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DEVELOPMENT AND AGE OF *AMELANCHIER SPICATA* SHRUBS

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One of the most rapidly spreading alien plant species in Lithuania is *Amelanchier spicata* (Lam.) K. Koch. Specific biological characteristics of *A. spicata* and its abundant aboveground biomass enables this species to compete with local plants and penetrate into natural and slightly disturbed forest habitats and communities. The studies have shown the positive correlation between all the investigated aboveground parameters and the age of shoots. Interspecific competition has little influence on the amount of aboveground biomass although large coverage of herbs slows down the formation of new partial shrubs of *A. spicata*. Formation of new sprouts of *A. spicata* is discontinuous, and it is more intensive once in a few years.

Key words: alien plant species, invasion, forest habitats, dendrochronology, annual rings.

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Introduction

Alien species penetrate into natural, disturbed and anthropogenic habitats, changing their structure and ecological conditions (Gurevitch & Padilla 2004; Herben 2007). Non-native species influence local plants (Funk at al. 2008) by decreasing biodiversity (Reinhart et al. 2005). Invasive plants cause significant economical losses and induce rapid changes of natural habitats (Dietz & Fattorini 2002). Plans from other regions of the world may be deliberately or accidentally introduced into the areas being far away from their natural ranges (Edvards et al. 1995, Qian 2008). Successful spreading and establishment of alien species is determined by life strategy of a species, high amount of ripened seeds, a long-term seed bank (Debra et al. 2006), conditions and micro-conditions of habitats (Burley et al. 2008), peculiarities of reproduction and weak biological barriers (Funk et al. 2008). Invasion of certain species also depends on various changes in ecosystems (Simonova & Lososova 2008), i.e, physical damages, post-fire changes, pasturage of cattle, an increased amount of nutrients in soil, etc. (Thomson & Leishman, 2005).

Kovarik (1995) points out that there are no ecosystems that have not experienced any human effect. Ecosystems located in the vicinity of settlements and towns are more affected by human activities, and they are usually rich in alien plant species. The majority of changes in ecosystems in the vicinities of settlements are determined by the changes of the soil structure (Lake & Leishman 2004, Thomson & Leishman 2005). Forests are considered to be relatively stable ecosystems resistant to plant invasions (Burley et al. 2008, Yates 2004, Muller-Scharer et al. 2004). However, both rapid increase of number of alien species and their population are observed recently in forests of Lithuania. The spread of the invasive plants in forest habitats is slowed down by insufficient amount of the sunlight (Jeremy et al. 2004). The lower is

the coverage of the forest plants, the larger is the number of alien plants and vice versa (Kovarik 1995).

According to Gudžinskas (2008), nowadays over 550 alien plant species are registered in Lithuania. *Amelanchier spicata* (Lam.) K. Koch is among alien naturalised woody species, which are widespread in the forests of Lithuania. *A. spicata* was introduced in Lithuania as an ornamental and berry-plant; in 1934 it was first recorded as escaped from cultivation (Gudžinskas 2000). The genus *Amelanchier* is native to temperate regions of the Northern Hemisphere (Navasaitis 2004, 2008). Various species of this genus primarily grow in habitats of early succession stages (Mabry & Fraterrigo, 2008). In spite of invasiveness of *A. spicata* in Europe, the data about shrub formation, impact on the local plant species, forest communities and habitats are scarce.

Methods

Investigations on *A. spicata* were performed in three populations in the environs of Vilnius (Antaviliai, Žemoji Veržuva and Aukštieji Paneriai). In each population *A. spicata* was studied in 100×100 m sampling plots (the area was 10000 m^2). The sampling plot was divided into sixteen 25×25 m sub-plots (area of each sub-plot was 625 m^2). Direction of transect depends on the character of shrub distribution, density and size of the population.

During field investigations, the structure of plant community, species diversity and their coverage were estimated. For characterization of plant communities, relevés were made following the methodological guidelines of J. Braun-Blanquet (1964) approach.

In the course of investigation, each shrub and each shoot in the shrub were consecutively numbered and their parameters were measured. The following parameters and characters of *A. spicata* were measured and determined: (a) height of a shoot (from the ground level to the top); (b) the diameter of shoot at the ground level; (c) the distance from the ground level to the first lateral branch; (d) group of maturity (vegetative, generative, dead).

In order to evaluate formation of *A. spicata* shrub, arrangement of shoots of a shrub was schematically drawn and the distances between nearest shoots were measured.

A lower section of approximately 10 cm length of *A. spicata* shoot was taken for the dendrochronological research. The age of each *A. spicata* shoot was determined using dendrochronological methods (Bitvinskas, 1997; Krapiec, 1998; Stravinskienė, 2002). Diameter of each annual ring was also measured.

The data were analysed using *Microsoft Excel* and *Statistica 6.0 for Windows* software.

Results

The population of Antaviliai was exceptional in its abundance of the samples – 785 shoots were found (Table 1). In Aukšieji Paneriai plot 399 shoots were found, and in Žemoji Veržuva – 263 shoots. Average density of shoots in Antaviliai population was 7.85 shoots/m^2, in Paneriai – 3.99 shoots/m^2, and in Žemoji Veržuva – 2.63 shoots/m^2.

The greatest variation of shoot height was revealed in Aukštieji Paneriai population (it varied from 27 cm to 768 cm; average 154.25±0.24 cm; $p< 0.00$). In Antaviliai population, which is characterised by extremely high number of shoots, they were the shortest: their height varied from 12 cm to 489 cm (average 145.75±0.08 cm; $p< 0.00$). The greatest average shoot height was in Žemoji Veržuva population – 174.55±0.15 cm ($p< 0.00$; it varied from 24 cm to 499 cm).

In the process of the analysis, the height of *A. spicata* shoots to the first lateral branch was measured. In Antaviliai population the average

height of the first branch was the smallest in comparison with other studied populations – 35.55±0.08 cm ($p<0.00$). In Žemoji Veržuva and Aukštieji Paneriai populations the average of *A. spicata* first branch height is similar: 44.47±0.15 cm and 48.70±0.24 cm, respectively (Table 1). However, in Antaviliai population maximum height of the first branch was 245 cm from the soil surface, and the lowest maximum height of the first branch was in Žemoji Veržuva – 167 cm. In all studied populations some shoots formed lateral branches very low – at 1 cm from the soil surface.

The diameter of the shoot in all studied populations was similar. In Antaviliai population it was 7.88±0.23 mm, in Žemoji Veržuva – 9.43±0.35 mm, and in Aukštieji Paneriai – 7.9±0.29 mm. The research revealed that the thickest shoot (125 mm in diameter) was only 7 years old.

The age of the analysed *A. spicata* shoots in Antaviliai and Žemoji Veržuva populations was similar. The highest age variations were revealed in Aukštieji Paneriai population. The oldest recorded shoot in Antaviliai population was 21 years old (average age was 5.52±0.08 years), in Žemoji Veržuva – 19 years old (average age 5.86±0.15 years), and in Žemieji Paneriai the oldest shoot was 34 years old (average age 6.66±0.15 years) (Table 1). The largest number of shoots was of three and four years: in Antaviliai population they were represented by 104 and 112 shoots, respectively (Fig. 1). In Žemoji Veržuva population both these age groups were represented by 31 shoot. The greatest difference in shoot age was determined in Aukštieji Paneriai population. The oldest *A. spicata* shoot was 34 years old. Furthermore, 4 and 5 years old shoots in this population prevailed (54 and 57 shoots, respectively).

Investigation revealed that the number of generative *A. spicata* shoots in all studied populations was very small. In Aukštieji Paneriai population vegetative shoots comprised 97.98%, in Žemoji Veržuva – 94.31%, and in Antaviliai population – 93.37% of the total number of shoots.

Discussion

Analysis of *A. spicata* populations revealed that the shoot number in a shrub little depends on the height and diameter of shoots, though correlation among these characters in all studied populations was statistically reliable (Table 2). The number of shoots in a shrub could be estimated as the whole complex of biological and ecological properties of the species (Naujalis 1992). In Aukštieji Paneriai population a strong and statistically reliable correlation was found between the height of *A. spicata* shoot and the height to the first lateral branch ($r=0.70$; $p<0.00$), in Žemoji Veržuva population – between the shoot height and its diameter ($r=0.86$; $p<0.00$).

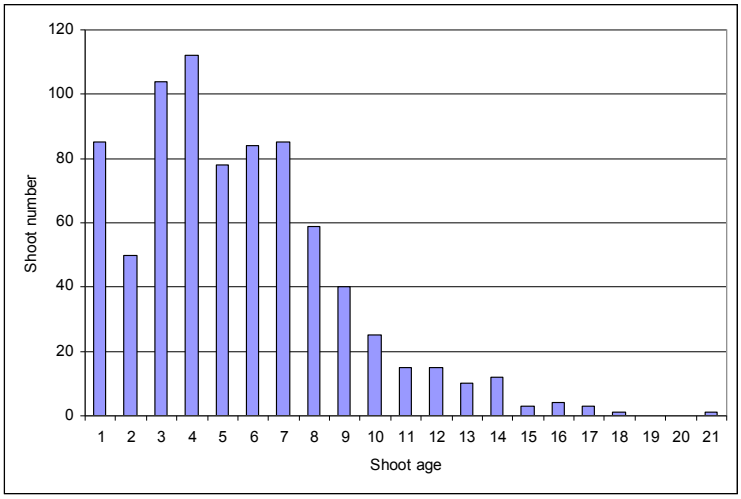

Fig. 1. Total number of *Amelanchier spicata* shoots in the sampling plots of the investigated populations

Table 1. Statistics of the investigated parameters of *Amelanchier spicata*

Character	N	Average	Median	Mini-mum	Maxi-mum	Standard deviation	Standard error	t	p
Antaviliai population									
Shoot height (cm)	785	145.72	129.00	12.00	489.00	88.61	0.08	46.07	0.00
Height to the first lateral branch (cm)	785	35.55	30.00	1.00	245.00	27.94	0.08	35.60	0.00
Shoot diameter (mm)	785	7.91	7.00	1.00	125.00	6.44	0.08	34.35	0.00
Shoot age (years)	785	5.52	5.00	1	21	3.33	0.08	46.41	0.00
Aukštieji Paneriai population									
Shoot height (cm)	399	154.25	143.00	27.00	768.00	83.88	0.24	36.73	0.00
Height to the first lateral sprout (cm)	399	48.70	40.00	1.00	223.00	35.35	0.24	27.51	0.00
Shoot diameter (mm)	399	7.92	7.00	1.00	57.00	4.58	0.24	34.50	0.00
Shoot age (years)	399	6.66	600	1	34	3.97	0.24	33.42	0.00
Žemoji Veržuva population									
Shoot height (cm)	263	174.55	152.00	24.00	499.00	107.24	0.15	26.39	0.00
Height to the first lateral sprout (cm)	263	44.47	37.00	1.00	167.00	32.37	0.15	22.27	0.00
Shoot diameter (mm)	263	9.43	8.00	1.00	36.00	5.72	0.15	26.67	0.00
Shoot age (years)	263	5.86	5.00	1	19	3.69	0.15	25.66	0.00

A moderate and statistically reliable correlation was found between the height of the first lateral branch and shoot diameter in all the studied *A. spicata* populations (Table 2). It was revealed that there are statistically reliable and strong correlations between the age of the shoot and its height (r=0.70) in Žemoji Veržuva population. The same correlation was found between the shoot age and its diameter (r=0.75) and between the shoot age and its height in Antaviliai population (r=0.76) (Table 2).

Though correlation between the age of the shoot and its height in Aukštieji Paneriai population is statistically reliable, it is not very strong in comparison to other studied populations

Table 2. Correlations of *Amelanchier spicata* parameters. Statistically significant correlations are marked by an asterisk

	Population								
	Žemoji Veržuva			Antaviliai			Aukštieji Paneriai		
Character	Shoot height	Shoot diameter	Shoot age	Shoot height	Shoot diameter	Shoot age	Shoot height	Shoot diameter	Shoot age
Shoot height	–	0.86*	0.70*	–	0.67*	0.76*	-	0.56*	0.29*
Shoot diameter	0.86*	–	0.75*	0.67*	–	0.56*	0.56*	–	0.65*
Shoot age	0.70*	0.75*	–	0.76*	0.56*	–	0.29*	0.65*	–

(r=0.29). Habitat of this population is characterised by lower coverage (60%) of the first and the second tree layers. It is probable that this factor has stronger influence on *A. spicata* shoot height. In this population the correlation between the shoots age and their diameter is strong and statistically reliable (r=0.65).

Characteristic feature of woody species is increment of the aboveground mass with the increase of plant age (Falinska 1998). However, comparison of the dendrochronological data and morphological parameters revealed that in *A. spicata* quantitative characteristics of shoot aboveground part does not reflect their exact age (Fig. 2). 33-year old shoots in Aukštieji Paneriai population had the largest aboveground part. These shoots were the tallest among the analysed shoots in this research. The shortest shoot of *A. spicata* (27 cm) was five years old. The oldest shoot in Antaviliai population was 21 years old and 397 cm tall, whereas in Aukštieji Paneriai population the tallest shoot (489 cm) was sixteen years old. In Žemoji Veržuva population the tallest shoot (449 cm) was only six years old. The oldest shoot (19 years old) was of 411 cm.

A. spicata growing in comparatively open habitats had taller and more luxuriant shoots. The shoots of *A. spicata* growing in thick forests were shorter, thinner; the shrubs were smaller and had fewer shoots. *A. spicata* in Antaviliai population can be divided into two coenopopulations. The first coenopopulation occurs at the forest edge where the first layer of trees is comprised of *Pinus sylvestris* L., *Acer platanoides* L. and *Quercus robur* L. with the coverage of 60–70%, and the second coenopopulation occupies the ass. *Melico nutantis-Picceetum abietis* with tree coverage reaching 90%. The height of *Amelanchier spicata* in the first coenopopulation was up to 489 cm, whereas in the second – up to 310 cm only. The diameter of shoots was up to 31 mm

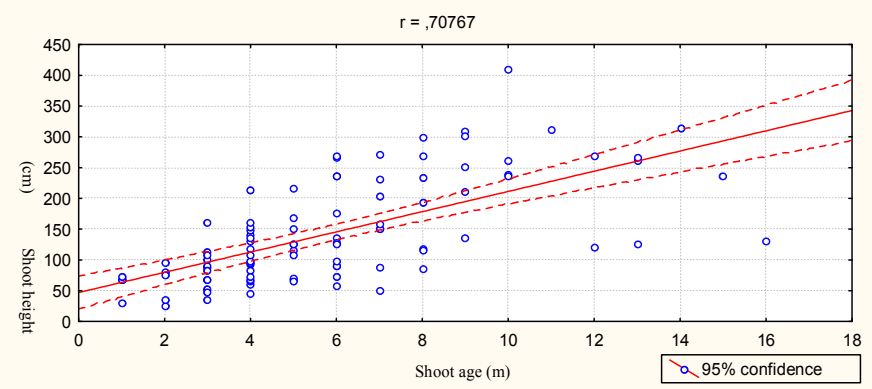

Fig. 2. Correlation between shoot age and shoot height of *Amelanchier spicata* in Žemoji Veržuva population

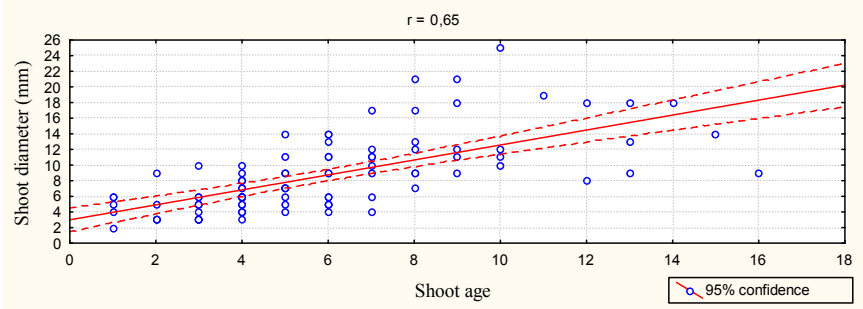

Fig. 3. Correlation between *Amelanchier spicata* shoot age and its diameter in Aukštieji Paneriai population

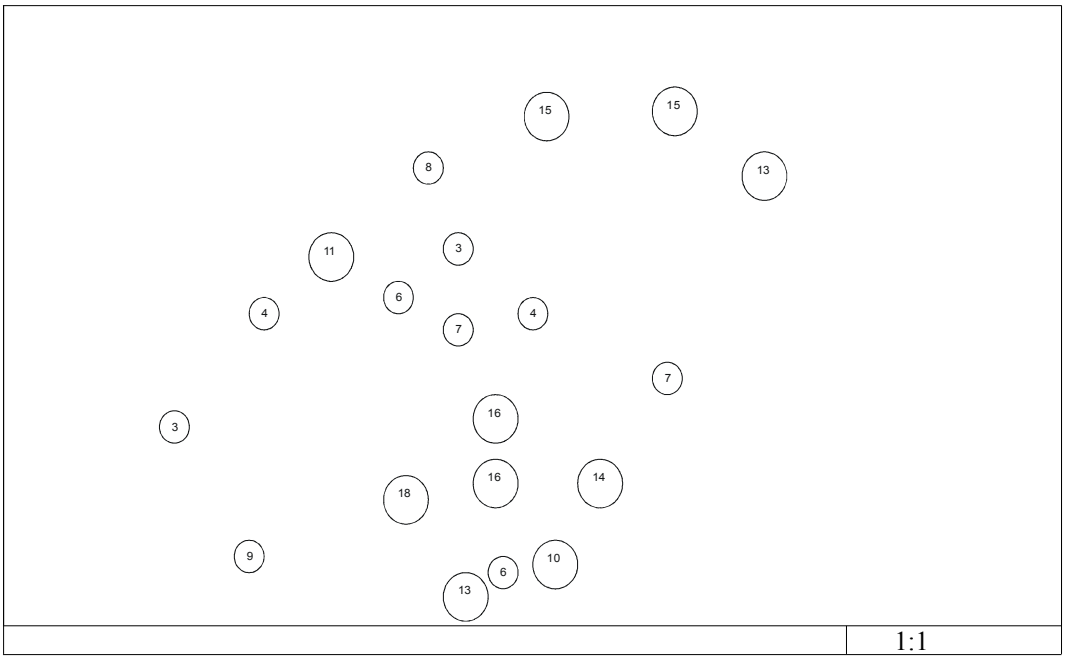

Fig. 4. The distribution of *Amelanchier spicata* shoots and their age in Antaviliai population. The number in the circle indicates the age of the shoot (in years)

(one shoot was 125 mm in diameter) and 18 mm, respectively.

Comparison of the shoot age and their diameter revealed positive and statistically reliable (in Antaviliai population $r=0.56$ $p<0.00$; in Žemoji Veržuva – $r=0.75$; $p<0.00$; in Aukštieji Paneriai – $r=0.65$; $p<0.00$) correlations of these parameters in all studied populations (Fig. 3). However, the diameter of some older *A. spicata* shoots was smaller than that of younger shoots, e.g. one 9-year old shoot of *A. spicata* and a 2-year old shoot were of the same 7 mm diameter. Evidently, the diameter of *A. spicata* shoots depends on the competition among shoots of the same shrub, individual shrubs of the same species, among different species and particular habitat conditions.

In Antaviliai population the time lag between the appearance of the first and the second shoot is 4 years, in Žemoji Veržuva – 2 years, and in Aukštieji Paneriai – 5 years. The further formation of new shoots is rather slow for the next 3 years in Antaviliai population. Starting with the 4th and 5th year the number of new shoots is much higher. In the following 4–5 years, the number of new shoots is similar and ranges from 12 to 15 shoots per year (Fig. 1.). In the 11th to 20th years of the shrub growth, the number of shoots starts to increase considerably again. It was revealed that the number of shoots in population increases considerably each 5–9 years. Thus, it is supposed that approximately 5 years old *A. spicata* individuals start to propagate vegetatively.

In Žemoji Veržuva population the number of shoots is increasing gradually and differences in the age of shoots are greater in the 9th year. Different growth conditions could have had certain influence on a period of new shoot formation in the studied populations. Another reason of such phenomenon could be stronger interspecific competition in a community.

Unfavorable growth conditions of that year could have been decisive for the decreased number of 2-year old shoots in all studied *A. spicata* populations (Myers & Bazely 2003).

Comparison of populations by the average shoot age did not reveal similarities in the average age (Table 1), because 1–5-year old shoots were more numerous in all studied populations. In Aukštieji Paneriai population 1–5-year old shoots comprise 68% of the total shoot number; in Antaviliai population such shoots comprise 65%.

Investigation revealed that distances among *A. spicata* shrubs in habitats are very different. In some cases distance between shrubs is less than 1 m, and in such cases one of the adjacent shrubs is usually smaller and younger. It is supposed that such shrubs grew from root suckers. Vegetative reproduction of *A. spicata* gives a possibility for a shrub to spread in the direction of free space or an area with weaker interspecific competition. Favourable conditions for young shoots formation occur inside a shrub, among the older shoots, where competition of other plant species is much weaker.

Analysis of the shrub formation revealed that older shoots are at greater distance apart. Later new shoots form from root suckers among them (Fig. 4). Further spread of young *A. spicata* shoots is slowed down but is not entirely stopped. A presumption could be made that mature *A. spicata* individuals are tolerant to interspecific competition. In some cases *A. spicata* individuals growing next to large, mature trees were found in the study plots. Such shrubs are characterised by high number of shoots and large aboveground mass. The ability of *A. spicata* reproduction by root suckers increases its invasiveness.

Young shoots, bent to the soil, soon take root and start functioning as independent individuals. Thus, even a small number of young *A. spicata* individuals in the population indicate ability of this species spreading in natural forest communities, which are considered comparatively stable and resistant to invasions (Muller-Scharer et al. 2004).

Conclusion

Comparison of the dendrochronological data and morphological parameters of *A. spicata* shoots revealed that quantitative characteristic of shoot aboveground part does not reflect their exact age. The diameter of some older shoots was smaller than that of younger shoots. Thus, the diameter of *A. spicata* shoots depends on the competition among shoots of the same shrub, individual shrubs of the same species, among different species and particular habitat conditions.

The analysis revealed that the number of shoots in a population increases considerably each 5–9 years. Thus, it seems that approximately 5-year old *A. spicata* individuals start to propagate vegetatively. Different growth conditions could have had certain influence on a period of new shoot formation in the studied populations. Analysis of the shrub formation indicated that older shoots are at greater distance apart. Later new shoots form from root suckers among them. The ability of *A. spicata* to reproduce by root suckers increases its invasiveness.

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