Alien species of vascular plants first reported for Bulgaria after 2000

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Received: November 10, 2023 ▷ Accepted: December 05, 2023

Abstract. Invasive alien species are considered some of the most important causes of biodiversity loss on a global scale. This explains why interest in their research has been steadily rising in recent years. A review of botanical literature for the Bulgarian flora shows that after 2000 more than 100 alien species of vascular plants have been reported for the first time for the Bulgarian flora. The report presents an analysis of these species in terms of their origin, pathways of introduction and further spread, affected floristic regions, etc.

Key words: biological invasion, Bulgarian flora, invasive plants

Citation: Vladimirov, V. & Petrova, A. 2023. Alien species of vascular plants first reported for Bulgaria after 2000. – Phytologia Balcanica, 29(3): 461-474 – ISSN 1310-7771 (print), 1314-0027 (online).

Introduction

Invasive alien species are considered some of the most important causes of biodiversity loss on a global scale. This explains why interest in their research has been steadily rising in recent years.

In 2002, the Biological Diversity Act was adopted in Bulgaria and texts on the need of control of alien and invasive alien species were included for the first time in the national nature protection legislation. In 2004, the Ministry of Environment and Water funded two projects: on studying the alien species of plants and of animals in the Bulgarian biota. This marked the beginning of a more targeted interest in that group of species. Subsequently, some other projects were implemented for studying the alien species of plants in the Bulgarian flora. In the course of these projects, special attention was paid to the earlier little-studied types of habitats, such as disturbed roadside habitats, railway network, ports, riverside habitats, urban environment, etc. As a result, a number of alien species new to the Bulgarian flora were discovered and reported for the first time.

The purpose of this article is to review and analyse all alien plant species published for the first time as new for the Bulgarian flora in the period 2001–2023.

DOI 10.7546/PhB.29.3.2023.12

Material and methods

A review of botanical literature for the Bulgarian flora was made. All articles published in the period 2001–2023, in which new species of plants alien to the country had been reported, were studied in detail. A list of all newly reported taxa has been compiled, completed with data on their taxonomic affiliation to the respective family, biological type (life cycle), origin, and the floristic regions from which they were first reported. Possible pathways of entry and spread of these species, their potential invasive behaviour and the most vulnerable habitats have been also analysed and discussed. In order to compile all data, apart from the articles on the Bulgarian flora, a number of other sources were used, such as Euro+Med PlantBase (Euro+Med 2006+), POWO (2023), WFO (2023), Flora of North America and Flora of China (eFloras 2023), etc.

Results and discussion

As a result of the literature review, it was established that 117 alien species have been reported in the period 2001–2023 as new for the Bulgarian flora. A list of these species is presented in Table 1.

These alien species belong to a total of 51 families, of which best represented are *Asteraceae* (19, 16.24%), *Poaceae* (8, 6.84%), *Chenopodiaceae* (6, 5.13%), *Onagraceae* (5, 4.27%), *Euphorbiaceae*, *Fabaceae*, *Lemnaceae*, *Rosaceae,* and *Solanaceae* (each with five species, 3.42%). A similar pattern of taxonomic structure of the alien flora has been also observed for the entire European continent (Pyšek & al. 2009), where the leading families are *Asteraceae*, *Poaceae*, *Rosaceae*, *Fabaceae*, *Brassicaceae*, and *Amaranthaceae* (incl. *Chenopodiaceae*). This can be explained easily by the fact that *Asteraceae*, *Poaceae*, *Fabaceae*, and *Rosaceae* are some of the largest plant families in the Bulgarian and European floras, as well as by the fact that the best represented families comprise a high number of species which have been used for different purposes by humans or have accompanied human economic activity (weedy and ruderal species).

An analysis of the life cycle (biological type) of the alien species shows that the group of annual species is most numerous (46 species, 39.32%), followed by the perennial herbaceous plants (36 species, 30.77%), shrubs (11 species, 9.40%), and trees (10 species, 8.55%).

An analysis of the origin of species shows that the largest number of species originate from the Americas (North and South America) – 67 species (57.26%), of which 41 species (35.04%) are native only to North America and 13 (11.11%) – only to South America, followed by Asia – 20 species (17.09%) and Europe – 11 species (9.40%). These proportions differ from the pattern for aliens in Europe, wherever Europe is the main donor area of the alien taxa (native to one part of the continent and alien to another part), followed by Africa and Asia (Pyšek & al. 2009). However, whenever only taxa alien to the entire European continent are considered, most numerous is the group of aliens originating from North America, South America and temperate Asia (Pyšek & al. 2009). This difference in the patterns for Bulgaria and Europe can be explained by the fact that only a subset of the aliens is analysed for Bulgaria (the taxa reported as new to the Bulgarian flora after 2000) and, therefore, only more recently introduced neophytes are included.

It many cases, it is difficult to infer the exact pathway of introduction of the species and such information is scarce in the analysed publications. It seems that at least 50.4% of the species have been deliberately introduced. The main pathway is 'escape from confinement', since many of the species have been introduced and cultivated for various purposes, and then escaped from cultivation. Typical examples are: ornamental plants, which outline one of the major pathways – *Fallopia ×bohemica*, *Helianthus tuberosus*, *Hemerocallis fulva*, *Impatiens balfourii*, *Ipomoea purpurea*, *Opuntia engelmannii*, *Opuntia fragilis*, *Solidago gigantea*, *Sternbergia lutea*, *Symphyotrichum novi-belgii*, etc.; edibles – *Cydonia oblonga*, *Helianthus tuberosus*; and forestry – *Pinus pinaster*, *Pseudotsuga menziesii*. Accidentally introduced species are 45.3%, however, it is very difficult to infer what the exact pathways of introduction for each species have been. Most likely pathways are 'seed contaminants' (e.g.

Table 1. List of the alien species of vascular plants first reported as new for the Bulgarian flora after 2000 [*Life cycle*: ann – annual, bien – biennial, per – perennial; *Origin*: Afr – Africa, Am – America, As – Asia, Austr – Australia, Eur – Europe, Medit – Mediterranean].

Species	Family	Life cycle	Origin	Floristic region of first report for the Bulgarian flora	Reference
Acalypha australis L.	*Euphorbiaceae*	*ann*	As	Sofia Region	Petrova (2017a), misidentified as *A. virginica* (Kočeva & Dimitrov 1997)
Amaranthus blitum subsp. *emarginatus* (Uline & W.L. Bray) Carretero & al.	*Amaranthaceae*	*ann*	S Am	Northeast Bulgaria	Petrova & Vladimirov (2012)
Amaranthus viridis L.	*Amaranthaceae*	*ann*	S Am	Black Sea Coast (*Northern*)	Petrova (2018)
Ambrosia artemisiifolia L.	*Asteraceae*	*ann*	N Am	Danubian Plain, Sofia Region	Dimitrov (2001), Dimitrov & Tzonev (2002)
Ambrosia trifida L.	*Asteraceae*	*ann*	N Am	Northeast Bulgaria, Sofia Region	Stoyanov & al. (2014)
Ammannia coccinea Rottb.	*Lythraceae*	*ann*	N Am, N Austr	Thracian Lowland	Vladimirov & al. (2017a)
Avena byzantina K. Koch	*Poaceae*	*ann*	SW As	Sofia Region	Petrova (2010)
Bidens bipinnata L.	*Asteraceae*	*ann*	S Am	Black Sea Coast (*Northern*)	Petrova & Vladimirov (2009)
Bidens frondosa L.	*Asteraceae*	*ann*	N Am	Northeast Bulgaria, Danubian Plain, Forebalkan (*Western*), Sofia Region, Thracian Lowland, Mt Strandzha	Šumberova & al. (2004)
Bidens subalternans DC.	*Asteraceae*	*ann*	C & S Am	Black Sea Coast (*Southern*)	Vladimirov (2023)
Bidens vulgata Greene	*Asteraceae*	*ann*	N Am	Danubian Plain	Petrova & Vladimirov (2009)
Bromus diandrus Roth	*Poaceae*	*ann*	Medit	Black Sea Coast (*Southern*)	Kunev (2021b), Stoyanov & al. (2022)
Bufonia perennis Pourr.	*Caryophyllaceae*	*per*	W Eur	Black Sea Coast (*Northern*)	Dimitrov & Vutov (2015)
Buglossoides minima (Moris) R. Fern	*Boraginaceae*	*ann*	Italy	Northeast Bulgaria	Dimitrov (2013)
Calendula officinalis L.	*Asteraceae*	*ann-bien*	SW Eur (Iberian Peninsula)	Pirin Mts (*Northern*)	Karakiev (2019)
Campanula lactiflora M. Bieb.	*Campanulaceae*	*per*	SW As	Rila Mts	Vassilev & al. (2023)
Campanula rotundifolia L.	*Campanulaceae*	*per*	Eur	Rila Mts	Ančev (2012)

Species	Family	Life cycle	Origin	Floristic region of first report for the Bulgarian flora	Reference
Cenchrus longispinus (Hack.) Fernald	*Poaceae*	*ann*	N Am	Northeast Bulgaria	Jehlík & Scholz (2009, as *C. incertus*)
Cenchrus purpurascens Thunb.	*Poaceae*	*per*	E As, NW Austr	Sofia Region	Dimitrov & Vutov (2015)
Cephalaria gigantea (Ledeb.) Bobrov	*Dipsacaceae*	*per*	N, NE Turkey	Pirin Mts	Petrova (2012)
Chenopodium missouriense Aellen	*Chenopodiaceae*	*ann*	C & E Am	Tundzha Hilly Country	Grozeva (2010)
Chenopodium pratericola Rydb.	*Chenopodiaceae*	*ann*	N Am	Black Sea Coast (*Northern*, *Southern*)	Grozeva (2012)
Chenopodium probstii Aellen	*Chenopodiaceae*	*ann*	N Am	Rhodopi Mts (*Eastern*), Thracian Lowland	Grozeva (2010)
Chenopodium pumilio R. Br.	*Chenopodiaceae*	*ann-per*	Austr	Balkan Range (*Eastern*), Thracian Lowland	Grozeva (2007)
Chenopodium schraderianum Schult.	*Chenopodiaceae*	*ann*	E & S Afr	Vitosha Region	Dimitrov (2001)
Chenopodium striatiforme Murr.	*Chenopodiaceae*	*ann*	NW Turkey, Greece	Thracian Lowland	Grozeva (2008)
Clematis tibetana Kuntze	*Ranunculaceae*	*shrub*	E As	Black Sea Coast (*Northern*)	Vladimirov & al. (2014b)
Cosmos bipinnatus Cav.	*Asteraceae*	*ann*	N Am	Pirin Mts (*Southern*), Tundzha Hilly Country	Petrova (2017b)
Cucurbita foetidissima Kunth	*Cucurbitaceae*	*per*	N Am	Thracian Lowland	Georgiev & al. (2022)
Cupressus sempervirens L.	*Cupressaceae*	*tree*	E Medit	Black Sea Coast (*Northern*)	Petrova & al. (2019)
Cydonia oblonga Mill.	*Rosaceae*	*shrub*	C As	Tundzha Hilly Country	Petrova & Vassilev (2016)
Cyperus eragrostis Lam.	*Cyperaceae*	*per*	Am	Black Sea Coast (*Southern*), Mt Strandzha	Stoyanov & Barzov (2018)
Cyperus odoratus L.	*Cyperaceae*	*ann-per*	Am, Afr	Danubian Plain	Tzonev & al. (2003, as *C. strigosus*, rev. by Verloove 2014)
Cytisus scoparius (L.) Link	*Fabaceae*	*shrub*	Eur	Thracian Lowland	Kunev (2020)
Datura innoxia Mill.	*Solanaceae*	*ann*	N Am	Danubian Plain, Sofia Region, Znepole Region, Valley of River Struma (*Southern*), Thracian Lowland	Dimitrov (2005)
Diplachne fascicularis (Lam.) P. Beauv.	*Poaceae*	*ann*	N & S Am	Thracian Lowland	Vladimirov & Delcheva (2016)
Duchesnea indica (Andrews) Focke	*Rosaceae*	*per*	C As	Black Sea Coast (*Northern*), Sofia Region	Dimitrov (2001)

Species	Family	Life cycle	Origin	Floristic region of first report for the Bulgarian flora	Reference
Eclipta prostrata (L.) L.	*Asteraceae*	*ann-per*	Am	Northeast Bulgaria	Tzonev (2007)
Elaeagnus multiflora Thunb.	*Elaeagnaceae*	*shrub-tree*	E As	Black Sea Coast (*Northern*), Sofia Region	Dimitrov (2003)
Elodea nuttallii (Planch). H.St. John	*Hydrocharitaceae*	*per*	N Am	Danubian Plain, Thracian Lowland	Georgiev & al. (2011)
Epilobium adenocaulon Hausskn.	*Onagraceae*	*per*	N Am	Sofia Region, Znepole Region, Rila Mts	Kalníková & Palpurina (2015)
Erigeron sumatrensis Retz.	*Asteraceae*	*ann-bien*	S Am	Black Sea Coast (*Northern*), Northeast Bulgaria, Forebalkan (*Western*), Valley of River Struma (*Southern*), Pirin Mts (*Northern*), Rila Mts, Thracian Lowland	Vladimirov (2009)
Eucommia ulmoides Oliv.	*Eucommiaceae*	*tree*	E As	Black Sea Coast (*Southern*)	Tashev & Tashev (2015)
Euphorbia davidii Subils	*Euphorbiaceae*	*ann*	N Am	Black Sea Coast (*Northern*)	Vladimirov & Petrova (2009b)
Euphorbia prostrata Aiton	*Euphorbiaceae*	*ann*	C & S Am	Black Sea Coast (*Northern*), Northeast Bulgaria, Forebalkan (*Eastern*), Sofia Region, Valley of River Struma (*Southern*), Pirin Mts (*Southern*)	Vladimirov & al. (2014a)
Euphorbia serpens Kunth	*Euphorbiaceae*	*ann*	Am	Black Sea Coast (*Northern*)	Petrova (2018)
Fallopia × *bohemica* (Chrtek & Chrtkova) J.P. Bailey	*Polygonaceae*	*per*	Eur	Sofia Region, Znepole Region, Rhodopi Mts (*Northern*)	Petrova & Vladimirov (2002, sub *Reynoutria japonica*); Vladimirov (2006a)
Geranium sibiricum L.	*Geraniaceae*	*per*	As	Sofia Region	Tanev & Velev (2020)
Gleditsia triacanthos L.	*Fabaceae*	*tree*	N Am	Black Sea Coast, Northeast Bulgaria, Danubian Plain, Sofia Region, Thracian Lowland	Assyov & Petrova (2006)
Grindelia squarrosa (Pursh) Dunal	*Asteraceae*	*bien -per*	N Am	Black Sea Coast (*Northern*), Northeast Bulgaria, Sofia Region	Vladimirov & Petrova (2012)
Helianthus tuberosus L.	*Asteraceae*	*per*	N Am	Sofia Region	Vladimirov (2003)
Hemerocallis fulva (L.) L.	*Asphodelaceae*	*per*	As	Northeast Bulgaria, Forebalkan (*Eastern*), Sofia Region, Znepole Region, Valley of River Mesta, Rhodopi Mts (*Western*, *Central*), Thracian Lowland	Petrova & Vladimirov (2019)

Species	Family	Life cycle	Origin	Floristic region of first report for the Bulgarian flora	Reference
Heracleum mantegazzianum Sommier & Levier	*Apiaceae*	*bien-per*	W Caucasus	Sofia Region, Rhodopi Mts (*Western*)	Vladimirov & al. (2017b, as *Heracleum sosnowskyi*), Vladimirov & al. (2019)
Heracleum sosnowskyi Manden.	*Apiaceae*	*per*	E Caucasus	Rhodopi Mts (*Western*, *Central*)	Vladimirov & al. (2019)
Heteranthera rotundifolia (Kunth) Griseb.	*Pontederiaceae*	*ann*	C & S Am	Thracian Lowland	Cheshmedziev & Stojchev (2005)
Hieracium petraeum Bluff & Fingerh.	*Asteraceae*	*per*	C & SW Eur, NW Afr	Rila Mts	Vladimirov (2018)
Humulus japonicas Siebold & Zucc.	*Cannabaceae*	*ann*	E As	Northeast Bulgaria	Vladimirov (2019)
Impatiens balfourii Hook. f.	*Balsaminaceae*	*ann*	S As	Valley of River Struma	Adamowski (2009)
Ipomoea purpurea (L.) Roth.	*Convolvulaceae*	*ann*	S Am	Black Sea Coast (*Southern*)	Vladimirov (2020)
Koelreuteria paniculata Laxm.	*Sapindaceae*	*tree*	SE As	Rhodopi Mts (*Central*)	Vladimirov (2006b)
Lagarosiphon major (Ridl.) Moss	*Hydrocharitaceae*	*per*	S Afr	Rhodopi Mts (*Western*)	Dimitrov (2020)
Larix decidua Mill.	*Pinaceae*	*tree*	Eur	Rhodopi Mts (*Central*)	Petrova & Gerasimova (2017)
Laurus nobilis L.	*Lauraceae*	*tree*	Medit	Black Sea Coast (*Southern*)	Tashev & Tashev (2015)
Lavandula angustifolia Mill.	*Lamiaceae*	*shrub*	Medit	Balkan Range (*Eastern*), Sofia Region, Znepole Region	Assyov & Vassilev (2004)
Lemna minuta Kunth	*Lemnaceae*	*ann*	Am	Rhodopi Mts (*Eastern*), Thracian Lowland	Velichkova & Kirjakov (2016)
Lemna obscura (Austin) Daubs	*Lemnaceae*	*ann*	Am	Rhodopi Mts (*Eastern*), Thracian Lowland	Velichkova & Kirjakov (2016)
Lemna perpusilla Torr	*Lemnaceae*	*ann*	N Am	Thracian Lowland	Velichkova & Kirjakov (2016)
Lemna valdiviana Phil.	*Lemnaceae*	*ann*	Am	Thracian Lowland	Velichkova & Kirjakov (2016)
Lepidium virginicum L.	*Brassicaceae*	*ann*	N Am	Northeast Bulgaria	Stoyanov & Vladimirov (2015)
Lilium candidum L.	*Liliaceae*	*per*	SW Turkey	Thracian Lowland	Karakiev (2019)
Lupinus gredensis Gand.	*Fabaceae*	*ann*	C & W Iberian Peninsula	Rhodopi Mts (*Eastern*)	Stoyanov & Apostolova-Stoyanova (2022)
Lupinus polyphyllus Lindl.	*Fabaceae*	*per*	N Am	Balkan Range (*Western*)	Vassilev & Pedashenko (2009)

Species	Family	Life cycle	Origin	Floristic region of first report for the Bulgarian flora	Reference
Malcolmia africana (L.) W.T. Aiton	*Brassicaceae*	*ann*	Medit, C As	Black Sea Coast (*Northern*), Balkan Range (*Central*)	Dimitrov & Assyov (2003)
Modiola caroliniana (L.) G. Don.	*Malvaceae*	*ann-bien*	S Am	Thracian Lowland	Cheshmedzhiev & Sokolov (2007)
Mollugo verticillata L.	*Molluginaceae*	*ann*	Am	Valley of River Struma (*Southern*)	Kunev (2019)
Oenothera glazioviana Micheli	*Onagraceae*	*bien*	N Am	Valley of River Struma (*Northern*)	Kalníková & Palpurina (2015)
Oenothera laciniata Hill	*Onagraceae*	*ann*	N Am	Black Sea Coast (*Northern*)	Petrova & Barzov (2017)
Oenothera speciosa Nutt.	*Onagraceae*	*per*	S & N Am	Sofia Region, Pirin Mts (*Southern*)	Petrova (2017b)
Oenothera stricta Link	*Onagraceae*	*ann-bien*	S Am	Valley of River Struma (*Southern*)	Velčev & Vassilev (2002)
Opuntia engelmannii Engelm.	*Cactaceae*	*shrub*	N Am	Mt Sredna Gora (*Western*)	Naydenova & al. (2019)
Opuntia fragilis (Nutt.) Haw.	*Cactaceae*	*shrub*	N Am	Mt Sredna Gora (*Western*)	Naydenova & al. (2019)
Opuntia macrorhiza Engelm.	*Cactaceae*	*shrub*	N Am	Black Sea Coast (*Southern*)	Stoyanov & al. (2021)
Oxalis articulata Savigny	*Oxalidaceae*	*per*	S Am	Black Sea Coast (*Northern*), Sofia Region, Valley of River Struma (*Southern*)	Petrova & Vladimirov (2019)
Panicum dichotomiflorum Michx.	*Poaceae*	*ann*	N Am	Northeast Bulgaria	Petrova & Vladimirov (2012)
Parthenocissus inserta (A. Kern.) Fritsch	*Vitaceae*	*shrub*	N Am	Sofia Region	Zieliński & al. (2012)
Parthenocissus quinquefolia (L.) Planch.	*Vitaceae*	*shrub*	N Am	Northeast Bulgaria, Forebalkan (*Eastern*)	Petrova (2006)
Paspalum distichum subsp. *paucispicatum* (Vasey) Verloove & Reynders.	*Poaceae*	*per*	Am	Danubian Plain	Kunev (2023)
Phalaris arundinacea var. *picta* L.	*Poaceae*	*per*	N Am, N Afr	Balkan Range (*Western*, *Central*), Sofia Region, Rhodopi Mts (*Western*, *Central*)	Petrova & Vladimirov (2019)
Physalis peruviana L.	*Solanaceae*	*per*	S Am	Valley of River Struma (*Southern*)	Kunev (2021a)
Physalis philadelphica Lam.	*Solanaceae*	*ann*	N Am	Black Sea Coast (*Southern*)	Vladimirov & Tashev (2017)

Species	Family	Life cycle	Origin	Floristic region of first report for the Bulgarian flora	Reference
Phytolacca acinosa Roxb.	*Phytolaccaceae*	*per*	E As	Sofia Region	Zieliński & al. (2012, sub. *Ph. esculenta*)
Pinus pinaster Aiton	*Pinaceae*	*tree*	W & C Medit	Black Sea Coast (*Northern*, *Southern*)	Petrova & al. (2017)
Platycladus orientalis (L.) Franco	*Cupressaceae*	*tree*	As	Northeast Bulgaria	Vladimirov (2012, sub *Thuja orientalis*)
Prunus serotina Ehrh.	*Rosaceae*	*tree*	N Am	Vitosha Region	Zieliński & al. (2012)
Ptelea trifoliata L.	*Rutaceae*	*shrub-tree*	N Am	Black Sea Coast (*Southern*)	Tashev & al. (2016)
Pseudotsuga menziesii (Murb.) Franco	*Pinaceae*	*tree*	N Am	Mt Sredna Gora (*Western*)	Assyov & Petrova (2006)
Rhus typhina L.	*Anacardiaceae*	*shrub-tree*	E N Am	Black Sea Coast (*Southern*)	Vladimirov & Tashev (2023)
Ribes aureum Pursh	*Grossulariaceae*	*shrub*	N Am	Balkan Range (*Western*), Vitosha Region	Zieliński & Petrova (2012)
Rosa rugosa Thunb.	*Rosaceae*	*shrub*	E As	Black Sea Coast (*Northern*), Balkan Range (*Western*), Rhodopi Mts (*Central*)	Vladimirov & al. (2018)
Rotala ramosior (L.) Koehne	*Lythraceae*	*ann*	Am	Thracian Lowland	Gussev & al. (2020)
Salvia hispanica L.	*Lamiaceae*	*ann*	N Am	Valley of River Struma (*Southern*)	Kunev (2021a)
Sedum sarmentosum Bunge	*Crassulaceae*	*per*	SE As	Forebalkan (*Eastern*), Sofia Region, Pirin Mts (*Southern*)	Petrova (2017b)
Senecio inaequidens DC.	*Asteraceae*	*per*	S Afr	Sofia Region	Vladimitrov & Petrova (2009a)
Sicyos angulatus L.	*Cucurbitaceae*	*ann*	N Am	Danubian Plain	Tzonev (2005)
Silene pendula L.	*Caryophyllaceae*	*ann*	Medit	Thracian Lowland	Tashev & al. (2022)
Silphium perfoliatum L.	*Asteraceae*	*per*	N Am	Northwest Bulgaria	Vladimirov & Petrova (2010)
Sisyrinchium rosulatum E.P. Bicknell	*Iridaceae*	*ann*	Am	Valley of River Struma (*Southern*)	Stoyanov & al. (2023)
Solanum elaeagnifolium Cav.	*Solanaceae*	*per*	C Am	Valley of River Struma (*Southern*)	Vladimirov & al. (2015)
Solidago gigantea Aiton	*Asteraceae*	*per*	N Am	Northeast Bulgaria, Balkan Range (*Central*), Sofia Region, Pirin Mts, Rhodopi Mts (*Western*), Thracian Lowland	Vladimirov (2003)
Stachys byzantina K. Koch	*Lamiaceae*	*per*	SW As	Rila Mts	Petrova (2017a)
Sternbergia lutea Spreng.	*Amaryllidaceae*	*per*	Medit, W & C As	Valley of River Struma (*Southern*)	Vladimirov & al. (2016)

Species	Family	Life cycle	Origin	Floristic region of first report for the Bulgarian flora	Reference
Symphoricarpos albus (L.) S.F. Blake	*Caprifoliaceae*	*shrub*	N Am	Sofia Region. Znepole Region	Zieliński & Petrova (2012)
Symphyotrichum novi-belgii (L.) G.L. Nesom	*Asteraceae*	*per*	N Am	Northeast Bulgaria, Danubian Plain, Forebalkan (*Eastern*), Balkan Range (*Central*), Sofia Region, Znepole Region, Valley of River Struma, Rila Mts, Mt Sredna Gora (*Western*), Thracian Lowland	Petrova & al. (2013)
Symphyotrichum squamatum (Spreng.) G.L. Nesom	*Asteraceae*	*per*	S Am	Black Sea Coast (*Northern*), Valley of River Struma (*Southern*)	Dimitrov & Assyov (2003, as *Aster squamatus*)
Tagetes patula L.	*Asteraceae*	*ann*	N Am	Pirin Mts (*Southern*), Thracian Lowland	Petrova (2017b)
Veronica filiformis Sm.	*Scrophulariaceae*	*subshrub*	Krym, N & E Turkey, Caucasus	Sofia Region	Dimitrov & Assyov (2003)
Vincetoxicum nigrum (L.) Moench	*Asclepiadaceae*	*per*	SW Eur	Sofia Region	Petrova (2010)

Ambrosia artemisiifolia, *A. trifida*), 'contaminants on plants', 'stowaways' on different means of transport (e.g. *Senecio inaequidens*), 'corridor' (e.g. *Bidens frondosa*, *B. vulgata*, *Eclipta prostrata*), and 'unaided' (e.g. *Elodea nuttallii*).

An analysis of the periods of first report of the aliens demonstrates a clear pattern (Fig. 1).

If the data published by Petrova & al. (2012) is taken into account, one can see that since 1991–1995 the number of reported species has been significantly increasing (10 times) by 2016–2020. There are two main reasons for this: 1. By 2005, alien species have been a neglected group of plants in the floristic studies; 2. Since 2004, several projects devoted particularly to

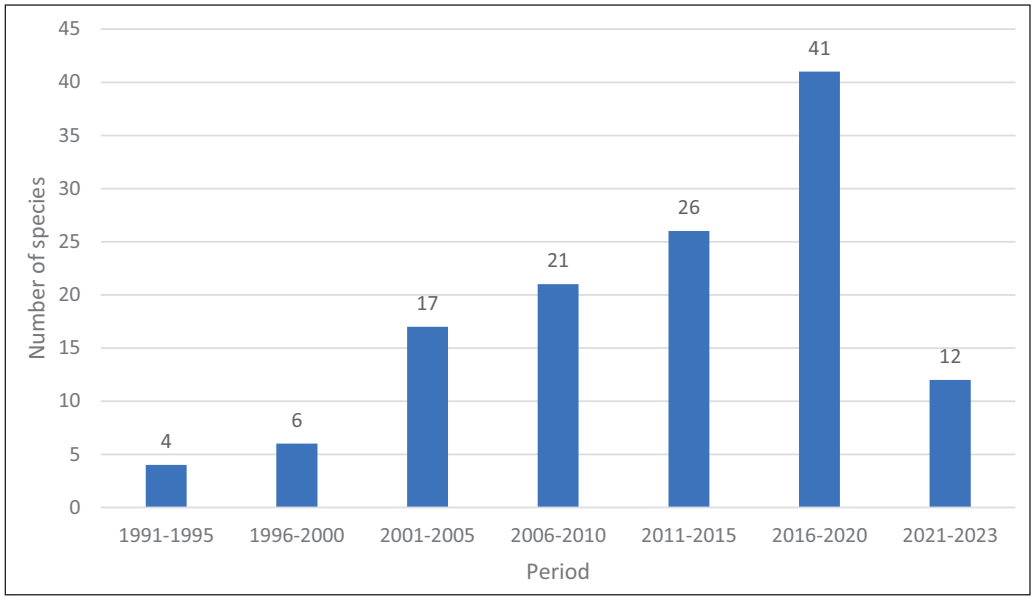

Fig. 1. Number of alien species by period of first report for the Bulgarian flora.

alien species have been funded and conducted: "*Assessment of species alien to the Bulgarian flora and mycota and measures to limit their impact on natural ecosystems and local species*" (2004–2006), "*Biology, ecology and control of invasive alien species in the Bulgarian flora*" (2009–2012), "*East and South European Network for Invasive Alien Species – a tool to support the management of alien species in Bulgaria* (ESENIAS – TOOLS)" (2015–2017), and "Improving the Bulgarian Biodiversity Information System (IBBIS), Task 3: *Module for data collection and risk assessment of invasive alien species in Bulgaria*" (2015–2017). The fact that these projects specifically focus attention on the alien species in the Bulgarian flora has led to the discovery of a number of naturalized species. In most cases, these species were introduced much earlier, but their occurrence in natural and seminatural habitats remained unnoticed for a long period of time. In regard to this, no direct relationship should be sought between the time of introduction and the time of first report of these species as new for the alien Bulgarian flora. The number of first reports of alien species appears to have reached its peak in the period 2016–2020, and such large numbers of aliens are not expected to be discovered in the Bulgarian flora in the coming years.

An analysis of data for the floristic regions, where the alien species have been first discovered and reported, also shows a clear pattern. The regions with the greatest number of species are in the lower parts of the country, where there are large settlements and active economic activity is carried out (transport, agriculture, tourism): Sofia region, Black Sea Coast, Thracian Lowland, Northeast Bulgaria, Rhodopi Mts, Valley of River Struma, and Danubian Plain (Fig. 2). On the other hand, mountainous areas, where there are no large settlements and where there are protected areas with a stricter protection regime, e.g. Mt Belasitsa and Mt Slavyanka, are not among the floristic areas where new species alien to the Bulgarian flora have been recorded since 2000. Some of the most vulnerable habitats are: urban and suburban sites, cultivated areas of gardens and parks, transport networks (road and rail networks, disused

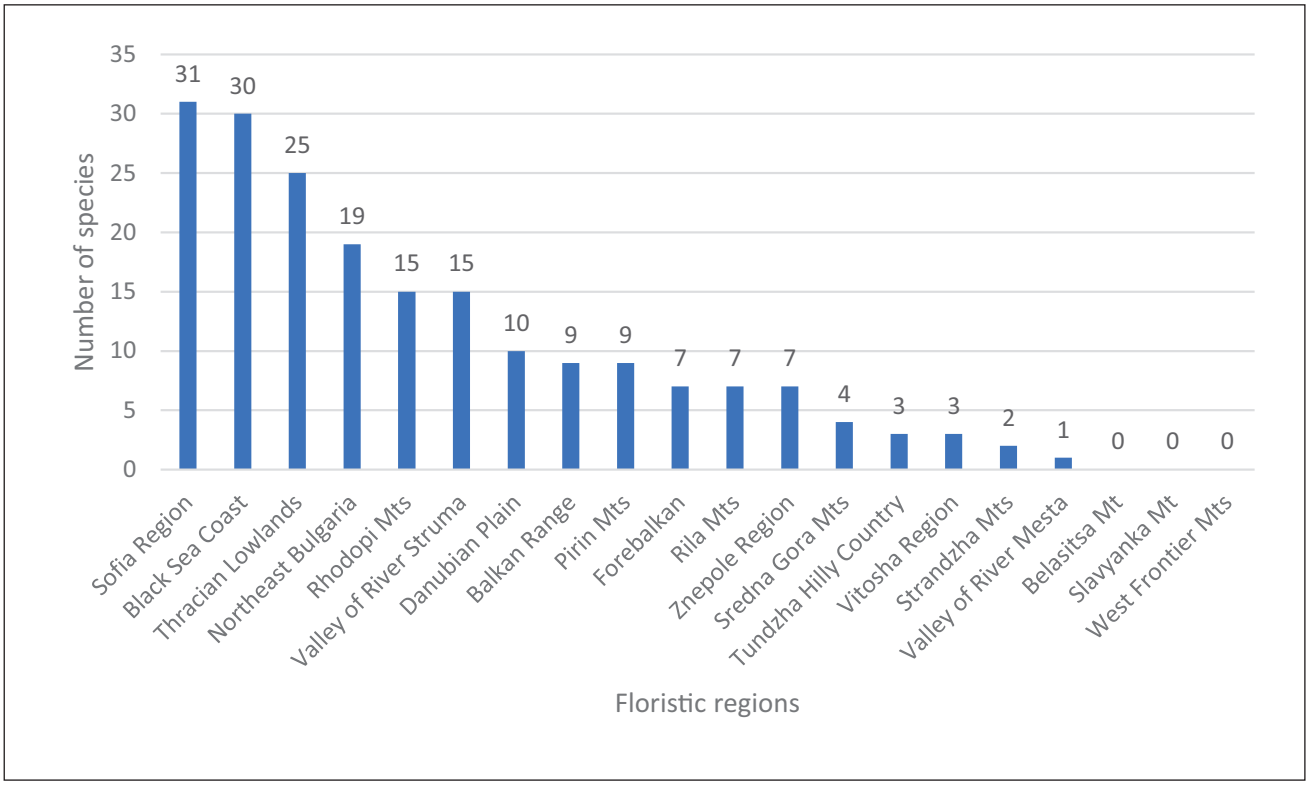

Fig. 2. Number of alien species first reported for Bulgaria as distributed by floristic regions.

roads and rails, hard-surfaced areas of ports), waste deposits, and sparsely vegetated land – coastal dunes and sandy shores, periodically inundated shores of inland surface waterbodies with pioneer and ephemeral vegetation.

Some of the reported species already demonstrate invasive behaviour, either on a local scale, or across the country, e.g. *Ambrosia artemisiifolia*, *Bidens frondosa*, *Elodea nuttallii*, *Erigeron sumatrensis*, *Fallopia ×bohemica*, *Gleditsia triacanthos*, *Helianthus tuberosus*, *Heracleum sosnowskyi*, *Humulus japonicus*, *Koelreuteria paniculata*, *Parthenocissus inserta*, *Parthenocissus quinquefolia*, *Solidago gigantea*, etc. On the other hand, some of the species are casual and cannot be considered naturalized yet, e.g. *Lilium candidum*, *Physalis peruviana*, *Physalis philadelphica*, *Salvia hispanica*, and *Tagetes patula*.

This analysis shows that alien species should not be neglected in floristic research. Although the peak in the number of newly registered alien plants has probably been reached, such species will undoubtedly be discovered in the future. Targeted projects, in which attention is focused particularly on this group of plants, are most effective in terms of the recording of new alien species. That is why it is necessary to periodically develop and implement such projects. Citizen science will also play an increasingly important role, as interest in different plants and visits to different parts of the country make it possible to record species unknown to the Bulgarian flora, as was the case, for example, with *Campanula lactiflora* and *Heracleum mantegazzianum*. Prevention of introduction or the earliest possible detection of invasive or potentially invasive alien species is crucial to managing invasive alien species in the country and minimizing risks to native biodiversity.

Acknowledgements. This work was carried out within the framework of the National Science Program "Environmental Protection and Reduction of Risks of Adverse Events and Natural Disasters", approved by Resolution No 577/17.08.2018 of the Council of Ministers and supported by the Ministry of Education and Science (MES) of Bulgaria (Agreement No Д01-271/09.12.2022).

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