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Original Article

CONSERVATION OF THE ENDANGERED FUNGI AND FUNGI-LIKE ORGANISMS IN UKRAINE

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ABSTRACT
In the paper the results of the long-term field observations on frequency of occurrence, distribution and real state of conservation of macro fungi in Ukraine are summarized. The data concerning the assign of macro fungi from the Red Book of Ukraine to certain Ukrainian biosphere and nature reserves and national nature parks are presented. Special attention is devoted to the influence of anthropogenic factors on macro fungi in the different types of vegetation. The modern trend in conservation of living beings directed on the widening of the protected organisms circle is reflected in proposals associated with the fungi-like myxomycetes.
KEYWORDS: fungi and fungi-like organisms in Ukraine, IUCN categories, Red Book of Ukraine.

INTRODUCTION

In today's world interest in nature conservation has strongly grown up concerning on protection of biodiversity and endangered species especially. The first serious information about the decrease of some macromycetous species in some nature ecosystems was promulgated at the 9th Congress of European Mycologists that was held in Norway, Oslo, 1985 (Arnolds, 1988). These data have promoted the establishment of special European Committee for Protection of Fungi. Later that Committee was reorganized in the European Council for Conservation of Fungi (ECCF). The ECCF has assumed the elaboration of the most important conservation aspects. Taking into account the experience of European field mycologists working on macromycetes the ECCF considered that it was necessary to concentrate the efforts on research of endangered macrofungi distribution and on observations for the state of its nature habitats (Arnolds, 2001). The first aspect was tightly connected with the mapping and the second one with the monitoring of macromycetous species belonging to the most threatened IUCN categories: critically endangered (CR), endangered (EN), vulnerable (VU) and of their ecological niches. According to ECCF strategy the results of above mentioned procedures had to be summarized in Red Data Lists or Red Data Books where, except of macromycetous species referring to CR, EN and VU categories, species of macrofungi from categories extinct (EX), extinct in the wild (EW), near threatened (NT), least concern (LC), data deficient (DD) and not evaluated (NE) should be included (IUCN, 2011). ECCF policy in relation of the information about the macromycetous species enumerated in the Red Data Lists or the Red Data Books was clearly denoted: to consider that document for any European country as a guide with all comprehensive data on taxonomy, distribution and ecology. In the ecological aspects of the document special attention was paid on the habitats of fungal species. The most perspective habitat for macromycetous species diversity, including the endangered ones, is

undisturbed primeval, virgin and old-growth forests. Some rare macrofungi are used as the indicators of those forest types (Parmasto, 2001). Grasslands, bogs, sandy soils, in particular sea dunes, have special significance in development and conservation of some unique macromycetous species. Therefore in the Red Data Books and Lists the descriptions of fungal habitats are presented with its characteristic features and notes concerning the range of disturbance.

The first European Red Data List that included 309 fungal species was published in East Germany (Benkert, 1982). Two years later the similar guide but with 1032 macromycetous species appeared in West Germany (Winterhoff, 1984). It should be noted that 2nd edition of the Red Data List with 1402 macrofungi species was prepared for united Germany and published in 1992 (Benkert et al., 1992). After 1982 the same documents appeared in many other countries of Europe. There is detailed review of European Red Data Lists (Arnolds, 2001), analysis of which shows significant variations in the number of fungal species proposed for conservation in different countries. Least of all the number of fungal species (17) was in the Red Data Book of the former USSR (Borodin et al., 1984). The highest number of macromycetous species (1655) was presented in 2nd edition of the Red Data List of the Netherlands (Arnolds, 2001). In conservation of macrofungi Ukraine follows the main trends formed in Europe and discussed above. There are two editions of the Red Data Book of Ukraine (Shelyag-Sosonko, 1996, Didukh, 2009), where the fungal species are presented. Comparison of macrofungi numbers included in those two editions has shown increase from 30 species to 57 ones. Comparatively low numbers of macromycetous species are explained with the Ukrainian peculiarities in organization of conservation management. As against the European countries where conservation of fungi combined with the conservation of appropriate habitats, in Ukraine the fungal species protection is realized in the main. Therefore Ukrainian mycologists consider that the inclusion of limited number of endangered species in the Red Data List is the better model for hard control of its conservation in Ukraine than compilation of formal lists including several hundreds of macromycetous species without their real protection (Akulov & Prylutski, 2010; Dudka, 2012).

MATERIALS AND METHODS

During the last two decades at the end of XX and at the beginning of XXI centuries endangered species of macromycetes from the Red Book of Ukraine were the objects of our careful searches and field observations in various regions of the country. *Dictyophora duplicata* (Bosc.) E. Fischer (now *Phallus duplicatus* Bosc.) (EN), *Galeropsis desertorum* Velen. et Dvor. (CR) and *Pseudocolus fusiformis* (E. Fischer) Lloyd (Syn. *Anthurus javanicus* (Penz.) Cunn.) (VU) were my objects in process of the manuscript preparation for the Red Book of Ukraine (Shelyag-Sosonko, 1996). *Anthurus archeri* (Berk.) E. Fischer (EN), *Boletus parasiticus* Fr. (VU), *Bovista paludosa* Lév. (CR), *Gomphus clavatus* (Pers.: Fr.) Gray (EN), *Lactarius lignyotus* Fr. (VU), *Laricifomes officinalis* (Vill.: Fr.) Kotl. et Pouzar (Syn. *Boletus officinalis* Vill.; *Fomes officinalis* (Vill.) Neum.; *Fomitopsis officinalis* (Vill.) Bond. et Sing.) (EW), *Limacella steppicola* Zerova et Wasser (DD), *Lycoperdon mammaeforme* Pers. (VU), *Phallus duplicatus* Bosc. (Syn. *Dictyophora duplicata* (Bosc.) E. Fischer) (EN), *Phellorinia herculeana* (Pers.) Kreisel (Syn. *Scleroderma herculeana* Pers., *Phellorinia inquinans* Berk.) (DD), *Scleroderma geaster* Fr. (DD), *Tuber aestivum* Vitt. (CR) together with three above mentioned species became the objects of research during the work on the next edition (Didukh, 2009). Implementation of the enumerated fungal species to the categories of extinction risk given in brackets are presented according with the Red List Categories & Criteria (IUCN,

2001). In the Red Book of Ukraine except fungi belonging to the IUCN categories there are some fungal species attributed to the group of rare ones, for example *Catathelasma imperiale* (Fr.) Sing., *Clathrus ruber* Pers., *Clavariadelphus pistillaris* (L.) Donk (Syn. *Clavaria pistillaris* Fr.), *Entoloma nidorosum* (Fr.) Quél. (Syn. *Rhodophyllus nidorosum* (Fr.) Quél, *R. speculum* Lange), *Myriostoma coliforme* (With.: Pers.) Corda, *Pisolithus arrhizus* (Scop.: Pers.) S. Rauschert, *Polyporus rhizophilus* (Pat.) Sacc. (Syn. *Polyporellus rhizophilus* Pil., *Melanopus rhizophilus* Pat.). Here and further such species will be given with abbreviation RA in brackets.

Certainly we registered all other 36 macrofungi species included in the last edition of the Red Book of Ukraine when they happen to have in our field routes. However, the main attention was concentrated on distribution and ecology of the above mentioned 21 species, our treatments of which were published in the last version of the Red Book of Ukraine (Didukh, 2009).

Mycological expeditions of 2002–2011 embraced three nature zones (Polyssia, Forest-Steppe and Steppe) and two mountain systems (Ukrainian Carpathians and Crimea mountains) of Ukraine. Observations on appearance of the fruit bodies of studied fungal species were held at the territories of reserves and national nature parks (NPP). During this period expeditions for revealing of ascoma and basidioma of the endangered macromycetous species from the Red Book of Ukraine were organized in "Prypiat'-Stokhid", Shatski, Mesynski and Desniansko-Starogutski NPP (Polyssia), nature reserves "Medobory" and Dniprovsko-Oril'ski, NPP Ichnianski, "Podil'ski Tovtry", "Kremenetski mountains" (Forest-Steppe), biosphere reserves Chornomorski and Dunaiski, Ukrainian steppe nature reserve, NPP "Holy mountains" (Steppe), Carpathian biosphere reserve, nature reserve "Gorgany", NPP "Bewitched Land", "Skolivski Beskydy", "Synevyr", "Gutsulshchyna", Galitski, Vyzhnytski (Ukrainian Carpathians), nature reserves Crimean, Yalta mountain-forest (Crimea mountains), "The Cape Martian" (the Southern shore of Crimea).

Among studied species there is rather compact group of gasteroid basidiomycetes with the various ecological requirements to the conditions of its natural habitats. Taking into account that the essential reason of endangered fungal species increase consists in disturbance or full destruction of its habitats we have chosen gasteroid basidiomycete *Clathrus ruber* (RA) as a model for monitoring on its development and distribution in dependence from recreation, changes of vegetation, soil structure, and humidity. Observations on *Clathrus ruber* development were made in Nikita botanical garden, Alupka, Livadia and Lower Oreanda parks, reserve "The Cape Martian" etc. (the Southern shore of Crimea).

In Ukraine the field observations for fungi-like organisms belonging to myxomycetes proved decrease of some species numbers in nature ecosystems. Our data are almost in full agreement with those already published, in particular with information about several endangered species of myxomycetes placed in the Red Book of Leningrad region (Morozova, 2001), in the IUCN Red List (IUCN, 2011). Therefore on the basis of our data about frequency of occurrence for some myxomycetous species in Ukraine we worked out proposals concerning the introduction of some rare slime-molds in the Red Book of Ukraine.

RESULTS AND DISCUSSION

In process of studies two patterns in distribution of endangered and rare species of macrofungi included in the Red Book of Ukraine were revealed. There are several macromycetous species from the Red Book of Ukraine the additional records of which in the new, previously unknown locations are rather regular and are sometimes repeated from year to year. They are following: *Amanita solitaria* (Bull.: Fr.) Mer. (VU), *Anthurus archeri* (EN),

Boletus parasiticus (VU), *Catathelasma imperiale* (RA), *Clavariadelphus pistillaris* (RA), *Grifola frondosa* (Dick.: Fr.) Gray (VU), *Hericium coralloides* (Scop.) Pers. (VU), *Lactarius sanguifluus* (Paulet: Fr.) Fr. (VU), *Leucocortinarius bulbiger* (Alb. et Schwein.) Sing. (RA), *Morchella steppicola* Zerova (RA), *Mutinus caninus* (Huds.) Fr. (RA), *Polyporus umbellatus* (Pers.) Fr. (Syn. *Grifola umbellata* (Pers) Pilát; *Polypilus umbellatus* (Pers.) P. Karst) (RA), *Russula turci* Bres. (VU), *Sparassis crispa* (Wulfen) Fr. (EN), *Strobilomyces strobilaceus* (Scop.) Berk. (Syn *S. floccopus* (Vahl.) P. Karst.) (EN), *Tricholoma focale* (Fr.) Ricken (VU) and some other.

The second pattern in distribution of macrofungi from the Red Book of Ukraine is presented with the species that were not collected in the country after 2002. Their list consists of 23 species, among them *Agaricus amanitaeformis* Wasser (CR), *A. romagnesii* Wasser (Syn. *A. radicatus* (Vitt.) Romagn.) (EN), *A. tabularis* Peck (EN), *Amanita caesarea* (Scop.) Pers. (EN), *Bovista paludosa* (CR), *Galeropsis desertorum* (CR), *Gomphus clavatus* (EN), *Hygrocybe calyptriformis* (Berk. et Broome) Fayod (RA), *Lactarius chrysorrheus* Fr. (VU), *L. lignyotus* (VU), *Laricifomes officinalis* (EW), *Leucoagaricus moseri* (Wasser) Wasser (Syn. *Lepiota moseri* Wasser) (RA), *Leucocoprinus bohusi* Wasser (CR), *Limacella steppicola* (DD), *Lyophyllum favrei* R. Haller Aar. et R. Haller Suhr (CR), *Morchella crassipes* (Vent.) Pers. (RA), *Paxillus zerovae* Wasser (EN), *Phallus duplicatu*s (EN), *Phellorinia herculeana* (DD), *Phylloporus pelletieri* (Lév. apud. Crouan) Quél. (Syn. *P. rhodoxanthus* (Schwein) Bres.) (CR), *Pseudocolus fusiformis* (VU), *Sarcosoma globosum* (Schmidel) Rehm (VU) and S*cleroderma geaster* (DD). Reasons of rare occurrence of the enumerated species are in the whole connected with the anthropogenic pressure on nature ecosystems, at first on its vegetation.

For example, several fungal species from the list (some members of genus *Agaricus*, *Galeropsis desertorum, Leucoagaricus moseri*, *Leucocoprinus bohusi*, *Limacella steppicola*) are habituated to the southern grasslands of the Ukrainian steppe zone. Unfortunately the vast massifs of those grasslands are plowed up under the cultivation of cereals. The virgin steppe fields with abundant herbage are kept only in reserves in the form of the small plots of nature vegetation with such typical for Ukraine steppe plant as a feather grass (members of genus *Stipa*). However, the areas of those plots are constantly decreased that has resulted in reduction of ecological niches suitable for development of the mentioned endangered and rare macrofungi.

Another example of anthropogenic influence on the macromycetous species deals with *Laricifomes officinalis.* The species is included in the Red Book of Ukraine as having status *extinct in the wild*. *L. officinalis* is the wood-destroying fungus that develops its fruit bodies on the larch trunks. *L. officinalis* fruit bodies produce agaricine acid which was used in the folk medicine at the treatment of .tuberculosis and some other diseases. Therefore .from XIX century till the beginning of XX century in the Ukrainian Carpathians the fungal fruit bodies were intensively stored up for the preparation of corresponding remedies. Apart from the plantations of *Larix* are sharply shortened in the region. As a result our attempts to find *L. officinalis* in the Ukrainian Carpathians in nature were unsuccessful. Only pure culture isolated from the fruit body of fungus many years ago is preserved in National collection of mushrooms' cultures at the M.G. Kholodny Institute of Botany in Kyiv (Buchalo et al., 2011). It should be mentioned that *L. officinalis* is considered as very rare and threatened species in Poland (Wojewoda & Ławrynowicz, 2006) but meanwhile for the last years it was collected in several Polish localities (Piętka & Szczepkowski, 2004) and was recently found in the mountains of the

External Western Carpathians (Wojewoda, 2010), not far from the Ukrainian Carpathians. It stimulates to continue our searches of *L. officinalis* in the region.

Along with the problem concerning the finds of new additional localities where threatened species of macrofungi have the refuge from unfavorable factors of environment and humane activity it is very important to decide the question of macromycetous conservation practice applicable to the local conditions of the certain country. According to our observations now in Ukraine the combination of fungal and habitats conservation is the most perspective form of macrofungi species protection. In Ukraine real fungal conservation may be successfully realized in those cases when species location (-s) is (are) situated on the territories of biosphere and nature reserves or national nature parks. Status and regime of those objects established on level of the state laws allow to protect biodiversity in general including the fungi and fungi-like organisms. We have analyzed the distribution of 56 (except *Laricifomes officinalis*) macromycetous species from the Red Book of Ukraine in Ukrainian reserves and nature parks (Dudka, 2010).

14 species of macrofungi from the Red Book of Ukraine (Didukh, 2009) that locations were revealed neither in the reserves or national parks nor in the botanical gardens or regional landscape parks have the least probability to be preserved. A half of them (*Anthurus archeri*, *Bovista paludosa*, *Gomphus clavatus*, *Leucoagaricus macrorhizus* Locq. ex Horak (CR), *Lyophilum favrei*, *Paxillus zerovae*, *Tuber aestivum*) belongs to the categories critically endangered or endangered. It means the probability of its survival in locations under anthropogenic stress is extremely low. Two other species of those categories – *Agaricus amanitaeformis* (CR) and *Phallus duplicatus* (EN) in spite of the location in Donetsk botanical garden (the first) and Nikita botanical garden, Crimea (the second) are also situated under high threat of disappearance because of a great number of visitors, constant reconstruction of territories in both gardens. Vulnerable *Boletus aereus* Bull (VU) and rare *Mutinus ravenelii* (Berk. et M.A.Curtis) E. Fischer (RA) are not recorded at the territories of reserves, nature parks or botanical gardens in Ukraine (Dudka, 2010).

Locations in one reserve or nature park of Ukraine are known for 13 macromycetous species from the Red Book of Ukraine. Vulnerable *Lactarius lignyotus* and *Russula turci*, critically endangered *Phylloporus pelletieri* are collected in the Carpathian biosphere reserve only. Locations of rare *Catathelasma imperiale* and vulnerable *Phaeolepiota aurea* (Matt.) Maire (Syn. *Pholiota aurea* (Matt.) Pers.) (VU) are found in the Yalta mountain-forest nature reserve; endangered *Boletus regius* Krombh. (EN) and rare *Leucoagaricus nympharum* (Kalcjbr.) Bon. (Syn. *Macrolepiota puellaris* (Fr.) M.M. Moser) (RA) – in reserve "The Cape Martian" (both on the Crimean peninsula). Locations of the remaining 6 species are connected with the following reserves and nature parks. Vulnerable species are recorded: *Boletus parasiticus* in reserve "Roztochia" (Lviv region), *Floccularia rickenii* (Bohus) Wasser (Syn. *Armillaria rickenii* Bohus) (VU) – the Dniprovsko-Oril'ski reserve (Dnipropetrivsk region), *Lycoperdon mammaeforme* – the Crimean reserve, *Tricholoma focale* – the Luhansk reserve (Luhansk region), critically endangered *Leucocoprinus bohusi* – the Ukrainian steppe reserve (Donetsk region) and rare *Helvella monachella* (Scop.) Fr. (RA) – the nature park "Golosiivski" (Kyiv region) (Dudka, 2010).

6 another species of macrofungi from the Red Book of Ukraine (Didukh, 2009) are rather near to the previous group. They are recorded in one reserve and have additional locations in one (several) regional landscape parks or memorials of nature. Vulnerable *Amanita solitaria*, rare *Gyromytra slonevski* Heluta (RA) and *Morchella crassipes* are

occurred in Kanivski reserve (Cherkasy region). Besides the locations in Kanivski reserve those species are known from one or two state memorials of nature. Rare *Morchella steppicola* found in two locations of the Ukrainian steppe reserve is also known from two local memorials of nature. In the reserves of Crimea there are locations of vulnerable species *Pseudocolus fusiformis* ("The Cape Martian") and *Tricholoma colossus* (Fr.) Quél. (Syn. *Armillaria colossa* (Fr.) Boud.) (VU) (the Yalta mountain-forest nature reserve). Both species are also collected in Nikita botanical garden.

The above mentioned 33 species should be referred to the group with the increased risk of extinction. Conservation of them can't be guaranteed. The additional records in regional landscape parks or memorials of nature don't secure their protection. Unfortunately in regional landscape parks and memorials of nature there are many reasons resulting in destruction and full disappearance of the single or limited locations suitable for macrofungi from the Red Book of Ukraine.

The probability of macromycetous conservation is significantly increased in the case when the separate species is recorded at the territories of two and more reserves and/or nature parks. 11 species from the Red Book of Ukraine (Didukh, 2009) are found in locations disposed at the areas of two reserves and/or nature parks. Among them endangered *Agaricus romagnesii* (the biosphere reserve "Askania-Nova", Kherson region; the Yalta mountain-forest nature reserve) and *Amanita caesarea* (the Crimean and the Yalta mountain-forest nature reserves); vulnerable *Crepidotus macedonicus* Pilát (VU), *Lactarius chrysorrheus* and *L. sanguifluus* (Paulet) Fr. (VU) (the same Crimean reserves); *Galeropsis desertorum* ("Askania-Nova" and Kanivski reserves), data deficient *Limacella steppicola* (the Ukrainian steppe and the Luhansk reserves), rare *Mutinus caninus* (reserves "Medobory", Ternopil region; Kanivski) and *Polyporus umbellatus* (the Crimean and Kanivski reserves); endangered *Sparassis crispa* (the Carpathian biosphere and the (the Southern shore of Crimea).

Crimean reserves) and *Strobilomyces strobilaceus* (the Carpathian biosphere and "Roztochia" reserves). Rare *Clathrus ruber* ("The Cape Martian" and the Yalta mountain-forest nature reserves) and *Myriostoma coliforme* (the Luhansk reserve and nature park "Gomil'schanski Forests", Kharkiv region) are adjoined this group too, the more so there is information on the records of both species in Nikita botanical garden.

The least number of macrofungi from the Red Book of Ukraine (8) contains the group of species that are revealed in three or more reserves and national nature parks of Ukraine. The members of the group are presented with endangered *Agaricus tabularis* ("Askania-Nova", the Ukrainian steppe and the Luhansk reserves); vulnerable *Grifola frondosa* (the Carpathian biosphere and the Crimean reserves, nature park "Holy Mountains", Donetsk region); rare *Entoloma nidorosum* (the Dniprovsko-Oril'ski, the Ukrainian steppe, the Luhansk reserves) and *Pisolithus arrhizus* (the Chornomorski biosphere, the Ukrainian steppe and the Karadag nature reserves, Crimea). The most widespread at the territories of reserves and nature parks of Ukraine there are vulnerable *Hericium coralloides* (the Carpathian biosphere, Kanivski, the Crimean, the Yalta mountain-forest, "Roztochia" reserves and nature park "Holy Mountains"); rare *Clavariadelphus pistillaris* (the Carpathian biosphere, the Yalta mountain-forest, Kanivski, "The Cape Martian" reserves and National nature park "Golosiivski"), *Leucocortinarius bulbiger* (the Luhansk, the Crimean, the Yalta mountain-forest, "Medobory" nature reserves) and *Polyporus rhizophilus* (the biosphere reserves "Askania-Nova" and Choromorski, the Ukrainian steppe and the Luhansk nature reserves). Thus the last enumerated 8 species have the optimal

prospects of survival and conservation since in comparison with the other macrofungi from the Red Book of Ukraine (Didukh, 2009) they are presented with the most number of populations connected with the nature conservation objects of the highest level.

Gasteroid basidiomycete *Clathrus ruber* included in the Red Book of Ukraine (Didukh, 2009) with the category "rare" was chosen as a model species for observations on the development, appearance and distribution of its fruit bodies in the nature habitats under the changeable recreation loads and associated changes of vegetation and soil structure. In Ukraine the mediterranean species *C. ruber* occurs on the southern shore of Crimea in the old parks or the forest-park zone on the boundary of park plantations and nature forest vegetation consisting of *Quercus pubescens* Willd., *Ulmus laevis* Pall., *Carpinus orientalis* Mill. and so on. It should be noted that the southern shore of Crimea is exposed to the high recreation loads as a center of sea rest in Ukraine. Regular annual observations (mainly in August and September) for the state of *C. ruber* populations, dynamics of the fruit bodies appearance in different years, development of its basidiomata in various biotopes were carried out during the vegetative seasons 1993–2010 (Dudka & Isikov, 1998). For this period the *C. ruber* fruit bodies were collected in Nikita botanical garden: park Montador , the Lower park, arboretum, Primorski park, arboretum; nature reserve "The Cape Martian", settlement Alupka, Alupka park, settlement the Lower Oreanda, park, several plots with the nature forest vegetation consisting of 1) *Acer campestre* L. and *Q. pubescens* (age 30 years, in the lower layer 5% *Ruscus ponticus* Woronow ex Grossh.) at the slope 45º; 2) *Q. pubescens, C. orientalis, Pistacia mutica* Fisch. et Mey., *Ailanthus altissima* (Mill.) Swingle, (age 50 years, in the herbaceous layer *Euphorbia rigida* Bieb. rarely) at the slope 50-60º; 3) *Q. pubescens* (200-300 years), *A. campestre*, *U. laevis*, *Cornus mas* L. (at the lower layer 100% *R. ponticus); 4) Juniperus excelsa* Bieb. (100-200 years), *Q. pubescens* (50-80 years) (in the lower layer 80% *Bupleurum fruticosum* L.). Analysis of *C. ruber* distribution in above pointed places of collection demonstrates that the most number of locations are placed in Nikita botanical garden, especially at the territory of arboretum. The numerous *C. ruber* basidiomata have developed on the plots with nature forest vegetation in the central part of arboretum in the Lower park. *U. laevis* (age 40-50 years, in the herbaceous layer there are 40% *Anthriscus sylvestris* (L.) Hoffm., 30% *Vinca minor* L., 20% *Galanthus plicatus* Bieb., 10% *Hedera helix* L.) is the main tree species on those plots disposed at the slopes 40º. However, the fruit bodies are formed at the parts of plots free from herbaceous vegetation.

The results of our observations on *C. ruber* may be summarized in the following way. The preferable locations for *C. ruber* are situated in the old parks or on the boundary of the park plantations and nature forest vegetation. Full absence or significant inhibition of herbaceous vegetation are typical for *C. ruber* locations. Basidiomata of *C. ruber* are more often developed on the loamy or carbonate soils under the closed tree canopy. Those conditions keep the sufficient soil humidity for basidiomata formation. The terms of *C. ruber* fruit bodies appearance are changed from the middle of April till the end of October with the maximum in the middle of August – the beginning of October. As to the influence of recreation loads our observations showed remarkable increase in the number of *C. ruber* fruit bodies on the southern shore of Crimea in the period 1998–2002. In that period social statistics registered decrease of visitors to Crimea after default 1998 in Russia. However, it is impossible to confirm it was a single factor in regulation of *C. ruber* basidiomata number. The intensive summer rains in 1996, 1997, 1998, 2000 raise air and soil humidity and stimulate the phenomenon of "meteorism" in the fungal fruit bodies appearance (Vasil'kov, 1955). Increased humidity causes formation of so called "nests" when 2–3 or sometimes more basidiomata

arise on the plot 1 m² instead of one fruit body as usual. It is difficult to separate the influence of supposed decrease of recreation loads from the influence of other ecological factors.

Decrease of biodiversity at the expense of separate species loss concerns not only kingdom of Fungi but also fungi-like organisms, in particular myxomycetes, that have macroscopic stages in the life cycle. Long-standing observations on the myxomycetes in the world proved the decline of its species composition in some habitats under pressing of strong anthropogenic influence. As a result several endangered species of myxomycetes were included in the Red Books and Lists of some regions or the world entirely (Morozova, 2001; IUCN, 2011). The situation with the myxomycetous species diversity and taxonomic structure of their biota is similar in Ukraine (Dudka et al., 2011). Therefore we have worked out the criteria for slime molds species that may be considered as the candidates in the next edition of the Red Book of Ukraine. It is proposed to select for the Red Book of Ukraine: 1) species that are only accustomed to the threatened habitats; 2) species that are described as new for science from the territory of Ukraine and are unknown in other countries or species with very limited world area; 3) species which are characterized with macroscopic features that gives possibility to register them in nature without use of special methods. Later it was offered to compile the list of myxomycetes included in the Red Books and Lists of other countries and use it for selection of really rare and endangered myxomycetes found in Ukraine (Dudka, 2012). The first attempt to test the criteria is connected with *Oligonema aurantium* Nann-Bremek. The first and single record of the species in the Eastern Europe and Ukraine was made at the Left-Bank Polyssia in NNP "Desniansko-Starogutski" (Sumy region) (Leontyev et al., 2012). The species uses dead wood as a substrate for formation of brightly orange or orange-yellow, shining sporocarps that are well noticeable on the dark wood. O. *aurantium* is very rare species, known only from two records in Europe: the first one in Netherlands (*locus cl;assicus*) and the second one in Great Britain. Now all necessary documents are prepared for inclusion of O. *aurantium* in the next edition of the Red Book of Ukraine.

CONCLUSIONS

1. 57 species of macromycetes included in the the Red Book of Ukraine (Didukh, 2009) are assigned to the IUCN Red List categories of extinction risk in the following way: one species belongs to extinct in the wild (EW), eight – to critically endangered (CR), ten – to endangered (EN), 17 ones – to vulnerable (VU). Three species are ascribed to data deficient (DD). Besides IUCN categories additional one – rare (RA) – is accepted in the Red Book of Ukraine. 17 species referred to category rare.

2. The long-term observations (2002-2011) on the development and distribution of macrofungi from the Red Book of Ukraine held in three Ukrainian nature zones (Polyssia, Forest-Steppe and Steppe) and two mountain systems (Ukrainian Carpathians and Crimea mountains) have demonstrated two patterns in its frequency of occurrence: the species with and the species without additional records after 2002.

3. Analysis of obtained data on the location distribution of macromycetous species from the Red Book of Ukraine showed that only 19 ones are known from 2–3 or more biosphere or nature reserves and/or nature parks. Conservation prospects for these species are much more hopeful than those ones which have no locations or have only few locations on the territories of protected nature objects.

4. The influence of vegetation and soil structure was established for model species *Clathrus ruber* (RA). *C. ruber* preferences in relation of the old parks and boundary zone between park plantations and nature forests, loamy and carbonate soils and plots with rather

limited grass vegetation are typical for the Southern shore of Crimea.

5 The criteria for inclusion of fungi-like organisms (myxomycetes) in the Red Book of Ukraine were worked out and tested on *Oligonema aurantium*.

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