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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy

ECOBIOLOGICAL AND PHYTOSENOLOGICAL STUDY OF *LAMIACEAE* FAMILY IN THE NORTH-EAST PART OF THE LESSER CAUCASUS

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INTRODUCTION

Relevance and degree of completion of the topic. The Lesser Caucasus botanical-geographical regions have always been in the center of attention of researchers due to the richness of flora, which differs sharply from other botanical-geographical regions of Azerbaijan, as well as the Caucasus[1,2]. The emergence of biodiversity in the flora of the region is associated with elements of the flora of the Mediterranean, Asia, and especially Iran-Turan. The vegetation is clearly divided into conspicuous zones due to the typical mountainous terrain.

Botanical analysis, bioecolojical specifications, spreading some important resources of representatives, ether oils, their component composition, physico-chemical constants actual conduct study and research complex narrative to the introduction of *Lamiaceae* Lindl. family spread in Lesser Caucasus flora is one of the issues.

Because most of these species have beneficial properties such as medicinal, food and ether oil plants. It should be noted that there are very valuable ether oil species (*Nepeta, Mentha, Thymus, Ziziphora, Salvia*, etc.) that are already used[3],[4] in scientific medicine, and although they are studied in the flora of Azerbaijan, the Lesser Caucasus is not covered separately.

Most of the plants grown in the region are useful plants and widely used in various sectors of the economy. Among these plants,

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[1] Novruzov V.S., Aslanova E.A. Features of the formation of vegetation on talus and rocks of the eastern part of the Lesser Caucasus // - Moscow: Agrarian science. –2013. –10, - p. 17-18.

[2] Ibadullayeva S.J. Recommended phyto-ameliorative restoration of vegetation in Ganja surroundings rivers /S.Ibadullayeva, N.Ismayilzade, A.Ismailov [et al] //International Jour. of Advanced Research in Botany. –2016. -v. 2, – is.1, –pp 1-6.

[3] Baranauskienė, R. Essential oil composition of five Nepeta species cultivated in Lithuania and evaluation of their bioactivities, toxicity and antioxidant potential of hydrodistillation residues /R.Baranauskienė, V.Bendžiuvienė, O.Ragažinskienė [et al.]// Food and Chemical Toxicology, –2019, –Vol. 129, –P. 269-280. https://doi.org/10.1016/j.fct.2019.04.039.

[4] Kordali, S., Tazegul, A., Cakir, A. Phytotoxic Effects of Nepeta meyeri Benth. Extracts and Essential Oil on Seed Germinations and Seedling Growths of Four Weed Species // Records of Natural Prod. – 2015. –v. 9, – is. 3, – p. 404-418.

Labiatae is used for food, medicine, dyes and spices, etc. They are considered to be an important source of raw materials, as well as being rich in biologically active substances.

The study of plants with such beneficial properties is very important for the area. Taking into account all the above, determination of the ways of formation, distribution, the taxonomic composition of *Lamiaceae* families in the biodiversity of the Lesser Caucasus flora, to identify and cultivate representatives rich in ether oils is actually.

The social and economic development of the region depends on a wide range of areas, including the study of flora and the use of their beneficial properties.

The chemical composition of many species of the family, biologically active substances, including ether oils, etc. have been studied both in our Republic and in other countries[5,6,7]. However, until now, the representatives of the Labiatae, which are widespread in the flora of the Lesser Caucasus, have not been the subject of a separate study.

Due to the fact that the species of families are rich in biologically active substances, a more in-depth study of their use in various fields of science and economics is currently in the spotlight. In particular, the war in the area underscores the importance of studying the region's natural resources in terms of biodiversity conservation and keeping. In this regard, the research topic is an integral part of the

[5] Mammadova Z.A., Mammadov R.M., Hajiyev V.N. Study of ether oils of the *Nepeta meyeri* Benth. species of flora of Azerbaijan // - Barnaul: Chemistry of Plant Raw Materials, –2011. –№3, –p. 135-138.

[6] Amirmohammadi, F.Z. Analysis of the ether oil composition of three cultivated *Nepeta* species from Iran / F.Z. Amirmohammadi, M.Azizi, N.S.Hossein [et al.] // Zeitschrift für Naturforschung C, –2020. –vol. 75, –no. 7-8, –pp. 247-254. https://doi.org/10.1515/znc-2019-0206

[7] Conforti F. Comparative chemical composition and antioxidant activity of *Calamintha nepeta* (L.) Savi subsp. glandulosa (Req.) Nyman and *Calamintha grandiflora* (L.) Moench (Labiatae) / F.Conforti, M.Marrelli, G.Statti [et al] //Natural Product Research, –2012. – 26, –p.91–97.

"Conservation and sustainable use of biodiversity" problem and is one of the current issues of theoretical and practical importance[8].

Object and subject of research. Species of *Lamiaceae* family, distributed in the north-eastern regions of the Lesser Caucasus within Azerbaijan were selected as the object and subject of research.

The aim and the tasks of the study. Taxonomically, bio-ecologically and phylogenetically analyze the species of *Lamiaceae* Lindl family in the flora of the Lesser Caucasus, to obtain ether oils from both wild and introduced species and varieties, to study their physical and chemical constants, component composition and to identify new areas of application are the main goal of the research.

The aim of the study is to assess the current status of cenopopulations of the species found in the flora, to identify the possibility of their supply from nature and to instill in the population the eco-protective effects of these plants by using them as both medicinal and food additives. In order to implement all this, the following tasks have been set:

- Determination of taxonomic composition and role of Labiatae in vegetation in the Lesser Caucasus;
- Study of bioecological features of species;
- Identification and protection of the genesis of species, ways of their formation;
- Assessment of cenopopulations of some species of the family, the study of the current state and care of biotopes;
- Introduction of species belonging to the family;
- Efficient use and protection of important types of the national economy.

Research methods. Classical and modern botanical, floristic, systematic, geobotanical, ecological and statistical methods were used in the development of the materials. The classification of vegetation has been evaluated on the basis of the principles of

[8] National Strategy for the Protection and Sustainable Use of Biological Diversity in the Republic of Azerbaijan for 2017-2020: [Electronic resource] // - Baku: Law, - 2016. http://www.e-qanun.az/framework/33817

ecological-phytocenological and dominance, which are widely used in modern geobotany.

The cenopopulations of species in different phytocenoses in natural populations have been studied, and the ontogenetic situation has been determined. Population indicators were evaluated to compare the integrated characteristics of the demographic structure of the plant. The reserves of plants in natural populations have been studied, and the component composition of ether oils has been determined.

The main provisions submitted to the defense.

- Resource assessments of useful species of the *Lamiaceae* family in the north-eastern part of the Lesser Caucasus provide a basis for their use as a raw material base in various industries;
- The antimicrobial and antifungal activity of ether oils derived from plants is important in folk medicine as a drug, aromatizer in the food and cosmetics industry, as well as to prolong the shelf life of the product;
- Varieties with high seed reserves are the basis for cultivation in order to enrich the raw material base.

The scientific novelty of the study. 100 species and subspecies of Labiatae belonging to 27 genus were identified in the region during the research. From them, *Thymus transcaucasicus* Ronniger, *Th.desjatovae* Ronniger, *Th.sipyleus* Boiss., *Th.fedtschenkoi* Ronniger, *Th.tiflisiensis* Klokov et Des.-Shost., *Stachys woronowii* (Schischk.ex Grossh.) R.R.Mill., *S.germanica* L. *S.byzantina* K.Koch., *S.palustris* L., *S.macrostachys* (Wender.) Briq., *S.discolor subsp. discolor* Benth., *Salvia xanthocheila* Boiss. et Benth., *S.limbata* C.A.Mey, *S.aethiopis* L., *S.karabachensis* Pobed və *S.grossheimii* Sosn., *Marrubium parviflorum* Fisch. et C.A.Mey., *Dracocephalum multicaule* Montbr. & Aucher ex Benth., *D.ruyschiana* L., *Hyssopus officinalis* L. subsp. *officinalis*., *Eromostachys laciniata* (L.) Bunge, *Clinopodium umbrosum* (M.Bieb.) Kuntze, *Satureja macrantha* C.A.Mey. new areas for this territory. 10 Caucasian endemics of Labiatae have been registered in the area. 71 perennial herbs, 16 annual herbs, 12 semi-shrubs, 1 shrub belonging to the family were spread in the area have been

revealed by biomorphological analysis. Biomorphological features of each species were determined. The main genus and species of the *Lamiaceae* family have been identified in the north-eastern regions of the Lesser Caucasus. The predominance of species in meadow, shrub, mountain xerophyte and forest vegetation types has been determined in the area. Xerophytes and xeromesophytes predominate according to their ecological groups. Distribution patterns of species in 7 vertical zones have been studied.

Phytocenological features and population structure of some species have been determined *Nepeta racemosa* Lam. subsp. *racemosa (*Δ=0,38-0,71; ω=0,35-0,61), *N.grandiflora (*Δ=0,09-0,58; ω=0,22-0,77), 4 species of *Salvia* genus - *S.limbata (*Δ= 0,26-0,57; ω=0,33-0,56), *Salvia verticillata (*Δ=0,39-0,62; ω=0,40-0,72), *Salvia sclarea (*Δ=0,23-0,24; ω=0,42-0,72), *Salvia nemorosa subsp. tesquicola (*Δ=0,52-0,58; ω=0,49-0,51), at the same time the recovery index of plants (I_r) varied between 0.24-1.67, and aging index (I_a) between 4.1-31.25.

The yield of ether oils in different phases of some species depending on environmental conditions was studied, ether oils were obtained from plants (*Melissa officinalis* L., *Nepeta grandiflora* M.Bieb., *N.racemosa* Lam. subsp. *racemosa*, *N.cataria* L., *Salvia verticillata* L., *Salvia virgata* Jacq.) and physical and chemical constants were determined.

Resource assessments of some important vegetable and food species have revealed that *Lamium album* on 948 ha, *Origanum vulgare* on 768 ha, *Mentha longifolia* on 140 ha, *Stachys macrostachys* on 495 ha, *Stachys discolor subsp.discolor* on 160 ha, *Stachys byzantina* on 370 ha, *Stachys palustris* on 180 ha, *Stachys woronowii* on 294 ha, *Salvia limbata* on 550 ha, *Salvia aethiopis* on 423 ha, *Satureja macrantha* on 170 ha, *Nepeta racemosa* Lam. subsp. *racemosa* on 440 ha, *Nepeta cataria* on 510, *Thymus desjatovae* on 375 ha, *Th.fedtschenkoi* on 380 ha areas have been spread. Reserves for each species have been identified.

Theorethical and practical significance of the research. The results of the research can be used to complete a scientifically

accurate description of the history of botanical research and to plan the direction of research. Also can be used in the new edition of "Azerbaijan flora" and "Useful plants of Azerbaijan" and Internet catalogs. Re-use the medicinal properties of the species identified in the species in phytotherapy, phytopharmaceuticals, dyeing for technical purposes, fodder plants to improve the fodder base for the development of animal husbandry is recommended. Proposals for the traditional use of food plants have been prepared.

Approbation and application: The main provisions of the dissertation have been discussed at the International Scientific Conferences of Ganja State University and Azerbaijan State Agrarian University, Ganja-2015, Ganja 2015-2016; Ganja-2018, Symposium on EuroAsian Biodiversity (SEAB) - Antalya, Turkey, 2016; Symposium on EuroAsian Biodiversity (SEAB) - Minsk, Belarus, 2017. Published in the Scientific Works of ASAU, Ganja-2017, in the Newsletter of the Ganja branch of ANAS Ganja-2017, Ganja-2018 and abroad in central journals.

The organization where the thesis is done. The dissertation was completed at the Azerbaijan State Agrarian University.

The total volume of the dissertation. The total volume of the dissertation consists of 184 pages of a computer writing. This includes an introduction, 6 chapters, conclusions, suggestions, appendices, and a list of 179 references. The general text of the dissertation consists of 106 pages of computer writing - 215846 characters (introduction - 9919 characters, Chapter I - 7905 characters, Chapter II - 6430 characters, Chapter III - 91909 characters, Chapter IV - 43578 characters, Chapter V - 43660 characters, Chapter VI 31,125 characters, Conclusion - 3,628 characters, suggestions - 933 characters). The dissertation is enriched by 26 tables, 72 illustrations, 10 diagrams and 1 map.

CHAPTER I. HISTORY OF STUDY OF *LAMIACEAE* FAMILY

The origin of the study of the representatives of the Labiatae, which are widespread in Azerbaijan, is connected with the botanists who inspected the flora of the Caucasus. Endemic species to the

Caucasus were first inspected by Sprengel. Later, the family was devided into semi-families in "Flora Taurico-Gaucacica" work of Marshall Bieberstein's. The flora of the Caucasus was inspected by M.Bieberstein and new species belonging to some genus (*Betonica* sp., *Nepeta sp., Salvia sp., Mentha sp.* etc.) were described. These species are endemic to the forest regions of the Caucasus. In 1810, Steven described 12 new species belonging to the family from the herbariums collected by him from the North-West of Azerbaijan.

Some of them are reflected in the third volume "Flora Taurica-Caucacica" of Bieberstein's. Later, in 1831, E.Meyer, compiling a list of Caucasian Labiatae, described several new species: several species belonging to the *Nepeta* and *Stachys* genus.

Some of these species are also recorded in the flora of Azerbaijan. A study of the literature shows that after Meyer (1831), the Labiatae were mainly appointed by Bentham, and the author associated some Caucasian species with Meyer's name (eg, *Nepeta meyeri*). Well-known researcher-scientist of the Caucasian flora A.A.Grossheim's views on the species composition of the Labiatae are reflected in the "Flora of the Caucasus" and "Determinants of the plants of the Caucasus." In our time, R.G.Askerova studied the systematics of the Labiatae. According to the author, the identities between the Caucasian plants and the Altai have long led to different results. Thus, 220 species of 37 genus are found in the wild, and 8 species of 5 genus are found in culture in the flora of modern Azerbaijan.

CHAPTER II. RESEARCH MATERIALS AND METHODS

The research was conducted in 2014-2017 by field routes, expeditions, semi-inpatient and in-laboratory. The object studied the species of the *Lamiaceae* family, which are distributed in the north-eastern regions of the Lesser Caucasus of Azerbaijan and cover the natural geographical areas at different heights above sea level. More than 100 military materials were collected, about 50 geobotanical descriptions were made. Classical and modern botanical, floristic, systematic, geobotanical, ecological and statistical methods were used in the development of materials. The collected herbarium

materials were specified using the flora of Azerbaijan, the Caucasus, the USSR and photo-illustrative identifiers on the websites.

Attention was paid to nomenclature changes in the specification of the names, genus, sections and species names of taxon, reference was made to the new "Concept of the flora of the Caucasus" and "Flora of Azerbaijan". In determining the life forms of species K.Runkerin and I.Q.Serebryakov's systems were used. Ecological analysis was done according to A.P.Shennikov. Geographical analysis was made by A.A.Grossheim and N.N.Portenier. Phytocenological researches were carried out, the spectrum of ontogenetic condition was compiled and the degree of efficiency of plants was studied. Modern and classical methods were used during field surveys and expeditions in the field of plant care, and the reserves of plants in natural populations were studied.

CHAPTER III. TAXONOMIC COMPOSITION AND BIOMORPHOLOGICAL FEATURES OF *LAMIACEAE* Lindl FAMILY IN THE NORTH-EAST PART OF THE LESSER CAUCASUS

For the first time, taxonomic analysis of plants belonging to the *Lamiaceae* Lindl. family which is distributed in the north-east of the Lesser Caucasus has been conducted based on field research and information from literature sources. *Guinea* subfamily has a simple structure, the seed is without endosperm were found. *Ajuga* and *Teucrium* genus from the flora of Azerbaijan includes there.

Rosemary-*Rosmarinoideae* subfamily is a monotype subfamily belonging to the Rosemary-*Rosmarinus* L. genus. The crown is 2-lipped, pestle 2-row, and the seed is endosperm-free. The *Scutellarioideae* subfamily includes 2 genus: *Scutellarea* L. with a wide range and the monotype *Salazaria* genus, which is not present in the flora of Azerbaijan. This subfamily is considered to be a more progressive subfamily due to the structure of the flower. The most widespread subfamily is *Lamioideae* with 35 genus, and in some literature, this subfamily is called *Stachyoideae*.

Most species of the genus that are distributed outside the tropics are included here: *Marrubium* L.- Marvel, *Sideritis* L.- Ironwort

(mountain tea, and shepherd's tea), *Nepeta* L.- Catnip, *Dracocephalum* L.- Dragonhead, *Lallemantia* Fisch. et C.A. Mey. - Lallemantia, *Hymenocrater* Fisch. et C.A. Mey.- Hymenocrater, *Prunella* L.- Self-heals (heal-all allheal), *Eremostachys* Bunge.- Jerusalem sage, *Phlomoides* Moench - Lampwick plant, *Phlomis* L.- Phlomis (lamp wick plant), *Galeopsis* L.- Hemp-nettle (hemp nettle), *Lamium* L.- Lamium, *Galeobdolon* Adans.- Yellow Archangel, *Chaiturus* Willd.- False motherwort, *Leonurus* L.- Leonurus, *Lagochilus* Bunge - Lagochilus, *Molucella* L.- Molucella, *Ballota* L.- Horehound, *Stachys* L.- Stachys, *Salvia* L. (= *Schraderia* Medik.-Sage (Salvia), *Ziziphora* L.- Ziziphora, *Melissa* L.- Melissa, *Satureja* L.- Winter savory (mountain savor), *Calamintha* Hill- Spring savor, *Antonina* Vved.-Antonina, *Clinopodium* L.- Calamint, *Acinos* Mill.-Galamintha, *Hyssopus* L.- Hyssop, *Origanum* L.-Oregano, *Majorana* Hill.- Sweet marjoram (Knotted marjoram), *Thymus* L.- Thyme, *Lycopus* L.- Lycopus, *Mentha* L.-Mint, *Ocimum* L.-Basil, *Perilla* L.-Parilla (Shiso), *Lavandula* L.- Lavender.

Representatives of the family can be easily selected with a two-lip crown. Although this sign is found in some families (*Cornflowers*, etc.), this is more typical for this family. Among the characteristic features should be noted the structure of the fruit, the arrangement of the leaves and the features of the stem. The trunks are 4 corners. The leaves are simple, the leaf axils are complete or divided into different parts, often intertwined or in groups of some species.

There is no foliage. The stems and leaves are usually covered with hairs that carry ether oils or scales on short legs. The flowers are grouped in three-flowered dichotomies or in a group of double-sided curly flowers. The axis of the inflorescence is very short, they appear in clusters in the form of balls, as they sit on the axils of the reciprocal leaves, sometimes in clusters of spikes, brooms, or head-like complex flowers. Thus, in the taxonomic list prepared on the basis of systematic assignment of plants in the flora of the Lesser Caucasus, 27 genus and 100 species and subspecies belonging to

each of the 3 subfamilies of the family were identified[9]. This is 6.56% of the total area flora. Data on the taxonomic composition of the main genus have been shown in table 1. 6 species of *Stachys*, 5 species by each of *Salvia* and *Thymus* genus, 2 species of *Dracocephalum*, 1 species of *Clinopodium*, *Satureja*, *Hyssopus*, *Marrubium* and 1 species of *Eromostachys* were found in the north-eastern regions of the Lesser Caucasus.

The biomorphological characteristics of the species of *Lamiaceae* family distributed in the north-east of the Lesser Caucasus have been determined and systematized. They consist of annual, perennial grasses and semi-shrubs (Fig.1).

Table 1

The genus of main species of the *Lamiaceae* family in the north-east part of the Lesser Caucasus

Genus	Species	
	Number	in % by 1524 species
Stachys L. – Stachys	17	1,12
Salvia L.– Salvia	12	0,79
Nepeta L. – Catnip	9	0,59
Lamium L. – Dead-nettle	5	0,33
Thymus L.– Thyme	11	0,72
Ajuga L.– Ajuga	5	0,33
Teucrium L. – Germanders	4	0,26
Marrubium L.-Marvel	5	0,33
Ziziphora L.– Ziziphora	5	0,33
The remaining 18 genus are represented by 1-3 species	27	1,77
Total	100	6.56% of the total flora

9Guliyeva S.H. Taxonomic structure of Lamiaceae family distributed in the flora of the Lesser Caucasus // -Ganja: Ganja branch of ANAS, News Bulletin,- 2017. -№1(67), -p.8-13.

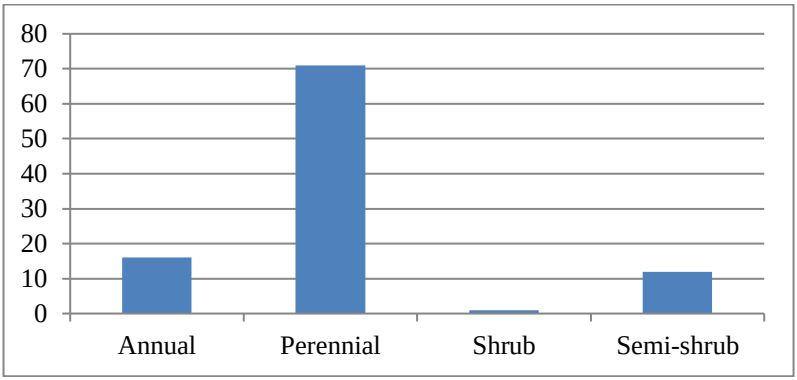

Figure 1. Biomorphological composition of *Lamiaceae* Lindl. in the Lesser Caucasus

Thus, 16 species of Labiatae belonging to 11 genus are distributed. Among them, *Lamium, Stachys, Nepeta* genus are represented by 2 species, *Ziziphora* by 3 species, and others (*Satureja, Ocimum, Salvia, Clinopodium, Sideritis, Galeopsis* and *Lallemantia*) by 1 species. 12 species belonging to 3 genus are semi-shrubs perennial plants. Of these, 10 species belonging to the genus *Thymus* L.-Thyme, each of the 2 genus is represented by one half-shrub and 1 species by *Rosmarinus* L. shrubs plant.

CHAPTER IV. BIOECOLOGICAL CHARACTERISTICS, ROLE AND FLORAGENESIS OF SPECIES OF *LAMIACEAE* FAMILY

The North-Eastern regions of the Lesser Caucasus in the geobotanical zoning selected as the object of study include the saline desert subregion, the wormwood semi-desert zone, the middle mountain belt, the mountain xerophyte (freeganoid) microregion, the mountain-steppe region, the alpine zone and the subalpine zone. They are suitable for semi-desert, mountain-xerophyte (freeganoid), meadow, bush, forest and meadow, which are large phyto-landscape units of plants.

The height of the territory is 678-1000m of plains, 1000-1500m of foothills and low mountains, 1500-2000m of medium mountains,

2000-2500m of highlands, 2500-3000m of subalpine, 3000-3500m of alpine belts. In particular, most of the area is mountainous. Here, the distribution of plant species changes from the plains to the highlands in the vertical direction due to changes in environmental conditions, subject to the law of zoning. 7 vertical belts, which differed from each other by physical and geographical conditions were taken in determining the flora and vegetation of the area by altitudes, their heights were specified, and the distribution patterns of the species of Labiatae were studied (table 2).

Table 2

Distribution of Labiatae in altitude zones in the north-eastern vegetation of the Lesser Caucasus

Belts	Absolute height above sea level, m	Plant types	Number of species
Plain	678 - 1000	Semi-desert	22
Foothills	1000 - 1200	Semi-desert, mountain - xerophyte	31
Low mountainous	1200 - 1500	Mountain - xerophyte	53
Medium mountainous	1500 - 2000	Grasslands, forests and thickets, water-swamp	63
Highlands	2000 - 2500	Forest, bush and meadow	24
Subalpine	2500 - 3000	Meadows, subalpine meadows	21
Alp	3000 - 3500	Alpine meadows and carpets	6

A number of difficulties have arisen in determining the exact boundaries of the species in these zones. Thus, while some plant species are found in several belts, there are some species that are found in only one belt. Therefore, the belts were compared with each other, and their floral composition was calculated using the Sorensen-Chekanovsky similarity coefficient (K_{sc}) (Table 3).

Table 3

Coefficient of similarity to the floral composition compared to the belts

Belts	Lower Plains	Foothills	Low mountains	Middle mountains	Highland	Subalpine	Alp
Plain	-	0,06	0,02	0,39	0,09	0, 01	-
The foothills	0,01	-	0,03	0,04	0,01	0,03	-
Low mountainous			-	0,37	0,09	0,05	-
Medium mountainous				-	0,02	0,10	-
Highlands					-	0,10	0,05
Subalpine						-	0,07
Alp							-

The degree of similarity (K_{sc}=0.39; 0.37; 0.07) was high in the subalpine compared to the alpine, the plain with the middle mountain and the lower mountain with the middle mountain were found. The main reason for this is that most of the territory consists of mountainous areas, where semi-desert, mountain-xerophyte, meadow, bush and forest vegetation are spread.

The development of Azerbaijani *Labiatae* shows that they belong to different phylogenetic ways. Most of them are autonomous representatives of the flora of the Caucasus and Westen Asia by origin, only a small number are foreign elements to Azerbaijan. It is associated with the expansion of the steppe-pontic elements in Azerbaijan, the main route of migration of which is the north of the Caucasus. Some species (*Nepeta cataria*) are widespread in Eurasia as a ruderal plant, and also came from the north of the Caucasus, as evidenced by the habitat of this species in the Caucasus.

The kinship relationship of Caucasian species (as endemic) extends mainly to Westen Asia. Relations with Central Asia are weak. There are no periodical elements for the Arctic, Boreal and Arctic among the Caucasus Labiatae. They are characterized by high endemism in the Caucasus.

Most of them are due to their origin in the main Caucasus Mountains, mainly in the eastern and central parts of the country. Some species are endemic to the Caucasus. Caucasian endemics are not the same for their age. They are still very young, narrow-minded, with no sharp boundaries along with the very ancient third-century species.

Endemic species of *Lamiaceae* family are mainly mountain species adapted to the heights of the mountains in the study area of the Lesser Caucasus: *Marribium propinquum, M.parviflorum, Stachys discolor subsp. discolor (=Betonica nivea), Nepeta betonicifolia* C.A.Mey. *subsp. betonicifolia (=N.betonicifolia), Salvia verbascifolia, S.karabachensis, S.limbata, Thymus kjapazi, Th.fedtschenkoi, Ziziphora clinopodiodes* Lam. subsp. *clinopodiodes (=Z.serpyllacea).*

CHAPTER V. SOME PERSPECTIVE SPECIES: DISTRIBUTION, FIELDS OF APPLICATION AND POPULATION STRUCTURE

Lameaceae family is one of the main medicinal, ether and wild vegetable plants in Azerbaijan. More than 70% of the species belonging to the family are used by humans due to their beneficial properties. For example, *Hyssopus officinalis* L. *subsp. officinalis (=H.angustifolius), Ziziphora capitata, Satureja macrantha* used in dishes as a spice when fresh. From ornamental plants *Nepeta supina subsp. buschii, Stachys grandiflora* and *Stachys discolor subsp.discolor* are beautiful-looking, *Clinopodium umbrosum* is a plant with a sharp lemon aroma.

Teucrium orientale is an ornamental plant is recommended to be cultivated and used in floriculture. *Salvia sclarea* is a valuable ether oil in the perfume industry, perfume, cologne, etc. widely used in the purchase of products. The seeds of *Galeopsis bifida* contain 40-50% fat with iodine numbers 131, 19-150. *Galeopsis* oil has a delicate pleasant aroma and can be added to food. *Clinopodium acinos, Stachys officinalis* is an ether oil and medicinal plant. It also contains tannins and bitter substances. It is used as a medicinal plant in folk medicine. *Melissa officinalis* is a medicinal plant with a weak

laxative effect. *Mentha longifolia* has been used as a food additive since ancient times. The plant is also widely used in the pharmaceutical and perfume industries. *Mentha piperita* L. is found in almost all regions of the country. The ether oil is found in the leaves and flowers of the plant. The plant is widely used in the chemical-pharmaceutical industry, perfumery and confectionery industry. It can be considered a raw material in the production of menthol. Infusions and decoctions made from the leaves of the plant are used as a painkiller in gastrointestinal diseases. Used as a spice. The plant contains a small amount of camphor. *Lallemantia iberica* is an oil plant from technical plants. Due to the fact that oil obtained from this species dries quickly and is used in the preparation of high-quality varnishes, lubrication of machine parts, etc. *Prunella vulgaris* is considered an oily plant. The seeds contain 16% fat. The oil contains linalylacetate, linalilforminate, linalool and other substances. The seeds contain a valuable drying oil, which is also used in the manufacture of varnishes and paints. *Clinopodium vulgare* is a dye plant. The most promising species of *Lameaceae* distributed in the northeast of the Lesser Caucasus were selected, their distribution, phytocenology and ether oil characteristics were studied. Taking all this into account, phytocenological research was carried out in the populations of *Lameaceae*, which are considered to be some priority.

The current state of cenopopulations of species belonging to some species of this genus in Azerbaijan has been studied before us. Phytocenological research on 6 species distributed in the north-eastern regions of the Lesser Caucasus has been conducted: *Nepeta grandiflora* Bieb. and *N.racemosa* Lam. subsp. *racemosa* Spreng. *(=N.mussinii* Spreng.; *N.transcaucasica* A.Grossh.) (fig.2) and 4 species belonging to the *Salvia* genus (Table 4).

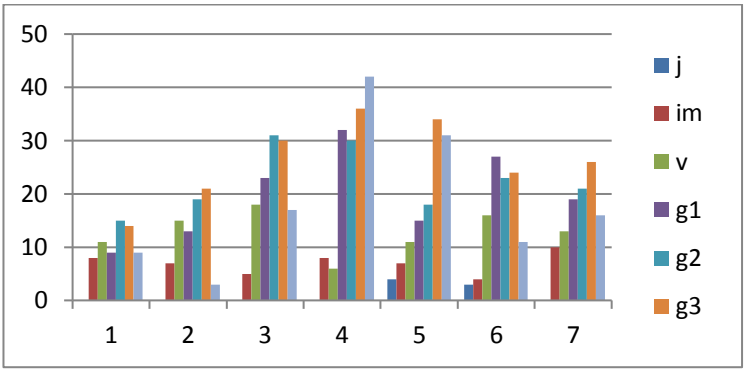

Figure 2. Phytocenological status of *N.racemosa* Lam. subsp. *racemosa* in nature (for 2016)

Table 4

Ontogenetic structure of species in *Salvia* populations

CP / Ont. periods	1	2	6	3	7	8	4	5	9	10	∑	%
	S.limbata			*Salvia verticillata*			*Salvia sclarea*		*Salvia nemorosa subsp. tesquicola*			
j	11	5	2	9	1	-	3	3	2	7	43	9,49
im	4	6	8	5	3	-	4	3	3	2	38	8,38
v	5	7	2	10	3	6	5	9	7	6	60	13,24
g_1	3	8	3	6	5	8	3	7	3	11	57	12,58
g_2	13	14	5	4	16	12	6	7	2	9	88	19,42
g_3	10	16	9	2	5	17	6	11	6	10	92	20,30
Ss,s	9	10	3	12	10	8	1	12	3	7	75	16,55
∑	55	66	32	48	43	51	28	52	26	52	453	100

The structure of the selected cenopopulations of 7 natural populations of *N.racemosa* Lam. subsp. *racemosa* species in 2016-2017 was specified as a result of studying the condition of the age group of the plant. The integral features of the demographic structure, other population indicators of plants were revealed as a result of studying. The base spectrum was compiled from the obtained results.

The age, efficiency, aging and recovery rates of the species were also calculated according to the methodology during the study.

Aging is characterized by a large number of individuals in most *s-ss* phases as shown from the table. Restoration is largely not the same in different years. This can be explained by the fact that there are more or less sunny and rainy days of the year (Table 5).

Table 5

Assessment of cenopopulations of species of *Salvia* genus

CP No	CP type	Growth phase of ontogeny, by %					Indexes			
		j	im	v	g_1- g_3	ss, s	Δ	ω	$İ_b$	$İ_q$
1	Young	20	22.2	13.3	35.6	9	0.26	0.33	1.56	8.88
2	Young	0	7.14	7.14	61	25	0.54	0.53	0.24	25
3	Trans.	0	0	22.20	72.41	28	0.62	0.72	0,34	13,5
4	Mature	26	18	29.10	40,00	11.76	0.24	0.42	1.4	5,9
5	Old	15	10.4	3.77	25.45	31.25	0.23	0.27	1.67	15,5
6	Trans.	0	42	19,32	7.55	0	0.57	0.56	0.32	31.25
7	Trans.	19	35.3	9.62	9,23	17.65	0,39	0,40	1,45	7.6
8	Mature	27	52.1	33.3	30.77	25	0,53	0,47	1,2	9,67
9	Mature	6.3	0	15	23.53	11.76	0,58	0,51	1,2	4,89
10	Mature	14	6	17.65	10.5	10,34	0,52	0,49	0,3	4,1

The ether oil properties of *Salvia virgata* Jacq., *S.verticillata* L., *Melissa officinalis* L. and some species of *Nepeta* genus belonging to the *Lamiaceae* family distributed in the north-east of the Lesser Caucasus have been determined in different phases. Their physical and chemical constant characteristics and qualitative and quantitative composition depending on environmental conditions were studied. Quantitative and some qualitative changes in the component composition of ether oils that occur in different organs have been established.

The ether oils of the studied species of *Lamiaceae* are whitish-yellow and greenish-yellow, light-moving liquids with different aromas, ie stable. The ether oil species of the *Lamiaceae* family are divided into several groups: 72-75% of the species found in rocky soils are fragrant. 39-42% of species grow in forest ecosystems. Ether oil is more concentrated in flowers and seeds in mesophilic plants. Ether oil accumulates to the maximum extent in the aboveground parts of plants (leaves and stems), and relatively little in seeds and flowers. For this purpose, samples were taken from

different ecological environments and ether oils were obtained at different phases of the plants in different years. In comparison, the quantitative composition of ether oils was found to be different (Table 6).

Table 6.

Release of ether oil in different phases of the *Nepeta* genus

№-	Names of plants in Latin	Area of collection	By phases in the whole plant	The amount of ether oil in%
1.	*N.cataria*	Dashkasan district	Leaf period	0,20+ 0,016
2.	*N.cataria*	Gadabay district	Leaf period	0,15±0,014
3.	*N.cataria*	Shamkir district	Flower period	0,42±0,017
4.	*N.grandiflora*	Dashkasan district	Leaf period	0,31±0,022
5.	*N.grandiflora*	Dashkasan district	Flower period	0,50±0,046
6.	*N.grandiflora*	Gadabay district	Seed period	Trace
7.	*N. racemosa* Lam. subsp. *racemosa*	Gazakh district	Flower period	0,70±0,01
8.	*N. racemosa* Lam. subsp. *racemosa*	Gadabay district	Leaf period	0,61±0,014
9.	*N. racemosa* Lam. subsp. *racemosa*	Goygol district	Seed period	0,27±0,021

There are some differences in the yield of ether oil in different environmental conditions even in the same phase of plants as can be seen from the table. For example, the difference in the yield of ether oil between Dashkasan and Gadabay districts is up to 0.05% in the leaf formation phase of *N.cataria*. At the same time, this difference is felt in the phases. For example, more than 0.5% of ether oil is collected in the flowering phase of *N.graniflora* collected from Khoshbulag. However, up to 0.2% less ether oil was accumulated in the area during leaf formation. Of course, these depend on environmental factors, including the impact of solar radiation on the plant, the amount of precipitation etc. This fact can be applied to other species of family (Table 7).

Table 7

Release of ether oil of some species of *Lamiaceae* family in different phases depending on environmental conditions (2014-2017)

Names of plants in Latin	Area of collection	In the whole plant by phases	The amount of ether oil in%
Salvia verticillata L.	Lesser Caucasus Dashkasan	Leaf	0,30± 0,016
	Lesser Caucasus Goygol	Leaf	0,6±0,074
Salvia virgata Jacq.	Lesser Caucasus, Gadabay	Flower	0,22±0,017
	Lesser Caucasus, Goygol	Leaf	0,31±0,022
Melissa officinalis L.	Lesser Caucasus, Goygol	Flower	0,117±0,009
	Culture	Leaf	0,20± 0,016

Salvia sclarea was found to be especially valuable among the studied species because the plant is rich in ether oils, fatty oils and vitamin C, as well as used in perfumery. The shoots and fruits of the plant are of nutritional value, and because of the use of fully ripe fruits for medicinal purposes, their reserves have been studied during the budding, fruiting, and full-ripening phases (Table 8).

The plant has the most reserves during the generative development stage as can be seen. 0 .3% ether oil from the seeds of the plant is possible to get. Thus, about 1.5 kg of natural ether oil can be obtained from 1 hectare, which can be used in the production of tons of perfumes with different compositions.

Table 8

Phyto-mass of *Salvia sclarea* species at different stages of ontogeny
(dry weight, by gr)

Age group	Surface phytocumple	Seeds
Im	9,5 ± 0.93	2,32 ± 0,52
V	21.36 ± 1.53	3.33 ± 3.56
g_1	228 ± 37.5	11.7 ± 1.27
g_2	420.3± 45.3	18.5 ± 2,65

g_3	381 ± 37.2	17.82 ± 3.6
Ss	72.45 ± 17.2	7.53 ± 2.7
S	36 ± 11.2	4.12 ± 1.35

Ether oils of *Lamiaceae* contain components reminiscent of the aroma of lemon and mint. The ether oils of these plants are clear, lighter than water. In order to determine the physical and chemical properties of the species, their specific gravity (D^{20}_{20}), refractive index (n^{20}_{D}), acid number (a.n.), ether number (en), ether number after acetylation (e.n.a. a.) (Table 9).

Table 9

Physicochemical constants of ether oils of *Nepeta* genus.

Species	Specific gravity D^{20}_{20}	Angle of refraction n^{20}_{D}	Acid number	Ether num (e.n.)	ether number after acetylation	The color of the ether oil
N.grandiflora	0,9404	1,4786	4,85	25,70	186,32	light yellow
Nepeta racemosa Lam. subsp. *racemosa*	0,8074	1,4656	6,28	70,64	230,75	light yellow
N.cataria	0,9326	1,4820	8,67	25,87	256,34	light yellow

The number of ethers is higher than the number of acids, the fact that the ether oils are higher than the number of ethers indicates that they contain free alcohols and esters formed from fatty acids and aliphatic alcohols as is clear from the table.

CHAPTER VI. RESOURCE ASSESSMENT AND RESERVES OF USEFUL SPECIES OF THE *LAMIACEAE* FAMILY

Species of the *Lamiaceae* family are mainly found on rocky hills, slopes, forest plains and bushes, ravines and wetlands. They grow well in good aerobic conditions, in soils rich in minerals. They are

more common around Kurekchay, Togana villages, Goygol reserve, Dashkasan, Gadabay districts and at the foot of Kapaz mountain.

They're mainly found in mountainous areas, meadow-bush formations were observed during the resource assessments of useful species. These species are collected en masse as both medicinal and food additives. These species are widely described in the dissertation. In addition, resource assessments[10] have been conducted for this family in the area and the distribution areas of some resource representatives have been studied: *Lamium album* - 948 hectare *Origanum vulgare* - 768ha, *Mentha longifolia* - 140 ha, *Stachys macrostachys* - 495ha, *Stachys discolor subsp.discolor* - 160ha, *Stachys byzantina* - 370ha, *Stachys palustris* - 180ha, *Stachys woronowii* - 294 ha, *Salvia limbata* - 550ha, *Salvia aethiopis* - 423ha, *Satureja macrantha* - 170ha, *Nepeta racemosa* Lam. subsp. *racemosa* - 440ha, *Nepeta cataria* - 510ha, *Thymus desjatovae* - 375ha, *Th.fedtschenkoi* - 380ha spread over an area of one hectare. The annual supply and biological resources of each species have been calculated.

CONCLUSIONS

1. 100 species and subspecies of Labiatae belonging to 27 genus were identified in the region during the research. From them, *Thymus transcaucasicus* Ronniger, *Th.desjatovae* Ronniger, *Th.sipyleus* Boiss., *Th.fedtschenkoi* Ronniger, *Th.tiflisiensis* Klokov et Des.-Shost., *Stachys woronowii* (Schischk.ex Grossh.) R.R.Mill., *S. germanica* L. *S.byzantina* K.Koch., *S.palustris* L., *S.macrostachys* (Wender.) Briq., *S.discolor subsp. discolor* Benth., *Salvia xanthocheila* Boiss. et Benth., *S.limbata* C.A.Mey, *S.aethiopis* L., *S.karabachensis* Pobed və *S.grossheimii* Sosn., *Marrubium parviflorum* Fisch. et C.A.Mey., *Dracocephalum multicaule* Montbr. & Aucher ex Benth., *D.ruyschiana* L., *Hyssopus officinalis* L. subsp. *officinalis*., *Eromostachys laciniata* (L.) Bunge,

[10] Guliyeva S.H. Resource assessments and resources of useful species of *Lamiaceae* family distributed in the north-eastern part of the Lesser Caucasus // – Ganja: Scientific works of Ganja branch of ANAS, –2018. –pp.93-98.

Clinopodium umbrosum (M.Bieb.) Kuntze, *Satureja macrantha* C.A.Mey. new areas for this territory. 10 Caucasian endemics of *Lamiaceae* have been registered in the area. 71 perennial herbs, 16 annual herbs, 12 semi-shrubs, 1 shrub belonging to the family were spread in the area have been revealed by biomorphological analysis, biomorphological features of each species were determined.

2. The main genus and species of the *Lamiaceae* family have been identified in the north-eastern regions of the Lesser Caucasus. *Stachys* -17, *Salvia* -12, *Thymus* - 11, *Nepeta*-9, *Lamium, Marrubium, Ziziphora* and *Ajuga* by 5 species, *Teucrium* by 4 species. The remaining 18 genus were identified by 1-3 species. Although some genus (*Salvia, Nepeta*, etc.) are widely distributed, the range is small, while some genus (*Mentha, Origanum*, etc.) are more numerous, although they are represented by a small number of species.

3. The role of the species in the plantation types has been determined in the area, mainly in steppe, meadow, shrub, mountain xerophyte and forest vegetation, they are found in small numbers in alpine meadows and carpets, wetlands. Xerophytes and mesoxerophytes predominate according to their ecological groups.

4. 7 vertical belts, which differ from each other in physical and geographical conditions were taken under determining the flora and vegetation of the area by altitudes, the distribution patterns of the species were studied: in the steppe, forest and shrub vegetation - 63, mountain xerophytes 53 species were determined. The number of species mainly varies between 21-31 in the remaining types. The similarity coefficient of the fluorescent composition compared by age groups varies between K_{sc}=0.39; 0.37 0.07.

5. Phytocenological features and population structure of some species have been determined: *Nepeta racemosa* Lam. subsp. *racemosa (*Δ=0,38-0,71; ω=0,35-0,61), *N.grandiflora (*Δ=0,09-0,58; ω=0,22-0,77), 4 species of *Salvia* genus - *S.limbata (*Δ= 0,26-0,57; ω=0,33-0,56), *S.verticillata (*Δ=0,39-0,62; ω=0,40-0,72), *S.sclarea (*Δ=0,23-0,24; ω=0,42-0,72), *S.nemorosa subsp. tesquicola (*Δ=0,52-0,58; ω=0,49-0,51), at the same time, the index of plant regeneration

(I_r) varied between 0.24-1.67, and aging (I_a) between 4.1-31.25. Fertility in the surface part and in the seed has been determined at different stages of ontogeny.

6. The yield of ether oils in different phases of some species depending on environmental conditions was studied, ether oils were obtained from plants (*Melissa officinalis* L., *Nepeta grandiflora* M.Bieb., *N.racemosa* Lam. subsp. *racemosa, N.cataria* L., *Salvia verticillata* L., *S.virgata* Jacq.) and physical and chemical constants were appointed.

7. Resource assessments have been conducted on some important types of vegetables and foods has been established - *Lamium album* spread over 948 hectares, *Origanum vulgare* - 768ha, *Mentha longifolia* - 140ha, *Stachys macrostachys* - 495ha, *Stachys discolor subsp.discolor* - 160ha, *Stachys byzantina* - 370ha, *Stachys palustris* - 180ha, *Stachys woronowii* - 294ha, *Salvia limbata* - 550ha, *Salvia aethiopis* - 423ha, *Satureja macrantha* - 170ha, *Nepeta racemosa* Lam. subsp. *racemosa* - 440ha, *Nepeta cataria* - 510ha, *Thymus desjatovae* - 375ha, *Th.fedtschenkoi* - 380ha. Reserves for each species have been identified.

SUGGESTIONS

1. The ether oils of the *Melissa officinalis* L., *Nepeta grandiflora* M.Bieb., *N.racemosa* Lam. subsp. *racemosa, N.cataria* L., *Salvia verticillata* L., *S.virgata* Jacq. species can be used as an antimicrobial agent against fungi.

2. Wide range of food additives, including medicinal teas, from aromatic herbs, for which resource assessments have been conducted and annual supply reserves are known (*Lamium album* 885,44 c/ha, *Origanum vulgare* 612,63 c/ha, *Mentha longifolia* 199,20 c/ha, *Stachys macrostachys* 251,50 c/ha, *S.discolor subsp. discolor* 174,70 c/ha, *Salvia limbata* 511,11 c/ha, *Satureja macrantha* 189,50 c/ha, *Thymus desjatovae* 254,46 c/ha, *Th.fedtschenkoi* 184,49 c/ha) is recommended to use.

3. The seeds of *Salvia sclarea* species, which are not so widespread in nature, but are important for their ether oil content can be supplied

for widespread use, given that the productivity is sufficient for sowing (17.82 g per plant at full maturity).

LIST OF PUBLISHED SCIENTIFIC WORKS ON THE SUBJECT

1. Guliyeva, S.H., Ahmadova, S.Z. Bioecological features of *Nepeta* L. (*Lamiaceae*) species of the Lesser Caucasus // Innovative development of Agrarian Science and Education: International conference World experience and modern priorities, -Ganja: -2015. -Volume, -pp. 338-343 (in azeri).
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