

REPUBLIC OF AZERBAIJAN

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ABSTRACT

of the dissertation for the degree of Doctor of Philosophy in Biology

**SYSTEMATICS AND BIOECOLOGICAL FEATURES
OF THE SPECIES OF THE GENUS ST. JOHN'S-WORT
(*HYPERICUM* L.) DISTRIBUTED IN AZERBAIJAN**

Specialty: 2417.01- Botany

Field of science: Biological sciences

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The dissertation work was carried out at the laboratory of Higher Plant Systematics and Geography, Department of Systematics and Biodiversity Institute of Botany, Azerbaijan National Academy of Sciences, Azerbaijan

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INTRODUCTION

Relevance and degree of development of the topic. One of the most important and global problems of our time is the sustainable use and conservation of biodiversity, which is an integral part of natural resources.

The Republic of Azerbaijan with a rich biodiversity occupies a special place in the Caucasus region. There are about 5000 higher plant species in the country (belonging to 1142 genera), which makes up 66% of the total number of plant species growing in the Caucasus. Among the widespread plant species in this rich nature, the genus *Hypericum* which dates back to the Caenozoic era and belongs to the family St.-John's-wort (*Hypericaceae* Juss.) takes special place. Although in previous classifications the genus St. John's wort belongs to the family *Clusiaceae* (*Guttiferae*), now, according to the classification called phylogenetic groups of angiosperms (APG IV), the genus was included in the composition of the family *Hypericaceae* Juss. of clusoid group in the *Malpighiales* order¹. Although the vast majority of species belonging to the *Hypericaceae* Juss. family are perennial, annual grass, shrub (47%), among them are semi-shrubs and, in rare cases, low trees (*H.bequaertii* De Wild., *H.revolutum* Vahl., *H.canariense* L.(5%) and aquatic (*H.elodes* L.) plants².

80% of the total number of species belonging to the St. John's wort family are concentrated in the genus *Hypericum*, which is distinguished by its mansided areas of application, especially in the pharmaceutical, decorative and dye industries.³

¹ APG IV (Angiosperm Phylogeny Group): An update of the angiosperm phylogeny group classification for the orders and families of flowering plants: APG IV // Botanical Journal of the Linnean Society, – 2016, 181(1), – p. 1-20.

² Meseguer, A.S. Integrating fossils, phylogenies, and niche models into biogeography to reveal ancient evolutionary history: the case of *Hypericum* (*Hypericaceae*) / A.S.Meseguer, M.L.Jorge [et al.] // Systematic Biology Advance Access, – 2015, 64(2), – p. 215-232.

³ Nürk, N.M. Morphological and phytochemical diversity among *Hypericum* species of the Mediterranean basin / N.M.Nürk, S.L.Crockett // Medicinal and aromatic plant science and biotechnology, – 2011, 5, – p. 14-28.

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St. John's wort genus, which has about 500 species, 70 subspecies, 3 species diversity and 11 hybrids in the world⁴ are represented by 19 species, 1 subspecies and 1 species diversity in the flora of Azerbaijan⁵.

The spread of diseases in modern times, the growing interest in herbal remedies compared to synthetic drugs, as well as research in this area require a comprehensive study of the medicinal substance of the *Hypericum* genus using modern approaches. The protection of plants, the discovery of their useful properties, the study of their bioecological properties make it possible to clarify the evolution and phylogeny of this genus.

Our research is devoted to the systematic, anatomical, molecular and ecological analysis of the species of the genus *Hypericum* L. distributed in the flora of Azerbaijan. The results of critical analysis of herbarium materials collected during expeditions to various botanical and geographical regions of Azerbaijan in 2015-2022 and herbarium specimens stored in the Herbarium Fund of the Institute of Botany of ANAS (BAK) show that taxonomic and bioecological traits of the species distributed in Azerbaijan have not been studied in the last 60 years. All this once again confirms the urgency of the issue. For this reason, a critical inspection of the species of the genus *Hypericum* distributed in the country is one of the important issues ahead.

Object and subject of research. The object of research is the study of the taxonomic composition of St. John's wort plant distributed in the flora. The subject of research is the study of the genus *Hypericum* by classical and modern methods.

Purpose and objectives of the research. The main purpose of our research is to study the systematic composition of the genus *Hypericum* distributed in the flora of Azerbaijan, their taxonomy and nomenclature, diagnostic study of vegetative and generative organs of some controversial species. For this, the following tasks have been set.

⁴ Nürk, N.M. Molecular phylogenetics and morphological evolution of St. John's wort (*Hypericum*; *Hypericaceae*) / N.M.Nürk, S.Madrian, M.Carine [et al.] // Molecular phylogenetics and Evolution, – 2013 a, 66(1), – p.1-16.

⁵ Конспект флора Кавказа // – Москва, – Т.3 (2), – 2012, – с. 308-312.

- Compilation of species composition and intergeneric system of the genus *Hypericum* L. distributed in Azerbaijan;
- Definition of new determinant key of the genus;
- Study of the importance of morphological diagnostic features in the taxonomy of genus;
- Conducting anatomical and molecular study of controversial species included in the genus;
- Analysis of geographical and phylogenetic relationships of St. John's wort species;
- Conducting chorological analysis of species;
- Study of phenology of species;
- Determining the distribution patterns of species depending on altitude;
- Identification and protection of rare and endemic species;
- Identification of new opportunities for the use of St. John's wort species, their economic importance and protection measures.

Research methods. The following methods were used in the research: Comparative - morphological, biomorphological, comparative-anatomical, molecular-phylogenetic method.

The main provisions of the defense.

➤ The taxonomic composition of the species of the genus St. John's wort distributed in the flora of Azerbaijan are characterized by certain changes.

➤ In addition to classical methods, molecular methods should be used to determine the taxonomic composition of species belonging to the genus.

➤ Assessment of the value of genera of medicinal importance as biological resources is an important part of biodiversity conservation.

➤ Assessment of rare and endangered species provides a basis for their effective use.

Scientific novelty of the research. As a result of the research, the following innovations have been identified:

➤ Critical inspection of St. John's wort species distributed in the flora of Azerbaijan was carried out, taxonomic composition was determined.

➤ One subspecies (*H.perforatum* subsp.*veronense* (Schrank) Lindb.) of the genus *Hypericum* L. not shown in “Flora Azerbaijan” was restored.

➤ The taxonomic composition of the genus St. John’s wort was determined by adding 4 species to the 15 species shown in the “Flora of Azerbaijan”, and 19 species were grouped into 7 sections.

➤ A new distribution area for the *H.tetrapterum* Fries. (Soyudlu village of Gadabay region, N40°35.234’.E045°50.313’.1473 m) and *H.scabrum* L. (Goydara village of Lerik region, N38°37.797’.E048°21.351’. 1704 m) species of the genus has been identified.

➤ A new determinant key was developed for the species including in the genus *Hypericum* distributed in the flora of Azerbaijan based on previously unused diagnostic signs.

➤ The distribution patterns of species of the genus St. John’s wort depending on the height were determined and an electronic map was compiled based on GPS coordinates.

Theoretical and practical significance of the research.Critical inspection of the species of *Hypericum* L. distributed in the flora of Azerbaijan was carried out and phylogenetic relationships were studied.

As a result of the research, it was found that among the species included in the genus, there are resinous, essential oil, tannic species, as well as species used for dyeing and decorative purposes. Materials related to the systematics, bioecology, geography, etc., reflected in the dissertation, can be used in the compilation of “Flora of Azerbaijan” and “Determination key of Azerbaijan plants”.

Approbation and application:Eight scientific articles, four theses (6 articles, 3 theses in Azerbaijan, 2 article and 1 thesis in abstracted and indexed journals (Web of Science, AGRIS, RINC) were published.

Materials related to the dissertation were discussed at a number of international conferences. These include the following: Web of Science, AGRIS, RINC) published in Poster presentation on “Species of medicinal importance of the genus *Hypericum* L. (St. John’s wort) in Azerbaijan” at the conference titled “ Academic science weekly International Multidisciplinary Forum materials” held in Baku in 2015; Poster presentation on “Species of the genus *Hypericum* L. in

Azerbaijan flora” at the conference titled “Materials from the international conference” held in Baku in 2016; Poster presentation on “Endemic species residing to the genus *Hypericum L.* in Azerbaijan” at the symposium “The 3rd International Symposium on EuroAsian Biodiversity” held in Minsk, Belarus in 2017; Poster presentation on “Endangered species residing to the genus *HypericumL.* In Azerbaijan” at the conference “Actual Problems of Modern Natural and Economic Sciences” held in Ganja in 2018.

Name of the organization where the dissertation work is carried out. The dissertation work was carried out at the laboratory of Higher Plant Systematics and Geography, Department of Systematics and Biodiversity Institute of Botany, Azerbaijan National Academy of Sciences, Azerbaijan

The total volume of the dissertation.The dissertation covers 181 pages, consisting of introduction, 6 chapters, conclusion, reference with 239 titles and addition. The dissertation consists of 266, 221 characters : (introduction : 8474 signs, chapter I- 40805 signs, chapter II- 7821 signs, chapter III- 27907 signs, chapter IV- 67791 signs, chapter V- 25549 signs, chapter VI- 20120 signs, results - 1821 signs, recommendation - 1061 signs).The list of literature consists of 239 titles, 15 of them are Azerbaijan, 5 Turkish, 40 russian and 179 foreign sources. The dissertation is enriched with 12 tables and figures.

CHAPTER I. LITERATURE REVIEW

1.1. HISTORY OF STUDY OF GENUS *HYPERICUM L.*

The first period begins with a genetic description of the genus, which was given by P.J.Tournefort, prominent French botanist in the first half of the XIX century⁶. K.Linney described 25 species belonging to the genus St.-John’s-wort in the second volume of work “Species plantarium”, published in 1753, and according to the structure of the ovary the species were divided into three groups with 2, 3 and 5 ovaries⁷. The works of M.Biberstein, Choisy, K.A.Meyer, R.F.Hohenacker, K.Koch, K.Ledebur, G.Bentham, J.D.Hooker, E.Buasye, E.R. Trautvetter

⁶ Tournefort, P.J. Institutiones Rei herbaria / P.J.Tournefort. –1, – 1700, – p. 254-256.

⁷ Linnaeus, C. Species plantarium / C.Linnaeus. – London, – vol. 2,– 1753, – p. 783-785.

and other prominent botanists, who contributed to the study of genus in the Caucasus region, were analyzed. A.A. Grossheim's services in the study of the genus St. John's wort are also invaluable. A.Grossheim (1962) described 33 species and 6 subspecies distributed on sections *Brathys* Spach., *Eremanthe* (Spach) Boiss., *Hypericum*, *Androsaemum* (Adans) Godr. et Gr. of the genus John's wort in the III volume of "Flora of Azerbaijan"⁸. The genus *Hypericum* L. was studied by the Russian botanist S.G.Gorshkova (1949) in the flora of the USSR⁹ and by R.Rzazade (1955) in the flora of Azerbaijan¹⁰. A.M.Asgarov described 16 species of the genus in his work "Abstract of flora of Azerbaijan" published in 2011. The author (2016) gave description of 21 species belonging to the genus in the flora of Azerbaijan in his work "Flora of Azerbaijan"¹¹. In the taxonomic spectrum of the flora of the Nakhchivan Autonomous Republic (2021) 12 species of this genus was described by T.Talibov¹².

Although the genetic description of the genus *Hypericum* was studied by Tournefort (1700), Spach (1836), Jaubert & Spach (1842-1843), Keller (1895-1925), Kimura (1951) and other scientists, monographic studies on the genus were conducted by the British botanist N.K. Robson (1967-2016). The British botanist divided the species included in the genus into 30 sections and 6 subsections in his monograph "Studies in the genus *Hypericum* L." based on the results of anatomical, morphological, ecological, cytological research and structural features of vegetative and generative organs. In this work, he described 486 new species of the genus St. John's wort, noted the evolutionary pathways of the genus, compiled a determination key based on the diagnostic characteristics of the sections that include

⁸ Qrossqeym, A.A. Azərbaycan florası / A.A.Qrossqeym, – c.3, – 1962, – s.163-166.

⁹ Горшкова, С.Г. Флора СССР / С.Г.Горшкова. – Москва, – Т.15, – 1949, – с. 203-258.

¹⁰ Рзазаде, Р.И. Флора Азербайджана / Р.И.Рзазаде. – Баку, – Т.6, –1955, – с. 247-259.

¹¹ Əsgərov, A.M. Azərbaycanın bitki aləmi / A.M.Əsgərov – Bakı: TEAS Press Nəşriyyat, – 2016, – s.173.

¹² Talibov, T.H. Naxçıvan Muxtar Respublikası Florasının Taksonomik spektri (Ali sporlu, çılpaqtoxumlu və örtülütoxumlu bitkilər) / T.H.Talibov, Ə.Ş. İbrahimov, Ə.İbrahimov // Bakı Şirvannəşr, – 2021, – 426 s.

genus and species included in them, and identified kinship relations between genera and sections¹³.

1.2. The economic importance of the genus *Hypericum*

The protection of medicinal plants is an important part of biodiversity. So, the increase in the use of medicinal plants collected from the wild nature causes genetic erosion and even extinction of these species. For this reason, it is important to evaluate their value as biological resources. *Hypericum* is one of the most important medicinal plant species on the territory of the republic (178 families, 1500 species)¹⁴. According to its biologically active compounds especially phenols, tannins, hypericin, pseudohypericin, hypeforin, rutin, quercetin, alkaloids, vitamins (A, B, C, E, P, PP), trace elements (Fe, Ca, K, Mg,) and essential oils (terpenes), sesquiterpenes, isovalerian) the species of the genus *Hypericum* attracts the attention of scientists around the world in recent years¹⁵. From ancient times, this genus has been used in folk medicine as an antibacterial, anti-depressant, antioxidant, antimicrobial, antiviral in diseases such as gastrointestinal tract, respiratory tract, nervous, cardiovascular, genital system and skin, injuries, burns, insomnia, cholecystitis, hepatitis, cystitis, stomatitis and tonsillitis¹⁶. Despite that *Hypericum* has a wide range of applications in medicine, some species of the genus are also used in industry as dyeing (dyeing of silk, lion, cotton fabrics)¹⁷. Out of 19 species of the genus *Hypericum* distributed in Azerbaijan, two species are used for decorative (*H.androsaemum*

¹³ Robson, N.K. Studies in the genus *Hypericum* L. (*Guttiferae*). 2. Characters of the genus // Bulletin of the British Museum of Natural History (Botany), – 1981, 8, – p. 55-226.

¹⁴ İbadullayeva, S. Dərman bitkiləri / S.İbadullayeva, R.Ələkbərov / – Bakı, – 2013, – s.280.

¹⁵ Istikoglu, C.L. History and therapeutic properties of *Hypericum perforatum* from antiquity until today / C.L.Istikoglu, V.Mavreas, G.Geroulanos // Psychiatrike, – 2010, 21(4), – p. 8-332.

¹⁶ Fatdayeva A.X. Medical species of the genus *Hypericum* L. Academic science weekly International Multidisciplinary forum materials. Baku 2015, p.351-352.

¹⁷ Kimakov, K.Relation between hypericin content and morphometric leaf parameters in *Hypericum* spp.: a case of cubic degree polynomial function /K.Kimakov, L.Petijova [et al.] // Plant Science, – 2018, – p.94-99.

L., *H.elegans* Steph.), four for dyeing (*H.androsaemum* L., *H.elongatum* Ledeb., *H.perforatum* L., *H.scabrum* L.), and eight (*H.androsaemum* L., *H.linarioides* Bosse., *H.elongatum* Ledeb., *H.elegans* Steph., *H.perforatum* L., *H.lydium* Boiss., *H.scabrum* L., *H.tetramerum* Fries.) for medicinal purposes.

CHAPTER II. MATERIAL AND METHODOLOGY OF RESEARCH

As a research material, herbarium specimens belonging to the genus of *Hypericum* L. distributed in the botanical-geographical regions of Azerbaijan and collected in different ecological conditions in 2015-2022, numerous herbarium specimens stored at the Institute of Botany of the Azerbaijan National Academy of Sciences (BAK), the Berlin Botanical Garden and Museum (BGBM), as well as in various herbarium funds of the world [GBIF] were used. Stationary surveys were conducted in all available areas from low mountain belt to high mountain belt in the administrative districts on different routes in 2015-2022.

The controversial species of the genus St. John's wort collected from different regions of Azerbaijan in 2016-2018 were used for molecular-phylogenetic researches and some of the plant samples collected from Guba and Gusar regions in 2021 for anatomical research.

In order to carry out molecular research, DNA was isolated from young leaves of collected plant samples which are dried using the set of << Dneasy Plant Mini Kit >>.

For the purpose of anatomical study, the collected plant specimens were placed in 70% alcohol solution, then the samples were transferred to 90% alcohol solution and drugs were prepared.

Prepared preparations were stained with safranin. Measurements and photographs of anatomical incisions obtained from the root and stem of the plant was performed with a AxioCam (Zeiss, 105 clor) camera Axio Imager Vert. Al (Carl Zeiss, Germany) light microscope.

Based on morphological-systematic studies by K.Linney, A.Meyer, F.Ledebur, E.Buasye, I.F.Schmalhausen, R.Rzazade, A.A.Grossheim, N.K.Robson, herbarium specimens collected in different

years as well as as a result of critical analysis of the obtained literature, taxonomy and nomenclature of species were specified, morphological structure of plants were studied using MJB-3 binocular magnifying glass.

The study of bioecological features of the species of this genus was carried out on the F.Babayev's methods [1964]¹⁸, the classification of life forms is implemented based on C. Raunkiaer's system [1934]¹⁹.

2.1. Molecular-phylogenetic study of genus

Preparation of the sample for DNA extraction

Some of the collected plant samples were used for molecular-phylogenetic research. 100-200 mg of young leaves from each sample are placed in 2ml tubes. After keeping the closed tubes in liquid nitrogen for a few minutes, the plant material is thoroughly crushed. DNA is extracted from dried and crushed plant samples with the help of «Dneasy Plant Mini Kit» set. 0.1 TE buffer is added to the dried DNA and stored in – 20⁰C refrigerator for 1 night. The amount of DNA extracted is determined on a spectrophotometer (at 260 and 280 nm wave lengths) (Nano Drop 2000 c UV-Vis Spectrophotometer – Thermo Scientific). Once the amount of DNA has been determined, a working solution at a concentration of 50 ng/μl is prepared from each sample DNA to carry out the PCR reaction. After the reaction is collected, the tubes are placed in a PCR system (Gene Amp PCR System 2720, Applied Biosystems Foster City, CA) and the program is developed in the following sequence. ITS 1 (TCC GTA GGT GAA CCT GCG G) and ITS 4 (TCC TCC GCT TAT TGA TAT GC) primers were used to amplify the DNA region (Table 2). The primers are then added to the PCR products, placed in an ABI 3730XL automated sequencer and the nucleotide sequences of trnL intron primers were read as follows (Table 1)²⁰.

¹⁸ Babayev, F.Ə. Bitki ekologiyası / F.Ə.Babayev –Bakı, BDU nəşriyyatı, – 2003, – 223 s.

¹⁹ Ellenberg, H.A key to Raunkiaer plant life forms with revised subdivisions / H.A.Ellenberg. – D.Mueller-Dombois, – 1968, – p. 56-73.

²⁰ Fatdayeva A.X. Molecular-phylogenetic research of the genus *Hypericum* L.in flora of Azerbaijan/ Bulletin of Science and Practice/2021,7(11),p.22-27.

Table 1
Nucleotide sequence of ITS primers (5-3)

DNA region	Primer	Nucleotide sequence 5-3	Reference
ITS	<i>ITS 1</i>	TCC GTA GGT GAA CCT GCG G	White and et al., 1990
	<i>ITS 4</i>	TCC TCC GCT TAT TGATAT GC	White and et al., 1990

Table 2
Nucleotide sequence of trnL intron primers (5-3)

DNA region	Primer	Primer sequence 5-3	Reference
<i>trnL</i> intron	trnL c	CGA AAT CGG TAG ACG CTA CG	Taberlet et al., 1991
	trnL d	GGG GAT AGA GGG ACT TGA AC	Taberlet et al., 1991

CHAPTER III. THE ROLE OF MORPHOLOGICAL FEATURES IN THE SYSTEMATICS OF THE GENUS *HYPERICUM* L. AND CONTROVERSIAL ISSUES

3.1. Diagnostic significance of morphological features of species

Morphological and diagnostic features are important in plant taxonomy, classification of plants and development of their phylogenetic systems. The taxonomy of the genus *Hypericum* has been studied by many scientists around the world.

What distinguishes the *Hypericaceae* family from other families is that they have stamen specialization (the base of the stamen is adjacent), apomixes, resins and essential oils in intercellular space of the leaf, the presence of a wing in its seed and special (thin, paper like) structure of the wing²¹.

The most important diagnostic features for the designation of the species of genus *Hypericum* L. are considered the structure of the

²¹ Crockett, S.L. Taxonomy and chemotaxonomy of the genus *Hypericum* / S.L.Crockett, N.K.Robson // Medicinal and aromatic plant science biotechnology, – 2011, 5, – p. 1-13.

flower organs, the shape of the secretor and translucent glands (dotted, striped, linear). These translucent glands, which are found in the vegetative (root - pericycle; stem - core, pericycle, phloem; leaf - phloem, veins) and generative (petal, sepal, ovary) organs, are divided into 3 groups that are anatomically different from each other²²:

1: This group includes multicellular black or red glands connected with veins, consisting of a single or two rows of smooth cell layers, containing hypericin, pseudohypericin;

2: The group includes spherical pale glands of schizogenic origin, surrounded by single or multilayered epithelial cells, containing hyperforin substance and essential oils;

3: This group includes resinous pale glands located in the ovary of the plant (especially in the wall of the ovary) and protecting the seed from external influences. The glands included in the first group play an important role in the process of photosynthesis. The glands included in the second group are mainly found in the leaves of species belonging to the genus. The size of the glands included in the third group grows during fruit formation and turns orange.

The structure of the sepal also plays an important role in determining the species of the genus (Figure 1).

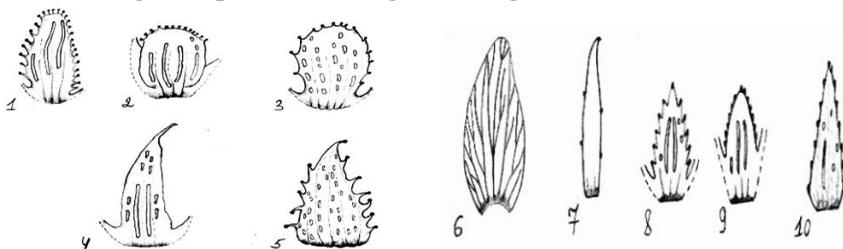


Figure 1. Shape of sepal

1. *H.venustum* Fenzl.; 2. *H.linarioides* Bosse.; 3. *H.formosissimum* Takht.;
 4. *H.perforatum* L.; 5. *H.elegans* Steph.; 6. *H.androsaemum* L.;
 7. *H.xylosteifolium* (Spach)N.Robson; 8. *H.lydium* Boiss.; 9. *H.scabrum* L.;
 10. *H.hirsutum* L.

²² Ciccarelli, D. Translucent glands and secretory canals in *Hypericum perforatum* L. (*Hypericaceae*): morphological, anatomical and histochemical studies during the course of ontogenesis / D.Ciccarelli, A.C.Andreucci, A.M.Pagini // Annals of Botany, – 2001, 88, – p. 637-644.

Cylindrical, oval, striped, netted porous, dotted-porous, linear-porous, hairy, with tip nose-shaped seed types are typical for species belonging to the genus St.-John's-wort (Figure 2).



Figure 2. Shape of seeds

1.*H.androsaemum* L.; 2.*H.lydium* Boiss.; 3.*H.formosissimum* Takht.; 4.*H.perforatum* L.

The shape of the capsule is of great importance in taxonomic research. Black, brown, berry, ovoid, ring-shaped, cone-shaped, grooved, striped, narrow short nose-shaped, glandular vesicular, dehiscent or non-dehiscent seed capsule types are found within the species of genus *Hypericum*²³(figure 3).

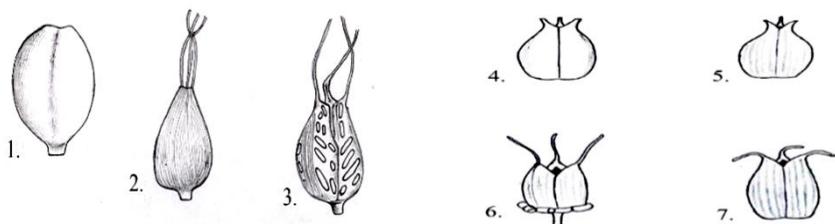


Figure 3. Shape of capsule

1.*H.androsaemum* L.; 2.*H.lydium* Boiss.; 3.*H.perforatum* L.; 4.*H.karjaginii* Rzaszade.; 5.*H.asperuloides* Czern ex Turcz.; 6.*H.elegans* Steph.; 7.*H.tetrapterum* Fries.

²³ [Elektron resurs] URL: <https://hypericum.myspecies>

3.2. Controversial issues in the taxonomy of the species of genus *Hypericum* L.

R.Rzazade showed that there are 15 species²⁴ and A.A. Grossheim 8 species belonging to the genus *Hypericum* L. distributed in the flora of Azerbaijan²⁵. We gave the description of 19 species in the taxonomic structure compiled by us.

At present, according to the results of modern research, the taxonomic composition of some species (*H.acutum* Moench., *H. antasiaticum* Grossh., *H.atropatanum* Rzazade., *H.polygonifolium* Rupr.) of the genus St.-John's-wort described in the work "Flora of Azerbaijan", published in 1955, has undergone a change. *H.elongatum* Ledeb. (= *H.antasiaticum* A.Grossh.), *H.helianthemoides* (Spach) Boiss. (= *H.atropatanum* Rzazade.), *H.tetrapterum* Fries. (= *H.acutum* Moench), *H.linarioides* Bosse. (= *H.polygonifolium* Rupr.)

We studied the research of various scientists in the study of the genus *Hypericum* L. and at the end of our research we relied on the system of the British scientist N.Robson, who studied the genus through anatomical, karyological and phylogenetic studies. Prominent botanist divided the genus St. John's wort into 30 sections and 6 subsections according to the structure of vegetative, generative organs and transcendent glands. Accordingly, we considered it expedient to place the St.-John's-wort species distributed in the flora of Azerbaijan on these sections. In addition to the morphological features noted above, this opinion is confirmed by the results of a molecular phylogenetic analysis of herbarium specimens collected in the botanical and geographical regions of the republic.

Results of molecular phylogenetic analysis

The obtained nucleotide sequences were compared with those in the US GenBank data center and the following results were obtained¹⁹:

In comparison of AZ0001 sample with GenBank data, *Hypericum helianthemoides* species is compatible.

In comparison of AZ0002 sample with GenBank data, *Hypericum perforatum* subsp. *veronense* subspecies is compatible.

²⁴ Рзазаде, Р.И. Флора Азербайджана / Р.И.Рзазаде. – Баку, – Т.6, –1955, – с. 247-259.

²⁵ Qrossqeym, A.A. Azərbaycan florası / A.A.Qrossqeym. – c.3, – 1932, – s. 372-378.

In comparison of AZ0003 sample with GenBank data, *Hypericum elongatum* species is compatible.

In comparison of AZ0005 sample with GenBank data, *Hypericum lydium* species is compatible.

In comparison of AZ0006 sample with GenBank data, *Hypericum androsaemum* species is compatible.

In comparison of AZ0007 sample with GenBank data, *Hypericum tetrapterum* species is compatible.

In comparison of AZ0008 sample with GenBank data, *Hypericum perforatum* species is compatible (Figure 4)

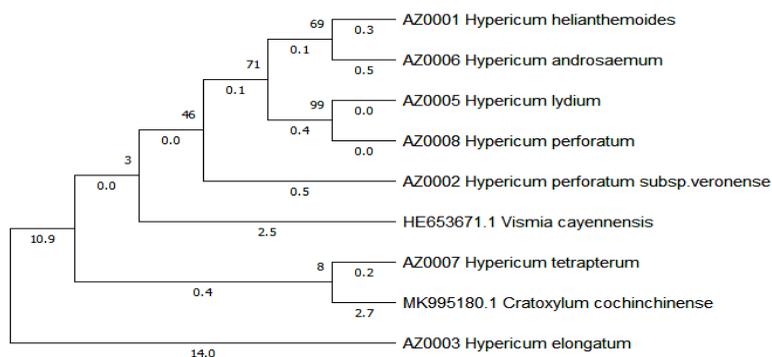
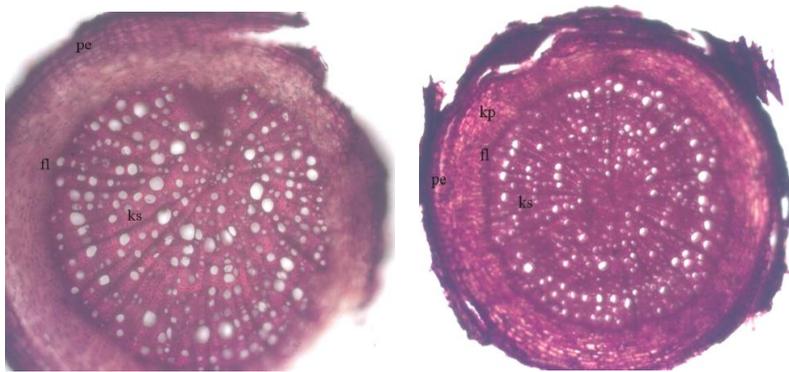


Figure 4. Phylogenetic tree drawn according to the Maximum Likelihood (ML) method of the ITS gene region of species of *Hypericum* genus

3.3. Anatomical studies on some species of the genus *Hypericum*

As a result of the activity of cambium cells in species belonging to the genus, a secondary structure is formed at the root (Figure 5), a ring-shaped secondary xylem in the stem and a secondary phloem outwards (Figure 6). As a result of anatomical research, it was found that in the species of the genus St. John's wort, the root has similar and the stem different structure. In the anatomical section of the stem of the genus, parenchyma, single-row radial rays, fibrils and wood with a thickened, spiral-shaped trachea are found. Usually there is no wood parenchyma in the species belonging to the genus. Epidermis cells are square in shape. Beneath there is a collenchyma consisting of annulate 1-2 layers.



a) *H.karjagini* R. Zazade.

b) *H.perforatum* L.

Figure 5. The anatomical structure of the root of the genus *Hypericum*

Xl:xylem, ph:phloem, pe:periderm, cp:cortex parenchyma

The cortex layer of the *Hypericum* genus is well developed, surrounded by secretory channels of schizogenic origin (A, B and C-type)²⁶ In St.-John's-wort species, the primary cortex, chlorenchyma, parenchyma and endoderm are found. In the wood of the genus *Hypericum*, xylem and phloem rings are located inside each other. The parenchyma is not found in the second xylem of the species included in the genus. Narrow pith rays are surrounded by secretory channels of schizogenic origin. These channels can also be found on the phloem, secondary phloem (lower cortex), pericycle and outer part of the primary cortex layer. In grass-like representatives of the genus, pith part is well developed and xylem and phloem are in the form of a narrow layer. In contrast to the grass-like species, annular sclerenchyma fibers are found in the pericycle in shrubs and semi-shrub species. In these species, the stem also has a narrow cortex layer.

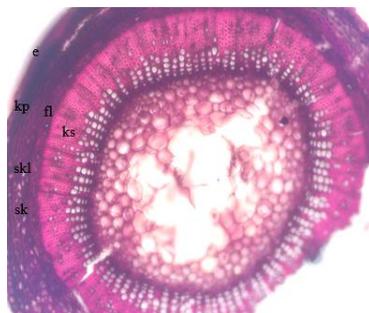
In species *H.perforatum* L. studied for the anatomic purpose, unlike the other three species (*H.hirsutum* L., *H.karjagini* R. Zazade., *H.linarioides* Bosse.), the chlorenchyma layer of the stem is located

²⁶ Silva, I.V. New reports on secretory structures of vegetative and floral organs of *Hypericum elodes* (Hypericaceae) / I.V.Silva, T.Nogueira, L.Ascensao // Microscopy and and Microanalysis, – 2015, 21(6), – p.56-57.

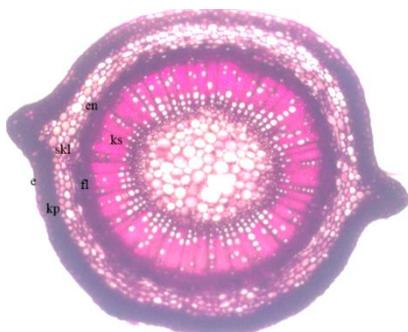
below the collenchyma cells²⁷.



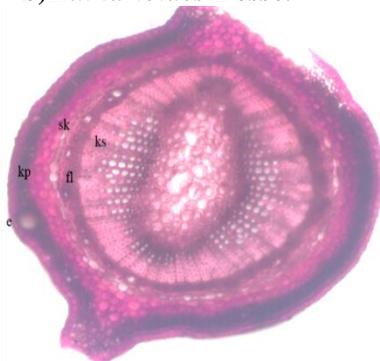
a) *H.hirsutum* L.



b) *H.linarioides* Bosse.



c) *H.karjagini* RZAZADE.



d) *H.perforatum* L.

Figure 6. The anatomical structure of the stem.

Xl: xylem, ph:phloem, en:endoderm, scl:sclerenchyma, cp:cortex parenchyma, sc:secretory channels, e:epidermis, tr:trichome

CHAPTER IV. SYSTEMATIC CONDITION OF THE GENUS *HYPERICUM* L.

Considered one of the largest genera of flowering plants in terms of species diversity (22%), although research on the systematics of the genus *Hypericum* L. has been conducted by many scientists around the

²⁷ Yuce, E. *Hypericum* L. (*Hypericaceae*) cinsine ait Drosanthe (Spach) Endl. seksiyonunun biyosistematigi // Doktora Tezi, Fırat Üniversitesi, Fen Bilimleri Enstitüsü, – Elazığ, – 2009, – 273 p.

world²⁸, the general characteristics and taxonomic composition of the species distributed in the flora of Azerbaijan have not been studied for the last 50 years. As a result of our research, it was determined that there are not 15 species, but 19 species, 1 subspecies and 1 species diversity belonging to the genus in the flora, their characteristics, descriptions and synonyms of sections, species, subspecies included in the genus were given.

4.1. Analysis of the taxonomic composition of the genus

The genus St.-John's wort was grouped according to the classification of phylogenetic groups (APG IV) of angiosperm as follows:

Regnum - Plantae

Division – Tracheophyta

Class – Magnoliopsida

Ordo – *Malpighiales*

Superordo – Rosanae

Familia – *Hypericaceae* Juss.

Subfamilia – *Hypericoideae* Engl.

Tribe – *Hypericae* Choisy.

Genus – *Hypericum* L.

They are annual or perennial bare, hairy grass, shrub, semi-shrub, and rarely short trees. The stem is cylindrical, rounded, ribbed, much branched erect, straight, creeping, stretching, 2-4-stalked, woody base, simple or dichotomic branching, pale, hairy, scabrid, glandular. The leaf is wide egg-shaped, ovoid, lanceolate or lancet-shaped, whorled, simple, papillose, hairy, vesicular, veiny, sessile or short-stalked, plain, without stipula, alternate, opposite or verticillate, twisted at the edges, black dotted or pale glandular, vascular branches are simple perforated, densely triangular spiral. The flowers ($K_{4-5} C_{4-5} A_{5-\infty} G_{(3-5)}$) are located mainly in the axils of the leaves, gathered in monosexual, spirocyclic or cyclic, diecious, actinomorphic, cyme-like, cylindrical, spike-like, pyramidal broom or racemose peltate

²⁸ Carine, M.A. About this volume: the monograph of *Hypericum* by Norman Robson / M.A.Carine, M.J.M.Christenhusz // *Phytotaxa*, – 2010, 4 (1), – p. 1-4.

flower groups. Seeds are small, cylindrical, elliptical, numerous, dotted-porous or linear porous, yellowish-brown, reddish-brown or dark purple-brown porous, hairy, tip nose-shaped, narrow-winged base, without endosperm, large, fleshy, straight or wrapped embryo. The fruit is a red or black dehiscent or non-dehiscent capsule or berry^{29, 30}.

4.2. Determination table of the genus

A new determination key has been developed for the genus St.-John's-wort distributed in the flora of Azerbaijan based on previously unused diagnostic features translucent glands located in the vegetative and generative organs)

4.3. Taxonomic conspect of genus

It was determined that the genus *Hypericum* distributed in the flora of Azerbaijan consists of 19 species, 1 subspecies and 1 species diversity belonging to 7 sections. A brief information on each section, species, subspecies and species diversity are given (Table 3).

Table 3

№	Sections	Species	Subspecies and species diversity
1.	<i>Androsaemum</i> (Duhamel) Godr.	<i>H.androsaemum</i> L.	
2.	<i>Coridium</i>	<i>H.asperuloides</i> <i>Czernex.Turcz.</i>	
3.	<i>Inodora</i> Stef.	<i>H.xylostelifolium</i> (Spach.) Robson.	
4.	<i>Hypericum</i>	<i>H.tetrapterum</i> Fries. <i>H.perforatum</i> L. <i>H. elegans</i> Steph.	<i>subsp.veronense</i> (Schrank)Lindb.

²⁹ Fətdayeva A.X., Qaraxani P.X. Azərbaycan florasında yayılan Dazı (*Hypericum* L.) cinsi növlərinin morfoloji xüsusiyyətləri. AMEA – nın xəbərləri, Biologiya elmləri, Bakı 2016. cild 71, səh. 50-53.

³⁰ Фатдаева А.Х., Гарахани П.Х., Касумова Т.А. Новый ключ для определения видов рода *Hypericum* L. во флоре Азербайджана Azerbaijan journal of Botany 2020. 1(2). p. 32-37.

Table 3 contunied

5.	<i>Adenosepalum</i> Spach.	<i>H.formosissimum</i> Takht.	
6.	<i>Hirtella</i> Stef.	<i>H.scabrum</i> L. <i>H.lydium</i> Boiss. <i>H.pseudolaeve</i> N.Robson. <i>H.karjagini</i> Rzaszade. <i>H.elongatum</i> Ledeb. <i>H.helianthemoides</i> (Spach.) N.Robson. <i>H.davisii</i> N.Robson.	<i>var.micranthum</i> Boiss
7.	<i>Taeniocarpium</i> Jaub.et Spach.	<i>H.hirsutum</i> L. <i>H.venustum</i> Fenzl. <i>H.linarioides</i> Bosse. <i>H.theodorii</i> Woronov. <i>H.nummularioides</i> Trautv.	

Label data of herbarium copies belonging to 12 species (1 subspecies, 1 species diversity) included in the genus and stored in the Herbarium Fund (BAK) of the Institute of Botany of ANAS were analyzed and an electronic database of these species was created. As a result of the analysis of the herbarium copies stored in the fund, it was revealed that there were 298 herbarium specimens on the genus. It has been established that these specimens were collected by prominent botanists such as A.A.Grossheim, I.I.Karyagin, L.Prilipko, R.Rzaszade, G.Gurvitch, I.Beydeman, T.Heydeman, I.Isayev, G.Akhundov, I.Hajiyev, N.Shipchinskiy, M.Sakhokia and etc. We collected 80 herbarium specimens belonging to the genus from different regions of the republic for 2015-2022 years and handed them over to the herbarium fund. Of these 298 samples collected from botanical and geographical regions of the republic in different years (1925-2022), 25 belong to *H.androsaemum* L., 12 to *H.elongatum* Ledeb., 9 to *H.hirsutum* L., 1 to *H.karjagini* Rzaszade., 49 to *H.linarioides* Bosse., 6 to *H.lydium* Boiss., 138 to *H.perforatum* L., 13 to *H.perforatum* subsp.*veronense* (Schrank) H.Lindb., 33 to *H.scabrum* L., 1 to *H.scabrum* var. *micranthum* Boiss., 3 to *H.tetrapterum* Fries., 4 to *H.theodorii* Woronov., 2 to *H.helianthemoides* (Spach) Boiss., 2 to *H.formosissimum* Takht. species (Figure 7).

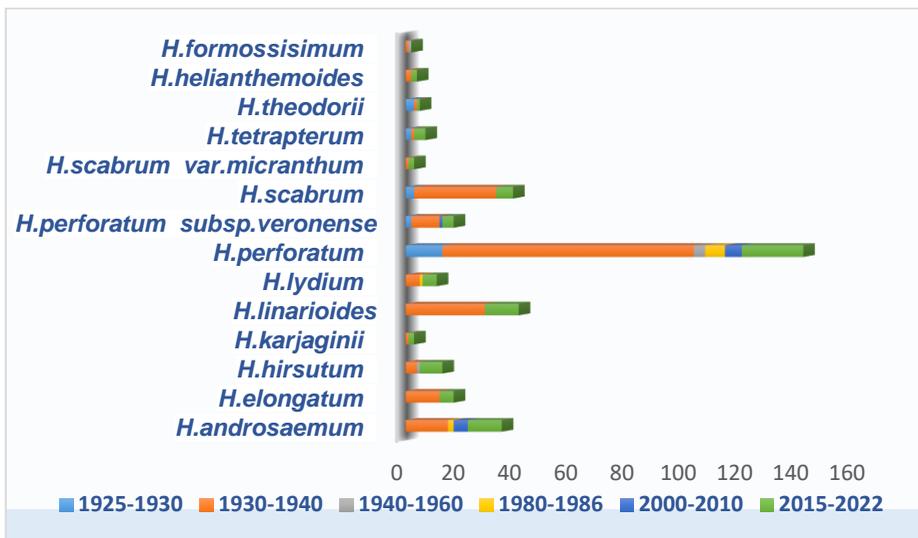


Figure 7. Quantity of herbarium samples belonging to the genus *Hypericum* stored in the Herbarium Fund of ANAS

CHAPTER V. BIOECOLOGICAL CHARACTERISTICS OF SPECIES OF THE GENUS *HYPERICUM* L.

5.1. Phenology of species

In the study of the bioecology of species of this genus, their phenology plays an important role.

In our research, phenological observations were conducted for 3 years, and the resulting figures are shown on average. As a result of these observations, the beginning and end of the vegetation period in St.-John's-wort species, the appearance of the first sprout, the development of the flower group, budding, blossoming, the time of budding of each flower, as well as the stages of seed and fruit ripening were studied. Although the vast majority of species belonging to the genus *Hypericum* are pollinated by insects (entomophilous), self-pollination and wind pollination also occur among these species. Reproduction of the representatives of genus takes place through seeds

or short roots³¹. As can be seen from the phenological observations, the vegetation of St.-John's-wort species in natural and ecological conditions begins in April-June, the blossoming period in May-July, and the development of the fruit lasts from early August to late September.

5.2. Ecology of species and participation in plant groups

Although the work of many scientists is devoted to the study of bioecological features of the genus *Hypericum* L., the bioecological features of species distributed in the flora of Azerbaijan have not been sufficiently studied. For this purpose, research was conducted on the genus of St. John's wort collected from different botanical and geographical regions of Azerbaijan under natural conditions in 2015-2022. As a result of the research, the bioecological features of the species belonging to the genus were studied and the regularities of the distribution of the species in the high belts, their attitude to climatic factors, phenology and ecological groups were determined. The "Life Forms" systems of C. Raunkiaer and I. Serebryakov were used to determine the life forms of the species included in the genus.

According to their attitude to moisture and adaptation, species belonging to the genus are divided into 3 groups (Figure 8).

We gave the classification of the life forms of the species of the genus St. John's wort distributed in the Republic of Azerbaijan on the basis of the division of the Danish scientist C. Raunkiaer (1934). According to this division, all species of the genus *Hypericum* L. distributed in the flora of Azerbaijan are hemicryptophytes (stem dries out in unfavorable conditions, the living part of the plant remains underground and remains with dried leaves until the new vegetation): *H. hirsutum*, *H. perforatum*, *H. asperuloides*, *H. tetrapterum*, *H. nummularioides*, *H. scabrum*, *H. elongatum*, *H. helianthemoides*, *H. theodorii*, *H. androsaemum*, *H. linarioides*, *H. xylosteifolium*, *H. davisii* and etc.

³¹ Pluhar, Zs. Comparative investigation on *Hypericum perforatum* L. populations of different origin / Zs. Pluhar, O. Rehak, E. Nemeth // International journal of Horticultural Science, – 2000, 6(1), – p. 56-60.

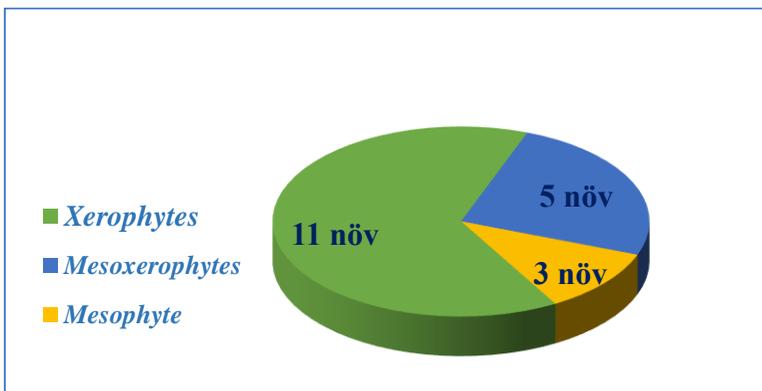


Figure 8. Ecological groups of species of genus St. John's wort in relation to humidity

According to the classification of the system of life forms by I.G. Serebryakov (1964), most of the species of the genus St.-John's wort (with the exception of semishrub species *H.asperuloides*, *H.androsaemum*, *H.xylosteifolium*, *H.nummularioides*) found in the flora of Azerbaijan are perennial grass plants.

Species of the genus found in the flora of Azerbaijan are distributed from the lower mountain range to the high mountain range, but are more common in the lower and middle mountain ranges. In order to clarify the distribution patterns of St. John's wort species depending on the height gradient, we used the scheme adopted by L.I. Prilipko in 1954 in our research. There are 10 species in the lower and middle, 3 in middle, 4 in subalpine, 2 in the high mountain belt. Although most species belong to both low and middle mountain ranges, some found in only one belt. According to this mountain belts were compared and the Sorensen-Chekonovsky similaity coefficient was used to determine the taxonomic composition of species living in these belts.

$$I_s = 2a / ((a+b)+(a+c))$$

a- total number of species, b- number of species in the first mountain range, c- number of species in other mountain ranges.

This similarity coefficient of the lower and middle mountain belt was found to be $I_s=0,74\%$, between the lower and upper belt is $I_s=0,76\%$ and between the subalpine and upper belt $I_s=0,86\%$.

CHAPTER VI. PHYLOGENY AND GEOGRAPHICAL ANALYSIS OF *HYPERICUM* L. SPECIES DISTRIBUTED IN AZERBAIJAN

6.1. Phylogenetic relationships of *Hypericum* L. Species distributed in Azerbaijan

One of the oldest and largest families according to the origin of the order *Malpighiales* Bercht. & J. Presl. represented by about 1,600 species, is the St.-John's-wortfamily (*Hypericaceae* Juss.). Thus, the remains of fruits and seeds of the representatives of this family are found in the 1st geological (Paleogene) period of the Cenozoic era. *Hypericum* is considered the largest and most ancient genus of this family³². The fact that most of the species belonging to the genus are endemic and relict plants of the third period proves the antiquity of the genus.

The family *Hypericaceae* is divided into 1 subfamily (*Hypericoideae* Engl.) and 3 tribes (*Cratoxyleae* Benth., *Hypericae* Choisy., *Vismiae* Choisy.) represented by 9 genera. In the flora of Azerbaijan, only representatives of the genus *Hypericum* included in the tribe *Hypericae* are found³³.

The complex taxonomic structure of the genus *Hypericum* makes it difficult to explain from which genus it originated. Based on research conducted by various researchers on the phylogeny, paleobiology of the genus and the results of our own research, we agree with the idea that this genus originated from an ancestor of Western Palearctic origin with the following diagnostic features: tall, bushy, sessile cuticular leaves, small-flowered, shedding crown and

³² Ruhfel, B.R. Phylogeny of the clusioid clade (Malpighiales): evidence from the plastid and mitochondrial genomes / B.R. Ruhfel, V. Bittrich, C.P. Bove [et al.] // American journal of botany, – 2011, 98, – p. 306-325.

³³ Robson, N.K. And then came molecular phylogenetics — reactions to a monographic study of *Hypericum* (*Hypericaceae*) // Phytotaxa, – 2016, 255 (3), – p. 181-198.

petal, adjacent base, 5-bundle stamen, parietal placenta, free-style, capitate stomata and etc.

Thus, the presence of sections (*Androsaemum*, *Campyloporus*, *Bupleuroides*, *Hypericum*, *Olympia*, *Thasia*, *Drosocarpium*, *Oligostema*, *Hirtella*, *Taeniocarpium*, *Coridium*) of paleartic origin, endemic, tertiary relict species in the composition of genus St. John's wort, as well as distribution of species from paleartic, equatorial zone to tropical and subtropical countries of the northern hemisphere is a visual proof of the antiquity of this genus.

The center of formation of species belonging to the genus St. John's wort divided into two parts: the Mediterranean and the Eurasian center. The Mediterranean is considered the center of species formation of the vast majority of species belonging to the genus. The Eurasian Center is considered the second relatively young species formation center. 72% of the species inhabiting Central Eurasia are found in tropical (high mountain ranges) and 42% in temperate (medium mountain ranges) countries.

6.2. Botanical-geographical analysis of species *Hypericum* L. distributed in Azerbaijan

The study of the species of the genus *Hypericum* is of great importance in the investigation of many unresolved issues related to the phylogenetics of the genus. As a result of research conducted by many scientists and analysis of the literature, the geography of the species was analyzed.

During the chorological analysis of species of genus St. John's wort distributed in the flora of Azerbaijan, 7 geographical elements were identified on the basis of N.N.Portenier's system³⁴:

Thus, most of the species found in the flora of Azerbaijan (36%) belong to the Iran-Turan geographical element (Figure 9).

³⁴ Портениер, Н.Н. Флора и ботаническая география Северного Кавказа / Н.Н.Портениер. – Москва, – 2012, – 293 с.

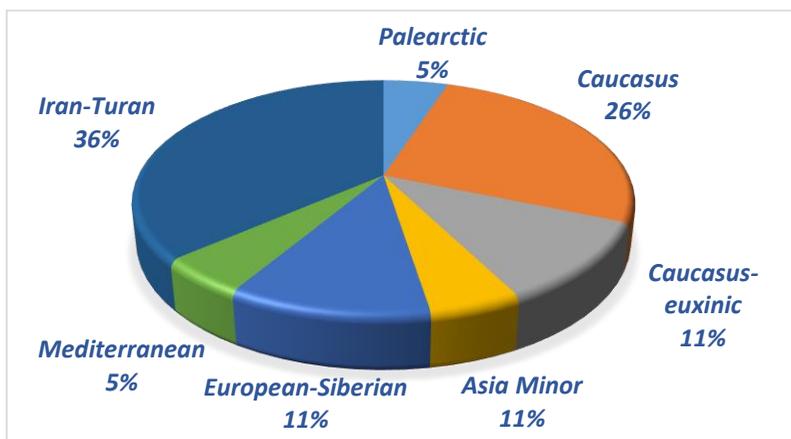


Figure 9. System of geographical elements of the species of genus *Hypericum* L.

Endemic and tertiary relict species are also found in the composition of the genus St. John's wort. The list of endemic species was specified in accordance with the "Red List of endemic plants of the Caucasus"³⁵. Based on this work, it was determined that 3 (*H. formosissimum* Takht., *H. nummularioides* Trautv., *H. xylosteifolium* (Spach) N. Robson) of the species distributed in the flora of Azerbaijan are endemic to Caucasus and 2 (*H. karjaginii* Rzaade., *H. theodorii* Woronov.) are endemic to Azerbaijan. Also, 2 out of 19 species found in our flora are relict³⁶ (*H. androsaemum* L., *H. xylosteifolium* (Spach.) N. Robson) plants from the glacial period (Figure 10).

The classification adopted by the International Union for Conservation of Nature (IUCN) was used to assess rare and endangered species of the genus St. John's wort distributed in the flora

³⁵ Solomon, J. Red list of the endemic plants of the Caucasus: Armenia, Azerbaijan, Georgia, Iran, Russia and Turkey / J. Solomon, T. Shulkina & G.E. Schatz // Missouri Botanical Garden Press, – 2014, – 353 p.

³⁶ Fatdayeva A.X. Taxonomic investigation of the relict species *Hypericum androsaemum* L. in flora of Azerbaijan. Nakhchivan State University, Scientific works, 2020, № 8 (109). p. 60-63.

of Azerbaijan (Table 4). In accordance with this classification system, the status of rare and endangered species of the genus distributed in the flora of Azerbaijan has been clarified. Thus, according to the quantitative criteria used in the assessment of the categories of rare species (A, B, C, D, E), out of the species of the genus found in our flora, 1 is defined as being critically endangered (CR), 1 as endangered (EN), 3 as weakened population, vulnerable to adverse effects (VU), and 1 as data deficient (DD).



Figure 10. Relict and endemic species of the genus *Hypericum*

**Table 4
Rare and endangered species of the genus *Hypericum***

IUCN	Species
VU A3C(Vulnerable)	<i>H.karjaginii</i> Rzazade
DD (Data Deficient)	<i>H.nummularioides</i> Trautv.
VU A3C(Vulnerable)	<i>H.lydium</i> Boiss.
CR A3c(Critically Endangered)	<i>H.linarioides</i> Bosse.
VU A3C(Vulnerable)	<i>H.theodorii</i> Woronov.
EN B2 ab(ii, iii)(Endangered)	<i>H.formosissimum</i> Takht.

CONCLUSIONS

1. It was determined that 19 species, 1 subspecies and 1 species diversity of the genus St. John's wort (*Hypericum* L.) belonging to 7 sections are widespread in Azerbaijan.
2. On the basis of a new taxonomic composition with the addition of St.-John's-wort species not shown in the "Flora of Azerbaijan" and new diagnostic signs not used before a determinant table has been drawn up for the species included in the genus. A new distribution area has been identified for *H.tetrapterum* Fries. (around Soyudlu village of Gadabay region) and *H.scabrum* L. (around Goydara village of Lerik region) species.
3. Based on the results of the research, it was found that there are 3 Caucasian (*H.xylosteifolium*, *H.nummularioides*, *H.formosissimum*) and 2 Azerbaijani endemics (*H.karjaginii*, *H.theodorii*) in the composition of the genus.
4. For the first time, molecular-phylogenetic analysis of plant samples collected from different botanical-geographical regions of the republic was carried out and ITS1 and ITS4 (internal transcribed space) sequence fields for species identification were reviewed. The obtained nucleotide sequences were compared with GenBank data and the status of the controversial species was clarified.
5. For the first time, anatomical studies were conducted on the wild species (*H.hirsutum*, *H.karjaginii*, *H.linarioides*, *H.perforatum*) of the genus *Hypericum* L. distributed in Azerbaijan, as a result, it was found that the root has similar (having a secondary structure, secondary xylem in the central part, the presence of primary xylem elements on the opposite side of the pith rays) and the stem (presence of a ring-shaped secondary xylem in the stem and an secondary phloem to the outside, presence of primary cortex chlorenchyma, parenchyma and endoderm) has a different anatomical structure as well as that there are translucent glands of schizogenic origin in the wood of the genus.
6. For the first time, electronic maps-schemes of species habitats have been developed based on field research and study of herbarium materials. As a result of study of the common habitats of the species

it was revealed that these species belong to 7 habitat types and the Iran-Turan geographical element dominate (36%).

RECOMMENDATIONS

1. It is expedient to use some species (*H. androsaemum* L., *H. elegans* Steph.) of the genus St.-John's-wort distributed in the flora of Azerbaijan for landscaping parks and gardens for decorative purposes.
2. Considering the medicinal (*H. androsaemum* L., *H. scabrum* L., *H. linarioides* Bosse., *H. elongatum* Ledeb., *H. elegans* Steph., *H. perforatum* L., *H. lyidium* Boiss., *H. tetrapterum* Fries.) and dyeing (*H. androsaemum* L., *H. elongatum* Ledeb., *H. perforatum* L., *H. scabrum* L.) importance of some part of the species included in the genus, these species can be widely used in pharmaceuticals and industry.
3. The information obtained as a result of systematic, anatomical, molecular-phylogenetic research can be used to determine the diagnostic features of St. John's wort species, to compile determinant keys, as well as "Flora of Azerbaijan" and teaching aids on botany.
4. It is recommended to include the species *H. lyidium* L., *H. linarioides* Bosse., *H. karjagini* Rzazade belonging to the genus *Hypericum* in the 3rd edition of the Red Book of the Republic of Azerbaijan in order to prevent the reduction of the number of species as a result of the limiting influence of ecological, zoogenic and anthropogenic factors.

List of published scientific works on the topic of the dissertation

1. Fətdayeva A.X., Qaraxani P.X. Azərbaycan florasında dəyişən (*Hypericum* L.) cinsi. AMEA Botanika İnstitutunun elmi əsərləri, Bakı "Elm" 2015. cild XXXV, səh. 43-45.
2. Fətdayeva A.X., Qaraxani P.X. Azərbaycan florasında yayılan Dəyişən (*Hypericum* L.) cinsi növlərinin morfoloji xüsusiyyətləri. AMEA-nın xəbərləri, Biologiya elmləri, Bakı 2016. cild 71, səh. 50-53.
3. Fətdayeva A.X. Medical species of the genus *Hypericum* L.

- Academic science weekly International Multidisciplinary forum materials. Baku 2015, p.351-352.
4. Fatdayeva A.X. Species of the genus *Hypericum* L. in Azerbaijan flora. International conference, Baku, 2016. 101 p.
 5. Fatdayeva A.X., Akbarova. A.E. Endemic species residing to the genus *Hypericum* L. in Azerbaijan. The 3rd international symposium on Euroasian biodiversity, Belarus, 2017. 643 p.
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