

The geographical analysis of apophytes fraction of urban floras of Ukraine

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Abstract: The results of study of geographical distribution of apophytes fraction of urban floras of various botanical and geographical zones of Ukraine are presented. The general list of apophytes of the urban floras includes 1377 species which included into 12 types of area (Cosmopolitan, Hemicosmopolitan, Holarctic, Palearctic, European–Siberian–Mediterranean–West Asian, Pannonian–Pontic–South Siberian–West Asian, European–Siberian, European–Mediterranean–Iran–Turanian, European–Mediterranean–East Asian, European, Pontic–Mediterranean–West Asian, and Mediterranean).

Keywords: apophytes, urban floras, Ukraine, geographical elements

Introduction

Geographic structure of apophytes group of urban floras is one of the main features which determining the dynamics of the regional flora under influence of urbanization. Analysis of areas of species growing in habitats where transformation or destruction of plant cover gives possibilities to establish modern tendency of anthropogenic transformation of flora within a city, find what species and from what floristic regions are able to grow in such condition, or even prefer these habitats by natural. Despite of habitats diversity and instability of areas of apophytes, identification of core of chorological groups and their affinities to certain regions provides valuable information regarding nature of changes of flora composition in the process of species adaptation to existing conditions. Distribution of apophytes is less dependent on historical climatic and

phytocoenotic conditions that define ranges of a natural flora species than on the nature and strength of anthropogenic influence.

Material and methods

The subject of present investigation is apophyte fraction of various urban floras (Lutsk, Chernihiv, Uzhgorod, Kamyanets-Podilskiy, Kirovograd, Kharkiv, Kryvyi Rig, Lugansk, Donetsk, Mariupol) of different botanical and geographical zones of Ukraine (Forest, Forest–Steppe and Steppe zones). The anthropogenic ecotopes are prevailed in the towns and cities. Semi-natural ecotopes (suburban forests, parks, herbaceous and stony slopes, coastal sands, grasslands and shrubs, etc.) are taking considerable part of the analyzed cities/towns, concentrated mostly in the azonal areas, and also mosaic-embedded in the built-up parts of the cities. Diaspores of plants of these ecotypes more or less often entered in anthropogenic ecotopes and settle down there to varying degrees.

The analysis is based on a cumulative list of apophyte species of studying urban floras. The list is prepared by the authors through generalization of the literature data (BURDA 1997, PROTOPOPOVA & SHEVERA, 2002, KAGALO et al. 2004; KOTSUN et al. 2009; KUCHEREVSKY & SHOL 2009; RYABOKON 2009; ARKUSHYNA & POPOVA 2010; ZAVYALOVA 2010) as well as our original data, and herbarium materials of the KW Herbarium, is therefore of somewhat preliminary character.

We discover apophytes according to the level of naturalization on anthropogenic ecotopes by Yu.A. Yurtsev and R.V. Kamelin classification (YURTSEV & KAMELIN 1991) with some authors correction. According to this classification, apophytes are divided into three groups: *euapophytes* – completely or almost completely moved to anthropogenic habitats; *hemiapophytes* – species actively spreading in anthropogenic habitats but still keeping their position in local flora; *eventapophytes* (unstable, or occasional) – comprising occasional anthropophobic element in anthropogenic localities. In our research we were referring to the interpretation of the species status by the authors of urban floras list in the publications and let ourselves to correct it only in a few special cases.

Comparative morphological and geographical methods of floristic are used in the present study. The A. Takhtajan scheme of Floristic Kingdoms and Regions of the Earth (TAKHTAJAN 1978) is used in the work. Characteristics of area species prepared according to Flora of European part of USSR (1974–1994) and Flora of Eastern Europe (1996–2004).

Results

The general list of apophyte species of the urban floras of various botanical and geographical zones of Ukraine includes 1377 species of vascular plants. The percentage of apophytes in investigated urban floras varies from 22,8 % (Chernigiv, Forest zone) [ZAVYALOVA 2012] to 37,2 % (Mykolayiv, Steppe zone) [MELNYK 2001]; it correlates with the tendency of increasing percentage of the

species in this group in synanthropic fraction of Ukrainian flora also in south direction (PROTOPOPOVA 1991). According to our previous data (PROTOPOPOVA & SHEVERA 2010) hemicryptophytes, mesoxerophytes and xeromesophytes; in the Forest and Forest–Steppe regions – meadow, in the Steppe – petro-stepants, and psammo-petrophanthes plant species are prevailed in the biomorphological and ecological spectra of the fraction, respectively.

With regard to their areas (Flora of European part of the USSR 1974–1994, Flora of Eastern Europe 1996–2004), apophyte species of studied urban floras of Ukraine are divided into 12 types, i.e. Cosmopolitan (29 species), Hemicosmopolitan (56), Holarctic (192), Palearctic (246), European–Siberian–Mediterranean–West Asian (141), Pannonian–Pontic–South Siberian–West Asian (57), European–Siberian (40), European–Mediterranean–Iran–Turanian (355), European–Mediterranean–East Asian (12), European (64), Pontic–Mediterranean–West Asian (169), and Mediterranean (16). In some area types we distinguished within smaller groups, reflecting a set of ranges of individual species according to their length.

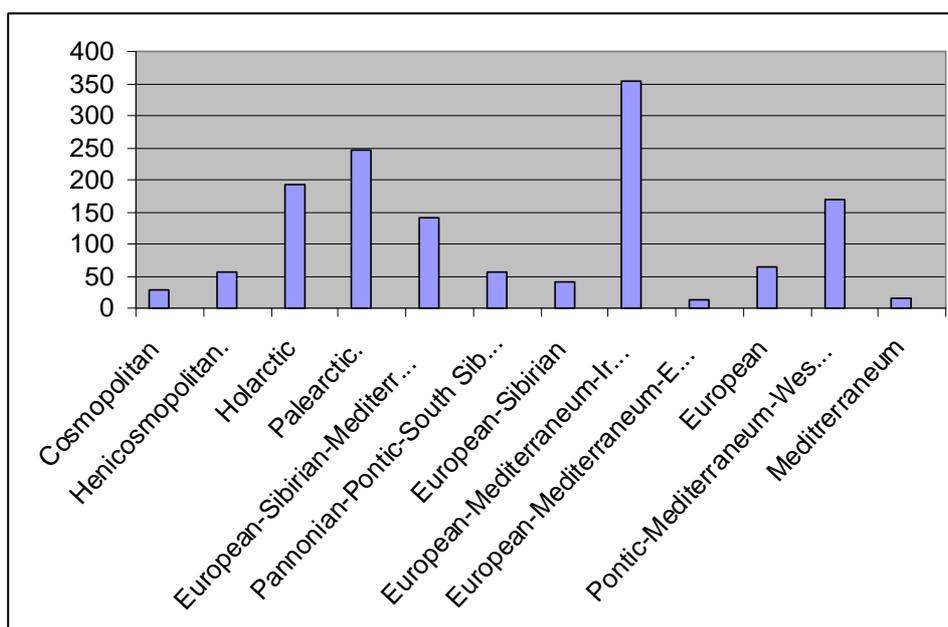


Fig. 1. Type of area of generalized composition of apophytes of urban floras of various botanical and geographical zones of Ukraine

List of area types and subdivision groups, and their short characteristics are presented.

- i. **Cosmopolitan type.** This area type includes species which distribution covers more than 3 continents. General list of the group includes 29 species. In the studied urban flora the following weeds (i.e. *Alsine media* L.

(*Stellaria media* (L.) Vill.), *Atriplex patula* L., *Bidens tripartita* L., *Bromus hordeaceus* L. (*B. mollis* L.), *Chenopodium album* L., *Melilotus officinalis* (L.) Pall., *Plantago lanceolata* L., *Rorippa palustris* (L.) Besser, *Turritis glabra* L., etc.), water (i.e. *Ceratophyllum demersum* L., *Lemna gibba* L., *L. minor* L., *Potamogeton pectinatus* L., etc.), bank river habitat (i.e. *Calystegia sepium* (L.) R.Br., *Phragmites australis* (Cav.) Trin. ex Steud., etc.), and rarely meadow (i.e. *Leucanthemum vulgare*), and other plants are presented.

- II. **Hemicosmopolitan type.** This area type includes species which distributed on 3 continents. General list consist 56 species. In the urban floras of this type weeds (i.e. *Barbarea vulgaris* R.Br., *Chenopodium glaucum* L., *Convolvulus arvensis* L. *Eupatorium cannabinum* L., etc.), meadow (i.e. *Carex lachenalii* Schkuhr (*C. leporina* L.), *C. echinata* Murray, *Lotus corniculatus* L., *Melilotus albus* Medik., etc.), meadow-swamp (i.e. *Triglochin maritima* L., *T. palustre* L., etc.), river bank habitat (i.e. *Lythrum hyssopifolia* L., *Mentha aquatica* L., etc.), water (i.e. *Lemna trisulca* L.), and other plants are presented.
- III. **Holarctic type.** In this area type the species which distributed in Holarctic Kingdom of both hemisphere of the Earth, mainly in the southern part of Boreal Region and penetrate in the northern regions of the Ancient Mediterranean are combined. General list of this type consist 192 species. It is presented by weeds (i.e. *Asperugo procumbens* L., *Cirsium vulgare* (Savi) Ten., *Hypochaeris radicata* L., etc.), margins (i.e. *Pilosella officinarum* F.Schultz & Sch.Bip.), meadow (i.e. *Leontodon autumnalis* L., *Carum carvi* L., etc.), bank river habitat (i.e. *Petasites hybridus* (L.) P. Gaertn., B. Mey. et Scherb., *Bidens cernua* L., *Cirsium palustre* (L.) Scop., etc.), and water plants and species which are characteristic for shrubs and forest plant communities (i.e. *Aegopodium podagraria* L., *Hieracium umbellatum* L., etc.) and others.
- IV. **Palaearctic type.** Areas of the species of this type include the temperate and subtropical zones of Holarctic Kingdom within the Old World boundaries. In the studies urban floras 247 species are presented, i.e. *Berteroa incana* (L.) DC., *Chenopodium urbicum* L., *Euphorbia virgata* Waldst. et Kit., *Geum urbanum* L., *Juncus articulatus* L. (*J. geniculatus* Schrank), *Poa nemoralis* L., *Potamogeton trichoides* Cham. & Schlecht., *Taraxacum officinale* Wigg. aggr., *Verbascum densiflorum* Bertol., etc. The species of this type are divided into 6 groups:
1. European–Siberian–Ancient Mediterranean–East Asia (187 species),
 2. European–Siberian–Ancient Mediterranean (9 sp.),
 3. East European–Siberian–Ancient Mediterranean (2 sp.),
 4. European–Ancient Mediterranean (25 sp.),
 5. Pontic–Ancient Mediterranean–East Asia (13 sp.),
 6. Pontic–Ancient Mediterranean (11 sp.).

- V. **European-Siberian-Mediterranean-West Asian type.** Areas of the species of this type cover European-Siberian subregion of Boreal Region, particularly Mediterranean Region and West Asian subregions of Irano-Turanian Region (predominantly desert regions of Central and Middle Asia and penetrate in submountainous Iran, central and eastern part of Asia Minor). This group includes mainly the species of steppe, deserts and also meadows and forest. General list of apophytes of studied urban floras consists 141 species, i.e., *Achillea nobilis* L., *Chondrilla latifolia* M.Bieb., *Tripolium pannonicum* (Jacq.) Dobroc., etc. The species of this type are divided into 12 groups.
1. European–Siberian–Mediterranean–Iran–Central Asia (18 species),
 2. European–Siberian–Irano–Turanian (9 sp.),
 3. European–Siberian–Caucasus–Iran–Middle Asia (4 sp.),
 4. European–Siberian–Mediterranean–Middle Asia (10 sp.),
 5. European–Siberian–Caucasus–Middle Asia (10 sp.),
 6. European–West Siberian–Middle Asia (19 sp.),
 7. European–Siberian–Iran (1 sp.),
 8. European–Siberian–Caucasus–Asia Minor (12 sp.),
 9. European–Siberian–Mediterranean–Asia Minor (11 sp.),
 10. European–Siberian–Mediterranean–Caucasus (14 sp.),
 11. European–Siberian–Mediterranean (25 sp.),
 12. East European–Siberian–Caucasus (8 sp.).
- VI. **Pannonian-Pontian-South Siberian-West Asian type.** The areas of these species cover some territory of Pontic subregion of Boreal Region (mostly in east part of Middle and south-east of Eastern Europe), Forest-Steppe and Steppe region of South Siberian, and Northern region of Iran-Turanian Region (Cis-Caspian region of Caucasus and northern part of Middle Asia) with some single sites in Mediterranean, Asia Minor and Iran. Most of them are steppe plants. The general list of apophytes of urban floras includes 57 species (i.e. *Isatis villarsii* Gaudin, *Poa bulbosa* L., *Rumex ucranicus* Fisch. ex Spreng., *Scabiosa ucranica* L., *Teucrium pannonicum* A. Kern., etc.). The species of this type are divided into 8 groups.
1. Pannonian–Pontic–South Siberian–Middle and Minor Asia (3 sp.),
 2. Pannonian–Pontic–South Siberian–Mediterranean (2 sp.),
 3. Pannonian–Pontic–Caucasus–Asia Minor–Turanian (4 species),
 4. Pannonian–Pontic–Mediterranean–Aral–Caspian (9 sp.),
 5. Pannonian–Pontic–Caucasian (1 sp.),
 6. Pannonian–Pontic–Mediterranean (18 sp.),
 7. Pannonian–Pontic–Iranian (1 sp.),
 8. Pannonian–Pontic (19 sp.).
- VII. **European-Siberian type.** The species areas are concentrated mostly in moderate zone of Boreal Region. General list of apophytes of studied urban floras consists of 40 species, i.e. *Artemisia austriaca* Jacq., *Centaurea biebersteinii* DC., *Cirsium heterophyllum* (L.) Hill, etc.

VIII. **European-Mediterranean-Iran-Turanian type.** Area of these species cover the most part of Europe, and usually in Mediterranean Region and West Asian subregion (plane and submontaneous parts) of Iran-Turanian Region. The type includes species of xerophytic and shrubby communities, thin forests, steppe mountain meadows, and semi-desert plant formations. The general list of apophytes of studied urban floras consists of 355 species (i.e. *Acinos rotundifolius* Pers., *Juncus inflexus* L., *Trifolium medium* L., etc.) and divided in to 13 groups.

1. European–West Asia (9 sp.),
2. European–Mediterranean–Iran–Middle Asia (8 sp.),
3. European–Mediterranean–Caucasus–Asia Minor–Iranian (57 sp.),
4. European–Mediterranean–Caucasus–Middle Asia (4 sp.),
5. European–Mediterranean–Middle Asia (11 sp.),
6. European–Mediterranean–Iran–Turanian (46 sp.),
7. European–Mediterranean–Caucasus–Asia Minor (27 sp.),
8. European–Mediterranean–Asia Minor (24 sp.),
9. European–Mediterranean–West Asia (17 sp.),
10. European–Mediterranean (113 sp.),
11. European–Mediterranean–Caucasus (21 sp.),
12. European–Caucasus–Asia Minor (6 sp.),
13. European–Caucasus (12 sp.).

IX. **European-Mediterranean-East Asian type.** Areas of these species are concentrated within Europe and predominantly in the West Mediterranean with disjunction in the East Asia. General list of apophytes of studied urban floras consists of 12 species (i.e. *Lappula barbata* (M.Bieb.) Guerke, *Torilis japonica* (Houtt.) DC., etc.).

X. **European type.** The majority of species (51, i.e. *Festuca trachyphylla* (Hack.) Krajina, *Lotus arvensis* Pers. *Potentilla collina* Wibel, *Persicaria maculosa* S.F.Gray (*Persicaria mitis* Delarbre), etc.) distribute in the different region of Europe, 13 species (i.e. *Dianthus carthusianorum* L., *Hieracium jablonicense* Woł., *Stellaria barthiana* Schur, *Symphytum popovii* Dobroc., etc.) in the mountain regions of Middle and East Europe. General list of apophytes of studied urban floras consists of 64 species.

XI. **Pontic-Mediterranean-West Asian type.** Areas of these species cover Aral-Caspian and Turan Region, stretch into the Mediterranean, Asia minor, Iran and also penetrate into the south part of Pontic subregion of Boreal Region. The species are spread in desert regions and low mountains with xerotic vegetation. Many species confined to salting soils, some species are component of riverside and thin forest communities. Most species are weeds. General list of apophytes of studied urban floras consists of 169 species (i.e. *Alcea rugosa* Alef., *Gagea dubia* Terr., *Linaria biebersteinii* Besser, *Melica altissima* L., etc.) and was divided into 12 groups.

1. Pontic–Iranian–Turanian–Central Asian (2 sp.),
2. Pontic–Caucasus–Mediterranean (18 sp.),

3. Pontic–Caucasus–Asia Minor (6 sp.)
4. Pontic–Caucasus (6 sp.),
5. Pontic–Balcan–Cis Azov–Cis Caspian (3 sp.),
6. Pontic–Cis Caspian–Turanian (29 sp.),
7. Pontic (48 sp.),
8. Pontic–Mediterranean–Asia Minor (10 sp.),
9. Pontic–Asia Minor–Iranian (7 sp.),
10. Cis Black Sea–Cis Caspian (2 sp.),
11. Cis Black Sea–Cis Azov (26 sp.),
12. Cis Black Sea (12 sp.).

XII. **Mediterranean type.** This type includes species with disjunctive area within Mediterranean and Iran–Turanian Regions. The species are usual in Mediterranean Region and penetrate in some northern regions. General list of apophytes of studied urban floras consists of 16 species (i.e. *Bufonia tenuifolia* L., *Polygonum maritimum* L., *Potentilla geoides* M.Bieb., etc.) and was divided into 4 groups.

1. Mediterranean–Crimea–Caucasus–Middle Asian (2 species),
2. Mediterranean–Crimea–Caucasus–Asia Minor–Iranian (5 sp.),
3. Mediterranean–Crimea–Caucasus (5 sp.),
4. Balcan–Crimea–Caucasus–Asia Minor (4 sp.)

Conclusion

The spectra of area types and comparison of their quantitative composition shows the predominance of species distributed in xeric regions. The most numerous are species with types of area widely represented in the Ancient Mediterranean (European–Mediterranean–Iran–Turanian (355), Pontic–Mediterranean–West Asia (169), European–Siberian–Mediterranean–West Asia (141) and Palearctic (246)), mainly in the plain and in less extent in the mountainous areas. Single sites of the region more or less are included in other area types, especially wide presented in area of Cosmopolitan and Hemicosmopolitan, species with an extensive Holarctic–Ancient Mediterranean area, and also for species which common for European-Asian steppes with area species which can extend to the Aral–Caspian and the Middle Asian desert territories. Fewer species are characterized with areas limited by temperate zone, i.e. European (64 sp.) and the European–Siberian (40).

Despite the diversity of areas of apophytes their affinity to certain floristic regions can be distinguished. The analysis of apophytes representation in the different types of floristic areas also shows their close connection with the Ancient Mediterranean, where the majority of species are concentrated, especially in the Iran–Turanian (539 species) and the Mediterranean (491) regions. The enough large group of species (249 species) has areas which cover the Pontic subregion of the Boreal floristic region. The areas of 178 species include Siberia, mainly its southern and south–western regions. Connection with areas of other floristic regions is less expressed.

Among the apophytes we noted 20 endemics species, i.e. *Sedum borissovae* Balk. (Ingul-Ingulets Region), *Astragalus tanaiticus* K. Koch (Lower Don), *Caragana scythica* (Kom.) Pojark., *Cymbochasma borysthenica* (Pall. ex Schlecht.) Klokov et Zoz (Cis Black Sea-Cis Azov), *Genista scythica* Pacz., *Corydalis paczoskii* N. Busch (Cis Black Sea-Crimea), *Delphinium sergii* Wissjul., *Trifolium borysthenicum* Grun. (Cis Black Sea-Cis Azov-Cis Caspian), *Asperula tephrocarpa* Czern. ex M.Pop. et Chrshan., *Poa versicolor* Besser, *Thymus graniticus* Klokov et Des.-Shost. (Pontic), *Papaver tumidulum* Klokov, *Polygonum novoascanicum* Klokov (South Pontic), *Gagea maeotica* Artemcz., *Odontites vulgaris* Moench (*O. vulgaris* subsp. *salinus* (Kotov) Tzvelev, *O. salinus* (Kotov) Kotov (Cis Black Sea), *Gagea podolica* Schult. et Schult. f. (Pontic-Cis Caspian), *Agropyron dasyanthum* Ledeb. (Lower Dniepr-Cis Black Sea), *Persicaria hypanica* (Klokov) Tzvelev (Cis Black Sea-Cis Caspian), *Galium tyraicum* Klokov, *G. semiamictum* Klokov (Pannonian-Pontic). All of them are associated with steppe and desert areas, and with xerophytic habitats. Among them are Pannonian-Pontic – 2 species, Pontic – 3, South Pontic – 2, Pontic-Cis Caspian – 1, Cis Black Sea – Cis Azov-Cis Caspian – 2, Cis Black Sea-Cis Caspian – 1, Cis Black Sea-Cis Azov – 2, Black Sea-Crimean – 2, Cis Black Sea – 2, Lower Don-Cis Black Sea – 1, Ingul-Ingulets – 1, Cis Azov – 1.

Thus, the analysis of geographic structure of apophytes of investigated urbanofloras of Ukraine showed their close connection with xerophytic areas. According to the character of geographical distribution the apophytes belong to the Temperate-Ancient Mediterranean flora, as well as, all the synanthropic fraction of Ukrainian flora. The results of analysis are confirmed that urbanization contributes xerophytization of the plant cover.

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References

- ARKUSHYNA G. F. & POPOVA O. M. (2010): Checklist of vascular plants of Kirovograd. – Kirovograd: Polimer-Servis Press. – 231 p. [In Ukr.].
- BURDA R. (1997): The checklist of Donbass urban flora. – Donetsk. – 50 pp.
- Flora of European part of the USSR 1974–1994; Vol. 1-6 / Ed. FEDOROV AN.A.; Vol. 7-8 / Ed. TZVELEV N.N. – Leningrad: Nauka Press [In Russ.].
- Flora of Eastern Europe 1996–2004; Vol. 9–11 / Ed. TZVELEV N.N. – Moscow-Sanct-Petersburg: Mir i Sem'ya-95 Press. [In Russ.].
- KAGALO O. O., SKYBITSKA N.V., LYUBINSKA L. G., GUZIK J., PROTOPOPOVA V. V. & SHEVERA M. V. (2004): Vascular plants of Kamyntents-Podilsky. In Biodiversity of Kamyants-Podilsky. A preliminary critical inventory checklist of plants, fungi and animals / Eds. KAGALO O. O., SHEVERA M. V. & LEVANETS A.A. – Lviv: Liga-Press.– Pp. 82–134. [In Ukr.].
- KOTSUN L. A., KUZMISHINA I. I., VOITYUK V. P., ROMANYUK N. Z., CHMIL O. S. & BESSMERTNA O. A. (2008): Systematical analysis of Lutzk urban flora. Nature of the West Polissya and adjacent areas. – Pp. 112–129. [In Ukr.].

- KUCHEREVSKY V. V. & SHOL G. N. (2009): Annotation list of the Kryvyi Rig urban flora. – Kryvyi Rig: Vydavnychiy dim Press. – 70 pp. [In Ukr.].
- MELNYK R. P. (2001): The urban flora of Mikolaev. – Comprehensive summary Ph. D. Thesis. 19 p. Yalta. [In Ukr.].
- PROTOPOPOVA V. V. (1991): Synantropic flora of Ukraine and ways of its development / Ed. DOBROCHAYEVA D.N. – Kiev: Naukova Dumka Press. – 231 p. [In Russ.]
- PROTOPOPOVA V. V. & SHEVERA M. (2002): A preliminary checklist of the urban flora of Uzhgorod / Sc. Ed. MOSYAKIN S.L. – Kyiv: Phytosociocentre Press. – 68 p.
- PROTOPOPOVA V. V. & SHEVERA M. V. (2010): Participation of apophytes in urban floras in different botanical and geographical zones of Ukraine: a preliminary assessment // IX International Conference Anthropization and Environment of Rural Settlements. Flora and Vegetation (Kamyanets-Podilskiy & Boyany, Ukraine, 29 June – 01 July 2010). – Program, Proceedings and Excursions. – Kyiv: M.G. Kholodny Institute of Botany, NAS of Ukraine, 2010. – P. 54.
- RYABOKON A. (2009): Urban flora of Kharkov
//http://samlib.ru/r/rjabokonx_a_a/florapredislowie.shtml // [In Russ.].
- TAKHTAJAN A. (1978): The Floristic Regions of the World. – Leningrad: Nauka Press. – 248 p. [In Russ.]
- YURTSEV YU.A. & KAMELIN R.V. (1991): The main concepts and terms of floristic. – Perm: Perm University Press. – 80 p. [In Russ.]
- ZAVYALOVA L. V. (2010): A checklist of Chernihiv urban flora / Sc. Ed. SHEVERA M. – Kyiv: Phytosociocentre Press. – 107 p.
- ZAVYALOVA L. V. (2012): The urban flora of Chernihiv. – Comprehensive summary Ph. D. Thesis. – 22 p. Kyiv. [In Ukr.].

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