

Research Journal of Pharmaceutical, Biological and Chemical Sciences

Flora of Razgrad Heights (Northeastern Bulgaria).

Dimcho Zahariev^{1*}, and Iliyana Koleva².

¹Department of Plant Protection, Botany and Zoology, Faculty of Natural Sciences, University of Shumen "Bishop Konstantin Preslavski", Shumen, Bulgaria.

²Student in Faculty of Natural Sciences, University of Shumen "Bishop Konstantin Preslavski", Shumen, Bulgaria.

ABSTRACT

The flora of Bulgaria is considered to be well studied. Unlike the flora of the country, the flora of its parts (local flora) is still unexplored and unknown. The purpose of this study is to study the flora of Razgrad Heights. Inventory of its flora is made for the first time. As a result of the field studies conducted in 2017, 763 wild species of vascular plants from 377 genera and 81 families are described. This represents 18.60% of the species, 41.29% of the genera and 58.27% of the families of vascular plants in Bulgaria. Most of the families (74.07%) and the genera (91.25%) are represented with a small number of species: from 1 to 4. The described plant species refer to 53 floristic elements. The percentage of adventive species and cosmopolites is relatively small - 3.15% and 5.50%, respectively. The hemicryptophytes are the most common life form (47.44%). Of the biological types with the highest number are the perennial herbaceous plants (58.23%). The economically valuable species are described in several groups: medicinal plants, ornamental plants, fruit plants, honey plants, forestry plants. The anthropophytes are 447 species (58.58%). The obtained results are compared with the data on the flora in three sites in Northern Bulgaria: Frangen Plateau, Provadiya Plateau and Tarnovo Heights.

Keywords: floristic analysis, comparison of local floras, economically valuable species

**Corresponding author*

INTRODUCTION

The Razgrad Heights are located in the eastern Danube plain (Northeastern Bulgaria). The name of the heights comes from the town of Razgrad in the northeast. They are located in 14 quadrants from the UTM network of Bulgaria: MJ12, MJ13, MJ22, MJ23, MJ31, MJ32, MJ40, MJ41, MJ42, MJ50, MJ51, MJ60, MJ61, MJ70 (Figure 1). The figure also presents the geographical position of three other sites in Northern Bulgaria, which will be used for comparison.

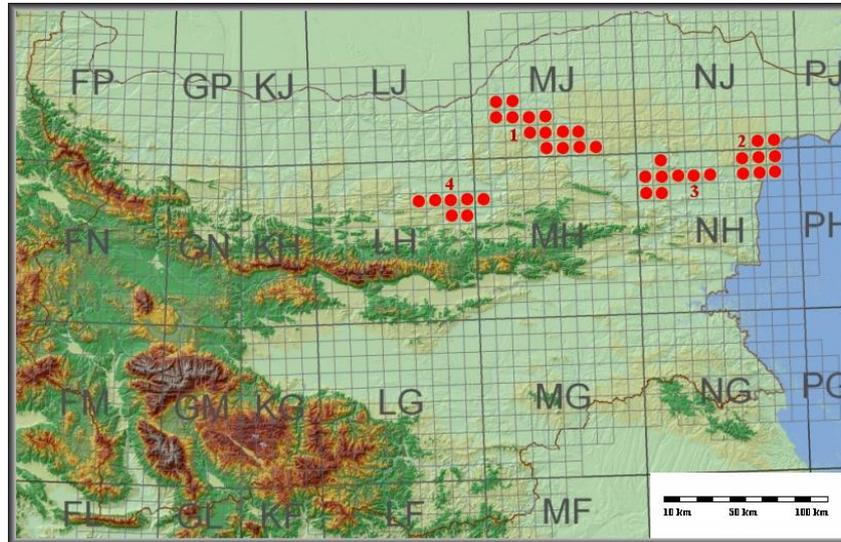


Figure 1: Geographical position of Razgrad Heights (1), Frangen Plateau (2), Provadiya Plateau (3) and Turnovo Heights (4)

The area of Razgrad heights is 1240 km². The maximum length from the northwest to the southeast is 55-60 km, and the maximum width from the northeast to the southwest is 20-25 km. The highest point is the Canarata Peak (479.3 m) at the southern parts of the heights. The relief is hilly-plated.

The climate is characterized by warm summer and cold winters, great annual amplitude of air temperature, spring-summer maximum and minimum winter rainfall, a relatively stable snow cover.

The biggest rivers in the region are the Beli Lom River and the Cherni Lom River, which outline the heights of the east, north and west. A large number of dams are located mainly in the eastern parts of the heights. The largest of the dams is Beli Lom Reservoir [1].

The soils of 4 types and 6 subtypes in the classification of the Food and Agriculture Organization (FAO) are distributed in the territory of Razgrad Heights: Calcic Fluvisols (FLc), Haplic Chernozems (CHh), Calcic Chernozems (CHK), Luvic Phaeozems (PHl), Gleyic Phaeozems (PHg) and Chromic Luvisols (LVx) [2].

On the territory of the heights are located five protected areas and two protected zones of the Natura 2000 ecological network. In floristic terms, the studied area is situated in the Northeastern Bulgaria floristic region [3]. The vegetation includes 13 forest communities, 4 grasslands and 3 types of farmland in the place of forests [4]. The flora of Razgrad Heights has not been studied so far. The aim of our study was to make a full inventory of the flora and to prepare a floristic analysis. The obtained results are compared with the data on the flora in three sites in Northern Bulgaria: Frangen Plateau, Provadiya Plateau and Tarnovo Heights.

MATERIALS AND METHODS

The present study was conducted on the route method in 2017. The following sources are used in the determination of taxa and life forms of the plants: Handbook for Plants in Bulgaria [5], Flora of PR Bulgaria [6, 7], and Flora of the Republic of Bulgaria [8, 9]. The names of the species are under Conspectus of the Bulgarian

vascular flora [10]. The abbreviations of the authors' names of the plants are according to the International Plant Names Index [11]. The names of the family are according to APG IV [12].

In the floristic analysis a comparison is made with the data on the flora of Frangen Plateau, Provadiya Plateau and Tarnovo Heights [13, 14, 15]. The relative taxonomic diversity coefficient was used in the comparison (RTD). It is formed as the sum of the number of families, genera and species divided by the area of the survey area in square meters ($RTD = \sum \text{taxa} / \text{survey area} \leq 1$) [16].

The life forms are represented in the system of Raunkiaer [17]. Biological types and economically significant species are defined by Delipavlov et al. [5]. The floristic elements and the endemics are according to Asyov et al. [10]. The anthropophytes are presented by Stefanov and Kitanov [18]. The Invasive alien plant species are by Petrova et al. [19].

RESULTS AND DISCUSSION

As a result of our study, 763 spontaneous prevalent vascular plants belonging to 377 genera and 81 families were described. This represents 18.60% from all species, 41.29% from all genera and 58.27% from all plant families in Bulgaria. The largest number of taxa belong to the Magnoliophytina division. Of the two subdivisions it includes, most taxa have been established for Magnoliopsida subdivision. The ratio between dicotyledonous and monocotyledonous plants depends on the latitude. For the flora of Bulgaria the ratio is 4.6, while for the flora of Greece it is 4.7 [20]. For Razgrad Heights its value is 4.42, which corresponds to the flora of the more northern latitude. The number of species of higher plants of Razgrad Heights is smaller than in other studied areas in Northern Bulgaria: Provadiya Plateau (863 species) and Tarnovo Heights (964 species) and almost equal to that of the Frangen Plateau (762 species) [13, 14, 15].

Comparing the ratio of relative taxonomic diversity (RTD) between Razgrad Heights and the neighboring larger studied areas, we found the following: The largest is the variety of taxa on Provadiya Plateau and Tarnovo Heights where there is the same value ($RTD = 0.000004$). Next are the Frangen Plateau ($RTD = 0.000003$) and the Razgrad Heights ($RTD = 0.000001$).

The majority of families, 60 (74.07%) are presented by 1-4 genera. Only 21 (25.93%) of the families are represented by 5 or more genera. Most genera belong to the following families: Ateraceae (50 genera), Poaceae (37 genera), Fabaceae (28 genera), Lamiaceae (24 genera), Apiaceae (23 genera) and Campanulaceae (21 genera). Compared with the other larger sites studied in Northern Bulgaria, the number of families with more genera is higher than that of Provadiya Plateau (18.56%) and Tarnovo Heights (18.1%) and smaller than that of Frangen Plateau (39.5%) [13, 14, 15]. Therefore, the flora of Razgrad Heights is relatively rich in families with more genera, which speaks of relatively preserved primacy.

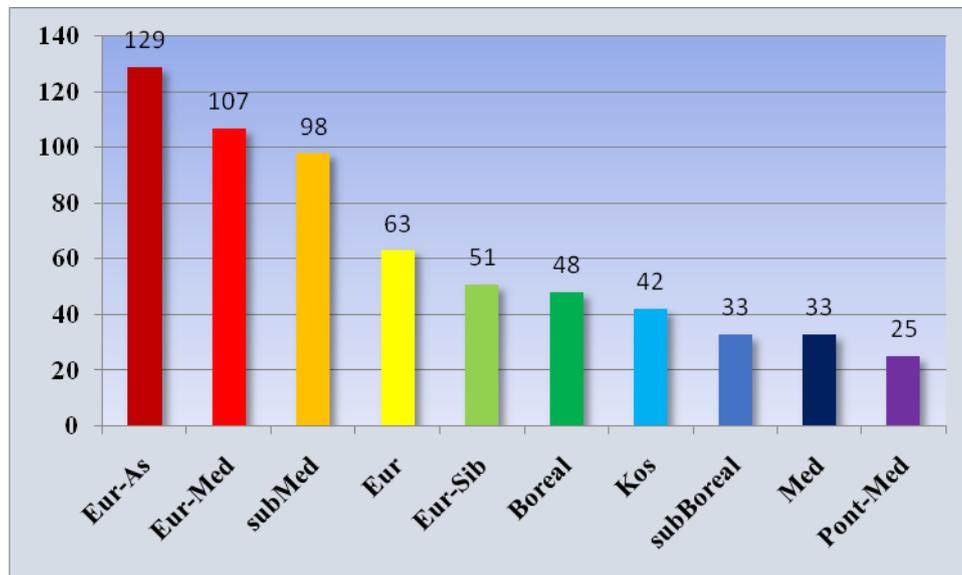
Most families, 50 (61.73%) are presented by 1-4 species. The remaining 31 families (38.27%) are represented by 5 or more species. Most species belong to the following families: Asteraceae (96 species), Fabaceae (74 species), Poaceae (66 species), Lamiaceae (61 species), Rosaceae (34 species), Caryophyllaceae (26 species), Scrophulariaceae (26 species), Brassicaceae (22 species), Ranunculaceae (20 species). This distribution is the closest to the ratio in Tarnovo Heights, where 41.5% of families are presented by 5 or more species. The wealth of families with more species of Razgrad Heights is higher than Frangen Plateau (19.8%) and Provadiya Plateau (22.1%) [13, 14, 15]. This also testifies to the comparatively preserved primary flora of the Razgrad Heights.

The majority of genera, 344 (91.25%) are presented by 1-4 species. Only 33 (8.75%) of genera are represented by 5 or more species. Most species belong to the following genera: *Carex* L. (14 species), *Trifolium* L. (13 species), *Vicia* L. and *Lathyrus* L. (11 species), *Veronica* L. (10 species).

The established taxonomically diversity can be explained by the variety of combinations of terrain, hydrological, climatic and soil conditions as a prerequisite for the variety of communities and habitats in the Razgrad Heights.

The specific physical-geographic conditions on the Razgrad Heights determine considerable diversity of floristic elements. On the basis of the inventory we made, we found that the described species belong to 53

different floristic elements. This is comparable to the results obtained from Tarnovo Heights (54 floristic elements), Provadiya Plateau (51 floristic elements) and Frangen Plateau (50 floristic elements) [13, 14, 15]. The largest number of species belongs to following floristic elements: European-Asiatic (16.91%), European-Mediterranean (14.02%), and Sub-Mediterranean (12.84%) floristic elements (Figure 2).



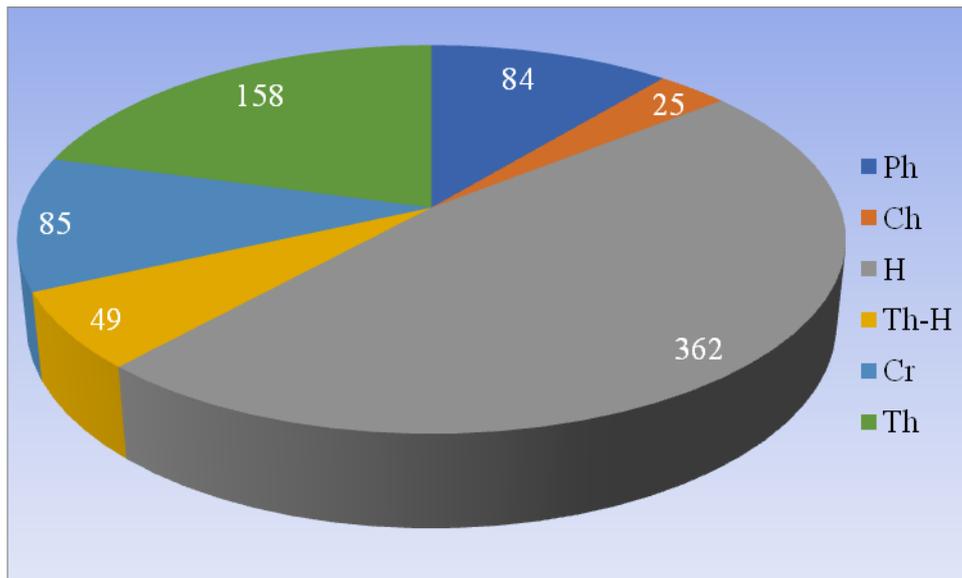
Legend: Eur-As - European-Asiatic, Eur-Med - European-Mediterranean, subMed - Sub-Mediterranean, Eur - European, Eur-Sib - European-Siberian, Boreal - Boreal, Kos - Cosmopolitan, subBoreal - Sub-Boreal, Med - Mediterranean, Pont-Med - Pontic-Mediterranean

Figure 2: Phytogeographical structure of the flora of Razgrad Heights (only the first 10 floristic elements that have the largest number of species)

Particular attention is paid to groups of cosmopolitan species and adventive species, as they are species that are directly or indirectly related to human activity. The cosmopolitan species are 42 (5.50%). The percentage of these species is higher than in the other territories we use to compare. In the Frangen Plateau, the cosmopolitan species are 40 species (5.26%), in the Provadiya Plateau they are 35 species (4.06%) and in the Tarnovo Heights they are 46 species (4.77%) [13, 14, 15]. An explanation of this fact can be found in the smaller number of species found in the Razgrad Heights. The richest local floras have a smaller percentage of cosmopolitan species. The adventive species of Razgrad Heights are 24 species (3.15%). In the Frangen Plateau they are 19 species (2.50%), in the Provadiya Plateau they are 24 species (2.78%) and in the Tarnovo Heights they are 39 species (4.55%) [13, 14, 15].

The life forms on the territory of Razgrad Heights are represented by all groups. The largest number species, 362 species (47.44%) belong to group of the hemicryptophytes (Figure 3). Next is the number of the therophytes: 158 species (20.71%). Groups of geophytes and phanerophytes have almost the same number, 85 and 84 species, respectively. The cryptophytes are represented mainly by geophytes, 65 species (8.52%). Among the phanerophytes most species belong to mesophanerophytes, 38 species (4.98%) and microphanerophytes, 27 species (3.54%). The least represented in the territory of Razgrad Heights are therophytes-hemicryptophytes, 49 species (6.42%) and chamaephytes, 25 species (3.28%).

Depending on the prevalence of a given life form, Raunkiaer [17] perceives different types of climate. On the basis of the ratio, which we established in our study, in the territory of Razgrad Heights we have a combination of life forms typical for the Temperate Climatic Zone with the influence of the Subtropical Climatic Zone. Razgrad Heights are located in the Temperate-continental Climatic Area, near the border with the Transitional-continental Climatic Area and just a few dozen kilometers from the Continental-Mediterranean Climatic Area. We believe that this proximity is the cause of such a deviation.



Legend: Ph - Phanerophytes, Ch - Chamaephytes, H - Hemicryptophytes, Th-H - Therophytes-Hemicryptophytes, Cr - Cryptophytes, Th - Therophytes

Figure 3: Distribution of the species by life form

The distribution of the life forms in the neighboring sites is similar to that described in the Razgrad Heights. This is expected because all the compared territories are located at the same latitude and have close climatic conditions.

In Razgrad Heights we have identified all biological types, as well as all possible transitions between them (Table 1). Most of the species are perennial herbaceous plants, 429 species (56.23%). Secondary in number of species are the annual herbaceous plants with 158 species (20.71%). With a smaller number of species are trees, 35 species (4.59%) and shrubs, 33 species (4.33%). The biannual herbaceous plants and transitions forms between the major biological types are represented with the smallest number of species. The predominant presence of perennial herbaceous plants can be explained by the wide variety of communities and habitats found on the territory of the Razgrad Heights. Neighboring geographic locations are characterized by a similar distribution and a close proportion of the biological types.

Table 1: Spectrum of the biological types

Biological type	Number of species	Percentage
Annual herbaceous plant	158	20.71
Annual or biannual herbaceous plant	39	5.11
Annual or perennial herbaceous plant	10	1.31
Biannual herbaceous plant	27	3.54
Biannual or perennial herbaceous plant	18	2.36
Perennial herbaceous plant	429	56.23
Perennial herbaceous plant or shrub	1	0.13
Shrub	33	4.33
Shrub or tree	13	1.70
Tree	35	4.59

The economically valuable species find a variety of uses: medicinal plants, ornamental plants, fruit plants, honey plants, forestry plants. The main purpose of medicinal plants is to obtain herbs from them. The following plants are produced in large quantities for the industrial production of herbs: *Achillea millefolium* L., *Cichorium inthybus* L., *Cornus mas* L., *Corylus avellana* L., *Crataegus monogyna* Jacq., *Cynodon dactylon* (L.) Pers., *Fragaria vesca* L., *Rosa canina* L., *Tilia tomentosa* Moench, *Urtica dioica* L. etc.

The ornamental plants on the territory of the Razgrad Heights are 17 species. Of these, the following species are trees: *Acer saccharinum* L., *Aesculus hippocastanum* L., *Elaeagnus angustifolia* L., *Koelreuteria paniculata* Laxm., *Picea pungens* Engelm., *Salix babylonica* L. The ornamental shrubs are as follows: *Forsythia suspensa* Vahl, *Mahonia aquifolium* (Pursh) Nutt., *Philadelphus coronarius* L., *Ptelea trifoliata* L., *Spartium junceum* L., *Spiraea x vanhouttei* (Briot) Carr., *Symphoricarpos albus* (L.) S.F.Blake, *Symphoricarpos orbiculatus* Moench, *Tamarix ramosissima* Ledeb., *Tamarix tetrandra* Pall. ex M.Bieb.

Forest fruit in industrial quantities can be obtained from the following species: *Corylus avellana* L., *Crataegus monogyna* Jacq., *Fragaria vesca* L., *Rosa canina* L., *Rubus discolor* Weiche & Nees, *Rubus thyrsoanthus* Focke etc.

Honey plants of economic importance are *Tilia tomentosa* Moench and *Robinia pseudoacacia* L.

As a source of wood are mainly used the following species: *Carpinus betulus* L., *Quercus cerris* L., *Quercus dalechampii* Ten., *Quercus frainetto* Ten. For this purpose, specially created forest crops of the following species are also used: Broad-leaved species: *Gleditsia triacanthos* L., *Populus x euramericana* (Dode). Guiner and *Robinia pseudoacacia* L. Coniferous species: *Picea abies* (L.) H.Karst., *Pinus nigra* L. and *Pinus sylvestris* L. This group of plants have the greatest economic importance.

The anthropophytes among the plants on the territory of Razgrad Heights are 447 species (58.58%). Most of them are perennial herbaceous plants, 211 species (27.65%). Secondary in number of species are the annual herbaceous plants with 128 species (16.78%). The group of annual to biennial herbaceous plants includes 33 species (4.33%). The biannual herbaceous plants are 20 species (2.62%). Shrubs are 15 species (1.97%) and trees are 13 species (1.70%). The remaining biological types have a smaller number of species.

When comparing with neighboring territories, there are similar results in the percentage of anthropophytes. In the Frangen Plateau they are 58.3%, in the Provadiya Plateau they are 54.00%, in the Tarnovo Heights they are 56.5% [13, 14, 15]. The percentage of the anthropophytes is the highest in the Razgrad Heights. The reason for this can be found in the presence of a large number of settlements, the considerable area of the arable lands around them and the well-developed road infrastructure in the heights.

In the territory of Razgrad Heights we found 23 species of invasive alien plant species (3.01% of all species): *Acer negundo* L., *Ailanthus altissima* (Mill.) Swingle, *Amaranthus hybridus* L., *Amaranthus retroflexus* L., *Ambrosia artemisiifolia* L., *Amorpha fruticosa* L., *Bidens frondosa* L., *Datura stramonium* L., *Erigeron annuus* (L.) Pers., *Erigeron canadensis* L., *Galinsoga parviflora* Cav., *Gleditsia triacanthos* L., *Impatiens glandulifera* Royle, *Laburnum anagyroides* Medik., *Lycium barbarum* L., *Parthenocissus quinquefolia* (L.) Planch., *Phytolacca americana* L., *Robinia pseudoacacia* L., *Solidago gigantea* Aiton, *Sorghum halepense* (L.) Pers., *Symphytotrichum novi-belgii* (L.) G.L.Nesom, *Xanthium italicum* Moretti, *Xanthium spinosum* L. Of these 5 species are trees, 3 species are shrubs, 5 species are perennial herbaceous plants, 9 species are annual herbaceous plants and 1 species are annual or biannual herbaceous plants.

In the DASIE list of the most dangerous invasive alien species threatening biodiversity in Europe [21] are included 4 species: *Ailanthus altissima* (Mill.) Swingle, *Ambrosia artemisiifolia* L., *Impatiens glandulifera* Royle. and *Robinia pseudoacacia* L. In the EPPO list of invasive alien species [22] are included 5 species: *Ailanthus altissima* (Mill.) Swingle, *Ambrosia artemisiifolia* L., *Amorpha fruticosa* L., *Impatiens glandulifera* Royle and *Solidago gigantea* Aiton. In the list of observed invasive alien species of EPPO is included *Bidens frondosa* L.

Of the invasive alien species mentioned, 3 species are the most dangerous: *Ailanthus altissima* (Mill.) Swingle, *Robinia pseudoacacia* L. and *Xanthium italicum* Moretti. The first 2 species are tree species and are distributed in a variety of habitats (often forest and shrubland) with rapidly growing numbers. The third species is an annual herbaceous plant, which is widespread in the arable lands of Razgrad Heights.

For comparison, the invasive alien species in the Frangen Plateau are 19 species (2.49%), in the Provadiya Plateau they are 17 species (1.97%) and in Tarnovo Heights they are 29 species (3.01%) [13, 14, 15]. As an absolute value, the number of invasive alien species in Razgrad Heights is smaller than that in Tarnovo Heights and higher than their number in Frangen Plateau and Provadiya Plateau. More accurately, however, is the comparison with invasive species according to the percentage of all spontaneous species in a given territory. This comparison shows that the percentage of invasive alien species in Razgrad Heights is the same as in Turnovo Heights. This is not a coincidence, as there are many common features between these two territories: a large number of settlements on their territory, a well developed road network, the presence of large rivers that pass through them. These are the most important ways of spreading invasive alien species.

CONCLUSION

The results obtained from the study of the flora of the Razgrad Heights are comparable with the results of analogous studies of the flora in the Frangen Plateau, Provadiya Plateau and Turnovo Heights situated in the northern part of Bulgaria. The results of this study can be used as a basis for comparison in local flora studies in other parts of the country.

ACKNOWLEDGMENTS

This publication is realized with the financial support of Project No. RD-08-120/ 06.02.2018 from the Scientific Research Fund of University of Shumen.

REFERENCES

- [1] Michev N, Mihailov C, Vaptsarov I, Kiradzhiev S. Geographical Dictionary of Bulgaria, Sofia, Nauka i izkustvo, 1980, p. 561 (in Bulgarian).
- [2] Ninov N. Soils. In: Koprarev I. (main ed.) Geography of Bulgaria. Physical and Socio-economic Geography. Sofia, Institute of Geography, BAS, Farkom, 2002, p. 760 (in Bulgarian).
- [3] Yordanov D. (main ed.) Flora of the People's Republic of Bulgaria, Vol. 1, Sofia, Publishing House of BAS, 1963, p. 507 (in Bulgarian).
- [4] Bondev I. The vegetation of Bulgaria. Map 1:600 000 with explanatory text. Sofia, Publishing House of University of Sofia "Sv. Kliment Ohridski", 1991, p. 183 (in Bulgarian).
- [5] Delipavlov D, Cheshmedzhiev I, Popova M, Teriyski D, Kovachev I. Handbook for Plants in Bulgaria. Plovdiv, Publishing House of Agricultural University, 2011, p. 591 (in Bulgarian).
- [6] Yordanov D. (main ed.) Flora of the People's Republic of Bulgaria. Vol. 1–7. Sofia, Publishing House of BAS, 1963-1979 (in Bulgarian).
- [7] Velchev V. (ed.) Flora of the People's Republic of Bulgaria. Vol. 8–9. Sofia, Publishing House of BAS, 1982-1989 (in Bulgarian).
- [8] Kozhuharov S. (ed.) Flora of the Republic of Bulgaria. Vol. 10. Sofia, Prof. M. Drinov Acad. Publ., 1995, p. 428 (in Bulgarian).
- [9] Peev D. (ed.) Flora of the Republic of Bulgaria. Vol. 11. Sofia, Prof. M. Drinov Acad. Publ., 2013, p. 523 (in Bulgarian).
- [10] Assyov B, Petrova A, Dimitrov D, Vassilev R. Conspectus of the Bulgarian Vascular Flora. Distribution Maps and Floristic Elements. Sofia, Bulgarian Biodiversity Foundation, 2012, p. 490 (in Bulgarian).
- [11] The International Plant Names Index (IPNI), Website: <http://www.ipni.org/> [accessed 2 November 2018].
- [12] Angiosperm Phylogeny Group. An update of the Angiosperm Phylogeny Group classification for the orders and families of flowering plants: APG IV, Botanical Journal of the Linnean Society 2016; 181: 1-20.
- [13] Zahariev D, Flora of Northeastern Bulgaria. Vol. 4. Flora of Frangen Plateau. Shumen, Himera, 2015, p. 400 (in Bulgarian).
- [14] Zahariev D, Flora of Northeastern Bulgaria. Vol. 1. Flora of Provadiya Plateau. Shumen, Himera, 2012, p. 443 (in Bulgarian).
- [15] Zahariev D, Taneva L. Flora of Tarnovski Heights (Northern Bulgaria). International Journal of Advanced Research 2017; 5 (8): 1011-1022.



- [16] Peev D, Delcheva M, Nenova I. Balkan vascular flora in numbers. In: Ivanova D. (ed.) Proceedings of the Fourth Balkan Botanical Congress, Sofia 2006. Sofia, Prof. M. Drinov Academic Publishing House, 2009.
- [17] Raunkiaer C. The Life forms of plants and statistical plant geography. Oxford, Clarendon Press, 1934, p. 147.
- [18] Stefanov B, Kitanov B. Kultigenen plants and kultigenen vegetation in Bulgaria. Sofia, Publishing House of BAS, 1962, p. 275 (in Bulgarian).
- [19] Petrova A, Vladimirov V, Georgiev V. Invasive alien plants in Bulgaria. Sofia, Institute of Biodiversity and Ecosystem Research, Bulgarian Academy of Sciences (BAS), 2012, p. 319 (in Bulgarian).
- [20] Stoyanov N. On the distribution of Mediterranean Vegetation in South Bulgaria and its relationship to Tobacco culture. Sofia, Hudozhnik, 1922, p. (in Bulgarian).
- [21] DAISIE List of 100 of the Worst Invasive Alien Species in Europe, Website: <http://www.europe-alien.org/speciesTheWorst.do> [accessed 2 November 2018].
- [22] European and Mediterranean Plant Protection Organization (EPPO). EPPO activities on Invasive Alien Plants. Website: http://www.eppo.int/INVASIVE_PLANTS/ias_plants.htm [accessed 2 November 2018].