

Utilization value of *Sorbus*.l. in Croatia and its potential enhancement

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Abstract

Due to their nutritive and therapeutic values as well as their decorative attributes, the usage of species from the genus *Sorbus* s.l. has been well known in folk tradition long since. According to the most recent taxonomic revision, in Croatian flora, *Sorbus* s.l. is represented with at least six native taxa and another six that are deficiently known and which presence should be further confirmed. In Croatia, species of *Sorbus* s.l. are distributed in three main geographical and climate regions (mountainous, lowland and Mediterranean) and grow under various environmental conditions. In Croatia, only a few taxa are infrequently used as ornamental plants while their usage as a wild edible fruit species is generally rather sparse. The purpose of this paper is to give an overview of Croatian species of *Sorbus* s.l. (*S. aria*, *S. aucuparia*, *S. austriaca*, *S. chamaemespilus*, *S. domestica*, *S. torminalis*) with their utilization values as wild edible fruit species and ornamental plants, together with their environmental requirements, resistance to urban conditions and pests as well as possible problems in their cultivation and their capacity for selection and plant breeding. We assume that Croatian native *Sorbus* s.l. species present quality and multifunctional species applicable for use in landscaping and for fruit cultivation.

Keywords: *Sorbus* s.l., usage, native ornamental plant, wild edible fruit, Croatia

INTRODUCTION

The most recent updated classification of the genus *Sorbus* L. s.l. (*Rosaceae*) in Europe (Sennikov and Kurtto, 2017) based on the latest phylogenetic and morphological studies, accepts five genera (*Aria*, *Chamaemespilus*, *Cormus*, *Sorbus* s. str. and *Torminalis*), previously treated mostly as subgenera, at the generic rank, and also introduces a new genera. The extraordinary taxonomic complexity of *Sorbus* s.l. results from polyploidy and apomixis (present in 93% of newly accepted species) as well as from extensive intergeneric hybridization. Therefore, Sennikov and Kurtto (2017) admit that “the species inventory of *Sorbus* s.l. in Europe is still far from being complete and new research will clearly bring many more novelties”. So far, there are 201 accepted species of European *Sorbus* s.l.

By comparing the new checklist from Sennikov and Kurtto (2017) with the data from Flora Croatica Database - FCD (Nikolić, 2017) the conclusion may be drawn that in Croatian flora, there are at least six native species and another six taxa which presence should be confirmed by further research. Except for *S. aucuparia* L. (including its typical subspecies), their binomial name underwent revision: *S. aria* (L.) Crantz into *Aria edulis* (Willd.) M. Roem.; *S. austriaca* (Beck) Hedl. into *Hedlundia austriaca* (Beck) Sennikov & Kurtto; *S. chamaemespilus* (L.) Crantz into *Chamaemespilus alpina* (Mill.) K.R. Robertson & J.B. Phipps; *S. domestica* L. into *Cormus domestica* (L.) Spach; and *S. torminalis* (L.) Crantz into *Torminalis glaberrima* (Gand.) Sennikov & Kurtto. A considered Croatian endemic *S. velebitica* Kárpáti that is data deficient (Nikolić, 2017) is treated under the new name, *H. velebitica* (Kárpáti) Sennikov & Kurtto. Three taxa, not listed in FCD (Nikolić, 2017), are noted for Croatia by Sennikov and Kurtto (2017). Two of them were recorded for Croatia by Kárpáti (1960): a highly variable *Aria graeca* (Spach) M. Roem (= *S. cretica* (Lindl.) Fritsch & Rech) and *S. aucuparia* ssp. *glabrata* (Wimm. & Grab.) Hedl. in Kongl., whose distribution covers mountains

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within the areal of typical *S. aucuparia*. The third one is *A. baldaccii* (C.K. Schneid.) Sennikov & Kurtto. On the other side, *S. borbasii* Jav. (= *H. borbasii* (Jáv.) Sennikov & Kurtto), is listed in FCD (Nikolić, 2017) as data deficient, but is not confirmed for Croatia by the new study. Supposed endemic with the spurious status (Nikolić, 2017), *S. austriaca* (Beck) Hedl. ssp. *croatica* Kárpáti remains an unresolved name (Sennikov and Kurtto, 2017).

Because of convenience, in this paper we kept binomial names of species that are widely in use. Within Croatia, the distribution of *Sorbus* s.l. encompasses all three main geographic/climatic areas: lowland, mountainous and Mediterranean (Figure 1). Due to their nutritive and therapeutic values as well as their decorative attributes, the usage of species from the genus *Sorbus* s.l. has been well known in folk tradition long since. The purpose of this paper is to review and analyse morphological and ornamental features with the usage value (as ornamentals as well as edible and medicinal plants) of autochthonous Croatian species of *Sorbus* s.l. Moreover, the aim of this paper is also to promote the use of native species applicable for use in landscaping and for fruit cultivation.

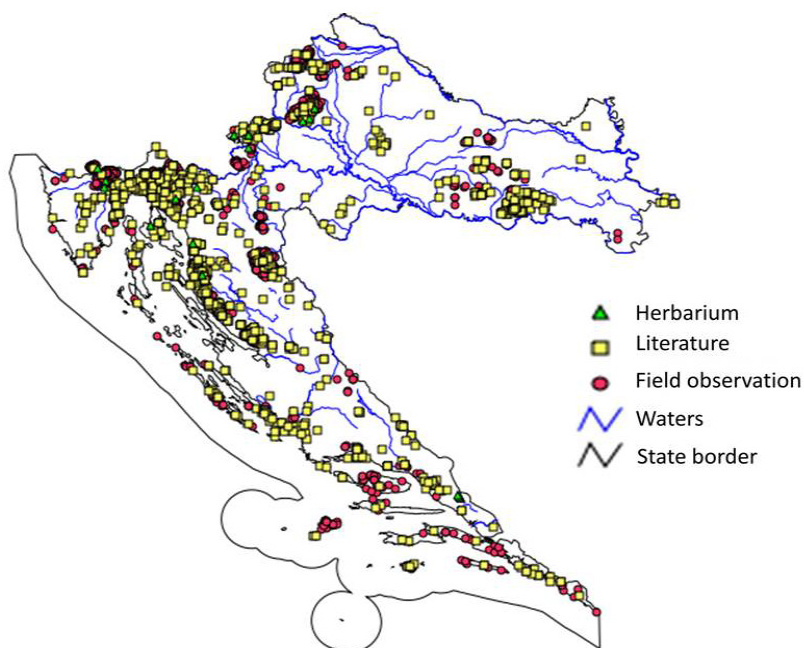


Figure 1. Distribution of *Sorbus* s.l. in Croatia by Flora Croatica Database (Nikolić, 2017).

RESULTS AND DISCUSSION

Environmental requirements and resistance

In the wild, species of *Sorbus* s.l. naturally grow as solitary trees or in smaller groups scattered in mixed forests, and are very important for the biodiversity of forest ecosystems (Poljak et al., 2011).

Analysed species of *Sorbus* s.l. (Table 1) are calciphillic, except *S. aucuparia* that prefers acidic soils; while *S. torminalis* has wide ecological amplitude. They generally grow on less humid soils, and tolerate drought, especially *S. austriaca*, that is a xerophyte. However, *S. aucuparia*, *S. domestica* and *S. torminalis* best grow on fresh and rich soils (Šilić, 1983). These species are also heliophilic, except *S. torminalis* and *S. domestica* that tolerate shade when young, but later require plenty of light (Šilić, 1983; Idžojtić, 2004). They have wide amplitude regarding their hardiness. The most resistant to low temperatures are *S. chamaemespilus*, an indicator of rather cold habitat (Nikolić, 2017) and *S. aucuparia* (hardiness zones 3-6) then *S. aria* (4-8), *S. torminalis* (5-9), *S. austriaca* (5-9); and the least resistant is *S. domestica* (zones 6-10) (PFAF, 2017).

Table 1. Ornamental features and utilization value of *Sorbus* s.l. species from Croatia. Sources: ^aIdžojtić (2005), ^bDirr (1998), ^cŠilić (1983), ^dIdžojtić (2009), ^eIdžojtić (2013), ^fVukičević (1987), ^gForenbacher (1990), ^h<http://www.pfaf.org>, ⁱ<http://www.plantea.com.hr>, ^jJohnson (2006).

Species	Habitus (t.-tree, s.-shrub)	Bark	Leaves			Flowers			Fruit			Med. use	Ornamental values	Landscape use
			Appearance	Summer colour	Autumn colour	Appearance	Inflorescence	Fl. time	Appearance	Ripening	Edibility ^g			
<i>S. aria</i>	t. to 15(-20) m (often multi-stemmed) or s. to 6 m; ovoid ^{a,b}	Red-brown to darkgrey, white lenticels ^c very long smooth ^a	8-12 cm, broad-elliptic, double-serrated, half-leathery ^d	Green and glossy; under-side white tomentose ^b	Pale green to golden brown to reddish ^d	1.5 cm, white ^e	6-10 cm (25-40 fl.), wolly axes ^e	V ^e	1-1.5 cm, red, rounded or ovoid ^b	IX-X ^e (stay in winter ^g)	3	+	Leaves, flowers, fruits, bark	Street trees, live fence, shelterbelts
<i>S. aucuparia</i>	t. to 6-12(-18) m, often multi-stemmed, ovoid/spherical ^b	Silvery-grey with lenticels, smooth ^a , older fissured	10-20 cm, 9-15 leaflets (oblong, serrated), herbaceous ^d	Darkgreen; underside glaucescent, pubescent ^d	Reddish purple ^a	1 cm, white petals ^e	10-15 cm (200-300 fl.), flat-topped ^e	IV-V ^e	~1 cm, orange-red to red, rounded ^a	VIII-X ^e (stay in winter ^g)	2	+	Leaves, habitus, bark, inflorescence, fruits	Solitaire, groups, alley-tree ^f
<i>S. austriaca</i>	t. up to 20 m or s. ^c	Yellow-brown to darkgrey-brown ^c , long smooth	8-11 cm, oval, lobed and serrated, leathery ^c	Darkgreen; beneath white wooly ^c	n/a	To 1.5 cm, white ^g	Dense terminal ^g	V-VI ^c	~1 cm, red, rounded ^g	IX-X ^h	2	n/a	Leaves wide, lobed and leathery	Solitaire, groups, alleys ^c
<i>S. chamaemespilus</i>	usually 1(-3) m erect s. ^c	Young reddish-brown, white lenticels ⁱ	Elliptic, 3-6 (-10) cm, finely serrated, half-leathery ^d	Darkgreen, glossy; lightgreen beneath ^d	Yellow to orange ⁱ	Petals pink-red to red, 5 mm, upright ^e	5-7 cm (cca 30 fl.) dense, hairy ^e	V-VI ^e	~1 cm, red, rounded, (ab)ovate ^e	VII-VIII ^e	+ ⁵	n/a	Leaves, flowers and fruits	Alpinarium, shrubbery
<i>S. domestica</i>	t. to 15-20 m, spherical/ovoid ^a	Grey, often flaking, then fissured ^a	15-18 cm, 11-21 leaflets (oblong, serrated), herbaceous ^d	Green matte; underside glaucescent ^d	Yellow, orange to red ^d	cca 1.5 cm, white ^e	6-10 cm (35-75 fl.), flat-topped ^e	IV-V ^e	To 3(-5) cm, green-yellow, apple/pear-shaped	IX-X ^e	5	+	Habitus, autumn leaf colour, gracefully domed ¹⁰	Solitaire, groups and alley-tree ^e
<i>S. torminalis</i>	t. to 25(-30) m, straight trunk (Φ to 1 m) dense rounded head ^{a,b}	Grey, first smooth, flaking, then fissured ^a	10-12 cm, ovate to triangular, 5-9 lobes, serrated, herb.-leathery ^d	Green, shiny; lightgreen beneath ^d , often hairy ^c	Orange-red/ red-brown ^f , bright red ^j	1-1.5 cm, white ^e	8-12 cm (30-50 fl.), upright ^e	V ^e	~1.5 cm, brown, obovate, leathery ^e	IX-X ^e (stay long in winter)	4	+	Habitus, bark, inflorescence, autumn leaf colours ^j	Solitaire, groups ^f

All species (data not available for *S. chamaespilus*) develop a strong root system. Its central root is usually deep, except in *S. austriaca* which root system is more or less in the surface area. In *S. torminalis* root penetrates 1-2 m in depth rendering it quite resistant to wind-throw and it spreads in the surface area.

According to Šilić (1983), the rate of growth for these species (data n/a for *S. chamaespilus*) is slow, (except in youth; e.g., *S. domestica*) while in *S. aucuparia* it is medium, 7-9 m/20 years (Dirr, 1998). The longevity of *S. domestica* is 200-300(-500) years, *S. aria* is also long-living (200 years); while lifespan of *S. torminalis* is around 100 years (Šilić, 1983).

In Croatia, whitebeam, *S. aria* grows from sub-Mediterranean and mountains in the Mediterranean area (Nikolić, 2017), lower foothills and thermophile woods with their thickets and open rockeries, to mountainous belt up to 1700 m (Šilić, 1983), sometimes alone on alpine pastures (Vukičević, 1987). It naturally comes on limestone. Given that it tolerates urban conditions, it has been cultivated for long (Dirr, 1998).

Rowan, *S. aucuparia*, inhabits mountainous to subalpine belt (communities of beech, spruce and fir to the mountain pine zone). It prefers fresh and rich acid soils (Šilić, 1983) and is often short-lived on chalky or compacted soils and polluted atmospheres. It likes cool and moist climate, while high summer temperatures limit its growth. Its disadvantage is the susceptibility to many pests (e.g., fireblight, canker, aphids, borer, etc.). Most susceptible are weakened trees, so the best line of defence is a healthy growing tree (Dirr, 1998).

According to Forenbacher (1990), Austrian Whitebeam, *S. austriaca*, on Mt Velebit, its primary habitat in Croatia, grows on shrubby slopes and in beech forests and mountain pine communities of higher mountainous and subalpine belt (700-1400 m), rarely lower as well as in open rockeries to 1800 m (Šilić, 1983).

False medlar, *S. chamaespilus*, is a subalpine shrub, in Croatia found on Mt Ivančica, Mt Risnjak, Mt Velebit and Mt Obruč (Forenbacher, 1990; Nikolić, 2017). It grows within subalpine scrub vegetation (at 1200-1630 m) on the border of forest vegetation (Forenbacher, 1990).

The centre of distribution of the service tree, *S. domestica*, in Croatia is the zone of holm oak in the Mediterranean and zone of downy oak in the sub-Mediterranean area. It rarely comes in the continental area (Matić and Vukelić, 2001, cited from Poljak et al., 2015), only in xerotherme woods and thickets of lower oak-belt (Šilić, 1983). It is a pioneer species with broad ecological valence, which often grows in dry to very dry and depleted soils of different types (Poljak et al., 2015), although best on deep and rich soils. It prefers warm and mild climate. In winter, it can withstand temperatures down to -30°C, but is sensitive to late spring frosts. Seedlings are resistant and not susceptible to insects and diseases (Idžojtić and Drvodelić, 2005).

The wild service tree, *S. torminalis* in Croatia is most common in the zone of downy oak in the sub-Mediterranean and Mediterranean mountainous belt area. In the continental region, it grows abundantly on slopes and hills (150-400 m) on deep hummus soils with sessile oak and hornbeam. It is a (post)pioneer species with broad ecological valence. It is thermophilic to mesophilic species that tolerates drought, cold and late spring frosts. Its role as a side species is contribution to biological diversity, support to the main tree species and improvement of the soil quality (Matić and Vukelić, 2001 cited from Oršanić et al., 2009). Regarding threats, herbivore arthropods such as apple aphid is known (Gotlin Čuljak et al., 2012), and honey fungus on older stems can be lethal.

Ornamental value and landscape use

The genus *Sorbus* s.l. encompasses deciduous, usually small to medium-sized trees of 8-20(-30) m or shrubs; without thorns, native to the northern hemisphere. Generally, they are densely branched, with branches ascending and creating a rounded or ovoid head. Leaves are alternate, simple or pinnately (odd) compound. Flowers consist of 5 sepals, 5 (mostly white) petals, 15-20(-25) stamens, and 2-5 styles and are entomophilic. Inflorescence is corymb. Flowering occurs in May-June (about the same time the leaves unfold). Fruit is a small berry-like pome. Most species develop ornamental fruit in orange, red or yellow clusters in September-October, and are often held through the winter (Vukičević, 1987; Forrest, 2006).

In Table 1 the most pronounced morphological features and utilization values (ornamental, edibility and medicinal) of Croatian *Sorbus* s.l. species are summarized. One has to be aware of the considerable intraspecies variability regarding size and shape. For instance, morphometric variability of leaves between the continental and the Mediterranean populations of *S. domestica* as well as with regard to altitude was associated with ecological factors, mainly temperature (Poljak et al., 2015). Also, a strong positive correlation between fruit length and altitude was confirmed in *S. torminalis* (Oršanić et al., 2009).

All six analysed Croatian species have decorative flowers. With the exception of *S. chamaemespilus*, their corolla is 1-1.5 cm across, with white spreading petals and 20-25 bristling stamens that contribute to the interesting look of the whole inflorescence.

The most decorative features of *S. aria* are broad-elliptic, half-leathery, green and glossy leaves with white tomentose under-side and double-serrate margin, as well as fruits that usually stay red, rounded and shiny during the winter (Idžojtić, 2005, 2009). Vukičević (1987) claims that despite its decorative leaves and fruits, it is rarely seen in parks of the region (including Croatia, authors' note). Šatalić and Štambuk (1997) quote its use as a live fence or shelterbelt for croplands, orchards and nursery crops. For comparison, *S. aria* (incl. *S. aria* 'Magnifica') is commonly grown as a street tree in Germany (Forrest, 2006).

Contrastingly, *S. aucuparia* is often grown in parks as a solitaire, group, and as an alley tree (Vukičević, 1987). Besides being excellent for the effect of large dense fruit clusters that sometimes stay red, rounded and shiny through the winter, its ornamental features also include large pinnately compound leaves, coloured red in autumn, gracefully open head, big inflorescence composed of 200-300 flowers, as well as a smooth and shiny bark, that make it attractive during the whole year (Dirr, 1998; Idžojtić 2005, 2009, 2013). Both *S. aucuparia* and *S. aria*, are suitable for naturalistic schemes, wildlife habitats and motorway planting schemes (Forrest, 2006).

Compared to similar *S. aria*, *S. austriaca* has wider and deeper lobed leathery leaves, and a bark that stays smooth for long. Its ornamental use can be as solitaires, groups, and it is also nice in alleys (Šilić, 1983). According to available data, it is almost unused in Croatia.

False medlar, *S. chamaemespilus*, is the only species of European *Sorbus* s.l. with upright and rose to reddish petals creating decorative inflorescence. As an erect shrub usually around 1 m tall, with its dark green, half-leathery and glossy, finely serrate leaves (Šilić, 1983; Idžojtić, 2009, 2013) this rare species has a great potential as an ornamental plant. Vukičević (1987) suggests its use in alpinariums.

Decorative features of *S. domestica* include its head, that may be gracefully domed (Johnson, 2006), pinnately compound leaves of 3-6 cm long, oblong leaflets with serrate margin, in autumn coloured yellow, orange to red; and flat-topped creamy heads (Idžojtić, 2009, 2013). It can be grown as a solitaire, in groups and as an alley-tree (Šilić, 1983).

The tree of *S. torminalis*, is up to 25(-30) m, and with its straight trunk up to 70(-100) cm across and dense rounded head with ascending branches it creates imposing habitus. Its young bark is grey, smooth and flaking in thin sheets. It also has showy inflorescence and very variable ovate to triangular leaves with sometimes exotically bright red, autumn leaf colours (Idžojtić, 2005, 2009, 2013; Johnson, 2006), making it interesting all-year-round.

In Croatia, only a few above-mentioned species are, though not frequently, used as landscaping plants as well as a few non-native ones. In a detailed inventory of the 30 most important parks of the city of Zagreb, members of *Sorbus* s.l. are registered in 5 parks with altogether 12 planted trees: *S. aria* (6), *S. aucuparia* (3), *S. mougeotii* (2), *S. torminalis* (1) (Aničić and Samardžija, 2015). Inventory of another 15 parks revealed only two trees (*S. aucuparia* and *S. mougeotii*) in one of the parks (Mlinar and Trošić, 2004). Their use as alley trees in Zagreb is also very rare. These data indicate a rather low utilization of this genus in the urban landscaping of the city of Zagreb. For comparison, in a smaller town of Bjelovar, 3 alleys are composed of *S. aria*, *S. aucuparia* and *S. intermedia* (Vidaković, 2016). However, data about the usage of this genus in planting schemes of other Croatian towns are scarce. The most numerous collection of *Sorbus* s.l. in Croatia in arboretum Lisičine is composed of *S. austriaca*, *S. domestica*, *S. torminalis*, *S. aria* 'Magnifica', *S. aucuparia* 'Fastigiata', two hybrids and two non-native species (Idžojtić et al., 2010). For comparison, in Britain and Ireland

suburban streets lined with *Sorbus* s.l. are common in cities (Forrest, 2006). For sub-Mediterranean and higher Mediterranean area, Rosavec et al. (2005) among other species, recommend the usage of *S. aria* and *S. torminalis*, as examples of species, whose possibilities and quality for landscaping are still insufficiently utilised. We share the opinion of the above-mentioned authors that autochthonous species should be favoured over allochthonous wherever possible, since the former is already well adapted to the habitat conditions.

Regarding their functional and ornamental uses, Forrest (2006) cites their general use as street trees. Except *S. domestica*, which is in some extent grown as a fruit species, other *Sorbus* species are not cultivated for their fruits. They could be planted in schemes where their multi-functionality as ornamentals with edible fruits would be utilized such as suburban and rural areas, urban gardens, edible landscapes, etc. They could also be used for landscaping naturalistic schemes or for wildlife habitats inside nature protected areas. Except for human consumption, in these kinds of landscapes, these species could serve as a food for birds in winter (e.g., *S. aria* and *S. aucuparia*) including their leafy stems/branches used as winter forage by goats and sheep (*S. aria* and *S. torminalis*).

Utilization value as wild edible fruit species

Owing to their edible fleshy fruits, species of *Sorbus* s.l. can be considered as a wild fruit species. According to the website Plants For A Future (PFAF) (2017) given edibility rates for analysed *Sorbus* s.l. species (Table 1) are as follows: *S. aucuparia* and *S. austriaca* – 2 (= reasonably useful plants); *S. aria* – 3 (= could be grown as standard crops); *S. torminalis* – 4 (= very useful plants); and *S. domestica* – 5 (= great value).

Fruit of *S. chamamespilus* are edible but not very tasty (Idžojtić, 2013). However, they can be used raw, in desserts, jams, etc. (Grlić, 1984). Its medicinal use is unknown.

When consumed raw, fruit of *S. aucuparia* taste very sour to bitter and can cause stomach and intestine irritations and diarrhoea (Gelenčir and Gelenčir, 1991). Therefore, they should be collected overripe, after frost (Šilić, 1983) and are edible as processed. They can be used for jams (Gelenčir and Gelenčir, 1991), in porridges (Grlić, 1984), desserts, juices, wines, as a food stabiliser (Šatalić and Štambuk, 1997), and also for spirits (Šafar, 1946), vinegar and tea (Dirr, 1998). The fruit consist mostly of water, and are rich in vitamins A, C, E and B2 (Nikolić and Kovačić, 2008). They can be used as a purgative, diuretic, and in cases of vitamin C deficiency, coughs and voice loss (Gelenčir and Gelenčir, 1991). Solitary trees start to give fruit in the age of 5 and usually fructificate every year (Idžojtić, 2013).

The fruit of *S. austriaca* have a pleasant semi-sweet flavour when fully ripe and are edible raw or cooked in preserves etc. (PFAF, 2017). Its medicinal use is unknown.

The fruit of *S. aria* are sweet only after freezing (Idžojtić, 2013). They can be eaten raw or in desserts, jams, juices, wines (Šatalić and Štambuk, 1997); and spirits (Grlić, 1984). They can be used against diarrhoea, intestine infections and haemorrhages (Kušan, 1956).

Overripe fruit of *S. torminalis* have a pleasant, sweet to sour taste and can be consumed raw, and used for jams, desserts, compote, alcoholic drinks, spirits, as starches (Grlić, 1984). Their medicinal use covers haemorrhages, intestine infections, while unripe fruit can be used against diarrhoea (Kušan, 1956). Solitary trees start to give fruit when they are 20-25 years old. The trees exposed to more sunshine yield more. The full yield may be obtained every second year or in three within four years (Idžojtić, 2004, 2013).

The service tree (*S. domestica*) has been grown for its quality fruit and quality wood since early times but has been forgotten in the last few decades (Idžojtić and Drvodelić, 2005). It is on the list of Top Rated Trees for Edibility (PFAF, 2017). Fruit are edible raw when fully ripe and are best after freezing. They can be used as dessert fruit, for jams, spirits (Šimić, 1980), juices, vinegar; wines (Šatalić and Štambuk, 1997). They can be used as diuretic, purgative as well as against stomachic, coughs, voice loss (Gelenčir and Gelenčir, 1991), intestine infections and haemorrhages (Kušan, 1956), but can also cause diarrhoea (Gelenčir and Gelenčir, 1991). Solitary trees start flowering when 7 years old and giving fruit in the age of 8-9 years. Flowering occurs almost every year (Idžojtić, 2013).

Besides, many species of *Sorbus* s.l. can be used as honey plants e.g., *S. aria*, *S. aucuparia*, *S. austriaca*, *S. domestica* and *S. torminalis* (Šimić, 1980); and have very valuable wood, such

as *S. domestica*, *S. aucuparia*, and *S. torminalis* (Šafar, 1946).

Capacity for selection and plant breeding

In Croatia and in the most of the European countries *S. domestica* is a rare and threatened species and is, together with *S. aucuparia*, protected in Croatia (Anonymous, 2009). Moreover, *S. domestica* and *S. torminalis* are on the list of priority species for the conservation of genetic resources in Croatia and in Europe (Idžojtić, 2004; Idžojtić and Drvodelić, 2005). The key factor for developing the strategy for the protection of such endangered species is to determine morphological and genetic diversity in their distribution area (Poljak et al., 2011). The protection of intraspecies variability besides directly contributing to the preservation of biodiversity in the ecosystem, ensures better results in selection and breeding (Idžojtić, 2004). Unlike for the other *Sorbus* s.l. species (e.g., *S. aria*), the interspecies hybrids are unknown for *S. domestica* (Idžojtić and Drvodelić, 2005).

Service tree is also a species with high economic potential, especially if high quality and improved plant material is used (Idžojtić and Drvodelić, 2005). Drvodelić et al. (2009) revealed a positive correlation between fruit weight and seed weight, and between fruit weight and the number of filled seeds for *S. domestica* (f. *pomifera*). Therefore, selecting larger fruits can result in higher vitality of seedlings, i.e., better seed germination, better survival and higher seedlings. Similarly, positive correlation between the number of filled seeds (that are more numerous in larger fruits) and seed weight was observed for *S. torminalis*. Larger seeds also require a shorter stratification period (Oršanić et al., 2009).

All analysed species of *Sorbus* s.l. (data not available for *S. chamaemespilus*) may be propagated by seeds but also vegetatively, since they have strong shooting power from the stump (Šilić, 1983) and some even more powerful shooting power from the root, e.g., *S. domestica* and *S. torminalis* (Idžojtić, 2004; Idžojtić and Drvodelić, 2005). The propagation with cuttings may also be used, e.g., for *S. aria* (Šilić, 1983) and *S. domestica*. The service tree may also be grafted on the stocks of its cultivars, on *S. aria*, *S. aucuparia*; but also onto pear and medlar tree as well as propagated by tissue culture (Idžojtić and Drvodelić, 2005). Also, some *Sorbus* s.l. can be grafted onto *S. aucuparia* or hawthorn rootstock (Forrest, 2006).

CONCLUSIONS

- In Croatian flora, *Sorbus* s.l. is represented with at least six native taxa and another six that are deficiently known and which presence should be confirmed by further research;
- Generally, they are resistant species with wide ecological amplitude for a number of ecological factors and can be propagated in various ways;
- Analysed Croatian native *Sorbus* s.l. species (*S. aria*, *S. aucuparia*, *S. austriaca*, *S. chamaemespilus*, *S. domestica*, *S. torminalis*) represent quality plants for usage as ornamentals as well as for cultivation for edible fruits;
- Besides standard usage for urban landscaping, their usage could cover schemes where their multi-functionality as ornamentals with edible fruits would be utilized such as suburban and rural areas, urban gardens, naturalistic schemes, edible landscapes, etc.

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