J. Plant Develop.
24(2017): 117-131

THREATENED MEDICINAL PLANTS OF UKRAINE: AN ASSESSMENT OF THE CURRENT PROTECTION STATUS

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Abstract: More than 2 200 vascular species of Ukraine were investigated as medicinal plants, containing biologically active substances which are used at present or can be used in the future for medicinal purposes, including production of commercial drugs. 1 975 from this number are wild plants and 537 are threatened in Ukraine and/or in Europe. For many medicinal plant currently highly threatened by direct or indirect human activities, which lead to transformation and loss of habitat. The overall purpose of the paper is to show the threats, current population trend and protection status of threatened species of medicinal plants. It has been established that the future of wild resource more than half (52%) of analyzed medicinal plants in Ukraine is at risk as are currently highly threatened the loss of its habitat. The current population trend of these species is mainly declining on assessment to Ukraine. The population trend near of 43.5% accessed species considered as stable. The state of only 3.7% of analyzed medicinal plants in Ukraine may be assessed as increasing.

Keywords: threatened medicinal plants, Ukraine, population trend.

Introduction

Ukraine is characterized by a considerable diversity of plants species because its location in different natural zones. There are more than 6 000 species of vascular plants in Ukraine (native, naturalized, occasionally introduced, and most common cultivated taxa) [MOSYAKIN & FEDORONCHUK, 1999]; more than 2 200 species were investigated to some extent as medicinal plants containing biologically active substances which are used at present or can be used in the future for medicinal purposes, including production of commercial drugs [MINARCHENKO, 2005, 2011]. About 10% of these (244 species, according to our estimates) are cultivated and introduced plants, while the remaining taxa are native or naturalized species growing in the wild. Among 1975 species of wild medicinal plants of Ukraine, 537 species are officially considered as threatened in Ukraine and/or at the European level [IUCN, 2015].

The *State Pharmacopoeia of Ukraine* (*SPU*) provides information on raw or processed products of 197 species of medicinal plants and lichens from 97 genus. Among them, 90 species are wild plants, including 16 taxa both: wild and cultivated (occurring in natural communities and also cultivated to obtain raw materials, or imported from other countries); 35 species are present in Ukraine only as cultivated plants. *SPU* also lists 72 species of medicinal plants, raw materials or substances of which are imported to Ukraine from other countries.

Ukrainian folk medicine uses raw materials of about 1 000 species of plants, more than 80% of which are wild-growing ones. Many of them have limited distribution and scarce resources, and thus are in need of various protection or conservation actions. Under the

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present-day anthropic influence, populations of many species are shrinking (both in terms of the area of occupancy and numbers of individual plants), and quite often such populations degrade to the level when they are not able anymore to restore or reproduce normally.

Harvesting amounts of wild medicinal plants is regulated by executive governmental authorities at the local and state levels. The Ukrainian legal system of environmental protection and management includes laws, by-laws and other regulatory documents which regulate the specific types of activities in the field of the sustainable use and conservation of plants [MINARCHENKO, 2011].

The present article summarizes the results of our analysis of selected wild-growing medicinal plants of Ukraine, which are listed in the IUCN Red List of Threatened Species (version 3.1) and some species with the national protection status in Ukraine, especially those listed in the *Red Data Book of Ukraine* [DIDUKH, 2009]. This article focuses on the analysis of the causes and factors leading to degradation of populations of medicinal plants, as well as pathways of their conservation and restoration.

The conservation status and current population trend of analyzed species on European regional level was assessed using the IUCN Red List Categories and Criteria (IUCN 2015-4 (http://www.iucnredlist.org/). A wide range of literature and other sources were reviewed and consulted to identify endangered medicinal plants of Ukraine and their present conservation status.

Results and discussion

Among 537 analyzed the threatened wild medicinal vascular plants, to 477 species assigned some protection status (including Data Deficient) at the European level (on regional or/and global assessment), according to data of the European Red List of Threatened Species (IUCN 3.1). Three of them belong to the category Endangered (EN), five are Vulnerable (VU), 11 – Near Threatened (NT), 434 – Least Concern (LC), and 24 – Data Deficient (DD), however only 61 species from this number are protected at the state (national) level and included in the Red Data Book of Ukraine [DIDUKH, 2009]. Further 141 species of medicinal plants have protection status as regionally rare in Ukraine.

Furthermore, 63 species of medicinal plant are considered as threatened only for Ukraine and absent in the IUCN Red List, because of insufficient data available to assess these taxa against the IUCN Red List criteria. Their populations threatened by depletion in Ukraine as a result of the negative impact of complex natural and anthropogenic factors. They are few in number and mostly present in a few localities each. It is our belief that if a taxon is more threatened in Ukraine as in the whole of Europe (it has a higher conservation category in Ukraine than in the European Red List), its populations must still be regarded as important components for protection with appropriate conservation measures in Ukraine.

Threatened species of medicinal plants listed on the European Red List of Threatened Species

Only three species are endangered on a global, regional or both levels: *Daphne sophia*, *Aldrovanda vesiculosa* and *Neottianthe cucullata.*

Daphne sophia (EN) is restricted endemic to the Central Russian Upland, including Russia and Ukraine. Area of occupancy of *Daphne sophia* is severely fragmented, estimated

to be less than 500 Km^2; area, extent and quality of habitat continuing decline, therefore the state of this plant species was estimated as endangered on regional and global levels [MELNYK, 2013].

Detailed investigations of biologically active substances of this species are unknown, but there is information that the plant of *Daphne sophia* contain coumarins and catechins, which have antibacterial and anti-tumor activity. For medical purposes in Ukraine this species is unused.

There are known only four localities in Ukraine and in the Red Book is listed as Endangered [DIDUKH, 2009]. The populations are very small, the number of individual are 175 shoots near Ochrimivka village, 770 shoots near Mala Vovcha village, 600 shoots near Zovtneve Druge and 1,500 shoots near Kolodjazne village in Kharkiv Region. The main threat to the habitats is changes of ecotopes due to exploitation felling, forest planting on slopes, and chalk mining. An important threat to *Daphne sophia* is also harvesting of flowering shoots for bouquets.

Aldrovanda vesiculosa is assessed at the European level as Endangered B2ab (iii, v), since there is evidence of its disappearance in many countries [CROSS, 2012] due to irreversible changes in the environment. To assess the status of *Aldrovanda vesiculosa* at the global level, it is have been not enough specific data on localities and population dynamics in time, so now it was assessed as Data Deficient at the moment with an urgent need for further research [BILZ & LANSDOWN, 2013].

The data about its use for medical purposes are not available, but it is known that *Aldrovanda vesiculosa* contains carotenoids and naphthoquinones [MINARCHENKO, 2005]. In Ukraine *Aldrovanda vesiculosa* is listed in the Red Data Book as a rare species with a disjunctive spread in freshwater flat territory [DIDUKH, 2009].There are more than 20 confirmed localities of this species mainly in the catchment areas of the rivers Pripyat, Dnieper, and Danube. In general, the state of its population can be characterized as digressive, although the number of individuals of different populations can change dramatically within a few years, depending mainly on the water temperature. The main threats to *Aldrovanda vesiculosa* in Ukraine are the draining of wetlands and water pollution from agriculture (fertilizers, herbicides, wastewaters, etc.).

Neottianthe cucullata has been listed as Endangered on the European Red List according to European regional assessment and EU 27 regional assessment [RANKOU, 2011]. It is a Eurasian species with the total range from the Baltic to Japan, with quite numerous populations in Russia. *N. cucullata* is included to herbal drugs of a traditional Chinese medicine for treating a post-hepatitis syndrome. It is not used, however, in officinal and traditional medicine of Ukraine.

In Ukraine *Neottianthe cucullata* occurs at the southern limits of its total range. Populations of its are few in number and have a pronounced tendency to decrease due to anthropogenic transformation of habitats, primarily wetland drainage, general ecosystem dehumidification, habitat fragmentation, and livestock grazing. It is found only in a few localities in Kiev Region. Therefore, this species is listed as endangered at the national level and included in the Red Data Book of Ukraine [DIDUKH, 2009]. It is known that the trend of its population is decreasing throughout its range due to numerous threats, especially woodland management, causing an increase in the amount of light reaching the forest floor, the use of heavy machinery in forestry operation, and weather conditions [IUCN, 2015].

At the pan Europe level, the status of five species of medicinal plants was identified as Vulnerable: *Chimaphila umbellata*, *Dianthus hypanicus*, *Moehringia hypanica*, *Crambe*

aspera and *Onosma polyphylla.* The current population trend this species is mainly decreasing on assessment to Ukraine due to narrow ecologo-coenotic amplitude and low adaptive properties to a destruction of the ecological balance of the environment.

Chimaphila umbellata have different protection rank in separate countries of Europe [ALLEN & al. 2014]. It is not enough use from wildlife for medicine or pharmacy, but the population of this species is strongly fragmented, have the weak adaptive properties and high sensitivity to changes of the ecological balance of their habitat, which are the main threats to their exhaustion. The population has declined sharply in many countries and on a set of IUCN criteria at the European level currently this species is categorized as Vulnerable A2ac [CHADBURN, 2014].

Chimaphila umbellata in Ukraine grows on the southern boundary of the spread. Therefore, its populations are fragmented, small and few in numbers. The main regions of its distribution are Polissya and Carpathians. Sporadically occur in the forest-steppe and the Crimea. Due to the scattered nature of populations of *Chimaphila umbellata* in Ukraine, there are potential future threats, but these are not considered significant at present. However, a tendency to reduce the number of individuals and populations in all regions as a result of the economic use of forests was identified, so this species is under regional protection in all areas. *Chimaphila umbellata* belongs to the list of species that are not listed in the Red Book of Ukraine, but are permanently or temporarily endangered at the territory of different regions (oblasts) and in the near future can be classified as "endangered" if will be extended the effect of negative factors.

The main biological substances of wintergreen are: flavonoids (quercetin, kaempferol, dihydroquercetin, avikulyarin and giperin), phenolic glycosides, triterpenoids and steroids which have anti-inflammatory effect mainly on organs of the urogenital system. With medical purpose is mainly used in homeopathy and traditional medicine of many countries. The wild plants of *Chimaphila umbellata* for medicinal purposes in Ukraine are used in very rare cases. In order to give a better understanding of its possibility of rehabilitation the further studies of biology, population structure and threats is needed.

Moehringia hypanica is endemic to the Ukraine where it is restricted to the southern part of the Pridnjeprovian upland in the Mykolaiv region. Mostly it grows in the clefts of the rocks on the northern slopes along the rivers. Only five localities are known in a restricted area of the canyons of the Yuzhniy Bug and Mertvovod rivers [DIDUCH, 2009]. This species is listed under Appendix I of the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention), the IUCN Red list of threatened species as Vulnerable D2 [MELNYK, 2013].

The populations are very small with a low number of individuals (50-300 individuals in local populations). It therefore assumed that the whole population counts less than 1,000 individuals and the species is therefore assessed as Vulnerable. *Moehringia hypanica* is included in the Red Book of Ukraine (2009) as Rare narrow local endemic and is protected in the National Nature park "Buskij Gard" and in the protected natural boundary (landmark) "Labirint" (Mykolaivska oblast).

Populations of *M. hypanica* characterized by narrow ecological range, are sensitive to reduce of the moisture of substrate and illumination. *M. hypanica* usually grow in the cracks of granite rocks with a small amount of soil. In dry years a sharp decline in the number of individuals of different age groups, especially on the slopes of the south-eastern exposure was revealed [SOLOMACHA & al. 2006]. Therefore, the prolonged absence of rainfall and high temperatures in summer often lead to die of plants. The main threat is changes of

ecological conditions of habitats; consequently, the current population trend is decreasing. Information about the possibility of cultivation of this species is absent. The state of populations is worsens, therefore continuous monitoring of the number of plants in some localities and control of threats are carried out.

Dianthus hypanicus is a South-Bug endemic, adapted to the growth on granite outcrops and rocks. It is common in the southern part of the Dnieper Upland (the area between the Southern Bug and Ingul).

This species is listed under Appendix I of the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention), the IUCN Red list of threatened species as vulnerable D2 with stable current population trend [MELNYK, 2013], in the Red Data Book of Ukraine [DIDUCH, 2009] as Vulnerable narrow local endemic. In Ukraine is protected in the National Nature Park "Buskij Gard" and at the protected areas of local significance in the Kirovograd and Mykolaiv regions.

The main habitats of *Dianthus hypanicus* are granite and gneiss outcrops, crack rocks (composed of rock plant communities). It is known the local populations where individuals density is near of 60 units per 100 sqm [BARMAK, 2006]. The reducing the number of habitats for this species is due to the construction of hydraulic structures, granite quarrying (mining), range firing, collecting plants for ornamental purposes (collection of flowers and digging of plants) and recreation.

Dianthus hypanicus successfully introduced and it is grown in many botanical gardens of Ukraine and domesticated for decorative purposes by people; under conditions *ex situ* the plants are better blossom and fructify than in the wild [GONCHARUK, 2014]. There are no known information about medicinal use of this species but it potentially can be used as source of saponines [MINARCHENKO, 2005].

The species has no known widespread threats at present, although many researchers [SOLOMACHA & al. 2006; BARMAK, 2006; DIDUCH, 2009; MELNYK, 2013] express some concerns about possible population decrease due to economic, tourism, recreational activities and collection plants from the wild. Its protection is not very secure at the moment and the loss of the protection status could may to lead to a rapid decline number of populations. In Ukraine, there is a successful experience of the reintroduction of this species in nature, so there is hope that it will manage to keep.

Crambe aspera has been assessed as Vulnerable (B2ab (ii, iii, iv) in the European Red List of Threatened Species according to European regional assessment [SMEKALOVA & al. 2013]. It does not occur within the EU 27.

It is an Eurasian species with disjunctive area. In Ukraine is listed in the Red Book as Vulnerable with sporadic distribution in the forest-steppe and steppe zone, including on the Crimean peninsula. It is found in Chersonska, Donecka, Dnipropetrovska, Kharkivska, Luganska, Odeska, Vinnicka regions and in Crimea. There are known more than 20 confirmed localities of *Crambe aspera* with low number (low numerically) of individuals at the territory of Ukraine [DIDUCH, 2009]. The data on population structure of this species is missing; the plants were found single or in separate groups. It may be ultimately affect to their genetic diversity and reduce their viability.

There is a little documented data of medicinal or other use for this species, only known that it contains vitamins, flavonoids and fatty oil [MINARCHENKO, 2005). This species have else potentially value as wild crop relatives. Overall in Ukraine there is a trend decline of populations due to anthropogenic alteration (agriculture, fires of grazing) and

fragmentation of *Crambe aspera* habitats. There is need to establish the current protection range and population status by monitoring and quantify. Order to determine the status of protection of *Crambe aspera* is needed the further study of stress-adaptive properties, the possibility of introduction and reintroduction.

Onosma polyphylla is a Crimeo-Caucasian endemic, the main habitats of which associate with petrophyte communities in the Crimean Mountains [DIDUCH, 2009]. It is listed under Appendix I of the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention). The species is classed as Vulnerable B1ab (iii) on European regional assessment and as Not Evaluated on EU 27 regional assessment (http://www.iucnredlist.org/details/165240/1).

In Ukraine listed in the Red Book as Vulnerable with sporadic distribution [DIDUCH, 2009].The increased intensive tourism and recreation may be a threat to its habitats.

In Ukraine are known four species of medicinal plants of the genus *Onosma*, two of which, including *Onosma polyphylla,* was found only in the Crimea. There is little published data on the medicinal properties and use in medicine these plants. It is only known that the main biological active ingredients of these species are naphthoquinones.

The main habitats of this species are confined to a particular spot on rocky slopes and rubbly talus with weakly developed grass cover. Now the clearly estimated threats for this species are not identified. The structure of the populations, the main current threats, as well as the possibility of the introduction have been poorly investigated. To clarify the protection status and the development of measures to restore this species in nature the further monitoring research is necessary.

Conservation status Near Threatened (NT) on both the European and EU 27 levels has nine medicinal plants of Ukraine: *Cypripedium calceolus*, *Drosera anglica*, *Drosera intermedia*, *Galanthus nivalis*, *Gypsophila perfoliata*, *Helichrysum arenarium*, *Iris sibirica*, *Trapa natans* and *Marrubium vulgare*. *Aster amellus* listed as Near Threatened according to data of EU 27 regional assessment and as Least Concern on European regional assessment. *Himantoglossum caprinum* is considered Near Threatened and in the EU27 member states is assessed as Data Deficient for the European regional assessment [RANKOU, 2011].

This species have different extinction risk; differ in distribution and their potential for adaptation to changing environmental conditions. However, most of them have weak adaptive abilities. These species mostly are associated with the specific conditions of habitat, disturbance of the ecological balance of which can lead to oppression and death of populations. So, the threat of depletion, considering the negative impact of various outside limiting factors, is rather high. Differences between species in such characteristics can be used to develop the measures of their protection.

The use of these species as a medicinal plant for most of these are little, but some of them have high decorative properties and people collect them for bouquets or digging for planting flower beds and gardens.

Cypripedium calceolus are included under the IUCN Red List of Threatened Species as Near Threatened on the European and EU 27 regional assessment [BILZ, 2013]. It listed in Annex B of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES). It is also listed on Annex II of the Habitats Directive and under Appendix I of the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention). This orchid is included in several national red lists as threatened.

The main threat to this species is collecting which led to major declines in the past and inappropriate forest management, but the current populations trend is assessed as stable.

Cypripedium calceolus belongs to the rare plants of Ukraine, having a considerable distribution at the main part of territory. This orchid is included in national Red Book as vulnerable [DIDUCH, 2009]. It has been well studied as a medicinal plant [MINARCHENKO, 2005], but it is more popular as an ornamental and it is a real threat to the populations of *C. calceolus* in the future, although collection plants are forbidden now by law.

There are known more than 50 sites localized mostly in the north-western regions and the Crimea. Number of individuals are very variable, from a few dozen up to a few hundreds.

The populations are commonly fragmented, sharply declines throughout its range as a result of anthropogenic transformation habitats and little control on the collection of plants for ornamental purposes. The species grows often as separate groups and the populations are decreasing in many locations. The rate of the decline has not been investigated at the whole territory, but many location have not been confirmed in the last decades [DMYTRASH & SHUMSKA, 2014; KUZMISHYNA & al. 2014]. However, it have been revealed some new localities for the species [DAVYDOV & al. 2014; MELNYK & LOGVYNENKO, 2013; TOKARYUK & CHORNEJ, 2009].

It has been introduced in many botanical gardens in Ukraine. Currently management of habitats and population monitoring is carried out.

Three species of genus *Drosera* spp., growing in Ukraine, there are known as medicinal plants: *Drosera anglica*, *Drosera intermedia* and *Drosera rotundifolia* [MINARCHENKO, 2005]. The first two species listed in the Red Book of Ukraine as Vulnerable; according to European regional assessment and EU 27 regional assessment as Near Threatened. *Drosera rotundifolia* has status as a regional protected species and it is classified as Least Concern in the IUCN Red List Threatened Species (Regional assessment) [KHELA, 2012].

This species has been shown by scientific research that is effective when used as an anti-inflammatory drug for the treatment of ailments involving the throat or chest [MINARCHENKO, 2005]. The most common usage of the plants is as a component of the complex homeopatic drugs for the treatment of bronchopulmonary diseases. The collection of wild species of genus *Drosera* for medicinal or other purposes is forbidden by law in Ukraine.

It have very narrow ecological amplitude and increased anthropopressure (mostly wetland amelioration) to the habitat of these species is a serious threat to their existence around the area, all of them are under the legal protection in many countries [KHELA, 2012].

The population data indicate that the populations of *Drosera anglica*, *Drosera intermedia* and *Drosera rotundifolia* are large at the Ukrainian Polissya, on the decline, due to changes in land management. The existing threats, especially dehumification of habitats, may cause the decline of species' populations to severely decline in the near future. Negative trends have been observed for their habitat and number of individuals in populations. However, the further research, conservation measures and monitoring are necessary.

Galanthus nivalis has been estimated as Near Threatened, Vulnerable or even Critically Endangered in several European countries and is included on nearly every country's Red Lists, including Ukraine. A rank of Near Threatened at the global level is suggested here due to all the above factors threatening the population as a whole, and the possibility of *G. nivalis* qualifying for a threat category in the near future (VU A3cd) [CROOK & DAVIS,

2013]. It is listed under Appendix II of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES), under Annex B of the EU Wildlife Trade Regulation 318-2008 and on Annex V of the EC Habitats Directive 92/43.

Biologically active compounds of *G. nivalis* were studied enough, but the use in medicine is limited by the toxicity of compounds [MINARCHENKO, 2005]. The plant is very popular, primarily, due to its decorative properties. Major threats for this species are illegal collection of plants for decorative purposes, habitat loss due to forestry measures, infringement of the ecological balance of the habitats as a result of agricultural activities (soil eutrophication), as well as tourism.

In Ukraine, this species is a significant spread over most of the territory. The number of individuals in the populations is high, but there is a tendency of reduction of number of flowering individuals as a result of picking its flowers for bouquets, digging out bulbs and habitat destruction [DIDUCH, 2009]. The plant was successfully introduced in many botanical gardens and nature reserves. Further measures for the protection and repatriation of species in natural habitats are necessary.

Gypsophila perfoliata is considered to be Near Threatened in the EU27 and Europe as a whole [CHADBURN, 2014]. Several research have of the opinion that further surveys are needed to confirm the current area of occupancy and monitoring is necessary to detect and enumerate declines or indeed any extension of range, if the spread of this species is enabled by man-made communication corridors in the form of railway line habitat [ALLEN & al. 2014].

In Ukraine this species occurs sporadically along the coast of the Black and Azov Seas. There are typical littoral species, occupying the halophytic-meadow ecotops. It is considered as an adventive species of a technogenic ecotopes [GLUKHOV & al. 2012]. The structure and state of its populations have been little studied. The threats to this species are unknown currently and there are no conservation measures in place.

Further research is needed to give a better understanding of its biology, regenerative capacity, population dynamics, threats and adaptation to changing environmental conditions. Further surveys are needed to establish the current population size of this species and monitoring is needed to detect and enumerate declines. Such information may help to establish a need for protection early on.

Helichrysum arenarium listed on the IUCN Red List of Threatened species as Near Threatened approaching criterion A2cd on both the European and EU 27 levels due to although widespread across Europe, it is widely collected and in many places is considered as rare and threatened plant [KHELA, 2013]. However, it is observed that more specific information on the current population size, trend and the overall rate of decline is needed, especially from countries in Eastern Europe, to verify whether the species needs to be included in a higher threat category.

Helichrysum arenarium has a large area of occupancy in Ukraine, occurs in a wide range of habitats and the populations are assumed to be more or less stable in whole. Its natural resources are large. A few tons of raw materials (inflorescence) for pharmaceutical purposes are harvested every year. Managements the volume of harvesting wild plants is carried out at the local (regional) level by setting limits. The limits are set on the basis of the resource assessment in each area. In addition, this medicinal plant is cultivated in plant-specialty agricultural community. It is known some of cultivars with a high content of biologically active compounds. The threats to this species are unknown, but in Ternopilska and Odeska oblast it listed in some regional Red Lists.

There has been a slight increase of the resources of this species at Polissya in recent decades due to an exclusion of sandy arable fields from the agricultural use. Some subpopulations cover an area of tens hectares with an estimated coverage through to 10%. The trend and the overall rate of decline are unavowed at present time. Further research may to verify whether needs to be included in define a threatened category this species.

It is an old medicinal herb used mainly to treat of digestive system, biliary dyskinesia and other liver diseases. There are known nine pharmaceuticals drugs from the *H. arenarium* in Ukraine (State register of Medicinal Products of Ukraine).

Iris sibirica is classified on both EU27 and Europe levels as Near Threatened approaching criteria A2ce due, as it could likely have declined in many countries across its range [KHELA, 2013].

In Ukraine, the protection status of *Iris sibirica* is estimated as Vulnerable and it include in the Red Book as a rare species resided on the southern border of area [DIDUCH, 2009]. It has a significant distribution mainly in the northern and north-western part of the territory. The overall population decline has not been quantified, but the reduction of the area of local populations and reducing the number of generative individuals in many localities was noted [PODOROJNY, 2013].

This species is threatened by habitat loss and degradation caused by wetland amelioration, habitat transformation and fragmentation, pasture load and wild plant collection. Although it is protected on state level in Ukraine, it is facing many threats and is decreasing across much of its range. The rehabilitation of its habitat is highly unlikely. Furthermore, the species has highly fragmented distribution, it is therefore necessary to collect the detailed data about structure and dynamic of population from each locality for development of protection measures.

This is an ornamental and medicinal plant, but there is few information on its use [MINARCHENKO, 2005]. *Iris sibirica* have been successfully introduced in many botanical gardens of Ukraine, which allows to make an estimate of possibilities of its repatriation (reintroduction) in protected areas.

Trapa natans listed as Near Threatened according to data of EU 27 and European regional assessment due to declining everywhere throughout its range [LANSDOWN, 2013]. *Trapa natans* is included under Appendix I of the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention).

It is considered as Uncertain on the Red Book of Ukraine. There are known many locations of this species on the plain territory of Ukraine, but many of them are not supported by the latest studies. In separate water bodies it forms large populations at an area of several hectares with a number of individuals 1,5-2,5 thousand per 100 m^2 [DIDUCH, 2009]. The major treats to the populations of *Trapa natans* in Ukraine are: wetland amelioration, habitat transformation (especially industrial and agriculture pollution of waterbodies). It has been lost from many sites in the Ukraine through habitat loss due to contamination of water bodies.

The data about its use for medical purposes is little, but seeds have a high nutritional value [MINARCHENKO, 2005]. Successfully propagated in a culture, it has been introduced in many botanical gardens and protected in the reserves.

Marrubium vulgare is listed as Near Threatened approaching criteria A2cd on EU 27 and European regional assessment, because it is showing strong declines in at least a quarter of its European range, due primarily to changes in land use practices in the agricultural and pastoral sectors [KHELA, 2013].

In Ukraine, this species is sporadically distributed throughout the flat territory, but its natural resources are negligible due to of the use of its habitats for agricultural purposes (plowing land and pastures). Therefore *M. vulgare* was successfully domesticated and now the selective breeding programs are developed. This plant is in extensive cultivation in home plots as an aromatic plant.

The species is harvested as an aromatic plant and for medicinal purposes. It has been well studied as a medicinal plant, however it is a mild remedy that is little used in modern medicine (phytotherapy), but it is sometimes employed by traditional medicine in treating of the chronic bronchitis [MINARCHENKO, 2005]. Also used in homeopathy.

It is not protected in Ukraine and currently does not face any major threats. The most effective measure to protect it can be cultivation and reintroduction into natural habitats.

Aster amellus has a wide distribution in Forest-Steppe some of Ukraine, but the area of suitable habitat is limited due to use it on agriculture purposes (mostly as grazing) and today the species has become rarer. It is not included on the Ukrainian Red Book, but is under regional protection in some oblasts, as the number of sites where is found is decreasing and the number of individuals are decline over the last decades.

Aster amellus classed as Near Threatened according to data of EU 27 regional assessment and as Least Concern on European regional assessment [KHELA, 2013]. Across Europe, *Aster amellus* is assessed as Least Concern as it occupies a wider range of habitats and there are few documented declines across its southeastern and eastern range. This species has been listed on many national red lists in Europe, but protection rank is differ in separate countries.

The loss of habitats is a significant threat to this species; the lesser danger is the wild collection of plants for ornamental and medicinal purposes. In order to estimate the trend and rate of decline of populations in Ukraine there is a need for further information on the threats to population in the concrete localities. More studies are needed to monitor the decline of the *Aster amellus* on the central regions of Ukraine.

Himantoglossum caprinum is classed as Near Threatened according to data of EU 27 regional assessment and as Data Deficient on European regional assessment [RANKOU, 2011]. It is also listed on Appendix I of the Convention on the Conservation of European Wildlife and Natural Habitats (Bern Convention); on Annex II of the Habitats Directive. All orchids are included under Annex B of the Convention on International Trade in Endangered Species of Wild Fauna and Flora (CITES).

In Ukraine the *H. caprinum* is considered as Vulnerable and listed in Red Book [DIDUCH, 2009]. It is endemic species, occasionally founded in Mountain Crimea and the southern coast of Crimea. The main threats are: afforestation and forestry maintenance, habitat dehumidification and fragmentation, recreation, tourism and collection. The underground part of the plant (bulbs) are harvested to prepare salep.

In a protected area the number of individuals and populations increase, so under the conditions of protection the population is stable, but there is an overall decline. The further monitoring and repatriation in ecologically optimal habitats are necessary.

Besides the groups of threatened species described above, the largest number of species (81%) has the status Least Concern. This species are characterized by different distribution in Ukraine, threats and adaptation possibilities to change of environment. Therefore, they have different protection status. For example, *Colchicum autumnale*, *Dictamnus albus*, *Gentiana punctata* s.l., *Gladiolus italicus*, *Leucojum vernum*, *Lilium martagon*, *Narcissus poeticus*, *Pulsatilla pratensis* are suffer through excessive use as

ornamental plants as well as through a violation of the environment. To *Adonis vernalis*, *Allium ursinum*, *Glycyrrhiza glabra*, *Rhodiola rosea*, *Scopolia carniolica* the collection for medicinal purposes and habitat destruction are threatens. A raw materials of many species, as *Betula humilis*, *Dactylorhiza incarnata*, *Huperzia selago*, *Nymphoides peltata*, *Iris sibirica* almost never used for medicinal purposes but the violations of ecological balance of their habitat leads to irreversible changes in the structure of populations, depression of resources and their gradual loss. The populations of all listed above species are decreasing in Ukraine and it are included in the Red Data Book [DIDUCH, 2009].

Some of the medicinal plants from the category LC are protected in Ukraine at the regional level, since their resources in certain areas or throughout are limited. For example, *Arctostaphylos uva-ursi*, *Centaurium erythraea*, *Centaurium pulchellum*, *Digitalis grandiflora*, *Ephedra distachya*, *Helleborus purpurascens*, *Lycopodium clavatum*, *Veronica officinalis* [Official …, 2012]. For these species a number of common features are peculiar: a small number of individuals in the population, negative reaction to the change of habitat, weak competitive and adaptive properties. Therefore, the harvesting of its resources can lead to a total depletion of resources and extinction. Some of them are protected only in certain areas (administrative units-oblast), where there is a threat of depletion of their populations, and in other regions they can be still harvested; for example, *Alnus incana*, *Convallaria majalis*, *Persicaria bistorta*, *Potentilla erecta*, *Sanguisorba officinalis*, *Vaccinium myrtillus*, *Veronica officinalis*, *Viburnum opulus* etc.

Several species from the category LC are popular medicinal herbs in Ukraine, their resources is large and raw materials for pharmaceutical purposes or phytotherapie used from environment. There are: *Alnus glutinosa*, *Artemisia absinthium*, *Bidens tripartita*, *Cichorium intybus*, *Equisetum arvense*, *Hypericum perforatum*, *Matricaria chamomilla*, *Mentha longifolia*, *Origanum vulgare*, *Plantago major*, *Symphytum officinale*, *Taraxacum officinale*, *Thymus serpyllum*, *Tussilago farfara* and others. The threats to their populations are small or not identified (unknown) and the current population trend are mostly stable**.** The use of resources shall be regulated by legislation at the local or national levels.

As a whole for most of the medicinal plants with the protection status Least Concern the current threats caused to reduction of population is undefined.

Special emphasis is known needs to be placed on Data Deficient species, especially as some are suspected to be in a critical state of decline at the national level in some parts of the EU and within pan Europe, but the lack of information from across the whole range or part of the range of these species meant that a threat category could not be assigned [ALLEN & al. 2014]. These species was recommended to further research across the region.

Among the analyzed medicinal plants only 23 species are assessed as Data Deficient. They have different protection status in Ukraine: nine species included in the Red Book, six are regionally rare; eight species there is insufficient data to determine it protected status. For example, *Paeonia tenuifolia* is considered as vulnerable due to steppe loss as the result of tilling, grazing and collecting for ornamental and medicinal purposes. This species, as has been founded, have a very high vulnerability to disturbance of habitats and low recoverability [DIDUCH, 2009].

Allium albidum, *Allium obliquum*, according to the data of Red Book, have been classified as endangered species; *Diplotaxis cretacea*, *Silene cretacea*, *Saxifraga hirculus*, *Prunus klokovii* – vulnerable; *Crambe koktebelica* – rare [DIDUCH, 2009]. *Hyssopus cretaceous* is classed as unknown due to the lack of reliable information that remains to be determined it protection status. Common characteristics of these species are their local or

limited distribution, weak adaptive capacity to change of the environment and lack of land for optimal growth and reproduction.

Glechoma hirsuta, *Beckmannia eruciformis*, *Crataegus pentagyna* are classified as Regional protected species due to their restricted range (distribution), but have stable populations and no major threats. The current population trend of *Iris pumila*, *Prunus fruticosa*, *Sisymbrium confertum* is decrease for a variety of reasons. *Iris pumila* has a widespread distribution; however it is vulnerable to collecting (digging) for landscape gardening, grazing, trampling and igniting of dry grass. The species are known to be endangered locally by habitat transformation and collection of the plant. *Prunus fruticosa* is sensitive to agricultural activities. *Sisymbrium confertum* has quite restricted distribution and is undergoing some local declines. Described above species are not considered to be of particularly important for medicinal use.

Lepidium syvaschicum, *Malus sylvestris*, *Potamogeton compresus*, *Pyrus elaeagrifolia*, *Rosa villosa*, *Rorippa brachycarpa*, *Vitex agnus-castus* are characterized as sporadically distributed species with stable trend of populations and the lack of known significant threats.

Armoracia macrocarpa is discribed in several countries as rare or very rare and is nationally threatened or Near Threatened throughout its range [STEVANOVIĆ & al. 2013]. It is currently assessed as Data Deficient on IUCN Red List due to the lack of reliable information that remains to be determined it protection status. The genus *Armoracia* is listed in Annex I of the International Treaty on Plant Genetic Resources for Food and Agriculture as part of the *Brassica* spp. complex and *A. macrocarpa* is listed in Annex I of the Convention on the conservation of European wildlife and natural habitats (Bern Convention). Currently it is unprotected at the state or regional level in Ukraine, as the data of its distribution, population structure and threats are being elaborated and an assessment is made.

In recent years, interest to *A. macrocarpa* significantly increased due to its rarity and reduction of habitats across human transformation of ecotopes and prospects for use in breeding practice as potential gene donor to cultivars.

Armoracia macrocarpa generally is rare throughout of the Ukrainian part of the valley of Danube - from the border (Reni district, Odessa region) to the sea. Most plants grow near streams or in their area of influence. It is known in the lower reaches of the Danube Kiliya it occurs in coastal areas of the islands. Also it is listed for Tisa river basin. The overall decline of *A. macrocarpa* at Ukrainian part of area is mainly attributed to secondary succession of grassland in the results of general ecosystem dehumidification; it is also threatened by afforestation, abandonment of livestock grazing on pastures and agricultural use of the habitat.

Proposals for inclusion of this species in the next edition of the Red Book of Ukraine are developed and monitoring of populations in the wild is carried out.

Threatened species of medicinal plants listed on Red Data Book of Ukraine

Red Data Book of Ukraine is the main state document that generalizes the current state of rare and endangered species under which development of scientific and practical measures for their protection, restoration and sustainable use is done. The harvesting of wild medicinal plant in Ukraine governed by national legislation and the collection of species listed in the Red Book of Ukraine and species under regional protection is prohibited.

There are 63 threatened species of medicinal plants in Ukraine, which are no listed in the IUCN Red List, but have national protection status in Ukraine and included in Red Book (2009). There are mainly relict species on the boundary of the spread or local endemics, its populations are highly fragmented and small with a few numbers of individuals. The factors, limiting their vitality are both natural (mainly weak adaptive properties) and various anthropogenic. The main threats to this species are habitats alteration (incl. dehumidification), fragmentation and loss, as well as forestry, pasture and other agricultural activities. Moreover, the illegal collecting of plants for ornamental or/and medicinal purposes is also one of the main threats for threatened species as *Astragalus dasyanthus*, *Campanula carpatica*, *Lycopodium annotinum*, *Crocus speciosus*, *Crocus banaticus*, *Daphne cneorum*, *Delphinium elatum*, *Gladiolus imbricatus*, *Pulsatilla pratensis*, *Salix myrtilloides*, *Tamarix gracilis*, *Tulipa schrenkii* and all species from family Orchidaceae, which are protected at the state level in Ukraine.

For many medicinal plant currently highly threatened by direct or indirect human activities, which lead to transformation and loss of habitat. It has been identified as the main causes of decline in medicinal plants populations. Any further significant impact of limiting factors listed above on populations of assessed plants lead to increase their stress levels and habitat loss therefore threatens their survival, according to the assessment.

The threats for 193 species, listed on European Red List, are not sufficiently important or unknown in order to assign of any protection category in Ukraine. The current trend of it population may be estimated mainly as a stable or increasing; for example: *Daucus carota*, *Equisetum arvense*, *Heracleum mantegazzianum*, *Lepidium ruderale*, *Papaver rhoeas*, *Persicaria maculosa*, *Rumex alpinus*, *Sambucus ebulus*, *Sambucus nigra*, *Urtica dioica*, *Verbascum densiflorum*, *Verbascum thapsus* and other. Many of them have large resources, which may be harvested from wild.

Among of analyzed threatened medicinal plants, more than half (281 sp., 52%) were assessed as having a decreasing population trend in Ukraine, whilst for Europe it is equivalent near to 20%. The population trend near of 44% Ukrainian species (234 sp.) considered as stable and it customary for 56% assessed species in Europe. The state of only 3.7% medicinal species of Ukraine may be assessed as increasing.

Conclusions

Most of medicinal plants, which are listed in the IUCN Red List of Threatened Species (version 3.1), have limited distribution and resources in Ukraine. Their populations are decreased, fragmented and depleted as a result of irreversible changes of its habitat. The population trend near 44% accessed species considered as stable. Many of them are widespread species, their populations are not very sensitive to changes of the ecological balance of their habitats, and therefore, threats to their loss have not been identified at present. The state only of 3.7% of medicinal plants populations, accessed as threatened on Global and/or European level, was estimated as increasing in Ukraine. Their resources are large and harvested, or, perhaps, will be use in future from wild.

Acknowledgments

Thanks are due to the Director of M. G. Cholodny Institute of Botany of National Academy of Science of Ukraine, Dr. Sergey L. MOSYAKIN for scientific consultations and encouragement.

References

ALLEN D., BILZ M., LEAMAN D. J., MILLER R. M., TIMOSHYNA A. & WINDOW J. 2014. *European Red List of Medicinal Plants*. Luxembourg: Publications Office of the European Union. Available at: http://cmsdata.iucn.org/downloads/iucn_european_red_list_of_medicinal_plants_web_1.pdf.

BARMAK I. M. 2006. Status of model populations of *Dianthus hypanicus* Andrz. (Caryophyllaceae) in Kirovograd region. *Ukrainian Botanical Journal*. **63**(5): 694-698 (in Ukraine with English abstract). Available at: http://nbuv.gov.ua/UJRN/UBJ_2006_63_5_11.

BILZ M. & LANSDOWN R. V. 2013. *Aldrovanda vesiculosa*. The IUCN Red List of Threatened Species 2013: e.T162346A5577046. Downloaded on 22 February 2016.

BILZ M. 2013. *Cypripedium calceolus*. The IUCN Red List of Threatened Species 2013: e.T162021A5532694. Downloaded on 11 March 2016.

CHADBURN H. 2014. *Chimaphila umbellata*. The IUCN Red List of Threatened Species 2014: e.T202955A2758231. Downloaded on 23 February 2016.

CROOK V. & DAVIS A. 2013. *Galanthus nivalis*. The IUCN Red List of Threatened Species 2013: e.T162168A5551773. http://dx.doi.org/10.2305/IUCN.UK.2011-1.RLTS.T162168A5551773.en. Downloaded on 17 March 2016.

CROSS A. 2012. *Aldrovanda vesiculosa*. The IUCN Red List of Threatened Species 2012:e.T162346A901031. http://dx.doi.org/10.2305/IUCN.UK.2012.RLTS.T162346A901031.en. Downloaded on 22 February 2016.

CHADBURN H. 2014. *Gypsophila perfoliata*. The IUCN Red List of Threatened Species 2014: e.T202973A2758339. Downloaded on 22 March 2016.

DAVYDOV D. A., DACIUK V. V. & VYNOKUROV D. S. 2014. New localities of rare plant species in Volyn region (Ukraine). *The Journal of V. N. Karazin Kharkiv National University*. Series: Biology. **20**(1100): 258-264 (in Ukraine with English abstract).

DIDUKH Y. P. (ed.) 2009. *Red Data Book of Ukraine. Flora*. Ukrainian Scientific Publishers, Kyiv, Ukraine, 900 pp. (in Ukraine).

DMYTRASH I. I. & SHUMSKA N. V. 2014. The demographic indexes dynamics of some *Orchidaceae* species populations at Halytsky National Natural Park. *Journal of V. N. Karazin Kharkiv National University*. Series: Biology. **20(**1100): 265-271.

GLUKHOV A. Z., KHARKHOTA A. I., PROKHOROV S. I. & AGUROVA I. V. 2014. Phytoadaptive typisation of technogenic ecotopes. *Industrial Botany*. Collection of scientific papers. Donetsk: Donetsk Botanical Garden of the National Academy of Sciences of Ukraine. **12**: 3-11 (in Ukraine with English abstract).

GONCHARUK L. L. 2014. Reproductive capacity *Dianthus hypanicus* Andrz. under conditions *in situ* and *ex situ* //Indigenous and introduced plants. **10**: 61-64. Available at: http://nbuv.gov.ua/UJRN/ atiru_2014_10_11.

KHELA S. 2012. *Drosera rotundifolia*. The IUCN Red List of Threatened Species 2012: e.T168798A1233285. Downloaded on 14 March 2016.

KHELA S. 2013. *Helichrysum arenarium*. The IUCN Red List of Threatened Species 2013: e.T201543A2708375. Downloaded on 21 March 2016.

KHELA S. 2013. *Aster amellus*. The IUCN Red List of Threatened Species 2013: e.T202938A2758129. Downloaded on 17 March 2016.

KHELA S. 2013. *Iris sibirica*. The IUCN Red List of Threatened Species 2013: e.T203236A2762502. Downloaded on 22 March 2016.

KHELA S. 2013. *Marrubium vulgare*. The IUCN Red List of Threatened Species 2013: e.T203247A2762568. Downloaded on 23 March 2016.

KUZMISHYNA I. I., KOTSUN L. A., VOJTYUK V. P., KOTSUN B. B. & LISOVSKAYA T. P. 2014. The Sozofity of Volyn Region Ukraine. *Nature West Polesie and adjacent areas*. **11**: 196-2001.

LANSDOWN R. 2013. *Trapa natans*. The IUCN Red List of Threatened Species 2013: e.T164153A5751867. Downloaded on 22 March 2016.

MELNYK V. I. & LOGVYNENKO I. P. 2013. Distribution and current status of populations of *Cypripedium calceolus* L. (Orchidaceae) in Volhynian Upland. *Ukr. Bot. J.* **70**(6): 788-791 (in Ukraine with English abstract).

MELNYK V. 2013. *Daphne sophia*. The IUCN Red List of Threatened Species 2013: e.T184432A8275763. http://dx.doi.org/10.2305/IUCN.UK.2011-1.RLTS.T184432A8275763.en. Downloaded on 23 February 2016.

MELNYK V. 2013. *Dianthus hypanicus*. The IUCN Red List of Threatened Species 2013: e.T165278A5999120. http://dx.doi.org/10.2305/IUCN.UK.2011-1.RLTS.T165278A5999120.en. Downloaded on 03 March 2016.

MELNYK V. 2013. *Moehringia hypanica*. The IUCN Red List of Threatened Species 2013: e.T165168A5985606. http://dx.doi.org/10.2305/IUCN.UK.2011-1.RLTS.T165168A5985606.en. Downloaded on 02 March 2016.

MINARCHENKO V. M. 2005. *Medycinal vascular plants of Ukraine* (*medicinal and resource values*). Ukrainian Scientific Publishers, Kyiv, Ukraine. 324 pp. (in Ukraine).

MINARCHENKO V. 2011. *Medicinal plants of Ukraine: diversity, resources, legislation*. Medicinal Plant Conservation Newsletter, vol. 14, February 2011.-P.7-13. Available at: http://cmsdata. iucn.org/downloads /mpc_14_1.pdf

MOSYAKIN S. L. & FEDORONCHUK M. M. 1999. *Vascular plants of Ukraine. A nomenclatural checklist.* Kiev: M. G. Kholodny Institute of Botany, 345 pp.

PODOROJNY D. S. 2013. Iris Siberian (*Iris sibirica* L.) in Ukraine (horolohiya, population, environmental protection and features coenotic): *Abstract. dis. PhD of Biol. Sciences*: 03.00.05. Kyiv. 20 ph. (in Ukraine with English abstract).

RANKOU H. 2011. *Himantoglossum caprinum*. The IUCN Red List of Threatened Species 2011: e.T162090A5533874. Downloaded on 17 March 2016.

RANKOU H. 2011. *Neottianthe cucullata*. The IUCN Red List of Threatened Species 2011: e.T175963A7155812. Downloaded on 23 February 2016.

SMEKALOVA T., MASLOVKY O. & MELNYK V. 2013. *Crambe aspera*. The IUCN Red List of Threatened Species 2013: e.T176428A7239400. Downloaded on 03 March 2016.

STEVANOVIĆ V., VÖRÖSVÁRY G., ELIÁŠ P. & STRAJERU S. 2013. *Armoracia macrocarpa*. The IUCN Red List of Threatened Species 2013: e.T165173A5986073. Available at: http://dx.doi.org/10.2305/IUCN.UK.2011-1.RLTS.T165173A5986073.en. Downloaded on 30 March 2016.

TOKARYUK A. I. & CHORNEJ I. I. 2009. State og populations *Cypripedium calceolus* L. (*Orchidaceae* Juss.) in Bucovina Prykarpatti. *J. Introduction plants*. **2**: 14-20. (in Ukraine with English abstract).

*** IUCN. 2015. *The IUCN Red List of Threatened Species*. Version 2015-4. Available at: www.iucnredlist.org. (Downloaded on 12 April 2016).

*** *Official lists of regionally rare plants of administration areas of Ukraine* (reference book). 2012. Compiled by ANDRIYENKO T. L. & PEREGRYM M. M. - Kyiv: Alterpres. 148 pp. (in Ukraine).

*** *State register of Medicinal Products of Ukraine*. (in Ukraine). Available at: http://www.drlz.com.ua/

How to cite this article:
MINARCHENKO V. M. 2017. Threatened medicinal plants of Ukraine: an assessment of the current protection status. *J. Plant Develop*. **24**: 117-131.

Received: **30 July 2017 / *Revised*: 24 November 2017 / *Accepted*: 29 November 2017**