Forest Ferns of the Caucasus, Its’ Systematic and Eco-Geographical Analysis

Aydin M. Askarov

1Doctor of biologic sciences, head of department ecobotany and systematic, Genetic Resources Institute of ANAS, Baku, Azerbaijan.
E-Mail: 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 (Czerepanov SK. Vascular plants of Russia and Adjacent States (the former USSR) 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 was 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. 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 in Ciscaucasia, Gabustan, Absheran, 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.

Key Terms: Ferns, taxonomy, ecology, rare species, spreading fields, paleobotanic, 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 10,000 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. Kolakovhsky and A.G. Dolukhanov gave me valuable advices about this.
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 materials which were kept the botanic institutes of Sankt-Peterburg and Caucasus have been critically analyzed. Mostly were used from the classic-morphological and geographical methods in this work. Also were used from critical taxonomies-comparative-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

A brief study of the Caucasus ferns history:

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 raddiana, D. alexeenkoana, D. oreades, Polystichum woronowii, Apleinum pseudolanceolatum, A. hermannii-christii. We meet some interesting information about ferns of Caucasus on the works of A. Grossheytm, A. Kolakovsky, I. Safarov, L. Pirilipko.

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: Polystichum kadyrovii, Polypodium issaevii, Polystichum x fominii, P.x safarovii, P.x dmitrievae, D.x. doluchanovii, D.x. schorapanensis, D.x kolakovskyi, Dryopteris raddeana var. talyschensis, Polypodium vulgare var. zvundicum.

The number of ferns families of Caucasus Flora increased from 5 to 20 and the genera from 23 to 31 compared to the current “flora” and “modifier”. 2 genera have been new for Caucasus: Cystromium C. Presl., Onoclea L. But 20 new species and 2 half-species have been found for the past Soviet Union: Pterisvittata, Adiantum cuneatum, Cystromium falcatum, Dryopteris remota, D. caucasia, D. atrata, D. ambroseae, D. x deweiveri, D. x euxinensis, D. x initialis, D. x montaniae, D. x sarveleae, Polypodium x montaniae, P. x shivasiae, Polystichum x illiricum, P. x bicknelli, P. x luerssenii, P. x wirtgenii, Asplenium x ticinense, A. x centovallense, A. septentroniale ssp. coriacea and ssp. persica (Askarov, 1977).

A lot of new species and new spreading fields have been found for South and North Caucasus as well (Askarov, 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 have been researched by us and were published in the large scale article named “The rare ferns of Caucasus” on the journal of “Botanic” (in 1983, №6) 25 species analyzed on this article. For example, Osmunda regalis (Abkhasia), Hymenophyllum tundbrigense (Adjariya), Anogramma leptophylla (Talish, Adjariya), Botrychium antemoides (Azerbaijan, Dagestan), Ophioglossum lusitanicum (Azerbaijan, Abkhasia) and others (Askarov, 1983).

Ecological analyze:

The ferns more reflective to ecological factors, especially against the factors of humidity. 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 biotopes where 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 millennia in these forms of relief. The species of fern (for example, very reflective changes in humidity, having thin anatomical structure – *Hymenophyllum tunbrigense*) in those areas were stayed at least from 3rd 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. The epiphytes of Caucasus and its substratum (growing above bodies) trees.

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<th>Substratum</th>
<th>Polypodium australe</th>
<th>P. issaevi</th>
<th>p. vulgare</th>
<th>P. x mantoniae</th>
<th>P. x schivasiae</th>
<th>Hymenophyllum tunbrigense</th>
<th>Phyllitis scolopendrium</th>
<th>Asplenium adiantum – nigrum</th>
<th>A. trichomanes</th>
<th>Polystichum aculeatum</th>
<th>Dryopteris filix – mas</th>
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**Figure 1.** *Polystichum aculeatum* (L.) Roth

**Figure 2.** *Polypodium vulgare* L. (shrubby place above the humid rocks in hornbeam forest).
A lot of species of fern are met in the formation of specific forest: for example, *Dryopteris raddeana*, *Polystichum woronowiis* typical for HirkanvKolkhida forests. There is decrease of species in spreading from lowland to mountain areas at the spreading period by the forest slopes.

**Areologic analyze:**

There 21 botanical-geographical regions are determined at the following graphic paying attention the spreading features of pteridophytes in Caucasus (look: the map-scheme of botanical-geographical regions).

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 Qobustan, 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.

**Chorological analyze:**

The forest ferns species of Caucasus belong 10 type of geographic areas: Kolkhid, Hirkan, Hirkan – Kolkhid, Eucaucasus, Daghestan, wholeCaucasus, Europe – Caucasus, Holarktic, Palearktic, Pluri regional. The relict species most related with the refugiums of Kolkhida and Talish and have 7 species: *Dryopteris aleixeenkoana* Fomin, *D. liliana* Golilts., *D. aemula* (Arit.) O.Kuntze, *D. raddeana* Fomin, *Polystichum woronowii* Fomin,*Asplenium woronowii* Christ, *Polypodiumsubuntegrum* (Fomin) A. Askerv. We are meet species belonging to the types of geographic areas - Holarktic (26 species), Paleartik (13 species) and Europe –
Caucasus (11 species). The event of endemism is weak at the pterydoflora of Caucasus (total 8 species): *Hymenocystis fragilis*, *Polystichum kadyrovii*, *Asplenium woronowii*, A. hermann-christii, A. daghestanicum and *Polypodium issaevii*.

**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).There are a lot of tropical and subtropical ferns and tree forms (*Dicksonia, Cyathea*). The ferns were spread much more inCenozoic, 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.

**Conclusions:** The present fern flora of Caucasus consists of 96 species, 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.

**Table 2.** The geochronologof modern ferns genera of Caucasus in Cenozoic (macrosediments - with intermittently lines, spors - with intact lines).
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 florogenic connection with the tropical and subtropical floras of Eastern Asia and Southern Paleoarctic. The florogenesis of some groups is close to the floras of South-western Asia and Southern Africa.
References
