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Ecological characteristics of habitats and occurrence of *Thymus pulegioides* (Lamiaceae) in Lithuania

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Abstract: *Thymus pulegioides* L. (Lamiaceae) is essential oils bearing, aromatic and medicinal plant of Central Europe, Scandinavia, Baltic States and South East England indigenous flora. The chemical polymorphism of essential oils can subservient to the selection of valuable clones of *T. pulegioides* as a selection donors from spontaneous populations for the cultivation. *T. pulegioides* grow in natural and semi-natural meadows, however, intensive agriculture led to decrease of areas of natural grasslands with habitats of *T. pulegioides*. The objective of study was to evaluate the occurrence of *T. pulegioides* in habitats belonged to different plant communities, characterize habitats according to soil chemistry and other ecological factors. The analysis of 131 different natural habitats of *T. pulegioides* showed that the higher total herb cover can influence on decrease of cover-abundance of *T. pulegioides* ($r = -0.24$, $p < 0.05$). More than half of habitats of *T. pulegioides* were established in slopes with the different inclinations; the exposition of majority slopes was southern, southeast and southwest. *T. pulegioides* is indifferent to the soil reaction and does not require a rich soil. Investigated *T. pulegioides* habitats were established in the plant communities of four phytocoenological vegetation classes: *Molinio-Arrhenatheretea elatioris*, *Festuco-Brometea erecti*, *Trifolio-Geranietea sanguinei* and *Koelerio-Corynephoretea canescentis*. More than half investigated *T. pulegioides* habitats belonged to the grassland communities of vegetation class *Molinio-Arrhenatheretea elatioris*.

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The significant positive correlation was established between the cover-abundance of *T. pulegioides* and vegetation classes ($r = 0.33$, $p < 0.05$): the sequence of frequencies of cover-abundance of *T. pulegioides* +>1>2>3 in habitats corresponds to the following vegetation classes *Molinio-Arrhenatheretea elatioris* > *Trifolio-Geranietea sanguinei* > *Festuco-Brometea erecti* > *Koelerio-Corynephoretea canescentis*, i. e. the higher probable of low cover-abundances of *T. pulegioides* is possible in the habitats belonged to the vegetation class *Molinio-Arrhenatheretea elatioris* than in the habitats belonged to the vegetation class *Festuco-Brometea erecti*.

Keywords: *Thymus pulegioides*, occurrence, natural habitats, plant communities, soil.

Introduction

The many species of numerous genus *Thymus* (Lamiaceae) are medicinal and aromatic plants whose essential oils characterized as a strong antibacterial and antioxidant (KARAMAN et al. 2001; RASOOLI & MIRMOSTAFA 2002; LOŽIENĖ et al. 2007). The intraspecific chemical polymorphism is typical of species of this genus, and different chemotypes synthesize essential oils with the significant amounts of such biologically active compounds as the thymol, carvacrol, geraniol, linalool and other (THOMPSON et al. 1998). The high intraspecific chemical polymorphism is also characteristic for the diploid (2n=28) large thyme (*Thymus pulegioides* L.), which is widespread in Central Europe, Scandinavia, Baltic States, and in South East England, and several different chemotypes were defined in this species (MÁRTONFI 1992; MÁRTONFI & MÁRTONFIOVÁ 1996; MOCKUTĖ & BERNOTIENĖ 1999, 2001, 2005; LOŽIENĖ et al. 2002, 2003; LOŽIENĖ & MÁRTONFIOVÁ 2004). *T. pulegioides* is suitable for the cultivation; therefore the chemical polymorphism can subservient to the selection of valuable clones of this species from natural habitats, and the hunting of individual plants as selection donors can be purposeful in spontaneous populations (LOŽIENĖ 2009).

T. pulegioides plants grow in natural and semi-natural meadows, slopes, and grasslands. From the nineteenth century onwards, the changes in traditional farming practices with higher human economic activity and more intensive agriculture led to decrease of areas of natural grasslands; it can be reason of dramatically decrease of natural populations of *T. pulegioides* in Flanders (Northern Belgium) during the last decades (VAN LANDUYT et al. 2006). Former studies also revealed very low levels of effective seed dispersal of *Thymus* species (and similarly *T. pulegioides*) from parent plant (ERIKSSON 1998; BROECK et al. 2015). Therefore, nowadays *T. pulegioides* is often represented by isolated and extremely small relict populations, often occurs along roadsides on sunny talus with a southern exposure and in remnant populations where previously grew natural or semi-natural grasslands (BROECK et al. 2015). The objective of the present study was to evaluate the occurrence of *T. pulegioides* in the habitats belonged to the different plant communities, characterize habitats according to soil chemistry and other ecological factors.

Material and methods

131 different habitats of *T. pulegioides* were described in July of 2013–2015; these habitats of *T. pulegioides* represented all territory of Lithuania and were chose by chance. The distances between habitats were not less as 10 kilometres. The study sites (habitats) are presented in Fig. 1, Fig. 2 and Tab. 1. The study was made in 16 m^2 fields of meadows according to the methodology of BRAUN-BLANQUET (1964). Plant communities were distinguished according to the vegetation classification systems of BALEVIČIENĖ (1991) and BALEVIČIENĖ et al. (1998). Relative lightening of the habitats was defined visually.

The samples of soil were collected from each habitat separately and dried at room temperature. Each sample of topsoil was prepared in the following way: in 5–9 subsamples (subject to area of habitat; each subsample ~ 100 g) were taken from the depth of 10–15 cm (from plant rhizosphere) by the envelope principle with the distance of 1 m from the central point of habitat and mixed (homogenised). The content of humus and mobile phosphorus (P_2O_5) was estimated photoelectrocolorimetrically, the content of mobile potassium (K_2O) – by flame photometry, the soil pH – electrometrically using 1 M KCl solution; the soil analysis was done at the Agrochemical Research Laboratory of the Lithuanian Research Centre for Agriculture and Forestry.

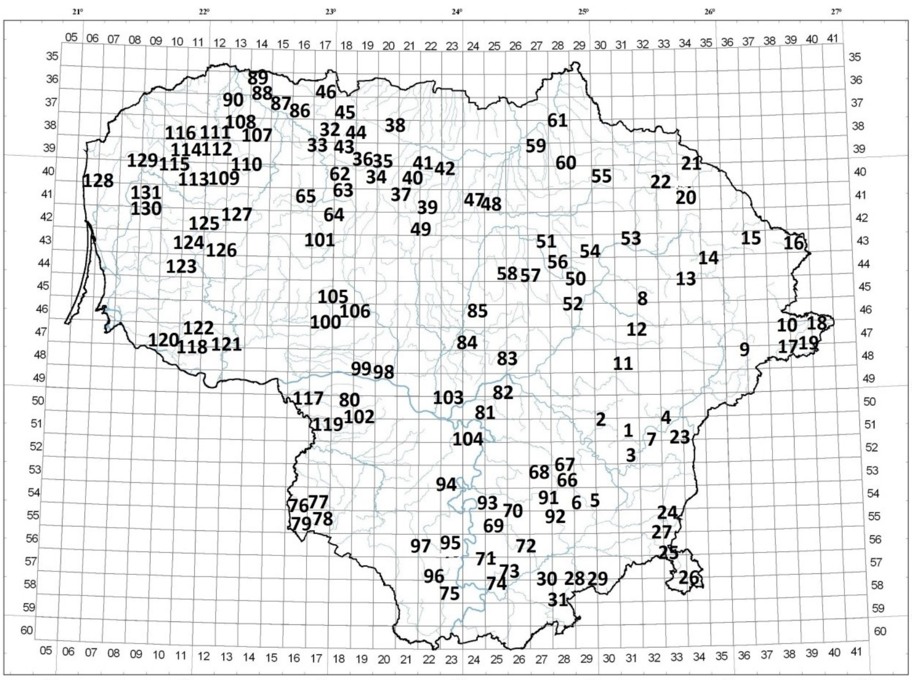

Fig. 1. Occurrence of *Thymus pulegioides* L. habitats in Lithuania (the numbers of habitats as in Tab. 1).

Fig. 2. Habitat of *Thymus pulegioides* L. in meadow of vegetation class *Molinio-Arrhenatheretea elatioris* R. Tx. 1937 (Širvintai dist., Kernavė, 54.822754, 24.949092)

The Spearman rank correlation analysis was used to test correlation of cover-abundance of *T. pulegioides* with vegetation classes and parameters of habitats (herb cover, lightning, etc.). The coefficients of variation were used to evaluate the variations of edaphic (soil pH, amounts of humus, mobile phosphorus, and mobile potassium) characteristics between investigated *T. pulegioides* habitats. Statistical data processing was carried out with the STATISTICA® 7 and MS Excel software.

Results and discussion

The climate of Lithuania changes gradually from oceanic in west (Baltic Sea) to continental in east, and the macroclimatic conditions differ in the west and east part of Lithuania (BUKANTIS 1994). However, the investigations showed that *T. pulegioides* is common in all territory of Lithuania (excluding the Curonian Spit in west of country where plants of *T. pulegioides* were not found) (Fig. 1). Therefore, the settling of plants in some spaces can depend on microclimatic conditions of habitat.

There the cover-abundance of *T. pulegioides* varied from value + to value 3 according to Braun-Blaquet scale in the different habitats (Tab. 1). The cover-abundance of *T. pulegioides* with value + (occasional and less than 5% of total plot area) was the most frequent: it was established in 77 habitats. The cover-abundance with value 1 (abundant and with very low cover, or less abundant but with higher cover; in any case less than 5 % cover of total plot area) was rarer in half and established in 33 habitats. Only 13 and 8 habitats were characterised with value 2 (very abundant and less than 5 % cover, or 5–25 % cover of total plot area) and value 3 (25–50% cover of total plot area, irrespective of number of individuals) of cover-abundance of *T. pulegioides*, respectively.

The total herb cover varied from 60 to 100% in the investigated *T. pulegioides* habitats (Tab. 1). It amounted 85–95% and was lower than 85% in 46% and 36% of investigated habitat, respectively. The total herb cover exceeded 98% in 18 habitats; the lowest cover of herbs was 60% and established in two habitats of *T. pulegioides*.

The total herb cover had significant negative influence on the cover-abundance of *T. pulegioides* ($r = -0.24$, $p < 0.05$): the implication is that higher total herb cover influence the decrease cover-abundance of *T. pulegioides* in habitats. *T. pulegioides* is a pioneer species and exhibit the low interspecific competition (LEKAVIČIUS 1976; LOŽIENĖ &VAIČIŪNIENĖ 1999). Therefore, if the higher plants begin to dominate in habitats and total herb cover begins to increase, it cuts out *T. pulegioides* and the cover-abundance of this species begins to decrease.

More than half of habitats of *T. pulegioides* were established in slopes with different inclinations (Tab. 1). The exposition of majority slopes was southern, southeast and southwest; only two habitats were found in slopes with northern exposition. *T. pulegioides*, as all species of genus *Thymus*, are heliophilous and thermophilous plants (LEKAVIČIUS 1976). Therefore, they occur in slopes with southern exposition often. However, the significant positive correlation between the exposition of slopes and the cover-abundance of *T. pulegioides* was not established.

The soils conditions (chemical composition, acidity and etc.) also much differ across Lithuania (BUIVYDAITĖ et al. 2001). So, the edaphic factors could affect the occurrence of *T. pulegioides*. The analysis of soil showed that the soil pH of *T. pulegioides* habitats varied from acid to alkaline (pH 5.1–8.3). The literature data also suggest that this species can tolerate acidic, alkaline and neutral soil (HADAČ et al. 1988; ELLENBERG et al. 1991; SIMON, 1992; MÁRTONFI et al. 1996). However, even three quarters of habitats had soil pH 7.0–8.0, i. e. neutral and alkaline (Fig. 3). The analysis of soil chemistry showed that this species of genus *Thymus* is not demanding to rich soil: the percentage of humus varied from 0.9 to 7.2% (CV = 40%), i. e. from very low and low to high (Fig. 3). The soil of mostly habitats was from little humous to humous. The percentage of humus was very high (exceeded 4%) in soil of 12 habitats; very low percentage of humus (not amounted 1%) was established only in one habitat (habitat no. 106). Amounts of mobile phosphorus and mobile potassium varied (CV = 75% and CV = 53%, respectively) from very low to very high (Fig. 3). All results showed that *T. pulegioides* is indifferent to the soil reaction and does not require a rich soil. The significant correlations were not detected between the cover-abundance of *T. pulegioides* and soil pH and investigated chemical characteristics of soil.

Tab. 1. General characteristics of *Thymus pulegioides* L. habitats sampled for the study (Cl. *F-B* – vegetation class *Festuco-Brometea erecti* Br.-Bl. et R. Tx.1943*,* Cl. *T-G* – vegetation class *Trifolio-Geranietea sanguinei* Th. Müller 1961*,* Cl. *M-A* – vegetation class *Molinio-Arrhenatheretea elatioris* R. Tx. 1937*,* Cl. *K-C* – vegetation class *Koelerio-Corynephoretea canescentis* Klika et Novak 1941)

No. of habitat	Locality	Coordinates WGS-84	Plant communities	Relief	Inclination of slope, (º)	Exposition of slope	Lightning, (%)	Total herb cover, (%)	Cover-abundance of *Thymus pulegioides* according to Braun-Blanquet
1	Širvintai dist., Kernavė	54.822754, 24.949092	Cl. *M-A*	wavy	–	–	100	95	1
2	Vilnius dist., Dūkštos	54.819913, 24.992296	Cl. *T-G*	slope	30	S	100	80	1
3	Vilnius dist., Karmazinai	54.819604, 24.926004	Cl. *T-G*	wavy	–	–	100	95	1
4	Vilnius dist., Pikutiškės	54.781978, 25.145164	Cl. *M-A*	slope	5	E	100	95	1
5	Trakai dist., Žaizdriai	54.623919, 24.888161	Cl. *M-A*	slope	15	NE	85	90	1
6	Trakai dist., Aukštadvaris	54.57973, 24.518565	Cl. *T-G*	slope	20	SW	100	90	1
7	Vilnius dist., Joneikiškės	54.868665, 24.908167	Cl. *F-B*	plane	–	–	85	80	3
8	Vilnius dist., Pakryžė	55.325132, 25.314583	Cl. *M-A*	wavy	–	–	100	95	+
9	Vilnius dist., Levonys	55.0043, 25.435393	Cl. *T-G*	slope	15	SW	100	85	1
10	Švenčionys dist., Melagėnai	55.091002, 25.959319	Cl. *K-C*	plane	–	–	80	80	3
11	Molėtai dist., Piktaraistis	55.089868, 25.251849	Cl. *M-A*	plane	–	–	100	98	+
12	Molėtai dist., Gojus	55.598745, 25.844687	Cl. *F-B*	plane	–	–	80	70	+
13	Molėtai dist., Suginčiai	55.598745, 25.844687	Cl. *K-C*	slope	10	W	100	60	1
14	Utena dist., Vaikutėnai	55.575074, 25.683695	Cl. *T-G*	slope	20	W	98	98	1
15	Utena dist., Daugailiai	55.588687, 25.822257	Cl. *M-A*	wavy	–	–	100	95	+
16	Zarasai dist., Baibiai	55.63082, 25.959328	Cl. *M-A*	slope	25	NE	100	90	1
17	Švenčionys dist., Baliuliai	54.980308, 25906264	Cl. *M-A*	plane	–	–	95	95	+
18	Švenčionys dist., Rykštelių mound	55.236822, 26.200065	Cl. *F-B*	plane	–	–	100	85	1
19	Švenčionys dist., Adutiškis	55.153929, 26.594358	Cl. *M-A*	plane	–	–	85	85	+
20	Utena dist., Sudeikiai	55.857427, 25.509436	Cl. *F-B*	wavy	–	–	95	98	+
21	Rokiškis	55.948763, 25.605583	Cl. *K-C*	plane	–	–	100	80	+
22	Rokiškis dist., Sėlynė	55.904976, 25.565041	Cl. *M-A*	wavy	–	–	80	90	+
23	Vilnius dist., Nemėžis	54.647679, 25.334577	Cl. *M-A*	slope	10	W	100	85	+
24	Šalčininkai dist., Turgeliai	54.454802, 25.524816	Cl. *M-A*	wavy	–	–	100	95	+
25	Šalčininkai dist., Stakai	54.293592, 25.536483	Cl. *M-A*	wavy	–	–	85	98	1

Tab.1. – cont.

No. of habitat	Locality	Coordinates WGS-84	Plant communities	Relief	Inclination of slope, (º)	Exposition of slope	Lightning, (%)	Total herb cover, (%)	Cover-abundance of *Thymus pulegioides* according to Braun-Blanquet
26	Šalčininkai dist., Norviliškės	54.23839, 25.770221	Cl. *M-A*	wavy	–	–	100	95	+
27	Šalčininkai dist., Jaglimainiai	54.409556, 25.36456	Cl. *M-A*	slope	5	SW	90	90	+
28	Varėna dist., Pirčiupiai	54.398794, 24.954165	Cl. *M-A*	wavy	–	–	100	90	+
29	Šalčininkai dist., Tetėnai	54.30947, 24.96926	Cl. *M-A*	plane	–	–	100	95	+
30	Varėna dist., N.Valkininkai	54.350769, 24.719482	Cl. *M-A*	plane	–	–	70	90	+
31	Varėna dist., Puvočiai	54.11808, 24.303389	Cl. *T-G*	wavy	–	–	90	98	+
32	Šiauliai dist., Smilgiai	55.94799, 23.015613	Cl. *M-A*	slope	10	S	100	85	+
33	Šiauliai dist., Ketūnai	55.885865, 23.004921	*	plane	–	–	80	90	+
34	Šiauliai dist., Bubiai	55.85179, 23.118614	Cl. *M-A*	slope	40	SW	100	80	+
35	Šiauliai dist., Aukštelkė	55.877157, 23.21402	Cl. *K-C*	slope	30	S	100	70	1
36	Šiauliai dist., Sauginiai	55.910051, 23.089362	Cl. *M-A*	plane	–	–	100	95	+
37	Radviliškis dist., Karčemos	55.802852, 23.5569162	Cl. *M-A*	plane	–	–	90	95	+
38	Joniškis dist., Beržėnai	56.144253, 23.323529	Cl. *M-A*	plane	–	–	85	90	+
39	Radviliškis dist., Šeduva	55.802852, 23.569162	Cl. *M-A*	wavy	–	–	100	70	3
40	Radviliškis dist., Aukštelkai	55.84631, 23.630632	Cl. *T-G*	Slope	40	S	100	80	+
41	Pakruojis dist., Vismantai	55.871603, 23664788	Cl. *M-A*	slope	10	W	75	90	+
42	Pakruojis dist., Šukioniai	55.942094, 23.719236	**	wavy	–	–	100	85	2
43	Šiauliai dist., Kužiai	55.979519, 23.130973	Cl. *M-A*	slope	15	SE	100	95	+
44	Šiauliai dist., Žarėnai	56.197488, 23.099191	Cl. *M-A*	plane	–	–	100	95	+
45	Akmenė dist., Kruopiai	56.241207, 23.034141	Cl. *M-A*	plane	–	–	100	95	1
46	Akmenė dist., Šapnagiai	56.294522, 22.98407	Cl. *M-A*	plane	–	–	100	95	+
47	Panevėžys dist., Smilgiai	55.798496, 24.009309	Cl. *M-A*	plane	–	–	100	95	+
48	Panevėžys dist., Liberiškės	55.747087, 23.89376	Cl. *M-A*	slope	15	SW	90	90	+
49	Radviliškis dist., Pakiršinys	55.646961, 23.763323	Cl. *M-A*	slope	10	SW	80	85	+
50	Ukmergė	55.2593, 24.766584	***	slope	20	SW	100	90	1
51	Ukmergė dist., Dainava	55.186551, 24.634857	Cl. *T-G*	slope	5	S	100	98	1
52	Anykščiai dist., Svirnų mound	55.370111, 24.891472	Cl. *F-B*	slope	20	S	100	90	2

Tab.1. – cont.

No. of habitat	Locality	Coordinates WGS-84	Plant communities	Relief	Inclination of slope, (º)	Exposition of slope	Lightning, (%)	Total herb cover, (%)	Cover-abundance of *Thymus pulegioides* according to Braun-Blanquet
53	Anykščiai dist., Vikonys	55.538945, 25.068726	Cl. *M-A*	slope	30	SE	100	80	+
54	Anykščiai dist., Andrioniškis	55.661659, 25.001629	Cl. *M-A*	plane	–	–	80	90	+
55	Kupiškis dist., Aukštupėnai	55.845753, 24.987768	Cl. *M-A*	plane	–	–	100	95	1
56	Ukmergė dist., Taujėnai	55.39156, 24.762008	**	slope	5	SE	95	90	2
57	Panevėžys dist., Mikėnai	55.495251, 24.484453	Cl. *M-A*	slope	30	SE	100	98	1
58	Panevėžys dist., Ramygala	55.514687, 24.306613	Cl. *M-A*	slope	45	W	100	70	3
59	Pasvalys dist., Smilgiai	55.992143, 24.519871	Cl. *M-A*	slope	15	S	100	95	1
60	Biržai dist., Vabalninkas	56.009279, 24.743536	Cl. *M-A*	slope	30	NE	100	70	+
61	Biržai dist., Pabiržė	56.185004, 24.633555	Cl. *M-A*	plane	–	–	100	80	+
62	Kelmė dist., Gaugariai	55.750477, 22.94773	Cl. *M-A*	slope	15	W	90	90	+
63	Kelmė dist., Vaiguva	55.702711, 22.758323	Cl. *F-B*	plane	–	–	100	95	3
64	Kelmė dist., Padubysis	55.561534, 23.075333	Cl. *F-B*	plane	–	–	100	95	3
65	Kelmė dist., Valpainiai	55.57172, 22.726659	Cl. *M-A*	plane	–	–	90	70	1
66	Kaišiadorys dist., Guronys	54.844314, 24.5765	Cl. *F-B*	slope	15	SE	100	80	2
67	Kaišiadorys dist., Zūbiškės	54.973374, 24.572662	Cl. *F-B*	plane	–	–	90	90	1
68	Kaišiadorys dist., Vladikiškės	54.849044, 24.429215	Cl. *F-B*	plane	–	–	95	90	2
69	Kaišiadorys dist., Kruonis	54.774519, 24.281041	Cl. *F-B*	slope	30	S	100	90	2
70	Kaišiadorys dist., Migonys	54.418544, 24.118012	Cl. *F-B*	wavy	–	–	100	90	+
71	Prienai dist., Jieznas	54.546697, 24.168139	Cl. *M-A*	slope	20	SE	100	98	+
72	Alytus dist., Vaisodžiai	54.455711, 24.325517	Cl. *M-A*	wavy	–	–	100	95	+
73	Varėna dist., Masališkės	54.212868, 24.201713	Cl. *F-B*	wavy	–	–	100	70	+
74	Varėna dist., Kibyšiai	54.147614, 24.110802	Cl. *M-A*	plane	–	–	100	85	2
75	Druskininkai mun., Leipalingis	54.090842, 23.886865	Cl. *F-B*	wavy	–	–	100	98	1
76	Vilkaviškis reg., Kaupiškių mound	54.538709, 22.687187	Cl. *F-B*	plane	–	–	100	90	1
77	Vilkaviškis reg., Pajevonys	54.530614, 22.824806	Cl. *F-B*	slope	15	SW	100	95	+
78	Vilkav iškis reg., Dabravolės mound	54.549694, 22.745525	Cl. *M-A*	slope	45	E	100	95	+
79	Vilkaviškis dist., Vištytis	54.450139, 22.742665	Cl. *M-A*	slope	15	N	100	90	+

Tab.1. – cont.

No. of habitat	Locality	Coordinates WGS-84	Plant communities	Relief	Inclination of slope, (º)	Exposition of slope	Lightning, (%)	Total herb cover, (%)	Cover-abundance of *Thymus pulegioides* according to Braun-Blanquet
80	Šakiai dist., Liepalotai	54.955461, 22.898752	Cl. *M-A*	slope	30	S	100	90	+
81	Kaunas dist., Karmėlava	54.992723, 24.111148	Cl. *M-A*	slope	10	W	100	95	+
82	Kaunas dist., Zatyšiai	55.039085, 24.165752	Cl. *F-B*	slope	10	E	80	80	1
83	Jonava dist., Šveicarija	55.056588, 24.169848	Cl. *M-A*	plane	–	–	100	98	1
84	Kėdainiai dist., Sirutiškis	55.353129, 23.972526	Cl. *M-A*	slope	25	S	100	95	+
85	Kėdainiai dist., Surviliškis	55.463185, 24.027255	Cl. *F-B*	slope	30	SE	100	90	2
86	Akmenė dist., Venta	56.198769, 22.709461	Cl. *T-G*	slope	30	S	100	90	+
87	Akmenė	56.251249, 22.725629	Cl. *F-B*	plane	–	–	100	80	+
88	Mažeiki ai dist., Krakiai	56.270339, 22.441345	Cl. *F-B*	slope	10	S	80	80	1
89	Mažeikiai dist., Buknaičiai	56.393449, 22.366032	Cl. *F-B*	slope	15	S	100	85	+
90	Mažeikiai dist., Bugeiniai	56.305037, 22.228703	Cl. *M-A*	slope	20	S	100	90	1
91	Elektrėnai mun., Pastrėvys	54.719355, 24.662316	Cl. *K-C*	slope	10	S	100	70	2
92	Elektrėnai mun., Semeliškės	54.663989, 24.661922	Cl. *F-B*	slope	5	S	100	85	+
93	Birštonas	54.603623, 24.02057	Cl. *M-A*	plane	–	–	100	95	+
94	Prienai dist., Balbieriškis	54.538394, 23.871271	Cl. *M-A*	slope	10	E	100	98	+
95	Alytus	54.401755, 23.957273	Cl. *F-B*	wavy	–	–	100	90	+
96	Lazdijai dist., Seirijai	54.223269, 23.789078	Cl. *M-A*	slaitas	15	NW	100	98	+
97	Lazdijai dist., Meteliai	54.338375, 23.69491	Cl. *F-B*	wavy	–	–	100	80	+
98	Kaunas dist., Paštuva	54.98844, 23.619009	Cl. *F-B*	plane	–	–	100	90	+
99	Jurbarkas dist., Seredžius	55.094607, 23.432181	Cl. *F-B*	slope	45	S	100	98	+
100	Tauragė dist., Skaudvilė	55.427181, 22.543326	Cl. *F-B*	slope	50	S	100	95	1
101	Kelmė dist., Palendriai	55.332967, 23.078126	Cl. *T-G*	slope	15	S	100	98	3
102	Šakiai dist., Kubiliai	55.067566, 23.245042	Cl. *M-A*	wavy	–	–	100	80	3
103	Kaunas dist., Lentainiai mound	54.961611, 23.947775	Cl. *F-B*	slope	20	S	100	98	+
104	Kaunas dist., Piliuona	54.784446, 24.12963	Cl. *M-A*	slope	15	NE	95	95	+
105	Raseiniai dist., Šienlaukis	55.468861, 23.061516	Cl. *M-A*	slope	10	SW	100	95	+
106	Raseiniai dist., Viduklė	55.420669, 22.821507	Cl. *M-A*	plane	–	–	100	100	+

Tab.1. – cont.

No. of habitat	Locality	Coordinates WGS-84	Plant communities	Relief	Inclination of slope, (º)	Exposition of slope	Lightning, (%)	Total herb cover, (%)	Cover-abundance of *Thymus pulegioides* according to Braun-Blanquet
107	Telšiai dist., Tryškiai	56.030517, 22.60559	Cl. *F-B*	slope	15	S	100	80	+
108	Telšiai dist., Nerimdaičiai	56.0771, 22.399239	Cl. *F-B*	slope	30	NW	100	70	+
109	Telšiai dist., Rainiai	55.957435, 22.303331	Cl. *F-B*	plane	–	–	100	90	1
110	Telšiai dist., Luokė	55.901767, 22.472698	Cl. *F-B*	slope	15	N	100	80	+
111	Telšiai dist., Rūdupiai	55.910776, 22.414353	Cl. *M-A*	slope	15	W	90	80	1
112	Telšiai	56.015282, 22.249665	Cl. *F-B*	slope	45	S	100	80	1
113	Plungė dist., Skirpsčiai	56.046116, 22.000183	Cl. *M-A*	plane	–	–	100	80	2
114	Telšiai dist., Lieplaukė	55.967372, 22.096693	Cl. *M-A*	plane	–	–	85	98	+
115	Plungė dist., Alsėdžiai	56.02579, 22.077263	Cl. *M-A*	plane	–	–	100	90	+
116	Plungė dist., Rotinėnai	56.084649, 22.008816	Cl. *M-A*	slope	15	SW	100	80	2
117	Šakiai dist., Slavikai	54.963758, 22.72749	Cl. *M-A*	slope	25	S	100	98	+
118	Pagėgiai mun., Šilgaliai	54.929174, 22.78638	Cl. *M-A*	wavy	–	–	100	95	+
119	Šakiai dist., Turčinai	54.86223, 22.845268	Cl. *T-G*	slope	20	S	100	95	+
120	Pagėgiai mun., Stoniškiai	55.200593, 21.751912	Cl. *M-A*	plane	–	–	100	95	+
121	Pagėgiai mun., Bardinai	55.100107, 22.017344	Cl. *M-A*	plane	–	–	100	70	1
122	Pagėgiai mun., Piktupėnai	55.158153, 21.988474	Cl. *F-B*	slope	30	S	100	60	2
123	Šilalė dist., Rubinavas mound	55.481667, 22.137222	Cl. *M-A*	wavy	–	–	100	85	+
124	Šilalė dist., Kaltinėnai	55.581383, 22.516638	Cl. *M-A*	slope	15	NE	100	80	2
125	Šilalė dist., Bilioniai	55.592525, 22.308574	Cl. *M-A*	slope	15	S	100	95	+
126	Šilalė dist., Medvėgalis mound	55.629697, 22.392619	Cl. *M-A*	wavy	–	–	100	95	+
127	Telšiai dist., Varneliai	55.744548, 22.267527	Cl. *M-A*	slope	5	P	100	90	+
128	Palanga	55.929134, 21.11941	Cl. *M-A*	wavy	–	–	85	70	+
129	Plungė dist., Didvyčiai	55.950892, 21.860225	Cl. *M-A*	wavy	–	–	85	85	+
130	Plungė dist., Aleksandravas	55.922913, 21.606017	Cl. *M-A*	slope	25	W	100	75	1
131	Kretinga dist., Kartena	55.918185, 21.511468	Cl. *M-A*	slope	25	NW	100	95	+

* – ecotonic plant community with prevailing *Equisetum arvense* L.
** – anthropogenic plant community
*** – anthropogenic plant community with predominating *Pilosella officinarum* F. W. Schultz et Sch. Bip. and *Poa annua* L.

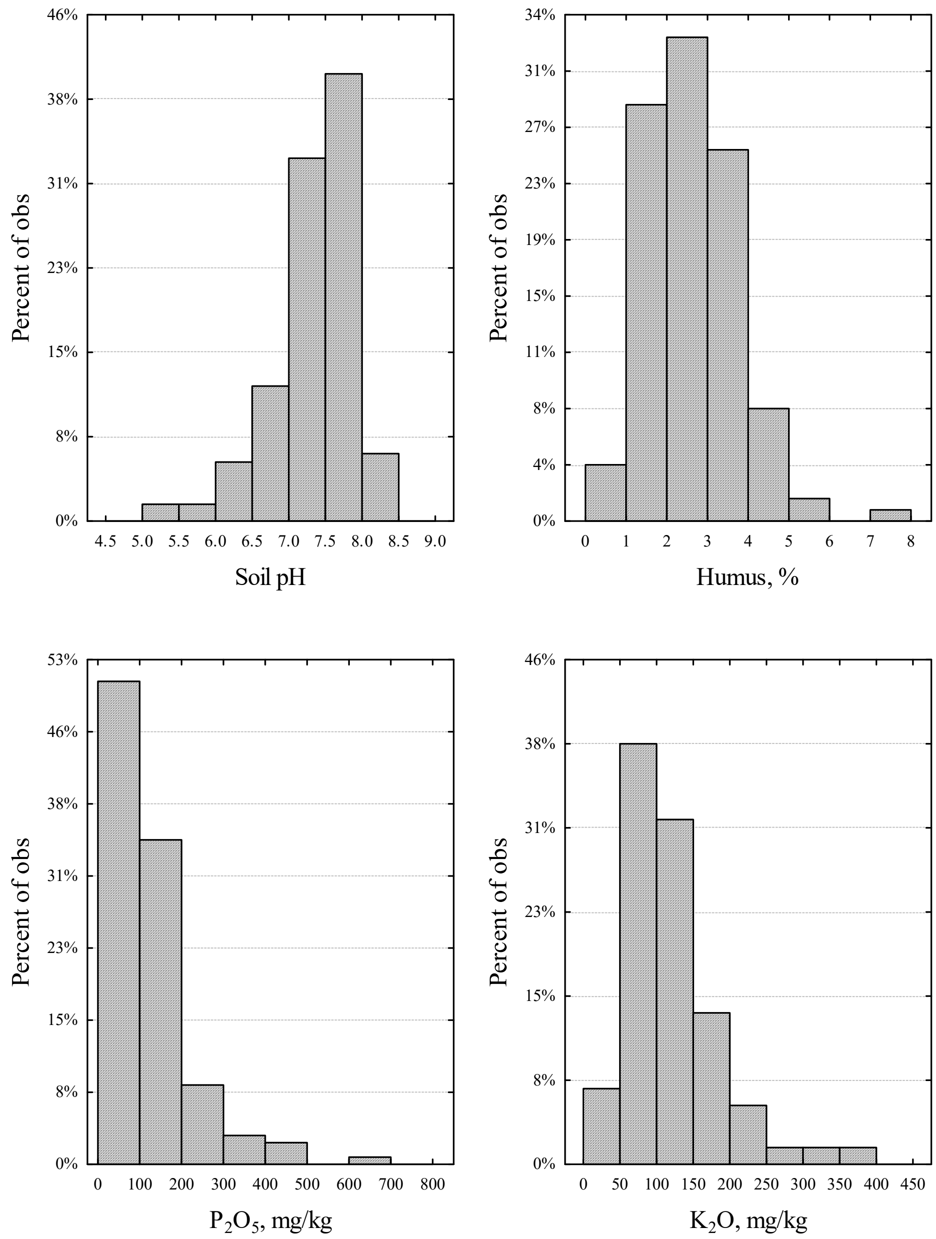

Fig. 3. Edaphic characteristics of *Thymus pulegioides* L. habitats sampled for the study (P_2O_5 – mobile phosphorus, K_2O – mobile potassium)

Investigated *T. pulegioides* habitats were established in plant communities of four different phytocoenological vegetation classes: *Molinio-Arrhenatheretea elatioris* R. Tx. 1937, *Festuco-Brometea erecti* Br.-Bl. et R. Tx. 1943, *Trifolio-Geranietea sanguinei* Th. Müller 1961, and *Koelerio-Corynephoretea canescentis* Klika et Novak 1941 (Tab. 1, Fig. 4). More than half investigated *T. pulegioides* habitats belonged to grassland communities of vegetation class *Molinio-Arrhenatheretea elatioris*. Almost one third of *T. pulegioides* habitats were attributed to plant communities of vegetation class *Festuco-Brometea erecti*, and only 11 and 5 habitats – in vegetation classes *Trifolio-Geranietea sanguinei* and *Koelerio-Corynephoretea canescentis*, respectively. BROECK et al. (2015) indicates that *T. pulegioides* is 'specialized' to semi-natural grasslands and often occurs in the similar vegetation along road verges and in remnant populations in areas that were previously semi-natural grasslands. The majority of our investigated habitats were more or less damaged by human activity: the grassland has been grazed and/or mowed; most of habitats were established along road verges. The syntaxonomic dependence of volatile ecological successions is difficult to assess, because the vegetation cover of such habitats is at stage of succession. Therefore belonging of grassland communities of *T. pulegioides* habitats to lower syntaxonomic units of vegetation classification was not carried out.

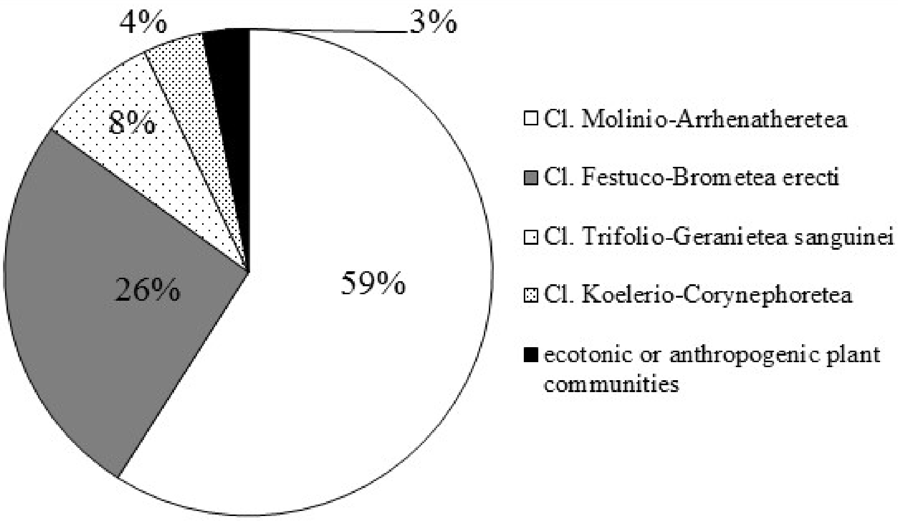

Fig. 4. The share of vegetation classes among *Thymus pulegioides* L. habitats sampled for the study

Only 9% habitats with values of cover-abundance of *T. pulegioides* 2 and 3 were found in plant communities of vegetation classes *Molinio-Arrhenatheretea elatioris* and *Trifolio-Geranietea sanguinei*; even 71% of habitats belonged to grassland communities of vegetation class *Molinio-Arrhenatheretea elatioris* had lowest value (+) of cover-abundance of *T. pulegioides* (Fig. 5). The highest percentage of habitats with high values (2 and 3) of cover-abundance of *T. pulegioides* was found in vegetation classes *Koelerio-Corynephoretea* and *Festuco-Brometea erecti* (Fig. 5). The natural and semi-natural communities of vegetation class *Molinio-Arrhenatheretea elatioris* are economically productive valuable hayfields and grazing grasslands in all Europe with the high average of humidity (MATUSZKIEWICZ 1984; BALEVIČIENĖ et al. 1998). The livestock grazing and haymaking do not have a negative impact on *T. pulegioides*: plants of this species are low and nor suffer from haymaking; also the herbivorous not eat essential oil bearing *T. pulegioides* because terpenes, the main compounds of essential oils, do protection role in deterring from livestock grazing (DRIJFHOUT & MORGAN, 2010). On the contrary, the grazing and haymaking can have positive effect on the spreading of *T. pulegioides* because these two anthropogenic factors help to compete for sun. Therefore, *T. pulegioides* is such frequent in communities of vegetation class *Molinio-Arrhenatheretea elatioris*. However, as suggest literature data, species of genus *Thymus* occur predominantly at dry sites (GOUYON et al. 1986; MÁRTONFI 1992; THOMPSON et al. 1998; AMIOT et al. 2005). Therefore, enough high humidity typical of natural and semi-natural grasslands of *Molinio-Arrhenatheretea elatioris* is not favourable for *T. pulegioides*: majority habitats belonged to grassland communities of vegetation class *Molinio-Arrhenatheretea elatioris* had the lowest value (+) of cover-abundance of *T. pulegioides*.

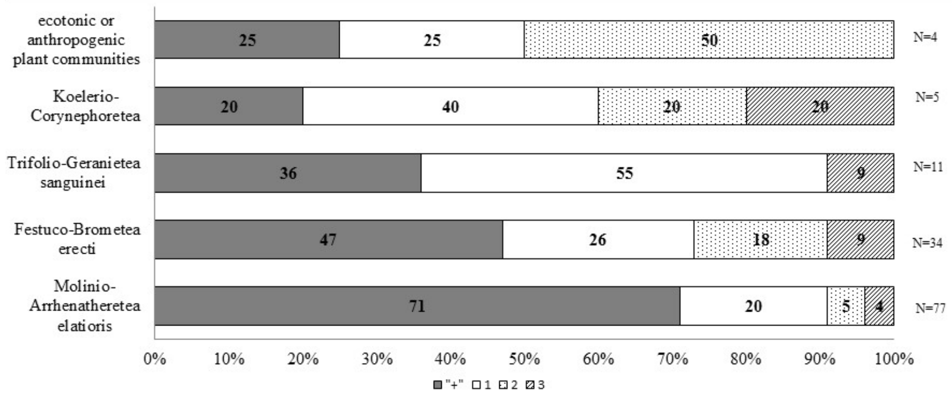

Fig. 5. The share of cover-abundance of *Thymus pulegioides* L. among vegetation classes in habitats sampled for the study („+“, 1, 2, 3 – cover-abundance according to Braun-Blaquet scale; N – number of habitats)

The grasslands of *Trifolio-Geranietea sanguinei* are heliophilous, thermophilous and ecotonic; the floristically-rich vegetation is characteristic of these grasslands, because they grow on the boundaries of meadows and forests often and are rarely mowing (BALEVIČIENĖ 1991; BALEVIČIENĖ et al. 1998). Although the ecological properties (sun and warm) are favourable for *T. pulegioides*, the floristically-rich vegetation (high competition) of these grasslands is unfavourable for weak competitive plants of *T. pulegioides.* Therefore, *T. pulegioides* was uncommon and often had low values (+ and 1) of cover-abundance in habitats belonged to grassland communities of vegetation class *Trifolio-Geranietea sanguinei* (Fig. 4 and Fig. 5). The grasslands of *Festuco-Brometea erecti* and *Koelerio-Corynephoretea canescentis* occurs in warm and dry sites with dominant xerophytic vegetation (BALEVIČIENĖ, 1991; BALEVIČIENĖ et al., 1998; LAIME & TJARVE, 2009). There the vegetation is less rich and has lower herb cover in such xerophytic meadows. These all properties can be the reason why the highest percentage of habitats with the high values (2 and 3) of cover-abundance of *T. pulegioides* was found in vegetation classes *Koelerio-Corynephoretea canescentis* and *Festuco-Brometea erecti* (Fig. 5). The Spearman rank correlation analysis showed the significant positive correlation between the cover-abundance of *T. pulegioides* and vegetation classes ($r = 0.33$, $p < 0.05$): the sequence of frequencies of cover-abundance of *T. pulegioides* +>1>2>3 in habitats corresponds to the following vegetation classes *Molinio-Arrhenatheretea elatioris* > *Trifolio-Geranietea sanguinei* > *Festuco-Brometea erecti* > *Koelerio-Corynephoretea canescentis*, i. e. the higher probable of low cover-abundances of *T. pulegioides* is possible in habitats belonged to vegetation class *Molinio-Arrhenatheretea elatioris* than in habitats belonged to vegetation class *Festuco-Brometea erecti*.

References

AMIOT J., SALMON Y., COLLIN CH. & THOMPSON J. D. (2005): Differential resistance to freezing and spatial distribution in a chemically polymorphic plant *Thymus vulgaris*. – Ecol. Lett. 8: 370–377.

BALEVIČIENĖ J. (1991): Sintaksonomo-fitogeografičeskaja struktura rastitel'nosti Litvy. – Vilnius, 217 pp.

BALEVIČIENĖ J., KIZIENĖ, LAZDAUSKAITĖ Ž., PATALAUSKAITĖ D., RAŠOMAVIČIUS V., SINKEVIČIENĖ Z., TUČIENĖ A. & VENCKUS Z. (1998): Vegetation of Lithuania. 1. Meadows. – Kaunas–Vilnius, 269 pp.

BRAUN-BLANQUET J. (1964): Pflanzensoziologie, Grundzüge der Vegetationskunde, 3rd ed. – Wien–NewYork, 865 pp.

BROECK A. V., CEULEMANS T., KATHAGEN G., HOFFMANN M., HONNAY O. & MERGEAY J. (2015): Dispersal constraints for the conservation of the grassland herb *Thymus pulegioides* L. in a highly fragmented agricultural landscape. – Conservation Genetics 16 (4): 765–776.

BUIVYDAITĖ V. V., VAIČYS M., JUODIS J. & MOTUZAS A. (2001): Classification of Lithuania soil. – Mokslas, Vilnius.

BUKANTIS A. (1994): Lithuanian climate. – Vilnius University.

DRIJFHOUT F. P. & MORGAN E. D. (2010): Terrestrial Natural Products as Antifeedants. – In: MANDER L. & LIU H.-W. (eds.): Comprehensive Natural Products II: Chemistry and Biology, 1st Edition, p. 457–501. – Oxford (U. K.), Elsevier.

ELLENBERG H., WEBWE H. E., DÜLL R., WIRTH V., WERNER W. & PAULIBEN D. (1991): Zeigerwertevon Pflanzen in Mitteleuropa. – Scripta Geobotanica, 18. – Göttingen.
ERIKSSON A. (1998): Regional distribution of *Thymus serpyllum*: management history and dispersal limitation. – Ecography 21: 35–43.
GOUYON P. H., VERNET P., GUILLERM J. L. & VALDEYRON G. (1986): Polymorphisms and environment: the adaptive value of the oil polymorphisms in *Thymus vulgaris* L. – Heredity 57: 59–66.
HADAČ E., HADAČOVA V. & POTOČEK V. (1988): Rostlinstvo Bukovskych vrchu na severovychodnim Slovensku a pudni reakce. – Preslia 60: 157–165.
KARAMAN S., DIGRAK M., RAVID U. & ILCIM A. (2001): Antibacterial and antifungal activity of the essential oils of *Thymus revolutus* Celak from Turkey. – J. Ethnopharmacol. 76: 183–186.
LAIME B. & TJARVE D. (2009): Grey dune plant communities (*Koelerio-Corynephoretea*) on the Baltic coast in Latvia. – Tuexenia 29: 409–435.
LEKAVIČIUS A. A. (1976): *Thymus* L. In: Natkevičaitė-Ivanauskienė M. (ed.): Flora of Lithuanian SSR, Vol. 5. – Mokslas: Vilnius, p. 308–314.
LOŽIENĖ K. & MÁRTONFIOVÁ L. (2004): *Thymus* chromosome numbers from Lithuania. – Thaiszia – J. Bot. 14: 63–73.
LOŽIENĖ K. & VAIČIŪNIENĖ J. (1999): Infraspecific diversity of *Thymus pulegioides* L. and characteristics of habitats. – Bot. Lith. 5: 27–40.
LOŽIENĖ K. (2009): Selection of fecund and chemically valuable clones of thyme (*Thymus*) species growing wild in Lithuania. – Industrial Crops and Products 29: 502–508.
LOŽIENĖ K., VAIČIŪNIENĖ J. & VENSKUTONIS P. R. (2003): Chemical composition of the essential oil of different varieties of thyme (*Thymus pulegioides* L.) growing wild in Lithuania. – Biochem. Syst. Ecol. 31: 249–259.
LOŽIENĖ K., VENSKUTONIS P. R. & VAIČIŪNIENĖ J. (2002): Chemical diversity of essential oil of *Thymus pulegioides* L. and *Thymus serpyllum* L. growing in Lithuania. – Biologija 1: 62–64.
LOŽIENĖ K., VENSKUTONIS P. R., ŠIPAILIENĖ A. & LABOKAS J. (2007): Radical scavenging and antibacterial properties of the extracts from different *Thymus pulegioides* L. chemotypes. – Food Chem. 103: 546–559.
MÁRTONFI P. (1992): Polymorphism of Essential Oil in *Thymus pulegioides* subsp. *chamaedrys* in Slovakia. – J. Ess. Oil Res. 4: 173–179.
MÁRTONFI P., GREJTOVSKÝ A. & REPČÁK M. (1996): Soil chemistry of *Thymus* species stands in Carpathians and Pannonia. – Thaiszia – J. Bot. (Košice) 6: 39–48.
MÁRTONFI P. & MÁRTONFIOVÁ L. (1996): *Thymus* chromosome numbers from Carpathians and Pannonia. – Thaiszia – J. Bot. 6: 25–38.
MATUSZKIEWICZ W. (1984): Przewodnik do oznaczania zbiorowisk roślinnych Polski. – Warszawa, 298 pp.
MOCKUTĖ D. & BERNOTIENĖ G. (1999): The Main Citral−Geraniol and Carvacrol Chemotypes of the Essential Oil of *Thymus pulegioides* L. Growing Wild in Vilnius District (Lithuania). – J. Agric. Food Chem. 47: 3787–3790.
MOCKUTĖ D. & BERNOTIENĖ G. (2001): The α-terpinyl acetate chemotype of essential oil of *Thymus pulegioides* L. – Biochem. Syst. Ecol. 29**:** 69–76.
MOCKUTĖ D. & BERNOTIENĖ G. (2005): Chemical composition of the essential oils and the odor of *Thymus pulegioides* L. growing wild in Vilnius. – J. Essent. Oil Res. 17: 415–418.

RASOOLI I. & MIRMOSTAFA S. A. (2002): Antibacterial properties of *Thymus pubescens* and *Thymus serpyllum* essential oils. – Fitoterapia 73: 244–250.
SIMON T. (1992): A magyarországi edényes flóra határozója. – Nemzeti tankönyvkiadó, Budapest, p. 867–868.
THOMPSON J. D., MANICACCI D. & TARAYRE M. (1998): Thirty-five years of thyme: a tale of two polymorphisms. Why so many females? Why so many chemotypes? – BioScience 48: 805–815.
VAN LANDUYT W., HOSTE I., VANHECKE L., VAN DEN BREMT P., VERCRUYSSE W. & DE BEER D. (2006): Atlas van de Flora van Vlaanderen en het Brussels Gewest. – Instituut voor natuur- en bosonderzoek, Nationale Plantentuin van België & Flo.Wer.

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