllum piliferum, Dicranella staphylina, Didymodon insulanus, Hygroamblystegium fluviatile, Nyholmiella obtusifolia*, *Orthotrichum pumilum, Physcomitrella patens, and Syntrichia latifolia.* Out of these species, 5 mosses (*Aloina aloides, Brachythecium glareosum, Dicranella staphylina, Didymodon insulanus* and *Orthotrichum pumilum*) were also recorded in the industrial area.

Indicator species denote by their mere presence a greater level of conservation value of the habitat where they occur (Papp *et al.*, 2010). Three out of the 16 taxa (*Aloina aloides, Orthotrichum pumilum* and *Rhynchostegium murale*) were also found in the industrial area while the remaining 13 taxa were spread across the housing estate and riverside areas and the cemetery.

Life strategies

There is an apparent difference between industrial and non-industrial areas concerning the number of species in each of the life strategy categories (Fig. 4.).

Non-industrial areas are more abundant in colonist, long-lived shuttle, perennial, competitive perennial, stress tolerant perennial and pioneer colonist species, compared to the industrial parts of the village.

Comparing non-industrial and industrial areas by the total number of species in each category the following species counts were recorded: colonists (30 *vs* 19), long-lived shuttle (4 *vs* 1), perennial (19 *vs* 13), competitive perennial (9 *vs* 5), stress tolerant perennial (5 *vs* 3), pioneer colonist (3 *vs* 2). The occurrence of annual shuttle and short lived shuttle species were evidenced only at the non-industrial parts of the village. Regarding ephemeral colonists, two taxa were identified at the industrial areas and one was found at the non-industrial territories, being *Dicranella staphylina* one of them, which is very uncommon in urban environments and was found on the disturbed soil of an illegal sand mine near the abandoned alumina factory. Only one species belonging to the fugutive category was indicated (*Funaria hygrometrica*) at Almásfüzitő village. This species was found at both industrial and non-industrial areas.

Summing up results it was established that the number of life strategy categories was higher at non-industrial areas, and these areas were also more abundant in species than the industrial areas of the village. A possible explanation of this is the greater diversity of the habitats as well as the dynamic variousness of

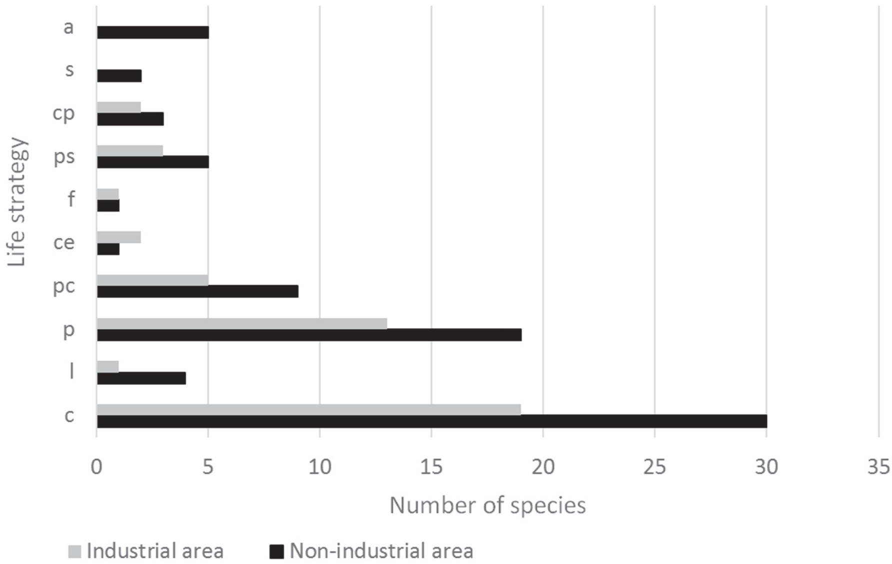

Fig. 4. Life strategies in detected bryophyte species growing in industrial and non-industrial areas of Almásfüzitő village (a: annual shuttle; s: short-lived shuttle; cp: pioneer colonist; ps: stress tolerant perennial; f: fugitive; ce: ephemeral colonist; pc: competitive perennial; p: perennial; l: long-lived shuttle; c: colonist).

human activity (e.g. gardening, constructions, traffic, etc.) and of natural disturbances (e.g. small floodings) at non-industrial areas compared to industrial sites.

Results indicated the increasing diversity of adaptation mechanisms for the found moss species. It is the environment which produces the pressure of selection; in this selection various fluctuations (short term, long term and stochastic) determine the success of the adaptation of different life strategies (During, 1992; Glime, 2007).

CONCLUSIONS

The bryophyte flora of Almásfüzitő is similar to that of nearby Middle-European metropolises (Bratislava, Linz and Vienna), which was primarily explained by the presence of common and frequent species, characteristic of urban environments.

The diversity of liverwort species was found to be lower in the investigated area compared to other Middle European cities, which was explained by the moderately dry climate of the region and by the fact that the village of Almásfüzitő does not have any historical districts with old buildings, thus the high proportion of new artificial surfaces does not favour the presence of liverwort habitats.

The occurrence of annual shuttle and short-lived shuttle life strategy mosses was more dominant in the non-industrial area of the village compared to the abandoned industrial parts, which was explained by a stronger human impact in the residential areas.

Regarding the distribution of indicator mosses, it was established that the habitats around the housing estate are more valuable for nature protection than the habitats of the industrial area.

Acknowledgements. The authors would like to express their gratitude to the Peter Erzberger for his help in sample analysis, to Tamás Pócs and János Csiky for their useful comments. The authors' special thanks go to Lukács Karánsebesy, mayor of Almásfüzitő for supporting the research, to Sándor Pirik (Almásfüzitői Iparfejlesztő és Hasznosító Kft.) and Lajos Tóth (Tatai Környezetvédelmi Zrt.) for making sample collection possible and also to the reviewers of this article for their suggestions. The authors are grateful to Harald Zechmeister, Zbyněk Hradílek, Katarina Mišíková, Eva Mikulášková, Marko Sabovljević and Anna Ganeva for their help in literature access and interpretation, as well as to Richard von Fuchs for proofreading the manuscript. The article was sponsored by the „Társadalmi Megújulás Operatív Program Kutatás, Innováció, Együttműködések – Társadalmi innováció és kutatási hálózatok együttműködésének erősítése az Eszterházy Károly Főiskola, a Bay Zoltán Alkalmazott Kutatási Nonprofit Kft. és az Agria TISZK Közhasznú Nonprofit Kft. együttműködésével" project (TÁMOP-4.2.1.D-15/1/KONV-2015-0013). The project was supported by the European Union and the European Social Fund.

REFERENCES

ALEFFI M., 1991 — Flora briologica e cualità dell'aria nella città di Jesi. *Archivio botanico italiano* 3(4): 128-140.

ALEFFI M. & TARUSCHIO E., 1996 — Flora briologica della città di Treia (Marche, Italia Centrale). *Archivio geobotanico* 2(1): 47-58.

AYUSO J.B., ELÍAS RIVAS M. J. & RUPIDERA GIRALDO J.L., 1995 — Brioflora de la Ciudad de Salamanca. *Botanica complutensis* 20: 45-53.

BALLESTEROS SEGURA T. & RON M.E., 1985 — Contribución al estudio de la flora briológica de la ciudad de Toledo. *Anales del jardín botánico de Madrid* 42(1): 87-91.

BENKERT D., ERZBERGER P., KLAWITTER J., LINDER W., LINKE C., SCHAEPE A., STEINLAND M. & WIEHLE W., 1995 — The moss list of Brandenburg and Berlin including the threat levels. *Verhandlungen des Botanischen Vereins der Provinz Brandenburg* 128: 1-68.

CARCANO L., 1989 — Moss inventory of the urban area of Rome (Italy). *Braun Blanquetia* 3: 147-150.

CORTINI PEDROTTI C., 1989 — La flore bryologique de la ville de Camerino (Italie centrale). *Braun Blanquetia* 3: 75-86.

DÖVÉNYI Z., 2010 — *Hungarian microregions*. Budapest, Geographical Institute, Hungarian Academy of Sciences, 876 p. (in Hungarian).

DURING H.J., 1979 — Life strategies of Bryophytes: a preliminary review. *Lindbergia* 5: 2-18.

DURING H.J., 1992 — Ecological classification of bryophytes and lichens. *In*: Bates J.W.& Farmer A.M. (eds), *Bryophytes and lichens in a changing environment*. Oxford, Clarendon Press, pp. 1-31.

ESTEVE CHUECA F., VARO ALCALÁ J. & ZAFRA VALVERDE M.L., 1976 — Estudio briológico de la ciudad de Granada (primera parte). *Trabajos del departamento de botánica de la universidad de Granada* 3: 203-229.

ESTEVE CHUECA F., VARO ALCALÁ J. & ZAFRA VALVERDE M.L., 1977 — Estudio briológico de la ciudad de Granada (segunda parte). *Trabajos del departamento de botánica de la universidad de Granada* 4: 45-71.

FILIPIAK E. & SIERADZKI J., 1996 — Preliminary studies for bryophyte flora of Łódź. *Fragmenta floristica et geobotanica* 3: 117-129 (in Polish).

FIOL L.A., 1983 — Briófites de l'habitació urbana de Palma de Mallorca. *Bolletí de la societat d'historia natural de les Balears* 27: 65-76.

FOJCIK B. & STEBEL A., 1999 — Preliminary studies on the bryoflora of Katowice town (Silesian Upland, Southern Poland). *Fragmenta floristica et geobotanica* 44(1): 129-140.

FOJCIK B. & STEBEL A., 2014 — The diversity of moss flora of Katowice town (S Poland). *Cryptogamie, Bryologie* 35(4): 373-385.

FRAHM J.P., 2006 — Die Moosflora von Rolandseck. Notulae Bryologicae Rhenanae 7. *Archive for bryology* 12: 1-7.
FUDALI E., 1994 — Species diversity and spatial distribution of bryophytes in urban areas. A case study of Szczecin. *Fragmenta floristica et geobotanica* 39: 563-570.
FUDALI E., 1996 — Distribution of bryophytes in various urban-use complexes of Szczecin (NW Poland). *Fragmenta floristica et geobotanica* 41(2): 717-745.
FUDALI E., 1998 — Investigations of bryophytes in Polish towns: A review of the bryological research and data. *Fragmenta floristica et geobotanica* 43: 77-101.
FUDALI E., 2012 — Recent tendencies in distribution of epiphytic bryophytes in urban areas: a Wrocław case study (South-West Poland). *Polish botanical journal* 57(1): 231-241.
GANEVA A., 2004 — Bryophytes in the city of Sofia. *In*: Penev L., J. Niemelä, D.J. Kotze & N. Chipev (eds), *Ecology of the City of Sofia*. Sofia. Pensoft, pp. 173-176.
GLIME J.M., 2007 — Bryophyte Ecology. Volume 1. Physiological Ecology. Ebook sponsored by Michigan Technological University and the International Association of Bryologists. Available at web site: http://www.bryoecol.mtu.edu/ (Accessed: 05.08.2016).
GOMOIU I. & ŞTEFÂNUŢ S., 2008 — Lichen and bryophytes as bioindicator of air pollution. *In*: Cracium I. (ed.), *Species monitoring in the central parks of Bucharest*. Bucharest, Universitatea din Bucureşti, pp. 14-25.
GRDOVIĆ S. & STEVANOVIĆ V., 2006 — The moss flora in the central urban area of Belgrade. *Archives of biological sciences* 58(1): 55-59.
GRUBER J. P., 2001 — Die Moosflora der Stadt Salzburg und ihr Wandel im Zeitraum von 130 Jahren. *Stapfia* 79: 3-155.
ISERMANN M. 2007 — Diversity of bryophytes in an urban area of NW Germany. *Lindbergia* 32: 75-81.
HERAS P. & SORIA A., 1990 — Musgos y hepáticas urbanos de la ciudad de Vitoria-Gasteiz. *Cuadernos de sección. Ciencias naturales* 7: 75-116.
HOHENWALLNER D., 2000 — Bioindikation mittels Moosen im dicht bebauten Stadtgebiet Wiens. *Limprichtia* 15: 1-91.
HRADÍLEK Z. & KOVAL Š., 2012 — *Bryophytes of the Botanical Garden of Faculty of Science of Palacký University in Olomouc*. Univerzita Palackého v Olomouci, 20 p. (in Czech).
HRISTEVA Y.G., GECHEVA G.M. & YURUKOVA L.D., 2011 — Bryophytes in Protected Territories of Plovdiv City (Bulgaria): Preliminary Species List and First Data of Air Pollution Monitoring. *Ecologia Balkanica* 3: 89-94.
JANOVICOVÁ K., KUBINSKÁ A. & JAVORČÍKOVÁ D., 2003 — Liverworts (Hepatophyta), Hornworts (Anthocerotophyta) and Mosses (Bryophyta) in the area Bratislava (Slovakia) Botanický ústav SAV, Bratislava, p. 38-98 (in Slovakian with English absract).
KIRÁLY G., 2009 — New Hungarian Herbal. The Vascular Plants of Hungary. Identification key. Aggteleki Nemzeti Park Igazgatóság, Jósvafő, 616 p. (in Hungarian with English summary).
KOLBEK J., VALACHOVIČ M. & MIŠÍKOVÁ K., 2015 — Wall Vegetation in Old Royal Mining Towns in Central Slovakia. *Hacquetia* 14(2): 249-263.
KOPERSKI M. 1998 — Die Moose der Stadt Delmenhorst und ihrer Umgebung. *Abhandlungen des Naturwissenschaftlichen Vereins zu Bremen* 44: 185-204.
LARA F. & MAZIMPAKA V., 1989 — Contribución al conocimiento de la flora briológica de la ciudad de Segovia. *Anales del jardín botánico de Madrid* 46: 481-485.
LARA F., LÓPEZ C. & MAZIMPAKA V., 1991 — Ecología de los briófitos urbanos en la ciudad de Segovia (España). *Cryptogamie, Bryologie* 12: 425-439.
LO GIUDICE R., 1992 — Contributo alla conoscenza della brioflora urbana di Catania. *Quaderni di botanica ambientale e applicata* 3: 3-10.
LO GIUDICE R., MAZIMPAKA V. & LARA F., 1997 — The urban bryophyte flora of the city of Enna (Sicily, Italy). *Nova Hedwigia* 64(1-2): 249-265.
MAZIMPAKA V., VICENTE J. & RON E. 1988 — Contribución al conocimiento de la brioflora urbana de la ciudad de Madrid. *Anales del jardín botánico de Madrid* 45(1): 61-73.
MAZIMPAKA V., LARA F. & LOPEZ-GARCIA C., 1993 — Ecological data on the bryophyte flora of the town of Cuenca (Spain). *Nova Hedwigia* 56: 113-129.
MIŠÍKOVÁ K., MIŠIK M. & KUBINSKÁ A., 2007 — Bryophytes of the forest park Hôrka (Veľký Krtíš town, Slovakia). *Acta Botanica Universitatis Comenianae* 43: 9-13.
MIŠÍKOVÁ K. & KUBINSKÁ A., 2010 — Bryophytes on historical cemeteries of selected cities in Central Europe. *Bulletin Slovenskej botanickej spoločnosti* 32(2): 137-145 (in Slovakian with English abstact).
MIŠÍKOVÁ K. & CIBULKOVÁ J., 2012 — Bryophytes on the cemeteries in the city of Žilina (Slovakia). *Acta Botanica Universitatis Comenianae* 47: 33-38.

MIŠÍKOVÁ K., 2013 — Bryophytes of the village Marianka (South Western Slovakia). *Acta botanica Universitatis Comenianae* 48: 3-8.
MÜLLER F., 1993 — Studien zur Moos- und Flechtenflora der Stadt Halle/S. *Limprichtia* 1: 1-167.
NAGY E.L., 2014 — People, Nature, Economy, Environment in Komárom-Esztergom Region. Gesher Ltd., Budapest, 188 p. (in Hungarian).
PAPP B., ERZBERGER P., ÓDOR P., HOCK ZS., SZÖVÉNYI P., SZURDOKI E. & TÓTH Z., 2010 — Updated checklist and redlist of Hungarian bryophytes. *Studia botanica hungarica* 41: 31-59.
POKORNY L., LARA F. & MAZIMPAKA V., 2006 — The bryophyte flora of the city of Trento (North Italy). *Crypogamie, Bryologie* 27: 265-284.
RAMS S., ROS R.M., CANO M.J. & GUERRA J., 2000 — Brioflora urbana de la ciudad de Murcia (SE Península Ibérica). *Boletín de la sociedad Española de briología* 7: 9-18.
ROS R.M., MAZIMPAKA V., ABOU-SALMA U., ALEFFI M., BLOCKEEL T.L., BRUGUES M., CANO M. J., CROS R.M., DIA M.G., DIRKSE G.M., EL SAADAWI W., ERDAĞ A., GANEVA A., GONZÁLEZ-MANCEBO J.M., HERRNSTADT I., KHALIL K., KÜRSCHNER H., LANFRANCO E., LOSADA-LIMA A., REFAI M.S., RODRÍGUEZ-NÚNEZ S., SABOVLJEVIĆ M., SÉRGIO C., SHABBARA H.M., SIM-SIM M. & SÖDERSTRÖM L., 2007 — Hepatics and Anthocerotes of the Mediterranean, an annotated checklist. *Cryptogamie, Bryologie* 28: 351-437.
ROS R.M., MAZIMPAKA V., ABOU-SALAMA U., ALEFFI M., BLOCKEEL T.L., BRUGUÉS M., CROS R.M., DIA M.G., DIRKSE G.M., DRAPER I., EL-SAADAWI W., ERDAĞ A., GANEVA A., GABRIEL R., GONZÁLEZ-MANCEBO J.M., GRANGER C., HERRNSTADT I., HUGONNOT V., KHALIL K., KÜRSCHNER H., LOSADA-LIMA A., LUÍS L., MIFSUD S., PRIVITERA M., PUGLISI M., SABOVLJEVIĆ M., SÉRGIO C., SHABBARA H.M., SIM-SIM M., SOTIAUX A., TACCHI R., VANDERPOORTEN A. & WERNER O., 2013 — Mosses of the Mediterranean, an annotated checklist. *Cryptogamie, Bryologie* 34: 99-283.
SABOVLJEVIĆ M. & GRDOVIĆ S., 2009 — Bryophyte diversity Within Urban Areas: Case Study of the City of Belgrad (Serbia). *International journal of botany* 5(1): 85-92.
SABOVLJEVIĆ M. & SABOVLJEVIĆ A., 2009 — Biodiversity within urban areas: A case study on bryophytes of the city of Cologne (NRW, Germany). *Plant biosystems* 143: 473-481.
SCHAEPE A., 1986 — Veränderungen der Moosflora von Berlin (West). *Bryophytorum biblotheca* 33: 1-392.
SCHRADER H. J., 1994 — Die Moosflora von Braunschweig. *Limprichtia* 2: 1-98.
SÉRGIO C., 1981 — Alterações da flora briológica epifítica na área urbana de Lisboa, nos últimos 140 anos. *Boletim da sociedade Broteriana* 2: 291-303.
SKUDNIK M., SABOVLJEVIĆ A., BATIČ F. & SABOVLJEVIĆ M., 2013 — The bryophyte diversity of Ljubljana (Slovenia). *Polish botanical journal* 58(1): 319-324.
SOLDÁN Z., 1982 — Bryophytes in Praha. *In*: Kubíková J. & Podzemský O. (eds), Century Prague. Naturalistic importance of Prague. Praha, Panorama, pp. 103-108 (in Czech with German summary).
SOLGA A., 1998 — Ergebnisse der Mooskartierung auf dem Stadtgebiet von Münster. *Natur und Heimat, Münster* 58: 107-121.
SORIA A. & RON, M.E., 1990 — Contribution to the urban bryophyte flora of the city of Logrono. *Anales del jardín botánico de Madrid* 46: 427-432.
SORIA A. & RON M.E., 1995 — Aportaciones al conocimiento de la brioflora urbana española. *Cryptogamie, Bryologie* 16: 285-299.
STINGL A., 1985 — Epiphytenmoose and Bäumen in Stadt und Raum Freiburg. *Mitteilungen des badischen Landesvereins für Naturkunde und Naturschutz* 13: 333-341.
SZEPESFALVI J., 1940 — Die Moosflora der Umgebung von Budapest und des Pilisgebirges I. *Annales historico-naturales Musei nationalis hungarici* 33: 1-104.
SZEPESFALVI J., 1941 — Die Moosflora der Umgebung von Budapest und des Pilisgebirges II. *Annales historico-naturales Musei nationalis hungarici* 34: 1-71.
SZEPESFALVI J., 1942 — Die Moosflora der Umgebung von Budapest und des Pilisgebirges III. *Annales historico-naturales Musei nationalis hungarici* 35: 1-72.
SZŰCS P., 2007 — The bryophyte flora of Dunaalmás and Neszmély region. *Botanikai Közlemények* 94: 91-115 (in Hungarian with English abstract).
SZŰCS P., BÖRCSÖK Z. & KÁMÁN O., 2014 — Occurrence of *Riccia glauca* L. and *Riccia sorocarpa* Bisch. in Barcs town. *Kitaibelia* 19(2): 365 (in Hungarian).
SZŰCS P., 2015a — Bryofloristial studies in an abandoned alumina refinery near Almásfüzitő, NW Hungary. *Kitaibelia* 20: 206-212 (in Hungarian with English abstract).

SZŰCS P., 2015b — *Kindbergia praelonga* (Hedw.) Ochyra in the urban bryoflora of the town of Sopron (W Hungary). *Kitaibelia* 20: 305 (in Hungarian).

SZŰCS P. & LÓTH H., 2008 — The bryophyte flora of anthropogenic habitats of Almásfüzitő. *Komárom-Esztergom Megyei Önkormányzat Múzeumainak Közleményei* 13-14: 399-423 (in Hungarian with German abstract).

VÁŇA J., 2004 — Bryophytes of north-western Praha. *Natura Pragensis* 15: 5-50. (in Czech)

VANDERPOORTEN A., 1997 — A bryological survey of the Brussels capital region (Belgium). *Scripta botanica Belgica* 14: 1-40.

VEJMELKOVÁ J., 2014 — Bryophytes growing on trees in the Smetana Park in Olomouc (Diploma thesis). Department of Botany, Faculty of Science, Palacký University in Olomouc, 66 p. (in Czech).

VICENTE J., GRANZOW DE LA CERDA I., MAZIMPAKA V. & RON M.E., 1986 — Contribución al conocimiento de la brioflora de la ciudad de Ávila. *Trabajos del departamento de botánica* 13: 39-43.

VINCENECOVÁ K., 1998 — The bryophyte flora of the town of Olomouc. Are there correlations in distribution of bryophytes in urban environment? (Diploma thesis). Department of Botany, Faculty of Science, Palacký University in Olomouc, 58 p. (in Czech).

VIERA C. & RON M.E., 1986 — Contribución al conocimiento de la brioflora urbana de la ciudadde Badajoz. *Trabajos del departamento de botánica* 13: 45-49.

VONDRÁČEK M., 1997 — Bryophytes (Bryophyta). *In*: Sofron J. & Nesvadbová J. (eds), *Flora and vegetation of the town of Plzeň*. Západočeské muzeum Plzeň, pp. 56-64 (in Czech).

WOLSKI G.J., STEFANIAK A. & KOWALKIEWICZ B., 2012 — Bryophytes of the experimental and teaching garden of the faculty of biology and environmental protection, University of Łódź (Poland). *Ukrainian botanical journal* 69(4): 519-529.

ŻARNOWIEC J., 1996 — The bryoflora of urban areas: A floristic-ecological case study of Oświęcim town (S Poland). *Fragmenta floristica et geobotanica* 41: 355-377.

ZECHMEISTER H.G., 2009 — Erfassung der Vorkommen von Moosarten des Anhanges II der FFH Richtlinie und Stichprobenartige Erfassung der Moosflora auf Wiener Stadtgebiet.Bericht zum gleichnamigen Projekt. Available at web site: http://www.zobodat.at/pdf/MA22-Wien_69_0001-0018.pdf (Accessed: 18.03.2016)

ZECHMEISTER H.G., TRIBSCH A. & HOHENWALLNER D., 2002 — Die Moosflora von Linz und ihre Bedeutung für die Bioindikation. *Naturkundliches Jahrbuch der Stadt Linz* 48: 111-191.