A REVIEW OF THE MEDICINAL FERNS OF UKRAINE

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ABSTRACT

The growing demand for natural medicines, food products and cosmetics stimulates the search and studies on the diversity of plant species. Ferns are a promising source of biologically active substances for pharmaceutical and medical purposes. Out of 63 species of wild ferns in Ukraine, 39 species contain biologically active substances, which are used or can be used for medicinal and food purposes. Most of them have limited distribution and resources. Many of them are endangered and are in need of protection. This article highlights some aspects of the distribution, resource significance, and protection status in Ukraine and/or Europe, as well as the medicinal value of the wild medicinal ferns of Ukraine.

Keywords: *wild medicinal ferns, resources significance, protection*

INTRODUCTION

Nowadays, the investigation of the available diversity and resources of medicinal plants has become an important subject and is progressing in the spheres of biodiversity and conservation. Ferns are an important component of phytodiversity and have value as medicinal, ornamental, edible and technical plants in different regions of the world.

Ferns are thought by most people to have low value for medical purposes. In the traditional medicine of Ukraine and that of most of the European countries, their useful aspects are largely limited. Ferns are popular plants as food, medicine, decoration, fiber, crafts and building material mostly in the countries of Southeast Asia (1-6).

Nowadays, the medicinal properties of ferns in regard to human health are being more thoroughly studied. According to various data, ferns contain many secondary metabolites, as well as polyphenols, flavonoids, triterpenoids, etc. (7,8). Ferns have various functional effects on human health, such as antioxidant, antimicrobial, antitumor, anti-inflammatory and more, which are classified as the effects of secondary metabolites (9,10). It has been confirmed that antioxidant activity of the secondary metabolites of ferns is the most useful bioactivity for countering aging and chronic disease (1).

Therefore, this study was conducted in order to create a database of wild medicinal ferns of Ukraine, their resource significance, protection status in Ukraine or Europe and medicinal value, based on a long-term research, results of literature data analysis and local ethnobotanical knowledge. There are nearly 63 wild species, subspecies and hybrids of fern in Ukraine (11). In this study, a total of 39 wild species of ferns native to Ukraine, which are considered medicinal in the world, were analyzed. This research

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Table 1. The state and medicinal values of ferns of Ukraine

Latin name	English name	Family	Distribution in Ukraine	Resource value	Number of individuals in population	Protection status in Ukraine	Protection status (by Global and European regional assessment)	Medicinal value
Adiantum capillus-veneris L.	Venus hair fern	Adiantaceae (Pteridaceae s.l.)	L	0	F	RB, endangered	LC	Flavonoids, triterpenoids, phenylpropanoids, carbohydrates, carotenoids. The presence of bitterness explains the use of leaves as a vermifuge. Used as expectorant, antitussive, febrifuge, galactogogue, emollient, antiparasitic and dandruff, to increase lactation, weak emmenagogue and kidney function,weak tonic, sudorific, emetic and astringent effect; anti-inflammatory, antiviral, antimicrobial, antifungal and significant analgesic activity (15,16); used by women who had just given birth in order to restore menstrual blood. It is anemollient, and adjuvant in bronchial diseases (17-19).
Asplenium adiantum-nigrum L.	Black spleenwort	Aspleniaceae	R	0	F	RB, rare		Saponins, triterpenoids, higher fatty acids, higher aliphatic carbohydrates, phenolcarbonic acids and their derivatives, xanthones (mahniferyn); inflammatory, laxative, lactogenic, anthelmintic, diuretic, expectorant, diseases of the spleen and jaundice (6, 20); in experiment - anesthetic, strong antioxidant and hepatoprotective activity (21); in diseases of the spleen, jaundice, conjunctivitis (4,7).
Asplenium cuneifolium Viv.	Serpentine spleenwort	Aspleniaceae	L	0	I	RP		Phytoestrogens, lipophilic substances; tocopherol, cholesterol, sitosterol, stigma sterols; estrogenic activity, in traditional medicine to treat menstrual pain and as a contraceptive (22).
Asplenium fontanum (L.) Bernh.	Smooth rock spleenwort	Aspleniaceae	L	0	I			Kaempferol 3-gentiobioside, kaempferol 3-polyglycoside, kaempferol 3,7-glycoside (24-25).

Asplenium ruta-muraria L.	Wall rue	Asplenia-ceae	M	0	F	RP		Caffeic acid glycoside, 2-O-caffeoyl-β-D-fructofuranosyl-(2→1)-α-D-glucopyranoside and an (α, β)-isomeric pair of 2E-caffeoyl-D-glucopyranoside, together with kaempferol-3-O-β-D-[6-E-caffeoyl-β-D-glucopyranosyl-(1→2) glucopyranoside]-7-O-β-D-glucopyranoside, 1-O-caffeoyl glycoside, sucrose, diploptene and β-sitosterol (26,27); astringent, diuretic, anthelmintic, expectorant; for respiratory diseases, respiratory infections, jaundice, ascites, scurvy (7).
Asplenium scolopendrium L. (Phyllitis scolopendrium (L.) Newman)	Hart's tongue fern	Asplenia-ceae	M	I	I	RP		Organic acids, triterpenoids, steroids, nitrogen-containing compounds, lipids, higher aliphatic hydrocarbons, flavonoids, flavonol glycosides (7,28-30); astringent, laxative, analgesic, wound healing, hemostatic, detoxification, hemostatic and expectorant effect. Externally it is used as an ointment in the treatment of piles, burns and scalds. An infusion is taken internally for the treatment of diarrhea, dysentery, gravelly deposits of the bladder and for removing obstructions of the liver and spleen; strong antioxidant activities (5); in folk medicine it is used for tuberculosis, infertility, diseases and tumors of the stomach, liver, spleen; in homeopathy in cases of pulmonary tuberculosis and malaria (8).
Asplenium septentrionale (L.) Hoffm.	Forked spleenwort	Asplenia-ceae	M	0	F	RP		Organic acids, nitrogen-containing compounds, terpenoids, flavonoids (kaempferol, quercetin) (29); aldehydes, alcohols, especially fatty acids are abundant (43%); sesquiterpene hydrocarbons and oxygenated diterpene phytol (31). Astringent, expectorant; liver diseases and respiratory diseases (4,7).

Asplenium trichomanes L.	Maidenhair spleenwort	Asplenia-ceae	M	0	F	RP			Triterpenoids, nitrogen-containing compounds, flavonoids (kaempferol, quercetin) (31); polyketide and aromatic compounds, isoprenoid derivatives (33); laxative, anthelmintic, diuretic, expectorant, sedative, abortive, estrogenic activity (22, 34); in case of bronchitis, respiratory infections, depression, jaundice, ascites. For irregular menses, breast diseases, coughs, and liver ailments (7,8).
Asplenium viride Huds.	Green spleenwort	Aspleniaceae	R	0	I	RP			Flavonoids: kaempferol, quercetin (35). Powder from the leaves of the plant is applied externally for injuries and wounds. As tea – for gastric ulcer gastritis (36,37).
Athyrium filix-femina (L.) Roth	Lady-fern (Female fern)	Athyriaceae	M	III	N	RP			Triterpenoids and polyphenols, carotenoids, higher fatty acids, steroids, tannins, vitamin C (7,38); cytotoxic, antioxidant and antimicrobial activity (5); analgesic, astringent, expectorant, weak anthelmintic and diuretic; use in the treatment of pregnant women to prevent their water from breaking prematurely, for aiding mothers with intestinal fevers, to help with breast pain, caked breasts and for treating men with venereal diseases. For treatment enterocolitis, dysentery, nephritis, metrorrhagia, hemorrhoids, headaches and rheumatism (7).
Azolla filiculoides Lam.	Water fern	Azollaceae	R	I	N				Flavonoids (anthocyanidins: lyuteolinidyn and apigenin); a mixture of lipids, unsaturated lipids, polysaccharides, polyphenols (O-dihydroxy phenols, phenols with free OH groups and tannins) and alkaloids; hepatoprotective and antioxidant activity (39-42).
Azolla mexicana C. Presl	Mexican mosquito-fern	Azollaceae	R	I	F				Flavonoids (43).

Blechnum spicant (L.) Roth	Hard fern	Blechnaceae	R	0	I	RP			Triterpenoids, flavonoids, steroids, higher aliphatic alcohols; in tumors of the spleen; slight antithrombin activity or wound healing (7). The leaflets in folk medicine have been chewed in the treatment of internal cancer, lung disorders and stomach problems. The fronds are used externally as a medicine for skin sores. A decoction of the root has been used in the treatment of diarrhea (44).
Botrychium lunaria (L.) Sw.	Common moonwort	Ophioglossaceae (incl. Botrychiaceae)	R	0	I	RB, vulnerable	LC		Moonwort is broadly antibacterial against many microbes, including most fungus and some viruses; used as a good vulnerary and also used in dysentery (45); it can be used on various kinds of injuries, pulled muscles, insect stings, contusions, cuts, infections, nerve pain and in anything itchy and irritated like contact dermatitis (7); also used in the treatment of hernias and dysentery.
Botrychium matricariifolium (A. Braun ex Döll) W. D. J. Koch	Chamomile grape-fern (Matricary grape-fern)	Ophioglossaceae (incl. Botrychiaceae)	R	0	I	RB, rare	NT		Leaves used as wound healing (7).
Botrychium multifidum (S.G. Gmel.) Rupr.	Leathery grape-fern, (Leathery moonwort)	Ophioglossaceae (incl. Botrychiaceae)	R	0	I	RB, rare	DD		Leaves used as wound healing (7).
Ceterach officinarum Willd.	Rusty-back fern	Aspleniaceae	L	0	I				Triterpenoids, phenolcarbonic acids, flavonoids, carbohydrates, tannins, higher fatty acid; used in diseases and tumors of the spleen, kidneys, bladder, skin diseases (7,46); as an astringent and anti-inflammatory on reddened or irritated skin, applied using poultices of crushed or fresh leaves. It is also known as an expectorant (47).
Cheilanthes acrosticha (Balb.) Tod.	Fragrant cheilanthes		L	0	I	RB, endangered			Carbohydrates, flavonoids (7), used in toothache (48).

Cystopteris fragilis (L.) Bernh.	Bladder fern	Cystopteridaceae	L	0	I	RB, rare		Proteins, carbohydrates, phenolic compounds, terpenoids (4); xanthones, phenols and their derivatives; toning, softening, expectorant, antipyretic, anthelmintic, bacteriostatic, analgesic; intestinal diseases, asthma, physical fatigue (7), treating trauma (44).
Dryopteris carthusiana (Vill.) H.P.Fuchs	Narrow buckler-fern	Dryopteridaceae	M	II	N	RP		Para-aspidin BB. Rhizomes can be used as an anthelmintic. Water and alcohol extracts of rhizomes, water extract of leaves show bacteriostatic activity (9). In Belarus rhizomes are used for dermatomycosis (7).
Dryopteris caucasica (A. Braun) Fraser-Jenk.& Corley	Caucasian buckler-fern	Dryopteridaceae	L	I	I			Phloroglucines: dezaspidyn BP, para-aspidin BB, PB (9).
Dryopteris cristata (L.) A. Gray	Crested buckler-fern	Dryopteridaceae	M	I	N	RP		Para-aspidin BB, PB, desaspidin BP, flavaspidic acid PB, flavaspidic acid PP (9); anthelmintic, expectorant, bacteriostatic (7).
Dryopteris dilatata (Hoffm.) A. Gray	Broad buckler-fern	Dryopteridaceae	M	I	F	RP		Astragalin, isoquercitrin and chlorogenic acid, caffoyltartronate and kaempferol-3-O-β-D-glucosido-7-O-a-L-rhamnoside were detected (49). Polyketide and aromaric compounds, isoprenoid derivative (33), desaspidin BP, flavaspidic acid BB (9). The root contains 'filicin', a substance that paralyzes tapeworms and other internal parasites and has been used as a worm expellent. It is one of the most effective treatments known for tapeworms. An infusion of the fronds is used as a hair rinse and to treat dandruff.
Dryopteris expansa (c. Presl) Fraser-Jenkis & Jermy (=D. assimilis S. Walker	Alpine buckler fern (Northern buckler-fern)	Dryopteridaceae	R	0	I	RP		Phenols and their derivatives desaspidin BB, trisdesaspidin BBB and phloropyron BB (9); anthocyanins, essential oils, saponins; anthelmintic, analgesic, wound healing, antibacterial (7).

Dryopteris filix-mas (L.) Schott	Male fern	Dryopteridaceae	M	III	N	RP			Astragalin, isoquercitrin and chlorogenic acid, rutin and kaempferol-3-O-rutinoside (49) Para-aspidin, flavaspidic acid PB, filixic acid BBB (9). Major compounds the phloroglucinols, have broad spectrum of pharmacological activities e.g. anthelmintic or antirheumatic effects (49). Rhizomes are used in folk medicine of many countries as a remedy against tapeworms. In Russia a drug "Phylixan" (Filixanum) from the rhizome Dryopteris filix-mas was used as anthelmintic remedy (7).
Dryopteris villarii (Bellardi) Woyn. ex Schinz & Thell. (=Dryopteris mindshelkensis N. Pavl.)	Rigid buckler-fern	Dryopteridaceae	L	I	F				Phloroglucines: albaspidin AP, AB, PP, PB, BB, apigenin 7-O-glucoside-4'-acetate, quercetin 3-O-rhamnoside-7-O-glucoside (9, 50).
Gymnocarpium dryopteris (L.) Newman	Common oak fern	Cystopteridaceae	M	I	F	RP			Carbohydrates, proteins, free amino acids, saponins, phenolic compounds, tannins, volatile oils, terpenoids (4). Possessing anti-inflammatory, anthelmintic, analgesic, antiseptic and other useful properties, it is known in folk medicine of many European and Asian countries. The flavonol glycoside astragalin possesses anti-inflammatory, anti-allergenic and antimicrobial activities. It together with other flavonoids is used to treat rheumatoid arthritis and osteoarthritis (51). Tincture of the leaves, as well as decoctions from the leaves, are used as an analgesic and anti-inflammatory agent for rheumatic pains, arthralgia, arthritis and arthrosis. From the decoction of leaves lotions for the treatment of wounds, ulcers, mastitis, bruises are made. The aqueous decoction of fern roots has an anthelmintic effect. It is used for diseases of the spleen, certain diseases of the digestive tract and excretory system (nephritis, cystitis) (7).

Marsilea quadrifolia L.	Water shamrock (Common water clover)	Marsileaceae	R	0	I	RB, vulnerable	NT		Carbohydrates, alkaloids, steroids, tannins, terpenes, protein, flavonoids and anthraquinone. Juice made from the leaves is diuretic and febrifuge and also used to treat snake bite and applied to abscesses, etc. The plant is anti-inflammatory, diuretic, depurative, febrifuge, refrigerant (6); has antibacterial cytotoxic, antioxidant and anticancer activity. The plants is useful in vitiated pitta, cough, bronchitis, diabetes, psychiatric diseases, eye diseases, diarrhea and skin disease (52). It has got profound antibacterial, cytotoxic and antioxidant effect and may have potential use in medicine (53).
Onoclea struthiopteris (L.) Hoffm. (Matteuccia struthiopteris (L.) Tod.)	Ostrich fern	Onocleaceae	M	0	F	RP	LC		A caffeic acid derivate, flavonoids, stilbenes and phenolic components: demethoxymatteucinol, matteucinol, matteuorien, pinosylvin and pinosylvin 3-O-β-Dglucopyranoside,5-β-DGlucosyloxy-3-hydroxyl-trans-stilbene-2-carboxylic acid (54- 59). The rhizomes and frond bases have been used as a traditional Chinese medicine for the treatment of pinworms, influenza, dysentery, hematochezia and uterine hemorrhage. The pharmacological activities of plants include antivirus, antiparasitic activities, and eliminating bacteria. Rhizomes were used for heavy menstruation, coughing, asphyxiation, as an astringent, fever and malignant tumors (60, 61).
Ophioglossum vulgatum L.	Adder's fern	Ophioglossaceae (incl. Botrychiaceae)	M	I	F	RP			Flavonoids (quercetin, kaempferol) (7). Wound healing and tissue repair properties. Traditionally used on wounds and burns in the form of ointments (62, 63).
Oreopteris limbosperma (Bellardi & All.) Holub	Lemon-scented fern	Thelypteridaceae	L	0	I	RP			Terpenic compounds incl. (E)-nerolidol, alpha-terpineol, beta-caryophyllene , linalool, pinenes, limonene, and gamma-terpinen-7-al) and carotenoid-type derivatives (64).
Pilularia globulifera L.	Pillwort	Marsileaceae	L	0	I	RB, endangered	NT		Flavonoids (quercetin 3-O-rhamnoside , kaempferol) (7,65).

Polypodium vulgare L.	Common polypody (Wall fern)	Polypodiaceae	M	I	F	RP	LC	Triterpenoids, steroids, carbohydrates, organic acids, phenols and their derivatives, essential oils (sesquiterpenes (39.6%) and their oxidized forms (21.9%), fatty oils, catechins (31). Polypody rhizome contains: ecdysteroids , phloroglucinol derivatives, volatile oil, 8% fixed oil and tannins. Polypody root contains also sugar, saponins, glycyrrhizin, mannitol, protein, starch and carbohydrates (slime) and calcium malate (66). The data of clinical pharmacology is not available, but the antibacterial effect was investigated (67). It is used in traditional medicine as an expectorant in cough and cold, and constipation. It stimulates bile secretion and is a gentle laxative. In European herbal medicine it is traditionally used as a treatment for hepatitis and jaundice and as a remedy for indigestion and loss of appetite. It should not be used externally since it can cause skin rashes (44,66). It has previously been used as a remedy against respiratory complaints and rheumatism. It has expectorant and laxative effect.
Polystichum aculeatum (L.) Roth	Hard shield-fern	Dryopteridaceae	R	I	I	RP		Triterpenoids, cardiac glycosides, polyphenols, anthraquinones and quinines; anthelmintic, antibacterial, strong antioxidant activity (5,7).
Polystichum lonchitis (L.) Roth	Alpine rouch fern (Holly fern)	Dryopteridaceae	R	0	I	RP		Lipids (spores); cholagogic, wound healing, diuretic properties; used in diseases of the spleen, skin rash (7,68).

Pteridium aquilinum (L.) Kuhn (incl. Pteridium tauricum Krecz. ex Grossh.)	Common bracken	Dennstaedtiaceae	M	III	N				Organic acids, carotenoids, sesquiterpenes and norsesquiterpenes, steroids, flavonoids, phenolic compounds, starches, tannins, lipids; anti-diabetic and anti-obesity activities, antioxidant, diuretic, astringent, antipyretic, antitussive, anthelmintic, healing, bacteriostatic (69). In Chinese medicine - diuretic, antipyretic, with infectious hepatitis; in Indian medicine - in spleen infiltrate. In folk medicine - laxative, tonic, wound healing; in diseases of the respiratory, stomachalgia, myalgia, diarrhea (7,16). Young leaves - used as a food in boiled, fried, pickled state mainly in countries of East Asia and South Africa. The use of its rhizomes and fronds as food appears to be widespread. Young croziers are consumed fresh, canned, dried or pickled, and they are regarded as a delicacy in many countries. However, consumption of the bracken fern has been shown to induce bladder and intestinal carcinomas in cattle and to cause a number of diseases in other farm animals. Some human populations also eat young bracken shoots and epidemiological studies in Japan and Brazil have shown a close association between bracken consumption and the occurrence of certain cancers. An unstable glucoside named ptaquiloside has been proven to have potent carcinogenicity (70).
Salvinia natans (L.) All.	Floating moss (Floating watermoss)	Salviniaceae	M	0	N	RB, data deffi-cient	LC		Glycosides, carbohydrates, proteins, tannins, terpenoids, flavonoids, phospholipids, fatty acids are the main classes of compounds was isolated from the leaves of *Salvinia natans* (4). Antioxidant properties were investigated (28, 71). In traditional Chinese medicine it is used as an antipyretic, analgesic, against poison, increasing circulation of blood (72).

Thelypteris palustris Schott (=Thelypteris confluens (Thunb.) C.V. Morton)	Marsh fern	Thelypteridaceae	M	II	N	RP	LC		Flavonoid compounds (73). Used in gynecology and as an anthelmintic agent (68).
Woodsia ilvensis (L.) R.Br.	Oblong woodsia	Woodsiaceae	L	0	I	RB, endangered			Essential oils: monoterpenes, diterpenes, sesquiterpenes, alcohols, aldehydes, acids (31); tannins; antipyretic, wound healing; for kidney diseases (7,68).

ABBREVIATIONS

Distribution in Ukraine: M - on much of the territory, R - in some regions, L - known in some locations;

Resources value: III - the raw resources of wild species are sufficient for harvesting in large volume, II - resources are limited; I - resources endangered; 0 - wild resources are not available, species needs to be protected ;

Number of representatives in a population: N - numerous, F - few in numbers, I - isolated individuals;

Protection status in Ukraine: RB - Red Book, RP - regional Protection;

Protection status (by Global and European regional assessment): NT - Near Threatened, LC - Least Concern, DD - Data Deficient.

is part of a complex study of the medicinal plants of Ukraine with a goal to provide necessary information about the diversity, raw resources and necessity of protection of medicinal plants in the state.

MATERIALS AND METHODS

Regular field studies (expeditions) were carried out in different regions of Ukraine during the years 2002-2016. In the field, we have made geobotanical descriptions of localities, studied medicinal species and performed analysis of their involvement in plant communities. Additional information about the diversity, distribution, protection status, medicinal properties and use of ferns was received as a result of analyzing herbarium materials from various institutions of Ukraine, population survey during trips and literature data.

RESULTS AND DISCUSSION

Ferns do not hold significant economic importance in Ukraine. They are mostly used for decorative purposes in landscape gardening and occasionally in folk medicine for health benefits . Some of them (*Pteridium aquilinum* (L.) Kuhn, *Onoclea struthiopteris* (L.) Hoffm. and *Matteuccia struthiopteris* (L.) Tod.) are occasionally used for cooking purposes. It is a good source of protein and trace elements.

The results of the survey are presented in Table 1, in which the plants are arranged in alphabetical order. For each species the following data is present: : Latin and English name of the fern species, name of the family, and family distribution and resource significance in Ukraine, population structure, protection status in Ukraine and Europe, and medicinal value.

The presented species of ferns belong to 16 families, with the obvious predominance of the *Aspleniaceae* (23%) and *Dryopteridaceae* (23%) families. Other families are few in numbers and mostly represented by small quantity of species.

A distribution analysis shows widespread species, which grow on most of the territory of Ukraine (41.02%). The rest of the ferns have a limited distribution in some regions (30.77%) (Polissya, Carpathian Mountains, forest-steppe zone, etc.) or are only known to be in certain locations (28.21%). The last of these are rare ones and included to Red Book of Ukraine (12). Their populations are small with few

representatives. Most of the fern species of Ukraine being shade and moisture-loving, grow under forest canopy or in specific habitats, mainly in the Polissya region. These forests are being heavily transformed by logging. Any disturbance of forest vegetation leads to ecological imbalance and destruction of most of the fern populations. With the increase of environment transformation the natural habitats of ferns are becoming small and fragmented, so some species are on the brink of extinction and protected at regional or national levels (see Table 1).

Based on the results of the evaluation of the resource potential of the analyzed ferns, they were divided into several groups of species (see Table 1). Based on estimation, only *Athyrium filix-femina* (L.) Roth, *Dryopteris filix-mas* (L.) Schott and *Pteridium aquilinum* have resource significance and are available for sustainable wild collection and wide economic importance. The resources of other species are limited and inaccessible for harvesting from the wild. Most of them are protected on regional, national or global level.

Thus, more than half of the medicinal ferns have little distribution in Ukraine and many of them are endangered and are in need of protection. Their populations, mostly, are small-numbered or represented by isolated individuals. For this reason, 11 species of medicinal ferns from the total number studied are protected at the state (national) level and are included in the Red Book of Ukraine (12); 19 species are protected at regional level and listed on the Regional Rare Checklists. Some of them are protected only in certain areas (administrative regions), where there is a threat of depletion of their populations. Besides that, ten species from the total number studied are threatened at a European level (see Table 1), according to data from global or European regional assessment (13).

The protection rank at European level of *Botrychium matricariifolium* (A. Braun ex Döll) W.D.J.Koch, *Marsilea quadrifolia* L. and *Pilularia globulifera* L. has been identified as Near Threatened. There are rare species with a scattered distribution throughout Europe. They are listed as threatened on all available national red lists, including Ukraine's, and populations are declining almost everywhere. Species, such as *Adiantum capillus-veneris* L., *Botrychium lunaria* (L.) Sw., *Salvinia natans* (L.) All., *Onoclea struthiopteris*, *Polypodium vulgare* L. and *Thelypteris palustris* (Salib.) Schott are classified in the European Red List as Least Concern as they are widespread and abundant, however they appear to be declining throughout much of their range with some localities going extinct (13). The first three species are added to the Red Book of Ukraine, however, the populations of *Salvinia natans* have been found lately in many localities with a high number of representatives and the overall trend is stable with range extensions around some river basins. *Onoclea struthiopteris, Polypodium vulgare* and *Thelypteris palustris* are abundant in large areas, although protected in some regions. *Botrychium multifidum* (S.G. Gmel.) Rupr. has been identified as Data Deficient (DD) on European level, but is in decline in Ukraine and included in the Red Book as rare species (Table 1). In addition, the Red Book of Ukraine includes *Asplenium adiantum-nigrum* L., *Cheilanthes acrostica* (Balb.) Tod., *Cystopteris fragilis* (L.) Bernh. and *Woodsia ilvensis* (L.) R.Br., as populations with a decreasing number of representatives.

The current main threat for many wild ferns of Ukraine is disturbance of the ecological balance of their living environment, including: general ecosystem dehumidification, wetland amelioration, forest exploitation (deforestation, intensive logging, decrease of the area of old-growth forests), habitat fragmentation as a result of anthropogenic transformation of the environment, wild fern collection, livestock grazing and related agricultural threats, local fires, recreation and tourism. The most sensitive ones to these threats are stenotopic species, the populations of which are characterized by weak adaptive properties, high sensitivity to any change in the habitat or the surrounding areas, slow regeneration after stress and implementation of life strategy in a stable environment (14).

There is a general trend in many parts of Ukraine towards a decrease in the humidity of ecosystems due to prolonged drought, draining of marshes and other wetlands, amelioration of wetlands and their subsequent use for agricultural purposes. As a result, we observe irreversible damage to the ecological balance of ecosystems and depletion in the populations of many medicinal ferns, such as *Adiantum capillus-veneris, Marsilea quadrifolia, Pil-*

ularia globulifera, Thelypteris palustris and others (Table 1). Further dehumidification of ecosystems threatens their survival. The majority of fern habitats are a fragmented and isolated as a consequence of human activity such as livestock grazing and pastures burning, recreation and tourism because plants cannot cope with the trampling, grazing and waste from stock.

Cutting of forest and unfavorable forest management are further dangers for most of the ferns growing under the canopy of trees, such as *Asplenium adiantum-nigrum*, *A. scolopendrium* L., *Blechnum spicant* (L.) Roth, *Gymnocarpium dryopteris* (L.) Newman, *Onoclea struthiopteris*, *Oreopteris limbosperma* (Bellardi & All.) Holub, *Ophioglossum vulgatum* L. The restoration of populations of these species may last a very long time. There is no information available on current population trends for these species, but the populations are likely to be declining and fragmented following the general trend of destruction and degradation of shallow wetland and forest habitats. In addition to the loss of habitats, overcollection of plants is a significant threat to some rare wild ferns. Many ferns of Ukraine are non-harvest plants, but some of them are used for landscape gardening that may be indicated as a potential risk of extinction.

The state of the majority of the studied medicinal ferns populations is threatened, as they have limited distribution and populations often are represented by isolated individuals and the resources are meager (see Table 1). Thus, harvesting of raw material from the natural environment poses a real threat of extinction.

Analysis of the data on the medicinal effect of biologically active compounds identified in the analyzed ferns showed a wide range of their properties. More than 80% of the ferns have anti-inflammatory, laxative, lactogenic, anthelmintic, diuretic, expectorant, anesthetic, antioxidant and hepatoprotective properties (Table 1). Most of the analyzed ferns (64.1%) have been studied and found to be useful with their anti-inflammatory effect on the stomach and intestines, and their anthelmintic, astringent or light laxative effects. The most famous among them are *Onoclea struthiopteris*, *Polypodium vulgare*, *Pteridium aquilinum* and some others. Concerning diseases of the respiratory system (including using them as an expectorant and antipyretic agent), it is known that nearly 45% of the analyzed fern species are used, indicating a vastly researched knowledge about medicinal ferns, which are used to treat respiratory problems. The information about the pharmacological properties or medicinal use of six species (*Asplenium fontanum* (L.) Bernh., *Azolla mexicana* C. Presl, *Cheilanthes acrostica* (Balb.) Tod., *Dryopteris caucasica* (A. Braun) Fraser-Jenk.& Corley, *Dryopteris villarii* (Bellardi) Woyn.ex Schinz & Thell., *Oreopteris limbosperma* (Bellardi & All.) Holun and *Pilularia globulifera* L.) is insignificant to indeterminate, however, the main biologically active ingredients were investigated.

The results of the present study demonstrate that these ferns are not as important medicinally as vascular plants in Ukraine, but have considerable importance as obligate components in most of forest systems. Many of them need protection due to irreversible changes in their habitat. The featured table shows the common characteristics of wild medicinal ferns of Ukraine.

CONCLUSION

The use of ferns in Ukraine for their medicinal and other economic value, including ornamental use, is limited, but at the same time, the population densities of many species have decreased primarily due to deforestation and disturbance of habitats. Further research is needed to gather information about the population size, threats and trend of these species throughout their range. Therefore, a significant effort should be taken for the conservation of the species, which are highly sensitive to any change in the habitat. If the protection measures are followed strictly, further studies on ferns as perspective potential for pharmaceuticals could bring many more medicinal benefits.

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