

NEW WOODY ALIEN PLANT SPECIES RECORDED IN LITHUANIA

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Abstract

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Many woody plant species that originate from various regions of the world have been introduced in other regions or continents and are used in ornamental gardening, silviculture, erosion control, for fruit sources or other purposes. Woody plants selected for introduction usually originate from regions with similar climate conditions; therefore, after certain time lag they start to spread outside places of cultivation, become naturalized or even invasive. In addition to 77 woody alien plant species reported in Lithuania, ten new species were recorded and analysed in this paper. Information on the native and anthropogenic ranges, first record in Lithuania, size of populations, habitats, reproduction and naturalization of *Aralia elata*, *Berberis thunbergii*, *Caragana frutex*, *Celastrus orbiculatus*, *Cornus alba*, *Cytisus austriacus*, *Hydrangea arborescens*, *Pinus strobus*, *Rhus typhina* and *Thuja occidentalis* is presented. All these species have been introduced intentionally and are used mainly in ornamental gardening. Three of the reported species, *Berberis thunbergii*, *Hydrangea arborescens* and *Thuja occidentalis*, currently are casual species. Remaining seven species were recognized as naturalized in Lithuania, and five of these, i.e. *Aralia elata*, *Celastrus orbiculatus*, *Cornus alba*, *Pinus strobus* and *Rhus typhina* as well as *Berberis thunbergii*, which currently is treated as a casual, have very high or high probability of getting invasive. Constant survey of potential habitats, detection of new escaped alien plants, particularly of trees and shrubs, is the best way to reveal potentially dangerous species and make timely decisions for their control or eradication, if necessary.

Keywords: distribution, invasion, naturalization, ornamental plants, reproduction, shrubs, trees.

INTRODUCTION

In the past few centuries, humans have introduced thousands of woody plant species in almost all regions of the world, and in recent decades, many species of trees and shrubs have become naturalized or invasive (RICHARDSON & REJMÁNEK, 2011). Almost all alien species of trees and shrubs currently known in Europe have been introduced for their aesthetic values, for purposes of erosion control, use in silviculture or gardening. Woody species to Central Europe the most intensively were introduced in the 19th and first half of the 20th centuries (KOWARIK, 1995; RICHARDSON, 1998, etc.). Introduction of ornamental plants in general contributed the most to the increase of alien species in Europe as well as in other regions

of the world (PYŠEK et al., 2009; RICHARDSON & REJMÁNEK, 2011; PERGL et al., 2016a).

The analysis of tree and shrub invasion on a global scale, performed by RICHARDSON & REJMÁNEK (2011), has revealed 622 species (357 species of trees and 265 species of shrubs) which are invasive at least in one region. At a regional scale, Europe with 107 woody invasive alien species (59 species of trees and 48 species of shrubs) is in the fifth place together with New Zealand. Regions with the largest number of woody invasive alien species are Australia (183 species), southern Africa (170 species), North America (163 species), and Pacific Islands (147 species). They found that only between 0.5% and 0.7% of the world's tree and shrub species are currently invasive outside their natural range (RICHARDSON &

REJMÁNEK, 2011). However, the studies on invasiveness and naturalization of woody species at a smaller scale show quite contrasting results. The analysis of 94 temperate species of trees and shrubs with native ranges in Central Europe showed that 27% of the species are known to be invasive in at least one region of the world (PYŠEK et al., 2014). Evaluation of naturalization success of introduced woody species on even smaller scale, i.e. on the scale of country or region of a country, the portion of naturalized and invasive woody species may increase even more significantly because of the influence of local natural conditions, history of ornamental plant introduction, culture and local traditions (GUDŽINSKAS, 2005).

Almost 800 introduced and with different frequency cultivated species of trees and shrubs have been registered in Lithuania (JANUŠKEVIČIUS et al., 2006; NAVASAITIS, 2008) and the process of introduction continues. Thus, high probability of new records of escaped woody species exists, because many of introduced species successfully reproduce in cultivation (JANUŠKEVIČIUS et al., 2006).

Based on previously published data, 77 species of alien trees and shrubs that belong to 47 genera have been reported occurring in Lithuania (GUDŽINSKAS, 1999; GUDŽINSKAS & ŽALNERAVIČIUS, 2015). Most of woody alien species belong to the Rosaceae family (29 species), whereas other families include less than six woody species.

Of the 18 alien plant species legally recognized invasive in Lithuania (GUDŽINSKAS & ŽALNERAVIČIUS, 2017), six are woody plants: three species of trees (*Acer negundo*, *Prunus serotina*, *Robinia pseudoacacia*) and three species of shrubs (*Amelanchier spicata*, *Cytisus scoparius*, *Rosa rugosa*).

The aim of this study was to evaluate distribution and status of the newly reported woody alien species as well as to estimate probability of their future spread and invasion in Lithuania.

MATERIALS AND METHODS

Alien plant species reported in this paper were collected in various regions of Lithuania mainly in the period from 2000 to 2017. Herbarium specimens of the reported plant species collected by the authors were deposited at the Herbarium of the Institute of Botany of the Nature Research Centre (BILAS). Two

alien woody species, *Cornus alba* and *Cytisus austriacus*, were recorded several decades ago by other researchers and their specimens deposited at BILAS were also studied. Populations of *Aralia elata*, *Cytisus austriacus* and *Pinus strobus* have been surveyed for several years aiming to reveal dynamics of their populations and evaluate generative and (or) vegetative reproduction.

Alien plant species in the text were arranged in alphabetical order. Plant families were provided in accordance with an updated Angiosperm Phylogeny Group classification for the orders and families of flowering plants (APG, 2016) and classification of extant gymnosperms (CHRISTENHUSZ et al., 2011).

Distribution maps of several alien woody species in Lithuania were compiled using a system of grid cells. The grid cells were arranged according to geographical co-ordinates with sides 6' latitude and 10' longitude. The area of grid cells varies from 116.5 km² in the northern to 123.2 km² in the southern part of Lithuania (GUDŽINSKAS, 1993). All localities recorded in the same grid cell on the map were marked by a single symbol. Maps of distribution were created employing *Adobe Illustrator 9.0.2 CE* software.

The list of selected examined herbarium specimens was provided in Appendix I. Geographical co-ordinates, when available, were indicated according to *WGS 1984* standard.

RESULTS

***Aralia elata* (Miq.) Seem.** (Araliaceae Juss.). Small tree or shrub with few branched stems covered with prickles. Leaves pinnately compound, with a pair of accessory leaflets at each division of rachis. Inflorescence is terminal panicle formed of umbels, densely yellow-brown or gray pubescent, without prickles. Fruit – globose berry, 3–4 mm in diameter (STACE, 1997; XIANG & LOWRY, 2007).

This species is native to East Asia (China, Japan, Korean peninsula and East Russia), where it grows in forests, along forest margins, in scrub fields and on roadsides (XIANG & LOWRY, 2007). In Europe and North America, *A. elata* is cultivated for ornamental purposes and it is also occasionally recorded as an alien species. In North America, this species is considered as potentially invasive (MOORE et al., 2009; GILMAN, 2016). Escaped populations of this species

in Europe have been recorded in Austria (BERG et al., 2009), Belgium (VERLOOVE, 2006), Great Britain (STACE, 1997; PRESTON et al., 2002) and Norway (GEDERAAS et al., 2012).

In Lithuania, escaped from cultivation this species was first recorded in 2004. Four individuals were found in grey alder stand on the bank of the River Veržuva (Vilnius city, Veržuva). One individual was about 3 m high, whereas other three individuals, probably grown from rhizomes, were about 1 m high. The same locality of *A. elata* was surveyed in 2017. Because of vegetative reproduction and spread, the area occupied by *A. elata* increased significantly and comprised about 300 m². A total of more than 80 plants were registered. Three of these were more than 5 m high, the height of about 50 individuals ranged from 1 m to 2 m and more than 30 individuals were less than 1 m high. It is evident that *A. elata* spreads quite intensely by rhizomes. Though flowering of this species in the surveyed locality was not recorded, plants cultivated in open areas produce many fruits and spread by seeds is possible. Means of introduction of *A. elata* in this locality are not known, but probably rhizomes or young plants were brought with garden wastes or by water from other places. Now this species is considered as locally naturalized and its further spread is very probable. New records of *A. elata* in the vicinity of settlements are expected and its capability for invasion should be monitored in Lithuania.

***Berberis thunbergii* DC.** (Berberidaceae Juss.). Small, usually about 1 m (rarely up to 3 m) high shrub with angulate, dark red branches. Spines simple, occasionally trifid. Leaves obovate, spatulate or rhombic ovate, grayish green (in most cultivars and escaped plants dark red). Inflorescence an umbel with 2–5 flowers. Sepals in two whorls, outer reddish. Petals light yellow or tinged with red. Fruit ellipsoid, about 8 mm long, shiny red berry with one or two seeds (WHITTEMORE, 1997; JUNSHENG, 2011).

Originating from Japan, *B. thunbergii* is widely cultivated for ornamental purposes, and it occurs as alien or even invasive species in many regions (MOSHER et al., 2009; JUNSHENG, 2011; BRAND et al., 2012). Popularity of *B. thunbergii* among the gardeners contributed significantly to its quite rapid spread and, therefore, in Canada and in several states of the United States of America, cultivation of this highly invasive species

is banned (WHITTEMORE, 1997; BRAND et al., 2012). Temporarily escaped from cultivation or as naturalized plant, *B. thunbergii* in Europe has been recorded in Austria (CHRISTENHUSZ & VAN UFFELEN, 2001), Belgium (VERLOOVE, 2006), the Czech Republic (PYŠEK et al., 2012), Germany (ADOLPHI, 1997), the Netherlands (FOLLAK et al., 2014), Norway, (GEDERAAS et al., 2012), Slovakia (MEDVECKÁ et al., 2012). In North America, *B. thunbergii* occurs in recently abandoned fields and pastures, reforested agricultural fields and deciduous woodlands (MOSHER et al., 2009; BRAND et al., 2012). In European countries, for example in Norway, this species occupies mainly coastal, forest, wetland and alluvial habitats, though occasionally it invades rock habitats (GEDERAAS et al., 2012). In Slovakia, *B. thunbergii* occurs mainly in human-made habitats (MEDVECKÁ et al., 2012), whereas in Austria, it invades a wide range of habitats, but mostly occurs on the edges of natural forests and in adjacent areas (FOLLAK et al., 2014).

In Lithuania, *B. thunbergii* is widely cultivated for ornamental purposes. Escaped individuals were first found in May 2016. Two shrubs of different size were recorded in a mixed forest habitat (*Picea abies* and *Betula pendula* stand with dense understorey of *Corylus avellana*) in the vicinity of Vanaginė (Vilnius city). One individual was at the beginning of flowering, whereas another young, about 0.5 m high shrub was in pre-generative stage. Another locality was revealed in Užutrakis (Trakai distr.) in 2016, on the shore of Lake Galvė, on the edge of reed-bed. Three shrubs with numerous unripe fruits were found. Another locality of escaped *B. thunbergii* was registered in the vicinity of Paneriai village (Elektrėnai distr.) in 2017. Two shrubs with ripening fruits grew close to the edge of pine forest glade, among young individuals of *Sorbus aucuparia*. Currently *B. thunbergii* in Lithuania should be ascribed to the group of casual species. Further spread and naturalization of this species is highly probable in Lithuania, because cultivated plants produce large quantities of fruits.

***Caragana frutex* (L.) K. Koch** (Fabaceae Lindl.). Shrubs usually 1–1.5 m, occasionally up to 2 m high. Branches brown, yellowish gray or dark grayish green. Leaves digitate, compound of four leaflets and 2–10 mm long petiole. Leaflet blades obovate or obovate-lanceolate, 6–10 mm long and 3–5 mm wide, glabrous or sparsely pilose. Flowers solitary

or two in a fascicle. Legume cylindric, 2–3 cm long (YINGXIN et al., 2010).

The native range of *C. frutex* includes South-East Europe eastwards from Bulgaria to the Caucasus, Siberia, Central and East Asia (BALL, 1968; YINGXIN et al., 2010). In the area of native distribution, it grows on dry slopes, in sparse woodlands, along forest edges. Formerly *C. frutex* was cultivated for ornamental purposes and in hedgerows, but now it is quite rare in cultivation. In Europe, outside of its native range as escaped from cultivation, *C. frutex* has been recorded in Austria (ESSL & RABITSCH, 2002), Hungary (KOHÁRI & PILLINGER, 2005), Norway (GEDERAAS et al., 2012), Sweden (KARLSSON, 1998) and Latvia (RUTKOVSKA et al., 2017).

In Lithuania, outside of places of cultivation, this species was first recorded in the environs of Tverečius (Ignalina distr.) in 2000. Quite large thickets of *C. frutex* occupied forest edge habitat. Means of introduction of *C. frutex* to this locality are unknown, as it is in ca. 1 km distance from the village; however, we suppose that vegetative parts of the plant got into the locality with garden wastes. In the same year, another locality of this species was revealed at the northern outskirts of Žagarė village (Joniškis distr.). Individuals were dispersed over a large area and mainly concentrated on a steep slope. In the period from 2000 to 2017, eleven new localities were revealed in Ignalina (Garalaukis, Navikai, Rimšė, Palūšė), Mažeikiai (Ašvėnai), Rokiškis (Lukštai), Švenčionys (Magūnai), Trakai (Užutrakis) and Zarasai (Lupenka, Smalvos, Zarasai) districts

(Fig. 1). In most cases *C. frutex* was recorded growing along forest edges, on open slopes, occasionally in sparse woodlands. Though this species produces seeds, we have no data about its generative reproduction in the country, but it spreads intensely by vegetative means. Currently, *C. frutex* is a naturalized species in Lithuania, however, its invasion is unlikely.

***Celastrus orbiculatus* Thunb.** (Celastraceae R. Br.). Deciduous woody climber with long, glabrous, gray-brown or brown branchlets. Leaf blade broadly ovate, suborbicular or rectangular-elliptic, 5–13 cm long and 3–9 cm wide, glabrous or on lower surface sparsely pubescent on veins. Leaf-base broadly cuneate to obtuse-orbicular, margin serrate, apex broadly rounded or shortly acuminate. Cymes axillary, sometimes terminal, 1–3 cm long, with 1–7 flowers. Capsule almost globose, 8–13 mm wide, yellow, with three valves. Seeds elliptic, slightly flat, reddish brown, with orange-red aril (ZHIXIANG & FUNSTON, 2008).

This species is native to East Asia and its range includes Central and North Japan, Korea and China north of the River Yangtze. It occurs in mixed forests, along forest margins, in thickets and on grassy slopes from lowlands to the mountains. This species tolerates very wide range of climates (OHWI, 1965; WILLIAMS & TIMMINS, 2003; ZHIXIANG & FUNSTON, 2008). In North America and New Zealand, this species is invasive and occupies large areas of temperate forests and alluvial woods as well as along roads (WILLIAMS & TIMMINS, 2003; PANDE et al., 2007; LEICHT-YOUNG et al., 2007). In Europe, this species as casual or naturalized alien has been registered in Belgium (VERLOOVE, 2006), the Czech Republic (PYŠEK et al., 2012), Germany (MAYER et al., 2017), Great Britain (STACE, 1997), Norway (GEDERAAS et al., 2012) and Poland (TOKARSKA-GUZIĆ et al., 2012).

In Lithuania, escaped from cultivation *C. orbiculatus* was first recorded in the environs of Palanga city, near Palanga Airport in June 2014. It was found growing on the edge of shrubbery and occupied about 20 m². Another locality of this species was revealed in the vicinities of Babrungėnai village (Žemaitija National Park, Plungė distr.). Dense thickets of *C. orbiculatus* occupy forest glade and surrounding mixed stand. Two populations of this species were recorded in Vilnius. The first locality was found in

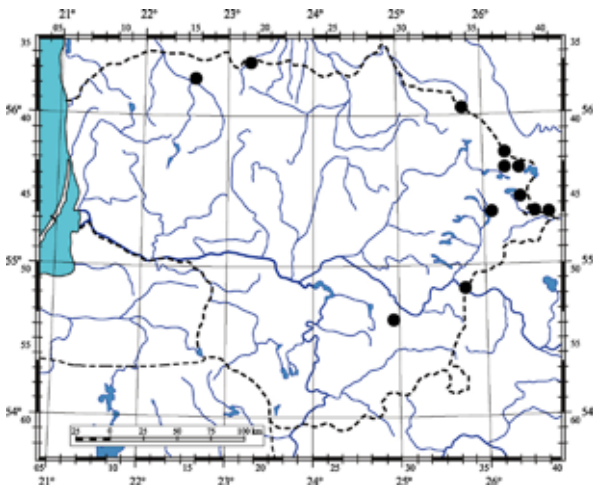


Fig. 1. Distribution of *Caragana frutex* in Lithuania



Fig. 2. *Celastrus orbiculatus* with ripe fruits (September 2016, Vilnius)

Visoriai (the north-western part of Vilnius city) in a mature mixed forest. The second locality with very large population of *C. orbiculatus* was discovered in a mature pine forest in Aukštieji Paneriai (the south-eastern part of Vilnius city). In this locality, *C. orbiculatus* occupies large area; individuals reach the top of pine-trees, produce large quantity of fruits (Fig. 2) and reproduce by seeds. Currently, this species is naturalized in Lithuania and further its spread and even invasion is expected.

***Cornus alba* L.** (Cornaceae Bercht. et J. Presl). Deciduous, much branched shrub up to 3 m high. Bark purplish red, young branches pubescent with whitish trichomes, later glabrous. Leaf blade elliptic or ovate-elliptic, 5–9 cm long and 2–6 cm wide, with appressed trichomes on the upper surface and glaucous green on the lower surface. Corymbose cymes dense. Flowers white or yellowish white. Fruit white or bluish white at maturity, about 8 mm long. Seeds rhombic, laterally compressed (XIANG & BOUFFORD, 2005; ZIELIŃSKI et al., 2014).

For a long time, *C. alba* L. native to Eurasia, has been treated as separate species from the North American *C. sericea* L. However, most of taxonomists tend to include *C. sericea* into *C. alba* as a subspecies (*C. alba* subsp. *stolonifera* (Michx.) Wangerin) (STACE, 1997; ZIELIŃSKI et al., 2014, etc.). Though *C. sericea* in the *Flora of North America* is accepted at the rank of species, the authors note that there is a little doubt that the European species *C. alba* is closely related to *C. sericea* and should be included into any future studies of this species complex (MURRELL & POINDEXTER, 2016). Here we also accept *C. alba* in a wide sense.

The native range of *C. alba* s.l. (with two subspecies, subsp. *alba* and subsp. *stolonifera* (Michx.) Wangerin) includes north-Eastern Europe, Siberia, East Asia and North America (XIANG & BOUFFORD, 2005; CHARLES-DOMINIQUE et al., 2009; ZIELIŃSKI et al., 2014). In Denmark, Finland, Slovenia and Sweden, *C. alba* has been listed as an invasive species quite recently (BAČIČ et al., 2015), whereas in Great Britain, the concern about invasiveness of this species was emphasized in 1980s (KELLY, 1990). It invades various types of forest habitats, including swamps, also meadows, riparian zones, wetlands and floodplains. This species has also been recorded in Austria (ESSL & RABITSCH, 2002), Germany (KEIL & LOOS, 2005), Finland (JONSELL, 2010a), Norway (GEDERAAS et al., 2012), Poland (ZIELIŃSKI et al., 2014), Slovakia (MEDVEČKÁ et al., 2012), Switzerland (WITTENBERG et al., 2005) and possibly in other European countries.

In Lithuania, escaped from cultivation *C. alba* was first recorded in the environs of Giruliai settlement (Klaipėda distr.), at a forest track in June 1974 by J. Jankevičienė. This species was registered in a few localities in the environs of Lentvaris railway station (Trakai distr.) in 1987 and in the vicinity of Nemėžis village (Vilnius distr.) in 1992. Nevertheless, to date, this species is not included into the list of alien species of Lithuania (GUDŽINSKAS, 1999). Intense spread of *C. alba* in Lithuania started more than decade ago and numerous new localities were revealed in various regions of the country. This species invades various habitats, however, the most frequently it is recorded in wet meadows, in swamp alder stands, along rivers, though quite often it invades various anthropogenic habitats. Currently, *C. alba* is fully naturalized and spreading alien species with traits of invasiveness. A

detailed study on the distribution, habitat preferences and populations of *C. alba* will be analysed in a separate publication.

***Cytisus austriacus* L.** (*Chamaecytisus austriacus* (L.) Link.; Fabaceae Lindl.). Small, usually up to 0.7 m high shrub with erect, densely hairy branches. Leaves trifoliolate, with 15–25 mm long and 3–6 mm wide, densely silvery hairy leaflets. Flowers usually in capitulate terminal (sometimes lateral) inflorescences. Calyx with two lobes. Upper lobe divided into two teeth, lower lip usually with three teeth. Corolla deep to pale-yellow, sometimes white, after anthesis turning yellowish-brown or reddish-brown (Fig. 3). Legume 20–30 mm long and about 5 mm wide, appressed-hairy (HEYWOOD & FRODIN, 1968; CRISTOFOLINI, 1991).

The native range of this species includes the southern and eastern parts of Central Europe and the southern part of East Europe. It is distributed from Germany, Austria and southern Poland to Balkan region, Ukraine and South Russia, where it occupies dry grasslands, slopes, forest glades and forest edges, usually on dry sandy soils (HEYWOOD & FRODIN,

1968; CRISTOFOLINI, 1991). There is no available information on occurrence of this alien species in other regions. *C. austriacus* is highly variable species and includes a complex of varieties differing by the form of leaflets, their hairiness, indumentum of calyx, etc. (CRISTOFOLINI, 1991). Plants from Lithuania according to most of the characters well correspond to the type variety (var. *austriacus*), except the dark spot on the standard. However, the number of teeth of the lower lobe of calyx is very variable on the same plant and even in the same head. Usually one or two flowers with three teeth of the lower calyx lobe are present in the head, while the lower lobe of other flowers is undivided or with two teeth.

Quite large population of this species was found by the first author of this paper in Smėlynė (the north-eastern part of Vilnius city) in August 2005, however, the study of herbarium samples provided by an amateur botanist V. Rinkevičius revealed that he recorded this species in the same locality nine years earlier, in August 1996. On the label of the herbarium specimen, the collector indicated that on the edge of the forest and in the forest approximately 50 individuals were counted. In 2005, *C. austriacus* occupied

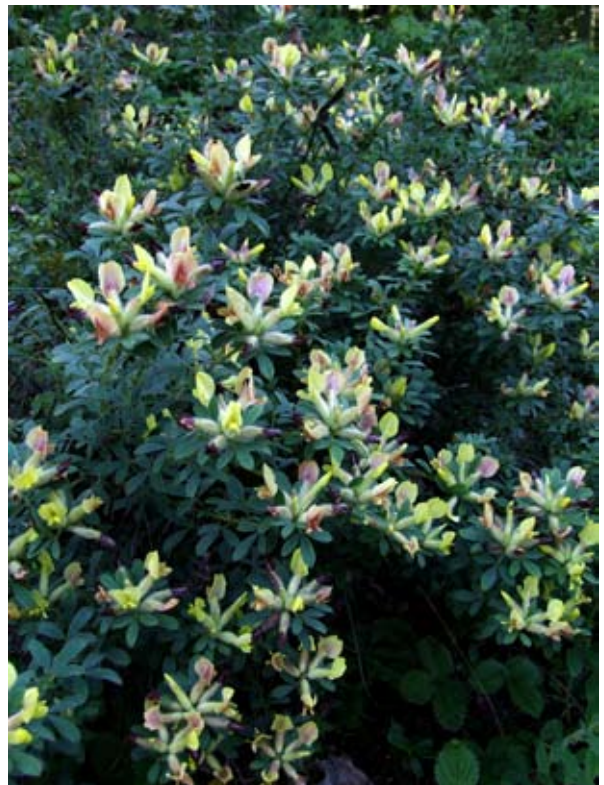


Fig. 3. Inflorescence of *Cytisus austriacus* (a) and abundantly flowering individual (b) (Vilnius, Smėlynė, 2009)

about 16 m long and 4 m wide belt in pine stand and along its edge, and the entire population comprised of more than 60 mature individuals. The survey of the population in 2017 revealed the decrease of mature individuals; however, solitary seedlings were recorded in more than 30 m long section of the eroded slope on the edge of the forest. Thus, this population of *C. austriacus* has survived for more than 20 years, and the species is considered as naturalized in Lithuania. However, its further spread and invasion is not expected.

***Hydrangea arborescens* L.** (Hydrangeaceae Dumort.). Shrubs up to 3 m high, with strigose hirsute twigs. Leaves opposite, glabrous or glabrous on the upper surface and sparsely tomentose on the lower surface, ovate, elliptic-ovate or broadly ovate, 6–15 cm long and 3–12 cm wide, base cordate, truncate or cuneate, margins dentate to serrate, apex acute to acuminate. Inflorescences compact, many-flowered, usually hemispheric. Sterile flowers white, greenish white, or yellowish white. Bisexual flowers with triangular sepals. Petals caducous, white to yellowish white, elliptic to narrowly ovate. Capsules hemispheric, with 0.3–0.6 mm seeds.

This species is native to North America. In some regions of Canada and the United States of America, *H. arborescens* is escaped from cultivation and is treated as an alien plant (FREEMAN, 2016). In the native range it grows in moist to dry deciduous forests, on moist slopes, along stream banks (FREEMAN, 2016). In Europe, *H. arborescens* as escaped from cultivation was reported only from Austria and Sweden, and in both countries, it is treated as a casual alien. In Austria, this species was first recorded in the middle of the 19th century (ESSL & RABITSCH, 2002), whereas in Sweden, it was first found in 1980 (KARLSSON, 2002).

In Lithuania, outside of places of cultivation, *H. arborescens* was first recorded in the environs of Margionys village (Varėna distr.) in July 2009. Several separated shrubs occurred in a pine forest on the southeastern outskirts of the village. Individuals were quite low, their height ranged from 0.4 m to 0.6 m, however, they were abundantly flowering (Fig. 4). Later studies in 2014 revealed several individuals of *H. arborescens* on the south-western outskirts of Margionys village. Solitary shrubs or small groups of individuals

were found in other localities in Varėna district (Dubininkas, Roduka and Zervynos villages). Three other localities were revealed in other parts of Lithuania: the environs of Ausiutiškės settlement (Elektrėnai distr.), the environs of Duburiai settlement (Ukmergė distr.) and Tytuvėnai (Kelmė distr.) (Fig. 5). In all cases, except for locality in the environs of Tytuvėnai, *H. arbo-*



Fig. 4. Flowering *Hydrangea arborescens* in pine forest (environs of Margionys, Varėna distr., 2009)

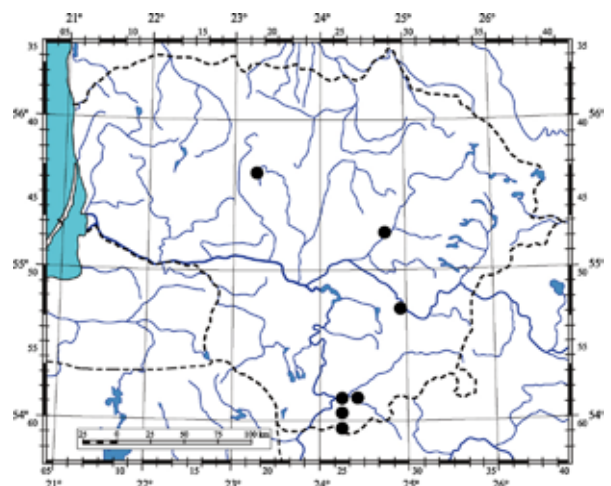


Fig. 5. Distribution of *Hydrangea arborescens* in Lithuania

rescens was found in dry pine forests. In the environs of Tytuvėnai, this species occurred on the edge of the mixed forest.

It is not clear yet, how *H. arborescens* gets to forest habitats: either they grow from thrown fragments of the underground parts of shrubs or from rooted fragments of branches or both. The study of the collected herbarium specimens revealed that bisexual flowers were present among the sterile flowers in the inflorescences of *H. arborescens*. Fruit set was not noted and reproduction by seeds was not confirmed. Thus, further studies on this species are required. Currently, *H. arborescens* is ascribed to the group of casual alien species.

***Pinus strobus* L.** (Pinaceae Spreng. ex F.Rudolphi). High trees with straight conic crown. Branches whorled, twigs slender, pale red-brown, glabrous or puberulent. Buds light red-brown, slightly resinous. Leaves five per fascicle, persisting 2–3 years, 6–10 cm long, slightly twisted, deep green or blue-green. Pollen cones ellipsoid, 10–15 mm long, yellow. Seed cones 8–20 cm long, ellipsoid cylindrical, gray brown, with purple or gray tints, resinous, maturing in two years. Seeds compressed, 5–6 mm long, red brown, with 1.8–2.5 cm wing (KRAL, 1993; CHRISTENSEN, 2000).

This species is native to Eastern North America. Large-scale plantings of this species in Europe started in the 18th century (SCHMITT, 1972; MÜNZBERGOVÁ et al., 2013; MANDÁK et al., 2013). Nowadays, this species is listed as invasive in the Czech Republic (PYŠEK et al., 2012) and Norway (GEDERAAS et al., 2012), potentially invasive in Austria (ESSL & RABITSCH, 2002), naturalized alien in Poland (TOKARSKA-GUZIK et al., 2012), Slovakia (MEDVECKÁ et al., 2012) and Sweden (CHRISTENSEN, 2000). As alien species, *P. strobus* has also been recorded in Germany and Denmark (CHRISTENSEN, 2000; KEIL & LOOS, 2005).

In Lithuania, outside of places of cultivation, *P. strobus* was first found in 2015, in the environs of Dūkštas village (Neris Regional Park, Vilnius distr.). Eight saplings from five to seven years old were recorded in swampy birch stand with sphagnum moss cover. Thorough studies of the locality in 2017 revealed much wider dispersal of *P. strobus* saplings in the area. The highest individuals growing in swampy cutting area of black alder were 3.6 m high.

The recorded saplings were dispersed up to 340 m from a group of planted mature trees. Seeds of this species from paternal trees were dispersed by wind. Currently, *P. strobus* is established alien species in Lithuania and new records of self-sown individuals are expected around the areas of its cultivation. Though invasion of this species is not expected, at least in the nearest future, its establishment in habitats of bogs and swamp forest may cause problems for their conservation.

***Rhus typhina* L.** (Anacardiaceae R. Br.). Deciduous small tree or high shrub, usually with short trunk. Young branches, petioles and leaf-rachis densely and softly hirsute. Leaves large, pinnate, composed of 9–29 lanceolate to narrowly oblong, 5–12 cm long leaflets. Inflorescence terminal, dense, cone-shaped. Fruit a drupe of 2–5 mm in diameter, covered with long, spreading, red hairs. Seeds with hard, impermeable seed coat (DUNCAN & DUNCAN, 1988; GLEASON & CRONQUIST, 1993).

This species is native to North America, where it is distributed in the south-eastern regions of Canada, the north-eastern and western parts of the United States. In the native range it grows in dry open places (GLEASON & CRONQUIST, 1993). *R. typhina* is widely cultivated as an ornamental plant throughout the temperate world and is increasingly recorded as alien or even highly invasive species (YUPING et al., 2015). In Europe, this species outside of places of cultivation has been recorded in Austria, Belgium (VERLOOVE, 2006), the Czech Republic (PYŠEK et al., 2012), Germany (BOYLE et al., 2008), Hungary (CSISZÁR, 2012), Luxembourg (PFEIFFENSCHNEIDER et al., 2014), Norway (GEDERAAS et al., 2012), Poland (TOKARSKA-GUZIK et al., 2012; ZAJĄC et al., 2015), Slovakia (MEDVECKÁ et al., 2012), Sweden (JONSELL, 2010b), Switzerland (WITTENBERG et al., 2005). In Great Britain, *R. typhina* spreads quite extensively by vegetative shoots, but very rarely or never by seeds and the same habits are expected in other parts of Europe (STACE, 1997).

In Lithuania, escaped from cultivation, *R. typhina* was first recorded in the environs of Sudargas village (Šakiai distr.) in July 1998. Groves of this small tree occupied grassy slope of the River Nemunas and occurred on the edge of grey alder stand. Since then, populations of *R. typhina* have been record-

ed in the environs of Kavoliukai (Rokiškis distr.), Puvočiai (Varėna distr.), Musninkai (Širvintos distr.), Kazitiškis (Ignalina distr.), Joneliškės (Utena distr.). In most of the registered localities, *R. typhina* occurred on slopes, on forest edges, occasionally in wastelands, and its populations consisted of a few to several dozen mature and numerous immature individuals of vegetative origin. Currently, *R. typhina* in Lithuania should be treated as established alien species and has a potential to become even invasive. Therefore, studies on the spread and development of *R. typhina* populations in Lithuania are required.

Thuja occidentalis L. (Cupressaceae Gray).

Evergreen tree or shrub. Mature individuals reach 15 m (in the native range up to 38 m) height. Leaves of branchlets 3–5 mm long, acute, dull yellowish green on both surfaces of branchlets. Pollen cones 1–2 mm long, reddish. Seed cones ellipsoid, 9–14 mm long, brown, usually with two pairs of fertile scales. Seeds usually eight in a cone, 4–7 mm (including wings), reddish brown (CHAMBERS, 1993; CHRISTENSEN, 2000).

This species is native to the eastern part of North America, where it usually grows on calcareous or neutral substrates in swamps, on hills and cliffs, shores of lakes and rivers (CHAMBERS, 1993). *T. occidentalis* is widely cultivated as an ornamental plant, which was introduced to Europe approximately in the middle of the 16th century (LEWIS, 1986; CHAMBERS, 1993). Escaped from cultivation and locally naturalized, this species has been recorded in many European countries such as Austria (ESSL & RABITSCH, 2002), the Czech Republic (PYŠEK et al., 2012), Germany (ADOLPHI, 1997), Denmark, Norway, Sweden (CHRISTENSEN, 2000; GEDERAAS et al., 2012), Poland (TOKARSKA-GUZIĆ et al., 2012; KALINOWSKI, 2014), etc.

In Lithuania, escaped from cultivation, *T. occidentalis* was first registered in Jeruzalė (part of Vilnius city) in April 2004. More than 30 seedlings and about the same number of saplings up to 0.5 m high were recorded near Jeruzalė cemetery, on a steep eroded sandy slope. Later this species was found in the environs of cemeteries in Čedasai, Lukštai (Rokiškis distr.), Kurtuvėnai, Kužiai (Šiauliai distr.), Dusetos (Zarasai distr.) (Fig. 6). In the vicinities of cemeteries, the seedlings and saplings grew on stone fences and on slopes, were also recorded in waste-

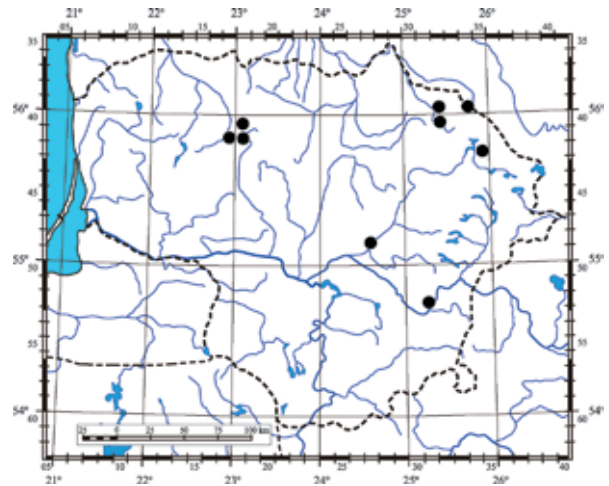


Fig. 6. Distribution of *Thuja occidentalis* in Lithuania

lands and around rubbish dumping areas. One locality of *T. occidentalis* was recorded in a pine stand in the Bečiai forest (vicinity of Aklasis Ežeras village, Jonava distr.). More than 60 seedlings and a few saplings occupied forest glade. We supposed that in this locality *T. occidentalis* grew from seeds, which were brought to the forest with garden wastes, whereas in the environs of cemeteries, self-sown individuals grew from seeds dispersed mainly by wind from mature individuals cultivated in the cemeteries. Currently, *T. occidentalis* is a casual alien species; however, its further spread and naturalization in Lithuania are expected.

DISCUSSION

Increase of the number of escaped species, formerly being only in cultivation, is a characteristic feature of contemporary alien flora formation in many European countries (PERGL et al., 2016a). All woody species reported in this paper have been introduced in Lithuania deliberately and are used mainly in ornamental gardening or occasionally in silviculture. Thus, their escape from cultivation is not a coincidence, but a regular phenomenon. Furthermore, almost all here analysed species have already been registered as temporal escapers from cultivation or are naturalized and even invasive in many European countries (ESSL & RABITSCH, 2002; GEDERAAS et al., 2012; TOKARSKA-GUZIĆ et al., 2012; PYŠEK et al., 2012; MÜNZBERGOVÁ et al., 2013, etc.). All here reported species, except *Cytisus austriacus*, which is

native in Central and south-eastern Europe (CRISTOFOLINI, 1991), have been registered in at least several countries of Central or North Europe. Some of the species analysed in this publication have already been recognized as invasive in one or several countries of Europe. For example, *Cornus alba*, *Pinus strobus* and *Rhus typhina* are included into the Black List of the Czech Republic (PERGL et al., 2016b), *Berberis thunbergii* and *Pinus strobus* are supposed to have severe impact in Norway (GEDERAAS et al., 2012).

The native range of a species is a very important predictor of the future fate of an alien species (HEJDA et al., 2009; PYŠEK et al., 2014, etc.). Native ranges of all studied species are located entirely or mainly in temperate regions of North America, Asia and Europe. Four studied species (*Hydrangea arborescens*, *Pinus strobus*, *Rhus typhina* and *Thuja occidentalis*) are native to North America and another three species (*Aralia elata*, *Berberis thunbergii* and *Celastrus orbiculatus*) are native to East Asia. *Cytisus austriacus* is native to Europe and the Caucasus, whereas the native range of *Caragana frutex* includes the south-eastern regions of Europe and temperate Asia. One species, *Cornus alba* s.l., has wide range, which includes north-eastern Europe, Siberia and North America (ZIELIŃSKI et al., 2014). Thus, based on the native ranges of species solely, it is possible to suspect their possible naturalization in Lithuania.

The success of naturalization of alien species depends on many factors; however, species native range as well as means and intensity of reproductions contribute the most to the success of naturalization and invasion (REJMÁNEK, 1995; REJMÁNEK & RICHARDSON, 1996; PYŠEK et al., 2014). Generative reproduction

was registered in the populations of three studied escaped woody species (Table 1): *Cornus alba*, *Celastrus orbiculatus* and *Cytisus austriacus*. Though *Berberis thunbergii*, *Caragana frutex* and *Rhus typhina* produced seeds, their generative reproduction outside the places of cultivation was not confirmed. However, there is no doubt that cultivated plants of *Berberis thunbergii*, *Pinus strobus* and *Thuja occidentalis* produce viable seeds and the escaped plants grew from seeds dispersed from the areas of cultivation. *Aralia elata* in some years will produce large number of fruits and its spread to natural or seminatural habitats by bird-dispersed seeds is plausible, though not confirmed in Lithuania.

Special attention should be paid to the spread and naturalization of bird-dispersed alien species, i.e. *Cornus alba*, *Celastrus orbiculatus* and *Berberis thunbergii*. *Cornus alba* and *Berberis thunbergii* are widely cultivated ornamentals in Lithuania (JANUŠKEVIČIUS et al., 2006; NAVASAITIS, 2008), therefore, a high propagule pressure on disturbed, seminatural and natural habitats is supposed (WARREN et al., 2013). Considering the fact that these species are already naturalized or recognized as invasive in certain regions of Europe and other regions of the world with similar climate (KELLY, 1990; BRAND et al., 2012; GEDERAAS et al., 2012; FOLLAK et al., 2014; BAČIČ et al., 2015, etc.), there is high probability of their invasion. As it was mentioned, *Cornus alba* already exhibits some traits of invasiveness.

Vegetative reproduction currently is the main mean of renewal and increase of escaped populations for *Aralia elata*, *Caragana frutex* and *Rhus typhina*. *Celastrus orbiculatus* and *Cornus alba* also repro-

Table 1. Year of the first record, reproduction, status and probability of invasion of the described alien woody species. Abbreviations: v – vegetative reproduction confirmed, g – generative reproduction confirmed, (g) – generative reproduction of escaped plants is possible in Lithuania, but not yet confirmed

Species	First record	Reproduction	Status	Probability of invasion
<i>Aralia elata</i>	2004	v, (g)	Naturalized	High
<i>Berberis thunbergii</i>	2016	(g)	Casual	High
<i>Caragana frutex</i>	2000	v, (g)	Naturalized	Low
<i>Celastrus orbiculatus</i>	2014	v, g	Naturalized	High
<i>Cornus alba</i>	1974	v, g	Naturalized	Very high
<i>Cytisus austriacus</i>	1996	g	Naturalized	Low
<i>Hydrangea arborescens</i>	2009	v	Casual	Low
<i>Pinus strobus</i>	2015	(g)	Naturalized	High
<i>Rhus typhina</i>	1998	v, (g)	Naturalized	High
<i>Thuja occidentalis</i>	2004	(g)	Casual	Moderate

duces vegetatively, but this mean of reproduction is less important than generative.

Analysis of the status of the studied species (Table 1) revealed that *Berberis thunbergii*, *Hydrangea arborescens* and *Thuja occidentalis* currently should be treated as casual species, though additional studies may reveal their different status, especially of *Berberis thunbergii*. All other studied species are treated as naturalized in Lithuania. The survey of the escaped populations (i.e. *Aralia elata*, *Cytisus austriacus* and *Rhus typhina*) confirmed that they survived and some of them increased significantly.

Based on the origin, reproduction, state of populations in Lithuania as well as on behaviour of the studied species in other regions, we can conclude that six woody species have very high or high probability of invasion (Table 1). Special attention should be paid to the spread of *Pinus strobus* because of its invasiveness into different landscapes and management problems (MÜNZZBERGOVÁ et al., 2013; NUÑEZ et al., 2017). First records of this species in Lithuania revealed that it has potential to invade bogs, mires and swamps as well as various forest habitats. Other three species have low probability to become invasive (*Caragana frutex*, *Cytisus austriacus* and *Hydrangea arborescens*). The probability of *Thuja occidentalis* invasion is estimated as moderate, because this species is very widely cultivated and its dispersal from multiple sources may lead to invasion in the future, after certain lag period (CROOKS, 2005).

Several of woody species introduced to Lithuania in the second half of the 19th century and in the first half of the 20th century started to spread and naturalize in 1960s–1970s, e.g. *Acer pseudoplatanus*, *Ligustrum vulgare*, *Pinus mugo*, *Pseudotsuga menziesii*, *Quercus rubra* (LEKAVIČIUS, 1976), others later became invasive (*Acer negundo*, *Cytisus scoparius*, *Padus serotina*, *Robinia pseudoacacia*, *Rosa rugosa*). A part of species introduced during that period have started to spread or have become naturalized during the last two decades of the 20th century and now some of these manifest features of invasiveness (*Parthenocissus quinquefolia*, *Physocarpus opulifolius*, *Pinus banksiana*, etc.). Much more species of trees and shrubs have been introduced to the country since the middle of the 20th century and they are being cultivated for ornamental purposes or used in forestry. To date, a total of almost 800 introduced

species of trees and shrubs have been registered in Lithuania (NAVASAITIS, 2008) and the process of introduction continues. Therefore, further increase of escaped and naturalized alien woody plants in Lithuania is supposed because many species introduced 6–7 decades ago after a certain lag period (KOWARIK, 1995; CROOKS, 2005; AIKIO et al., 2010) may start or have already started to reproduce and spread outside places of their cultivation. Thus, summarizing currently available information, 87 woody (trees, shrubs and woody climbers) alien species were recorded in Lithuania.

Constant survey of potential habitats, detection of new accidentally introduced or escaped alien plants, particularly of trees and shrubs, is the best way to reveal potentially dangerous species and make timely decisions for their control or eradication, if necessary.

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LIETUVOJE APTIKTOS NAUJOS SVETIMŽEMĖS SUMEDĖJUSIŲ AUGALŲ RŪŠYS

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Santrauka

Daug sumedėjusių augalų, kilusių iš įvairių pasaulio regionų, buvo introdukuota kituose žemynuose arba regionuose ir auginama dėl jų dekoratyviųjų savybių, sodinama miškuose, naudojama erozijai stabdyti, auginama maisto gamybai ar kitais tikslais. Introdukuoti atrinkti medžiai ir krūmai paprastai būna kilę iš regionų su panašiomis klimato sąlygomis, todėl po tam tikro laiko jie ima plisti iš auginimo vietų, natūralizuojasi arba netgi tampa invaziniais.

Anksčiau Lietuvoje buvo užregistruoti 77 rūšių sulaukėję medžiai ir krūmai. Šiame straipsnyje pateikiami duomenys apie 10 naujai Lietuvoje aptiktų medžių ir krūmų rūšių savaiminį paplitimą, jų antropogeninį arealą, nurodoma, kada jie Lietuvoje pirmą kartą užregistruoti sulaukėję, aptariamasi populiacijų dydis, buveinės, dauginimasis ir natūralizacija. Straipsnyje aprašyti sulaukėję sumedėjusieji augalai: *Aralia elata*, *Berberis thunbergii*, *Caragana frutex*,

Celastrus orbiculatus, *Cornus alba*, *Cytisus austriacus*, *Hydrangea arborescens*, *Pinus strobus*, *Rhus typhina* ir *Thuja occidentalis*.

Trijų rūšių augalai (*Berberis thunbergii*, *Hydrangea arborescens* ir *Thuja occidentalis*) dabar laikomi atsitiktinai sulaukėjusiais, o kitų septynių rūšių sumedėjusieji augalai Lietuvoje yra natūralizavęsi. Yra labai didelė arba didelė tikimybė, kad šešių rūšių naujai aptikti sumedėję augalai (*Aralia elata*, *Berberis thunbergii*, *Celastrus orbiculatus*, *Cornus alba*, *Pinus strobus* ir *Rhus typhina*) gali pradėti sparčiai plisti Lietuvoje ir tapti invaziniais.

Labai svarbu nuolat vykdyti potencialių svetimžemių augalų buveinių tyrimus, kad būtų galima kuo anksčiau nustatyti sulaukėjusius arba atsitiktinai patekusius svetimžemius augalus, ypač medžius ir krūmus, laiku įvertinti jų galimą pavojų ir, esant reikalui, imtis jų kontrolės ir naikinimo priemonių.

APPENDIX I.

List of selected specimens of the studied species

Aralia elata: 1. Vilnius, Veržuva, on the left bank of the River Veržuva, in alluvial forest of *Alnus incana*, four individuals; 54.763702° N, 25.371557° E; 6 August 2004, leg. Z. Gudžinskas; 2. Vilnius, Veržuva, on the left bank of the River Veržuva, in alluvial forest of *Alnus incana*, occupies about 300 m²; 54.763704° N, 25.371554° E; 18 June 2017, leg. Z. Gudžinskas.

Berberis thunbergii: 1. Vilnius, Vanaginė, near Vanaginės Sodai Str., in a mixed forest with *Picea abies*, *Betula pendula* and *Corylus avellana*, two individuals; 54.769533° N, 25.261066° E; 7 May 2016, leg. Z. Gudžinskas; 2. Trakai distr., Užutrakis,

on the shore of Lake Galvė, on the edge of reed-bed, several individuals; 54.654450° N, 24.946406° E; 18 June 2016, leg. Z. Gudžinskas & L. Petrulaitis; 3. Elektrėnai distr., about 1.5 km south-west of Paneriai village, near the road Dūkštas–Vievis, in the pine forest between *Sorbus aucuparia* shrubs, two individuals; 54.782073° N, 24.887056° E; 23 July 2017, leg. Z. Gudžinskas.

Caragana frutex: 1. Ignalina distr., 1 km south-west of Tverečius, on the edge of the forest, quite large thickets; 55.315576° N, 26.576743° E; 23 June 2000, leg. Z. Gudžinskas; 2. Joniškis distr., northern edge of Žagarė village, in the vicinity of the Lutheran cemetery, on a steep slope, quite abun-

dant; 56.369537° N, 23.267116° E; 6 July 2000, leg. Z. Gudžinskas; **3.** Ignalina distr., Palūšė, in the vicinity of the village cemetery, in the pine forest, quite abundant; 55.327498° N, 26.109030° E; 5 August 2002, leg. Z. Gudžinskas; **4.** Mažeikiai distr., environs of Ašvėnai village, protective zone of the Kamanos Strict Nature Reserve, in a meadow on the edge of the forest, large thicket; 56.272250° N, 22.592611° E; 14 July 2004, leg. Z. Gudžinskas.

Celastrus orbiculatus: **1.** Palanga, on the right side of the road Šventoji–Palanga, close to the airport, on the edge of the forest, occupies about 20 m² area, plants with unripe fruits; 55.959117° N, 21.091500° E; 23 July 2014, leg. Z. Gudžinskas & E. Žalneravičius; **2.** Vilnius, Visoriai, near the 23rd Visorių Sodai Str., in a mixed stand of *Picea abies*, *Betula pendula* and *Populus tremula*, reaching up to 14 m high in the trees; 54.740307° N, 25.260600° E; 5 October 2014, leg. Z. Gudžinskas & L. Petrulaitis; **3.** Plungė distr., Žemaitija National Park, the environs of Babrungėnai village, in the forest glade, occupies about 90 m² area; 55.998605° N, 21.869934° E; 18 September 2016, leg. Z. Gudžinskas; **4.** Vilnius, Aukštieji Paneriai, between Kirtimų and Galvės Str., occupies more than 2600 m² area; 54.634442° N, 25.152651° E; 28 September 2016, leg. Z. Gudžinskas.

Cornus alba: **1.** Klaipėda distr., Giruliai, in the forest, along the forest track; [coordinates not indicated]; 27 June 1974, leg. R. Jankevičienė; **2.** Trakai distr., Lentvaris, the environs of railway station, in a ditch; [coordinates not indicated]; 2 September 1987, leg. Z. Gudžinskas; **3.** Vilnius distr., 2 km south of Nemėžis, on the edge of the forest; [coordinates not indicated]; 8 June 1992, leg. Z. Gudžinskas.

Cytisus austriacus: **1.** Vilnius, Smėlynė, on the edge of the forest, about 50 individuals; [coordinates not indicated]; 2 August 1996, leg. V. Rinkevičius; **2.** Vilnius, Smėlynė, near Nemenčinės Plentas Str. intersection with Gvazdikai str., on a dry slope and in the pine forest, more than 60 individuals; 54.752611° N, 25.363528° E; 3 August 2005, leg. Z. Gudžinskas.

Hydrangea arborescens: **1.** Varėna distr., Dzūkija National Park, Margionys, south-eastern edge of the village, in the pine forest, several individuals; 53.999583° N, 24.299610° E; 26 July 2009, leg. Z. Gudžinskas; **2.** Elektrėnai distr., about 2.5 km south-east of Paneriai village, Neris Regional Park, in the pine forest, 3 individuals; 54.768122° N, 24.938179° E; 29 July 2017, leg. Z. Gudžinskas; **3.** Ukmergė distr., 5 km north-east of Ukmergė, the Dukstyna Forest, along the road to Duburiai settlement, on the forest edge, thicket occupying about 3 m² composed of three or four individuals; 55.273825° N, 24.827645° E; 11 August 2017, leg. Z. Gudžinskas.

Pinus strobus: **1.** Vilnius distr., about 2.5 km south-east of Dūkštos, Neris Regional Park, the Dūkštos Forest, swampy birch stand, eight individuals; 54.811056° N, 25.005041° E; 24 September 2015, leg. L. Petrulaitis; **2.** Vilnius distr., about 2.5 km south-east of Dūkštos, Neris Regional Park, the Dūkštos Forest, old cutting area of swampy black alder stand, three high individuals; 54.810430° N, 25.002825° E; 22 October 2017, leg. Z. Gudžinskas & L. Petrulaitis.

Rhus typhina: **1.** Šakiai distr., the environs of Sudargas, on the northern edge of the village, on a slope of the River Nemunas, close to the mound, abundantly, forms thickets; 55.047623° N, 22.646799° E; 30 July 1998, leg. Z. Gudžinskas; **2.** Rokiškis distr., Kavoliškiai village, in a wasteland between shrubs, several individuals; 55.952963° N, 25.522498° E; 28 July 2014, leg. Z. Gudžinskas & L. Petrulaitis.

Thuja occidentalis: **1.** Vilnius, Jeruzalė, the environs of Verkiai cemetery, on a steep slope, more than 30 self-seeded individuals of different age; 54.742214° N, 25.281208° E; 29 April 2004, leg. Z. Gudžinskas; **2.** Rokiškis distr., Lukštai, south-eastern edge of the village, wasteland overgrown with shrubs, several individuals; 56.027218° N, 25.733162° E; 25 July 2014, leg. Z. Gudžinskas; **3.** Jonava distr., about 2 km east of Aklašis Ežeras village, the Bečiai Forest, close to Pageležiai bog, in the pine forest, quite abundant; 55.148776° N, 24.510750° E; 16 July 2017, leg. Z. Gudžinskas.