ANNUAL OF SOFIA UNIVERSITY "ST. KLIMENT OHRIDSKI"
FACULTY OF BIOLOGY
Book 2 – Botany
Volume 100, 2015

ANNUAIRE DE L'UNIVERSITE DE SOFIA "ST. KLIMENT OHRIDSKI"
FACULTE DE BIOLOGIE
Livre 2 – Botanique
Tome 100, 2015

A NEW METHOD FOR ASSESSMENT OF THE RED LIST THREAT STATUS OF MICROALGAE

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Abstract. Although the IUCN Red List Categories and Criteria is a widely internationally used system for classifying species at high risk of extinction, the micro-organisms are still practically excluded from the appropriately enlisted taxa. The present paper provides a method, which gives means to assess microalgae threat status much more objectively than it was possible before and in this way to achieve quite high degree of generalization in work with this peculiar group of organisms. The method described below uses the widely accepted standard IUCN Red List system of categories, but proposes their assignment on the basis of a complex application of seven criteria relevant to microalgae and classical data, available for them. These criteria can be interpreted in the same way for all taxonomic groups of algae and for all possible territorial levels (local, national, regional, global). The criteria are denominated with Latin capital letters A-G and each of them has a numerical expression with values (points) ranging between 4 and 1. The final assessment of the threat status is done on the basis of the total amount of points (T), which ranges between 7 and 28. In this way each alga is supplied with a formula (a combination of letters and numbers), which indicates its threat status and in the same time outlines its most critical, "weak spots" on which special attention has to be paid when conservation measures

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have to be proposed. As it is exemplified in detail in the paper, the formula could be expressed in a table or in a text format, in full or in a short version, depending on the needs of the relevant studies or proposals (e.g. *Anabaena lapponica* Borge [VU – A3 B4 C4 D2 E2 F2 G3], or *Anabaena lapponica* Borge [VU – A3 B4 C4 D2 E2 F2 G3 T20], or *Anabaena lapponica* Borge [VU – T20]), or *Anabaena lapponica* Borge [VU]).

Key words: threat categories, algae, conservation status

INTRODUCTION

The IUCN Red List Categories and Criteria is a widely internationally used system for classifying species or taxonomic units below the species level at high risk of extinction. Since its first adoption by IUCN Council in 1994, this system underwent some revisions which lead to its essential improvement: 1) better possibilities for application of categories and criteria to different taxonomic groups and assessment of an increasingly more diverse range of taxa occurring in a wide variety of habitats; 2) appearance of more and more successful applications of Red List categories and criteria at regional, national or local levels.

However, according to the Second Edition of Version 3.1 of The IUCN Red List Categories and Criteria (IUCN 2012) the micro-organisms are still practically excluded from the appropriately enlisted taxa. The reason lies in the obstacles in applying the accepted criteria to different types of micro-organisms, including prokaryotic and eukaryotic microscopic algae. In spite of the fact that "ongoing technological advances continue to provide more scope of improving data analysis" (OP. CIT.), it is practically impossible to use for microalgae the standard IUCN criteria related with number of mature individuals, real area of occupancy, population size, *etc*. The reason is not only in the fact that "different from *lovely or charismatic wildlife*, such as vertebrates, beetles, butterflies, and flowering plants, algae have not received extensive attention" (WATANABE 2005), but lies also in the uneven state of knowledge of algal groups in different countries, as well as the uneven studies of different algal groups in a given country and, in addition, often there is a lack of recent studies in places, which have been visited by phycologists of previous generations. Nevertheless some national or regional Red Lists of microalgae (or including microalgae) have been created, as separate lists or as parts of Red Data Books (*e.g.* SIEMIŃSKA 1986, 1992, 2006; GUTOWSKI & MOLLENHAUER 1996; LANGE-BERTALOT & STEINDORF 1996; PALAMAR-MORDVINTSEVA ET AL. 1998; LENZENWEGER 1999; ENVIRONMENTAL AGENCY, JAPAN 2000; NÉMETH 2005; algal lists in regional Red Data Books of Moscow District, Leningrad District, Kirov District, Kamchatka District, Vologda District, Nizhegorod District, Nenets Autonomic Region, of Tatarstan Republik and of Komi Republic – all cit. acc. to KOMULAINEN 2009). Most of them do not provide a clear indication of the reasons for assigning a certain category to given

species and it is obvious that they are based only on the personal expertise of the authors and more rare the methodological approaches and criteria used are clearly defined (*e.g.* Németh 2005; Watanabe 2005). The lack of commonly accepted methodology leads to the application of different approaches for evaluation of taxa from different taxonomic groups of algae even in the same country or region, and to an assignment of different threat categories, ranging around those proposed in the global IUCN system (*e.g.* potentially threatened, rare, indeterminate) or using only some of the IUCN categories (*e.g.* Vulnerable, Endangered and Critically Endangered). This results in difficulties for further comparisons between the different Red Lists and taxa status, as well as in the lack of a stable basis for creation of microalgal Red Lists in other regions and countries, in spite of the clear recognition of their necessity due to loss of habitats and biodiversity in many regions of the world. Most of these problems (often related also to Red Data Books) have been recognized and discussed from different aspects by other authors (*e.g.* Palamar-Mordvintseva et al. 1998; Denys 2000; Kondratieva 2003; Siemińska 2006; Németh 2005; Ellis 2008) and it was even proposed to exclude microalgae from such lists due to recent lack of objective criteria and sufficient knowledge for their assessment (*e.g.* Komulainen 2009).

The aim of the present paper is to provide a method, which will give means to assess microalgae threat status much more objectively than it was possible before and in this way to achieve quite high degree of generalization in work with this peculiar group of organisms. The method described below uses the widely accepted standard IUCN Red List system of categories, but proposes their assignment on the basis of criteria relevant to microalgae and classical data, available for them. These criteria can be interpreted in the same way for all taxonomic groups of algae and for all possible territorial levels (local, national, regional, global). We strongly believe that the chosen criteria correspond well with the general ideas, lying behind the already accepted IUCN Red List criteria and that in the proposed combination they represent the minimum necessary information for the species assessment. We approbated the proposed method using all available data on microalgal biodiversity in Bulgaria, provided over a century in more than 300 publications. The results obtained corresponded strongly with our personal expert assignment of threat status to a given alga. In this way the first Red List of Bulgarian microalgae was prepared (Stoyneva-Gärtner et al., this volume) as a first practical application of the method proposed in the present paper and therefore the exemplification in the text below is based on Bulgarian cases.

Description of the proposed *Method for assessment of the Red List threat status of microalgae*

The method proposed in this paper is **aimed at objective assessment of the threat status of prokaryotic and eukaryotic microscopic algae**. It is based on a **complex application of seven criteria, denominated with Latin capital letters**

A–G, organized in alphabetical order. The criteria, described in details below in the text, are of equal importance for assessment, and their alphabetical order should not be accepted as an importance weight. For example, criterion E is not less important than criterion B, or criterion A is not more important than criterion B. **Each of the criteria A-G has a numerical expression with values (points) ranging between 4 and 1.** The lowest optional value 1 practically reflects all cases, which do not fit to the descriptions relevant to values 4, 3 and 2. The unification of the range and the usage of the same step (4 levels in descending way of importance) in combination with alphabetical denomination of criteria was done with the idea for obtaining an elegant and cozy for work system, the steps of which are quite easy to remember.

The final assessment of the threat status has to be done on the basis of the total amount of points (sum of the points for all seven criteria), which ranges between 7 and 28. The range of points for each threat category is provided in the text below. **The threat category follows the standard IUCN Red List categories and their standard denominations**: EX – Extinct, CR – Critically Endangered, EN – Endangered, VU – Vulnerable, LR – Low Risk (with the subcategories NT – Near Threatened, LC – Least Concern and DD – Data Deficient), NE – Not Evaluated. On conformity with the standard IUCN GUIDELINES (2012), "listing in the categories of Not Evaluated and Data Deficient indicates that no assessment of extinction risk has been made, though for different reasons ... Taxa listed in these categories should not be treated as if they were non-threatened and it may be appropriate (especially for Data Deficient forms) to give them the same degree of attention as threatened taxa, at least until their status can be properly assessed". Therefore algae in both NE and DD categories should not be supplied with numerical values for any of the seven proposed by us criteria. In our opinion, in cases of microalgae the category Extinct should be assigned with a high degree of circumspection, since these organisms often are capable to develop resting stages of long surveillance and it is extremely difficult to prove the death of the last individual.

Below are enlisted the **seven proposed criteria and their numerical values (points)** with relevant explanations and denominations (in all cases when "species" is used below, it has to be read as "species or taxonomic units below the species level"). It has to be boldly underlined that their scope is dependent on the area, country, or region for which the Red List is created:

A. Number of localities in which the species was found (number of all known localities for a given species, regardless of the period and frequency of its finding):

4 – 1 locality

3 – 2–5 localities

2 – 6–10 localities

1 – ≥11 localities

B. Species affiliation to differen number of habitats and threat habitat

categories listed in relevant Red Data Book/Red List[1]*:*

4 – species affiliation to one or more than one habitat, all of which are assigned with the threat status of Critically Endangered and/or Endangered according to the relevant Red Data Book of Habitats/Red List of Habitats, *e.g.* for Bulgaria here and below we consider the Bulgarian Red Data Book of Natural Habitats (BISERKOV ET AL. 2015)

3 – species affiliation to one, or more than one habitat, all of which are assigned with the threat status of Vulnerable and/or Potentially Endangered according to the relevant Red Data Book of Habitats/Red List of Habitats

2 – species affiliation to two or more habitats, which are with a significant difference in their threat status according to the relevant Red Data Book of Habitats/Red List of Habitats (*e.g.* CR and VU) or, among which are habitats not assigned with any threat status in relevant Red Data Book of Habitats/Red List of Habitats

1 – species affiliation only to habitats without threat status in the relevant Red Data Book of Habitats/Red List of Habitats.

C. Affiliation of the species to a certain number of main ecological groups (hydrophyton, thermophyton, cryophyton, edaphophyton, aerophyton, spelaeophyton, symbiotic algae, parasitic algae)

4 – species affiliation to a single ecological group (*e.g.* only to hydrophyton, regardless if the species is planktonic or benthic)

3 – species affiliation to two ecological groups (*e.g.* hydrophyton and aerophyton)

2 – species affiliation to three ecological groups

1 – species affiliation to 4–8 ecological groups

D. Affiliation of the species to a conservationally important area[2]**:**

4 – species found only in one protected area of highest possible category relevant to the territory in consideration for a given Red List (*e.g.* for Bulgaria it should be read as "taxon found only in a Reserve (regardless of its type) or only in a National Park")

3 – species found only in one territory with lower national nature conservation status, or another conservation status/value (*e.g.* for Bulgaria it should be read as "species found in a Protected locality, in a Nature monument, etc.

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[1] When this method is applied in countries without a Red Data Book or a Red List of Habitats, it is suggested to replace this criterion with the following one**: B*. Affiliation of the species to a number of habitats (or habitat types): 4** – species is known from only one habitat; **3** – species is known from 2 habitats; **2** – species is known from 3–5 habitats, and **1** – species is known from ≥ 6 habitats. In case of such replacement, it is strongly recommended to use the criterion B with an asterisk, as it is shown above.

[2] if the territory has more than one conservational status, in this assessment the highest one has to be taken into account (*e.g.* if a given locality is situated in a Reserve and has been declared as a Ramsar site, the criterion D should get 4 points)

or in a Natura 2000 site, or in a wetland from the Red List of Bulgarian wetlands (regardless of its category; MICHEV & STOYNEVA 2007), or in a Ramsar site, or in Corine site, or in other area with national or international conservational importance and status (UNESCO site, Monument of World Cultural and Natural Heritage, *etc.*)

2 – species found in two or more territories, among which at least one is of conservational importance (according to their enlistment above for values 4 and 3)

1 – species found only in area/areas without conservational importance

***E. Species endemism*:**

4 – local endemic (*e.g.* Rila endemic), declared as an endemic species by its author, or afterwards by other author(s), or a species which have not been reported as endemic, but has been described from a given country (*e.g.* Bulgaria) and have been found only in one of its floristic regions

3 – national endemic (*e.g.* Bulgarian endemic), declared as an endemic species by its author, or afterwards by other authors, or species which has not been reported as endemic, but has been described from the country (*e.g.* Bulgaria) and has been found in more than one of its floristic regions

2 – regional endemic (*e.g.* Balkan endemic) or continental endemic (*e.g.* European endemic, Australian endemic)

1 – non-endemic species

***F. Species areal*:**

4 – globally rare species (*e.g.* found in small number of localities/countries (≤10) or no more than 3 continents)

3 – continentally rare species (*e.g.* found in a limited number of localities/ countries (≤5) of Europe or another continent, relevant for the country for which the Red List is prepared)

2 – locally rare species (*e.g.* rare for Bulgaria, found in ≤5 (–10) localities in the relevant country)

1 – species with another distribution (*e.g.* cosmopolitan and found in 12 localities in Bulgaria)

G. Expert weight. This is an expert and in some way "subjective" addition of points to the species assessment, strongly based on the personal knowledge and experience of the phycologists, who make the assessment. It is recommended values 4, 3 or 2 to be applied when at least one of the following cases concerns the species under assessment: **a)** the species is typical inhabitant of an important for algae habitat to which lower status is assigned in relevant Red Data Lists/Books of Habitats, or the habitat still has not any status, or the species belongs to a territory with a potential conservation value; **b)** there are historical data which prove or strongly suggest the decline in species areal (decrease of number of localities, incl. destruction of some of the localities), decline in the number of habitats, loss of habitats or decline in species numbers (for the period of at least 20 years calculated

back from the assessment time); **c)** expert opinion about the unique character of the species in terms of distribution or its potential endemism (*e.g.* species described from a given country which during more than 10 years after the description has not been found anywhere else), or its stenobiont character, *etc.*; **d)** another expert reason or reasons (with a strong recommendation for its /their argumentation in the relevant proposal or publication):

4 – high expert weight
3 – mean expert weight
2 – low expert weight
1 – no need to apply additional expert weight because the other points describe well enough the species status or because it is possible to suggest that the species has not been reported due to lack of investigations and not because of its real extinction from the wild

The scale of compliance between total counted points and threat status is as follows (it is strongly suggested not to include in Red Lists species with a total of 7 points only):

28–25 – CR
24–21 – EN
20–17 – VU
16–13 – NT
12–8 (7) – LC

Additional considerations which have to be taken into account when the proposed method is applied: species which are taxonomically unclear, species which are subjects of occasional transport, saprobionts or other species typical for strongly polluted habitats should be excluded from the Red List proposals. The proposals should be based on published data, which could be checked by readers and, when necessary, changed after obtaining of new data. For special considerations concerning criteria B and D, readers are kindly invited to check the footnotes to this paper.

When all the steps described above are properly followed, then **each alga is supplied with a formula** (a combination of letters and numbers), **which indicates its threat status** and in the same time **outlines its most critical, "weak spots" on which special attention has to be paid when conservation measures have to be proposed**. For example, if alga has A4 in the formula where other values are 1, the weak point is its occurrence in only one locality, or if the formula is expressed as A3B1C1D1E1F4G4, then it is to be seen that it is a globally rare species with a declining population and occurs/or occurred in 3–5 localities only to which special attention in further conservation measures has to be paid.

An advantage of the proposed method is that the **formula for each taxon can be expressed in different ways**, depending on the necessity in a given publication or report, either as data in a table or as a simple text. An example of table format is given below (***Example 1***). In this format, cozy applicable to more taxa, the values

(4 to 1) of each criterion (A-G) and their total (T) for a given taxon are easily seen. For a better and immediate orientation, the first column following the taxa names shows the assigned IUCN threat status.

Example 1: Presentation of a Red List with the formula for each species in a table format.

Taxon/Conservation status (CS), criteria (A-G) values and their total points (T)	**CS**	**A**	**B**	**C**	**D**	**E**	**F**	**G**	**T**
Achnanthidium temniskovae **Ivanov et Ector**	**CR**	**3**	**4**	**4**	**3**	**4**	**4**	**4**	**26**
Actinotaenium crassiusculum **(De Bary) Teiling**	**EN**	**4**	**4**	**4**	**4**	**1**	**4**	**2**	**23**
Anabaena lapponica **Borge**	**VU**	**3**	**4**	**4**	**2**	**2**	**2**	**3**	**20**
Trachydiscus minutus **(Bourrelly) Ott**	**NT**	**4**	**1**	**4**	**1**	**1**	**4**	**1**	**16**
Trachelomonas pseudobulla **Svirenko**	**LC**	**4**	**1**	**1**	**1**	**1**	**2**	**1**	**11**
Oedogonium jordanovii **Vodenicharov**	**DD**	–	–	–	–	–	–	–	–

In case when a single species or a small group of species are discussed or cited, it is recommended to express the formula as a text, as it is shown in ***Example 2:*** *Anabaena lapponica* Borge [VU - A3 B4 C4 D2 E2 F2 G3], or *Anabaena lapponica* Borge [VU – A3 B4 C4 D2 E2 F2 G3 T20]. Depending on the need, the formula can also be used in shortened versions, for instance providing a combination of the threat status and the total counts for a given taxon (***Example 3:*** *Anabaena lapponica* Borge [VU – T20]), or providing only the species threat status ***(Example 4:*** *Anabaena lapponica* Borge [VU]). It has to be underlined that in the last cases, it would be impossible to compare the exact level of threat for two species, which belong to the same category and have equal totals, but have different distribution of the points in the seven criteria (***Example 5:*** *Ophiocytium arbuscula* (A. Braun) Rabenhorst [VU – A4 B4 C4 D2 E1 F1 G3 T19] and *Ophiocytium lagerheimii* Lemmermann [VU – A3 B4 C4 D2 E1 F4 G1 T19]), or for species, which belong to the same threat category but have different total points (***Example 6:*** *Goniochloris triradiata* Pascher [VU – A4 B4 C4 D2 E1 F4 G1 T20] and *Mischococcus sphaerocephalus* Vischer [VU – A3 B2 C4 D2 E1 F4 G1 T17]). In case of different total points, when a comparison is necessary to be done, the species with higher total should be considered as more threatened. In all other cases it is obvious that future conservation measures should take into account exactly the "weak points" of a given taxon.

CONFLICT OF INTERESTS

The authors declare that there is no conflict of interests regarding the publication of this article. It was written after the propsal of the first author and all the other authors contributed equally to the discussions of the text.

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Accepted 26.01.2016