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VARIATION OF CHEMICAL AND MORPHOLOGICAL CHARACTERS OF LEAVES AND UNRIPE CONES IN *JUNIPERUS COMMUNIS*

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Abstract

Vaičiulytė V., Ložienė K., 2013: Variation of chemical and morphological characters of leaves and unripe cones in *Juniperus communis* [Paprastojo kadagio (*Juniperus communis*) lapų bei neprinokusių kankorėžėlių cheminių ir morfologinių parametrų įvairavimas]. – Bot. Lith., 19(1): 37–47.

The variation of content of essential oil and pinene isomers and morphological parameters of leaves and unripe cones in *Juniperus communis* L. was studied. Leaves and cones were collected separate from 110 *J. communis* individuals in 11 different habitats throughout Lithuania. Essential oils were analysed by capillary gas chromatography (GC). The study showed more intensive essential oil accumulation and higher intraspecific variation of essential oil amount in unripe cones than in leaves. Significant differences between α- and β- pinene amounts were observed in *J. communis*. β-Pinene was detected in much higher quantities than α-pinene. Positive correlation was detected between pinene isomers in cones and leaves ($r = 0.44$, $p < 0.05$ and $r = 0.50$, $p < 0.05$, respectively) of the same tree showing pinene isomers common biosynthetic pathway. Significant differences between populations were characteristic of *J. communis* according to leaf length, unripe cones mass and essential oil yield in leaves, however, significant correlation was established between essential oil yield of leaves and habitat illumination ($r = -0.67$, $p < 0.05$) and soil acidity ($r = -0.80$, $p < 0.05$) only.

Keywords: *Juniperus communis*, leaves, unripe cones, essential oils, pinene isomers, morphological and chemical variation, abiotic factors.

INTRODUCTION

Juniperus communis L. (*Cupressaceae* Rich. ex Bartl.) is a volatile secondary metabolites essential oils bearing and wide spreading conifer in the world (Adams, 2004; Rook, 2006). The quantitative and qualitative composition of essential oils extracted from cones (ripe and unripe), leaves, wood and roots varies both between individual plants and between plant parts in this species (Berta, 1993; Butkienė et al., 2006; Gonny et al., 2006; Marongiu et al., 2006). The highest amounts of essential oil were established in unripe cones (twice more than in ripe cones), the lowest – in wood and roots. Commonly predominant essential oil compound in all parts of *J. communis* is monoterpene α-pinene, the contents of which can reach up to 80.4% (Angioni et al., 2003; Shahmir et al., 2003; Butkienė et al., 2006, Butkienė et al., 2009; Filipowicz et al., 2009). α-Pinene is considered as biologically active compound, determining the main pharmacological properties of *J. communis* (Cavaleiro et al., 2006; Leite et al., 2007). The literature suggests that another pinene isomer β-pinene is characteristic of wider spectrum of antibacterial activity than α-pinene (Dorman & Deans, 2000). Isomer β-pinene is sometimes found in the essential oils of *J. communis*, however, in lower amounts (Ložienė et al., 2010).

The high ecological amplitude is typical of *Juniperus communis*: it is frequent in dry pinewoods, on river valleys, however, occurs on wet soils, too (Garcia et al., 2000; Thomas et al., 2007); it is light-demanding and intolerant of deep shade (< 1.6% daylight), but can grow in little as 20.5% daylight (Grubb et al., 1996; Humphrey, 1996). Such ecological amplitude of *J. communis* can be one of the reasons for morphological variation as well as quantitative and qualitative diversity of essential oils (Adams, 1998; Chatzopoulou & Katsiotis, 2003; Cavaleiro et al., 2003). Cones and its essential oils are pharmaceutical raw material (Council of Europe, 2008). Leaves accumulate lower amounts of essential oil, therefore, form a big part of plant biomass, which evaporate volatile compounds to atmosphere.

The purpose of this study was to quantify the variation of *Juniperus communis* cones and leaves by some morphological and chemical (amount of essential oils and pinene isomers) characters in relation to different ecological conditions of habitats in Lithuania.

MATERIALS AND METHODS

Plant material. First-year (unripe) cones and current-year shoots of *Juniperus communis* were sampled from 11 natural habitats, which differed by illumination intensity (open or shaded habitats) and soil characteristics, such as soil acidity, contents of organic nitrogen, mobile phosphorus, mobile potassium and humus in Lithuania in August 2010 (Table 1). Distances between habitats were no less than 10 km (Fig. 1). Ten female individuals being of normal development, similar in height and stem diameter were selected in each habitat randomly. In order to avoid any effect of dioeciousness, which is typical of this species (Adams, 2004), only female individuals were used for leaves and unripe cones sampling. Plant material was collected separately from each of the individuals and dried at room temperature.

Table 1. Characteristics of studied habitats of *Juniperus communis* (habitat numbers in Table 1 are in character with habitat numbers in Fig.1)

No.	Habitat locality (municipality) coordinates WGS-84	Short ecological characteristics	pH_{KCL}	N_2 (%)	P_2O_5 (mg/kg)	K_2O (mg/kg)	Humus	Lighting (klux)
Open habitats								
1	Arlaviškės (Kaunas) 54.812828, 24.181667	Dry meadow, slope, inclination 40°, aspect S	6.5 ± 0.6	0.20 ± 0.03	67 ± 23	156 ± 21	3.6 ± 0.4	35.0
2	Sekionys (Kaišiadorys) 54.688837, 24.097153	Dry meadow, slope, inclination 40°, aspect S–SW	7.3 ± 0.1	0.33 ± 0.06	153 ± 35	311 ± 72	4.9 ± 0.3	31.0
3	Savaitiškės (Trakai) 54.500552, 24.707439	Dry meadow, slope, inclination 35°, aspect E7	5.1 ± 0.4	0.31 ± 0.08	180 ± 72	194 ± 106	4.9 ± 1.5	28.0
4	Šaukliai (Skuodas) 56.127208, 21.591581	Dry meadow, moraine, plain	5.1 ± 0.9	0.25 ± 0.11	54 ± 41	78 ± 18	5.1 ± 1.8	30.0
5	Bradesiai (Zarasai) 55.838684, 25.848121	Dry meadow, slope, inclination 40°, aspect S–SW	6.7 ± 0.3	0.18 ± 0.03	86 ± 26	131 ± 10	3.3 ± 0.2	30.0
6*	Šuminai (Ignalina) 55.3995, 26.0559	Calcareous fen, plain	7.7 ± 0.1	1.01 ± 0.30	75 ± 14	71 ± 13	14.4 ± 4.6	29.0
Shaded habitats								
7	Tetervinai (Šalčininkai) 54.318833, 25.040402	Coniferous wood, riverside, undulated plain	4.3 ± 0.1	0.05 ± 0.00	88 ± 16	16 ± 3	1.7 ± 0.2	12.0
8	Degsnės (Varėna) 54.381604, 24.7848	Coniferous wood, plain	4.2 ± 0.0	0.13 ± 0.03	149 ±5 1	25 ± 6	3.7 ± 0.5	11.5
9	Rudnia (Šalčininkai) 54.199572, 25.706204	Coniferous wood, plain	5.6 ± 0.2	0.04 ± 0.01	103 ± 7	24 ± 1	1.4 ± 0.2	5.0
10	Peleniai (Kelmė) 55.844219, 22.897986	Coniferous wood, plain	4.1 ± 0.2	0.07 ± 0.02	115 ± 6	28 ± 10	2.1 ± 0.9	13.0
11	Ginučiai (Ignalina) 55.392444, 25.994218	Coniferous wood, undulated relief	4.8 ± 0.6	0.04 ± 0.02	88 ± 16	24 ± 4	1.9 ± 0.4	9.0

* – control habitat No. 6 was not included in the statistical analyses of this paper.

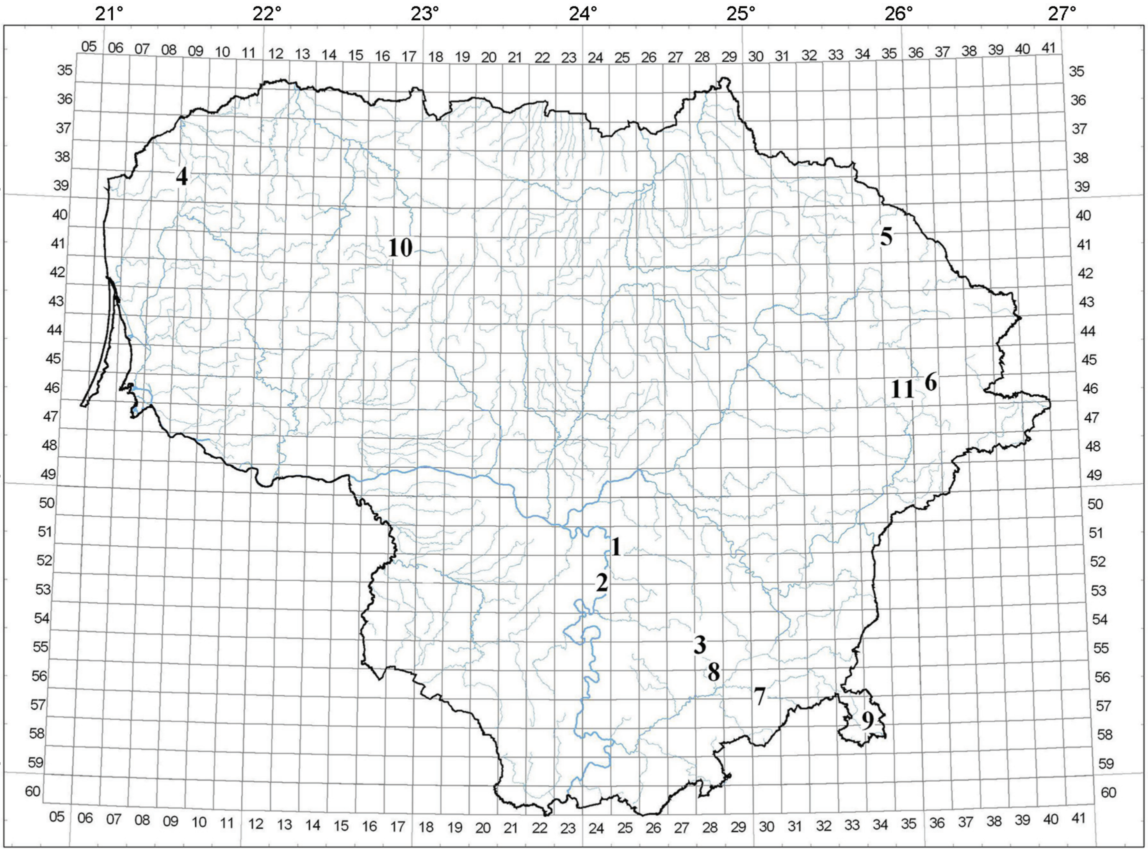

Fig. 1. Locations of the studied *Juniperus communis* habitats in Lithuania

Habitat evaluation. Illumination was measured in kiloluxes with photoradiometer HD 2302.0 in three places per habitat at around the midday time and a clear sky condition. Soil samples were taken from the depth of 10–15 cm at three randomly chosen, remote from each other places per habitat. The contents of organic nitrogen (N_2), mobile phosphorus (P_2O_5) and humus in soil were estimated photoelectrocolorimetrically, and mobile potassium (K_2O) – by flame photometry. Soil acidity (pH) was estimated electrometrically using 1 M KCl solution.

Morphological analysis. The mass of 100 leaves, the mass of 100 unripe cones and the lengths of leaves were assessed in 110 plants (in ten plants from each habitat). Three hundred randomly selected leaves per sample were used for length measurements. In three weighing per individual plant were used for the measurement of the mass of leaves and unripe cones.

Essential oil isolation and quantitative analysis. Essential oils were isolated from 110 samples of leaves and 110 samples of unripe cones by hydrodistillation in Clevenger-type apparatus (Simax) during two hours (Council of Europe, 2008). The contents of essential oils were evaluated by percent (%) in air-dry weight.

Analysis of pinene isomers using GC-FID. Essential oils solutions of 1% were prepared in mixture of diethyl ether and n-pentane (1:1) for further investigations. The analysis of monoterpene pinene isomers was carried out using a FOCUS GC (Thermo Scientific) gas chromatograph with a flame ionisation detector (FID). Data were processed with the CHROM-CARD S/W.

The silica capillary column TR-5 (30 m, i. d. 0.25 mm, film thickness 0.25 μm) was used for the analysis of the α- and β-pinene with the following GC parameters: carrier gas helium flow rate 1.6 ml/ min; temperature programme from 40°C to 250°C increasing at 4°C/min; detector temperature 260°C; split injector was heated at 250°C. The identification of α- and β-pinene was carried out by the comparison of the retention time (RT) of their GC peaks in the FID chromatograms with the RT of α- and β-pinene analytical standards (Sigma-Aldrich) (Fig. 2). The percentage amounts of pinene isomers were recalculated according to the areas of the FID chromatographic peaks assuming that all constituents of the essential oil comprise 100%.

Statistical analysis. The statistical analyses were carried out only in 10 habitats: habitat No. 6 was not included in the statistical analyses, because it distinguished by some ecological characters (was calcareous fen and had signally higher contents of humus and organic nitrogen in soil) from other habitats (Table 1). The normality of the data distribution was tested by the Shapiro-Wilk test. The Pearson correlation coefficient was used to test whether the investigated morphological and chemical parameters of *Juniperus communis* are interdependent and how they correlate with the parameters (soil characteristics, lighting) of the habitats. The one-way analysis of variance (ANOVA) and the *t*-test were used to test the differences in the investigated morphological and chemical parameters of *J. communis* at between-population level. Statistical analyses were conducted using STATISTICA® 7 and MS Excel software.

RESULTS

After the study of 100 cone-bearing juniper trees, the following averages of leaf length, mass of 100 leaves and mass of 100 unripe cones were estimated: 12.3 ± 1.55 (SD) mm, 0.163 ± 0.029 (SD) g and 2.928 ± 0.877 (SD) g, respectively. Leaf length and leaf mass varied similarly at individual plant level: min–max values of leaf length (9.0–16.4 mm) and leaf mass (0.114–0.291 g) differed twice; variation coefficients were similar (13% and 18%, respectively). The variation of cones mass was higher – from 1.461 to 5.617 g (V = 30%). Also statistically significant positive correlation was observed between leaf length and leaf mass ($r = 0.44$, $p < 0.05$) (Fig. 3).

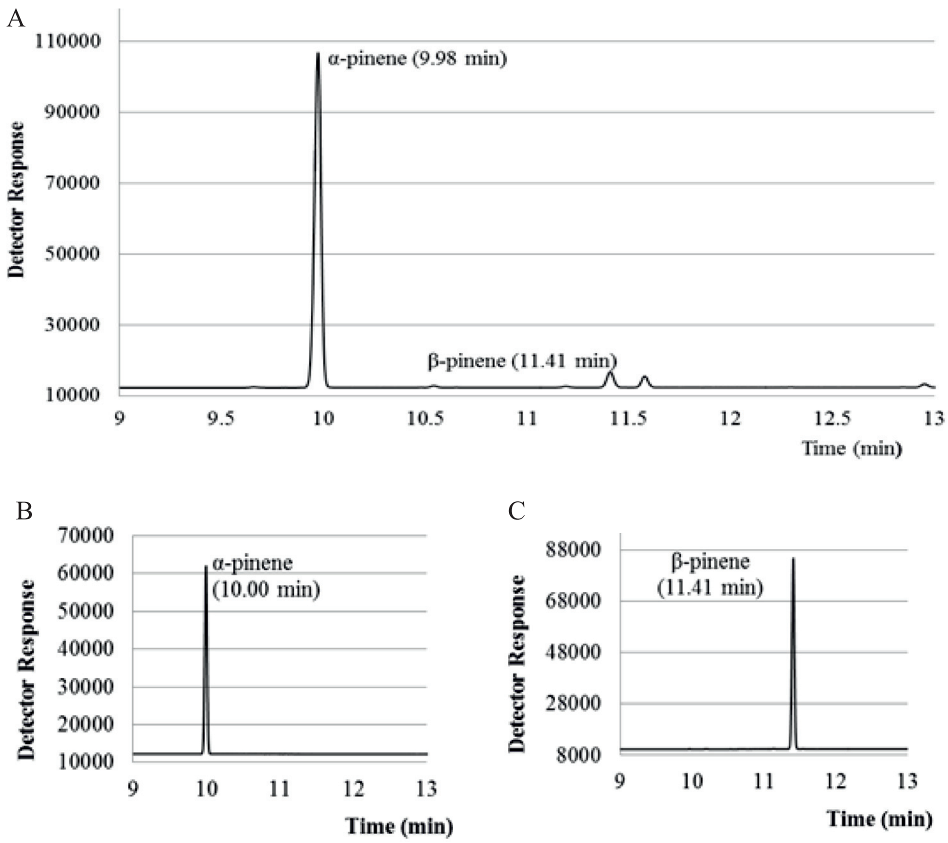

Fig. 2. Capillary GC analysis of pinene isomers in the studied *Juniperus communis* (A) in comparison with its analytical standards (B, C)

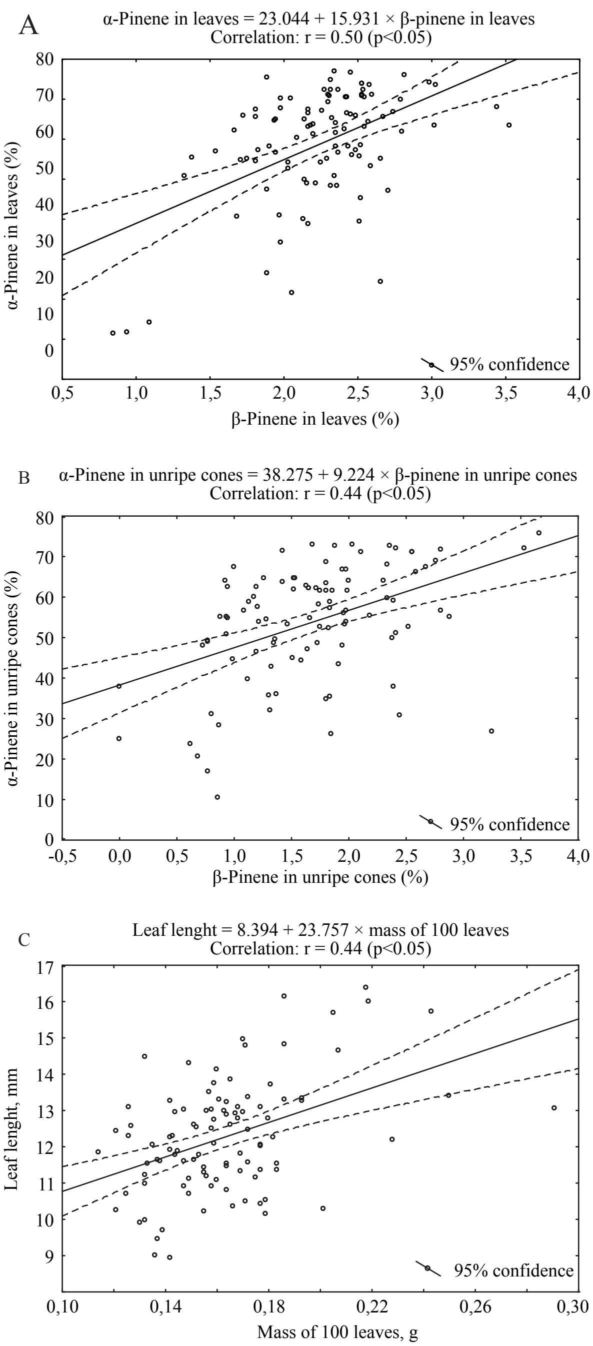

Fig. 3. Correlations between percentages of pinene isomers in leaves (A) and unripe cones (B) and between leaf length and leaf mass (C) (n = 100 *Juniperus communis* individuals)

The investigations of individual *Juniperus communis* shrubs (n = 100) showed that unripe cones accumulate thrice more essential oils than leaves (1.3 ± 0.64% (SD) and 0.4 ± 0.14% (SD), respectively). The wide ranges of values (in leaves 0.1–0.9% and in cones 0.3–4.2%) and high coefficients of variation (in leaves 36% and in cones 49%) were established.

α-Pinene was detected in leaves and cones in all investigated samples of *Juniperus communis*. It was the main essential oil compound in 97% of all analysed leaves and in 98% of all analysed unripe cones. The leaves and unripe cones contained very similar amounts of this monoterpene – 58.9 ± 14.2% (SD) and 53.9 ± 14.2% (SD), respectively. α-Pinene varied within wide range, which was similar both in leaves and unripe cones: the min–max values of this monoterpene in leaves and cones were stated 11.5–76.8% and 10.4–75.8%, respectively. The amounts of isomer β-pinene were less in comparison with α-pinene: leaves contained 2.3 ± 0.4% (SD) and cones 1.7 ± 0.7% (SD) of β-pinene only. As distinct from α-pinene, the cones of two *J. communis* shrubs absolutely did not accumulate β-pinene.

Correlation connections were observed between pinene isomers: if tree accumulated higher α-pinene amount in cones or leaves, the higher values of β-pinene also were detected in cones or leaves of the same tree ($r = 0.44$, $p < 0.05$ and $r = 0.50$, $p < 0.05$, respectively) (Fig. 3).

The one-way analysis of variance (ANOVA) showed that the investigated 10 habitats significantly differed in leaf length, mass of 100 unripe cones, essential oil yield in leaves and β-pinene percentage in unripe cones; the highest differences between the habitats were estimated according to morphological characters (Table 2).

All investigated habitats were grouped in open habitats (No. 1–5) and shaded habitats (No. 7–11) (Table 1), because these two habitat groups differed clearly according to illumination ($t = 11.23$, $p = 4\times10^{-6}$), soil acidity ($t = 2.94$, $p < 0.02$), contents of mobile potassium ($t = 3.85$, $p < 0.005$), organic nitrogen ($t = 5.54$, $p < 0.0006$) and humus ($t = 4.0$, $p < 0.004$). Although the majority of chemical characters (excluding β-pinene in leaves) were higher in shaded habitats group (Table 3), these two habitat groups differed significantly according to essential oil ($t = 3.32$, $p < 0.001$) and β-pinene ($t = 2.11$, $p < 0.04$) yields in leaves only (Table 2). Leaf length was significantly higher in shaded habitats group ($t = 2.91$, $p < 0.004$); while the mass of leaves and cones was higher in open habitats, however, differences were not statistically significant between open and shaded

Table 2. One-way analysis of variance (ANOVA) of investigated 10 habitats and *t*-test comparison of two habitat groups (shaded No. 1–5 and open No. 7–11 habitats)

Morphological and chemical characters		One-way ANOVA testing of habitats (df = 9)		*t*-testing of shaded and open habitat groups (df = 98)	
		F	p	*t*	p
Leaf length (mm)		9.25	$8 \times 10^{-10*}$	2.91	0.004*
Mass (g) of 100 leaves		1.78	0.08	1.96	0.05
Mass (g) of 100 cones		4.62	$5 \times 10^{-5*}$	0.82	0.42
Essential oil yield (%)	Leaves	3.00	0.004*	3.32	0.001*
	Unripe cones	1.52	0.15	1.36	0.18
α-Pinene (%)	Leaves	1.71	0.09	0.65	0.52
	Unripe cones	0.32	0.97	0.39	0.70
β-Pinene (%)	Leaves	1.15	0.34	2.11	0.04*
	Unripe cones	2.36	0.02*	1.69	0.09

* – significant differences between habitats and habitat groups ($p < 0.05$)

Table 3. Descriptive characteristics of morphological and chemical characters of leaves and unripe cones of *Juniperus communis* in open (No. 1–5) and shaded (No. 7–11) habitats

Morphological and chemical characters		Habitat type					
		Open			Shaded		
		Average ± SD	Min	Max	Average ± SD	Min	Max
Leaf length (mm)		11.8 ± 1.4	8.9	15.7	12.7 ± 1.6	8.9	16.4
Mass (g) of 100 leaves		0.169 ± 0.03	0.114	0.291	0.158 ± 0.03	0.121	0.243
Mass (g) of 100 cones		2.999 ± 0.89	1.461	5.351	2.856 ± 0.86	1.730	5.617
Essential oil yield (%)	Leaves	0.35 ± 0.1	0.11	0.70	0.44 ± 0.1	0.20	0.86
	Unripe cones	1.23 ± 0.5	0.28	2.35	1.40 ± 0.7	0.38	4.15
α-Pinene (%)	Leaves	58.0 ± 13.8	14.1	76.8	59.9 ± 14.6	11.5	76.7
	Unripe cones	53.4 ± 14.5	23.9	73.0	54.5 ± 14.1	10.4	75.8
β-Pinene (%)	Leaves	2.3 ± 0.4	1.1	3.5	2.2 ± 0.4	0.9	3.0
	Unripe cones	1.6 ± 0.6	0.0	2.7	1.8 ± 0.7	0.7	3.7

habitat groups according to these two characters (Table 2 and 3).

Statistically significant correlations were established between habitat illumination and essential oil yield in leaves ($r = -0.67$, $p < 0.05$) and between soil acidity and essential oil yield in leaves ($r = -0.80$, $p < 0.05$) only.

DISCUSSION

Cones of *Juniperus communis* matured in late autumn of the second year; therefore, both first-year unripe (green) cones and second-year ripe (blue or black) cones grow simultaneously on the same plant (Čibiras, 1959; Navasaitis et al., 2003). The unripe cones are heavier than ripe ones (Slavėnas & Ražinskaitė, 1962); also the previous study showed that unripe cones accumulate twice more essential oils than ripe cones and up to sextuple than leaves (Butkienė et al., 2006). Our study on *J. communis* at individual plant level showed that unripe cones accumulate on an average thrice more essential oil than leaves, and intraspecific variation of essential oil amount is higher in unripe cones than in leaves. The reason of differences in essential oil yield in cones and leaves of *J. communis* is the structure of the secretory elements: needles, which contain ducts and transfusion tissue, act as conduction structures, and the berries containing elongate tubercles, which act as reservoirs of volatile oils (Shahmir et al., 2003). The intraspecific variation of the studied leaf morphological characters was also less than intraspecific variation of cones mass. Wider morphological variation of unripe cones can be related to their different ripening stage in the investigated *J. communis* plants. Established significant correlative connections between leaf length and leaf mass (Fig. 3) implied that these morphological characters of leaf can be under the influence of same genetic and/or environmental factors.

Pinene is the main volatile compound of such common coniferous genera as *Picea*, *Pinus*, *Juniperus* (Persson et al., 1996). Different biological activity is characteristic of this monoterpene, which has different applicable significance or influence on environment. For example, pinene is important constituent of *Pinus* sp. resins, whereof high-grade commercial solvent turpentine is producible (Dawson, 1994); accumulation of pinene in *Juniperus* sp. cones determines pharmacological properties of junipers (Council of Europe, 2008). Natural emission of this monoterpene from foliage of conifers is important in tropospheric chemistry, which upon oxidation has significant consequences for the ozone balance (Hallquist, 1997; Atkinson & Arey, 2003; Williams, 2004). Two structural isomers of pinene are found in nature: α-pinene and β-pinene. α-Pinene is more frequent than β-pinene in plenty of conifers. For example, α-pinene and β-pinene amounts 84.8 ± 1.5% and 4.1 ± 0.7%, respectively, in *Pinus sylvestris* needles growing wild in Turkey (Semiz et al., 2007), and up to 76% and 4%, respectively, in resin of *Pinus laricio* growing in south-east Corsica (Cannac et al., 2009); analysis of the turpentine fraction from loblolly pine (*Pinus taeda*) stem xylem and phloem tissue, needles and roots demonstrated this material to be a complex mixture containing up to 12 different monoterpenes, with a-pinene predominating in all cases (> 65%), while β-pinene generally comprising only a small fraction of the turpentine (4–13%) (Phillips et al., 1999). β-Pinene absent or found up to 20–60 times less than α-pinene in different parts of many species of genus *Juniperus* (*J. excelsa* in Iran, *J. communis* in Poland) (Ochocka et al., 1997; Shanjani et al., 2010). In our study, α-pinene was detected in leaves and cones in absolutely all investigated *J. communis* and not established as the main essential oil compound only in 3% and 2% of all analysed leaves and unripe cones, respectively. If unripe cones accumulated thrice more essential oil than leaves, amounts of α-pinene were very similar in them. *J. communis* growing in Lithuania, same as other above-mentioned coniferous species, accumulate very few amounts of another pinene isomer β-pinene: to 26 times less in leaves and to 32 times less in unripe cones compared to α-pinene. Furthermore, as distinct from α-pinene, the cones of two *J. communis* shrubs absolutely did not synthesize β-pinene, i.e., α-pinene is not always followed by β-pinene. The literature data suggest that there is a negative correlation between amounts of α-pinene and 3-carene and between amounts of α-pinene and terpinolene in *Pinus sylvestris* (Pohjola et al., 1989; Semiz et al., 2007). Such negative relationships may arise due to contrasting biochemical pathways affecting directly or indirectly each of the related compounds (Manninen et al., 2002). The synthesis of both pinene isomers in our investigated *J. communis* is interdependent: positive correlations between pinene isomers both in leaves and in cones show that α- and β-pinene have a common biosynthetic pathway (Fig. 3).

Morphological and chemical characters of plants are determined genetically, but many quantitative features may vary under different environmental conditions of habitats and so determine the interpopulation variation of species. *Juniperus communis* is the species of a global distribution exhibiting wide range of ecological adaptations (Rook, 2006). In Lithuania, *J. communis* occurs mostly in dry pinewoods, mixed forests, on river slopes, being light demanding, but also shade tolerant (Navasaitis, 2004). All our investigated habitats were grouped into two groups, which significantly differed according to illumination and soil chemistry (excluding phosphorus only). One-way ANOVA and *t*-test showed significant differences between habitats and habitat groups according to leaf length and essential oil yield in leaves (Table 2), however, statistically significant correlation connections were established between essential oil yield in leaves and illumination and between essential oil yield in leaves and soil acidity only. It is known that essential oil content and composition can depend on many different environmental factors: atmospheric temperature, rainfall, light quality, soil chemistry (Sangwan et al., 2001; Başer & Buchbauer, 2009). Negative correlation connection between essential oil yield in leaves and illumination could be explained by more intensive evaporation of volatile essential oils in sunnier than in shaded habitats. On the same score, 14% lower amount of essential oil was in cones of open habitats group, though significant correlation connection was not detected be-

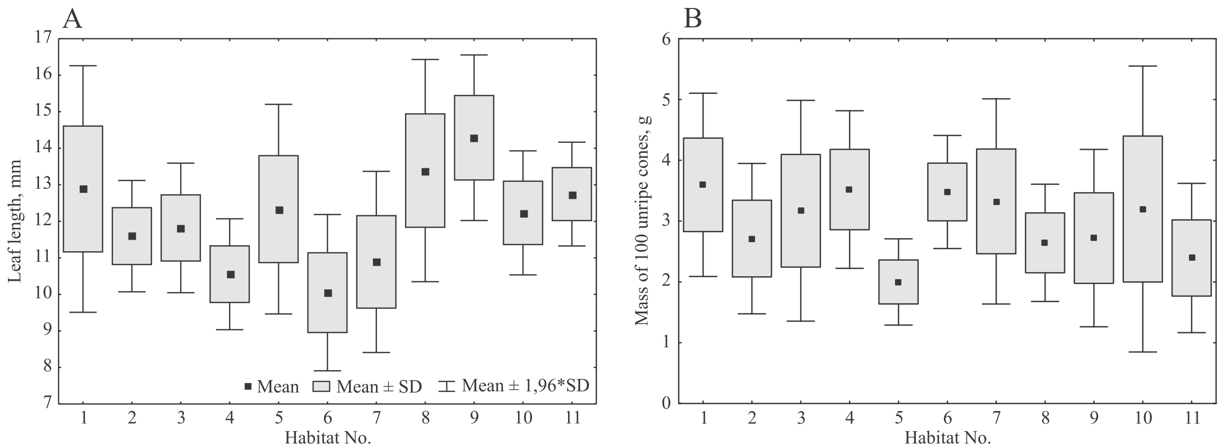

Fig. 4. Column dispersion diagrams of *Juniperus communis* leaf length (A) and unripe cones mass (B) in different habitats

tween essential oil yield in cones and illumination. Conifer litter caused up to 35% much higher soil pH in shaded habitats, which were chosen in the pinewoods, compared to the open habitats. The correlation between illumination and soil acidity was quite strong ($r = 0.68$, $p < 0.05$). Therefore, it is difficult to judge, which of the two environmental factors influence the essential oil accumulation synergetically.

In our study, both leaf length and leaf mass of *Juniperus communis* varied alike at individual level and positive correlation connection was observed between these leaf morphological characters, however, habitats and habitat groups significantly differed according to leaf length only (Table 2). In many plant species it is common that leaf size adapts to the light conditions of a habitat by getting larger with decreasing light intensity; also it is indicated that the length of conifer needles is strongly related to nitrogen and phosphorus availability (Conroy et al., 1986; Raison et al. 1992; Niinemets et al., 2001). In the present study, the longest leaves were produced by *J. communis* growing in shaded habitats group; also the longest leaves were established in habitat No. 9 with the least illumination. *J. communis* is ascribed to oligotrophs, therefore, even on an average fourfold lower amount of nitrogen in shaded habitats group did not influence leaf length. It should be noted that open control habitat No. 6 distinguished by least leaf length (Fig. 4). Although the soil of this habitat was richer (to 5 times) by organic nitrogen and humus compared to other open habitats, there trees grew under the influence of one strong natural water-stress factor: this habitat was located in a swamp, where the groundwater was at a depth of 10 cm. The plants in high moisture amount case hardly assimilate nutrients; therefore, the abundance of moisture could have negative influence on leaf growth in this habitat.

Morphological parameters are often used for interpretation of forest status and production. One of the most widely used, and perhaps most important tests of tree quality, is the biomass and growth parameters of assimilating organs – needles (Mandre & Ots, 2003). The morphological characteristics are greatly influenced by carbohydrates produced in photosynthesis and by nutrients assimilated from soil and their partitioning in the organism (Klõšeiko, 2003; Mandre, 2003). In our study, no statistically significant difference was obtained between the investigated habitat groups according to biomasses of leaves and unripe cones, however, the mass of leaves and cones were 7% and 5% higher in open habitats, respectively. The fact that on shaded habitats, the level of photosynthetically active radiation, on which the photosynthesis of trees and the formation of organic matter in them directly depend, absorbed in the crowns of trees is somewhat lower than on the open habitats, may explain the formation of the smaller needle and cone biomass on the shaded habitats. Bigger mass of leaves and cones could also be conditioned by the higher contents of nitrogen and humus in the soil as it is proved by many studies on plant cultivation. The highest contents of nitrogen were in open habitats, where the highest contents of humus were observed as well. In shaded habitats, which occurred in pinewoods with sandy soils, where a leaching moisture regime prevails, the mobile nitrogen is leached into the deeper layers of the soil.

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PAPRASTOJO KADAGIO (*JUNIPERUS COMMUNIS*) LAPŲ BEI NEPRINOKUSIŲ KANKORĖŽĖLIŲ CHEMINIŲ IR MORFOLOGINIŲ PARAMETRŲ ĮVAIRAVIMAS

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Santrauka

Buvo tirtas paprastojo kadagio (*Juniperus communis*) lapų bei neprinokusių kankorėžėlių cheminių ir morfologinių parametrų įvairavimas tarppopuliaciniame ir individų lygiuose. Lapai ir kankorėžėliai buvo surinkti atskirai nuo 110 individų iš dešimties ekologiškai skirtingų augaviečių Lietuvoje. Eterinių aliejų analizė atlikta dujų chromatografijos metodu. Tyrimai parodė, kad eterinio aliejaus daugiau susikaupia ir jų kiekis labiau įvairuoja neprinokusiuose kankorėžėliuose nei lapuose. Nustatyti dideli pineno izomerų kiekio skirtumai: lapuose ir kankorėžėliuose β-pineno buvo atitinkamai 26 ir 32 kartus mažiau nei α-pineno. Nustatyti teigiami koreliaciniai ryšiai tarp pineno izomerų kiekio kankorėžėliuose ($r = 0,44$, $p < 0,05$) ir lapuose ($r = 0,50$, $p < 0,05$) rodo, kad egzistuoja bendras α- ir β-pineno biosintezės kelias. Nustatyta patikima teigiama koreliacija tarp lapų ilgio ir lapų masės ($r = 0,44$, $p < 0,05$). Statistinė analizė parodė, kad *J. communis* lapų ilgiui, neprinokusių kankorėžėlių masei ir eterinio aliejaus kiekiui lapuose yra būdingi patikimai dideli tarppopuliaciniai skirtumai. Tačiau statistiškai patikimi koreliaciniai ryšiai nustatyti tik tarp eterinio aliejaus kiekio lapuose ir augavietės apšviestumo ($r = –0,67$, $p < 0,05$) bei dirvožemio rūgštingumo ($r = –0,80$, $p < 0,05$).