ARTICLE; BIODIVERSITY AND ECOSYSTEMS

Spontaneous flora of the Rila Monastery (Bulgaria)

Dolja Pavlova* and Elka Georgieva

Department of Botany, Faculty of Biology, Sofia University “St Kliment Ohridski”, 1164 Sofia, Bulgaria

(Received 20 March 2014; accepted 29 April 2015)

The spontaneous flora of the largest and most popular Rila Monastery, symbol of Bulgaria, included in the UNESCO World Heritage list was investigated during 2008–2012. The objectives of the study were to explore species composition and to characterize the plants spontaneously spread in the inner court of the monastery. The total number of the found vascular plants is 110 species from 43 families and 94 genera. The analysed group included predominantly native species, perennial plants — hemicyrptophytes (61 species; 58.65%). The most common species were classified into three groups: (1) species, typical for the rocks flora; (2) common species with wide ecological amplitude and high colonization possibilities; and (3) species, typical for the flora surrounding the monastery. Frequently found species were Ceratochloa dura, Poa annua, Polygonum aviculare, Plantago major, Trifolium repens, Agrostis capillaris, Geum urbanum and Stellaria media. The distribution of the species is a result of specific ecological conditions, such as soil moisture and quantity, lightening of the site area during the day, exposition and intensity of use. The anemochoric woody species (Acer pseudoplatanus, Acer Heldreichii, Fraxinus excelsior, and Ulmus glabra) found in the court as seedlings were also observed on the walls and roof of the Hrelyo’s Tower, which can cause severe damage to the buildings and problems for the conservation of the archaeological monuments.

Keywords: ecology; flora; pavements; Rila; species distribution

Introduction

The study of the flora in archaeological places (ruins, castles), architectural and touristic complexes (walls and pavements) is of great importance for the maintenance and preservation of the monuments. Moreover, these places are suitable to study plant invasions and anthropogenic influence. Investigations on the peculiarities of urban flora and vegetation revealed a high specie diversity and a dynamic development of vegetation.[1] Floristic data about archaeological and touristic places in Bulgaria are very scarce, [2−5] mainly related to low altitudes. Rila Monastery is the largest Eastern Orthodox monastery and a symbol of Bulgaria. It was founded in the tenth century AD and has become a spiritual, educational and cultural centre of Bulgaria. Since 1983 the monastery has been included in the list of World Cultural Heritage of UNESCO. Rila Monastery, Hrelyo’s Tower and the monastery buildings were declared a group of architectural, artistic and historical complex of national importance. Rila Monastery is attractive and important in a role of sustainable tourism and welcomes around a million visitors every year.

Data about the spontaneous flora in the area of the Rila Monastery and the neighbouring most visited by tourist places are sporadic.[6,7] Although in the montane region street and wall flora resemble rocks flora and do not form important singular habitat,[8] its investigation is necessary in order to prevent the natural flora from the influence of invasive plants species. Vascular plant colonization is essentially conditioned by the adaptability of the species and the efficiency of their mode of reproduction.[9] This survey is designed to detect the species that contribute mostly to anthropophytization of the flora and appeared potential threat for the cleanliness of the nature. Such knowledge are critical to the choice of appropriate preventive and eradication methods of these species.

The aim of the study was to investigate the spontaneous flora with the cultivated ornamental plants of the different parts (sites) in the inner court of the Rila Monastery in order to: (1) evaluate similarity between sites; (2) estimate the relative importance of particular factors on species composition; (3) evaluate the anthropogenic impact on the studied flora; and (4) evaluate the potential role of the invasive plants on the natural flora.

Materials and methods

Study area and data collection

The highest mountain on the Balkan peninsula located in south-western Bulgaria, Rila Mts., forms a separate floristic region in the Bulgarian flora with many relict and endemic species.[10,11] This mountain is considered one of the important biodiversity hot spot places in the mountain
areas on the Balkan peninsula on global level, since 100 endemic taxa are recorded.[12] The Rila Monastery is situated in the western part of the mountain at 1147 m above sea level (a.s.l.) (42°07′58.88″N, 23°20′22.62″E) in the beech vegetation belt.[13] It is surrounded by an old forest of *Fagus sylvatica*, mixed with *Abies alba*, *Picea abies*, *Acer pseudoplatanus*, *Acer heldreichii*, *Sorbus aucuparia*, *Carpinus betulus*, *Fraxinus excelsior*, etc. A territory of 250,000 m² around the Rila Monastery was declared in 2000 as the Rila Monastery Nature Park.

The mountain is situated in the transitional zone between the moderate-continental and continental-mediterranean climate.[14,15] The climate in the area of the monastery is montane. The lowest measured air temperature is approximately −25°C at the end of January and the highest does not exceed 36°C in July. The mean annual precipitation is between 1000 and 2200 m a.s.l. varies from 1050 to 1200 mm.[15]

The monastery complex occupies an area of 8800 m² and is rectangular in form, centred around the inner court (3200 m²) where the Hrelyo’s Tower and the main church are situated.[16] For the aim of the study, the inner court of the monastery was divided into four sites, more or less equal in size, following the four corners of the court and the geographic directions (Figure 1). The court is paved with different in size and form sienite and granite cobblestones, and pavement made by round river stones with large joints and definite dip for water drainage. The joints vary in width 5–10 cm.

**Site 1**: It is situated in front of the Samokov door (entrance B) and around Hrelyo’s Tower (app. 908 m²). This is the northern part of the court, unshaded, with high and intermediate use.

**Site 2**: It is situated behind the church in front of the Monastery Museum (app. 712 m²). This is the eastern part of the court where one of the two fountains are situated, forming a microhabitat with some hygrophytes (*Juncus bufonius, Juncus compressus, Carex* sp.). Most of the site is a shaded area with intermediate use. Ornamental trees, shrubs and herbs are planted in this site.

**Site 3**: This is the southern part of the court with 770 m². The second fountain is found here and, like in site 2, several ornamental plants are found. This is a territory with an intermediate and low use by the visitors. The southern corner of the court is a shaded area, while the area around the southern wall of the church is unshaded.

**Site 4**: It is situated in front of the main entrance (Dupnitza door) of the monastery (app. 810 m²), covered with the biggest granite cobbles. This is the western part of the court, intensively used by the visitors. This is an unshaded area.

This study was conducted during 2008–2012. The floristic list (except Bryophyta) is arranged in alphabetical order of the taxa (Table 1).

Bryophytes are included in the total number of species of the study flora. The ornamental plants and bryophytes are listed separately (Table 2).

The distribution of the taxa in the sites, life forms, life cycles, reproduction, dispersal mode and geoelement of the species, except Bryophyta, are also given (Table 1). Information concerning life forms of the taxa and their reproduction mode was taken from the literature sources. [17] Life strategies were classified following Grime.[18] The data on the biology of the species, such as mode of reproduction, dispersal of diaspores, were compiled from the available sources [17–21] and personal observations. The frequency of occurrence in the sites is given in a four-scale gradient [21]: (1) presence in small scattered spots; (2) presence in a few, rather large spots or in spots of medium size, easily overlooked at a rapid passage through the collection site; (3) presence locally in parts of the site; (4) presence impossible to be overlooked, appearing almost over the collection site.

The floristic analysis is presented after Assyov and Petrova.[22] The geographical and historical classification (status) of the flora follows the data provided by different Bulgarian authors.[23–25] The terminology is based on the definitions proposed by Pyšek et al.
Table 1. List of spontaneously spreading taxa in the inner court of the Rila Monastery and their frequency (numbers in brackets).

| Taxa | Sites (frequency) | Status | Life cycle | Life forms | Life strategy | Reproductions | Dispersal mode | Geoelement |
|------|-------------------|--------|------------|------------|---------------|---------------|----------------|-------------|
|      | 1 2 3 4           |        |            |            |               |               |                |             |
| Aspidiaceae                               |        |        |            |            |               |               |                |             |
| Dryopteris filix-mas (L.) Schott.         | +(1)   | Ap     | per        | H          | C             | spv           | ane           | Boreal      |
| Athyriaceae                               |        |        |            |            |               |               |                |             |
| Cystopteris fragilis (L.) Bernh.          | +(1)   | Ap     | per        | H          | C             | spv           | ane           | Kosm        |
| Polypodiaceae                             |        |        |            |            |               |               |                |             |
| Polypodium vulgare L.                     | +(1)   | Ap     | per        | H          | C             | spv           | ane           | Boreal      |
| Spermatophyta                             |        |        |            |            |               |               |                |             |
| Acer pseudoplatanus L.                    | +(1)   | Ap     | h2         | M          | C             | s             | ane           | EurMed      |
| A. heldreichii Orph. ex Boiss.            | +(1)   | Ap     | h2         | N,M        | C             | s             | ane           | Balk        |
| Amaranthaceae                             |        |        |            |            |               |               |                |             |
| Amaranthus retroflexus L.                 | +(1)   | Inv    | ann        | T          | CSR           | s             | ane; hyd; epi | Kosm        |
| Apiaceae                                 |        |        |            |            |               |               |                |             |
| Anthriscus sylvestris L.                  | +(3)   | +(1)   | +(3)       | Arch       | bi-per        | H             | C             | s           | Eur         |
| Heracleum sibiricum L.                    | +(1)   | +(1)   | Ap         | bi-per     | H             | C             | sv            | ane         | EurAs       |
| Myrrhoides nodosa (L.) Cann.              | +(1)   | Ap     | ann        | T          | CS            | s             | epi; ane      | EurAs       |
| Pastinaca hirsuta Panc.                   | +(1)   | Ap     | per        | H          | CS            | sv            | ane           | Bakl        |
| Araliaceae                               |        |        |            |            |               |               |                |             |
| Hedera helix L.                           | +(3)   | +(4)   | Ap         | hl         | N             | CS            | sv            | epi         | EurAs       |
| Asteraceae                                |        |        |            |            |               |               |                |             |
| Achillea millefolium L.                   | +(3)   | +(3)   | +(1)       | Ap         | per           | H             | CR            | sv          | EurSib      |
| A. pannonica Scheele                      | +(1)   | Ap     | per        | H          | C             | sv            | ane           | Pann-Balk   |
| Artemisia vulgaris L.                     | +(1)   | Ap; Inv| per        | H          | CSR           | sv            | ane           | SubBoreal   |
| Bellis perennis L.                        | +(2)   | +2     | Inv        | per        | T             | CSR           | sv            | ane; auth   | EurAs       |
| Matricaria discoidea DC.                  | +(2)   | +(2)   | Inv        | per        | T             | CSR           | sv            | ane; epi    | EurAs       |
| M. chamomilla L.                          | +(3)   | Ap; Inv| ann        | T          | CSR           | sv            | ane           | EurAs       |
| Crepis conyzifolia (Gouan)A.Kern.         | +(2)   | ?      | per        | H          | CS            | sv            | ane; auth    | SubMed      |
| Hieracium murorum L.                      | +(1)   | +(1)   | Ap         | per        | H             | CS            | sv            | ane; auth   | SubMed      |
| Lapsana communis L.                       | +(1)   | +(1)   | Ap; Inv    | ann        | H             | CS            | sv            | ane         | EurSib      |
| Leontodon hispidus L.                     | +(1)   | +(1)   | Ap         | per        | H             | CSR           | sv            | ane         | EurMed      |
| Mycelis muralis (L.) Dum.                 | +(1)   | +(3)   | Ap         | per        | H             | CS            | sv            | ane         | Med         |
| Petasites albus (L.) Gaertn.              | +(1)   | +(1)   | Ap         | per        | H             | CS            | sv            | ane; auth   | EurPont     |
| Senecio rupestris Waldst. & Kit.          | +(1)   | +(1)   | Ap         | per        | T,H           | CSR           | s             | ane         | SubMed      |
| Tanacetum corymbosum (L.) Sch.Bip.        | +(1)   | +(1)   | Ap         | per        | H             | CS            | sv            | ane; auth   | EurMed      |

(continued)
Table 1. (Continued)

| Taxa                                 | Sites (frequency) | Status | Life cycle | Life forms | Life strategy | Reproductions | Dispersal mode | Geoelement          |
|--------------------------------------|-------------------|--------|------------|------------|---------------|---------------|----------------|-------------------|
| *Tanacetum vulgare* L.               |                   | +1     | Ap; Inv    | per        | H             | CS            | sv             | ane; epi; auth   | EurSib            |
| *Taraxacum officinale* Weber         | +(3)              |        | Ap         | per        | H             |CSR            | sv             | ane; epi; auth   | EurMed            |
| *Tussilago farfara* L.               | +(3)              | +(3)   | Ap; Inv    | per        | H             |CSR            | sv             | auth             | EurAs             |
| Betulaceae                           |                   |        |            |            |               |               |                |                   |                   |
| *Corylus avellana* L.                | +(1)              |        | Ap         | h1-h2      | N             | C             | s              | ane; epi         | Med-CAs           |
| Boraginaceae                         |                   |        |            |            |               |               |                |                   |                   |
| *Echium vulgare* L.                  | +(1)              | +(1)   | Ap; Inv    | bi-per     | H             |CSR            | sv             | epi              | EurAs             |
| *Pulmonaria rubra* Schott            |                   | +(1)   | Ap         | per        | H             | C             | sv             | myr              | Carp-Balk         |
| Brassicaceae                         |                   |        |            |            |               |               |                |                   |                   |
| *Alliaria petiolata* (M.Bieb.)       | +(2)              |        | Ap         | ann-bi     | H             | CS            | s              | ane              | EurAs             |
| Cavara & Grande                      |                   |        |            |            |               |               |                |                   |                   |
| *Berteroa incana* (L.)DC.            | +(2)              |        | Ap         | ann-per    | H, T          | CS            | s              | ane              | sPont             |
| *Capsella bursa-pastoris* (L.) Medik.| +(3)              | +(3)   | Ap         | ann-bi     | T             | CSR           | s              | auth             | Kosm              |
| *Cardamine pectinata* Pall. ex DC.   | +(1)              |        | Ap         | ann-bi     | H             | CS            | s              | auth             | SubMed            |
| *Rorippa sylvestris* (L.) Besser    | +(1)              |        | Ap         | per        | H             | C             | sv             | auth             | EurAs             |
| *Campanula rapunculoides* L.         | +(1)              |        | Ap         | per        | H             | C             | sv             | auth             | Eur               |
| *Caryophyllaceae*                    |                   |        |            |            |               |               |                |                   |                   |
| *Arenaria serpyllifolia* L.          | +(3)              | +(3)   | Ap         | ann-bi     | T, H          | SR            | s              |                  | EurAs             |
| *Cerastium fontanum* Baumg.          | +(2)              | +(2)   | Ap         | per        | T             | SR            | sv             | ane; hyd         | Eur               |
| *Herniaira glabra* L. subsp. nebrodensis Jan ex Nyman | +(2)              | +(2)   | Ap         | ann-bi     | T, H          | SR            | sv             |                  | Eur-Cauc-OT       |
| *Herniaira hirsuta* L. subsp. Hirsuta| +(2)              | +(2)   | Ap         | ann-bi     | T, H          | SR            | sv             |                  | EurAs             |
| *Sagina procumbens* L.               | +(4)              | +(3)   | Ap         | per        | Ch            | SR            | sv             | ane              | Boreal            |
| *Spergularia rubra* (L.) J.Presl & C.Presl | +(3)              | +(2)   | Ap         | ann        | T, H          | SR            | s              | ane              | SubBoreal         |
| *Stellaria media* (L.) Vill.         | +(3)              | +(4)   | +(4)       | +(4)       | Arch          | ann-bi        | T, H           | SR               | Kosm              |
| Chenopodiaceae                       |                   |        |            |            |               |               |                |                  |                   |
| *Chenopodium album* L.               | +(1)              | +(1)   | Arch       | ann        | T              | CSR           | s              |                  | Kosm              |
| Cyperaceae                           |                   |        |            |            |               |               |                |                  |                   |
| *Carex sp.*                          | +(1)              | +(1)   | per        |            | H             | CS            | sv             | auth             | Kosm              |
| Convolvulaceae                       |                   |        |            |            |               |               |                |                  |                   |
| *Convolvulus arvensis* L.            | +(3)              |        | Ap         | per        | H             | SR            | s              |                  | Kosm              |

(continued)
Table 1. (Continued)

| Taxa                        | Sites (frequency) | Status | Life cycle | Life forms | Life strategy | Reproductions | Dispersal mode | Geoelement       |
|-----------------------------|-------------------|--------|------------|------------|---------------|---------------|----------------|------------------|
| *Sedum album* L.            | +(+4)             | Ap     | per        | Ch         | CS            | sv            | myr; hyd; auth  | SubMed           |
| *S. acre* L.                | +(3)              | Ap     | per        | Ch         | CS            | sv            | myr; hyd; auth  | EurMed           |
| Dipsacaceae                 |                   |        |            |            |               |               |                |                  |
| *Knautia drymeia* Heuff.    | +(1)              | Ap     | per        | H          | C             | sv            | epi            | Alp-Carp-Balk    |
| Fabaceae                    |                   |        |            |            |               |               |                |                  |
| *Coronilla varia* L.        | +(1)              | Ap     | per        | H          | C             | ?             | epi; ane; auth  | EurMed           |
| *Medicago lupulina* L.      | +(2)              | Arch   | ann-bi     | H          | CSR           | sv            | ane; auth      | EurAs            |
| *M. minima* (L.) Batal.     | +(3)              | Ap     | ann        | T          | CSR           | sv            | epi; ane; auth  | EurAs            |
| *Melilotus officinalis* (L.) Pall. | +(1)          | Arch   | bi         | H          | CS            | s             | ane; auth      | EurAs            |
| *Robinia pseudoacacia* L.   | +(1)              | Inv    | h2         | M          | CS            | s             | ane            | N Am             |
| Fabaceae                    |                   |        |            |            |               |               |                |                  |
| *Trifolium medium* L.       | +(3)              | Ap     | per        | H          | CSR           | sv            | ane; epi       | EurSib           |
| *T. repens* L.              | +(4)              | Ap     | per        | H          | CSR           | vvs           | ane; epi       | EurSib           |
| *T. pratense* L.            | +(3)              | Ap     | per        | H          | CSR           | sv            | ane; epi       | SubBoreal        |
| Geraniaceae                 |                   |        |            |            |               |               |                |                  |
| *Geranium macrorrhizum* L.  | +(2)              | Ap     | per        | H          | C             | sv            | auth; epi      | EurMed           |
| *G. pusillum* L.            | +(2)              | Arch   | ann-bi     | T,H        | C             | sv            | auth; epi      | EurMed           |
| *G. robertianum* L.         | +(1)              | Arch   | ann-bi     | T,H        | C             | sv            | auth; epi      | EurMed           |
| Hypericaceae                |                   |        |            |            |               |               |                | SubBoreal        |
| *Hypericum perforatum* L.   | +(1)              | Ap     | per        | H          | CS            | sv            | ane            | Kosm             |
| Juncaceae                   |                   |        |            |            |               |               |                |                  |
| *Juncus bufonius* L.        | +(2)              | Ap     | ann        | T,H        | CS            | sv            | ane; epi       | SubBoreal        |
| *J. compressus Jasq.*       | +(2)              | Ap     | per        | H          | CS            | sv            | ane; epi       | EurAs            |
| *Luzula sylvatica* L.       | +(1)              | Ap     | per        | H          | C             | sv            | myr            | Eur              |
| Lamiaceae                   |                   |        |            |            |               |               |                |                  |
| *Ballota nigra* L.          | +(3)              | Ap     | per        | Ch,H       | CSR           | sv            | epi            | EurMed           |
| *Clinopodium vulgare* L.    | +(1)              | Ap     | per        | H          | CS            | sv            | ane; epi; auth | SubBoreal        |
| *Lamium purpureum* L.       | +(3)              | Arch   | ann        | T,H        | CSR           | s             | auth           | EurMed           |
| *Prunella vulgaris* (L.) L. | +(2)              | Ap     | per        | H          | CSR           | sv            | hyd;epi; dys; auth | Kosm         |
| Liliaceae                   |                   |        |            |            |               |               |                |                  |
| *Allium flavum* L.          | +(2)              | ?      | per        | G          | CS            | ssv           | end            | Med              |
| Onagraceae                  |                   |        |            |            |               |               |                |                  |
| *Malva sylvestris* L.       | +(1)              | Ap     | ann-per    | H          | CS            | sv            | auth           | Kosm             |
| Malvaceae                   |                   |        |            |            |               |               |                |                  |
| *Epilobium roseum* Schreb.  | +(3)              | Ap     | per        | H          | C             | sv            | ane            | Eur-OT           |
| subsp. *subsessile* (Boiss.)|                   |        |            |            |               |               |                |                  |
| *P. H. Raven*               |                   |        |            |            |               |               |                |                  |

(continued)
| Taxa                  | Sites (frequency) | Status  | Life cycle | Life forms | Life strategy | Reproductions | Dispersal mode | Geoelement  |
|----------------------|-------------------|---------|------------|------------|---------------|---------------|----------------|-------------|
| Oleaceae             |                   |         |            |            |               |               |                |             |
| Fraxinus excelsior L.| +(1)              | Ap      | h2         | M          | C             | s             | ane            | EurMed      |
| Papaveraceae         |                   |         |            |            |               |               |                |             |
| Chelidonium majus L. | +(1) +(2) +(1)    | Ap      | per        | H          | CSR           | s             | myr            | EurAs       |
| Plantaginaceae       |                   |         |            |            |               |               |                |             |
| Plantago lanceolata L.| +(3) +(3) +(3)    | Ap      | per        | H          | CSR           | sv            | auth           | Kosm        |
| P. major L.          | +(3) +(3) +(4) +(3)| Ap      | per        | H          | CSR           | sv            | auth           | Boreal      |
| Poaceae              |                   |         |            |            |               |               |                |             |
| Agrostis capillaris L.| +(4) +(3)         | Ap      | per        | H          | CS            | vvs            | ane           | Boreal      |
| Dactylis glomerata L.| +(1) +(1)         | Ap      | per        | H          | CSR           | vvs            | ane; epi       | EurAs       |
| Festuca pratensis L. | +(1)              | Ap      | per        | H          | C             | vvs            | ane           | Boreal      |
| Hordeum murinum L.   | +(2) +(2)         | Ap      | ann        | T, H       | CS            | s             | ane           |             |
| Lolium perenne L.    | +(3)              | Ap      | per        | H          | CS            | vvs            | ane           | EurAs       |
| Poa annua L.         | +(4) +(3)         | Ap      | ann        | T, H       | CSR           | s             | ane           | Kosm        |
| P. bulbosa L.        | +(2) +(1)         | Ap      | per        | H          | CS            | vvs            | auth          | EurAs       |
| P. nemoralis L.      | +(1) +(3) +(2)    | Ap      | per        | H          | C             | vvs            | ane           | Boreal      |
| Sclerochloa dura (L.)P. Beauv. | +(4) | Ap      | ann        | T          | CS            | sv             | ane           | EuroAs      |
| Polygonaceae         |                   |         |            |            |               |               |                |             |
| Rumex acetosella L.  | +(3) +(3)         | Ap      | ann        | H, G       | CS            | s             | auth          | EuroSubMed  |
| Polygonum aviculare L.| +(4) +(3) +(3)    | Ap      | ann        | T          | CSR           | s             | ?             | Kosm        |
| Primulaceae          |                   |         |            |            |               |               |                |             |
| Primula veris L.     | +(1) +(1)         | Ap      | per        | H          | CSR           | sv             | ane           | EurMed      |
| Ranunculaceae        |                   |         |            |            |               |               |                |             |
| Clematis vitalba L.  | +(1) +(1)         | Ap      | h1         | N          | CS            | s             | ane; auth; epi | Eur         |
| Ranunculus repens L. | +(2) +(3)         | Arch    | per        | H          | CS            | sv             | epi           | SubMed      |
| Rosaceae             |                   |         |            |            |               |               |                |             |
| Crataegus monogyna Jacq. | +(1)            | Ap      | h1         | N          | C             | s             | end           | SubBoreal   |
| Fragaria vesca L.    | +(2)              | Ap      | per        | H          | CSR           | sv             | end; epi; auth | SubBoreal   |
| Geum urbanum L.      | +(4) +(2) +(3)    | Ap      | per        | H          | CSR           | ssv            | epi           | SubBoreal   |
| Potentilla argentea L.| +(2)             | Ap      | per        | H          | CS            | sv             | ane; myr; end | Pont        |
| P. reptans L.        | +(2)              | Ap      | per        | H          | CS            | vvs            | ane; myr; end | Kosm        |
| Primus cerasifera Ehrh. | +(1)        | Ap      | h2         | M          | CS            | sv             | end; anthr    | EurAs       |
| Rosa canina L.       | +(1)              | Ap      | h1         | N          | CS            | vvs            | auth; end     | SubMed      |
| Rubus sp.            | +(1)              | Ap      | h1         | S          | CS            | vvs            | auth; end     | SubBoreal   |
| Sorbus aucoparia L.  | +(1) +(1)         | Ap      | h1         | M          | C             | s             | end           | SubBoreal   |

(continued)
### Table 1. (Continued)

| Taxa                        | Reproductions | Life strategy | Life forms | Dispersal mode | Goodshootent | Status          |
|-----------------------------|---------------|---------------|------------|----------------|--------------|----------------|
| Scrophulariaceae            |               |               |            |                | have           |                |
| Antirrhinum majus L.        | Ap per Ch     | SR            | Ch         | ane            | Med          |                |
| Veronica arvensis C. L.     | C             | (3)           | C          | ane; auth      | Boreal       |                |
| Ulmus glabra Huds.          |               |                | H2         | M              | C            |                |
| Urtica dioica L.            |               |                |            |                | myri          |                |
| Violaceae                   |               |                | H          |                |               |                |
| Viola odorata L.            | Ap per H      | CSR           | vvs        | auth EurSib    |               |                |

Note: Abbreviations and symbols: Status (affiliation to geographical-historical groups): Ap, C, arch, C, arch; Inv, C, arch; life forms: Ch, C, arch; G, C, arch; T, C, arch; life cycle: per, C, arch; ann, C, arch; bi, C, arch; h1, C, arch; h2, C, arch; life strategy: C, C, arch; S, C, arch; R, C, arch; types of reproduction: s, C, arch; sv, C, arch; ssv, C, arch; mostly by seed, rarely vegetatively, vvs, C, arch; mostly vegetatively, rarely by seed, spv, C, arch; dispersal mode: ane, C, arch; auth, C, arch; anthr, C, arch; dyszoochory, C, arch; end, C, arch; epizoochory, C, arch; hyd, C, arch; hydrochory, C, arch; myr, C, arch; (?), C, arch; SubBoreal, C, arch; European, C, arch; Eurosiberian, C, arch; SubMed, C, arch; European-submediterranean, C, arch; Eur-Cauc-OT, C, arch; European-caucasus-rockturanese; EurPont, C, arch; European-pontian; Pont, C, arch; Pann-Balk, C, arch; Pannonian-Balcanian; Balk, C, arch; Balkonian; Carp-Balk, C, arch; Alp-Carp-Balk, C, arch; Kosm, C, arch; cosmo.
The proportion of the woody species (megaphanerophytes, nanophanerophytes and hemiphanerophyte) was also well presented (13; 12.5%). The highest number of the nanophanerophytes was characteristic for site 3. Poorly represented were the chamaephytes (4; 3.85%) and geophytes (1; 0.96%). The species composition found in the study area resembled the floristic composition of pavements in other European regions.[33,37] This biological spectrum is also a reflection of the species composition of the Bulgarian flora.[38]

The high number of perennials in urban areas can be related to their ability to produce vegetative propagation organs.[32] Most of the vegetative reproducing species (T. repens, Potentilla reptans, Lolium perenne, A. capillaris, P. bulbosa, Urtica dioica) were very frequent in the study sites. These species occupy places with wide joints and soil. In these places the number of annuallys is low. One of the frequently appearing annuallys was P. aviculare. This species is also capable to colonize rapidly trampled places near to walking paths, where it often forms long and narrow or irregular patches.[39] P. aviculare is more competitive in comparison with other annual or annual—biennial weed species like Chenopodium album and S. media. While Ch. album was rarely found, S. media was a very frequent in all sites, mainly in semi-shaded and more humid places. The rare appearance of the ruderal Ch. album can be related to the montane climate and the higher altitude where its survival and growth is reduced, particularly under cool soil conditions.[40] Some of the more frequently found perennials on the pavements, such as P. major, T. repens, Taraxacum officinale, Ranunculus repens, Tussilago farfara are known to tolerate compacted and poorly aerated soils.[32] The perennial species Anthriscus sylvestris, a plant of moderately disturbed habitats and edges in moist or mesic sites,[41] was also well presented. It is widely distributed in the natural flora of the mountain up to 1500 m a.s.l.

The flora of the pavements in places intensively used by visitors (sites 1 and 4) was poorly presented. On such trampled areas more often are found S. dura and Sagina procumbens, but rarely P. annua and P. aviculare. The first species is known to invade and rapidly colonize disturbed sites, such as fairground and athletic fields.[42] This species is able to compete with other weedy species in severely trampled areas. The frequency of this plant, predominantly in sites 1 and 4, can be related to the mode of dispersal, which appears to be either by plant fragmenting or by the entire inflorescence.[43] S. procumbens was also found in the crevices of the low part (up to 50 cm) of the walls of the Hrelyo’s Tower, the church, etc. (sites 1 and 2).

The geoelement characteristics of the plants growing on the pavement court revealed that the Euro-Asiatic (29; 27.88%) and European (19; 18.27%) plants were the most well-presented group. The studied flora was also characterized by a high percentage of Boreal (9; 8.65%), sub-Boreal (10; 9.62%) and cosmopolitan species (13; 12.5%) from one hand and low participation of Mediterranean—sub-Mediterranean species (10; 9.62%) on the other. The

| Bryophytes | Ornamental plants |
|------------|------------------|
| *Homalothecium sericeum* (Hedw.) Schimp. (Brachytyciaceae) | *Chamaecyparis lawsoniana* (A. Murray) Parl. (Cupressaceae) |
| *Ceratodon purpureus* (Hedw.) Brid. (Ditrichaceae) | *Picea abies* (L.) H.Karst. (Pinaceae) |
| *Encalypta streptocarpa* Hedw. (Encalyptaceae) | *Picea pungens* Engelm. (Pinaceae) |
| *Orthotrichum anomalum* Hedw. (Ortotrichaceae) | *Pseudotsuga menziesii* (Mirbel) Franco (Pinaceae) |
| *Tortula muralis* Hedw. ssp. muralis (Pottiaceae) | *Sequoiadendron giganteum* (Lindl.) Buchholz (Taxodiaceae) |
| *Weissia controversa* Hedw. (Pottiaceae) | *Citrus limon* (L.) Burm.f. (Rutaceae) |
| *Nerium oleander* L. (Apocynaceae) | *Rosa sp.* (Rosaceae) |
| *Syringa vulgaris* L. (Oleaceae) | *Calendula officinalis* L. (Asteraceae) |
| *Leucanthemum vulgare* L. (Asteraceae) | *Sedum maximum* (L.) Suter (Crassulaceae) |
| *Geranium macrorhizum* L. (Geraniaceae) | *Pelargonium pelatum* (L.) L’Hér. (Geraniaceae) |
| *Pelargonium zonale* (L.) Aiton (Geraniaceae) | *Aquaflgia vulgaris* L. (Ranunculaceae) |
| *Antirrhinum majus* L. (Scrophulariaceae) | *Petunia hybrid* (Solanaceae) |
| *Tropaeolum majus* L. (Tropaeolaceae) | *Viola hybrida* (Violaceae) |
| *Phlox dactylifera* L. (Palmae) | *Aquilegia vulgaris* L. (Ranunculaceae) |
| *Viola hybrida* (Violaceae) | *Tropaeolum majus* L. (Tropaeolaceae) |
| *Petunia hybrid* (Solanaceae) | *Aquaflgia vulgaris* L. (Ranunculaceae) |
| *Antirrhinum majus* L. (Scrophulariaceae) | *Petunia hybrid* (Solanaceae) |
| *Pelargonium zonale* (L.) Aiton (Geraniaceae) | *Aquaflgia vulgaris* L. (Ranunculaceae) |
| *Antirrhinum majus* L. (Scrophulariaceae) | *Petunia hybrid* (Solanaceae) |
| *Tropaeolum majus* L. (Tropaeolaceae) | *Viola hybrida* (Violaceae) |
| *Phlox dactylifera* L. (Palmae) | *Aquilegia vulgaris* L. (Ranunculaceae) |
Balkan, Pontic and Oriental-Turanian species were few. This distribution of the geoelements on the pavements was similar to that reported for the Nature Reserve Rilomanastirska gora, Kiriłova Poljana locality.[7] The reasons for such similarity were the ecological conditions (mountainous climate, altitude, exposure) and intensity of use by man.

The prevalence of competitor and stress-tolerant type (CS type; 38 species) and competitor, stress-tolerant and ruderal type (CSR type; 32 species) of Grime’s life strategies over competitor type (C type; 24 species) in the described flora reflects the habitat conditions as an anthropogenically influenced area. In such habitats the number of ruderals is increased. Nine species are included in the group of the stress-tolerant and ruderal type (SR) and only Achillea millefolium is presenting competitor and ruderal (CR) life-strategy group. The probability of the reproduction success in disturbed habitats of the ruderals is associated to a short life-span and self-pollination.[18] The relation between life strategies found in the studied flora was confirmed by the preference of high number of species with generative-vegetative (58; 55.77%) and vegetative-rarely generative (11; 13.56%) mode of reproduction. Only G. urbanum, Allium flavum and U. glabra prefer seed and rarely vegetative reproduction. The trade-off between vegetative propagation and generative reproduction is expected as a flexible adaptation to the habitat conditions within the species.[18] The number of species reproducing by seeds (28; 26.92%) was also well presented. The success of these species in a competitive environment is associated with the size and number of produced seeds: a high number of small seeds improve the species dispersal ability at the expense of the ability of the seedlings to get established successfully.[44] The spontaneously spreading plants in the monastery court use several different ways of dispersion of propagules. A species dispersal ability is largely determined by its seed characteristics that allow it to sample a wide range of environments and colonize places where it will be competitively dominant.[44] The highest number of anemchoric species (34; 32.69%) was related to the species composition of the flora: prevailing of the species from the Asteraceae and Poaceae families. The woody species (A. pseudoplatanus, A. heldreichii, F. excelsior, U. glabra) found in the court as seedlings are also anemchoric. These species were also observed on the walls and roof of the Hrelyo’s tower and can cause severe damages to the buildings. Tree species, due to the expansion of their root systems, are considered hazardous for the architectural monuments, having the highest hazard index (H index).[9]

Species with diverse spreading strategies (40 species) in the studied flora were comparatively high in number. Obviously, this helps them to spread, migrate and settle on new habitats.[20] Species, spreading in zoochoric or anthropochoric ways, were found on places, most often used by the visitors, a fact, confirmed by previous authors. [19] The number of species with myrmeko-, epi- and endochorous mode of distribution was more or less equal. The autochorous species (13; 12.5%) also formed a significant group.

Most of the studied species were apophytes (82; 78.85%). The archaeophytes were 10 species (9.62%). The calculated index of total archaeophytization of the flora was 9%, whereas the index of anthropophytization was 45.99%. The richest in archaeophytes families in Bulgaria are Asteraceae, Poaceae, Fabaceae, Brassicaceae, Chenopodiaceae, Caryophyllaceae, Polygonaceae, Scrophulariaceae and Amanthaceae.[23] The same families were rich in anthropophytes in this study. Species Amaranthus retroflexus, Artemisia vulgaris, Matricaria discoidea, M. chamomilla, Lapsana communis, Tanacetum vulgare, T. farfara, Echium vulgare, Alliaria petiolata, Berteroa incana, Capsella bursa-pastoris, Arenaria serpyllifolia, Spergularia rubra, S. media, Ch. album, Convolvulus arvensis, Medicago lupulina, M. minima, Mellilotus officinalis, Robinia pseudoacacia, Geranium pusillum, Hypericum perforatum, Ballota nigra, Lamium purpureum, Malva sylvestris, Chelidonium majus, Plantago lanceolata, P. major, Hordeum murinum, L. perenne, Poa annua, Sclerochloa dura, Rumex acetosa, Polygonum aviculare, Prunus cerasifera, Antirrhinum majus and U. dioica found in the studied flora are part of the alien flora of Europe.[45,24] These species are 5.02% (37 species) of terrestrial magnoliophyta alien species provided for Bulgaria (736) according to DAISIE European Invasive Alien Species Gateway.[46] The species A. retroflexus, R. pseudoacacia, M. discoidea, H. murinum, P. cerasifera, and Ch. album are part of the most widespread (150) alien plant species in Europe.[45] R. pseudoacacia (native to North America), A. retroflexus, and M. discoidea (South America) are included in top 100 alien species in Europe, according to DAISIE European Invasive Alien Species Gateway.[46]

**Data analyses in the study area**

Although the sites are neighbouring each with an approximately equal territory they show some specifics in species diversity. The cluster analysis (Figure 2) demonstrated that two clusters (A and B) are formed at a linkage distance around 17. The highest similarity was shown between sites 2 and 3 as the Euclidean distance is the shortest.

The high per cent of perennial and species with all three life strategies – competitor, stress tolerant and ruderals, were found in all studied sites. Intensity of use is the major factor affecting species composition on pavements mainly in site 1 (0.33; 2001, Table 3) showing lower similarity with other sites. The same factor as well as joint width and paver type were considered important for the
The calculated high index of similarity between sites 1 and 4 was owed to the intensive regime of use and light regime, whereas similarities between sites 2 and 3 can be related to more humid and shaded areas. The annual and biennial weeds were considered to rely on humid germination conditions and are more abundant in shaded pavements. Significant correlation between species composition and life cycle was found only in site 3. Indeed, species composition on pavement in site 1 had a lower significant correlation coefficient with life strategy and life cycle. Light regime and dispersal mode do not correlate significantly with species composition in all sites.

**Ornamental plants**

The plants used for decoration in the monastery court are listed in Table 2. They are present in the interior of a monastery as mobile or fixed flowerpots or laid-out on the ground. Usually in Orthodox monasteries ornamental plants are dislocated round the main architectural structures of the yard: the gate, the faucet (fountain), the wall and the stairs. The cultivated roses (*Rosa* sp.) and *Syringa vulgaris* in the Rila Monastery court are grown near the southern sunny wall of the church in the middle of the court. The trees *Sequoiadendron giganteum*, *Pseudotsuga menziesii*, *Picea pungens*, *Chamaecyparis lawsoniana* were planted there together with *P. abies*, which is typical for the natural vegetation of the mountain.

The monasteries were always considered as the most secure and reliable place for the introduction of flowers. The ornamental plants introduced in the Rila Monastery court originate from North America, Asia and the Mediterranean. The species *Leucanthemum vulgare*, *Aquilegia vulgaris*, *Pelargonium zonale*, *P. peltatum*, *Petunia hybrida*, *Sedum maximum*, *Calendula officinalis*, *Tropaeolum majus*, *Geranium macrorhizum* and *Antirrhinum majus* are plants considered typical for the interior in other Bulgarian monasteries. The Mediterranean shrub *Buxus sempervirens*, which is also typical for the yards in other Bulgarian monasteries, was not found here. The cultivated Mediterranean plants were presented by few species (*Nerium oleander*, *Citrus limon*). The main reason for this was the higher altitude and the long winters, which are not suitable for the growth of these xerothermic plants. It is difficult to say if *G. macrorhizum* and *Hedera helix* are planted as ornamentals or are self-populated in the court because of their natural distribution close to the monastery. The species *A. majus* was found only outside the study area, on the nearest wall north from the monastery. The same species is typical for the walls of many urban floras in Bulgaria and other European countries.

**Conclusions**

The frequency analyses showed that the most common species on the pavement court of the Rila Monastery can be classified into three groups: (1) species typical for the rocks flora as it was considered flora of pavements and walls (*Sedum* sp. dev., *A. serpyllifolia,* *S. rubra*); (2) common species with a wide ecological amplitude and high colonization abilities (*P. major*, *S. media*, *P. aviculare*, *H. murinum*, *A. capillaris*, *U. dioica*, *C. bursa-pastoris*, *T. farfara*); and (3) species typical for the surrounding areas (*Knautia drymeia*, *Cardamine pectinata*, *Hieracium murorum*, *Myrrhoides nodosa*, *Pastinaca hirsuta*, *Corylus avellana*, *A. heldreichii*, *F. excelsior*). The high percentage (90%) of accidental species that were recorded in one or two sites only with very rare occurrence indicated the influence of the surrounding flora on the species

![Cluster diagram showing the groups of similarity among sites.](image)

**Figure 2.** Cluster diagram showing the groups of similarity among sites.

**Table 3.** Pearson correlation coefficient between species composition in sites and life cycle, life strategy, reproduction mode, light regime and regime of use.

| Site | Life cycle | Life strategy | Reproduction mode | Dispersal mode | Light regime | Regime of use |
|------|------------|---------------|------------------|---------------|--------------|---------------|
| Site 1 | -0.25* | -0.32** | -0.22* | 0.07 | -0.01 | 0.33*** |
| Site 2 | -0.01 | 0.06 | 0.06 | -0.19 | 0.19 | -0.02 |
| Site 3 | 0.25* | -0.31** | 0.19 | -0.04 | 0.17 | 0.02 |
| Site 4 | -0.25* | -0.06 | 0.04 | -0.07 | 0.10 | 0.18 |

Note: ***p < 0.001; **p < 0.01; *p < 0.05.
composition. Comparisons between the sites give reason to consider the distribution of the species as a result of some specific ecological conditions like soil moisture and quantity, lightening of the site area during the day and intensity of use. On pavements with wide joints and high amount of soil, a more dense and diverse plant cover appears. The study flora consisted predominantly of heliophilous to shade-tolerant plants, which indicated moderate to warm habitat and semi-dry to freshly moist soils. Some species distributed in the court (F. excelsior, A. pseudo-platanus, A. majus, H. helix) were also observed on the monastery walls and Hrelyo’s tower. These species have a deteriogenic effect and may cause serious problems for the conservation of the archaeological monuments. Possible escape of the alien species outside of the studied area is dangerous to the native flora if it contributes to the expansion of invasive species. For this reason weed prevention measures and weed control is likely to be the most effective strategy for the cleanliness of the surrounding native flora.

Acknowledgements
We would like to express our thanks for the taxonomic determinations of bryophytes to Ass. Prof. Dr A. Ganeva.

Disclosure statement
No potential conflict of interest was reported by the authors.

References
[1] Sukopp H. On the early history of urban ecology in Europe. Preslia. 2002;74:373–393.
[2] Dimitrov D, Gussev Ch, Kimesov G, Bosseva Y. Botanical characteristics of the Vrana Park. Sofia: Trud; 2005.
[3] Nedelcheva A. Observations on the wall flora of Kyustendil (Bulgaria). EurAsian J Biosci. 2011;5:80–90.
[4] Nedelcheva A, Vasileva A. Vascular plants from the old walls in Kyustendil (Southwestern Bulgaria). Biotechnol Technol Equip. 2009;23:145–157.
[5] Pavlova D, Tonkov S. The vascular wall flora of the architectural reserve Nebet Tepe in the city of Plovdiv (Bulgaria). Acta Bot Croat. 2005;64:357–368.
[6] Sakalyan M. Biodiversity in National Park Rila. Sofia: Pensoft; 1999.
[7] Tonkov S, Pavlova D, Atanassowa J, Nedelcheva A, Marianova E. Floristic catalogue of the natural reserve “Rilomanastirksa gora” (central Rila Mountains). I. The locality Kirilova Poljana. Annual of Sofia University, Faculty of Biology. Book 2. 2006;97:71–89.
[8] Segal S. Ecological notes on wall vegetation. The Hague: Dr. W. Junk Publishers; 1969.
[9] Motti R, Sticina A. Analysis of the biiodeteriogenic vascular flora at the Royal Palace of Portici in southern Italy. Int Biodeter Biodegr. 2011;65:1256–1265.
[10] Petrova A, Vlecev V. List of Bulgarian endemic plants. In: Petrova A, editor. Atlas of Bulgarian Endemic plants. Sofia: Gea Libris; 2006. p. 362–369.
[11] Petrova A, Vladimirov V. Balkan endemics in the Bulgarian flora. Phytol Balcan. 2010;16:293–311.
[12] Stevanovic V. Biodiversity estimation from interpretation to conservation example of endemic vascular flora of the Balkans. In: Andjelkov M, editor. Biodiversity at the onset of the new millennium. [Proceedings of Scientific Meeting; 2005 Nov 24]. Belgrade: Serbian Academy of Sciences and Arts; 2005;111:53–73.
[13] Veleev V. Characteristic features and regularities in the distribution of the present-day vegetation. In: Koprave I, editor. Geography of Bulgaria. Physical geography. Socio-economic geography. Sofia: Publishing House ForCom; 2002. p. 321–324.
[14] Velev S. Climatic regioning. In: Koprave I, editor. Geography of Bulgaria. Physical geography. Socio-economic geography. Sofia: Publishing House ForCom; 2002. p. 155–157.
[15] Velev S. Climate in Bulgaria. Sofia: Heron Press Publishing House; 2010.
[16] Koeva M. The Rila Monastery. Sofia: Academic Publishing House “Prof. Marin Drinov”; 2000.
[17] Rothmaler W, Basler M, Jager J, Werner K. Exkursionsflora von Deutschland. Berlin: Spektrum Akad Verlag Heidelberg; 1999.
[18] Grime JP. Plant strategies and vegetation processes. Chichester: Wiley; 1979.
[19] Bomanowska A, Kurzac M, Stefanik A. Floristic diversity of plants spontaneously spreading in the botanical garden of the University of Łódź (Poland). Biologica Nyssana. 2012;3:1–10.
[20] van der Pijl L. Principles of dispersal in higher plants. Berlin: Springer-Verlag; 1972.
[21] Witting R, Sukopp H, Klaussen ter B. Die ökologische Gliederung der Stadt. [The ecological structure of the city]. In: Sukopp H, Witting R, editors. New York: Gustav Fischer Verlag; 1993. p. 217–318. Deutsch.
[22] Assybov B, Petrova A, editors. Conspectus of the Bulgarian vascular flora. Distribution maps and floristic elements. 4th ed. Sofia: Bulgarian Biodiversity Foundation; 2012.
[23] Petrova A, Vladimirov V. Anthropophyte flora of Bulgaria. In: Temniskova D, editor. Trudove na VI Nacionalna Konferenca po Botanika [Proceedings of Sixth National Conference of Botany]. Sofia: University Press “St. Kl. Ohridski”; 2001, p. 77–82. Bulgarian.
[24] Petrova A, Vladimirov V. Anthropophyte flora of Bulgaria. Sofia: Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences; 2013.
[25] Stefanov B, Kitano B. Kultigenni rastenija i kultigenna rastitelnost v Balgariya. [Cultivated plants and cultivated flora]. Sofia: Publishing House Bulgarian Academy of Sciences; 1962. Bulgarian.
[26] Pysek P, Richardson DM, Rejmanek M, Webster G, Williamson M, Kirscher J. Alien plants in checklists and floras: towards better communication between taxonomists and ecologists. Taxon. 2004;53:131–143.
[27] Kozuharov M. Biodiversity in National Park Rila. Sofia: Bulgarian Biodiversity Foundation; 2012.
[28] Tutin TG, Burges NA, Chater AO, Edmondson JR, Heywood VH, Moore DM, Valentine DH, Walters SM, Webb DA, editors. Flora Europaea. 2nd ed. Vol. 1. Cambridge: Cambridge University Press; 1993.
[29] Tutin TG, Heywood VH, Burges NA, Moore DM, Valentine DH, Walters SM, Webb DA, editors. Flora Europaea.
[30] Bomanowska A, Witoslawski P. 2008: selected aspects in diversity of synanthropic flora in the chosen cities in central Poland. Biodivers Res Conserv. 2008;9–10:35–42.

[31] Dimitrov D, Stoyneva M, Ivanov D. Sofia. In: Kalcev JG, Muller N. editors. Plant habitats in European Cities. New York: Springer; 2011. p. 453–475.

[32] Fagot M, De Cauwer B, Beeldens A, Boonen E, Bulcke R. Weed flora in paved areas in relation to environment, pavement characteristics and weed control. Weed Res. 2011;51:650–660.

[33] Krigas N, Kokkini S. A survey of the alien vascular flora of the urban and suburban area of Thessaloniki, N Greece. Willdenowia. 2004;34:81–99.

[34] Altay V, Ozygit I, Yanci C. Urban ecological characteristics and vascular wall flora on the Anatolian side of Istanbul, Turkey. Maejo Int J Sci Technol. 2010;4:483–495.

[35] Eskin B, Altay V, Ozygit I, Serin M. Urban vascular flora and ecologic characteristics of the Pendik District (Istanbul-Turkey). Afr J Agric Res. 2012;7:629–646.

[36] Pyšek P. Compositae as invaders: better than the others? Preslia. 1997;69:9–22.

[37] Melander B, Holst H, Grundy AC, Kempenaar C, Riemens MM, Verschwele A, Hansson D. Weed occurrence on pavements in five North European towns. Weed Res. 2009;49:516–525.

[38] Petrova A. The flora of Bulgaria, past present and future. In: Ožhatay N. editor. Plants of the Balkan Peninsula: into the next millennium. Proceedings of the second Balkan Botanical Congress, Istanbul; 2000 May 14, 2001;1:47–52.

[39] Costea M, Tardif FJ. The biology of Canadian weeds. 131. Polygonum aviculare L. Canadian J Plant Sci. 2005;85:481–506.

[40] Maganti M, Weaver S, Downs M. Responses of spreading orach (Atriplex patula) and common lambsquarters (Chenopodium album) to soil compaction, drought, and waterlogging. Weed Sci. 2005;53:90–96.

[41] Darbyshire SJ, Hoeg R, Haverkort J. The biology of Canadian weeds. 111. Anthriscus sylvestris (L.) Hoffm. Canadian J Plant Sci. 1999;79:671–682.

[42] Cusick A, Rabeler R, Oldham M. Hard or fairground grass (Sclerochloa dura, Poaceae) in the Great Lakes region. The Michigan Botanist. 2002;41:125–135.

[43] Brandenburg DM, Estes JR, Thieret JW. Hard grass (Sclerochloa dura, Poaceae) in the United States. Sida. 1991;14:369–376.

[44] Šerá B, Šerý M. Number and weight of seeds and reproductive strategies of herbaceous plants. Folia Geobot. 2004;39:27–40.

[45] Lambdon P, Pyšek P, Basnou C, Hejdama M, Arianoutsou M, Essl F, Jarůšek V, Perql J, Winter M, Anastasiou P, Andriopoulou P, Bazos I, Brundu G, Celesti–Grapow L, Chassot Ph, Delipetrou P, Josefsson M, Kark S, Klotz S, Kokkoris Y, Kuhn I, Marchante H, Perglová I, Pino J, Vilia M, Zikos A, Roy D, Hulme Ph. Alien flora of Europe: species diversity, temporal trends, geographical patterns and research needs. Preslia. 2008;80:101–149.

[46] DAISIE. Handbook of alien species in Europe. Invading nature, Springer series in invasion ecology. Vol. 3. Dodrecht: Springer Science + Business Media B.V.; 2009.

[47] Kabatlynska Z. Flowers in the Bulgarian Monasteries — interior and exterior, traditions and future. In: Kvarda W, editor. Vita Nova II Sustainable development concept in the monastery Klisura in Bulgaria. Vol. 5. Vienna: Academia Danubiana; 2007. p. 10–14.