

Rare Ferns of the Amur Region (Russia)

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Rare fern species of Amur region are identified. These ferns have unstable positions in plant communities and need in conservation. The reasons for their rarity and limitative factors are identified. 21 fern species are rare on the Amur region territory, 10 fern species among them are known only from one location. The most endangered species are *Leptolepidium kuhnii* (Milde) Hsing et S.K. Wu, *Protowoodsia manchuriensis* (Hook.) Ching and *A. tenuicaule* Hayata. Most of rare ferns grow as isolated individuals, they have difficulties in spore and vegetative reproduction. Both Khingan and Zeya State Reserves are the territories of concentration of rare ferns: 8 and 6 rare ferns respectively inhabit here. Some approaches to conservation of rare species are suggested.

Key words: Ferns, Rare species, Distribution, Amur region.

The ferns consists an ancient group of the flora of the south of the Russia Far East and one of original elements of the plant communities of this region. The highest fern diversity within Russia is characteristic precisely for the Russian Far East. They are the elements of plant cover of the coniferous and coniferous-deciduous forests and rocks. Amur region is the west part of the Russian Far East, it borders with Eastern Siberia. Region is situated in the temperate climate zone, the most part of its territory localizes in the basin of the Upper and Middle Amur. Four type of flora participate in formation of flora and vegetation of Amur region, namely East Siberian, Daurian,

Manchurian, and Okhotsk flora types. For that reason many plant species are on the border of their geographical range. The south part of the Russian Far East including Amur region has never been under glaciation, in particular Pleistocene one. This has allowed many ancient forms of plants to persist to the present day¹.

Unfortunately, many plant communities of Amur region are currently experiencing a high anthropogenic pressure or have destroyed as a result of human activities. In addition, some species of ferns have medicinal, edible, ornamental and technical value, so they are widely used by peoples. In this regard, there is an urgent necessity to develop and realize the measures for conservation of the fern diversity for the Russian Far East in general and for the Amur region in particular. Primarily, the fern species, which are vulnerable, rare or economically valuable, require to be protected.

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It is necessary to identify rare and endangered fern species, to find out the causes of vulnerability, the strongest depressing factors and to develop the variants for the conservation of such species “*in situ*” or “*ex situ*”. Several causes of plant rareness in general and fern rareness in particular are distinguished. They are historical causes (the limited or disjunctive range, being on the boundary of the range); ecological causes (narrow adaptation to the certain habitats and scarce distribution of such habitats, insufficient resources), anthropogenic causes (disturbance or destruction of the habitats), and especially biological causes (low competitiveness, depressed spore and vegetative renewal)^{2,3}.

MATERIALS

The results of our own observation within the Amur region were used for the compilation of list of rare species and for identification of their ecological preferences and biological peculiarities. Furthermore we used fern collection of some large Herbaria: LE (St. Petersburg), MHA (Moscow), TK (Tomsk), ALTB (Barnaul), NS and NSK (Novosibirsk), VLA and VBG (Vladivostok), and other Herbaria such as Herbarium of Amur Branch of the Botanical Garden-Institute, Herbarium of Blagoveshchensk Pedagogical Institute, Herbaria of Zeya State Reserve, Hingan State Reserve.

RESULTS AND DISCUSSION

Fifty one fern species occur currently in the territory of Amur region⁴. Analysis of the distribution of these species on the studied territory of upper and middle Amur region as well as analysis of both the state of their populations and risks associated with anthropogenic impact, allowed to distinguish fern taxa in need of special attention and protection. According to our study, 21 fern species can be included in the category of “rare” species for the territory of Amur region. They are the following: **Botrychium alaskense* W.H. Wagner et J.R. Grant, *B. multifidum* (S.G. Gmel.) Rupr., *Ophioglossum nipponicum* Miyabe et Kudo, *Aleuropteris argentea* (S.G. Gmel.) Fée, *Asplenium inAisum* Thunb., *A. ruta-muraria* L., *A. tenuicaule* Hayata, *Cryptogramma raddeana* Fomin, *C. stelleri* (S.G. Gmel.) Prantl, *Cystopteris*

sudetica A. Br. et Milde, *Dryopteris goeringianum* Koidz., *D. sichotensis* Komarov, *Leptolepidium kuhni* (Milde) K.H. Shing et S.K. Wu, *Lunathyrium pycnosorum* (Christ) Koidz., *Parathelypteris nipponica* (Franch. et Savat.) Ching, *Polystichum braunii* (Spenn) Fée, *Protowoodsia manchuriensis* (Hook.) Ching, *Woodsia gorovoi* Krestsch. et Shmakov, *W. kitadakensis* Ohwi, *W. polystichoides* D.C. Eaton, *W. pseudopolystichoides* (Fomin) Kiselev et Shmakov (Table 1).

Most of species listed in Table 1 are rare because of historical cause. The frequency of their occurrence is explained by historical and geographical features of the territory. They have a small range or boundary of the range (mostly northern) in studied region and occur here in low number of locations. All these species grow in Russia only in the Far East territory, so loss of their populations in Amur region would be damage for biodiversity of Russian flora in general.

The next important cause of rareness is biological peculiarities of species. Long-term survival demands a regular renewing of the populations either vegetatively or by spores. Reproduction by spores through development of gametophytes plays the main role in colonization of new habitats and in occupation of the vacant places in the same habitat. Vegetative reproduction is significant for fixing and retention of places within the same habitat. The most effective is vegetative reproduction with rejuvenation of vegetative progenies. Such reproduction can maintain population and extend its area. But most of rare species have not effective vegetative reproduction of sporophytes and have ability only to senile fragmentation². Many studied rare species of Amur region have problems with reproduction. Their sporophytes have not ability to effective vegetative reproduction, and the development of gametophytes demands a combination of many favourable factors (for example, a presence of safe sites for spore germination, an invasion of sufficient number of spores, favourable temperature and humidity), therefore take place infrequently. In such condition existence of the species in coenosis is equally with the sporophyte lifetime. Some fern species are rare because of inhabiting in specific condition, such as limestone (*Aleuropteris argentea*, *Asplenium tenuicaule*,

Table 1. Rare fern species of the Amur region and causes of their rareness

No	Name of species	Causes of rareness		
		Historical	Ecological Ophioglossopsida	Anthropogenic
1	* <i>Botrychium alaskense</i>	East-Asian-North-American range, four locations		
2	<i>B. multifidum</i>	One location		
3	<i>Ophioglossum nipponicum</i>	East-Asian range, one location		
4	* <i>Aleuritopteris argentea</i>		Polypodiopsida Occurrence on limestone rocks	Limestone mining
5	* <i>Asplenium in Aisum</i>	East-Asian range, northern boundary of range, two locations	Occurrence on moist shadow	
6	* <i>A. ruta-muraria</i>		Occurrence on limestone rocks	Limestone mining
7	<i>A. tenuicaule</i>	Asian range, northern boundary of range, two known locations are destroyed	Occurrence on limestone rocks	Limestone mining, flooding by reservoir of hydroelectric power station
8	* <i>Cryptogramma raadeana</i>	Asian range, two locations	Occurrence in high mountains	
9	* <i>C. stelleri</i>	Two locations	Occurrence in high mountains	
10	* <i>Cystopteris sudeutica</i>			Deforestation

Microtophy, difficulties in reproduction
Microtophy, difficulties in reproduction
Microtophy, difficulties in reproduction

Isolate individuals, difficulties in reproduction
Isolate individuals, difficulties in reproduction

Isolate individuals, difficulties in reproduction

Isolate individuals, difficulties in reproduction
Small lifetime, difficulties in reproduction

Isolate individuals, difficulties in reproduction

11	<i>*Dryopteris goeringianum</i>	Far-Eastern range, northern boundary of range, one location	Deforestation	Isolate individuals
12	<i>*D. stichotensis</i>	East-Asian range, northern boundary of range, one location	Potential flooding by reservoir of hydroelectric power station	Isolate individuals
13	**Leptolepidium kuhni	East-Asian range, northern boundary of range, one location	Potential flooding by reservoir of hydroelectric power station	Isolate individuals, difficulties in reproduction
14	<i>Lunathyrium pycnosorum</i>	East-Asian range, northern boundary of range, one location	Occurrence on limestone rocks	
15	<i>Parathelypteris nipponica</i>	East-Asian range, one location		
16	*Polystichum braunii			
17	<i>Protowoodia manchuriensis</i>	East-Asian range, one location	Deforestation	Isolate individuals, difficulties in reproduction
18	<i>Woodia gorovoi</i>	Small range, one location	Potential flooding by reservoir of hydroelectric power station	Isolate individuals, difficulties in reproduction
19	<i>W. kitadakensis</i>	Far-Eastern range, northern boundary of range, two locations	Occurrence on moist shadow rocks	Isolate individuals, difficulties in reproduction
20	*W. polystichooides	Asian range, northern boundary of range	Potential flooding by reservoir of hydroelectric power station	Isolate individuals, difficulties in reproduction
21	<i>W. pseudopolystichooides</i>	East-Asian range, one location		Isolate individuals, difficulties in reproduction

* – species is included in the “Red book of Amur region”

** – species is included in the “Red book of Russian Federation”

A. ruta-muraria), moist shadow rocks (*Asplenium inAisum*), and highlands (*Cryptogramma raddeana*, *C. stelleri*). Some ferns have become rare under the direct or indirect human impact. Population of ferns, which dwell on the limestone rocks, might be destroyed due to limestone mining. The only habitat of *Dryopteris sichotensis* in vicinity of village Kulikovka in the valley of Bureya river is situated in the flooding area of further Nizhnebureiskaya hydroelectric power station. *Cystopteris sudetica* grows in the forests, which are subjected to intensive lumbering.

The most endangered species are these, which are characterized by all of rareness causes. They are the following: *Asplenium tenuicaule*, *Leptolepidium kuhnii*, *Protowoodsia manchuriensis*.

Asplenium tenuicaule grows as isolated individuals and is at the northern border of its range. A single habitat, which is known according to published results of the Moscow State University expedition, is kept currently in the territory of Zeya State reserve⁵. This species occurred in two more habitats in the 60s of XX century: “on the rocks in the upper stream of the river Zeya near village Zhurban” and “in 10 km from village Cheugda on the river Bureya”. But now both of these habitats are flooded by reservoirs of Zeya and Bureya hydroelectric power station.

Leptolepidium kuhnii has a small range and occurs within Russia only in the Far East, where six populations are known in Khabarovskiy krai and four ones in the south of Primorskiy krai (Khasansky district). The number of populations is decreased, for example, one population situated in the middle stream of Anui river, was destroyed during reconstruction of the road Lidoga-Vanino. In Amur region *L. kuhnii* is situated at the northern border of its range. Its single population is located in the flood zone of a future reservoir of Nizhnebureiskaya hydroelectric power station. Considering this, the loss of that very northern population of this species in Amur region might be a significant damage for its gene pool and for the flora of region in general.

Protowoodsia manchuriensis is the single representative of the genus *Protowoodsia*. In Russia this relic species occurs only in the Far East, the single location is known in Amur region.

Several zones of the concentration of rare fern species were identified as the result of distribution analysis of the rare species on the territory of Amur region. Two such zones are situated on the territory of Hinggan State reserve (8 species) and Zeya State reserve (6 species). Ten rare fern species grow in the middle stream of the river Bureya. The unique place is situated in the middle stream of the river Zeya in the vicinity of the village Cagoyan (6 species). The populations of rare fern species there are in the basin of the upper stream of Amur (7 species). An interesting territory is located in the upper stream of Selemdzha river, where the rocky ferns and ferns of coniferous-deciduous woods occur.

The system of nature protection is effective only as combination of conservation of native plant communities with conservation of the separate species. One of form of inventory of the rare species is the compilation of the state and regional “Red books”. Among the ferns growing in Amur region only one species – *Leptolepidium kuhnii* – is included in the “Red book of Russian Federation”⁶, several other species have different conservation status on the Russian Far East^{7,8,9,10}. The “Red book of Amur region”¹¹ includes 10 fern species (Table 1).

The “Red books” can’t include all species in need of conservation. As a rule, they include the taxa, which are threatened in the most of habitat or potentially vulnerable due to their being in one or few locations, which could be disturbed or destroyed. The ferns are relic plants and often have not wide adaptive abilities. Most of species did not survive after considerable disturbances of environmental condition. Elimination of some fern species in their locations happened during the building of Zeya and Bureya hydroelectric power stations, deforestation, limestone mining. A flooding of the big territories by the reservoir of Nizhnebureiskaya hydroelectric power station is a huge threat in the near future. All the habitat of rare species in the middle stream of Bureya river may be disturbed by this reservoir, as well as reservoirs now projected hydroelectric power stations on the rivers Selemdzha, Zeya, Gilui. Most of habitats of ferns, which are in need of conservation, will be under water in case of their building. Organization of natural botanical reserve or wildlife refuge is necessary for the protection of

unique flora.

Preservation of the fern biodiversity is possible not only “*in situ*” but also “*ex situ*”. Cultivation in the collections of botanical gardens is an effective method of saving of endangered species. Most species of Polypodiopsida are perspective for cultivation, but representatives of Ophioglossopsida are very heavy for cultivation due to their biological features, especially micotrophy. Some species of ferns of Amur region, for example *Leptolepidium kuhnii*, can be successfully grown in greenhouses. This provides additional opportunities for the conservation of rare and endangered taxa¹². Maintenance of the natural population and creation of cultivated fern populations is necessary in the specially protected areas and botanical gardens. The method of cryopreservation is perspective for long-term storage of fern spores^{13, 14}. Spores after cryopreservation can be used for cultivation of ferns.

CONCLUSION

The flora of Amur region includes 21 rare fern species. 10 fern species among them are known only from one location. The most endangered species are *Leptolepidium kuhnii* (Milde) Hsing et S.K. Wu, *Protowoodsia manchuriensis* (Hook.) Ching and *A. tenuicaule* Hayata. Preservation of the fern biodiversity is possible “*in situ*” in natural habitat, which are under protection in the specially protected areas such as State reserve and wildlife refuge, as well as “*ex situ*” in the Botanical gardens.

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