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RESEARCH ARTICLE

Coenotic and biomorphological analysis of Lamiaceae in the West Siberian floristic province

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Abstract

We analyzed the distribution, coenotic habitat, ecological preferences, and biomorphology of the 80 Lamiaceae species from 30 genera found in the West Siberian province. The plant species are primarily found in boreal and forest-steppe vegetation communities and are equally distributed in both lighted and shaded areas. Most species have a narrow range of humidity preferences. The study also highlights the diversity of life forms, with long-rhizomatous grasses being the most common, and morphological traits such as monocyclic elongated shoots, orthotropic growth direction, terminal arrangement of inflorescences, sympodial development, appearance of replacement axes due to basiton branching, and a long development period of more than three years. The research reveals that the diversity of life forms and biomorphological features of the shoot system play a significant role in determining the distribution of species in different ecological and coenotic conditions within the West Siberian province.

Keywords

West Siberian floristic province, Lamiaceae, ecological and coenotic characterization, biomorphological traits

Introduction

The Lamiaceae Martinov family is a significant component of the global flora, consisting of approximately 236 genera and over 7000 species (Harley et al. 2004; APG

IV 2016). These plants are found on all continents, from tropical to Arctic regions, and hold key ecological and economic importance. They thrive in diverse ecological niches, ranging from coastal water areas of plain rivers to cryophytic plant communities of rocky slopes in subalpine and alpine mountain belts. In Eurasia, there are over 500 Lamiaceae taxa organized into systematic groups of varying sizes and ranks. Researchers from Asian and European countries have shown particular interest in these plants due to their theoretical and practical significance (Jamzad 2013; Lazkov 2016; Massoud, Chonour 2013; 2018; Safkhani et al. 2018; Zhao et al. 2020; 2021) and Europe (Paton 1990; Hedge 1992; Mathiesen et al. 2011; Carovic-Stanko et al. 2016; Salimov et al. 2018). On the territory of Russia and neighboring countries, Lamiaceae species have been studied for the most part only in terms of taxonomic diversity (Klokov1954; Shishkin 1954; Shishkin Yuzepchuk 1954; Adylov 1987; Budantsev 1990; Kamelin, Makhmedov 1990) and chemical composition of their natural compounds (Budantsev 2011; Mamadalieva et al. 2017). Often individual taxa are used by researchers as model objects when studying the mechanisms of plant adaptation to different habitat conditions (Astashenkov 2015; Talovskaya (Kolegova) 2015; Cheryomushkina et al. 2020, 2022; Talovskaya, Cheryomushkina 2022). The study of the distribution of large taxa is of particular importance, as these data will further make it possible to assess the current distribution of species of the family in a certain area, predict the response of vegetation to changes in habitat conditions, and characterize the peculiarities of the morphological structure of species in the spectrum of habitats (Pyšek, Liška 1991; Körner 1992; Anthelme et al. 2014; Talovskaya, Cheryomushkina 2022).

In Russia and neighboring countries, Lamiaceae species have primarily been studied for taxonomic diversity and the chemical composition of their natural compounds. Some taxa are also utilized as model organisms for studying plant adaptation mechanisms to different habitats. Understanding the distribution of these taxa is crucial for assessing their current presence in specific areas, predicting vegetation responses to habitat changes, and characterizing species' morphological structures across different habitats. Siberia, the largest region in North Asia, offers a wide range of ecological conditions and is home to 148 Lamiaceae species from 30 genera (Doronkin 2012). These species exhibit various life forms, including perennial and annual herbs, semi-shrubs, and shrubs.

The goal of this study was to investigate the distribution, coenotic habitat, ecological preferences, and biomorphology of Lamiaceae species in the West Siberian floristic province.

Materials and methods

The study was carried out in Western Siberia within the West Siberian province, encompassing Tobolsk, Kurgan, Omsk, Tomsk, Novosibirsk, Kemerovo, and Barnaul floristic regions (Takhtajyan 1978; Malyshev et al. 2000). Floristic zoning was

performed with contrast zoning (Malyshev et al. 2000) by flora species composition (Fig. 1). The province is situated in the West Siberian Plain and features a predominantly uniform landscape, with occasional minor elevations and depressions (0-300 m above sea level). The distinctiveness of the province's vegetation cover lies in its extensive swampy areas. The taiga and forest-steppe zones dominate the province, while the steppe zone is only sporadically present.

Figure 1. Map of the West Siberian floristic province according to L.I. Malyshev et al. (2000). Bold dashed line – border of Western Siberia, blue line – border of the floristic province, dotted line – borders of the province districts.

Species distribution

The material for the analysis consisted of herbarium collections gathered independently during field studies in Western Siberia, as well as from the NS (CSBS SB RAS, Novosibirsk) and ALTB (Altai State University, Barnaul) herbarium collections. Floristic works by L.I. Malyshev (1997), V.M. Doronkin (2012), and M.M. Silantieva (2013), along with data from the Global Biodiversity Information Facility (GBIF) at https://www.gbif.org/ru/ and Plants of the World Online (POWO) at https://powo.science.kew.org/, were utilized to establish the general distribution pattern of species. Relying on R.V. Kamelin's approach (2017), the species of the Lamiaceae family were classified into 8 chorological (geographical) groups: multiregional, Holarctic, Palaearctic, Volga-South Ural-Southwest Siberian, South Siberian-Central Asian, South Siberian, Altai-Central Asian, and endemic (subendemic).

The phytocoenotic assignment of Lamiaceae species was determined based on A.V. Kuminova (1960), L.I. Malyshev (1997), N.B. Ermakov (2003), D.M. Doronkin (2005), N.I. Makunina (2016), and data from herbarium collections. The species names were referenced from the international database World Checklist of Vascular Plants at https://powo.science.kew.org/. Eight coenotic complexes were identified, namely: sandy shores and dunes, shrub thickets, mountain-tundra, anthropophytic, petrophytic, meadow, steppe, and forest.

Ecological traits

To determine the ecological preferences of Lamiaceae species, we conducted an analysis of their tolerance to moisture, light, and substrate type. Regarding moisture, we identified eight groups: mesoxerophytes, euxerophytes, xeromesophytes, eumesophytes, mesohygrophytes, hygrophytes, hydrophytes, and psychrophytes. In terms of illumination, we distinguished three groups: heliophytes, sciophytes, sciogeliophytes, or facultative heliophytes. Additionally, we categorized all Lamiaceae species into three groups based on substrate type: psammophytes, petrophytes, and non-petrophytes. We then used Ward's method, as outlined by Siegel and Castellan in 1989, to associate Lamiaceae species distributed in the West Siberian province according to their ecological and coenotic preferences. This analysis was conducted using the Statistics 10 software package.

Morphological traits

Biomorphological characters were analyzed on at least five herbarium specimens of each species. A total of 400 Lamiaceae specimens were analyzed. Eight traits were selected as initial data: stem elongation cycle (mono-, di- and polycyclic), stem structure (semi-rosette, rosette, and elongated), auxiliary shoot position/branching (acrotonic, basitonic, mesotonic, monopodial or sympodial), inflorescence position (terminal or lateral), flowering types (polycarpic, monocarpic), life cycle (an-

nual, biennial, and perennial), axes differentitation (orthotropic, plagiotropic, and anisotropic) (Serebryakov 1959; Barthélémy, Caraglio 2007). When characterizing branching, the positioning of the second-order shoots along the parent axis was determined (acrotonic, basitonic, and mesotonic).

Life form and biomorph types

In this study, we examine two approaches to classifying life forms. The first is the C. Raunkiaer (1934) classification, which is based on the position of the renewal buds. The second approach is the ecological-morphological classification of E. Warming (1909) and I.G. Serebryakov (1962, 1964), which analyzes a set of morphological features of plants based on specific habitat conditions.

Result

Taxonomic composition

The study showed that 80 species of Lamiaceae belonging to 30 genera grow on the territory of the West Siberian province. The leading among them are *Thymus* L. (10 species), *Dracocephalum* L. (9 species), *Scutellaria* L. (6 species) and *Mentha* L. (6 species) (Table 1). The character of distribution of genera and species over the territory of the province shows that their greatest number is concentrated in the Barnaul district (95% of the total number of genera and 89% of the total number of species). A nucleus consisting of 8 genera is distinguished, which are found in all districts of the province: *Dracocephalum*, *Galeopsis* L., *Leonurus* L., *Mentha*, *Origanum* L., *Prunella* L., *Scutellaria*, and *Stachys* L.

Distribution and ecology of Lamiaceae

As a result of chorological analysis, all studied species of Lamiaceae were divided into 8 chorological groups (Table 2). The largest number of species (43 species) constitutes the Palaearctic realm. Among them, most species have Palaearctic origin (18 species, like *Lamium album* L., *Scutellaria supina* L., and *Thymus marschallianus* Willd.) and West Palaearctic (17 species, among them *Betonica officinalis* L., *Chaiturus marrubiastrum* (L.) Ehrh. ex Rchb., *Dracocephalum thymiflorum* L.) origin. The Altai-Central Asian group is represented by 14 species, among them *Dracocephalum integrifolium* Bunge, *Lagopsis marrubiastrum* (Stephan) Ikonn.-Gal., and *Phlomoides agraria* (Bunge) Adylov, Kamelin & Makhm. as well as species not entering Mongolian territories, like *Hyssopus ambiguus* (Trautv.) Iljin ex Prochorov. & Ledel, *Thymus petraeus* Serg., *T. proximus* Serg., and *T. roseus* Schipcz. The same number of species form South Siberian-Central Asian (7 species, among them *Dracocephalum discolor* Bunge, *D. grandiflorum* L., and *Leonurus deminutus* V.I.Krecz.), Hol-

arctic (6 species, like *Glechoma hederacea* L., *Lamium purpureum* L., and *Lycopus europaeus* L.) and pluriregional or cosmopolitan groups (5 species, among them *Clinopodium acinos* (L.) Kuntze, *Leonurus japonicus* Houtt., and *Mentha aquatica* L.). For some species the cosmopolitan range is secondary. For example, *Clinopodium acinos* is a weed in neglected fields; *Mentha aquatica*, *M. arvensis* L., and *M. longifolia* (L.) L. are the species widely used by humans in culture as medicinal and aromatic plants; *Leonurus japonicus* – formerly cultivated as a medicinal plant, but now occurring as a weed. There are three endemic and subendemic species of Lamiaceae in the study area: *Scutellaria altaica* Ledeb. ex Sweet, *Scutellaria mongolica* Sobolevsk. and *Thymus elegans* Serg. *Thymus jenisseensis* Iljin belongs to South Siberian areal and *Thymus punctulosus* Klokov belongs to Trans-Volga-South Ural-South-West Siberian range.

Table 1. Distribution of Lamiaceae in the West Siberian Province

Genera	Species number	Species number per administrative district						
		1	2	3	4	5	6	7
Acinos	1	0	1	0	1	1	0	1
Amethystea	1	0	0	0	0	1	0	1
Antonina	1	0	0	0	0	0	0	1
Betonica	1	1	0	0	1	0	1	1
Chaiturus	1	0	0	1	0	1	0	1
Clinopodium	1	1	0	0	0	0	0	0
Dracocephalum	9	2	3	3	3	3	6	8
Elsholtzia	1	0	0	0	1	1	1	1
Galeopsis	3	3	3	3	3	3	3	3
Glechoma	1	1	0	0	1	1	1	1
Hyssopus	1	0	0	0	0	0	1	1
Lagopsis	1	0	0	0	0	0	0	1
Lamium	3	3	2	1	3	3	3	3
Leonurus	5	2	2	2	3	3	4	4
Lycopus	2	1	2	2	2	2	2	2
Melissa	1	0	0	0	0	0	0	1
Mentha	6	2	1	1	1	2	2	6
Nepeta	4	0	2	2	3	4	1	4
Origanum	1	1	1	1	1	1	1	1
Panzerina	1	0	0	0	0	0	0	1
Phlomoides	4	1	1	1	1	2	1	4
Prunella	1	1	1	1	1	1	1	1
Salvia	4	0	2	1	0	2	2	4

Genera	Species number	Species number per administrative district						
		1	2	3	4	5	6	7
Satureja	1	0	0	0	0	0	0	1
Schizonepeta	2	1	0	1	0	1	1	1
Scutellaria	6	2	1	2	3	4	3	4
Stachys	4	2	2	2	2	3	3	4
Teucrium	1	0	0	0	0	0	0	1
Thymus	10	0	2	3	3	1	6	8
Ziziphora	1	0	0	0	0	1	1	1
Total	80	24	26	27	33	41	44	71

Notes: 1 – Tobolsk, 2 – Kurgan, 3 – Omsk, 4 – Tomsk, 5 – Novosibirsk, 6 – Kemerovo, 7 – Barnaul.

Table 2. Chorological groups of Lamiaceae

	Areals	Species number	Species number (% from total)
1	Multiregional	5	6.3
2	Holarctic	6	7.5
3.1	Palaearctic realm	18	22.5
3.2	Eastern Palaearctic	5	6.3
3.3	Western palaearctic	17	21.3
3.4	Central palaearctic	3	3.8
4	Trans-Volga-South Ural-Western Siberia	1	1.3
5	South Siberian-Central Asian	7	8.8
6	South-Siberian	1	1.3
7	Altai-Central Asian	14	17.5
8.1	Altai-Sayan-Tuva	2	2.5
8.2	Altai	1	1.3

The analysis of ecological tolerance has shown that according to water content adaptation, most species belong to mesophytes (*Amethystea caerulea* L., *Dracocephalum nutans* L., and *Glechoma hederacea* L.), slightly less are mesoxerophytes (*Nepeta nuda* L., *Phlomoides tuberosa* (L.) Moench, and *Salvia verticillata* L.) and euxerophytes (*Hyssopus ambiguus* and *Ziziphora clinopodioides* Lam. – see Fig. 2. According to light adaptation, most of the studied species belong to sciogeliophytes (*Clinopodium vulgare* L., *Origanum vulgare* L., and *Satureja hortensis* L.). In relation to the substrate, the absolute majority of species are non-petrophytic. The obligate petrophytes include *Thymus altaicus* Klokov & Des.-Shost. and *T. punctulosus*, while the psammophytes include *Satureja hortensis*.

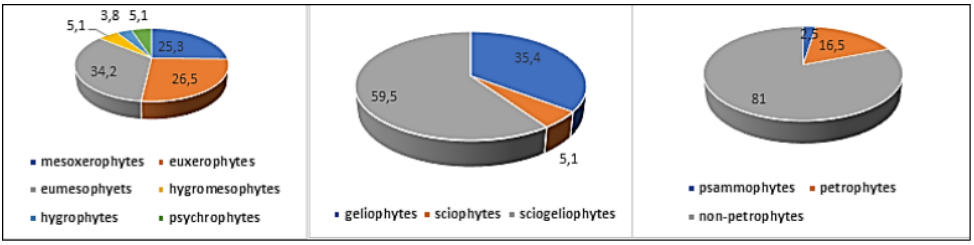

Figure 2. Number of Lamiaceae species (%) in different ecological groups (a - humidity, b - light, c - nutrition).

Lamiaceae in the West Siberian province plant communities

The greatest number of Lamiaceae species is found in communities of four coenotic complexes: petrophytic (61 species), meadow (56), anthropophytic (52 species), and steppe (35 species, see Table 3). Only two Lamiaceae species were recorded in the communities of the mountain-tundra complex. The petrophytic complex unites Lamiaceae growing in rock crevices (*Thymus elegans* and *T. petraeus*), on stony-rubble slopes (*Lagopsis marrubiastrum*, *Hyssopus ambiguus*, and *Ziziphora clinopodioides*) and scree slopes (*Thymus mongolicus* (Ronniger) Ronniger and *T. roseus*). The meadow complex is one of the most diverse in composition of coenotic groups. Among them, the steppe-meadow group is the richest in the number of species – 26 species (*Chaiturus marrubiastrum*, *Lamium purpureum* and *Leonurus tataricus* L.); in the forest-meadow group there are 16 species (*Dracocephalum thymiflorum*, *Galeopsis speciosa* Mill., and *Glechoma hederacea*); in the floodplain-meadow group – 11 species (*Scutellaria hastifolia* L., *Stachys palustris* L., and *Teucrium scordioides* Schreb.); in mountain-forest and subalpine – 3 species (*Phlomoides alpina* (Pall.) Adylov, Kamelin & Makhm., *P. oreophila* (Kar. & Kir.) Adylov, Kamelin & Makhm.); in alpine-meadow group only *Dracocephalum grandiflorum*. In the steppe complex, the steppe coenotic group proper is the richest in the number of Lamiaceae species, which unites 24 species (*Amethystea caerulea*, *Leonurus glaucescens* Bunge, and *Nepeta ucranica* L.). Meadow-steppe coenotic group includes 9 species (*Nepeta nuda* and *Schizonepeta multifida* (L.) Briq.), shrub-steppe – 2 species (*Salvia deserta* Schangin and *Scutellaria supina*). Anthropophytic complex combines ruderal and segetal species, like *Elsholtzia ciliata* (Thunb.) Hyl., *Mentha spicata* L., and *Stachys byzantina* K.Koch.

Most of the forest complex species are associated with light coniferous (*Clinopodium acinos*, *Dracocephalum nutans*, and *Origanum vulgare*) and small-leaved (*Dracocephalum ruyschiana* L., *Phlomoides tuberosa*, and *Prunella vulgaris* L.) forests. In dark coniferous forests there is one Lamiaceae species *Stachys sylvatica* L. In addition, the flora of alpine tundra is not rich in Lamiaceae species, in this habitat species of the genus *Dracocephalum* can occur: *D. grandiflorum* and *D. imberbe* Bunge.

Table 3. Phytocoenotic assignment of species of the Lamiaceae family

Coenotic complex	Coenotic group	Species number
Forest	1.1 Light coniferous	8
	1.2 Dark coniferous	2
	1.3 Small-leaved	7
Steppe	2.1 Steppe-meadow	9
	2.2 Shrub-steppe	2
	2.3 Steppe	24
Meadow	3.1 Wooded meadow	16
	3.2 Steppe meadow	25
	3.3 Floodplain meadow	11
	3.4 Alpine-forest and subalpine	3
	3.5 Grassland meadows	1
Alpine tundra	Alpine tundra	2
Petrophytic	5.1 Rocks	14
	5.2 Rocky slopes	26
	5.3 Rubble slopes	13
	5.4 Taluses	8
Anthropophytic	6.1 Ruderal	31
	6.2 Segetal	21
Shrub thickets		10
Sandy riverbanks and dunes		14

Shrub thickets with 10 species of Lamiaceae (*Clinopodium delibe* (Bunge) Kuntze, *Galeopsis speciosa*, *Lycopus europaeus*, and *Mentha longifolia*) and sandy river banks and dunes with 14 species (*Leonurus japonicus*, *Lycopus exaltatus* L.f., and *Scutellaria scordiifolia* Fisch. ex Schrank) were identified as special coenotic complexes.

A significant part of species (74 species) of the family participates in several coenotic complexes. For example, *Amethystea caerulea* is found in steppe, petrophytic and anthropophytic complexes; *Dracocephalum ruyschiana* – in forest, meadow and petrophytic complexes; *Origanum vulgare* – in forest, steppe, meadow and petrophytic complexes. Single species are confined to one coenotic complex. *Dracocephalum integrifolium* is found only in communities of the petrophytic complex; *Elsholtzia ciliata* and *Galeopsis bifida* Boenn. – in communities of the anthropophytic complex; *Phlomoides agraria* – in communities of the steppe complex.

Diversity of morphological characters in Lamiaceae

Most plants of the Lamiaceae growing in the West Siberian Province are characterized by monocyclic (55.7%) elongated (57.0%) shoots, orthotropic growth direc-

tion (83.5%), terminal inflorescence arrangement (82.3%), sympodial development (73.4%), appearance of substitute axes as a result of basiton branching (52.6%) and long development period (from three years) (80.0%, see Table 4). Plants with polycyclic shoots are less common. Species with at least one of the following traits are found only rarely: rosette shoots, plagiotropic growth direction, acrotonic branching, and biannual growth duration.

Table 4. Diversity of morphological characters in Lamiaceae

Stem elongation cycle			
Monocyclic (55.7%)	Dicyclic (29.1%)		Polycyclic (15.2%)
Amethystea caerulea, Antonina debilis, Galeopsis bifida	*Lagopsis marrubastrum, Leonurus japonicus, Panzerina lanata* (L.) Soják		*Dracocephalum imberbe, Phlomoides oreophila, Thymus jenisseensis*
Shoot structure			
Elongated (57.0%)	Rosette (5.1%)	Semi-rosette (25.3%)	Mixed (12.7%)
Clinopodium acinos, Clinopodium vulgare, Ziziphora clinopodioides	*Dracocephalum grandiflorum, D. imberbe, Phlomoides alpina*	*Betonica officinalis* L., *Chaiturus marrubiastrum, Leonurus deminutus*	*Thymus*
Axes differentiation			
Orthotropic (83.5%)	Anisotropic (15.1%)		Plagiotropic (1.3%)
Elsholtzia ciliata, Hyssopus ambiguus, Lamium album	*Clinopodium vulgare, Dracocephalum discolor, Thymus*		*Glechoma hederacea*
Inflorescence position			
Terminal (82.3%)		Lateral (17.7%)	
Lycopus exaltatus, Melissa officinalis L., *Nepeta cataria* L.		*Dracocephalum grandiflorum, D. imberbe, Phlomoides oreophila, Tthymus*	
Flowering type			
Monocarpic (21.5%)		Polycarpic (78.5%)	
Amethystea caerulea, Chaiturus arrubiastrum, Galeopsis ladanum L.		*Hyssopus ambiguus, Lamium album, Lycopus exaltatus*	
Auxiliary shoot position			
Monopodial (26.6%)		Sympodial (73.4%)	
Galeopsis bifida, Amethystea caerulea, Chaiturus marrubiastrum		*Nepeta sibirica* L., *Lagopsis marrubiastrum, Glechoma hederacea*	
Positioning of the second-order shoots along the parent axis			
Acrotonic (10.1%)		Mesotonic (37.3%)	Basitonic (52.6%)
Thymus altaicus, T. proximus, T. petraeus		*Scutellaria supina, S. hastifolia, Stachys palustris*	*Phlomoides tuberosa, Thymus marschallianus, T. roseus*

Life cycle		
Annual (15.0%)	Biennial (5.0%)	Perennial (80.0%)
Galeopsis ladanum L., *Dracocephalum thymiflorum, Elsholtzia ciliata*	*Leonurus deminutus*, *L. japonicus, Schizonepeta annua* (Pall.) Schischk.	*Betonica officinalis, Clinopodium vulgare, Mentha aquatica*

The analysis of biomorphological characters showed that plants of 21 Lamiaceae genera distributed in the territory of the West Siberian province have no variability of morphological characters. In the species of the remaining 9 genera, which constitute 60% of the total number of all the Lamiaceae species in the study area, the polyvariance of at least one of the biomorphological characters was revealed (Table 5). Such genera include *Dracocephalum*, *Lamium* L., *Leonurus*, *Phlomoides* Moench, *Salvia* L., *Schizonepeta* (Benth.) Briq., *Scutellaria*, *Stachys* and *Thymus*. The characters, diversity of which is noted in representatives of these genera, are shoot development cycle and type of branching. Polyvariance of shoot structure, duration of development of an individual, frequency of flowering and development is also often noted.

Table 5. Matrix of morphological traits variability

Genera	**Morphological traits**							
	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
Dracocephalum	+	+	+	+	+	+	+	+
Lamium	+	+	+				+	+
Leonurus	+	+	+	+			+	+
Phlomoides			+	+		+	+	+
Salvia			+	+				
Schizonepeta	+	+					+	+
Scutellaria				+				
Stachys	+	+	+	+				+
Thymus				+				+

Note: 1 – Life cycle, 2 – Flowering type, 3 – Shoot structure, 4 – Shoot elongation structure, 5 – Axes differentiation, 6 – inflorescence position, 7 – auxiliary shoot position, 8 – positioning of the second-order shoots, "+" – polyvariance of the trait.

Life forms and phenorhythmotypes

The analysis of Lamiaceae species using Raunkiaer's (1934) approach revealed that hemicryptophytes (50.6%) are the most common life form among species such as *Betonica officinalis*, *Dracocephalum peregrinum* L., and *Mentha aquatica*. Thero-

phytes account for 22.8% (including *Chaiturus marrubiastrum*, *Dracocephalum moldavica* L., and *Satureja hortensis*), while chamaephytes make up 20.3% (including *Dracocephalum integrifiolim* and *Hyssopus ambiguus*). Additionally, 6.3% of the species (such as *Lycopus europaeus*, *Stachys palustris*, and *Teucrium scordioides*) are cryptophytes.

Furthermore, applying the ecological-morphological approach of C. Warming (1909) and I.G. Serebryakov (1962) to Lamiaceae species in the West Siberian province, it was found that 82.3% are herbs, 11.4% are dwarf semi-shrubs, and 6.3% are dwarf shrubs (see Fig. 3). Herbaceous plants are further categorized based on their lifespan, with perennial and one- or two-year herbaceous plants identified. Perennial grasses exhibit a high diversity in their underground organs, with five types identified: Taproot caudex, short-rhizomatous, long-rhizomatous, ground creeping, and subterrain-stoloniferous (refer to Table 6). Notably, long-rhizomatous perennial grasses (21 species) are the most prevalent among the diverse range of grasses.

Table 6. Grasses diversity in Lamiaceae

Life form	% from total species	Species
Taproot ephemeral grass	16.5	*Clinopodium delibe, Elsholtzia ciliata, Lamium purpureum*
Taproot biannual grass	6.3	*Chaiturus marrubiastrum, Leonurus deminutus, Schizonepeta annua*
Perennial grasses		
Taproot caudex	15.2	*Panzerina lanata* (L.) Sojak., *Phlomoides alpina*, *Salvia stepposa* Des.-Shost.
Short-rhizomatious	11.4	*Dracocephalum nutans, Nepeta ucranica, Prunella vulgaris*
Long-rhizomatous	26.6	*Clinopodium vulgare, Mentha arvensis, Nepeta sibirica*
Creeping	1.3	*Glechoma hederacea*
Stoloniferous	25	*Lycopus exaltatus, Scutellaria scordiifolia*

In multi-species genera like *Dracocephalum*, *Scutellaria*, and *Thymus*, a range of life forms is observed (see Fig. 3). For example, *Dracocephalum* species can exhibit dwarf semi-shrub or herbaceous biomorphs. The herbaceous type further encompasses various forms, such as short-rhizomatous, long-rhizomatous, perennial taproot caudex, and annual taproot. The majority of *Dracocephalum* species develop as rhizomatous (short- or long-rooted) plants. In contrast, *Scutellaria* species are known for forming dwarf semi-shrub and herbaceous (long-rhizomatous and subterrain-stoloniferous) life forms. *Thymus* species, on the other hand, predominantly exhibit shrubby or semi-shrubby life forms.

A research on the phenological development of Lamiaceae species in the West Siberian province found that all these plants exhibit a similar phenorhythmotype.

They are summer-green plants that become dormant in winter. These plants bloom from spring to fall and lose their leaves during the winter months.

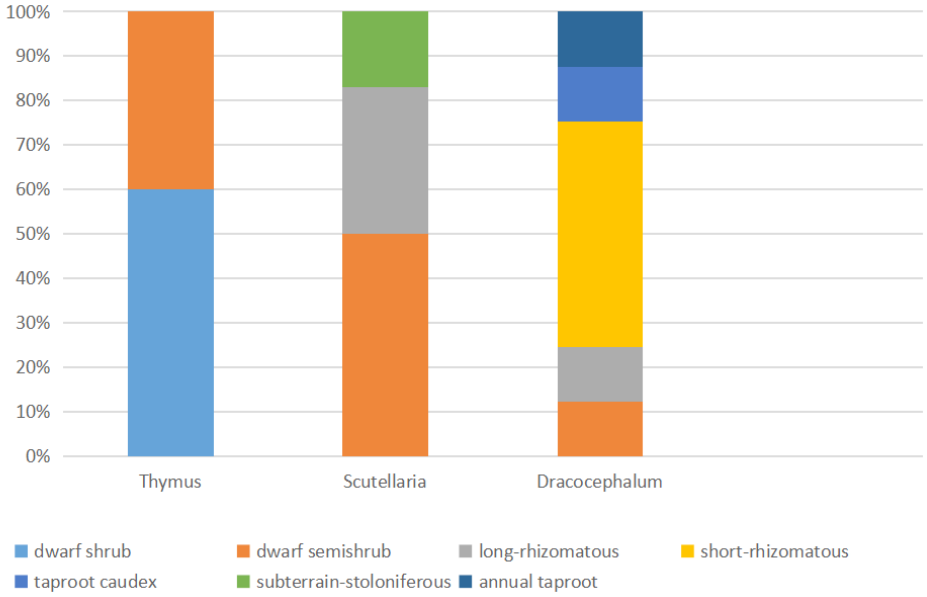

Figure 3. Life forms in three multispecies taxa (*Dracocephalum*, *Scutellaria* and *Thymus*).

Discussion

In the West Siberian province, there are 80 species of the Lamiaceae family, which account for 54% of their total number in Siberia. Their distribution across the province is uneven, with a concentration in the Barnaul district, known for its boreal and forest-steppe vegetation. The Barnaulsky District boasts 71 species from 29 genera, rivaling and sometimes surpassing neighboring regions in species diversity. For instance, the Altai Republic has 67 species from 24 genera (Doronkin, Ebel 2012), Tuva has 60 species from 22 genera (Timokhina, Zykova 2007), and Khakassia has 61 species from 20 genera (Myadele 2008). Genera such as *Dracocephalum*, *Thymus*, and *Scutellaria* are known for their multiple species. Most Lamiaceae species in the West Siberian province have wide ranges, with only 4% being endemics or subendemics. The family's representatives are found in various coenotic complexes, and 93% of species thrive in a wide range of ecological and coenotic habitats. In terms of ecological and phytocoenotic features, all species were grouped using clustering (Ward's method) into two clusters (Fig. 4).

Group 1 includes three species (*Dracocephalum grandiflorum*, *D. imberbe*, and *Phlomoides oreophila*) primarily found in high mountain cold conditions, although

they are also present in meadow and forest communities. These species have different herbaceous life forms but share similar morphological features in their shoot systems.

The second group encompasses the remaining guboflower species, which display a diverse range of features. This group can be further divided into four subgroups. Notably, subgroup 2c consists of 37 species mainly categorized as eumesophytes or euxerophytes, with varying light regime preferences and the ability to grow on different soil types. These species are commonly found in meadow, petrophytic, and anthropophytic communities. They exhibit a high diversity of life forms and morphological characters. Subgroup 2d comprises 24 species associated with forest, steppe, and petrophytic communities, with a prevalence of annual grasses. Subgroup 2b includes four species with semi-shrubby/shrubby life forms, while subgroup 2a consists of ten species with perennial herbaceous life forms. Some species within the second group share a high degree of similarity in ecological and phytocoenotic features, even across different genera. For example, *Stachys sylvatica* L., *Scutellaria hastifolia* and *Prunella vulgaris* are closely related.

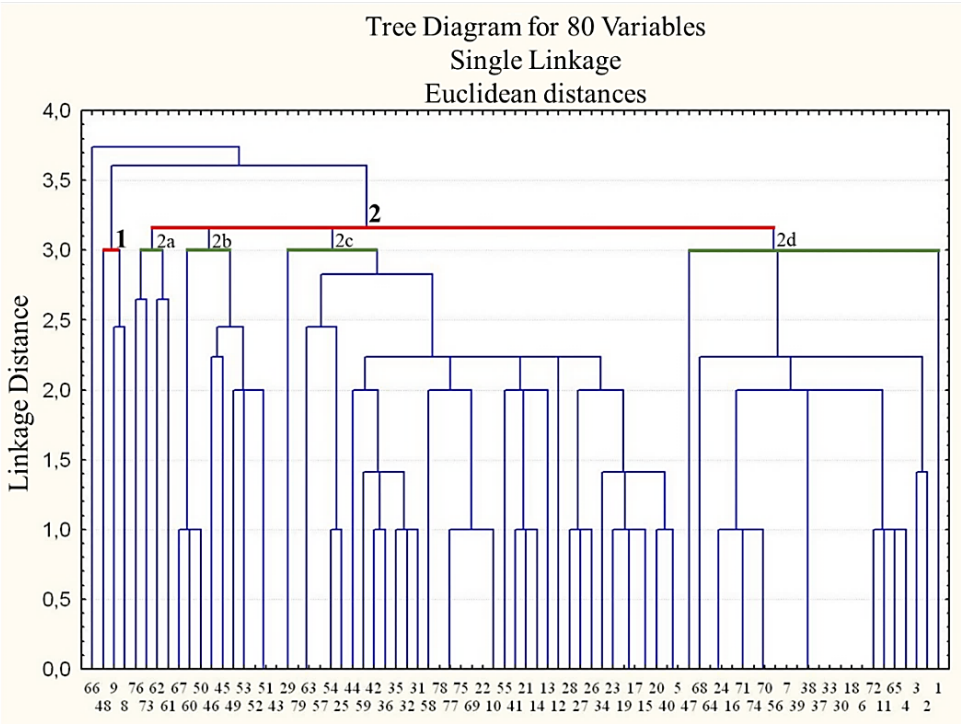

Figure 4. Similarity of ecological-phytocoenotic preferences in Lamiaceae species of the West Siberian province.

The comparison of our results with existing literature on the biomorphology and ecological-phytocoenotic preferences of hibiscus species in Siberia (Myadel 2008; Vodolazova et al. 2010; Kolegova, Cheryomushkina 2013; Cheryomushkina, Guseva 2015; Denisova et al. 2018; Talovskaya et al. 2018; Cheryomushkina et al. 2020; Komarevtseva 2020) revealed that the diverse life forms, prevalence of herbaceous perennials, and variation in morphological characteristics are key factors that have enabled the family's representatives to thrive in this region. Consequently, Lamiaceae species in the West Siberian province exhibit a broad range of ecological and coenotic preferences, spanning from flat steppes to mountain tundra, and adapting to various substrate types and light conditions. The distribution of these species is determined by the diversity of life forms, with perennial grasses being the most common, and biomorphological traits.

Conclusion

A comprehensive approach was applied to study the Lamiaceae family in the West Siberian floristic province. This approach helped determine the taxonomic composition, distribution, coenotic distribution, ecological preferences, and biomorphology of the species. Among the 30 genera in the study area, the leading genera in terms of species number are *Thymus* L., *Dracocephalum* L., *Scutellaria* L., and *Mentha* L. The species exhibit a wide range of ecological and coenotic preferences. They are mainly found in boreal and forest-steppe vegetation communities, equally distributed in both lighted and shaded areas, and prefer a narrow range of humidity changes. Most Lamiaceae species are nonpetrophytes growing on various types of soils. There are 7 different life forms observed among the species, with herbaceous perennial long-rhizomatous being the most common. The study also revealed common morphological features such as monocyclic elongated shoots, orthotropic growth direction, terminal arrangement of inflorescences, sympodial development, appearance of replacement axes due to basiton branching, and a long development period of more than three years. The diversity of life forms and biomorphological traits in the shoot system is influenced by the spectrum of ecological and coenotic conditions in the West Siberian province, reflecting species adaptation to these conditions.

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