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Acta Botanica Caucasica

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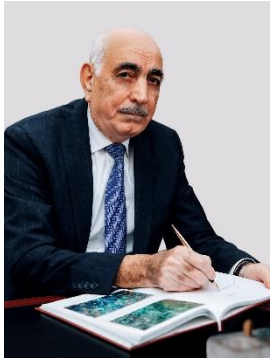
The purpose of the journal is to stimulate the development of botanical science. The issues posed by the Journal are the publication of the results of research that are relevant for professional botanists.

The journal "Acta Botanica Caucasica" publishes the results of researches in various fields of fundamental Botany: Systematics, phylogeny, floristics, geobotany, morphology, structural Botany, Plant Physiology; articles on protection of the plant world, as well as the study of vegetation in the Caucasus; chronic materials on scientific events (symposiums, conferences); important botanical innovations; articles on the history of Botany. In the journal "Acta Botanica Caucasica" the Articles of Caucasian and foreign authors are published in English. Articles should include the latest, previously unpublished factual information and theoretical considerations.

Dear colleagues!



Since recently, with its rapid development, the botanical science entered the era of the "Renaissance". Botanical science, which has been considered an attractive field of knowledge throughout history, has been able to gather scientists and researchers around each period with its rich, interesting research materials.

As far as I know, plants play a key role in the life and formation of the biosphere, determining the modern appearance of the Earth, the climatic conditions of the planet and the reserves of minerals.

Plants are very diverse in structure, distribution and systematic position.

With its unique uniqueness, plants control the order of such a vital process as photosynthesis and organic metabolism, forming the basis of food chains in biocenoses.

In the process of self-regulation of the ecosystem, violations of the ecological balance create great stresses for the habitat of many living things in nature, including plants. Recently, the urbanization process has led to a narrowing of natural zonalities and an increase in degraded environmental problems. There is a need for sustainable, high-quality, high-yielding, rural and forest crop production to balance the growth burden of the ecosystem.

In this regard, as a result of the distant vision of World botanists, the science of Botany has achieved great success over the past few decades and continues to develop rapidly. At present, the increase in the number of botanical scientists in advanced countries and the improvement of research institutes in the field of Botany in the new innovative design, the emergence of Botanical Gardens, which contribute to the formation of plant bases with species poverty, promise more than previous years to contribute to the improvement of the well-being of mankind.

Today, when science and technology are developing rapidly, the publication of local and international scientific-research journals, teaching aids and popular scientific books based on modern methods is of great importance in the field of Botany. A large collection of materials will be presented, which will create a written and Electronic Library base rich in literature materials. At the same time, young researchers will help scientists to carry out research works.

In order to support the latest scientific-research innovations in the field of Botany, exchange of ideas and research results of domestic and foreign researchers, as well as to support the research that studies the impact of biological factors on the theoretical and practical aspects of the design work, as well as to support the transfer of innovative results among specialists, "Acta Botanica Caucasica" The journal includes the study of fundamental and applied botany anatomy, morphology, phytocenology, agrobotany, paleobotany, mycology, briology, algology, etc. it is planned to publish the latest research data and scientific innovations in such areas.

The "Acta Botanica Caucasica" periodic scientific research journal has been included in the state registration register of publications by the Media Development Agency of the Republic of Azerbaijan. Jural aims to publish the results of actual scientific research works in the fields of Natural Sciences, as well as Pedagogical Sciences by the employees studying and working in higher educational institutions and Research Institutes of our republic and abroad. We believe that the representation of well-known scientists and specialists in the editorial board of the journal will contribute to the improvement of the quality of scientific creative activity of researchers and will play an important role in bringing the results of their research to the wider scientific community.

I congratulate the editorial staff of the Journal and my colleagues working with us on the occasion of the publication of the first issue of the periodic scientific journal" Acta Botanica Caucasica" and wish them creative success in their scientific activities.

Editor-in-chief,
Correspondent Members of ANAS, DrSc, prof. ELSHAD GURBANOV

NEW SPREADING AREAS OF SOME SPECIES IN THE BOTANICAL-GEOGRAPHICAL REGIONS OF THE MIDDLE PART OF THE CASPIAN COAST

*ELSHAD M. GURBANOV, HUMIRA Z. HUSEYNOVA
DOI: 10.30546/abc.2022.1.1.4
Baku State University, Baku, Azerbaijan
**elshadqurbanov@bsu.edu.az*

Abstract. The article provides information on the discovery of new spreading areas in the Botanical-geographical regions of Absheron and Gobustan, as well as phytocenoses formed in the middle part of the Caspian coast. In this regard, the "map on the new distribution area of plant species in the botanical-geographical regions of the Caspian coast" of those species registered in the vegetation cover of the territory was com-piled for the first time on the scale of 1:600000, as well as "map of the middle part of the Caspian coast" 1:5000. Ecological-geobotanic studies and systematic taxon studies were carried out in the middle part of the Caspian coast. During ecologicalgeobotanic researches in the central part of the Caspian coast in Ab-sheron and Gobustan botanical-geographical regions new distribution areas of the following species have been identified: Suaeda forrsk belonging to the family. Chenopodiaceae Vent ex. Suaeda heterophylla Kar.et Kir belonging to Scop genus, Atriplex turcmenica (Moq.) Boiss belonging to Atriplex L., Salsola nitraria Pall., in the genus Salsola L., Erysimum caspicum N. Busch belonging to Brassicaceae Burnett. Family, Erysimum L. genus, Astragantha falcatus Lam. belonging to Fabaceae Lindl. Family, Astracantha Podlech.genus and Scrophularia divaricata Lebed belonging to Scrophulariacae Juss. Family and Scrophularia genus.

Keywords: phytocenosis, areal, formation, flora, genus

Introduction. Botanical-geographical region of Absheron is located in the middle part of the western coast of the Caspian Sea between the lowland of the Caspian coast and the Administrative District of Alat. In particular, the vegetation cover of the Absheron Peninsula is spread on gray-brown, saline grassy gray and sandy soils from 25 to 50 meters above sea level. The climate is mainly mild, hot and dry subtropical. Part of the Samur-Absheron canal, Jeyranbatan water reservoir, Masazir, Mirkhalid and other years are located on the territory of Absheron botanical-geographical region. Gobustan Botanical-geographical region borders on Absheron (Peninsula) and Lankaran-Mugan geobotanical regions along the Caspian region; it is surrounded by Alat, Pirsaat and Atbulag administrative-territorial circles. Mud volcanoes were observed here.

Climate of the area is characterized by hot dry summer and mild humid winter. The relief is slightly sloping. The vegetation is spread on grey-brown, saline grass-grey, saline, and sandy soils. It spreads at an altitude from 27 m to 70 meters above sea level.

The object and methodology of research. While conducting researches on geobotanical study, morphological signs and systematic taxa in the middle part of the Caspian coast, as well as in the corresponding botanical-geographical regions, it was established that information on the spread of these species herein Floristic literature was not disclosed.

When determining the Botanical Institute of the National Academy of Sciences of Azerbaijan and the types of systematictaxa in herbarium funds of the Botany Department of BSU, "Flora of Azerbaijan" [Flora of Azerbaijan1950-1961], "Absheron Flora" [Karyagin, 1952], [Grossgeim, 1939-1967], [Askerov 2005;

2006], [Gajiyev and Musayev 2008], [Gurbanov, 2009] and other scientific works [Agadzhanov, 1967] mainly found that these species are new to the middle part of the Caspian coast, as well as to the botanical-geographical regions of Absheron (III) and Gobustan (IV) (pic.).

The results of the research. According to the literature, *Suaeda heterophylla* Kar.et.Kir. Bunge. plant is spread in the Shirvan, South-Eastern Shirvan, Salyan and Mugan plains in the Kur-Araz lowland of Azerbaijan, as well as in the saline and saline soils of the lowlands (plains) and foothills. As noted in the reference books on the wild flora of the Caucasus, Azerbaijan and Absheron, *Suaeda heterophylla* Kar.et.Kir. Bunge. species is spread in most countries of the world, including desert and semi-desert regions and in the eastern part of the South Caucasus.

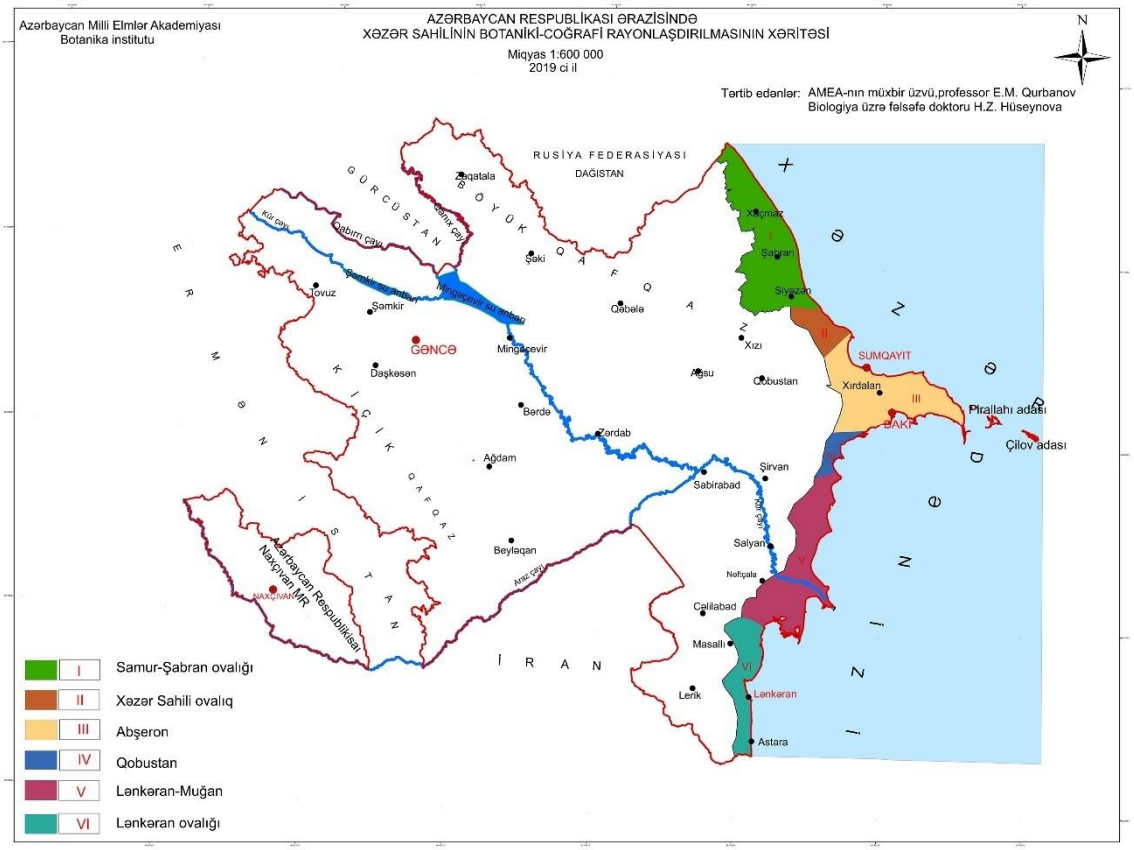
Geographical area - *Suaeda heterophylla* species belonging to Turan type has the following morphological, systematic and ecological features.

Suaeda heterophylla Kar.et.Kir. Bunge. - stem bare, unitary shoots, easily broken and 20-80 cm high with branches. The leaves are simple, alternate or intertwined, loose and gradually dry. The flowers are small, the spike is in a group of flowers. Flowering is a bowl–shaped.

The stamens are 1-5, the females are formed from two to five fruit leaves. The fruit is hazelnut. The petals of the flower remain close to the fruit and help it to spread with the wind. It is a perennial herb. It blooms in May and bears fruit in October. It is a fodder plant and contains potash. Sufficiently eaten by cattle in the last month of autumn.

Suaeda heterophylla is found in the middle part of the Caspian coast-saline (halophytic) desert vegetation in the Absheron botanical-geographical region as a dominant species in the formation of *Eremopyreta-Salsoletum-Suaedaosum* in the forest (2-3 points abundance). Resistant to salt and drought. It is a fodder plant.

PICTURE. Map of New Plant Species Distribution Area In Botanical-Geographical Regions Of The Caspian Coast. Scale 1:600 000



Location: Absheron peninsula. Sumgayit-chay and SAK crossing area at an altitude of 26 m above sea level. May 20, 2019.

Collectors: E.M. Gurbanov, H.Z. Huseynova.

Salsola nitraria Pall of the genus *Salsola* L. The species is widespread in Northern Iran, Iran-Turan and the Caucasus, as noted in the descriptive literature on the flora of the Caucasus and Azerbaijan.

According to the literature, *Salsola nitraria* is distributed in Azerbaijan on the plains of Nakhchivan (Ordubad and Julfa districts) and on dry-clay slopes in the Kur-Araz lowland, as well as on saline soils.

Geographical area - The type of dry salt marsh belonging to the Atropatan type has the following morphological, systematic and ecological features.

Salsola nitraria Pall. The body is grayish, branched and reaches a height of 40-80 cm. The branches are woody, the annual shoots are broken, finely hairy and smooth. The leaves are sessile, alternate, linear, blunt and covered with whitish-gray hairs. Inflorescence leaves are short, broad-ovate, the tips of these leaves are long and hairy. The mouth of the tooth is sharp, the column is equal or blackish-red, wide and sometimes narrow. The wings of the fruits are yellowish and dark red in the form of a curtain. It blooms in May and bears fruit in October.

In the middle part of the Caspian coast (Absheron botanical-geographical region and Absheron peninsula) saline desert vegetation is rarely (1-2 points) in the formation of *Salsoletum-Artemisiosum*. It is well eaten by cattle as a fodder plant for winter pastures. It can be used for potash and soda.

Location: Absheron peninsula. Gobustan reserve and Shikhlar municipality grazing area. On saline gray-brown soil, at an altitude of 28 m above sea level. May 25, 2019.

Collectors: E.M. Gurbanov, H.Z. Huseynova.

Erysimum caspicum N.Busch, specific to the genus *Erysimum* L., is widespread in Europe, the Mediterranean, as well as in temperate Asia and the Caucasus, as noted in the descriptive literature on the flora of the CIS, Caucasus and Azerbaijan.

Location: Absheron peninsula. Gobustan reserve and Shikhlar municipality grazing area. On saline gray-brown soil, at an altitude of 28 m above sea level. May 25, 2019.

Collectors: E.M. Gurbanov, H.Z. Huseynova.

Erysimum caspicum N.Busch, specific to the genus *Erysimum* L., is widespread in Europe, the Mediterranean, as well as in temperate Asia and the Caucasus, as noted in the descriptive literature on the flora of the CIS, Caucasus and Azerbaijan.

According to the literature, *Erysimum caspicum* is distributed on clayey and mountain slopes in the middle mountain belt of Azerbaijan - Greater Caucasus (Eastern) and Eastern Transcaucasia.

Geographical area - *Erysimum caspicum* N.Busch, belonging to the type of Central Asia, as an endemic plant species of Azerbaijan is characterized by the following morphological, systematic and ecological features.

Erysimum caspicum N.Busch trunk is thin, covered with straight and branched hairs, rising to a height of 15-35 cm. The leaves are lanceolate. The bowl leaves are 4, arranged alternately in two circles. The petals are 10 mm long, yellow, sometimes whitish, and the fruit is horny. It is a perennial herb. It blooms in June and bears seeds in July.

Erysimum caspicum is found in the middle part of the Caspian coast, as well as in the semi-desert vegetation of the Absheron botanical-geographical region in the formation of *Ephemereta-Salsoletum*-Artemisiosum with an abundance of 1 point (singly). It is a honey-giving and ornamental plant.

Location: Baku city, Garadagh district. In front of Sahil settlement - the border of the

State Land Fund. Winter pasture. At an altitude of 32.4 m above sea level. June 15, 2019.

Collectors: E.M. Gurbanov, H.Z. Huseynova.

Astracacantha Podlech. *Astrafalus falcatus* Lam. The Caucasus, including the Caucasus, Dagestan, East and South Transcaucasus, is widespread, as noted in the descriptive literature on the flora of the former USSR, the Caucasus and Azerbaijan.

Astracantha falcatus Lam. According to the literature, the plant is distributed in Azerbaijan - in the Guba mountain range and west of the Greater Caucasus, in the north and center of the Lesser Caucasus, as well as in the mountains of Nakhchivan (from low to high mountain range) in bushes, forest areas, open forests and meadows.

Astracantha falcatus Lam, geographical area of Iran-Turan type. has the following morphological, systematic and ecological features.

Astracantha falcatus Lam. trunk 40 - 90 cm high; The leaves are 6 - 15 cm long and consist of 9 - 18 pairs of leaves. Clusters dense, many-flowered, 8 - 12 cm long; The crown is black and white, the beans are linear-curved and reach 14 - 25 mm. It is a perennial herb. It bloomsin May-June and beans ripen in June - August.

Astracantha falcatus Lam. - Rarely (with 1 - 2 points) in the formation of the semi-desert plant *Artemisietum-Ephemerosum* in the middle part of the Caspian coast (in the territory of Gobustan botanical-geographical region). It is a fodder plant.

Location: rocky area with the border of Gobustan historical-artistic reserve. At sea level - 30.4 cm high. May 25, 2019.

Collectors: E.M. Gurbanov, H.Z. Huseynova.

Atriplex turcmonica (Mog.) Boiss belonging to the genus *Atriplex* L. The species is widespread in Europe, Asia, America, Central Asia and the Caucasus, as noted in the descriptive literature on the flora of the CIS, the Caucasus and Azerbaijan. Atriplex turcmonica is shown to be widespread in Azerbaijan - in most lowlands, foothills, sometimes up to the middle mountain range. This species is found in saline and saline soils, weeds and litter.

Atriplex turcmonica, belonging to the Mediterranean - Iranian type, has the following morphological, systematic and ecological features.

Atriplex turcmonica (Moq.) Boiss. The stem-reaches 60-100 cm in height together with the stem; the lower leaves on the trunk are round, rhomboid, toothed, and the upper leaves are lanceolate or hatvar. Flowers are homogeneous. The floriculture of masculine-bearing flowers is a bowl shaped. The males are 5. The tooth - bearing flowers do not have burns, and they are surrounded by two free or adjacent leaves of Floriculture. The upper ovary of the tooth and the mouth are two. Its fruit belongs to hazelnut group. It is an annual herb. It blooms in June-July and gives seeds in August-September.

Atriplex turcmonica-Ephemereta-Artemuisiebum-Suaedaosum formation is registered sparsely (1-2 points) from halophyte desert plants formed in the middle part of the Caspian coast, as well as on clay-saline gray-brown soils in Absheron botanical-geographical region.

Location: Garadagh District, northern slope of Sangachal settlement, 2 km distance from Baku-Gobustan Highway - winter pastures. At an altitude of 35, 2 m above sea level. June 20, 2019.

Collectors: E.M. Gurbanov, H.Z. Huseynova.

*Scrophularia*typical of the genus *Scrophularia* Lebed wallicata as mentioned in the literature on the wild flora of Caucasus and Azerbaijanthe species is spread in Eurasia, Mediterranean countries and the Caucasus.

According to the literature data, *Scrophularia wallicata* plant is spread in Azerbaijanin the Greater Caucasus (Guba mountain range), Nakhchivan and Talish (in shady forests and bushes till Arandan-Alpine zone, Mountain Meadows, among rock and river valleys).

Scrophularia wallicata, which belongs to the Atropatan type of geographical area, is the Endemic plant of the Caucasus, as well as has the following morphological, systemic and ecological features.

Scrophularia Lebedwallicata. the body is a flat shield, four-cornered and reaches 40-70 cm in height. The leaves are located opposite. The lower part is divided into five, the crown has

two lips, the tube is swollen, the number of males is 4, two of them are longer, the trunk of the crown is adjacent, the fifth is reduced. The tooth is formed from two fruit leaves, and the ovary is in the upper position. Open the box with two-volume, multi-volume and lids. Its fruit is box-shaped. It is a perennial herb. It blooms in May and gives seeds in August-September.

Scrophularia wallicata is found individually (1 point) in the *Salsoletum-Artemisiosum* formation of semi-desert plant in the middle part of the Caspian coast (in the territory of Gobustan botanical-geographical region). It is a honey-bearing plant. It is used in folk medicine.

Location: Garadagh district, Gobustan art reserve, south-slope of Alatsettlement, 1-2 km from Baku-Salyan Highway, saline grey-brown soil, winter pastures. At an altitude of 58, 2 m above sea level. May 15, 2019.

Collectors: E.M. Gurbanov, H.Z. Huseynova.

Discussion of results. In general, during the ecological-geobotanic researches carried out in the middle part of the Caspian coast, as well as morphological and systematic analyses of wild flora in natural plants of Absheron and Gobustan botanical-geographical regions, it was revealed that *Suaeda belongs to Forsk.ex.Scop. species., Suaeda heterophylla* belongs to Kar. et. dirt. Boiss., *Atriplex,* to the genus L, *Atriplex turcmonica* belongs to (Moq.) Boiss., Salsola, to L,

Salsola nitraria to Poll, *Erysimum, to L, Erysimum Caspicum to* N.Busch., *Astracantha Podlech*. to the genus *Astracantha Palcatus* Lam. and *Scrophularia* L. specific to the genus *Scrophularia Lebed wallicata.* For the first time the spread of species was determined by us and new spreading areas were noted. These species are endemic, rare, as well as essential oil, decorative and fodder plants.

Herbariums of the assigned plant species are kept in herbarium fund of the Botany Department of Baku State University.

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COLUTEA KOMAROVII TAKHT. SPECİES AT NAKHCHIVAN AUTONOMOUS REPUBLİC

TARIYEL H. TALIBOV
DOI: 10.30546/abc.2022.1.1.9
Institute of Bioresources of ANAS, Nakhchivan, Azerbaijan
t_talibov@mail.ru

Abstract. İn article, Colutea komarovii Takht. distributed in Nakhchivan Autonomous Republic, its position in the world flora and the phytocenoses formed by it are presented. At the result of conducted studies, due to the small population of this species and negative effects of zoogenic and anthropogenic factors it has been included in the protection status of Critically Endangered -CR B1ac (ii,iv); C2a(i) as a rare species. The condition of the species in nature has worsened due to the effects of continuous drought during last 3 years. This species was introduced in the collection of rare plants in the Botanical Garden and Institute of Dendrology.

Keywords: Colutea komarovii Takht., Nakhchivan AR, biological properties, rare species, phytocenosis

Introduction. Flora of Azerbaijan Republic occupies one of the most important places among the natural resources due to its biodiversity. The territory of Nakhchivan AR is also one of the selected regions in the Caucasus due to its soil-climate and orographic characteristics. Along with the vertical zonation (600-3906 m a.s.l.), the presence of many different landscapes has caused to the creation of a rich biodiversity of flora and fauna in the area. Currently, according to our research in the territory of Nakhchivan AR, there are 3020 species of higher plants belonging to 160 families and 910 genera, which is 60.4% of the flora (5000 species) of the Republic [Talibov and Ibrahimov et.al., 2021].

Discussion. The conducted studies showed that it is appropriate to include about 300 species of higher plants in the republished Red Book of Azerbaijan Republic, which the vast majority of those species were included in the Red Book of the former USSR at its period. Most of the rare or endangered species are represented by the only species within the genus. - 262 species belonging to 47 genera were found in the Leguminosae family (Fabaceae Lindl. family of Fabales Bromhead order, 1836 nom. cons. (= Leguminosae Juss., nom. cons.)) in the territory of Nakhchivan Autonomous Republic. Most of the species are of economic importance. In the territory of Nakhchivan AR three species which belong to the genus Colutea L. were found: *Colutea cilicica* Boiss. & Bal., *Colutea orientalis* Mill. and *Colutea komarovii* Takht. Among these species, *Colutea cilicica* Boiss. & Bal. is found in cultivated form, and others in nature. *Colutea komarovii* Takht. was considered an endemic plant of Azerbaijan and was included as a rare species at the Red Book of the former USSR and our Republic, and at the same time of Nakhchivan AR [Talibov and Ibrahimov 2010].

Colutea L. is a small genus that includes thorny shrubs or small trees with swollen capsule-like fruits. There are about 30 species distributed in the Mediterranean region, up to China, Himalayas, Northern and Southern Africa, mainly in arid zone mountains [Lock & Simpson, 1991]. 13 species in the territory of the former USSR [Sokolov and Shipchinsky, 1958] is indicated. From them 6 species are found in the Caucasus [Grossheim, 1952], 5 species (one species is cultivated) in Azerbaijan [Flora of Azerbaijan 1954], 2 species in Georgia [Flora of Georgia 1981].

PICTURE. *Colutea komarovii* - Flowers, fruits and seeds.

Currently, there are 3 species of the genus in the territory of Nakhchivan AR, including new species discovered by us. 13 species belonging to the genus Colutea have been found in the Iranian plateau, five of which are endemic.

For the first time, the *Colutea komarovii* was collected and described on June 24, 1929 by A.V. Shelkownikov and E. Gara Mirza from the dry, stony, gravelly, poorly vegetated slopes of Chaggal Mountain (the local population calls it Yellow Hill) on the right side of the stony road between the city of Ordubad and the village of Kotam.

In 1979, A. Sagatelyan noted that this species was found on the border between Kotam village of Ordubad region and Mehri village belonging to Armenia, but since 1984, we have conducted observations on this species with the aim of discovering new distribution biotopes. Our searches showed the absence of this species in the mentioned area. A. Sagatelyan's second mistake is that he did not know that there is Kilit village between Kotam village and Mehri village. In our opinion, A. Sagatelyan wanted to mention about the Chaggal Mountain (Yellow Hill) between Ordubad and Kotam village. Thus, this species is spread only in one place, including the territories of the former USSR - on the Chaggal mountain, located near Kotam village of Ordubad district, at an altitude of 857 m above sea level. During conducted researches, new distribution zones of *Colutea komarovii* were

identified, so we determined that the *Colutea komarovii* developed in the Alkar Rock near Chaggal Mountain and on the hills adjacent to it. F. Ghahremaninejad and M.A. Ghahremani for the first time collected *Colutea komarovii* species near the Araz River in Northern Iran. Those areas are close to the mentioned areas on the banks of the Araz river, in Ordubad region.

It is a bush with a height of 1-1.5 m and a particularly beautiful appearance when it blooms. The bark of its branches is smooth, its branches are thorn-like. The leaves are small, one, sometimes 2 pairs. The leaves are single, rarely bipinnataly, round or elliptic in shape, obtuse-pointed, 4-5 mm in length and 3-4 mm in weight, thick, finely wrinkled and sparsely, but densely hairy. The calyx is bell-shaped, the teeth are sharp. The corolla has a beautiful shape, the banner is red with a yellowish line, and the keel is with a reddish-yellowish line, and the nail is bigger than the calyx. Crescent-shaped wings are pressed into the keel. In the corolla petals, the nails are about equal, but the nail of the oval-shaped banner is larger than the calyx. Calyx wide, tubular or bell-shaped, covered with short, dense black or whitish hairs, teeth almost equal in length or two upper teeth shorter. 9 of the stamens are united and one is free. The ovary is on a freely visible pedicel, the ovules are numerous, the upper part of the style is bent into a hook shape. There are 5-6, and sometimes many seeds in a pod located on the stalk, which twists open from the tip as it ripens. The seed is kidney-shaped, naked, has a long stalk-shaped leg and is 18-22 mm long and 15 mm wide.

During our observation, we found out that the plant sprouted on April 8, flowered singly on April 17, and on May 15, there were flowers and newly formed seeds on it. While following the biology of the species, we discovered that the flowering continues intermittently, so that a bud, flower and fruit can be on the bush at the same time. Partial flowering is characteristic of almost all plants living in the harsh continental climate zone, because if return frosts destroy the opened flowers, after a few days the newly opened flowers are enough to produce seeds. Flowering with such intervals should be considered characteristic for Nakhchivan AR, which has a harsh continental climate. At the base of the bush there are many capsules of plant from last year. It reproduces by seeds. It is an important species for decoration and selection. It is a xerophyte.

Atropatan is included in the geographical area type. The vegetation which C*olutea komarovii* is also included belongs to mountain-xerophyte (frigana) vegetation, and the following species have been noted in the phytocenosis, formed at the lowest border of the autonomous republic. Although the dominance of the phytocenosis here is played by C*olutea komarovii*, other groups of plants, especially ephemerals and ephemeroids, are widespread, sometimes semi-desert elements are also found. In this vegetation type, *Rhamnus pallasii* Fisch. et C.A. May., *Zygophyllum atriplicoides* Fisch. et C.A. Mey., *Ephedra procer* Fisch et C.A. Mey., *Reaumuria persica* (Boiss.) Boiss., *Artemisia lerchiana* Web., *Astracantha microcephala* (Willd.) Podlech, *Astracantha aurea* (Willd.) Podlech, *Atraphaxis spinosa* L., *Acanthophyllum pungens* (Bunge) Boiss., *Onobrychis cornuta* (L.) Desv., *Peganum harmala* L., *Geranium tuberosum* L., *Papaver persicum* Lindl., *Hypericum scabrum* L., *Thymus kotschyanus* Boiss. et Hohen., *Teucrium polium* L., *Plantago lanceolata* L., also *Tulipa florenskyi* Woronow, *T. julia* C.Koch, *Ziziphora biebersteiniana* Grossh., *Glaucium elegans* Fisch. et C.A. May., *Stipa szovitsiana* L., *Aegilops cylindrica* Host. etc. have been noted.

C*olutea komarovii* has no natural reserve as it spreads in limited areas on the rocky, dry stony-pebble slopes of the middle mountain belt, and at the same time it is included in conservation status CR B1ac(ii,iv) ;C2a(i) as a critically endangered species due to its small population and the negative impact of zoogenic and anthropogenic factors. The condition of the species in nature has worsened due to the effects of continuous drought in the last 3 years. It was introduced by us in the collection of rare plants in the Botanical garden of the Institute of Bioresources, and at the same time

it was given to the Institute of Dendrology for introduction.

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THE CORRELATION BETWEEN COLOR OF FLOWERS AND HEALING ABILITIES OF MEDICINAL PLANTS

*NAZIM A. MAMEDOV, **SAYYARA C. IBADULLAYEVA

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**University of Massachusetts, Amherst, USA*
***Institute of Botany of ANAS, Baku, Azerbaijan*
***ibadullayeva.sayyara@mail.ru*

Abstract. The purpose of this paper is to study the correlation between the colors of medicinal plants' flowers and their pharmacological effects on the human body. It has been known from traditional herbal medicines that certain medicinal plants with the same color of flowers have similar effects on the body. By comparing the same color of flowers of medicinal herbs, we have found that there is a shared effect amongst medicinal plants with the same color flowers. Our findings

conclude that purple flowering herbs are mainly adaptogenic and also support the immune system, blue flowering herbs have anti-inflammatory properties, red flowering herbs will affect the blood, yellow flowering herbs help with digestion, white flowering herbs are mostly sedative or affect the nervous system, and herbs with no flowers help provide nutrients to the body. In the future, more investigation is needed to determine specific constituents in plants that are responsible for their pharmacological actions. The study of the correlation between colors of flowers and their healing abilities will help us select the correct medicinal plants for these future clinical studies.

Keywords: medicinal plants, color therapy, doctrine of signatures, adaptogens, sedatives, flowers

Introduction. Medicinal plants have been used for centuries to help aid the human body. Ancient Chinese and Indian medicinal systems focus on using herbs to treat diseases and to support the body's internal balance [Patwardhan *et al.,* 2005]. The basis of the healing that occurs in ancient medicine derives from the idea of balance. In Chinese medicine this balance is called yin and yang. Yin is considering cooling and dampening, while yang is warming and drying. By balancing these elements, the body will remain in a healthy, diseasefree state. Ayurvedic (Indian) medicine also focuses on balancing the elements of the body. In this tradition, the elements are referred to as: pitta, kapha, and vata. Pitta stands for heat and digestion, vata is wind, or movement, such as muscles and nerve impulses, and kapha is growth of tissue. These elements of balance are used to describe the energetics, the properties of something in terms of energy, of the herb. The energetics of a ginger root, for example, is warming because it stimulates digestion.

Characterizing an herb as hot or cold is one classification system to help the observer identify what kind of healing purpose the herb will have. The purpose of this paper is to provide a new schema to work with when identifying medicinal plants. The schema that we are proposing is the color of flowers. This framework will be based off of the doctrine of signatures, which states that the physical form of a plant will give a clue as to its healing purpose [Bennett, 2008]. By looking at a list of herbs and their flower colors, we are going to see if there is a correlation between flower color and effects on the body.

Studies have shown that color can have a direct effect on the psyche [Birren 1972] and physiologically [Vodvarka 2008]. Because color is such an obvious physical characteristic when looking at herbs, we believe it is an important concept for further research. Ancient systems have long regarded color as being beneficial to the mind/body. Egyptians used color rooms for healing by splitting the sun's rays into components. By using individual colors, they were able to see the effects of colors on persons. Using color as a way of healing has evolved into the new century and is now described as chromotherapy [Azeemie & Raza, 2005]. Another ancient practice that incorporates color in healing modalities is Ayurveda. The chakras are wheel like force centers that run down the body and correlate to specific functions and color. The first chakra starts at the base of the body and is red. The chakras then ascend up the color spectrum with orange near the sexual organs, yellow near the stomach, green near the heart, blue in the throat, indigo near the pineal gland, and purple on the crown of the head [Frawley, 1989].

In order to determine correct color of flowers we use our personal experience with plants and books for plant identification [Newcomb, 1977; Randushka et al., 1990].

Doctrine of Signatures / Hypothesis. The Doctrine of Signatures is a philosophy shared by herbalists. This theory promotes the idea that herbs resemble certain parts of the body, and therefore are effective at treating those

areas of the body. An example of this is the Panax Ginseng Root, which looks like the human body, and is also a very beneficial herb for the whole human body. Panax Ginsengis an adaptogen. The term adaptogen was originally coined by pharmacologist N.V Lazarev [Capasso et al., 2003; Mamedov, 2005] Adaptogenic plants increase the ability of the organism to adapt to environmental factors and resist the damage from stress-factors. Stimulants, on the contrary, only give a temporary increase of work capacity. Adaptogenic plants are thus performance enhancers. They work longer and do not drop off as sharply as stimulants do, but rather "taper off". We hypothesize that purple flowering plants will be adaptogenic. Purple is also the color of the crown chakra, which governs the nervous system. Another example of the doctrine of signatures is Red Clover that will be discussed later in this article. Red Clover has red flowers and it helps clean the blood, which is also red. We hypothesize that red is therefore stimulating and helps in blood circulation. Yellow is associated with the digestive system chakra. Bile is yellow and a lot of yellow flowering herbs help in bile production. We hypothesize that yellow flowering herbs help the digestive system. The doctrine of signatures serves as a theory to build correlation between physical characteristics of plants and their effects on the body. Therefore, we believe it is important to mention the doctrine of signatures in this paper.

Plant Constituents with Color Results. We hypothesize that purple flowering herbs are correlated with being adaptogens and helping the immune system. A study by Amagase & Nance [2008] showed the benefits of goji berries (a purple flowering herb) in a double-blind, placebo-controlled clinical study. The results show that the berries effects had significant differences between day 1 and day 15 in quality of sleep, ease of awakening, energy levels, athletic performance, ability to focus, calmness, and overall feelings of health, contentment, and happiness. In the chakra system, the color purple was used to signify the crown, or head chakra. This chakra governed the nervous system and any dis-ease related to it. *Vitex agnus-castus* L. is a purple flowering herb that helps regulate female hormones through the pituitary gland. *Astragalus membranaceus* L. and *Echinacea purpurea* (L.) Moenchn are both beneficial to the immune system [Block and Mead, 2003]. *Astragalus* is known as Huang Qi in Chinese medicine and is very beneficial to the immune system. *Astragalus* is highly regarded as an extremely beneficial herb due to its antioxidant, anti inflammatory, antibacterial, and immune stimulating properties. Holy Basil is an equivalent to *Astragalus* in Indian medicine. It is a sacred herb that has been called "The Elixer of Life." It was used by Hindus as a religious plant to aid in meditation and spirituality. Purple is a color that through the Indian chakra system, correlates to spiritual power. One of the ways that Holy Basil (*Ocimum tenuiflorum* L.) helps us deal with stress in our lives is it has a connection to cortisol levels. Cortisol is what we release under stress. So by regulating the cortisol levels, Holy Basil can help our bodies not become overly stressed. Holy Basil has a hot energetic level and it stimulates blood circulation, increasing blood flow to the brain. It nourishes our system because it is high in vitamins and minerals. Holy Basil relaxes the muscles and allows circulation to take place. High levels of cortisol may lead to insomnia. Sleep is imperative for a healthy, stress- free body. So, by consuming Holy Basil, you can allow your body to get a good night's rest so that the body can do its own job of keeping the stress levels at a balance. Holy Basil helps regulate the body's natural bipolar adaptonogenic hemeostatic balance. Holy Basil is so nourishing to the body that it can even work as anti-aging. Aging occurs when our cells stop working as they should and start dying faster than the rate that they can repair themselves. Therefore, if we keep our cells nourished and healthy, they will continue to regenerate, slowing down the process of aging. Holy Basil does this directly by assisting the liver, which is in charge of recycling toxins. The less toxins that are in the body, the less damage there are to cells. Common Sage (*Salvia officinalis* L.), Holy Basil, Astragalus, Burdock (*Arcticum lappa*

L.), Thyme (*Thymus vulgaris* L.), and Lavender (*Lavandula angustifolia* Mill.) are all antibacterial and purple flowering herbs. Astragalus, Holy Basil, Burdock, Licorice (*Glycyrrhiza glabra* L.), and Goji Berries are all purple flowering herbs that are adaptogens. Sage, Garlic, Holy Basil, Astragalus, Burdock, Milk Thistle, Thyme are all antioxidant herbs. Sage has hormonal properties and also helps those suffering from nervousness, overexertion, and insomnia. Lavender helps nervous system problems and insomnia. Chaste berry normalizes pituitary function. Milk thistle is a powerful live detoxifier and it is also antioxidant. Thyme prevents memory loss and inefficiency and also helps mental stability. Purple flowers seem to help the body resist disease from illness and stress by acting as adaptogens.

Ancient knowledge states that blue has a calming effect, brings down blood pressure, and helps in mouth/throat problems. We hypothesize that blue will have anti-inflammatory effects. A lot of blue flowers help reduce inflammation. Comfrey, Woodland Sage (*Salvia nemorosa* L.), Meadow Sage (*Salvia officinalis*L.), Lilac sage (*Syringa* L.) Common Harebell (*Campanula rotundifolia* L.), Throatwort *(Campanula trachelium* L.), Cornflower, Lungwort (*Pulmonaria officinalis* L.), and *Viola mandshurica* all are anti-inflammatory. Rosemary reduces stress and is used for tension headaches and relieves lung congestion. Comfrey also helps with the lungs. Himalayan Blue Poppy helps with high blood pressure, so its energetic property would be a slowing, or calming effect on the body. Himalayan Blue Poppy helps in pain, and so does Woodland Sage and Bellflower. Skullcap is antispasmodic, a nervine tonic, and relaxes nerve and muscle tension [Zhang, Lian, and Stringer, 2009]. Siberian Iris and Himalayan Blue Poppy help the lungs because they are expectorants. Chicory is mucilaginous and helps in liver problems.

Yellow helps in digestion, stimulating the stomach, gallbladder, and pancreas, and gives you the power to digest nutrients. We hypothesize that yellow will help ion digestion. While purple helps relax so that the body can digest, yellow helps stimulate (increasing gastric juice release) so that the body can digest. In the Doctrine of Signatures, bile is yellow and is very important to help digestion. St. John's Wort (Hypericum perforatum L.), Witch Hazel (*Hamamelis virginiana* L.), Calendula (*C.officinalis*), Damiana (*Turnera diffusa* Willd. ex Schult), Dandelion, (Taraxacum officinale (L.) Weber ex F.H.Wigg.) Mullein, Calendula, Golden Marguerite, Woundwort, Yellow Marsh Marigold, and Elecampane are all yellow flowering medicinal herbs that are bitter. Bitter taste stimulates the digestive system [Ibdullyeva et all., 2017]. This is done through the enteric nervous system. The bitter principle is known to aid in digestion by either bringing more blood to the stomach or stimulating the liver to create bile. Elecampane's bitter principle stimulates biliary secretion, which is important for the digestion of fats. Elecampane also helps in the digestive process because it contains insulin, a hormone produced by the pancreas. The role of insulin is to regulate our body's blood sugar content. Calendula helps the digestive system through its bitter principles and by healing any gastric and duodenal ulcers. It also helps in reducing inflammation in the digestive tract through its anti-inflammatory, anti bacterial, and wound healing abilities Akihisa [1996] and Chandran [2008]. Fennel is carminative and thus expels gas from the digestive tract. Yellow flowering medicinal herbs help the body by aiding in digestion, and also through their energetic properties. St. John's Wort is a bright yellow flower that helps in depression Lecruibier et. Al [2002]. Yellow is the color of the sun and life. Seasonal Affective Disorder (SAD) is a type of depression that occurs from lack of sunlight. St. John's Wort has bright yellow flowers like the sun, and it also aids in depression, which often occurs from lack of sunlight. This is an example of the Doctrine of Signatures. St. John's Wort has been studied over various experiments and is slowly becoming an acceptable alternative to anti-depressants, which often leave people feeling more depressed than they did before. St. John's Wort is a healthy alternative to treating depression because it

stimulates digestion, which might be a problem with people that are depressed and have a low appetite, it increases capillary blood flow, and it increases theta waves in the brain which may improve perception and clarify the thinking process. St. John's Wort is known to bring light to people to that are prone to fear and anxiety attacks. It does this by detoxifying the liver. All of these effects together allow St. John's Wort to be beneficial to the body and aiding it in general, but especially for people who are depressed. St. John's Worts' flowers resemble the sun and the light energy that it gives us. California Poppy is another yellow flowering herb that helps depression by helping relax the nervous system. Dandelion and Burdock are one of the most common herbs used in liver detoxifying and they both are yellow flowering medicinal herbs. Cornelian cherry helps in stomach aches, cramps, and diarrhea. Bladder Senna is diuretic, purgative and laxative.

A lot of red flowering herbs are stimulating. Cloves, Ginger, Valeriana Collina, and Papaver Sominferum are all stimulating to the body. We hypothesize that red affects blood. Red is the color of blood and a lot of red flowering herbs also help the blood. *Valeriana sambucifolia* reduces blood pressure, *Rhododendron arboretum* is anti-inflammatory and anti-diabetic, French Rose is stimulating and lowers elevated levels of cholesterol in the bloodstream, *Althea rosea* is anti-inflammatory and improves blood circulation, and the dwarf almost is stimulating and improves digestion. Ginseng balances blood pressure and normalizes blood protein levels. Red Clover, Cloves, Gotu Kola and Ginger all are stimulating and help move the blood. It is important to move the blood so that the body can get its oxygen and nutrients, and it is also important to have clean blood so that the blood is not delivering toxins to the body. Red Clover is a wonderful herb for cleaning the blood. A lot of disease occurs and skin conditions result from toxins in the blood. The skin is an organ used to protect toxins from getting in, and for releasing toxins. Our skin is a protective layer, and when our blood is full of toxins, it shows in skin conditions such as acne or eczema. So if there is a skin condition, it is important to look at the blood and also the functioning of the liver and kidneys. This is why red clover is often found in liver detoxifying formulas. The red clover helps detoxify the liver, which enables the liver to do its job of detoxifying the blood. Gotu Kola stimulates the blood, and is also an important herb in helping to stimulate mental activity, which it does by stimulating circulation to the brain. In Chinese medicine, Gotu Kola was used to improve memory. Recent studies show Gotu Kola also helps in Alzheimer's Xu et. Al (2008) This may be due to the herb's antioxidant quality or that this herb reduces an oxidant known as nitric oxide, which is triggered by the build-up in the brain of beta-amyloid plaques associated with Alzheimers. The dwarf almond is a stimulating herb because it stimulates both respiration and improves digestion.

Medicinal herbs that do not have a distinct color to their flowers or are non-flowering are going to be classified under the color green. We hypothesize that green non-flowering herbs are building herbs that help support the body by being high in vitamins and nutrients. Some such herbs that are high in vitamins and nutrients are: Stinging Nettle, Mugwort, Aloe, Yellow dock, Blue Cohosh, Stoneroot, Wild Yam, and Horsetail. These herbs are supportive due to their nutritional value. Stinging Nettles are extremely high in minerals and vitamins. Yellow Dock stimulates the liver and is a laxative. They are a very high source or iron and also vitamin A, and vitamin K. Mugwort is also very nutritive and contains vitamin A, and vitamin K. Other than being extremely nutritive, a lot of green flowering and non-flowering medicinal herbs are called tonics. Tonic herbs nourish specific cells, tissues, organs, and can be used for long periods of time. Tonic herbs can help normalize the body by restoring balance by either increasing an action or decreasing, depending on what the body needs. Green medicinal herbs that are tonics include Blue Cohosh, Wild Yam, Horsetail, and Stinging Nettles. More specifically, False Unicorn Root is a uterine tonic, Aloe is a

bitter tonic and Mugwort is a liver tonic. Seabuckthorn is good for the stomach, kidneys, ulcers, skin cancer, skin burns, and orange berries.

We hypothesize that white flowering herbs will either be sedative or affect the nervous system. A lot of white flowering herbs are part of the mint family. Basil, Chamomile, Spearmint, Catnip, Feverfew, Valeriana, Lemon Balm and Lemon Verbena are all white flowering herbs that are in the mint family. A lot of white flowering herbs are sedatives. A sedative lowers blood pressure and is calming. Basil, Chamomile, Spearmint, Catnip, Feverfew, Valerian, Lemon Balm, Valerian Off., Cramp Bark, Black Cohosh and Lemon Verbena are all sedatives. A lot of white flowers herbs are also nerviness. A nervine is something that supports the nervous system. Black Cohosh, Basil, Spearmint, and Chamomile are nerviness. Cleavers are lymphatic and cleanse the lymphatic system and cools down any "hot" inflammation. Chamomile, Lemon Verbena, Lemon Balm, Basil, Spearmint, Catnip, Valerian, Cramp Bark, and Black Cohosh are antispasmodic. Elderberry is one of the top herbs used to cure colds and flus. While the flowers of the plant are white, the berries themselves are purple. It is important to note that if an herb calms down the nervous system or muscles, then it will in turn have a positive effect on the digestive system.

Experimental Procedure. By comparing our classification system to a random list of commonly used herbs [O'Hara *et al.,* 1998], we will see if our hypothesized effects are congruent with the common uses of these herbs. We hypothesized that white will affect the nervous system or be a sedative. Chamomile is listed as a sedative, which is in line with our hypothesis, Feverfew helps with headaches and helps diarrhea in children, Saw Palmetto effect's androgen and estrogen receptors, and Valerian is spasmolytic. Ginseng is listed as adaptogenic, reducing stress, having estrogenic and androgenic effects, and improving cognitive functioning. Goldenseal is not in line with our hypothesis becauses it is listed as having berberine and antiseptic effects. We hypothesized that purple should either be an adpatogen or support the immune system. Echinacea is listed as helping the immune system. Garlic is light purple/light pink and helps the immune system with its antioxidant and antibacterial properties. It also lowers blood pressure. Milk Thistle helps the immune system by protecting against hepatitis and cirrhosis and is also antioxidant. We predict yellow helps in digestion and St. John's Wort helps digestion by restoring bowel tone, reducing inflammation. Because some serotonin is produced in your intestines, this explains the connection between the digestion improvement and alleviation of depression. We hypothesize that red will affect the blood. Ginger is listed as helping against nausea, which is not in line with the hypothesis. Garlic is listed as being antiplatelet (helping against blood clots) and is antihypertensive, which is in line with our hypothesis.

Plants with adaptogenic properties

Purple: *Lycium barbarum* (Solanaceae) - antioxidant

Astragalus membranaceus (Fabaceae)- antibacterial, antioxidant, cardiotonic, diuretic, febrifuge, hypoglycaemic, tonic, tterine tonic, vasodilator.

Arctium lappa (Asteraceae) - alterative that moves body into a state of nourishment, promotes healing of wounds. Works through the liver and kidneys to remove waste, so it's great for the end result of skin. Mildly bitter, aids in digestion (Rost, 2009)

Ocimum sanctum (Lamiaceae) - antibacterial, anti-inflammatory, antioxidant, anti-stress, anti-toxic effect, anti-tussive, anti-ulcer, cardiovascular activity, diaphoretic, febrifuge, nervine, antispasmodic, antibacterial, antiseptic, wound-healing activity.

Glycyrrhiza glabra (Fabaceae)- adaptogen, helps stomach ulcers, helps bronchitis and sore throats because it is mucilangenous.

White: *Panax ginseng* (Araliaceae) -adaptogen. Its adaptonogenic qualities means it prevents against infectious diseases, lessens muscular fatigue. It helps balance hypertension and reducse damage from radiation. It has effects on adrenal cortex, also has affinity for balancing either a too low or too high

blood pressure – circulatory affinity (Rost, 2009).

Green (orange berries): *Hyppophae rhamnoides* (*Eleagnacceae*) -skin disease, skin cancer, skin burn, ulcers.

Plants used for treatment of upper respiratory tract diseases

Bright Blue: *Symphytum officinale* (Boraginaceae)- anodyne, alterative, anti-inflammatory, antiheumatic, antiseptic, astringent, biogenic stimulator, demulcent, emollient, expectorant, haemostatic, immune stimulant, lung tonic, nutritive, pectoral, Refrigerant, styptic, vulnerary, yin tonic, nutritive tonic. Vulnerary, demulcent, one of the best herbs for wound healing. Anti-inflammatory and soothing to a dry digestive tract, astringent

Salvia nemorosa L. (Lamiaceae)- has anti-nocioceptive activities (helps in the head against pain), anti-inflammatory.

Salvia pratensis L. (Lamiaceae)- bactericidal (against breathing diseases), heals ulcers and wounds, anti-asthmatical and helps inflammation. Leaves contain estrogen substance, vitamins B1 and C. Carminative, estrogen, astringent, antiseptic. Bitter and used as stimulant due to hypothermic effect.

Blue/Purple: *Salvia verticillata* L. (Lamiaceae)-antioxidant activity, anti-inflammatory.

Pulmonaria officinalis (Boraginaceae) Helps diseased lungs, chest and asthma. It is demulcent, expectorant, astringent, anti-inflammatory and vulnerary.

Blue: *Campanula rotundifolia* (Campanulaceae) -helps inflammation (of the mouth). *Campanula trachelium*-helps in pain in throat. Inflammatory and throat help.

Centaurea cyanus (Asteraceae) - astringent, reduces inflammation.

Viola mandshurica (Violaceae) - anti-asthmatic and anti-inflammatory.

Iris sibirica L. (Iridaceae) - it is an expectorant and anagelsic (treats pain).

Purple: *Thymus vulgaris* (Lamiaceae) - antihelmintic, antibiotic, antifungal, antimicrobial, antioxidant, antiseptic, antispasmodic, antitussive, aromatic, astringent, bronchial dilator, carminative, decongestant, diaphoretic, emmenagogue, expectorant, immune tonic, rejuvenative, rubefacient, sedative (in small), stimulant (in large), vermifuge, vulnerary. Strong antibacterial for mouth and lung infections, destroys intestinal worms. Relieves indigestion, coughs, and lung congestion. Prevents memory loss and inefficiency. Helps in mental stability (ibadullayeva, 2013).

Echinaceae purpurea (Asteraceae) - antioxidant, supports immune system, immune stimulant, anti-microbial, anticararrhal, and alterative (Rost 2009).

Plants for treatment of gastro-intestinal tract diseases

Hypericum perforatum (Hypericaceae) - anti-inflammatory, antiseptic, antispasmodic, aromatic, astringent, antidepressant, cholagogue, digestive, diuretic, expectorant, nervine, resolvent, stimulant, vermifuge vulnerary, sedative, analgesic, antiseptic. Immune stimulant, good for retro-viral infections, expectorant, antibacterial, speeds wound and burn healing, antidepressant.

Yellow: *Hamamelis virginiana* - astringent, anti-hemorrhagic, anti-inflammatory, antihydrotic, haemostatic, homeopathy, miscellany, sedative, stypic, tonic.

Calendula officinalis (Asteraceae) - anti-inflammatory, astringent, styptic, emmenagogue, vulnerary, lymphatic, antimicrobial, antifungal. Excellent for digestive inflammation and ulcers. Cholagogue for relief of gallbladder problems. Good for wounds, ulcers, burns, abscesses. It is a bitter herb

Turnera aphrodisiaca (Passifloraceae) tonic, antidepressant, euphoric, aphrodisiac, urinary antiseptic, aperient, mild laxative, aphrodisiac, digestive, infertility, tonic, astringent, purgative, stimulant. Mood elevating that helps calm anxiety and induce a relaxed state of mind. Aphrodisiac (Rost 2009)

Taraxacum officinale (Asteraceae) - alterative, anti-rheumatic, astringent, blood purifier, cholagogue, carminative, bitter, detergent, diuretic, diaphoretic, laxative, nutritive tonic, stimulant, stomach, sudorific, tonic. Liver tonic, hepatic “cools” or detoxifies the liver, cholagogue decongests the gallbladder by increasing bile flow, choleretic action promotes bile production, alterative relieving skin

disorders, laxative, bitter, lots of potassium.

Verbascum thapsus (Scrophulariaceae) - expectorant, respiratory remedy because it tones the mucous membrane, reduces inflammation, stimulates antispasmodic, alterative, astringent, anodyne, vulnerary, anti-infammatory. Very good for inflammation of the skin fluid production. Demulcent, diuretic, nervine (Rost 2009).

Inula helenium (Asteraceae) -expectorant, antispasmodic, carminative, analgesic, rejuvenative.

Foeniculum vulgare (Apiaceae) Carminative, stimulates digestion and appetite, antispasmodic, anti-inflammatory, galactogogue.

Orange/yellow: *Anthemis tinctoria* L. (Asteraceae). Bitter tonic and antispasmodic

Anthyllis vulneraria L. (Fabaceae) - antiseptic, antispasmodic, astringent, bitter tonic, cholagogue, diuretic, immune stimulant, support metabolism, also for wound healing

Caltha palustris L. (Ranunculaceae) - anodyne, antispasmodic, diaphoretic, diuretic, expectorant. Bitter!

Cornus mas L. (Cornaceae) -astringent. Used in cases of fevers and diarrhea. Helps in stomach aches, cramps, diarrhea

Colutea arborescens L. (Fabaceae) Diuretic, purgative, laxative.

Green, Reddishbrown/whitishgreen: *Rumex crispus* (Polygonaceae)-alterative, astringent, laxative, antipyretic. Hepatic liver stimulant (cleansing) and laxative. Cholagogue. Alterative for oily and exudative skin conditions. Helps remove metabolic waste from the blood = better skin.

Cichorium intybus (Asteraceae)-appetizer, cardiac, cholagogue, depurative, digestive, diuretic, hypoglycaemic, laxative, tonic, warts.

Artemisia vulgaris emmenagogue, antispasmodic, hemostatic, diaphoretic, anthelmintic, antiseptic bitter tonic and digestive stimulant, antioxidant, cholagogue, nervine tonic, eases tension, emmenagogue.

Urtica dioica (Urticaceae) -alterative, detoxifying agent which clears out waste, streghtens the mucosa of the urinary, digestive, and respiratory system. Prevents uric acid buildup in joints and helps in arthritis. Astringent so it helps in excessive blood loss and sischarge. Good prostate tonic. Diuretic and hypotensive

Dioscorea villosa (Dioscoreaceae) - antiinflammatory, antispasmodic, cholagogue, contraceptive, diaphoretic, homeopathy, vasodilator.

Aloe vera (Liliaceae) -alterative, bitter tonic, rejuvenative, emmenagogue, purgative, vulnerary, laxative

Equisetum arvense (Equisetaceae) anodyne, antiseptic, astringent, cardiac, carminative, diaphoretic, diuretic, galactogogue, haemostatic, homeopathy, nervine, vulnerary.

Yellowish green: *Caulophyllum thalictroides* (Berberidaceae) antibiotic, anti-inflammatory, anthelmintic, antispasmodic, diaphoretic, diuretic, emmenagogue, immune-stimulating, antimicrobial

White: *Galium aparine* (Rubiaceae) - lymphatic, lymphatic cleanser that relives swelling, especially where there is an acute “hot” inflammation, it is a cooling diuretic that soothes an irritable urinary tracts; tonic, and alterative (Rost 2009)

Hydrastis canadensis (Ranunculaceae)- Hepatic, cholagogue, bitter digestive stimulant, antimicrobial, great tonic stimulant for profusely excreting mucous membranes, anticatarrhal, astringent, emmenagogue

Plants for improving blood circulation

Red: *Zingiber officinale* (Zingiberaceae) - adjuvant, antiemetic, analgesic appetizer, aromatic, carminative, diaphoretic, expectorant, indegestionrubefacient, sialagogue, stimulant,

Stimulant, warming ny increasing peripheral circulation; very great fr nausea and motion sickness, anodyne for intensinal pain, carminative, anti-spasmodic in digestive tract, anti-inflammatory, emmenagogue, anti-microbiral (Rost 2009)

Rosa canina L. (Rosaceae) Stimulating. It lowers the elevated cholesterol levels in our bloodstream, and rose water is astringent, cardiovascular system stimulant

Papaver somniferum L. (Papaveraceae) - Stimulant that induces euphoria and reduces anxieties and tensions, analgesic

Valeriana sambucifolia Mikan fil. (Valeria-

naceae) -Nervine tonic, stimulating, good for poor blood circulation, antispasmodic and emmenagogue. (Rost 2009)

Rhododendron arboreum Sm. (Ericaceae)- Anti-inflammatory, anti-cocipceptive, hepto-protective, anti-diabetic, antioxidant

Althaea rosea (L.) Cav. (Malvaceae) - antiiflammatory, astringent, demulcent, emollient.

Improves blood circulation

Trifolium pratense (Fabaceae) - -alterative, anti-inflammatory, antispasmodic, dermatonic, diuretic, expectorant, sedative. Blood cleanser, nutritive, galactagogue (İbadullayeva et al., 2013)

Eugenia caryophyllata (Myrtaceae) - Stimulant, carminative, aphrodisiac, expectorant. Eliminate tooth ache, treats flu, sore muscles, arthritis, colds, and bronchial congestion, and is heating. Helps in pain. As a stimulant clove helps overcome nervousness, stress, and mental fatigue, and poor memory.

Light purple/light pink: *Allium sativum (*Liliaceae) -antioxidant, antibiotic, antimicrobial, antiseptic, antiviral, anthelmintic. Good for colds, chronic bronchitis, and infections.

Reduces blood pressure and cholesterol (Gasimov et al., 201)

Amigdalus nana L. (Rosaceae) - In small amounts, the hydrocyanic acid of the plant

stimulates respiration and improves digestion.

Silybum marianum (Asteraceae) - antidepressant, antioxidant, appetite stimulant, Astringent,

Bitter, cholagogue, demulcent, diaphoretic, diuretic, emetic, emmenagogue, galactagogue, hepatic, hepatoprotective, stimulant, stomachic, tonic. Powerful liver detoxifier, increases secretion and flow of bile. Galactagogue (İbadullayeva).

Centella asiatica (Mackinlayaceae) - nervine, Rejuvenative, alterative, febrifuge, diuretic, helps heal wounds

White: *Sambucus nigra* (Caprifoliaceae) - Leaves externally- vulnerary and emollient; internally leaves are purgative, expectorant, diuretic, and diaphoretic. its flowers are diaphoretic, and gently stimulating. Berries are diaphoretic, diuretic, aperients. Very well known for curing colds, fues, skin eruptionsm tension, constipation.

Plants used for treatment of CNS diseases

Ocimum basilicum (Lamiaceae) antifungal, antioxidant, antispasmodic, aromatic, carminative, cephalic, diaphoretic/sudorific, digestive, emmenagogue, expectorant, febrifuge, galactagogue, nervine, refrigerant, stimulant, stomachic, relives headache, sinus congestion, nauseam ubdegestionm sore muscles, and herpes. Stimulates the adrenal glands and menstruation. Reduces stress and rattled nerves, and menta fatigue.

Matricaria recutita (Asteraceae) Sedative, carminative, anodyne, anti-inflammatory, pain relieving, antispasmodic for easing muscle cramps; nervine (İbadullayeva).

Mentha spicata (Lamiaceae) antiemetic, antiseptic, antispasmodic, cancer, carminative, diuretic, nervine poultice, restorative, stimulant, stomachic. stimulant (Rost 2009).

Nepeta cataria (Lamiaceae) - Anaesthetic, antibiotic, anodyne, antispasmodic, aromatic, astringent (Mamedova)

Tanacetum parthenium (Lamiaceae) - antiecchymotic, antiinflammatory, antispasmodic, aperient, bitter, carminative, emmenagogue, nervine, sedative, stimulant, stings, stomachic, vasodilator, vermifuge, carminative, diaphoretic, diuretic, nervine.

Valeriana officinalis (Valerianaceae) - Nervine, antispasmodic, sedative, carminative

Melissa officinalis (Lamiaceae) - Antispasmodic, antiviral, carminative, cholinergic activities diaphoretic, digestive tonic, emmenagogue, febrifuge, hypotensive, memory-improving (due to cholinergic activities identified in extracts of lemon balm), nervine, rejuvenative, sedative, sleep disorders, stomach tonic. Reduces fevers in a cold or flu as it induces mild perspiration. Aids digestion, reduces flatulence. Antiviral and used for herpes. Treats indigestion, lung congestion, high blood pressure, menstrual problems, and infertility. Fights inflammation and viral infections such as strep. Its sedative to it can help in distress, shock, depression, *a* nervousness, and insomnia.

Aloysia citrodor (Lamiaceae) -

antispasmodic, aromatherapy, astringent, febrifuge, sedative, stomachic.

Viburnum opulus (Adoxaceae) - antispasmodic that relives voluntary and involuntary muscle spasms, helps in convulsions, asthma, thigh and back pain, anti-inflammatory and a nervine, astringent

Cimicifiga racemosa (Ranunculaceae) - antispasmodic, anti-inflammatory, analgesic, nervine (Rost, 2009)

Purple: *Salvia officinalis* (Lamiaceae)-alterative, antioxidant, antiseptic, antispasmodic, astringent, carminative, cholagogue, emmenagogue, galactofuge, rejuvenative, stimulant, tonic, vasodilator. Antiseptic that treats throat and mouth infections. Hormonal properties help regulate both the mentraul and menopausal cycle and decrease lactation. Reduces perspiration, oily skin, and acne. Helps those suffering from nervous devility, excessive sexual desire, overexertion, and insomnia.

Lavandula angustifolia (Lamiaceae) - analgesic, antibacterial, antidepressant, antifungal, antirheumatic, antiseptic, antispasmodic, aromatic, carminative, cholagogue, digestive tonic, diuretic, nervine, rubefacient, sedative, stimulant, stomach tonic.

Treats lung, sinus, and vaginal infections, relieves muscle pain, headaches, and other types of inflammation. Used for digestive disturbances and boosts immunity. A skin-cell generator, prevents scarring and stretch marks. Helps central nervous system problems and insomnia.

Vitex agnus-cactus (Verbenaceae) Uterine tonic and stimulates and normalizes pituitary function (Rost 2009)

Lycium barbarum (Solanaceae)- adaptogen, antioxidant

Astragalus membranaceus (Fabaceae) - adaptogen, antibacterial, antioxidant, cardiotonic, diuretic, febrifuge, hypoglycaemic, tonic, uterine tonic, vasodilator

Arctium lappa (Asteraceae)-adaptogen, alterative that moves body into a state of nourishment, promotes healing of wounds. Works through the liver and kidneys to remove waste, so its great for the end result of skin. Midly bitter, aids in digestion.

Ocimum sanctum (Lamiaceae) - adaptogen, antibacterial, anti-inflammatory, antioxidant, anti-stress, anti-toxic effect, anti-tussive, anti-ulcer, cardiovascular activity, diaphoretic, febrifuge, nervine, antispasmodic, antibacterial, antiseptic, wound-healing activity

Glycyrrhiza glabra (Fabaceae)- adaptogen, helps stomach ulcers, bronchitis, sore throats, because it is mucilangenous

Lycium barbarum (Solanaceae) - adaptogen, antioxidant

Blue/Purple: *Scutellaria lateriflora* (Lamiaceae)- Nerve tonic, mild sedative, antisasmodic. Primary nervous system tonic and relaxant for nerve and muscle tension. Good for seizures and epilepsy. Cardiac relaxant. Bitter

Rosmarinus officinalis (Lamiaceae) Reduces stress Circulatory and nerve stimulant, used for tension headache assosciated with dyspepsia. Antibacterial, antifungal. Stimulates poor blood circulation, low pressure, adrenal glands, and gallbladder. Lowers cholesterol and relieves lung congestion, sore throat, and canker sores. Improves memory and is a spiritual streghtening herb.

White: *Serenoa repens* (Arecaceae)- affects androgen and estrogen levels

A reliable peripheral vasodilator, excellent

Green: Ginkgo biloba (Ginkgoaceae) Slows cognitive deterioration supportive agent to help remedy erectile dysfunction. Increases blood circulation and flow of oxygen to the brain and helps counter the effects of antideoressants on sexual function. It has a direct effect on endothelial cells that enhance blood flow of both penile arteries and veins without any change in systemic blood pressure. Support sexual function by enhancing blood circulation while concurrently improving the nitric oxide pathways.

Yellow: *Eschscholzia californica* -nervine relaxant, antidepressant.

Conclusion. In conclusion, our hypothesis predicted that purple flowering herbs will either be adoptogenic or support the immune system, and three out of three herbs fit this description from the List of 12 Common Herbs. There were no blue flowering herbs listed. One out of 2 red flowering herbs fit our hypothesis,

1 out of 1 herbs fit out hypothesis for yellow flowers, 5 out of six white flowering herbs fit our hypothesis, and there were no non-flowering herbs in the list. The results from our research show that there is a correlation between white flowering herbs having sedative or affecting the nervous system, purple in being either adaptogenic or immune supportive, yellow with helping the stomach, and perhaps that red effects the blood. This is in line with our hypothesis that there is a correlation between the color of medicinal plants' flowers and their effects on the body. Further investigation should determine shared biologically active compounds medicinal plants of a certain color have that may affect their flower color. It is important to continue research as there is no previous research in this area. Future research will help choose appropriate herbs for clinical studies.

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ENVIRONMENTAL CHALLENGES AND THE FUNDAMENTAL IMPORTANCE OF BIOMONITORING AND BIOINDICATION AS FACTORS FOR OPTIMIZING BIO-SOCIAL ECOSYSTEMS IN THE TERRITORY OF AZERBAIJAN

AFAT O. MAMMADOVA
DOI: 10.30546/abc.2022.1.1.23
Baku State University, Baku, Azerbaijan
afatmammadovat@bsu.edu.az

Abstract. On the territory of the Azerbaijan Republic, significant research has been carried out in the field of biomonitoring, bioindication and biotesting of components of natural landscapes. The development of these studies is relevant both from scientific and practical points of view by conducting systematic research in the field of biomonitoring, bioindication, and biotesting in the arid zone of the country as a unified landscape system, considering the possibility of using the results obtained in the field of tasks the development needs of the current and prospective economy.

Keywords: arid zone; intensive farming; pollution; biomonitoring; biotesting; organic farming

The area of the Republic of Azerbaijan is 86, 692 km^2. The growing pace of anthropogenic development of the territory and the intensification of their farm or agricultural use raises questions about rational planning of territories, their optimization and sustainable balanced development. This problem can include the preservation of biological and landscape diversity and the ecological stabilization of territories, and often, especially characteristic of the Aran zone of the country, and the restoration of lost ecological balance and sustainability. High rates of urbanization, a high degree of plowing of territories, excessive fragmentation and transformation of preserved natural territories make it impossible to ensure the sustainability of ecosystems. Therefore, the unfulfillment by their elements of essential ecosystem functions calls into question the possibility of sustainable development of the territory because environmental degradation inextricably affects economic and social development.

In this regard, taking into account the aggravation of environmental problems in a significant part of the territory of Azerbaijan (deforestation, pollution, degradation, soil erosion, pollution of aquatic ecosystems (surface and ground waters), atmosphere), in the country along with other areas of ecology, multifaceted studies were launched in the field of biomonitoring, bioindication and biotesting of natural and technogenic landscapes. These studies were carried out at various levels of

the landscape system (vegetation and soil cover, water), and at the level of individual species and populations.

The ecobiological traits of the *Quercus* L. species were studied, and the prospects of their use for environmental monitoring were shown [Mammadova A.O., 2021]. It was revealed that the fluctuating asymmetry indicators of *Quercus longipes* Stev. leaves can be used to assess the quality of the environment [Mammadova R.N. and Mammadova A.O., 2014]. An integrated assessment of the environmental quality was carried out by the fluctuating asymmetry of some woody plants species leaves under the conditions of Absheron [Mammadova, R.N. et all., 2015]., and parameters of chlorophyll fluorescence and fluctuating asymmetry of the leaves of a woody plant – *Quercus castanefolia* C. A. Mey. in the conditions of the city of Baku [Mammadova, 2020].

In a comparative aspect, the bioindicative parameters of *Quercus pubescens* Willd. were studied in natural forest phytocenoses and under the influence of traffic flows [Mammadova R.N., 2019].

An integrated assessment of the disruption of individual stable development in the ontogenesis of woody plants *Platanus orientalis* L., *Populus nigra* L., *Pinus eldarica* Medw., which arose as a result of motor vehicle pollution in the conditions of Absheron, was carried out [Farzaliyeva N.M., 2018]. Based on the results, the ecological situation of the study areas was assessed, and their ecological zoning was carried out using GIS technology. For the first time, based on the indicative parameters of the studied plants, a map of the environmental assessment of motor transport territories was compiled. Also, the indicative parameters of the studied plants and mycobiota were determined in conditions of motor transport pollution [Farzaliyeva N.M., et al., 2018].

Some works have been carried out in biomonitoring soils contaminated with petroleum hydrocarbons [Ismayilov, 1982]. It was shown that hydrocarbon pollution is accompanied by substantial changes in the structure and functional activity of soil microbiocenosis – their number and qualitative composition change, which leads to partial or complete degradation of soils. In gray-brown soil, the number of denitrifying, ammonifying and nitrogen-fixing bacteria may increase [Ismayilov, 1983]. The increase of denitrifiers and nitrogen fixers in oil-contaminated soil may be associated with an excess of organic compounds and an increase in the number of anaerobic microzones in polluted soil [Ismayilov, 1982, 1988a].

The role of microorganisms in the self-purification of oil-contaminated soils and and the resistance of various types of soils along export pipelines to oil pollution was shown. The ability of hydrocarbon-oxidizing microorganisms to grow at elevated temperatures in soils was determined [Ismayilov, et all., 2004]. The effect of hydrocarbons on soil enzymes was investigated [Ismayilov, and Panahova, 2010].

Bioindication of reservoir waters in the oil fields of Absheron revealed the possibility of using reservoir microorganisms to develop modern biotechnologies to increase the oil recovery of oil reservoirs with a high economic effect [Ismayilov, 2016].

Studies have been carried out on the bioindication and assimilation potential of mud volcanoes in the territory of Azerbaijan, and for the first time, measures have been proposed for the formation of phytocenosis networks around volcanoes as an integral part of a single eco-framework in the country [Ismayilov, et all., 2018].

Bioindication methods were used to assess the degree of self-purification of groundwater on the territory of Azerbaijan and the environmental risks associated with the entry of polluted waters into the coastal zones of the Caspian Sea and the negative impact on its biosystems [Ismaylov, Aliyeva, 2018].

Bioindication has shown that in gray-brown soil contaminated with crude oil, the number of soil invertebrates decreases as the contamination increases, up to their complete absence with a high degree of contamination [Samadov, 2008; 2011]. Significant changes in the structure and activity of soil microfauna on technogenically polluted soils were shown [Samedov, et al., 2011].

A monograph covering modern approaches and methods of biomonitoring, bioindication and biotesting was published for the first time in the country [Mammadova A.O., 2008].

The conducted studies are undoubted of great scientific importance. They demonstrate the sensitivity of biosystems under the pressure of anthropogenic and technogenic factors, as a result of which their structure changes, trophic relationships are disrupted, and, in general, the homeostasis of biosystems is disturbed.

At the same time, it should be noted that a systematic analysis of the studies conducted in biomonitoring or bioindication is generally fragmented and disparate. At the present stage, to solve the problems of sustainable development and ensure self-sufficiency in agricultural products, it is difficult to assess changes in the soil cover, phytocenoses as a single biosystem in a specific soil-climatic zone, to develop programs and proposals for their optimization.

In this regard, it becomes relevant both from scientific and practical points of view to conduct systematic research in the field of biomonitoring and bioindication together with biotesting in a specific soil-geographical zone as a single landscape system, taking into account the possibility of using the results obtained in the field of problems of the development needs of the current and promising economy.

Thus, carrying out systematic research in the field of biomonitoring, bioindication in the arid zone of the country (pic.) as a single landscape biosystem, which is most susceptible to anthropogenic and technogenic pressure, will make it possible to identify the most sensitive, most disturbing zones in order to give on this basis an objective assess the degree of their disturbance, create modern systems for the effective management of these zones, restore their biogenicity, sustainability, bioproductivity, ensure the production of environmentally friendly agricultural products.

The problem is that the intensification of agricultural production using chemical technologies in Azerbaijan and throughout the world in the previous period was accompanied by the development and aggravation of environmental problems – degradation, pollution of soil covering and aquatic ecosystems by pollutants of organic or inorganic nature. Currently, Azerbaijan is making efforts to prepare the infrastructure necessary for organic agricultural production. The Law "On Organic Agriculture" (June 13, 2008) established general rules for developing organic agriculture in Azerbaijan.

PICTURE. Arid zone of Azerbaijan – light green color

In this regard, the issues of Azerbaijan's policy in the field of agriculture are considered, and it is noted that organic agriculture products are a potentially promising direction, including for export. are considered [Kharitonov, 2015; Uygun Aksoy et al., 2018]. At the same time, these works and projects do not at all consider environmental problems (anthropogenic and technogenic pollution of soils and water ecosystems), which potentially hinder the production of agricultural products in some regions of Azerbaijan, primarily in the arid zone, and do not discuss ways to overcome them.

System analysis shows that there are some limitations to the development of ecological farming in the arid zone of the country. These are first-order limiters of anthropogenic and technogenic nature (population growth and the rate of use of natural resources with negative environmental consequences) and second-order limiters are of a natural character.

The first-order limiters include:

• Polluted soil cover in the Aran zone;

• Polluted surface waters – waters of the Kur, Aras, and Samur rivers.

The second-order limiters include climatic factors:

• a consistent increase in the average annual temperature in the country, to the greatest extent in the Aran zone - about 1.90 C in recent years, and negative forecasts in the coming decades);

• as a consequence of climate change, the water balance in the country has decreased by about 30% in recent years.

The territory of the arid zone is characterized by the production of food and industrial crops: fruit and berry (walnut, pear, pomegranate, quince, plum, fig, cherry, dates, pistachios, medlar, apricot), cotton, cereals, and legumes (barley, wheat), vegetables (onions, cucumbers, tomatoes, cabbage). In this regard, we consider it necessary to conduct biomonitoring of the state of crops growing in the fields of the arid zone. In laboratory conditions, it is necessary to conduct fundamental research on biotesting the resistance of different types of crops to different doses of pesticides used in this zone and heavy metals polluting the soil cover. In particular, many crops can bioaccumulate heavy metals, and then these compounds, when passing through the trophic relationship, accumulate in the organisms of animals and humans [Sokolov O.A., Chernikov V.A., 1999]. Biotesting should be carried out at the level of morphology, biochemistry, and physiology in order to identify the main patterns of penetration of different types of pollutants and their transport, movement, metabolism, and bioaccumulation in different types of crops - in roots, leaves, seeds, fruits.

The research results carried out at this stage will allow us to identify and select the most resistant to bioaccumulation of pesticides and heavy metals crops grown in the Aran zone. And also, most importantly, it will make it possible to allocate chemical protection products for crops used in the Aran zone, which can be recommended for use as chemicals, to develop MPC chemicals used in the soils of the Aran zone. The results of systematic studies in the field of environmental risks of growing agricultural products in the arid zone of the country, which has been most exposed to anthropogenic and technogenic impacts for decades, will allow, firstly, to develop of regional strategies to reduce environmental pollution from organic and inorganic pollutants. Secondly, it will contribute to the development of agriculture that does not harm the environment and reduce the risk of pollutants entering the coastal zones of the Caspian Sea.

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LICHENS AND MOSSES IN BOZDAG MOUNTAIN RANGE, OPPORTUNITIES OF THEIR USE FOR MONITORING

*VAGIF S. NOVRUZOV, FADAI F. ALAKBAROV
DOI: 10.30546/abc.2022.1.1.28
Ganja State University, Ganja, Azerbaijan
**vnovruzov1@rambler.ru*

Abstract: The present paper is devoted to species composition, taxonomic status, distribution, and monitoring opportunities of lichens and mosses in the Bozdag mountain range. In general, 29 lichen species belonging to 22 genera, 17 families and 30 moss species belonging to 21 genera, 12 families were detected in Bozdag. Lecania triseptata, Lecanora gllabrat species of lichens and Leskea polycarpa, Leucodon immerses species of mosses have been recommended for biomonitoring.

Lichens and mosses of different origins of the Bozdag mountain range entered the study area at different times. It is known that the Poltava-type tropical flora dominated during the Oligocene. This tropical flora had a Poltavian tropical character of the Caucasian flora in the early Neogene. In the early Oligocene and Neogene, Lecidea, Lecanora, Caloplaca were widespread in the Caucasus.

Shrubby epiphyte and epigey lichens are tolerant to atmospheric pollutants. Indicator species for use in the biomonitoring system have been identified. Lichen species such as Lecania triseptata, Lecanora gllabrat and moss species, such as Leskea polycarpa, Leucodon immerses are recommended for use in biomonitoring.

Keywords: Bosdag, Korchay, moss, lichen, synusia, lichen, moss, species, tolerant, biomonitoring

Introduction. Bozdag mountain range is located at $45^0 50'$ north latitude, $46^0 45'$ north longitude. The absolute height is 520 m, the length is 150 km, the formation period is Neogene and Anthropogenic. The rocks are clay, sand, and sandstones. The Bozdag massif is a mid-mountain and foothill slope, semi-desert steppe, small hills, the Korchay valley, mountain ranges stretching from west to east, and Tugai forests along the Kura River. The Bozdag massif is a large area of low and medium mountain ranges extending from west to east. The area is surrounded by the Mingachevir Reservoir in the north and the Korchay River Valley in the south. The geographical relief of the area is semi-desert, dry steppe, middle and low mountain ranges. Vegetation is poorly developed. Wormwood, saltwort, various grasses, juniper, wild pistachio, pomegranate, paliurus, etc. are grown in arid forests. The landscape is a semi-desert, dry steppe, arid forest, and shrubs.

A little sparse forest massif of tamarix, willow, elm, paliurus occurs in Janavar valley and Soy Khanlı zones of Korchay State Nature Reserve. A sparse forest massif of juniper and mastic is spread in the eastern zone of the mountain range called Kerpijli.

Materials and methods. The research objects were lichens and mosses of the Bozdag mountain range. The research was carried out by the route and stationary methods. At the same time, floristic, floristic-systematic, areological, botanical-geographical, phytocenological, statistical methods were taken into account. The nomenclature of taxa was given according to modern catalogs. The Index of Atmospheric Purity was calculated according to H.H.Trass [Alverdiyeva S.M. et all., 2014; Andreyeva E.N., 2009; Novruzov V.S., 2000; Ignatov M. S. et al., 2006; Trass, X.X., 1985]

Results and discussion. In Bozdag moun-

tain range, 29 lichen species belonging to 22 genera, 17 families and 30 moss species belonging to 21 genera, 12 families were detected. The lichens and mosses of the Bozdag mountain range (150 km), which does not have a large area, are of a regional nature. The diversity of lichens and mosses is attributed to the geographical location of the area, and the variety of ecological conditions [Alverdiyeva S.M. et all., 2014; Andreyeva E.N., 2000].

Mosses such as *Pottia bryoides (Dicks.) Mitt, Leskea polycarpa Hedw., Brachythecium rutabulum (Hedw.) B.S.G., Amblystegium serpens (Hedw.) B.S.G.* occur on soil, *Grimmia pulvinata (Hedw.) Sm., Trichostomopsis crispulum Bruch., Camptothecium lutescens (Hedw.) B.S.G.* on stones and *Barbula vinealis Brid., Leucodon immersus Lindb., Neskera besseri (Lobar.) Jur.* on trunks of mastic and pistacia. Species of *Hylocomium, Pleurozium* genera form synusia with lichens in the southern foothills of the Bozdag mountain range [Andreyeva E.N., 2009; Ignatov M. S. et al., 2006].

Mosses forming synusia with lichens are *Dicranum polysetum Sw, Orthodicranum montanum (Hedw.) Loeske,* mosses found in large numbers are *Polytrichum hyperboreum R.Br., Polytrichum strictum Brid.,* rarely occurred moss *isBrachythecium albijans (Hedw.). Polytrichum commune Hedw., Pohlia nutans (Hedw.) Lindb.* species are dominant in wet places. *Barbula unguiculata Hedw., Barbula rigidula (Hedw.) Mitt., Schistidium gracile (Schleich.) Limpr* are widespread on rocks, sediments, and among sod layers of poorly developed cereals.

The species composition and distribution of moss synusiae in the Bozdag mountain range depend on the degree of illumination, water and mineral supply of their habitat. The occurrence of *Pottiaceae, Dicranaceae* families in the steppe, desert, and semi-desert phytocenoses, in the lower zones is due to climate aridity. *Tortula ruralis*, a member of the *Pottiaceae* family, is a species of poikiloxerophytes that signals the onset of dehydration in forests, steppes, and agroecosystems [Novruzov V.S., 2000; Andreyeva E.N., 2009].

Rizocarpon expallens Th.F., Acarospora bicolor Norm, L.coniferata (Duby ex Fr.Grognot., Parmelia discordans Nyl., Lecidea lapicida Ach. species oflichens predominate on silicate rocks, *Toninia candida (Web.) Th.Fr.Glypholecia scabra (Gers.) Mull., Rhizocarpon petraeum (Wulfen) Mass., Rhizoplaca melanopthalma (DC) Ley., Aspisilia calcarea (L.) Mud., Lecanora disperesa (Pers.) Sommerf., Pertusaria subdactylina Nyl.* on limestones, *Peltigera apthosa (L.) Villd.* on soil, *Lecanora gllabrata (Ach.) Malme., L.crenulata Hook.* on paliurus shrub bark, *Lecania triseptata (Vain) Zahlbr.* on the trunk of pistachio, *Pertsaria constricta Erichs.* on juniper, *Ochrolechia arborea (Krey)Almq., Candelariella reflexa (Nyl)Lettau* on pomegranate bark. *Xanthoria parietina (L,) Th.Fr., Physconia grisea (Lam.) Poelt., Anaptychia ciliaris (L.) Koerb., Arthonia punctiformis Ach.* are tolerant species of Bozdag mountain range.

TABLE 1. Systematic composition of lichens of the Bozdag mountain range

Family	Genus	Species
Arthoniaceea	*Arthonia*	1
Opegraphaceae	*Opegrapha*	1
Verrucariaceae	*Verrucaria*	1
Peltigeraceae	*Peltigera*	1
Lecideaceae	*Lecidea*	2
Ramalinaceae	*Toninia*	1
Rhizocarpaceae,	*Rhizocarpon*	2
Lecanoraceae	*Lecanora*	1
	Rhizoplaca	2
Megasporaceae	*Aspicilia*	2
Parmeliaceae	*Parmelia*	2
Cladoniaceae	*Cladonia*	1
Acarosporaceae	*Acarospora*	1
	Glypholecia	
Pertusariaceae	*Pertusaria*	2
Candelariaceae	*Candelariella*	1
Teloschistaceae	*Teloschistes*	1
	Caloplaca	1
	Xanthoria	1
Physciaceae	*Physcia*	3
	Anaptychia	1
Ochrolechiaceae	*Ochrolechia*	1
17	22	29

Currently, species related to the ancient 3rd period, the end of the Cretaceous period, and the last 4th period are found in the composition of lichens and mosses of the Bozdag mountain range. The centers of formation of the found species mainly cover different plant climatic zones of the Holarctic, the Mediterranean sea, and arid regions [Andreyeva E.N., 2009].

TABLE 2. Systematic composition of mosses of the Bozdag mountain range

Family	Genus	Species
Pottiaceae	*Pottia*	2
	Barbula	2
	Trichostomopsis	1
	Tortula	3
Grimmiaceae	*Grimmia*	2
	Schistidium	1
Leucodontaceae	*Leucodon*	2
Neckeraceae	*Neskera*	2
Leskeaceae	*Leskeella*	1
	Leskea	1
Amblystegiaceae	*Amblystegium*	1
	Hygroamblystegium	1
	Leptodictym	1
Brachytheciaceae	*Brachythecia*	1
	Camptothecium.	1
Hypnaceae	*Hypnum*	1
Dicranaceae	*Dicranum*	1
	Orthodicranum	1
Hylocomiaceae	*Hylocomium*	1
Polytrichaceae	*Polytrichum*	3
Mniaceae.	*Pohlia*	1
12	21	30

Bioindication is one of the most important methods for assessing the state of the environment. Unlike other methods, bioindicators provide a consistent assessment of adverse environmental factors, including chemical pollution. Besides, it allows the assessment of the total impact of a set of unfavorable factors [6 Ivanov A.I., 2007].

Based on the biodiversity indices, the level of occurrence of lichen and moss species was determined in test objects of biopolygons and agroecosystems. According to the degree of tolerance, the species are divided into 3 groups: cosmopolitan species, species that are selective against certain pollutants, and sensitive species. Lichens *Lecanora gllabrat, L.crenulata, Lecania triseptata, Xanthoria parietina Physconia grisea,* and mosses *Pottia bryoides, Amblystegium serpens*are toxitolerant, while lichens *Ramalina farinacea, R.fraxinea, Usnea hirta,* and mosses *Leucodon immersus, Neskera besseri, Polytrichum commune* are sensitive to atmospheric pollutants.

Mosses and lichens play an important role in the initial successions on the bare rocks of the Bozdag mountain range. The chemical composition of the rocks, the inclination of slopes, the temperature regime create conditions for the spread of mosses and lichens in the Bozdag mountain range [Alverdiyeva S.M. et all., 2014; Novruzov V.S., 2000;].

Shrubby epiphyte and epigey lichens are tolerant to atmospheric pollutants. Indicator species for use in the biomonitoring system have been identified. Lichen species such as *Lecania triseptata, Lecanora gllabrat* and moss species, such as *Leskea polycarpa, Leucodon immerses* are recommended for use in biomonitoring.

Based on test species selected as biopolygons, the direction, radius, and extent of anthropogenic anomalies in Mingachevir and Samukh districts in relation to the standard area were revealed.

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METHOD OF FIELD AND COMPUTER MORPHOMETRY IN DIAGNOSTICS OF DIPHASIASTRUM (LYCOPODIACEAE S.L.) TAXA IN THE MOSCOW REGION

*VITALY M. EFANOV, NATALIA A. GUSEVA, ANNA G. BEGA
DOI: 10.30546/abc.2022.1.1.31
State Educational Institution, Moscow, Russian Federation
Moscow State Regional University, Moscow, Russian Federation
** worm@nextmail.ru*

Abstract: The article deals with the topic of species diagnosis in the genus Diphasiastrum. At the moment, all the methods available to researchers require the removal of whole plant samples or parts of plants from populations. In this paper we propose a new express method for obtaining morphometric data of species of the genus Diphasiastrum without plant damage and give its hardware implementation. The method allows the identification of species directly in the field. Field and desktop testing of the proposed method was carried out. The low variance of repeated measurements of species-specific traits suggests that the method is suitable. Three new locations of Diphasiastrum in the Moscow region have been discovered and described. The plants were described according to a set of diagnostically relevant qualitative and quantitative indicators and identified as D. complanatum (L.) Holub subsp. complanatum. For each finding, a standard description of the biotope is given and a conclusion is made as to the degree to which the location is potentially suitable for the long-term existence of the species population. We consider the proposed method to be potentially suitable for many members of the Lycopodiaceae family. The relative rarity of many of these plants in nature makes the appearance of the method timely.

Keywords: species identification, morphometry, plants conservation, Diphasiastrum.

Running title: V.M. Efanov et al. The method of field morphometry in the diagnostics of *Diphasiastrum*

Different approaches and methods have been used to decide on the species rank of the clubmosses taxon. This has sometimes led to contradictory interpretations and to the complication of synonymy. In our view, the best solution to this problem should be to adopt a conventional approach [Evo J.S., 2016]. A combination of methods, ranging from in-depth morphological analysis to molecular diagnos-

tics, is desirable to improve the accuracy of direct detection [Stoor A.M. et all., 1996; Horn K. et.all., 2006; Bennert W. et.all., 2011; Klein L.L., 2012; Szypula W.J., 2013]. This will improve credibility through an independent method of identification. In this article we propose a field method for obtaining morphometric data for species of the genus *Diphasiastrum*. At the moment, all existing methods of identification of clubmosses are associated with an increase in anthropogenic impacts on wild populations. Morphological analysis involves collecting living plants or plant parts for cameral morphometry (herbarium and fixed sporophyte specimens). In our opinion, all of the clubmosses in the Moscow region are in need of increased protection. The use of non-destructive methods of investigation has already been raised in a number of papers [Panchenko S.M., 2000; 2009; Panchenko S.M. and Chernous O.P., 2005;] on the vitality analysis of clubmosses. However, the authors were not able to exclude phylloid harvesting and only managed to reduce it to 28-32 specimens from orthostichia, which, by definition, is not a nondestructive action proper and can be dangerous because of the probable rotting of the damaged part of the shoot [Benca J.P., 2020]. There are also separatepapers that note the need to analyse lifetime images of plants, but do not propose field morphometric methods themselves [Bjork C.R., 2020].

Diphasiastrum Holub, 1975 – isolated by the Czech botanist Josef Holub in 1975 during the revision of *Lycopodium* s.l., is considered a relatively young, Cenozoic genus of clubmosses [Schnittler M. et all., 2019]. *Diphasiastrum* is distinguished from other *Lycopodium* s.l. by flattened (in most species) lateral vegetative branches of orthotropic shoot systems with a decussate arrangement of scale-like phylloids, radical gametophyte form (so-called "complanatum-type") and a chromosome number unique among the clubmosses genera, 2n=46 [Holub J., 1975].

The species *Diphasiastrum complanatum* (L.) Holub and *D. tristachyum* (Pursh) Holub occurring in the Moscow area have a differentiated above-ground shoot system with a well-defined main axis and fan-like systems of dichotomous lateral branches. The general habitus of the orthotropic shoot systems of these species is described as tree-like by the genus Joan Wils [Wilce J.H., 1965]. The life form of *Diphasiastrum* species can be described as bushy, as these plants are characterised by low perennial systems of above-ground shoots [Ivanenko Y.A., 2016]. The phylloids of *Diphasiastrum* can be iso-, di- or trimorphic, which is related to the degree of flattening of the twigs. Plagiotropic shoots are creeping or crawling and can be located at different substrate depths, allowing them to be considered functionally as epi- and hypogeogenic. Deeper in the substratum, hypogeogenic shoots are paler in colour, but green when they come above the ground and are capable of surviving forest fires. Strobili is on strobilus-bearing peduncle, less often sessile, and the species near Moscow have a peduncle of varying degrees of branching [Ivanenko Y.A., 2016; 2004; 2013].

The genus *Diphasiastrum* found in different latitudinal and vertical zoning belts. In sympatric zones, interspecific hybridisation is known. For example, in Central Europe, three parental and three hybridogenic species are distributed sympatrically [Bennert W. et all., 2011; Schnittler M. et all., 2019; Hanusova K. et all., 2014]. The ecological niches of *Diphasiastrum* species of the Moscow region partially overlap. *D. tristachyum* inhabits drier and brighter habitats, whereas *D. complanatum* can also be found in more shaded, wetter habitats, and the hybridogenic *D.* x *zeilleri* (Rouy) Holub, with the parent formula *D. tristachyum* x *D. complanatum*, occupies an intermediate position both morphologically and ecologically [Ivanenko Y.A., 2016; 2004]. *Diphasiastrum* is thus a very interesting subject for sistemic-biological research. However, in terms of species identification, *Diphasiastrum* is a complex group that requires consideration of many diagnostic features. The International Pteridophyte Phylogeny Group recognises the genus *Diphasiastrum* as monophyletic, comprising 20 species [Evo J.S., 2016]. Some taxa are treated as hybridogenic species [Ivanenko Y.A., 2016; 2004; 2013], which is also widely recognized as

a scientific community [World Flora Online 2000].

The aforementioned features of *Diphasiastrum* structure, such as the presence of fairly compact systems of orthotropic shoots with often prostrate, flattened lateral branches bearing polymorphic decussate phylloids, allowing easy survey of diagnostically significant morphological characters in the field, led to the choice of this genus as an object for testing a new method of field morphometry.

The aim of our work was to create a rapid*in vivo* method for obtaining a set of diagnostically relevant morphometric data of representatives of the genus *Diphasiastrum*. To this end, the following objectives were set:

1. Develop an algorithm for field and cameral studies of clubmosses, and propose a hardware implementation of the method.

2. Conduct a field test of the method when searching for new locations of *Diphasiastrum*.

3. Evaluate the applicability of the method by comparing data collected under different *modusoperandi* of obtaining samples. Suggest possibilities for prospective improvements to the method.

Materials and methods. This paper proposes a method for collecting morphometric data of *Diphasiastrum* without plant damage, based on photography in the field. The method is designed to evaluate the features used in the single-input dichotomous textual [Sviridov A.V., 2012] keys proposed by Y.A. Ivanenko and N.N. Tzvelev [Ivanenko Y.A. and Tzvelev N.N. 2004]. We have designed and manufactured a model of a field measurement device, the Field Morphometer (FM). The unit consists of three functional parts: the base with the measuring scale, the mounting feet and the clamping device (pic. 1).

The morphometer made it possible to attach plant parts easily, without damaging them, to capture morphological features. The morphometer algorithm consisted of the following steps: the instrument was fixed in the soil by selecting a suitable angle for the mounting feet, and sections of the partial shrub with well-developed branches that had finished their growth and branches with current year's increment, were selected for measurement. The plants were attached to the FM and then photographed together with a 13.0 megapixel camera scale with a resolution of 4208x3120 pixels. Particular attention was paid to filming the ventral side of the branches of orthotropic shoot systems.

In addition to obtaining photographic images, scanned images were obtained for each clonal colony if possible. To obtain them, senile and dead parts of orthotropic shoot and branch systems meeting the conditions given above were collected. The material was labelled and immediately placed for transport in a herbarium folder or a tightly closed container. Scanned images were obtained by digitising the collected material together with the scale on a Brother DCP-7055R MFP at maximum resolution (1200x1200 dpi), the image format being uncompressed tif.

In the cameral phase, ImageJ v.1.52n (Oracle Java v.1.7.8 32-bit) was used as the software component of the method. The measuring scale was calibrated before working with each sample [Konyukhov, 2012]. If necessary, the images were sharpened using an appropriate filter in Paint.Net v.3.5.11. Each sample was measured in quadruplicate. The measurements were taken on developed parts of the shoots that were not susceptible to rotting. The linear measurement data obtained in ImageJ were entered into Apache Open Office Calc v.4.1.8 worksheets and the average values were calculated (Table 1).

The description of the colonies included a set of qualitative indicators: habitus, nature of formation of fertile structures: presence of strobils and length of peduncle, degree of peduncle branching and separation from the fertile branch, number of strobils on the peduncle and presence or absence of peduncle branches, colour of plagiotropic shoots, depth and nature of their occurrence. The flattening of lateral branches of orthotropic shoot systems and their colour on the developed part of the branch and in the areas of annual growth, if any, were visually assessed.

PICTURE 1. Field Morphometer (FM). Explanation. A - base with measuring scale; B - mounting feet; C - general view of the device (scheme); D - FM with sample in working position, thin, narrow rings of transparent latex are used for fixation of plants.

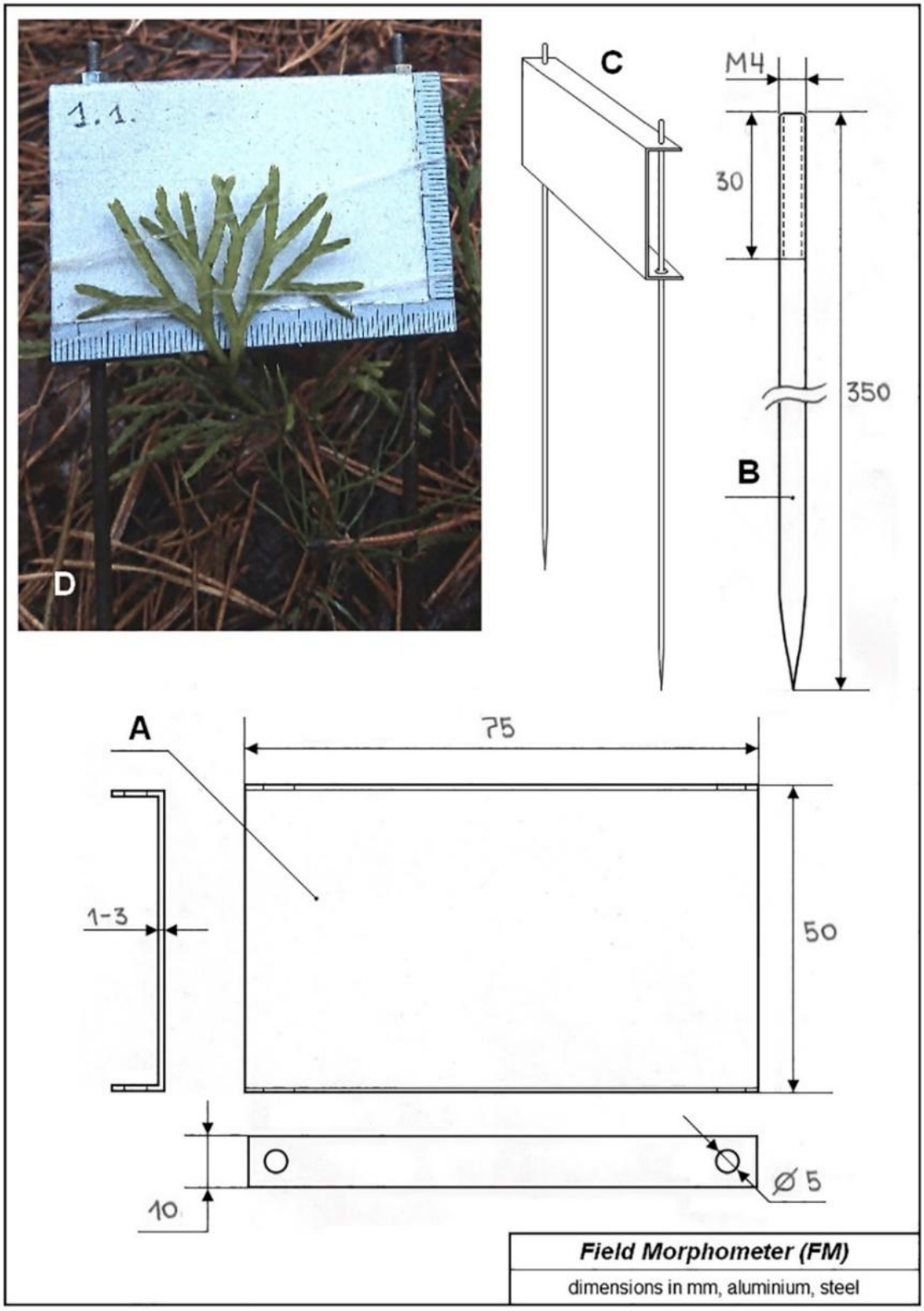


TABLE 1. Morphometric data of the Diphasiastrum specimens examined

Sample code	Average width of lateral branches W, (mm)	Free part of the ventral phylloid		Ratio of average sample values (mm)	Average values for colonies		
		Average width w, (mm)	Average Length (mm)		Ventral phylloid width, w (mm)	Ventral phylloid length (mm)	W/w
m15XI2020Ec1s1	2, 99	0, 56	1, 15	5, 36	0, 54	1, 13	5, 65
m15XI2020Ec1s2	3, 13	0, 53	1, 10	5, 95			
m15XI2020Ec2s1	3, 08	0, 51	0, 96	5, 99	0, 51	1, 11	5, 83
m15XI2020Ec2s2	3, 55	0, 60	1, 25	5, 96			
m15XI2020Ec2s3#	2, 95	0, 49	1, 24	5, 97			
m15XI2020Ec2s4#	2, 45	0, 45	1, 01	5, 40			
m29VII2020Sc1s1	4, 50	0, 69	1, 23	6, 50	0, 57	1, 03	6, 86
m29VII2020Sc1s2	4, 12	0, 55	1, 01	7, 54			
m29VII2020Sc1s3	3, 54	0, 51	0, 98	6, 99			
m29VII2020Sc1s4	3, 36	0, 52	0, 91	6, 42			
m29VII2020Sc2s1	3, 07	0, 54	0, 99	5, 70	0, 51	1, 08	6, 11
m29VII2020Sc2s2	3, 57	0, 48	0, 96	7, 39			
m29VII2020Sc2s3	3, 08	0, 55	1, 27	5, 61			
m29VII2020Sc2s4#	2, 86	0, 50	1, 08	5, 74			
m29VII2020Sc2s5#	3, 05	0, 50	1, 09	6, 13			
m22III2020Sc1s1#	2, 82	0, 47	1, 15	5, 96	0, 48	1, 15	5, 90
m22III2020Shc1s2#	2, 88	0, 49	1, 15	5, 84			

Notes: m - morphometric *sample, # - scanned sample, 15XI2020 - date of collection, E - Yegoryevsk district, S - Stupino district, Sh - Shatura district, c1 - colony number, s1- sample number.*

As quantitative indicators, the width of lateral branches of orthotropic shoot systems (W); the base width of the free part of the ventral phylloid (w) on the developed part of the branch (2 measurements) and in the current year's growth zone (2 measurements); and the length of the free part of the ventral phylloid. The W value, taking into account the free part of the lateral phylloids, was measured in the area of their maximum width by placing the ends of the measuring line near the middle of the free parts of the lateral phylloids, orienting the line perpendicular to the branch axis.

Measurements of the base width and free length of the ventral phylloids were made in a similar manner, orienting the measurement line perpendicular to the organ axis in the first case and parallel in the second (Fig. 2A). As the most diagnostically valuable feature, the ratio of the width of the lateral branches of orthotropic shoot systems to the width of the ventral phylloid base (W/w), measured as described above, was taken (with due consideration of the others). This feature, is given in definitional keys [Ivanenko and Tzvelev 2004] and helps to distinguish parental species of *Diphasiastrum*.

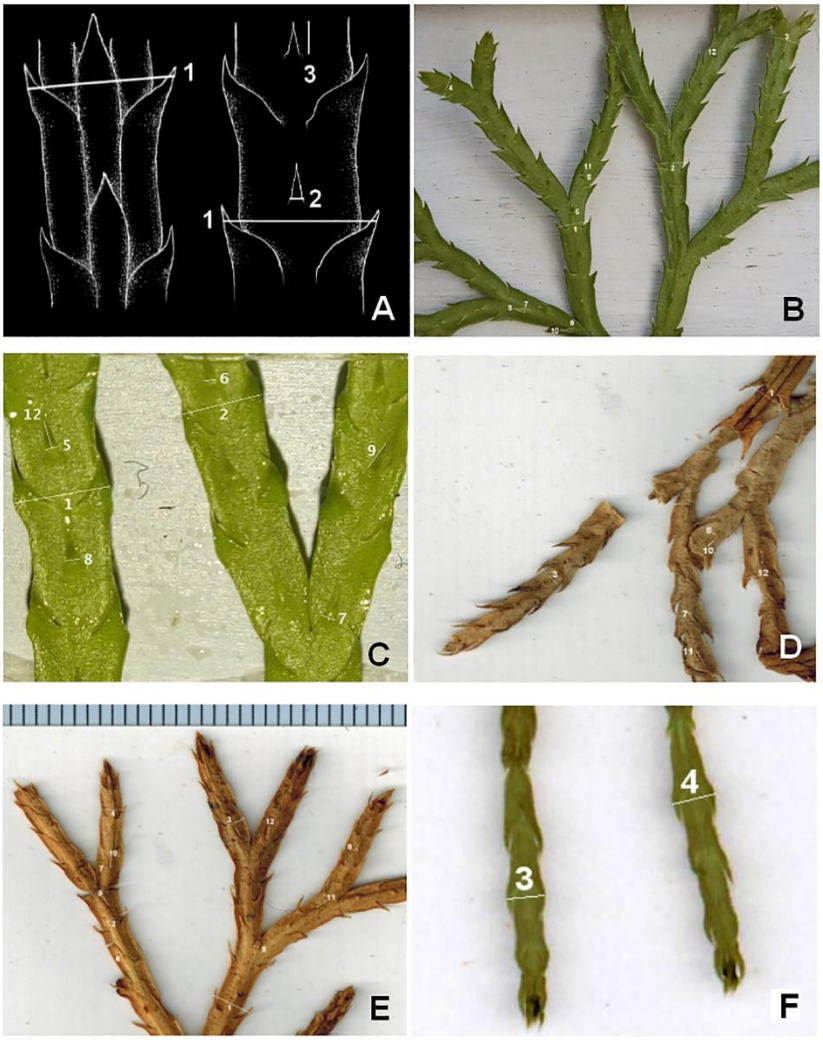
To test the applicability of the method, digital specimens from the Syreyschikov Moscow University Herbarium, Faculty of Biology, Moscow State University (MW) [Seregin, 2021], assigned to *D. tristachyum*, *D. complanatum* and *D.* x *zeilleri*, were processed. One sample of each species, originating from the Moscow region and with an informative label, was chosen. When processing these samples, only the W values were recorded, as the low resolution of these samples prevented the re-

maining measurements from being taken with comparable accuracy. Each sample of any type was assigned a unique code (matching the sample file name or MW code), including information on the date, location, type and number of the sample. All measurements of the sample were assigned a number from 1 to 12.

This detailed coding of objects allows you to go back to any criticised measurement at the right moment and double-check it.

During the field assay, the plants were searched using the route method [Artayev, et all., 2014] and a biotope description was prepared for each find [Kharitonov N.P., 1998]. As it is difficult to establish the exact boundaries of the colonies without harming the plants, a colony at least 300 metres away was treated as a separate colony, otherwise it was taken as a clonal particula of the colony in question. A total of three locations of *Diphasiastrum* from Shatura, Stupino and Yegoryevsk districts of Moscow Region were found and described, and 11 photographic and nine scanned images were analysed (pic. 2B-F).

PICTURE 2. Computer morphometry of *Diphasiastrum*. Explanation. A - localization of measurements: 1 - width of lateral branch of orthotropic shoot systems (W); 2 - base width of ventral phylloid free part (w); 3 - length of ventral phylloid free part. B - some measurements of sample m29VII2020Sc1s1; C - also, sample m15XI2020Ec2s2; D - sample of poor preservation m22III2020Shc1s2#; E - sample m29VII2020Sc2s5#; F - fragment of herbarium specimen MHA0032405.



Results and discussion. In the course of our fieldwork we discovered three new locations of *Diphasiastrum* in Shatura, Stupino and Yegoryevsk districts of Moscow Region, where geobotanical descriptions were made and studies of *Diphasiastrum* colonies were carried out.

In Shatura District *Diphasiastrum* sp. was discovered on 22.03.2020 half a km east of Pozhoga village (55°25'24.6 "N, 39°42'35.9 "E). The site is located in the south-western part of the Meshchera lowlands, the terrain is poorly rugged, mostly flat, and the soils are sod-podzolic, on sands.

A single colony of *Diphasiastrum* was found on the edge of a recent windfall in a lightened (30-35% crown cover) pine forest. *Pinussylvestris* L., *Picea abies* (L.) H.Karst., *Betula pendula* Roth, less frequently *Sorbus aucuparia* L. and *Quercus robur* L., in the shrub layer – *Rubus idaeus* L., *Juniperus communis* L., *Lonicera xylosteum* L., *Frangula alnus* Mill. and occasionally *Daphnemezereum* L. Grass-bush layer includes *Callunavulgaris* (L.) Hull, *Convallariamajalis* L., *Vacciniummyrtillus* L., *V. vitis-idaea* L., *Asarumeuropaeum* L., *Fragariavesca* L., *Stellariaholostea* L., *Pteridiumaquilinum* (L.) Kuhn, *Rubussaxatilis* L., *Luzulapilosa* (L.) Willd., *Oxalisacetosella* L., *Calamagrostisepigeios* (L.) Roth. and *Carexericetorum* Pollich. The shrub and herb-shrub tiers are not always equally expressed here; in the latter, the projective coverage of background species (*Vacciniummyrtillus*, *Calamagrostisepigeios*, *Carexericetorum*, *Callunavulgaris*) is uneven, which leaves free green-mossy areas with rare sandy outcrops on windfalls. The moss-lichen layer is composed of *Dicranum* sp., *Pleuroziumschreberi* (Willd. ex Brid.) Mitt., *Climaciumdendroides* (Hedw.) F. Weber & D.Mohr, *Polytrichumcommune* Hedw., *Atrichumundulatum* (Hedw.) P. Beauv. and in wet depressions, *Sphagnum* sp. and *Mnium* sp.

The small (0.75-1 m^2) colony (m22III2020Shc1s1-2#) is located in a green-mossy biotope with small participation of shrub, grass-bush and undergrowth. Orthotropic shoots are intensively branched, spreading, 11-15 cm high, their lateral branches flattened, deep green on the dorsal side, including shoots from the previous growing season, ventral side light green, current year shoots not expressed. The plagiotropic shoots are greenish-white or light green, epigeogenic. Senile shoots in insignificant numbers, found 4 last year's strobils sitting alone on a double-branched (4.5-5 cm) peduncle, clearly detached from the lateral fertile branch of the orthotropic shoot. Two other species of the family, *Lycopodiumclavatum* L. and *Spinulumannotinum* (L.) A. Haines, of which the former occurs most frequently, were also found here.

Location from 29.VII.2020 two kilometres south-west of Belopesotsky station (54°51'16, 2''N, 38°06'56, 2''E), Stupino district, located in south-eastern part of Moskvoretsko-Oka plain, in flood plain mixed pine forests between river Kremnitsa and Oka. The terrain is rugged, hilly, with sparse natural outcrops, and the landscape has been heavily transformed by anthropogenic activity. Soils are grey forest loamy, sandy loam and sod-podzolic, on sands. Two large colonies of *Diphasiastrum* were found, the first containing two and the second four clonal particulas.

The first of the colonies (m29VII2020 Sc1s1-4) occupies the top and northeast hillside in a dry biotope (55-60% crown cover), in a hilly area. *Betulapendula* and *Pinussylvestris*, less often *Piceaabies*, *Quercusrobur* and *Sorbusaucuparia*, *Frangulaalnus*, *Juniperuscommunis*, *Euonymusverrucosus* Scop, *Loniceraxylosteum* and *Rubusidaeus*, in herb-shrub layer: *Stellariaholostea*, *Callunavulgaris*, *Melampyrumnemorosum* Baumg., *Ajugareptans* L., *Vacciniumvitis-idaea* and *V.myrtillus*, *Pyrolarotundifolia* L., *Pteridiumaquilinum*, *Oxalisacetosella*, *Asarumeuropaeum*, *Calamagrostisepigeios*, *Luzulapilosa* and *Carexpallescens* L.As in the previous location, the projective cover of the background species of the grass-bush layer is uneven and the colonies found here are confined to areas with less participation of marginal grassland species such as *Calamagrostisepigeios* and *Carexpallescens*. The moss-lichen layer is dominated by *Pleuroziumschreberi*, *Dicranum* sp. and *Poly-*

trichumcommune, with *Climaciumdendroides* and *Atrichumundulatum*, *Rhodobryumroseum* (Hedw.) Limpr. in wetter depressions, and *Polytrichumjuniperinum* Hedw., *P. piliferum* Hedw. and *Cladonia* sp. on dry sandy outcrops. The colony consists of two clonal particulas measuring 6.5 x 6 and 2 x 2.5 m, spaced a few metres apart. Intensively branched orthotropic shoots systems prostrate, 12-16 cm tall, lateral branches flattened, dark green dorsally, light green ventral side, lettuce-green shoots. The plagiotrophic shoots are epigeogenic, located in moss cushions and/or leaf litter, greenish-white to green. The senile parts of the shoots are relatively evenly distributed over the colony area. The smaller of the clonal particula has no strobili, the larger has a high (over 200) number of strobili, 2-5 arranged on long, separated from the lateral fertile branches peduncles, and a single case of strobilus dichotomy was observed.

More than half a kilometre north-east of the first colony, a second colony (m29VII2020Sc2s1-5), even larger, consisting of four clonal particulas, was found. The colony is located in a sloping somewhat more shaded and moist, green-mossy depression of the same biotope, with low projective cover of the background species of the herbaceous-bush layer. In terms of external diagnostic features, the plants of the second colony correspond to those of the first colony. The presence of strobili was noted in half of the second colony particulas.

In Yegoryevsk District, *Diphasiastrum* sp. was found 15.XI.2020, one kilometre northeast of Rudnikovskaya Station, (m15XI2020Ec1-2s1-4) less than one kilometre north of the Lopatinsky Phosphorite Mine (55°20'31.2" N 38°55'31.5" E), located in the southwest part of the Meschera lowlands. This *Diphasiastrum* habitat is of a distinctly secondary nature and is located in medium-aged regenerative mono-planting of *Pinussylvestris*, on sandy, weakly podzolized soils, probably on the site of former geological workings. The thickness of the upper horizons of the soil profile here is extremely low (>>10 cm), resulting in oligotrophic conditions, along with the landslide nature of some sections of the bank of a large marshy ravine, which skirts this location in a semicircle. With moderate (40-50%) crown cover, *Pinussylvestris* and *Piceaabies* are rare in the undergrowth, while the admixture of deciduous species is negligible, sometimes *Sorbusaucuparia* and even more rarely *Betulapendula*.The shrub tier is almost not expressed and represented mainly by *Juniperuscommunis*, much less often *Loniceraxylosteum* and *Fragulaalnus*. The herb-shrub tier is poorly developed and is represented by *Antennariadioica* (L.) Gaertn. (in some places in mass), *Callunavulgaris*, *Vacciniummyrtillus*, less frequently *V. vitis-idaea* and *Luzulapilosa*, *Calamagrostisepigeios* (single) and *Carexpallescens*. Two other species of clubmosses, *Lycopodiumclavatum* and *Spinulumannotinum*, have been recorded as part of the herb-bush layer. Both species grow explerentially, with high levels of projective cover. *Lycopodiumclavatum* predominates. Moss-lichen layer of *Dicranum* sp., *Polytrichumjuniperinum*, *P. commune* and *P. piliferum*, *Climaciumdendroides*, *Pleuroziumschreberi*, *Cladonia* sp. and *Cetrariaislandica* (L.) Ach. Due to the oligotrophic conditions and the low development of herbaceous-shrub layer, the biotope is characterised by a low level of competitive pressure. Here, two colonies of *Diphasiastrum* were found at a sufficient distance, the plants of which appeared to be similar in terms of a set of external diagnostic features. Lateral branches of orthotropic shoots broad, strongly flattened, ventral side light, lettuce-green, dorsal side dark green, without a bluish-grey tint. Plagiotropic shoots of epigeogenic type, greenish-white to greenish colouration. No strobili were found.

The morphometric data of all samples are shown in Table 1. In the course of cameral processing of the materials obtained, we found that plants from all three locations described above can be assigned to the nominal subspecies of *D. complanatum* (L.) Holub subsp. *complanatum*. All specimens examined have fairly broad and flattened, fan-shaped lateral branches of orthotropic shoot systems with broad lateral and reduced, narrow, often sty-

loid ventral phylloids. This set of features has a low (less than 20%) coefficient of variation, suggesting low variability of the featuresand their high diagnostic significance. The width of lateral branches of orthotropic shoot systems is the most variable, while the width of the base of the free part of the ventral phylloid is the least variable (Table 2). The average values obtained for the base width of the free part and the length of the ventral phylloid proved to be fairly constant consistently for samples of each colony and location. The diagnostic value W/w depends on the accuracy of the measurement of the base width of the free ventral phylloid (w).

The morphometric data of the samples we collected agree with the values of the diagnostic keys used. Some deviations into the area of larger mean branch widths are present for the Stupino district (m29VII2020Sc1-2s1-4-5). However, the average measurements of the ventral phylloid of these specimens are consistent with those from other locations, with its slightly shorter average length. From a systems-biological perspective, one explanation for this deviation could be the relatively lower light conditions. The large admixture of deciduous species in the stand at this location and the significant development of undergrowth are consistent with the observed greater branching width and reduction of the ventral phylloid. However, such a pattern must be proven on statistically significant material. In order to obtain objective data on light levels, we consider it promising to use the luxmeter in further system-biological studies.

The open-source program ImageJ was chosen because of its cross-platform nature, low resource requirements, extensibility and automatability [Konyukhov, 2012; Mitsik, 2011].

TABLE 2. Statistical indicators of the sample

Indicator	Yegoryevsk district			Stupino district			Shatura district			The whole sample		
	W, mm	w, mm	l, mm	W, mm	w, mm	l, mm	W, mm	w, mm	l, mm	W, mm	w, mm	l, mm
Standard error	0,10	0,01	0,04	0,12	0,01	0,05	0,15	0,03	0,08	0,08	0,009	0,028
standard deviation	0,48	0,07	0,17	0,71	0,08	0,27	0,40	0,08	0,20	0,645	0,076	0,228
coefficient of variation of the indicator (%)	0,15	0,14	0,15	0,21	0,14	0,25	0,14	0,16	0,17	19,9	14,5	20,9

Notes: W - width of lateral branches of orthotropic shoot systems, w - width of the free part of the ventral phylloid, l-length of the free part of the ventral phylloid

The applicability of the method depends directly on the quality of the images being processed. Thus, analysis and verification of our photographic and scanned images is not difficult, whereas for MW specimens this was not always possible due to insufficient scanning resolution (Fig. 2F) and the peculiarities of the herbarization of individual specimens. The lateral branch width (W) of the orthotropic shoot systems of the MW samples falls within the range of reference values of the diagnostic keys used [Ivanenko and Svelyev 2004]. However, while specimens MW0208486 and MW0208335 that we examined are informative on the entire complex of external, and on part of the traits available for measurement, for MHA0032405 it was impossible to evaluate the entire diagnostic complex given in the special literature [Ivanenko Y.A., 2016; 2004; 2013], as the specimen has no strobili and fully preserved plagiotropic areas at all. For this specimen, only the available part of the morphometric data, the branching pattern and the shading of the lateral branches of the orthotropic shoot systems were evaluated. We consider it mandatory to check the location of MHA0032405 in order to clarify the diagnosis, the identification of other MW samples is con-

firmed by us comprehensively.

From our point of view, we characterise the *Diphasiastrum* occurrences described here differently for the purposes of phytodiversity protection. The Shatura district location is of less concern due to its low population density and the presence of suitable plant microhabitats, as evidenced by the combined occurrence of the three species of the family. The biggest concern is the find from the Stupino district. Despite the large size of the colonies and the potential abundance of spore production, plants at this location are clearly at risk of extinction due to high recreational pressure, signs of which were observed along the entire route. The absence of other clubmosses species and the observed successional changes in this section of the Oka floodplain indigenous woodland confirm our fears. Despite indications of *D. complanatum* at other locations in the Stupino and Serpukhov districts [Bega and Yefanov, 2018], we note that some of them are not confirmed, and the repeated searches we have undertaken since 2017 have shown a high level of recreational pressure and increased succession in many parts of the south of the Moscow region. The find from the Yegoryevsk district is interesting because it shows the high ability of the plants to successfully develop suitable secondary habitats. Nevertheless, secondary habitats, as opposed to the increasingly rare primary habitats, cannot be considered a reliable reservoir of clubmosses populations.

The method proposed in this paper has produced photographic images that are as informative as herbarium specimens ("*in vivo* herbarisation"). The hardware implementation of the proposed method was successfully tested in the description of three *Diphasiastrum* locations in the Moscow region. Thus, it can be concluded that it is suitable for obtaining diagnostically relevant information on the *Diphasiastrum* species complex. The method has a number of positive characteristics: high accuracy, limited only by technical equipment; ease of use and versatility, expressed in the adaptability of the morphometric protocol. The method allows for an increase in the number of features analysed; the introduction of a number of geometric morphometry parameters into the measurement protocol; and an increase in the multiplicity of measurements.

The most important feature of this method is the ability to obtain accurate diagnostic data without damaging the plants. We consider it possible to extend the use of the developed method to further field studies of Lycopodiaceae s.l.

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FOREST FERNS OF THE CAUCASUS, ITS SYSTEMATIC AND ECO-GEOGRAPHICAL ANALYSIS

AYDIN M. ASGAROV
DOI: 10.30546/abc.2022.1.1.42
Institute of Botany of ANAS, Baku, Azerbaijan
askerov1@mail.ru

Abstract. The forests of the Caucasus are one of the most important regions of the taxonomic diversity of ferns. Here are 70 species and 29 genera, or 64% of genera and 44% of species of ferns of Eastern Europe as given by Cherepanov, with exception of hybrid and adventive ferns [Cherepanov, 1995]. Critical revision of the forest ferns of the Caucasus made possible to identify two new genera in the flora of the region (Cyrtomium, Onoclea). In general, as a result of taxonomic revision of the number of fern families of the Caucasus increased from 4 to 20, and the number of genera - from 23 to 31. New for the flora of Eastern European were 20 species and hybrids of the species range, 5 subspecies: Pteris vittata, Adiantum cuneatum, Cyrtomium falcatum, Dryopteris remota, D.caucasica, D.atrata, D.ambroseae and others. For the first time in the Caucasus were found Botrychium virginianum, Onocle sensibilis, Cystopteris dickieana and Dryopteris expansa. The most favorable for the development and dispersal of ferns in the Caucasus were forest areas with moderately warm and humid climate. At the same time, along with the humidity, the most important factors that influence the spread of ferns were the degree of rocky and stony habitats and the nature of slope exposures.

Key words: Ferns, Taxonomy, Ecology, Rare species, Pteridoflora

Introduction. The fern being one of the most ancient groups of high plants take its beginning from Devon geological period (300 million years BC). More than 10000 samples belonging to 300 genera are spread around the world. The most of its species diversity and the forms of life (biomorphs) is in the tropical countries. The fern species is one of the main phyto-components among the plant cover, especially in forest plants. There is much kind of medicines, food, technical and decorative species among the ferns. We were researched the ferns before on the flora of Thalish and then on the flora of whole Caucasus since 1970. I was published the monograph “The ferns of Caucasus” in 1984. When I was doing these scientific researches the well-known researchers-professors of Caucasus A.A. Kolakovsky and A.G. Doluchanov gave me valuable advices about this.

Ecological groups of ferns – mesophytes, xerophytes, mezoxerophytes, hydrophytes and geophiles were identified. Over 70% of the ferns of the region were mesophytes, typical for wooded ravines, riverside habitats and rocky - forest complexes. The main regularities in the distribution of ferns along vertical zones were determined. The richest in number of species were foothills and lower mountain (50 species, or 52% pteridophlora) and middle mountain (49 species, or 51.5%) zones. In the highlands, the number of species decreased. Of all types 8 were not typical for the forest zone. From forest ecotypes were particularly rich forest ravine (51 species), river valley (34 species). Lithophilous group includes 57 species, out of which 13 were calcephilous; epiphytes - 13 species, 23 species of forest ferns were found in secondary coenoses. This distribution of species probably was due to the peculiarities of climatic, orographic and other factors, as well as the main natural ecosystems

of the Caucasus Isthmus. Analysis of the distribution of fern species in botanical and geographical areas of the Caucasus showed that for the abundance of fern populations were allocated two provinces - Evksinski (Colchis) and Hirkanian, but for the number of species Colchis exceeded Talysh by more than 2 times (respectively 67 and 36 species). Colchis for the number of species followed by the rest of the Greater Caucasus (51 species) and forest areas of the North Caucasus (36 to 42 species). Respectively less ferns were in Ciscaucasia, Gobustan, Absheron, Nakhchivan (2 - 10 species). Thus, in the Caucasian isthmus number of species of ferns decreased with distance from the forest regions in the direction of semi-deserts and steppes. Arealogical and florogenetical analyzes established a connection with the forest ferns of the Caucasus and flora of the tropics and subtropics of Eastern Asia and South Paleoarctic on the one hand and South - West Asia and South Africa - on the other hand.

Materials and methods. The materials for research were herbarium materials and ecologic-botanic information collected by author from whole regions of Caucasus. As well as the herbarium fund materials which were kept the botanic institutes of Sankt-Petersburg Caucasus have been critically analyzed. Mostly were used from the classic- morphological and geographical methods in this work. Also were used from critical taxonomiescomparative-morphological-anatomic, polynological, karyological and experimental methods. As well as there were used from areological, paleobotanic and florogenetical methods in the work.

Result and discussion. The main researcher of ferns was acad. A. Fomin [Fomin, 1913] in the former Soviet Union. He published the monograph “Pteridoflora of Caucasus” in 1911 and described 6 new species which is special for the forests of Caucasus: *Dryopteris raddeana*, *D.alexeenkoana*, *D.oreades*, *Polystichum woronowii*, *Asplenium pseudolanceolatum*, *A.hermannii-christii*. We meet some interesting information about ferns of Caucasus on the works of A.Qrossheym, A.Kolakovsky, I.Safarov, L.Pirilipko [Kolakovsky and Asgarov, 1981].

The taxonomic analyze of Caucasus ferns. 96 species of ferns belonging to 20 family and 31 genera have been found at the results of our researches in Caucasus. The 51 species from these is special for the forest phytosenoz. Numerous new genus and species have been found for the science and flora by the expeditions and researches keeping materials in the Herbaria funds. 8 new species and 2 species diversity have been described by us: *Polystichumkadyrovii, Polypodiumissaevii, Polystichum x fominii, P. xsafarovii, P. xdmitrievae, D.x. doluchanovii, D.x. schorapanensis, D. xkolakovskyi, Dryopteris raddeana var. talyschensis, Polypodiumvulgarevar. zuvandicum.*

The number of ferns families of Caucasus Flora increased from 5 to 20 and the generas from 23 to 31 compared to the current “flora”and “modifier”. 2 genera have been new for Caucasus: *Cyrtomium*C.Presl., *Onoclea* L. But 20 new species and 2 half-species have been found for the past Soviet Union: *Pterisvittata, Adiantumcuneatum, Cyrtomiumfalcatum, Dryopterisremota, D.caucasica, D.atrata, D.ambroseae, D. x deweveri, D. x.euxinensis, D. x.initialis, D.x.mantoniae, D. x.sarvelae, Polypodium x mantoniae, P. x shivasiae, Polystichum x illiricum, P. x bicknellii, P.xluerssenii, P. x wirtgenii, Asplenium x ticinense, A. x centovallense, A.septentrionale ssp. coriacea* and *ssp. persica* [Asgarov, 1977].A lot of new species and new spreading fields have been found for South and North Caucasus as well [Asgarov, 2001].

The rare and endangered species. Generally, the ferns were considered the group of relict plant and have to protect. There are many species among them which is tagged in category prepared by the Union Environmental Protection, especially being critically endangered species. This species has been researched by us and were published in the large scale article named “The rare ferns of Caucasus” on the journal of “Botanic” 25 species analyzed on this article. For example, *Osmundaregalis* (Abkhasia), *Hymenophyllumtundbrigense* (Adjariya), *Anogrammaleptophylla* (Talish, Adjariya), *Botrychiumantemoides* (Azerbaijan,

Daghestan), *Ophioglossumlusitanicum* (Azerbaijan, Abkhasia) and others [Asgarov, 1983].

Ecological analyze. The ferns more reflective to ecological factors, especially against the factorsofhumidity. This is related with its reproduction. The forest regions having temperate and humid climate is more suitable for developing of ferns in the Caucasus. As well as there are a lot of places in mountainous areas, humid stony and rocky biotopeswhere the ferns develop intensive.

The ferns vertically conform to the legality on spreading in mountain slopes in Caucasus. From this point of view the alp, sub alp and forest slopes clearly chosen on its spreading. Let's talk shortly about the spreading of ferns in the forest slopes. The ferns spreading easy and larger at the deep valleys of forests, banks of the rivers and humid slopes cause of having constant humidity background. Humid climate was stayed basically unchanged during the millenniums in these forms of relief. The species of fern (for example, very reflective changes in humidity, having thin anatomical structure –*Hymenophyllumtundbrigense*) in those areas were stayed at least from 3 rd geological period.

Ecological factors are special in forests and humid stony and rocky biotopes. There are about 57 species (approximately 65% of forest ferns) at this kind of places. One of the important bimorphs of ferns is epiphyte. The epiphytes give the special beauties to our forests (table 1).

A lot of species of fern are met in the formation of specifical forest: for example, *Dryopterisraddeana, Polystichumworonowii*istipical for Hirkan and Kolkhidaforests. There is decrease of species in spreading from lowland to mountain areas at the spreading period by the forest slopes. *Polypodium vulgare* L (shrubby place above the humid rocks in hornbeam forest) (pic.).

Areologic analyze. There 21 botanical-geographical regions are determined [Asgarov, 2001] at the following diagram paying attention the spreading features of pterydophites in Caucasus (diag.).

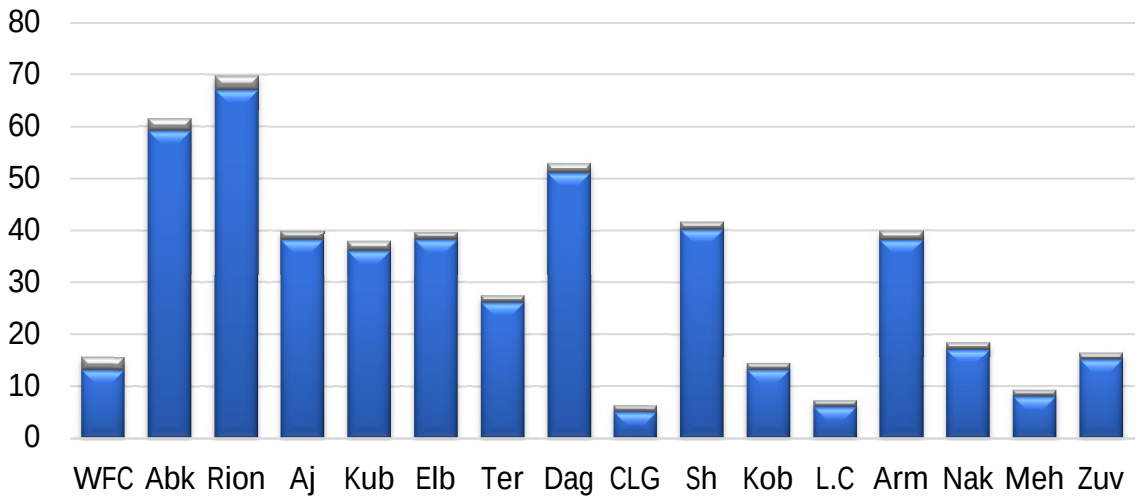
The spreading of ferns has seen easily in this scheme on those regions. Actually, there are 2 regions in Caucasus - Kolkhida and Talish are chose on the normal progress and compactness of ferns population. According to number of species compared with Talish there are 2 times more species in Kolkhida. This is related with humid climate of areas and with other climate - the factors of soil. The regions of North Caucasus with forests have much more species after Kolkhida region (51 species) and 40 species in South Caucasus. The Gobustan, Nakhchivan and Absheron regions have less species. Thus, the number of species were observed gradually reduce from regions with forests to semi-desert and steppe.

TABLE 1. Theepiphytes of Caucasusand its substratum (growing above bodies) trees.

Species	Substratum
Polypodium australe	*Quercus iberica,* *Carpinus caucasica*
P.issaevii	*Carpinus caucasica* *Alnus subcordata* *Pterocarya pterocarpa* *Junglans regia* *Tilia begonifolia*
P.vulgare	*Zelkova carpinifolia*
P. x mantoniae	*Carpinus caucasica* *Pterocarya pterocarpa* *Junglans regia*
P. x schivasiae	*Acer velutium* *Pterocarya pterocarpa* *Junglans regia*
Hymenophyllum tunbrigense	*Lauroserasus officinalis*
Phyllitiss colopendrium	*Parrotia persica* *Acer velutium* *Alnus barbata* *Pterocarya pterocarpa* *Zelkova carpinifolia*
Asplenium adiantum –nigrum	*Parrotia persica* *Acer velutium*
A.trichomanes	*Parrotia persica*
Polystichum aculeatum	*Parrotia persica* *Quercus castaneifolia*
Dryopteris filix – mas	*Carpinus caucasica* *Pterocarya pterocarpa*
D.raddeana	*Fagus orientalis* *Pterocarya pterocarpa*

PICTURE. *Polypodium vulgare*L.

DIAGRAM 1. Thespreading scheme of fern species in botanical-geographical regions of Caucasus. 1-Western Front Caucasus, 2-Abkhazia, 3-Rion, 4-Ajaria, 5-Kuban, 6-Elbrus, 7-Ter, 8-Dagestan, 9-Caspian Littoral-Guba, 10-Shamakhi, 11-Gobustan, 12-Lesser Caucasus, 13-Armenia, 14-Nakhchivan, 15-Mehri, 16-Zuvand, 17-Talish, 18-Northern Caucasus, 19-Absheron, 20-Estern Front Caucasus, 21-Cherquez.



Chorological analyze. The forest ferns species of Caucasus belong 10 type of geographic areas: Kolkhid, Hirkan, Hirkan – Kolkhid, Eucaucasus, Daghestan, wholeCaucasus, Europe – Caucasus, Holarktik, Palearktik, Pluriregional. The relict speciesmost related with the refugiums of Kolkhida and Talish and have 7 species: *Dryopterisalexeenkoana* Fomin, *D.liliana* Golits., *D.aemula* (Arit.) O.Kuntze, *D.raddeana* Fomin, *Polystichumworonowii* Fomin, *Aspleniumworonowii* Christ, *Polypodiumsubuntegrum* (Fomin) A. Askerov. We are

meet species belonging to the types of geographic areas - Holarktik (26 species), Palearktik (13 species) and Europe – Caucasus (11 species). The event of endemism is weak at the pterydoflora of Caucasus (total 8 species): *Hymenocystisfragilis*, *Polystichumkadyrovii, Aspleniumworonowii, A.hermannii- christii, A.daghestanicum and Polypodiumissaevii*.

About the genesis of pterydoflora of Caucasus.For the researching of genesis and ways of formation of Caucasus forest ferns and all of pterydoflora have been used a lot of paleobotanical materials. The paleobotanical materials of Caucasus ferns–partsof leaves and spors have been known from paleozoymillennium (Carbon period) but main finds begin from mesosoy (Cretaceous period) (table 2.). There are a lot of tropical and subtropical ferns and tree forms (*Dicksonia, Cyathea*). The ferns were spread much moreinCenozoic, especially-inoligosen (the species of 12 genera), in miosen (11 genera). The leaves vestige of 24 species and the spors of 41 species have been found on Caucasus ferns. The species of 24 genera are met in modern flora.

TABLE 2. The geochronologicof modern ferns generaof Caucasus in Cenozoic (macrosediments - with intermittently lines, spors - with intactlines).

Genera	PALEOGEN			NEOGEN										ANTROPOGEN					
				MIOSEN						PLIOSEN				PLEYSTOSEN					
	Paleosen	Eosen	Oligosen	Karagan	Konk	Tarkhan	Chokrak	Sarmat	Meotis	Pont	Kimmeriya	Kuyalnik	Guriya	Chauda	Ali-cientevksin	The longs	Karangat	New evksin	Holosen
Adiantum								*	*										
Anogramma									*	*	*	*	*						
Asplenium			*	*	*			*					*				*	*	*
Athyrium													*	*		*			
Blechnum			*																
Botrychium									*		*	*	*	*	*	*	*	*	*
Cystopteris				*	*			*	*		*	*	*						
Cryptogramma								*	*		*	*	*	*	*	*	*	*	*
Dryopteris			*											*					
Gymnocarpium													*	*					
Hymenocystis																			
Hymenophyllum								*	*		*	*							
Matteuccia											*								
Onoclea								*											
Ophioglossum									*	*	*	*	*						
Oreopteris														*					
Osmunda			*	*	*			*	*		*	*	*	*	*	*	*	*	*
Polypodium			*	*	*			*	*	*	*	*	*	*	*	*	*	*	*
Polystichum									*					*					
Pteridium				*	*			*	*	*	*	*	*	*	*	*	*	*	*
Pteris							*			*									
Salvinia												*			*	*	*	*	*
Thelypteris								*			*		*	*					
Woodsia																			

Conclusions. The present fern flora of Caucasus consists of 96 species [Kudryashova, 2003], 21 of them hybridogenous from 31 genera and 20 families, 20 species and hybrids were newly described. There are 21 interspecific hybrids, 9 of them are new. The species richness of the various parts of the Caucasus is discussed. As to the general distribution of the taxa, 10 geo-elements can be distinguished; the holarctic is predominant. 15 species are endemic or almost endemic and are mostly confined to certain, limited parts of the area.

A lot of tropical and subtropical fern species were destructed in Pliosen and the pterydoflora was getting its modern situation in pleystosen. The chronological and paleobotanical analyze show that the pterydoflora of Caucasus has florogenetic connection with the tropical and subtropical floras of Eastern Asia and Southern Paleoarctic. The florogenesis of some groups is close to the floras of Southwestern Asia and Southern Africa.

Then under our leadership, from 2016 to 2018 the species of ferns in differentregionsofthe Caucasus were studied by different Phd students (U.Akchay and L.N.Verdieva).

As a result of the monographic processing of Caucasian ferns by A.M.Asgarov, as well as the monograph of the genus by Fraser-Jenkins, the composition of the genus [Asgarov and Akchay, 2016]. Dryopteris was supplemented by 6 more species: *D.assimilis* S. Walker, *D.remota* (A. Br. ex Döll.) Druce, *D.pseudorigida* (Christ) Askerov, *D.caucasica* (A. Br.) Fr. – Jenk., *D.schorapanensis* Asgarov, *D.iranica* Fr. – Jenk. In addition, 5 more hybrid species of ferns were found (Asgarov, 2013): *D. x sarvelae* Fr. – Jenk. et Jermy (*D.expansa* x*D.carthusiana*); *D.x euxinensis* Fr. – Jenk. et Corley (*D.caucasica* x D. filix-mas); *D. x initialis* Fr. – Jenk. et Corley (*D.oreades* x *D.caucasica*); *D. x mantoniae* Fr. – Jenk. et Corley (D. filix – mas x D. oreades); *D. x tavelli* Rothm. (*D. filix* - mas x *D.borreri*).

Also, during the expeditions in the northeastern part of the Lesser Caucasus between 2014-2016 and based on the results analysis of the collected herbarium and descriptor informations three species (*Polypodium interjectum* Shivas, *Polystychum illyricum* (Borb), Hahne, *Cystopteris anthriscifolia* Fomin), one botanical variety (*Polystychum aculeatum* var. *aristatum* (Christ) A.Askerov) and one new ecotype (*Adiantum capillus - veneris* L., "Dwarf plant - Ganja") has been identified [Verdieva and Asgarov, 2018].

Fam: *Ophioglossaceae (Ophioglossum - O.lusitanicum, O.vulgatum; Botrychium- B.lunaria; Botrypus - B.anthemoides);*

Fam: *Osmundaceae (Osmunda, O.regalis);*

Fam: *Salviniaceae (Azolla, A.filiculoides, S.natans);*

Fam: *Marsileaceae (Marsilea, M.quadrifolia, M.strigosa);*

Fam: *Pteridaceae (Cryptogramma, C.crispa; Anogramma, A.leptophylla (L.);Pteris, P. cretica; Adiantum, A.capillus-veneris;Oeosporangium, O.persica, O.pteridioides; Paragymnopteris, P.marantae);*

Fam: *Dennstaedtiaceae (Pteridium, P.aquilinum);*

Fam: *Cystopteridaceae (Cystopteris, C.fragilis, C.dickieana; Gymnocarpium, G.dryopteris, G.robertianum);*

Fam: *Aspleniaceae (Asplenium, A.adiantum-nigrum, A.ceterach, A.scolopendrium, A.ruta-murari, A.septentrionale, A.trichoma¬nes, A.viride, A.woronowii);*

Fam: *Woodsiaceae (Pseudathyrium, P.alpestre; Woodsia, W.alpina, W.fragilis, W.glabella);*

Fam: *Onocleaceae (Onoclea, O.struthiopteris);*

Fam: *Athyriaceae (Athyrium, A.filix-femina, A.multidentatum);*

Fam: *Thelypteridaceae (Phegopteris, P.connectilis; Oreopteris, O.limbosperma; Thelypteris, T.palustris);*

Fam: *Dryopteridaceae (Dryopteris Adans, D.borreri, D.carthusiana, D.caucasica, D. expansa, D.filix-mas, D.oreades, D.raddeana, D.talyschensis; Polystichum, P.aculeatum, P.braunii, P.kadyrovii, P.lonchitis, P.setiferum, P.woronowii);*

Fam: *Polypodiaceae (Polypodium, P.cambricum, P.vulgare).*

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THE EPR PARAMETER'S INVESTIGATION OF PLANTS UNDER THE INFLUENCE OF RADIATION FACTORS

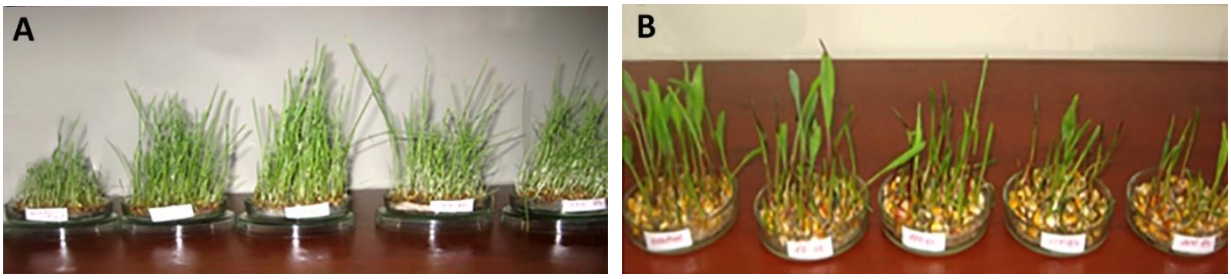
*ROVSHAN I. KHALILOV, **AYGUN N. NASIBOVA
DOI: 10.30546/abc.2022.1.1.48
*Baku State University, Baku, Azerbaijan
**Institute of Radiation Problems of ANAS, Baku, Azerbaijan
*hrovshan@hotmail.com

Annotation: In this paper, by using the method of Electron Paramagnetic Resonance (EPR) spectroscopy, the influence of some stress factors (ionizing gamma radiation, radioactive contamination, and UV radiation) on C-3 (wheat) and C-4 (corn) plants has been investigated. Under the influence of stress factors on C-3 plants, a stimulating effect is observed in their development, and in C-4 plants, stress factors have the opposite, inhibitory effect on the development of these plants. It is assumed that this process is related with photorespiration - with a protective system that prevents an increase in reactive oxygen species (ROS) during stress in type C-3 plants. In addition, the work shows that the stress factor has a stimulating effect on the generation of biogenic nanophase magnetic particles (Fe3O4 - magnetite and γ-Fe2O3 - maghemite) and leads to the appearance of anomalous magnetic properties in living systems. This effect can be used in the synthesis of functional magnetic iron oxide nanoparticles. The results show that stress factors play a stimulating role in the formation of paramagnetic centers in biological systems. This effect of exposure can be used as a bioindication parameter in environmental assessment and monitoring.

Keywords: radiation, radioactive contamination, stress factors, photorespiration, EPR signals.

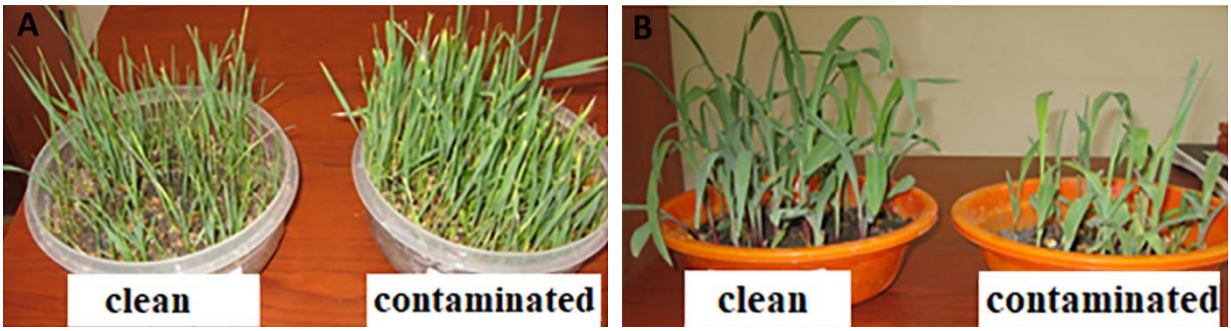
Introduction. At present the study of the effects of ionizing radiation is becoming an important task. Currently a large amount of data has been accumulated on the effects of ionizing radiation on plant growth and reproduction, and also about changes caused by ionizing radiation at the genetic level. Primary physicochemical reactions caused by ionizing radiation, including the formation of various reactive oxygen species (ROS), are the cause of the observed changes in the functional activity of plants. We investigated the effects of some stress factors (ionizing gamma radiation, radioactive contamination and UV radiation) on plants. Changes and regularities in the morphological characteristics of C3 and C4 plants, as well as in the paramagnetic centers formed in them, were studied under the influence of radiation factors.

PICTURE 1. 10-days-old seedlings of control and irradiated with different doses of ionizing gamma radiation seeds of wheat (A) and corn (B)



Materials and methods. The objects of our research were plants C-3 - wheat (*Triticum* L.) and C-4 - corn (*Zea Mays* L.). The studies were carried out by EPR spectroscopy (BRUKER - EMXPlus). When studying the effect of radioactive contamination and ionizing gamma radiation on the paramagnetic centers in *Triticum* L. and *Zea Mays* L. plants, morphological changes occurring in plants during these influences are of great interest. The morphological diversity and observed pattern in C-3 and C-4 plants during stress were confirmed in EPR studies. The role of photorespiration in the results obtained is not excluded. In the experiments, wheat and corn seeds were irradiated in different doses (50 Gy, 100 Gy, 200 Gy, 300 Gy) using a K-25 irradiation device. Then they were grown for 10 days at room temperature and under natural conditions (pic. 1). When studying the effect of radioactive contamination, wheat and corn seeds were germinated in clean (control) and radioactively contaminated soil (pic. 2).

PICTURE 2. 10-days-old seedlings of wheat (A) and corn (B) seeds grown in control and radioactively contaminated soils



Results and discussion. Figures 1 and 2 clearly show that the influence of ionizing gamma radiation and radioactive contamination have a stimulating effect on the growth of wheat, which belongs to C-3 plants. In these plants, when exposed to stress, growth improves and the percentage of germination increases. But in corn plants we see the opposite. Stress factors have an inhibitory effect on corn.

We assume that photorespiration plays an important role in the resulting result. Analysis of our results and literature data indicates the high biological significance of the glycolate pathway of photorespiration. Photorespiration is a mechanism that removes molecular oxygen from the sensitizer site and reduces the formation of electrons [Astrid Wingler et al., 2000; Stefan Timm and Martin Hagemann, 2020]. When exposed to stress in C-3 plants, photorespiration acts as a defense system, decreasing the concentration of ROS. According to the literature, it is known that photorespiration is enhanced under conditions when too many carbohydrate products of photosynthesis are formed. This condition leads to the oxidation of "excess" sugar and amino acids are formed. Thus, if, for some reason, with the use of the products of the light stage of photosynthesis in dark reactions, difficulties arise in the reduction of carbon dioxide or with the consumption of sugars, then the photooxidative processes are enhanced.

As a result, no sucrose is formed, but amino acids are formed, which are used for growth processes in the leaf [Chikov, 1996; Polevoy, 1989; Maurino and Peterhansel, 2010]. In our experiments, wheat seedlings under the influence of ionizing gamma radiation, as well as under radioactive contamination, significantly increase.

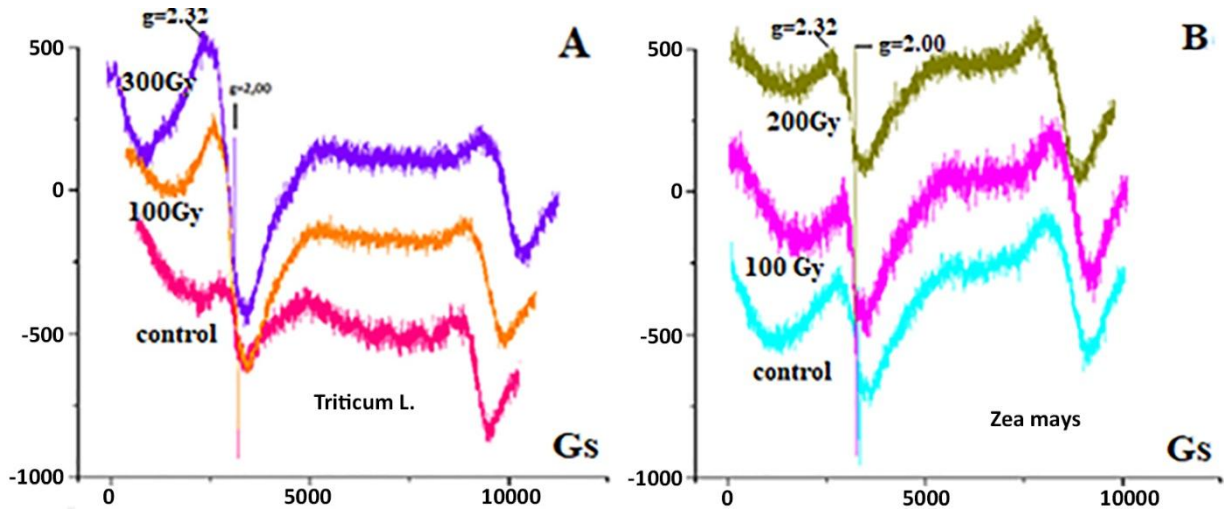
As for C-4 plants (in our case, corn), as it is known, they don't have a pronounced photorespiration [Kozaki and Takeba, 1996; Peterhansel and Maurino, 2011; Bari et al., 2004]. Plants C-4 have a special structure and anatomy. The fact is that they have chloroplasts, which are present not only in the mesophyll cells, but also in the sheath cells. In the mesophyll cells, CO_2 assimilation takes place and a four-carbon compound is formed, which are then transferred to the sheath cells. In the cells of the mesophyll, CO_2 is absorbed, and in the cells of the sheath, it is restored to sugars. We believe that here the mesophyll cells play the role of a "transformer" regulating the absorption of CO_2 by the sheath cells. In the cells of the sheath, CO_2 is assimilated according to the usual mechanism of C-3 plants, but already at increased concentration of CO_2, formed during decarboxylation of malic or aspartic acid. This fact explains the absence of visible photorespiration in C-4 plants [Astrid Wingler et al., 2000; Chikov, 1996; Polevoy, 1989].

Then, by EPR spectroscopy, the spectra of the studied plant species were recorded. Under the influence of stress factors on plants, it was found that increase of the dose ionizing gamma radiation leads to the formation of broad EPR signals, which are characteristic of nanophase iron oxide magnetic particles ($g = 2.32$; $\Delta H = 320Gs$) and an increase in the intensity of the free radical signal ($g = 2.0023$) (pic. 3A).

The obtained results allow us to assume that a moderate dose of radiation stimulates the formation of magnetic iron oxide nanoparticles in plants [Khalilov and Nasibova, 2010; Khalilov et al., 2015; Nasibova et al., 2016]. There is every reason to believe that the formation of magnetic nanoparticles giving broad lines in the EPR spectrum is associated with the operation of the photosynthetic apparatus in plant leaves. It can be assumed that the stimulation of the formation of magnetic nanoparticles in plants exposed to radiation may be associated with a partial disturbance of chloroplast intactness due to the action of gamma radiation.

In this case, the accessibility of exogenous sources of nanoparticle formation (for example, iron ions) to the electron transport chains of chloroplasts will increase, thereby stimulating the formation of nanoparticles.

PICTIRE 3. EPR spectra of seedlings of wheat (A) and corn (B) seeds irradiated with different doses of ionizing gamma radiation



Hence, as a result of biomineralization processes under the influence of stress factors, biogenic formation of magnetic nanoparticles occurs in plant systems, which leads to the formation and increase of their signals [Khalilov et al., 2015; Nasibova et al., 2016; Nasibova et al., 2017].

Such influence effects did not impact on the EPR spectra of corn (pic. 3B). This result is explained by the fact that the stress factor in C-4 plants suppresses the electron transport chain in thylakoid membranes. Despite the fact that the number of free iron ions increases, the number of electrons decreases. Therefore, the number of forming nanoparticles of iron ions does not change.

The results of our experimental work allow us to evaluate photorespiration as one of the key homeostatic defense mechanisms of plants. It is due to photorespiration that the rate of ROS formation decreases. In addition, in the glycolate pathways of photorespiration, energy costs and needs in reducing units of photosynthesis increase, so that they contribute to the protection of the electron transport chain.

Also, research results have shown that stress factors play a stimulating role in the creation of paramagnetic centers in plant systems. This effect can be used as a bioindication parameter in environmental assessment of the environment.

Experiments using EPR spectroscopy have shown that this method is a very promising method for detecting paramagnetic centers in plant systems and can provide new information in environmental assessment and biomonitoring. The results will allow us to better understand the origin and role of biogenic paramagnetic centers in biological systems.

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THE DIVERSITY OF PLANT ASSOCIATIONS OF AZERBAIJAN'S WATER-MARSH VEGETATION

VAGIF V. ATAMOV
DOI: 10.30546/abc.2022.1.1.52
Recep Tayyip Erdogan University, Rise, Turkey,
vhatemov@yahoo.com

Abstract: This study of the years 2007-2012 in Azerbaijan's water-marsh vegetation, plants spread was carried out with the aim of determining the troops. According to phytosociological features five types of habitat and a total of 101 plant associations and groupings were determined. Of these, 33 units of water to the coastal marshes troops 31, 13 birliklər wet çimən, aquatic forest birliklər 8, hidrohalofit to consist of the 17 plant associations.

Azerbaijan's water-marsh vegetation cooperation for the 15 new plants have been identified. Vegetation formation of a at; Carex , Juncus , Ranunculus, Potamogeton, Schoeneplectus, Cyperus, Salix, Tamarix, Phragmites, Arundo belonging to the genus, in particular: Pragmites austuralis, Juncus litoralis, J. acutus, Typha latifolia, T. angustifolia, Schoeneplectus marittimus, Potamogeton salicifolius, P. pectinatus, Najas minor ssp. intermedia, N. minor ssp. armata, N. minor ssp. marina, Ceratophyllum submerse, C. demersum, Polygonum amfibium taxa dense population are. Water-marsh vejetation spread in 92% of the herbaceous, 8% woody plants body.

Rivers, streams, creeks and water channels around the flora richer (312 taxa), marshes (160) , still slow flowing water and quaint water lakes (127), salt lakes and the sea coast halophytic marsh and sand dunes as habitats are even poorer (114). Today: Nymphetum albae, Nelimbio caspici-Nymphetum albae, Trapetum hyrcanae, Butometum umbellati, Spargenieto-Menyantetum trifoliati areal narrowing , which is under threat and in need of protection associations. Azerbai-

jan's water -marsh vegetation in the various hazard categories entered a total of 68 taxa that and they ; 25 VI (13.5%) , each of which is 11 to LR (cd) and LR (lc) (2.2%) , 10 LR (nt) (2.0%) , 5 of the taxa (1.0%) were identified as belonging to EN and DD category.

Keywords: Water-marsh, ecosystems, vegetation, plant diversity, Azerbaijan

Introduction. There are 4500 vascular plants belonging to 125 families and 920 genera in the territory of Azerbaijan [Flora of Azerbaijan, 1950-1961]. According to the general number of species, the vegetation of Azerbaijan is quite rich compared to other republics of the Caucasus. The plant species seen in our country cover 66% of all plant species seen in the Caucasus [Grosshaym, 1936, 1948].

One of the reasons why our country's vegetation and flora is rich is that it has different ecological environments and habitat diversity. One of these ecological environments is water-swamp areas.

Its depth is less than 6 meters, some common property has sweet, flat and brackish water, lakes, swamps, stagnant stocks of streams, floodplains, sea shores, gulfs, rivers transform into watery ecosystems.

There are 450 lakes in Azerbaijan with a total surface area of 395 km^2. These are divided into 7 types as: glacial lakes, flooded lakes, weir sourced lakes, lagoon sourced lakes, karst sourced lakes, landslide sourced lakes and relict sourced lakes [Mammadov, 2011].

Settled in different regions of Azerbaijan; Sarisu (65 kv.km), Agzibirchala (13.8), Akgol (56.2), Candargol (10.6), Buyuk Alagol (5.1), Gokgol (0.79), Hajigabul (8.4) , Buyuk-Shor (16.2), Ashık Kara (1.76), and Karachug (0.45 kv.km) lakes are among the most important areas where water-swamp vegetation spreads [Sultanov, 2011].

The longest river in Azerbaijan is the Kur River, which is 1,364 km long and empties into the Caspian Sea. Aras river is 1.072 km long. The largest natural lake is Sarısu Lake with 67.0 km², and the largest artificial lake is Mingachevir Dam Lake with 605.0 km².

There are many plants that love the aquatic environment and spread around lakes and their surroundings, swamps and stagnant waters, channels and their surroundings, streams, lakes, ponds, artificial dam lakes, which form an important part of Azerbaijan's land. These are plants that love aquatic and swampy environments and form associations in these environments. This type of plants can be found in all regions of Azerbaijan, in plains and mountainous lands. The water-swamp plant associations are among the relict plant associations and were not affected by the icing cycle and caused the formation of aquatic ecocenoses [Grossheym, 1940]. Water-swamp plants spread widely on the edges of lakes, marshes, reservoirs and canals due to their long evolutionary development time due to their adaptations.

Water-swamp ecosystems are widespread all over the world [Kats, 1961; Aliyev, 1969; Grandstein & Smittenberg, 1977; Katanskaya, 1981; Seçmen & Leblebici, 1984; Bechet & Altan, 1994; Chakan & Temiz, 1993; Chivelek & Chetin, 1993; Golub and Losev et.al., 1991].

Water-swamp vegetation has been explored in many parts of the world. Wetlands in Turkey [Behchet, 1994a, b; Seçen and Leblebiçi 1996; Chakan et al. 2003; Karaomeroglu, 2007], salty wetlands [Aydogdu et al., 2002; Hamzaoglu and Aksoy 2009], flooded areas [Kutbay et al. 1998; Özen, 2010; Kavğacı, 2010] and dune fields [Kılınç and Özkanca 1991; Kılınç and Karaer 1995; Karaer et al., 1997; Çakan et al., 2003; Karagmeroğlu, 2007] some phytosociological studies have been carried out.

[Sechmen and Leblebici 1996] recorded that there are 23 plant associations in the wetlands of Turkey, 31 in coastal meadows, 7 in wet meadows, 1 in wet tree assemblages, and 21 plant associations in salty associations.

[Richard Hırıvnak 2002a., 2002b] gave the vegetation classification of Potametea, Lemnetea and Charetea classes in the region in his

studies on the distribution and classification of aquatic plant communities of Slovakia and Bulgaria and examined the phytosociological properties of plant associations belonging to these classes.

İnvestigated the floristic composition of aquatic macrophytes of teas in Bulgaria and in this study divided the aquatic flora of the region into three groups as hydrophytes, helophytes and amphiphytes. [Yucel, 2010] investigated the heavy metal biomonitor feature of Myriophyllum spicatum, which is distributed along the Porsuk River in Turkey [Gecheva et al. et al 2013].

Some of these associations are also found in the water-swamp plant associations of the high mountainous regions of Azerbaijan [Ocakverdi et al. 2009].

Examined the plant associations of the forest vegetation around Taiwan's Yuanyang Lake and showed that the water-swamp type forest associations are located at an altitude of 1650-2432 m above sea level [Chang-Hung Chou et al., 2000].

[Korkmaz et al. 2012] In a study he carried out in the Golardi Wildlife Protection Area within the borders of Samsun Province in Turkey; It has psammophyte, hygrophyte and forest type vegetation and made a syntaxonomic evaluation of these types. Among the vegetation types determined in this study, it is seen that the degree of similarity among the plant associations found in the coastal areas of the Caspian Sea of Azerbaijan is high [Atamov, 2007].

Water-swamp vegetation in the Azerbaijani land is common in many botanists [Grossheym, 1936, 1948; Prilipko, 1970; Aliyev, 1969; Babayev, 1974; Efendiyeva, 1998; Hajiyev, 1970; Hajiyev et al, 1991; Atamov, 2008; Talibov, Ibrahimov, 2008; Ibrahimov, 2008; Musayev, et.al., 2010]. However, there is a need to make a classification of the syntaxonomic structure of the vegetation in these ecosystems, which is accepted in the world today. In order to explain the syntaxonomic structure of such areas, new and detailed studies are needed [Mucina, 1997].

In the vegetation of Azerbaijan, these ecosystems are more widespread in regular areas and are also encountered in mountainous regions.

One of the regions where this vegetation type is most common is the Lankaran plain located in the southeast of Azerbaijan. In this region, there are many lakes, ponds, swamps and gulfs in orderly parts [Mammedov, 2011]. The Big and Little Kizilagac Bays, which form a natural water-swamp ecosystem in the region and are on the Ramsar list, are among the most important areas in this sense [Sultanov, 2000].

In this area, which is known as the migration route of many birds, the water-swamp vegetation is. It was explored by [Grossheym, 1936, 1948] and later by Aliyev.

[Aliyev, 1969] In the Lankaran plain where water-swamp vegetation is common in Azerbaijan, [Babayev, 1974] İn the high mountain areas of the Lesser Caucasus, [Efendiyeva, 1989] conducted research on the Absheron peninsula, and [Musayev, 2010] on the Kur-Araz plain for many years.

The general vegetation and water-swamp areas of Nakhchivan have also been investigated for many years by Talibov and Ibrahimov. As a result of the studies carried out by these researchers, we see that there are water-swamp ecosystems in different regions of Nakhchivan, adding many taxa to the flora as new records [Talibov and İbrahimov, 2008].

Mammadov shows that factors such as ecological conditions of the environment, water composition, chemical content, salinity degree, altitude above sea level, and temperature play an important role in the emergence of differences in lakes in curing.

While the mesophyll species that prefer ecologically less humid habitats settle in the area, the hygrophilous species that prefer flooded habitats withdraw from the area and a different floristic and structural structure develops. Because there is a strong correlation between the water table depth, soil water content and wetland types in flooded areas and seaside plains (Meendino et al., 1990).

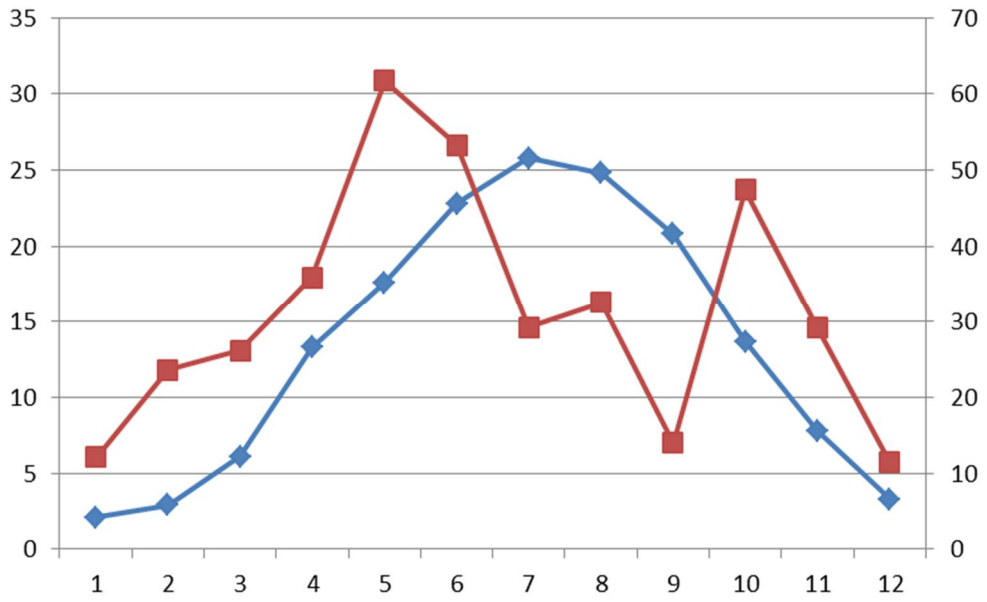
According to the warth the study area can be diveded as temperate zone (over 1800m.), hot zone (between 700-1500m) and extreme hot zone (between 0-500m.).

Annual rainfall per year at the water-marsh vegetation zones is differs between 300-650(700)mm. Summers are extremely hot while winters are cold. The study area is under continental climate which determine the character of the plant cover.

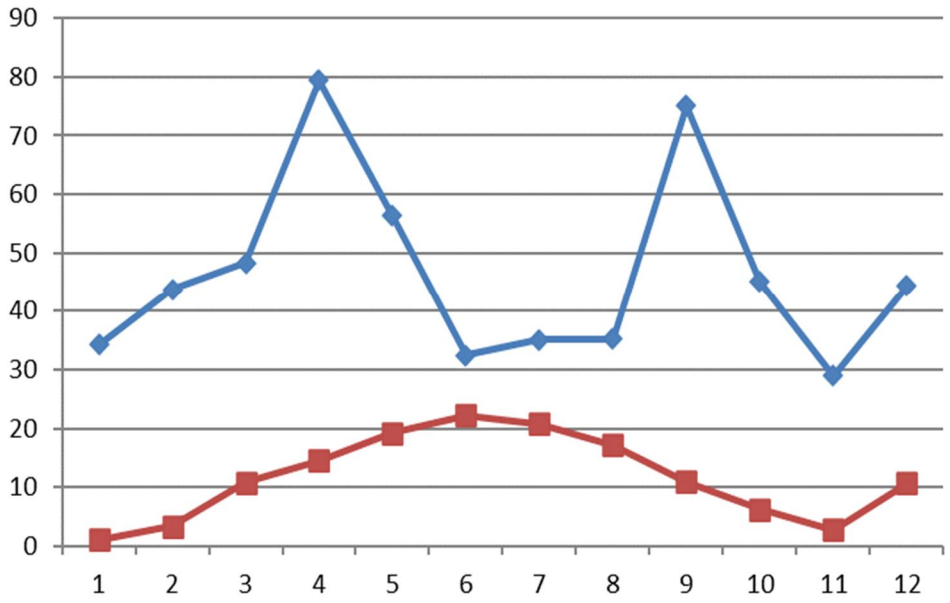
Kur-Araz plain, Kacheti and Avtaran are at the Caucas provence of Azerbaijan which has a tempature betwwen +2 or +3 C° in winters (climate Azerbaijan, 1968.)

In summers izoterm changes in different direction, it rises from North-west to South-east (pic. 1,2).

PICTURE 1. The distribution of Temperature and Rainfall (P. mm) according in Water-Marsh regions of Azerbaijan between 1990-2013



PICTURE 2. Temperature (^{0}C) Kur-Aras Lowland 300m 13,4 376,6 Rain (mm)



The physical-geographical and soil-climatic conditions of the region, vertical belting and many other features also affect the development of vegetation. Desert, semi-desert and water-swamp plants have developed up to 200 meters high in the plains of Azerbaijan. Water-swamp ecosystems are also encountered in the mountainous and high mountain regions of Azerbaijan, along with the regular sections. Especially in the subalpine and alpine belts of the Greater and Lesser Caucasus Mountains, many mountain lakes, streams and streams are encountered.

Water-swamp plant associations are seen in the form of spots against the background of desert and semi-desert type plant groups, but in the coastal areas of many lakes and especially on the Caspian coast, Mil, Mugan and Shirvan plains.

Halophytic desert, semi-desert vegetation spreads in the plains along the rivers of Shirvan, Mugan, Mil, Jeyranchol, Kobustan and Aras. In Kur-Aras, Kobustan, and Ceyranchol, zonal formations (*Artemisetum*) covered a larger area. Other formations, *Salsoletum dendroidesae*, (Kur-Aras) and *Salsoletum nodulosae* (Kobustan, Nakhichevan) units are common.

One of the most characteristic plant associations for these lands is the gallery forests formed by water-loving tree species. In particular, the main types of forests along the Kur and Aras river valleys are *Populus, Alnus, Fraxsinus, Salix, Eleagnus, Tamarix* etc. species belonging to the genus.

Material and Method. Field studies between 2007-2013 in the lakes and marshes settled in the plain and mountainous regions of Azerbaijan, in the coastal areas, especially the Lankaran plain (Great and Little Alder Agac Bay), Samur-Devechi plain (Devechi Harbour), Candar Lake and the lowland and mountainous areas of Nakhchivan. sections (Batabat lake, Araz deryaçası, Goygol lake in Ordubad land), Kur-Araz plain (Hacıgabul, Sarısu) and Absheron peninsula (Masazır duz lake, Lokbatan and Kanlıgöl).

Plants were collected at different vegetation periods and in all seasons. The identification of the collected plant specimens was made according to the 8-volume "Flora of Azerbaijan". Identified plant samples are kept in the Herbarium Laboratory of the Botanical Institute of the Azerbaijan National Academy of Sciences. Rare, endemic and threatened species were evaluated according to the Red Book of Azerbaijan. The life forms of plants are given according to the [Raunkier, 1934] system. Phytosociological properties and formation of vegetation tables of plant associations Syntaxonomic nomenclature of associations according to the "smallest area" principle according to the [Braun-Blanquet, 1964] method [Weber et al., 2000] was made according to.

Results. As a result of this research, the water-swamp vegetation of Azerbaijan was investigated according to the Braun-Blanquet(1964) method and the syntaxonomic evaluation result is given below.

1. In-water (Hydatophyte) units

They are pure plant plants whose bodies settle on or in water in slow-flowing streams, lakes and sea coasts, in gulfs, in places where the water depth is not more than 6 m.

Class: Charetea Fukarek ex Krausch 1964
Ordo: *Charetalia* Sauer ex Krause ex Krausch 1964
Alyans: *Charion vulgaris* (Krause et Leng 1977) Krause 1981
Association: *Charetum vulgaris* Collion 1957
Potamogeteneto natansi-Charetum vulgaris MM & VA 2013
Class: Ruppietea
Ordo: *Ruppietalia*
Alyans: *Ruppion marittimi*
Association: *Ruppietum maritimae* Beguinot

Class: Lemnetea De Bolos et Masclans 1955
Ordo: *Lemnetalia minoris* De Bolos et Masclans 1955
Alyans: *Lemnion minoris* De Bolos et Masclans 1955
Association: *Lemnetum minoris* (Oberq. 1957) Millee et Görs 1960
Lemnetum gibbae Miyawaki et J. Tx. 1960
Lemnetum trisulcae Soo 1927
Class: Potametea R.Tx.et Preising 1942
Ordo: P*otametalia* Koch 1926
Alyans: *Potamion pusilli* Heyny 1978
Association: *Potametum pectinati* Carstensen 1955
Alyans: *Potamion lucentis* Rivas-Martinez 1973
Association: *Potametum lucentis* Hueck 1931
Elodeetum canadensis Eggler 1933
Valisnerietum spiralis MM & VA 2013
Alyans: *Potamion pusilli* Heyny 1978
Association: *Potametum perfoliati* Koch 1926 em Pass 1964
Potametum pectinato-perfoliati Den Hortog Segal 1964
Potameto-Najadetum (Hartovic 1931) Micevski 1958
Potamogeteneto heterophylli-Vallisnerietum spiralis MM & VA 2013
Alyans: *Najadion marinae*
Association: *Najadetum marinae* (Oberd. 1957) Fukarek 1964
Najadeto marinae-Zannichellietum palustris MM & VA 2013
Ordo: *Hydrocharitetalia* Rubel 1933
Alyans: *Hydrocharition* Rubel 1933
Association: *Hydrocharitetum morsus-ranae* Van Langendonck 1935
Ceratophylletum demersi (Soo 1928) Eggler 1933
Ceratophylletum submersum MM & VA 2013
Alyans: *Nymphaeion albae* Oberd.1957
Association: *Nymphaetum albae* Vollmar 1957
Nelimbio caspici-Nymphaetum albae (Now.1930) Tomaz 1977
Trapetum hyrcanae (Muller et Görs 1960) M. Musaev 2013
Polygonetum amphibii Soo 1927
Potametum natantis Soo 1927
Urticularietum vulgaris MM & VA 2013
Spirodeletum polyrrhiza MM & VA 2013
Salvinietum natansi MM & AV 2013
Ordo: *Callitricho-Batrachietalia* Passarge 1978
Alyans: *Ranunculion fluitantis* Neuhause 1957
Association: *Myriophylletum verticillati Soo. 1927*
Myriophylletum spicati Soo 1927
Alyans: *Ranunculion aquatilis* Passarge 1964
Association: *Potamo perfoliati-Ranunculetum scleratus* MM & VA 2013
Ranunculetum trichophyllum MM & VA 2013

2. Coastal (Hydrophyte) water-swamp troops

They are plant plants found in streams, lakes and swamps, in places where the water depth is not very deep. The lower parts of their trunks settle in the marsh, in the soil that is always or occasionally (seasonally) submerged (Helophyte plants). Since they have a developed root system, it becomes easy for them to form troops.

A large number of associations consisting of various species belonging to this class are encountered. It is not possible to set a definite limit among them. Because most of the taxa that participated in the formation of the union are common, but it seems that they passed on to other unions.Sınıf: Phragmitetea Koch 1926

Ordo: *Phragmitetalia* Koch 1926

Alyans: *Phragmetion* Koch 1926

Association: *Phragmetum communis* (Gams 1927) Schmale 1939

Typho *angusfiliae-Phragmetum communis* R. Tx Preis. 1942

Scirpo-Phragmetum communis W. Koch 1926

Calamagrostetum *epigejosae* MM & VA 2013

Ordo: *Typhetalia* MM& VA 2013

Alyans: *Typhetion* MM& VA 2013

Association: *Typhetum angustifoliae* Pignatti 1953

Typhetum latıfoliae (Soo 1927) Lang 1973

Potamogeto-Typhetum domingensis Vural Duman etal 1994

Typhetum domingensis MM & VA 2013

Polygonetum amphibii-hydropiperae MM & VA 2013

Irisetum pseudocorusae MM & VA 2013

Alyans: *Scirpion* MM & AV 2013

Association: *Scirpetum lacustris* Schamale 1939

Scirpetum marıtımı Beeft 1957

Hippurisetum vulgarisae MM & VA 2013

Ordo: *Schoenoplectetalia* MM & VA 2013

Alyans: *Schoenoplection* MM & VA 2013

Association: *Schoenoplectetum litoralis* MM & VA 2013

Potamogeton-Schoenoplectetum litoralis Vural Duman et. Al. 1994

Cladio-Schoenetum lacustris MM & VA 2013

Butometum umbellati (Konczak 1968) Phillippi 1973

Butomo-Eleocharitetum palustris Golub all. 1991

Triglochino-Bolboschoenetum marıtımı Behçet 1948

Class: Caricetea MM & VA 2013

Ordo: *Caricetalia* MM & VA 2013

Alyans: *Caricion* MM & VA 2013

Association: *Caricetum paniculatae* Wong 1926

Caricetum vesicariae Br.-Bl. et Denis 1926

Mentho aquatici-Caricetum ripariae MM & VA 2013

Mentho aquatici--Carietum pseudo-cyperae MM & VA 2013

Alyans: *Heleocharion* MM& AV 2013

Association: *Heleocharetum iupalustrisi* MM & VA 2013

Heleocharetum euuniglumisi MM & VA 2013

Atropietum giganteae MM & VA 2013

Aeluropetum littoralis-repensae MM & VA 2013

Aeluropo aequalis-Alopecuretum ventricosusae MM & VA 2013

Alopecuruetum ventricosusi MM & VA 2013

Mentho pulegio-Lithretum salicariae MM & VA 2013

Mentho pulegio-Oenanthetum aquaticae MM & VA 2013

3. Wet (Hygromesophilic) grass associations

They are found in wet grasses and marshes with high humidity, in swampy areas and are the units dominated by hygromesophyte plants.

Alyans: *Menyantion* MM & VA 2013

Association: *Carici-Menyantetum trifoliatae* Behçet 1994

Sparganieto-Menyantetum trifoliatea MM & VA 2013

Sparganietum neglecti-Paspalietum digitariae MM & VA 2013

Rumici hydrolapathum-Sparganietum neclectum MM & VA 2013

Rumici hidrolapathum-Heracleum trachylomae MM & VA 2013

Geranio-Heraclietumm trachylomae MM & VA 2013

Veronico anagalis aquatico-Calthetum polypetalae MM & VA 013

Ordo: *Cyperetalia* MM & VA 013

Alyans: *Cyperion* MM & VA 2013

Association: *Cyperetum longusiae* MM & VA 2013

Paspalietum paspalodesi MM & VA 2013

Veronico anagalis-aquatico-Equsetum arvensae MM & VA 2013

Potamogetono natansi-Equisetum palustrsae MM & VA 2013

Alyans: *Juncuion* Braun-Blanq. 1931

Association: *Juncetum lampolodesi* MM & VA 2013

Juncetum inflexusi MM & VA 2013

Digraphietum arundinaceae MM & VA 2013

Beckmannietum eruciformi-syzigachnei MM & VA 2013

Catabrosetum aquaticae MM & VA 2013

4. Wet (Hygromesophilic) grass associations

They are found in wet grasses and marshes with high humidity, in swampy areas and are the units dominated by hygromesophyte plants.

Soil layers:.a.b,c,d,e,f,g,h

This banding is more evident around the Kuchuk Gizilagaj Bay located on the Lankaran plain, around the Candar Lake located on the Georgian and Azerbaijan border, and in the areas along the Kur and Aras rivers (Figure 3.).

Class: Ammophiletea Br.-Bl. & Tuxen ex Westhoff, Dijk & Passchier 1946

Ordo: *Ammophiletalia* Br.-Bl. 1933

Alyans: *Salici purpureae-Populetea nigrae* Rivas-Martinez, Fernandez Conzalez, Loidi, Lousa et Penas 2001

Association: *Salici purpureae-Populetum nigrae* Rivas-Martinez, Fernandez Gonzalez, Loidi, Louse et Penas 2001

Populetum nigrae MM & VA 2013

Salixetum albae MM & VA 2013

Pterocaryo fraxinifoliae–Alnetum barbati Vural, Ocakverdi et.all. 2009

Alyans: *Populetalia albae* Br.-Bl.ex Thou 1948

Association: *Populetum albae* Br- Bl. Ex Tchou 1948

Alyans: *Ammophilion australis* Br.-Bl. 1921 corr. Rivas-Martinez, Costo& İzco in Revas-Martines, Lousa, T.E.iaz, Fernandez-Gonzalez &J.C.Costa 1990

Association: *Verbasco thapsus-Hippophaetum rhamnoidesae* MM & VA 2013

Rubeto-Elagnetum angustifoliae MM & VA 2013

Class: Phragmito-Magnocaricetea Klika et Novak 1941

Ordo: *Phragmitetalia* Koch 1926

Alyans: *Phragmition* Koch 1926

Association: *Phragmeto communisae-Tamaricetum ramosissimae* MM 2013
Ordo: *Tamaricetalia* MM & VA 2013
Alyans: *Tamaricion* MM & VA 2013
Association: *Tamaricetum ramassisimae* MM & VA 2013

5. Hygrohalophyte plant associations

They are associations of hygrohalophyte plants that grow in salty lakes or sea shores, in watery places and salty marshes. These types of units are mostly distributed in the coastal areas of the Caspian Sea, in terrestrial habitats and in flooded areas in the close vicinity of lakes. Distributing in many salty and sweet flooded areas around the world: *Halocnemum strobilaceum, Salicornia europea, Frankenia hirsuta, Halimionea verrucifera, Juncus littoralis, J. maritimum, J. acutus* are dominant communities in many regions of Azerbaijan, adjacent to coastal dunes, They can spread to lightly salted areas.Sınıf: Salicorniotea Braun-Blanq. 1931

Ordo: *Halostachyetalia* (Grossh.) Topa 1938
Alyans: *Halocnion* MM & VA 2013
Association: *Halocnetum strobilacei* Oberd 1957
Haliminetum verruciferae E.Topa 1938
Carici extensor-Holocnetum strobilacei Vural, Duman et al. 1994
Salicornio europeo-Halocnemetum strobilacei MM & VA 2013
Carici extenco-Salicornietum europaei MM & VA 2013
Spergulario-Haliminetum verruciferae MM & VA 2013
Franketum hirsutae MM & VA 2013
Class: Juncetea Braun-Blanq. 1931
Ordo: *Juncetalia marittimi* Braun-Blanq. 1931
Alyans: *Juncuion marittimi* Braun-Blanq. 1931
Association: *Limonio-Juncetum littoralis* Vural, Duman et al. 1994
Halimio-Juncetum littoralis Vural, Duman et al 1994
Phragmito-Juncetum maritime Vural, Duman et al.1994
Juncetum maritimum Pignatti 1953
Juncetum litoralisal MM & VA 2013
Juncetum acutusae MM & VA 2013
Juncetum gerrdiae MM & VA 2013
Junco-Tamarici parviflorae Vural, Duman et al 1994
Tamaricetum ramosissimae
Alopecuretum ventricosal MM & VA 2013

If the plant associations are evaluated according to the "EUNIS habitat classification" (2004) system, it is seen that there are 101 plant associations belonging to 5 habitat types in our research area.

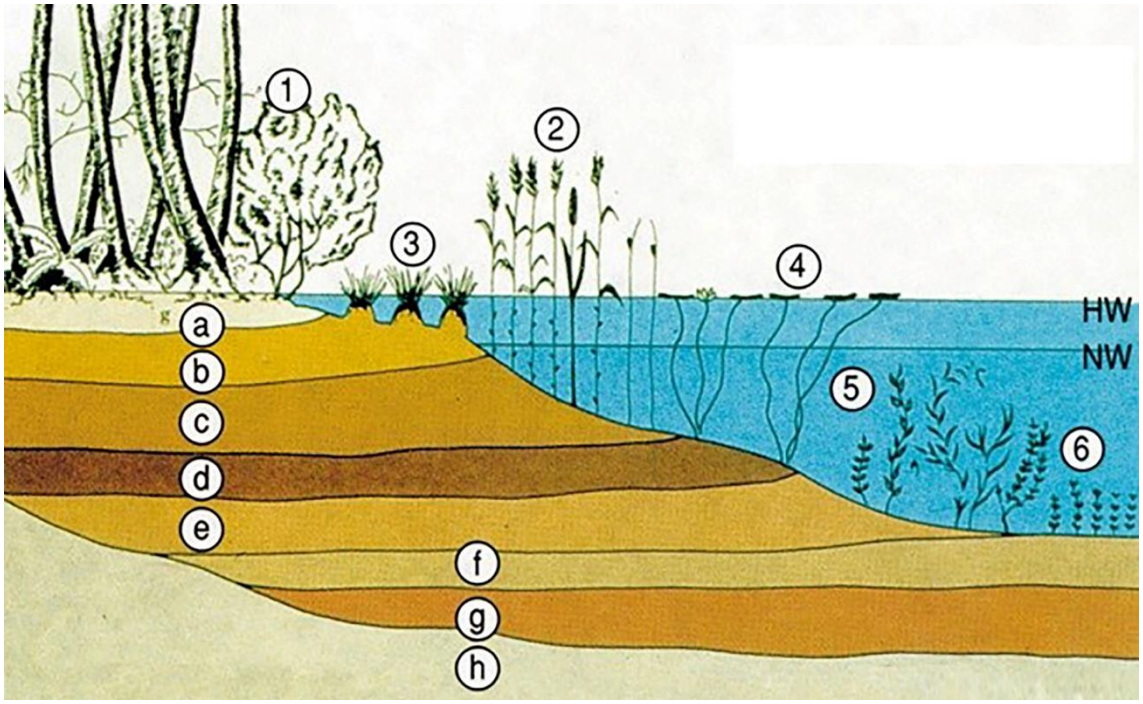
33 plant associations belonging to in-water associations, 31 coastal marsh associations, 13 wet (moist) grass associations, 8 aquatic forest units and 17 plant associations belonging to hydrohalophytes were encountered. Vegetation tables of each of these unions; It was created by considering parameters such as abundance and degree of overlap, life forms, and randomness class of plant taxa that make up the flora of the bird.

Haciyev and Musayev, together with the plant species found in the Caucasus and other regions, there are 240 unique to Azerbaijan only, but 140 plant species according to the newly published "Azerbaijan's Red Book" work. Among these plants, there are also plants that spread only in water-swamp ecosystems and are under the threat of extinction. It is important to protect water-swamp

type habitats in order to protect them and not be threatened.

A total of 502 taxa distributed in the water-swamp ecosystems of Azerbaijan; There are four types of life forms: tree, bush, semi-shrub and herbaceous body [Musayev, et al., 2013].

PICTURE 3. Vertical profile of water-marsh plants of the Sea coast near the gulf of Gizilagaj: 1, 3 – Hygrophytes; 2,4-Hydrophytes; 5-6 Hydaphytes. Plants:1. *Populus nigra, Tamarix ramosissima, Eleagnus angustifolia; 2. Phragmites communis, Schoenoplectus litoralis 3. Juncus acutus, J. İmflectus; 4. Nymphaea alba, 5. Potamogeton pectinatus, P. nodosus ; Ceratophyllum demersum; 6. Najas marina, N. minor*



Most of these plants (92%) are herbaceous, while a few (8.0%) have woody stems. 63% of herbaceous stem plants are perennial and 29.1% are annual. 12 (2.4%) trees (*Elaeagnus angustifolia, Salix acmophylla, Populus nigra, P.alba, P. hybrida, Tamarix ramosissima, Alnus glutinosa, Quercus araxsina, Pterocaria pterocarpa* etc.) and 27 (5%, 4 of them) shrub and semi-bush stem plants were encountered. They participate as character species in the composition of aquatic forest associations. In the water-swamp ecosystems of Azerbaijan; Cryptophyte 219 (43.6%), therophyte 139 (27.7%), hemicryptophyte 101 (20.1%), phanerophyte 40 (7.8%), kamephyte 3 (0.6%) were found to be all life forms [Musayev et al, 2013].

The fact that cryptophytes, hemicryptophytes and therophytes are richer in water-swamp vegetation seems to be one of the characteristic features of this vegetation. Plants with this type of life form adapt easily to the water-swamp environment, and easily reproduce by vegetative means in the aquatic environment. Some of the aquatic plants with rhizome and perennial herbaceous stems grow easily in salty lakes and marshes, and some in freshwater lakes and marshes. These types of plants seem to be characteristic and distinctive and dominant species in water-swamp plant associations, sometimes forming pure and sometimes mixed associations.

It is noteworthy that plants with rhizomatous, reptilian and grassy stems are common and dominant species in the phytosociological structure of water-swamp vegetation. A total of 412 species, which are morphologically divided into different types but have herbaceous

life forms, were encountered, of which 128 were rhizome (49%), 37 grass-forming (7.4%), 33 reptile (6%, 6), 14 of them are bulbous (2.8%) and 4 of them are herbaceous stems (0.8%).

40 woody stem plants were found living in a water-swamp environment. This constitutes 8.0% of the total water-swamp flora (table 1).

Water-swamp plant associations are found everywhere in Azerbaijan, starting from sea level to high mountain areas. It is found in wider areas, especially in the Absheron peninsula, Samur-Deveçi, Kur-Araz plain, Alazan-Eyricay, Mil-Mugan, Ceyranchol, Qobustan plains and in the orderly parts of Nakhchivan. Compared to the mountainous areas, the areas covered by the water-swamp vegetation in the regular areas are wider and poor in terms of plant diversity.

When we evaluate according to habitat diversity: plant diversity in habitats around rivers, streams, streams and water channels (312 taxa) is richer than habitats such as swamp (160), calm slow flowing water (127) and salty lakes and sea coast (114 taxa) (table 2).

Aliyev (1969) in his research on the water-swamp vegetation of Azerbaijan recorded a total of 94 plant associations, with 20 in water and 46 in both water and land (table 3).

It was revealed by Babayev (1974) that in the water-swamp vegetation of the high mountain parts of the Lesser Caucasus within the borders of Azerbaijan, there are a total of 51 plant associations: 20 in water, 31 both in water and on land (table 3).

Efendiyeva (1989) determined that in the water-swamp vegetation of the Absheron peninsula, there are 41 plant associations in total, 11 in water and 30 in both water and land (table 3).

It was determined by Musayev that there are 32 plant associations in the water-swamp vegetation of the Kur-Araz plain, 12 in water and 20 in both water and land (table 3).

Table 1. Distribution of Azerbaijan water-swamp flora according to biomorphological features

Morphological Type	Number of species	%
Woody	40	8,0
Herbaceous	246	49.0
Herbaceous with rhizomes	128	25.5
Grass-forming herbaceous	37	7.4
Creeping herbaceous	33	6.6
Bulbous herbaceous	14	2.8
Wrapper	4	0.8
Total	502	100

Table 2. Distribution of Azerbaijan water-swamp flora by ecosystems

Spreading Environment	Total/ %
By height	
Level	401 / 79,8
Mountainous	200 / 39,8
By habitat	
Around Stream, Stream, Water Canal	312 / 62,1
Swamp	160 / 31,8
Still Slow Flowing Water, Cute Watery Lake	127 /25,3
Salt Lake, Sea Beach	114 / 22,7
Total	502 / 100

Table 3. Comparison of water-swamp vegetation in different regions of Azerbaijan

Systematic categories and habitats	On the territory of Azerbaijan (C.Aliyev, 1969)	Small Caucasus high mountain lakes (F.Babayev, 1974)	The peninsula of Absheron (Sh.Afandiyeva, 1989)	Kur-Araz plain (M.Musayev, 2010)	According to this research
Vejetasyon					
Order	1	1	1	1	1
Formasya class/Classis	2	2	2	2	12
Formation group/Order	12	8	9	8	16
Form. subgroup	-	8	2	4	-
Formation	46	33	18	13	26
Asosation	94	62	37	30	100
Beach Water-Swamp	-	-	-	-	34
Wet grass	-	-	-	-	10
Water-Swamp Forest	-	-	-	-	9
Salt Lake and swamp	-	-	-	-	17
in water	20	22	11	12	32
in water and on land	31	73	30	20	68

Researches and syntaxonomic classifications carried out by us have shown that the water-swamp vegetation of Azerbaijan consists of a total of 101 plant associations, of which 12 classes, 16 orders, 26 wedding rings (table 3).

Our studies on vegetation have been carried out based on the principle of dominance only, without considering the habitats, phytocenological structure of the vegetation, and ecologic conditions.

In the next stage, a more detailed investigation of the great lake and water-swamp ecosystems within the territory of Azerbaijan in the separation shows that new plant associations will emerge together with the new flora records.

Results.

1. One of the vegetation types in the vegetation of Azerbaijan is the water-swamp vegetation. This vegetation spreads locally from the plain to the high mountain areas in Azerbaijan. They are plant associations that spread especially in the marsh environments of lakes and rivers, watering canals and artificial dam lakes.

2. Water-swamp ecosystems are divided into 5 types according to habitat types: 1. In-water associations; 33 total; 2. 31 belonging to the coastal marsh units; 3. Age 13 belonging to the grass units; 4. 8 plant associations belonging to aquatic forest units, 5. 17 plant associations belonging to hydrohalophytes were encountered.

3. Belonging to in-water units; *Ruppietum maritimae, Lemnetum minoris, Lemnetum gibbae, Lemnetum trisulce, Potametum pectinati, Potametum lucentis, Potametum perfoliati*, *Potametum pectinato – perfoliati, Potameto Najadetum, Myriophylletum trisulce, Potametum pectinati, albametum pectinato – perfoliati, Potameto Najadetum, Myriophylletum slimetum spicinetum, Nebaphyllehyphaetacetum Polygonetum amphibii, Najadetum marinae, Ceratophylletum submersum, Myriophylletum verticillati*; Belonging to the coastal marsh associations: *Phragmitetum communis , Typho angusfiliae-Phragmitetum communis , Scirpo-Phragmitetum communis, Typhetum angistifoliae, Typhetum latıfoliae, Potamogetono- Typhetum domingensis, Sci-*

petum lacustriteum-Scipetum latifoliae- , Triglochino-Bolboschoenetum martinis, Sparganietum poluedrum, Butometum umbellati, Caricetum paniculatae, Caricetum vesicariae, Typhetum domingensis, Schoenoplectetum litoralis, Calamagrostisetum epigejosae, Hippurisetum vulugarisae, Caricetum vesicariae, Typhetum domingensis; Belongs to wet (wet) grass associations: *Carici-Menyantetum trifoliatae, Paspalietum paspalodesi, Juncetum lampolodesi, Juncetum inflexusi, Cyperetum longusiae, Sparganieto-Menyantetum trifoliatea*; Belonging to the water-marsh forest associations: *Salixetum albae, Phragmeto-Alnetum barbati, Populetum nigrae, Rubeto- Elagnetum angustifoliae, Verbasco thapsus-Hippophaetum rhamnoidesae, Phragmeto communisae-Tamaricetum grabatumae, Populetum alnetume, Populetumegrapulae*; Belonging to the hydrohalophyte plant associations: *Halocnetum strobilacei, Haliminetum verruciferae, Carici extensor-Holocnetum strobilacei, Salicornio europeo-Halocnemetum strobilacei, Carici extenco-Salicornietum europaei, Spergulario-Haliminetumitumiolitolitor-Jerrucicetum-maritime, Juncetum maritimum, Juncetum litoralisal, Juncetum acutusae, Juncetum gerrdiae, Junco-Tamarici parviflorae, Tamaricetum ramosissimae Alopecuretum ventricosal* associations were defined.

4. 15 new plant associations have been defined for the water-swamp vegetation of Azerbaijan.

5. A total of 502 taxa belonging to 62 families and 208 genera were found in the water-swamp ecosystems of Azerbaijan. In vegetation; Poaceae, Cyperaceae, Ranunculaceae, Potomagetonaceae, Juncaceae, Tamarixaceae families and Carex, Juncus, Ranunculus, Potomageton, Schoeneplectus, Cyperus, Salix, Tamarix, Phragmites, Arundo, etc. taxa belonging to the genus are more represented.

6. Population status: *Pragmites austuralis, Juncus litoralis, J. acutus, Typha latipholia, T. angustifolia, Schoeneplectus marittimus, Potomageton salicifolius, P.pectinatus, Najas minor ssp.intermedia, N. minor ssp.armata, N. minor* ssp. *marina, Ceratophyllum submersum, C. demersum, Polygonum amphibium* etc. are taxa that are more common and have formed associations and groupings in larger areas.

7. *Nymphetum albae, Nelimbio caspici-Nymphetum albae, Trapetum hyrcanae, Butometum umbellati, Spargenieto-Menyantetum trifoliataea* are among the units that are exposed to extreme anthropogenic effects, narrow their areal, are under threat and need to be protected.

7. 92% of the plants distributed in the water-swamp ecosystem have herbaceous stems, and a few (8%) have woody stems. 63% of herbaceous stem plants are perennial, 29.1% are annuals. 12 (2.4%) trees and 27 (5.4%) shrub and semi-shrub stem plants were found that adapt to water-swamp ecosystems.

8. Cryptophytes represented 43.6% of the water-swamp flora, therophytes 27.7%, hemicryptophytes 20.1%, phanerophytes 8.0%, and camefirs 0.6%.

9. When we evaluate according to habitat diversity, 312 around streams, streams and water channels; It has been determined that there are 160 taxa in the marsh environment, 127 taxa in still slow flowing water and cute watery lakes, and 114 taxa from habitats such as salty lakes and sea coasts.

10. It has been determined that there are a total of 68 taxa in the water-swamp ecosystems of Azerbaijan, which fall into the danger categories, and these constitute 13.5% of the plants belonging to the total water-swamp flora. The majority of these plants were in the categories VU(25 taxa, 13.5%), Lr(cd), Lr(lc) (2.2% each with 11 taxa) and Lr(nt) (2.0% with 10 taxa), EN and 5 taxa (1.0%) were determined for each of the DD categories.

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OBTAINING AND RESEARCHING FLAVONOID-SAPONIN COMPLEX FROM MEDICAGO FALCATA L. RAW MATERIAL

*TAHIR A. SULEYMANOV, **AYTAKIN S. GARIBLI

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*Azerbaijan Medical University, Baku, Azerbaijan
**Azerbaijan State Agricultural University, Gandja, Azerbaijan
**garibli90@mail.ru

Abstract. In this study, we choose Medicago falcata L., also known as "alfalfa" or "Lucerne", it belongs to the family Fabaceae. M. falcata L. is a perennial flowering plant. M. falcata L. produce different kinds of secondary metabolites such as saponins, flavonoids, coumarins, alkaloids, phenols which have antimicrobial and antibacterial properties which play medicinally vital role. The chemical constituents obtained from plant can cure high cholesterol, kidney problems, asthma, stomach, bladder problems and menopause issues. The aim of the study is to obtain the flavonoid-saponin complex of M. falcata L., which is common in the Azerbaijani flora, and to examine its antioxidant activity. The isolated flavonoid-saponin fraction when analyzed by A.B.T.S. and D.P.P.H. showed high activity.
The technical effect of the claimed invention consists in expanding the raw material base of medicinal plants, namely the base of crescent alfalfa (M. falcata L.) and the sum of the flavonoid-saponin complex of biologically active substances with antioxidant activity isolated from it.

Keywords: M. sativa L., biological active compounds, antioxidant, flavonoid, saponin

Introduction. Medicinal plants are producers and carriers of many biologically active substances. It is known that the flora of Azerbaijan is very rich of species composition. These species are not used enough to meet their health needs. The main reason for this is that phytochemical and pharmacological studies on plants have not been sufficiently studied. Especially after the independence of our republic, this problem has become even more important.

Antioxidants are substances that can neutralize the oxidative effects of free radicals and other substances. The role of antioxidants in our lives cannot be overestimated. They help limit the aggression of free radicals and repair the damage caused by them, resist free radicals, interrupting the destructive process of oxidation, strengthen the body's own antioxidant system, and help restore metabolism [Mahdieh Raeeszadeh et al., 2022]. The plant world is diverse in the range of biologically active substances with an antioxidant effect, which are of considerable interest for the further search for new raw materials sources [Martyna Zagórska-Dziok et al., 2020].

A large number of natural antioxidants are known: ascorbic acid, tocopherol, beta-carotene, retinol, biogenic amino-serotonins, histamine, polyphenols and phospholipids, etc., contained in medicinal plants, on the basis of which various drugs are being developed.

In this study, we choose *Medicago falcata* L., also known as "alfalfa" or "Lucerne", it belongs to the family Fabaceae [Flora of Azerbaijan, 1954]. M. falcata L. is a perennial flowering plant [Sadowska-Bartosz and Bartosz, 2014]. M. falcata L. produce different kinds of secondary metabolites such as saponins, flavonoids, coumarins, alkaloids, phenols which have antimicrobial and antibacterial properties which play medicinally vital role [Martyna Zagórska-Dziok et al., 2020, D. Tungmun-

nithum et al., 2018]. The chemical constituents obtained from plant can cure high cholesterol, kidney problems, asthma, stomach, bladder problems and menopause issues [Suleymanov and Garibli, 2019].

As a continuation of our research, the flavonoid-saponin complex of *M. falcata* L. was studied.

The aim of the study is to obtain the flavonoid-saponin complex of *M. falcata* L., which is common in the Azerbaijani flora, and to examine its antioxidant activity.

Materials and methods. In the present study the plants collection was performed from Shamakhi and identified. Plants were processed for different extractions and antioxydant activity in the laboratory of Aix Marseille University of France.

Bioactive substances of flavanoid-saponin complex is obtained as follows.

The dried and crushed aboveground part of the plant material *M. falcata* L. (0.6 kg) is extracted at room temperature 3 times with 6.0 l of 80% ethanol. The combined extract is evaporated under vacuum to a dry residue (52.9 g), then separated into fractions by sequentially extracting the resulting dry residue with petroleum ether to remove lipophilic substances and obtaining a dry residue; dichloromethane to remove chlorophyll; and ethyl acetate with the release of a complex of flavonoids and saponins, which is dried and washed with water from triglycosides and hydroxycinnamic acid. The resulting product, in the amount of 2.48 g, containing a complex of bioactive substances with antioxidant activity, is a yellowish powder, odorless and tasteless [Garibli et al., 2021]..

The yield on raw materials is 1.8%. It dissolves well in methanol and ethanol. Qualitative and quantitative composition of the resulting complex, studied in the following way.

The ethyl acetate extract (1.9 g) was fractionated on a Combi Flash Rf flash chromatograph. C18 RediSep Rf 130 g (CV 133ml - 85ml/min.) was chosen as the column. Fractionation was carried out at a pressure of 225psi (15.5 bar) and a wavelength of 254mm. Flow rate 40 ml/min. with MeOH and H2O gradient. Fractions X, A, B, C, and D were obtained.

Results of the study. The obtained fractions were tested in the system ethyl acetate-formic acid - glacial acetic acid - water (100:11:11:26) by thin-layer chromatography and by spraying cumic aldehyde and the content of saponin-flavonoid compounds in them was determined.

fractions X 0.0050 g
fraction A 0.0078 g
fraction B 0.3473 g
fraction C 0.4153 g
fraction D 0.009 g

The resulting fractions were dissolved in methanol and analyzed by thin layer chromatography. Ethyl acetate-formic acid-glacial acetic acid-water (100:11:11:26) was used as a system, and cumaldehyde was used as a developer. Based on the obtained analysis, fractions B and C were taken for further study. Fraction B (0.34 g) was again processed by flash chromatography. As a result of flash chromatography of fraction B obtained from the ethyl acetate fraction, 10 new fractions (B-1 - B-10) were obtained. A C18 Redi Sep Rf 30 g column (CV 26.4 ml - 35 ml/min) was chosen for fractionation in flash chromatography. The assay is run at 350 psi (24 bar), wavelength 254 nm, flow rate 15 ml/min, gradient MeOH and H2O.

fractions B-1 0.0008 g
fractions B-2 0.0001 g
fractions B-3 0.0002 g
fractions B-4 0.0012 g
fractions B-5 0.0071 g
fractions B-6 0.022 g
fractions B-7 0.2026 g
fractions B-8 0.0315 g
fractions B-9 0.009 g
fractions B-10 0.0363 g

The resulting fractions are processed by thin layer chromatography. Ethyl acetate-formic acid-glacial acetic acid-water (100:11:11:26) was used as a system, and cumaldehyde was used as a developer. According to the obtained results Fraction B-10, Fraction B-8, Fraction B-7 and Fraction B-6 were taken for further research.

From fraction V-10 (20 mg) obtained by chromatography in a column with Sephadex (eluent: pure methanol), 3 fractions (V-10-1 - V-10-3) were obtained. Of which fractions B-10-2 and B-10-3 are identified as Kaempferol and Quercetin.

From fraction B-8 (20 mg) obtained by chromatography in a column with Sephadex (eluent: pure methanol), 4 fractions (B-8-1 - B-8-4) were obtained. Of which fraction B-8-3 was identified as Kaempferol-7-O-α-L-rhamnopyranoside-3-O-β-D-glucopyranoside.

As a result of chromatography in a column with polyamide fraction B-7, 8 new fractions were obtained (B-7-1 - B-7-8). 6 fractions (B-7-4-1 – B-7-4-6) were obtained from fraction B-7-4 by chromatography in a polyamide column (eluent: pure methanol and water). Of which fraction B-7-4-3 is identified as Naringenin.

From fraction B-6 (22 mg) as a result of chromatography in a column with Sephadex (eluent: pure methanol), 4 fractions were obtained (B-6-1 - B-6-4). Of which fraction B-6-2 is identified as Kaempferythrin.

As a result of flash chromatography of fraction C (85.2 mg) obtained from the ethyl acetate fraction, 5 new fractions (C-1 - C-5) were obtained.

As a result of flash chromatography of the C-2 fraction, 6 new fractions (C-2-1 - C-2-6) were obtained.

Four fractions (C-2-3-1 – C-2-3-4) were obtained from the C-2-3 fraction by chromatography in a Sephadex column (eluent: pure methanol). Of which the C-2-3-3 fraction is identified as Apigenin.

6 fractions (C-2-5-1 - C-2-5-6) were obtained from the C-2-5 fraction by chromatography in a Sephadexm column (eluent: pure methanol). Of which the C-2-5-4 fraction is identified as Luteolin.

As a result of flash chromatography of the C-3 fraction, 7 new fractions (C-3-1 - C-3-7) were obtained.

From the C-3-5 fraction, chromatography in a Sephadex column (eluent: pure methanol) yielded 5 fractions (C-3-5-1 – C-3-5-5). Of which the C-3-5-3 and C-3-5-5 fractions are identified, respectively, Ursolic and Oleanolic acid.

Discussion of results. The development of new anti-bacterial agents by plant extracts is very much of importance nowadays. Phytotherapy is increasing by time to cure many diseases and serve humanity. The plant screened for phytochemical constituents appeared to have the ability to act as a source of useful drugs and improve the health status of consumers as a result of presence of various compounds that are essential and beneficial for good health. So it could be concluded that the M. sativa extract produce significant and remarkable phytochemicals which can be used as anti-microbial, anti-cancer and anti-fungal agents. The leaves, and stems are of great importance in the field of pharmacy. This identification of various phytochemicals leads to the production of more vaccines and supplements for many diseases and can promote better health and survival. However further work must still be conducted.

In recent years, great progress has been made in the field of chemistry and pharmacology of natural flavonoids and triterpene saponins, which are widely distributed in the plant world. Of particular interest are well-known valuable agricultural crops, namely representatives of the legume family, characterized by a wide range of biologically active substances (BAS), in particular, a representative of the alfalfa genus (*Medicago* L.) - alfalfa (*M. sativa* L.), which has long been used in folk medicine. However, another representative of this genus, sickle alfalfa (*M. falcata* L.), is little studied and is of considerable interest as a raw material source of biologically active substances with antioxidant activity [Xue-Gui L. et al., 2018].

The search and analysis of sources in this area showed that crescent alfalfa (M. falcata L.), as a medicinal raw material, is little studied, one source was found in which the herb M. falcata L is part of the medicinal collection.

The essence of the work consists in a complex of flavonoid-saponin biologically active substances with antioxidant activity isolated from sickle alfalfa (*M. falcata* L.), which

includes: quercetin, kaempferol, kaempferythrin, kaempferol-7-O-α-L-rhamnopyranoside-3-O-β-D-glucopyranoside, apigenin, luteolin, naringenin, oleanolic and ursolic acids.

The components included in the sum of the complex are known in medicine as antioxidants and medicines:

Quercetin is a flavonoid, a non-carbohydrate biologically active component and belongs to the vitamin preparations of the P group. Quercetin has anti-inflammatory and antioxidant effects, reduces the synthesis of leukotrienes, serotonin and other inflammatory mediators.

Kaempferol - a flavonoid has anti-inflammatory, antimicrobial, cardioprotective, analgesic properties, reduces the synthesis of fatty acids in malignant cells, and this reduces the development of certain types of cancer, reduces "oxidative stress" in the body, enhancing protective functions and accelerating metabolism, prevents lipofuscin from accumulating in the body - aging pigment.

Kaempferitrin and kaempferol-7-O-α-L-rhamnopyranoside-3-O-β-D-glucopyranoside are kaempferol glycosides. They have a wide range of pharmacological activities, including antioxidant, anti-inflammatory, antimicrobial, antitumor, cardioprotective, neuroprotective, antidiabetic, antiosteoporotic, estrogenic/antiestrogen, anxiolytic, analgesic, and antiallergic activities.

Apigenin is a flavonoid widely distributed in the plant world. It acts as a free radical scavenger and antioxidant to reduce oxidative stress.

Luteolin is a flavonoid with an anti-inflammatory effect.

Naringenin is a flavonoid with powerful antioxidant, anti-allergic and anti-inflammatory properties.

Oleanolic acid, a monounsaturated fatty acid, exhibits weak anti-HIV and weak anti-HCV activity in vitro and may slow the progression of adrenoleukodystrophy (ALD).

Ursolic acid - the compound belongs to pentacyclic triterpenes, which are characterized by high biological activity. It has found wide application in cosmetology, nutrition and bodybuilding.

As a result of chromatographic and spectroscopic studies, it was found that the flavonoid-saponin sum consists of the following substances: quercetin, kaempferol, kaempferythrin, kaempferol-7-O-α-L-rhamnopyranoside-3-O-β-D-glucopyranoside, apigenin, luteolin, naringenin, oleanolic and ursolic acids.

The antioxidant activity of the flavonoid-saponin fraction obtained from the species M. falcata L. was studied by three methods: 2, 2-diphenyll-1-picryl-hydrazyl hydrate (D.P.P.H.), acid (A.B.T.S.) and the iron reduction antioxidant power (F.R.A.P.) method. Gallic acid, ascorbic acid, quercetin, caffeic acid, trolox, and kaempferol were used as standard samples. Standards and sum of saponin flavonoids for D.P.P.H., A.B.T.S. and F.R.A.P. used in 6 different concentrations.

For D.P.P.H. analysis used solutions of substances in the following concentrations: gallic acid, caffeic acid, kaempferol and quercetin, respectively 0.5 µg/ml, 1 µg/ml, 1.25 µg/ml, 2 µg/ml, 2.5 µg/ml, 5 µg/ml, ascorbic acid 3 µg/ml, 5 µg/ml, 6 µg/ml, 7.5 µg/ml, 10 µg/ml, 15 µg/ml, Trolox 2.5 µg/ml, 3 µg/ml, 5 µg/ml, 7.5 µg/ml , 10 µg/ml, 15 µg/ml, flavonoid-saponin fraction 5 µg/ml, 10 µg/ml, 20 µg/ml, 25 µg/ml, 50 µg/ml, 100 µg/ml.

For A.B.T.S. analysis used solutions of substances in the following concentrations: caffeic acid 1 µg/ml, 2 µg/ml, 2.5 µg/ml, 5 µg/ml, 10 µg/ml, 12.5 µg/ml, gallic acid 0.25 µg/ml, 0.5 µg/ml ml, 1 µg/ml, 2 µg/ml, 2.5 µg/ml, 5 µg/ml, quercetin 0.5 µg/ml, 1 µg/ml, 2 µg/ml, 2.5 µg/ml, 5 µg/ml, 10 µg /ml, ascorbic acid, trolox and kaempferol 2.5 µg/ml, 5 µg/ml, 6.25 µg/ml, 10 µg/ml, 12.5 µg/ml, 25 µg/ml, flavonoid-saponin fraction 2.5 µg/ml, 5 µg /ml, 10 µg/ml, 20 µg/ml, 25 µg/ml, 50 µg/ml.

For F.R.A.P. analysis used solutions of substances in the following concentrations: gallic acid and quercetin 0.25 µg/ml, 0.5 µg/ml, 1 µg/ml, 1.25 µg/ml, 2 µg/ml, 2.5 µg/ml, caffeic acid and ascorbic acid 0.5 µg/ml ml, 1 µg/ml, 1.25 µg/ml, 2 µg/ml, 2.5 µg/ml, 5 µg/ml, Trolox 1 µg/ml, 2 µg/ml, 2.5 µg/ml, 5 µg/ml, 8 µg /ml, 10 µg/ml, kaempferol 2.5

µg/ml, 4 µg/ml, 5 µg/ml, 8 µg/ml, 10 µg/ml, 20 µg/ml, flavonoid-saponin fraction 2.5 µg/ml, 4 µg /ml, 5 µg/ml, 8 µg/ml, 10 µg/ml, 20 µg/ml.

The isolated flavonoid-saponin fraction when analyzed by A.B.T.S. and D.P.P.H. showed high activity.

The technical effect of the claimed invention consists in expanding the raw material base of medicinal plants, namely the base of crescent alfalfa (*M. falcata* L.) and the sum of the flavonoid-saponin complex of biologically active substances with antioxidant activity isolated from it.

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