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ORIGINAL ARTICLE

Evaluating the conservation status of epiphytic lichens of Italy: A red list

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Abstract
Despite the fact that Italy is among the lichenologically best known areas worldwide, a national red list of lichens is still lacking. The aim of this work was to provide a red list of the epiphytic lichens of Italy which could facilitate the inclusion of lichens in national conservation plans. The evaluation of the species against International Union for Conservation of Nature (IUCN) criteria was based on data from multiple sources which represent the best available information on the epiphytic lichens of Italy. The species were assigned to the IUCN categories mainly using criteria D and B. A total of 368 species were evaluated: for 23 species, information is missing from more than 50 years and they were listed as regionally extinct, 64 as critically endangered, 75 as endangered, 74 as vulnerable, 58 as near threatened, 20 as least concern and 54 species as data deficient. Our results indicate that more than one-fourth of the epiphytic lichens of Italy are likely to be threatened, so that further research and effort are needed to include lichens in the main national conservation plans. Our results also highlight the lack of information that still hampers the rigorous evaluation of Italian lichens against IUCN criteria.

Keywords: *IUCN criteria, lichens, Natura 2000, threatened species, red listing*

1. Introduction

Red lists are an important tool for planning nature conservation actions from the global to the local scales (Gärdenfors et al. 2001; Rodrigues et al. 2006; Mace et al. 2008), since conservation priorities are often based on the rank of a species in a red list. Red lists are not necessarily linked to legislation, but environmental policies and funding for conservation activities are mainly focused on organisms which are included in a red list (Jørstad & Skogen 2010). This situation may create some bias in the effort devoted to the conservation of organisms which are scarcely represented in red lists, such as many invertebrates (Cardoso et al. 2011), bryophytes (Hallingbäck et al. 1998; Hallingbäck 2007) and fungi, including lichens (Dahlberg & Mueller 2011). The under-representation of these organisms may be related to a number of reasons. Among them, difficulties in applying IUCN (2001) criteria for red listing are probably a major constraint (Scheidegger & Goward 2002). Although IUCN criteria were developed to be applicable to almost all species, they were mainly used for mammals, vascular plants and for species which are easily sampled. Research aiming to fill this gap by providing plausible adaptations of IUCN criteria to the case of overlooked organisms is rapidly increasing (e.g. Hallingbäck et al. 1998; Keller et al. 2005; Cardoso et al. 2011; Dahlberg & Mueller 2011), giving new perspectives for building multi-taxon conservation plans.

At the global level, lichens were largely overlooked in the IUCN Red List, only two species (*Cladonia perforata* A. Evans and *Erioderma pedicellatum* (Hue) P.M. Jørg) having being evaluated according to IUCN criteria (Scheidegger 2003; Yahr 2003). At the European level, the main reference is the red list by Sérusiaux (1989), which, however, includes epiphytic macrolichens only. The lack of an exhaustive European red list was probably among the main causes of the exclusion of lichens from Natura 2000, one of the major biodiversity conservation programmes within the European Community, so that lichens were not considered in the implementation of the Convention on Biological Diversity (CBD) Global Strategy for Plant Conservation (Ravera et al. 2011). This situation contrasts with the great amount of recent literature demonstrating that many lichens, mainly epiphytic

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species, are severely threatened in Europe. The main causes of threat are air pollution, forest management and climate change (e.g. Ellis et al. 2007; Nascimbene et al. 2007; Johansson 2008; Aragón et al. 2010; Ellis and Coppins 2010; Marini et al. 2011). In this perspective, the Natura 2000 programme may fail to ensure the long-term conservation of many lichens in Europe. This negative scenario may be mitigated by the fact that some European countries have national red lists for lichens, such as Germany (Wirth et al. 2011), the Netherlands (Aptroot et al. 1998), Austria (Türk & Hafellner 1999), Switzerland (Scheidegger et al. 2002), Norway (Timdal et al. 2006), Czech Republic (Liška et al. 2008), Estonia (Randlane et al. 2008) and Sweden (Thor et al. 2010).

Despite the fact that Italy is among the lichenologically best known areas worldwide, an exhaustive national red list of lichens is still lacking, the only official available document being a preliminary red list provided by Nimis (1992), which, however, was prepared before the completion of the modern checklist of Italian lichens (Nimis 1993) and it is therefore of scarce practical use.

In Italy, the increase in lichenological knowledge was substantial over the last decades (Nimis & Martellos 2003), especially for epiphytic lichens which are being largely used for monitoring the effects of air pollution (Cislaghi & Nimis 1997), for evaluating the effects of forest management (Nascimbene et al. 2007) and for long-term monitoring of forest conditions (Giordani et al. 2006, 2012). Moreover, improvements in biodiversity informatics have facilitated ecological studies on Italian lichens, providing user-friendly identification tools (Nascimbene et al. 2010) and increasing the accessibility of information on distributional and ecological data on Italian lichens (Nimis & Martellos 2008).

The aim of this work was to provide a red list of the epiphytic lichens of Italy which could facilitate the inclusion of lichens in national conservation plans. We have followed a pragmatic approach (Dahlberg & Mueller 2011), based on our evaluation on the combination of (a) data from multiple sources which represent the best available information on the epiphytic lichens of Italy and (b) the guidelines proposed by Dahlberg and Mueller (2011) for the application of IUCN criteria to fungal species. The scope behind this work is that of stimulating further indispensible research on the ecology, distribution and conservation status of Italian lichens.

2. Materials and methods

2.1 Selection of the species for red listing

The first step of the red listing process was the selection of species that, at our best knowledge, may be threatened. This selection was based on information already available in the Information System on Italian Lichens (ITALIC; Nimis & Martellos 2008), which provides rarity values for each species at the national level on the basis of (a) number of samples in the TSB lichen herbarium, (b) number of literature records and (c) expert judgement. In ITALIC, eight commonness–rarity classes are used, from "extremely rare" to "extremely common". Commonness–rarity of each species is calculated for each of the nine phytoclimatic areas of Italy (Nimis & Martellos 2008). Rare species are potentially very sensitive to stochastic events or to already unknown threats (Dahlberg & Mueller 2011) and, according to Scheidegger and Werth (2009), a conservation priority should be assigned to extremely rare species or to lichens for which the country has a high international responsibility, for example, in our case to lichens related to Mediterranean habitats. For these reasons, in this work, we concentrated our attention only on species assigned to the extremely/very rare classes at the national level. The remaining species were not evaluated and are listed as "least concern", since there is no indication that they are experiencing a declining trend. We, however, acknowledge that further effort should also be devoted to the assessment of the conservation status of currently common species.

2.2 Information for red listing

For each species, we accessed all the available literature, including grey literature, in order to establish:

(1) Whether the species was not reported in any Italian region during the last 50 years.
(2) Whether the species is currently known from one locality only, including information on possible decline over the last 50 years (records older than 50 years were not considered).
(3) The number of Italian regions from which the species was reported.
(4) The number of Italian regions from which the species was not found again in the last 50 years, to estimate whether a given species is likely to experience a declining trend at the national level. The coarse grain of this information (presence/absence within each region) did not allow reliable estimates of the rate of decline.
(5) The association of each species with a declining habitat according to Petrella et al. (2005) and Ministero dell'Ambiente e della Tutela del Territorio e del Mare (MATTM 2008). This information was only applied when the classification of the habitat in which the species was found was absolutely sure and recorded from an Italian Special Areas of Conservation, according to the

MATTM's (2011) database. This information was also used for estimating whether a given species is likely to experience a declining trend at the national level; in this case, we were not able to provide estimates of the decline rate. When possible, we also added information on the occurrence of the species in Natura 2000 habitats, since these are among the main targets for conservation activities, an information which, however, was not directly used for red listing.

(6) The sensitiveness of each species to human disturbance (e.g. air pollution, forest management) according to the poleophoby value assigned by Nimis and Martellos (2008) to epiphytic lichens. In particular, we used the classes "extremely/very sensitive" of the poleophoby value. This parameter was used as a proxy for estimating potential decline of the species occurring in less than five Italian regions, only when they were not classified as declining according to points 4 and 5.

2.3 Assessment of the conservation status and proposing IUCN categories

The conservation status of each species (IUCN categories) was assessed on the basis of the interpretation of IUCN criteria proposed by Dahlberg and Mueller (2011) for fungal species, adapted to the information available for Italian lichens. Since available data were mainly in the form of presence at the regional level, even rough estimations of population size in term of individual numbers were not possible.

The species were assigned to the IUCN categories mainly using criterion D, related to their rarity and criterion B, related to the geographic range (expressed as occurrence of the species in the 20 administrative regions of Italy) and decline.

Extreme fluctuations, which are used in the IUCN criteria B and C, have not been used here, as there is seldom any information on the dynamics of populations. Criterion E was not used, as it requires a population viability analysis, which is normally not available for cryptogams (Hodgets 2000).

Regionally extinct (RE) species: this category was assigned to species which were not reported in Italy during the last 50 years. These species are possibly extinct at the national level, but we acknowledge that some of them should be more intensively searched in suitable habitats. They could be better addressed as "possibly extinct" but we avoided to use this term since in the IUCN codes it has a different meaning (Butchart et al. 2006).

Critically endangered (CR) species: this category was assigned to (1) species presently known from a single locality in Italy (criterion D).

Endangered (EN) species: this category was assigned to (1) species known from one to two Italian regions in more than one locality (criterion D) and that (2) are likely to have a declining trend, following criteria B1ab(i), B1ab(ii), B2ab(i) and B2ab(ii) and/or (3) are associated with a declining habitat according to Petrella et al. (2005) and MATTM (2008), following criteria B1ab(iii) and B2ab(iii) and/or (4) are extremely/very sensitive to human disturbance according to Nimis and Martellos (2008), following criterion A4e.

Vulnerable (VU) species: this category was assigned to (1) species that are known from three to five Italian regions in more than one locality and that (2) are likely to have a declining trend, following criteria B1ab(i), B1ab(ii), B2ab(i) and B2ab(ii) and/or (3) are associated with a declining habitat according to Petrella et al. (2005) and MATTM (2008), following criteria B1ab(iii) and B2ab(iii) and/or (4) are extremely/very sensitive to human disturbance according to Nimis and Martellos (2008), following criteria A4e.

Near threatened (NT) species: this category was assigned to (1) species that are known from more than five Italian regions and that (2) are likely to have a declining trend and/or (3) are associated with a declining habitat according to Petrella et al. (2005) and MATTM (2008) and/or (4) are extremely/very sensitive to human disturbance according to Nimis and Martellos (2008).

Least concern (LC): this category was assigned to species that are known from more than five Italian regions and that have no negative trend.

Data deficient (DD): in this category we put (1) species that are taxonomically poorly known to critical groups; (2) species whose Italian distribution is poorly known, including lichens that were only recently described from Italy and (3) species whose distributional information in Italy may be biased by identification mistakes.

The species whose conservation status was previously assessed in detail on the basis of a more rigorous application of IUCN criteria (*Collema italicum*, *Pyxine subcinerea*, *Seirophora villosa*, *Usnea longissima*) were assigned to the IUCN category proposed by the authors (Ravera & Giordani 2008a, 2008b; Nascimbene & Tretiach 2009; Benesperi & Ravera 2011). Nomenclature follows Nimis and Martellos (2008).

3. Results

A total of 368 species were evaluated for their inclusion in the Italian red list, representing 46% of the epiphytic lichens of Italy (Appendix):

For 23 species, there is no information on their occurrence during the last 50 years; they are listed

Table 1. Number of species for each IUCN category which are known to occur in 44 Natura 2000 habitats.

		IUCN category							
	Natura 2000 habitat	RE	CR	EN	VU	NT	LC	DD	Tot endangered (CR, EN, VU)
2250[a]	Coastal dunes with *Juniperus* spp.	–	2	4	2	1	1	–	10
2260	Cisto-Lavenduletalia dune sclerophyllous scrubs	–	2	–	–	1	–	–	3
2270[a]	Wooded dunes with *Pinus pinea* and/or *Pinus pinaster*	–	1	–	2	2	–	1	6
3280	Constantly flowing Mediterranean rivers with Paspalo-Agrostidion species and hanging curtains of *Salix* and *Populus alba*	–	3	8	16	21	5	5	58
4060	Alpine and Boreal heaths	1	1	–	–	–	–	–	1
4070[a]	Bushes with *Pinus mugo* and *Rhododendron hirsutum* (Mugo-Rhododendretum hirsute)	–	1	–	–	–	–	–	1
5130	*Juniperus communis* formations on heaths or calcareous grasslands	–	–	–	–	1	–	–	1
5210	Arborescent matorral with *Juniperus* spp.	–	4	2	5	5	3	3	22
5230[a,b]	Arborescent matorral with *Laurus nobilis*	–	9	7	4	1	–	–	21
5310	*Laurus nobilis* thickets	–	–	–	–	–	–	1	1
5330	Thermo-Mediterranean and pre-desert scrub	–	–	1	5	1	–	–	7
6310	Dehesas with evergreen *Quercus* spp.	–	–	4	2	1	–	1	8
9110	Luzulo-Fagetum beech forests	2	5	10	6	14	2	1	38
9130	Asperulo-Fagetum beech forests	1	5	8	4	10	1	1	29
9140	Medio-European subalpine beech woods with Acer and Rumex arifolius	–	1	–	2	1	–	–	4
9150	Medio-European limestone beech forests of the Cephalanthero-Fagion	–	–	1	4	2	1	–	8
9160	Sub-Atlantic and medio-European oak or oak-hornbeam forests of the Carpinion betuli	–	–	–	1	1	–	–	2
9180[a]	Tilio-Acerion forests of slopes, screes and ravines	1	–	–	2	10	1	–	13
91AA	Eastern white oak woods	–	–	6	9	21	7	8	51
91B0	Thermophilous *Fraxinus angustifolia* woods	–	–	–	2	2	–	–	4
91E0[a,b]	Alluvial forests with *Alnus glutinosa* and *Fraxinus excelsior* (Alno-Padion, Alnion incanae, Salicion albae)	1	1	3	7	12	1	2	26
91F0	Riparian mixed forests of *Quercus robur*, *Ulmus laevis* and *Ulmus minor*, *Fraxinus excelsior* or *Fraxinus angustifolia*, along the great rivers (Ulmenion minoris)	–	–	–	3	3	–	–	6
91H0[a]	Pannonian woods with *Quercus pubescens*	–	–	1	1	9	1	–	12
91K0	Illyrian *Fagus sylvatica* forests (Aremonio-Fagion)	1	1	1	8	13	2	–	25
91L0	Illyrian oak-hornbeam forests (Erythronio-carpinion)	–	–	1	4	4	1	1	11
91M0	Pannonian-Balkanic turkey oak – sessile oak forests	–	1	2	10	17	8	3	41
9210[a]	Apeninne beech forests with *Taxus* and *Ilex*	1	–	2	11	21	4	3	41
9220[a]	Apennine beech forests with *Abies alba* and beech forests with *Abies nebrodensis*	–	3	10	7	23	4	4	51
9250	*Quercus trojana* woods	–	–	–	1	–	–	–	1
9260	*Castanea sativa* woods	–	3	10	6	26	9	4	59
92A0	*Salix alba* and *Populus alba* galleries	–	3	8	17	21	5	5	59
92D0	Southern riparian galleries and thickets (Nerio-Tamaricetea and Securinegion tinctoriae)	–	–	–	1	2	–	1	4
9320	*Olea* and *Ceratonia* forests	–	1	–	1	–	2	–	4
9330	*Quercus suber* forests	–	2	5	14	10	5	6	42
9340	*Quercus ilex* and *Quercus rotundifolia* forests	1	5	14	32	28	14	10	104
9350[b]	*Quercus macrolepis* forests	–	–	–	–	1	–	–	1
9380	Forests of *Ilex aquifolium*	–	–	1	–	1	–	–	2
9410	Acidophilous *Picea* forests of the montane to alpine levels (Vaccinio-Piceetea)	6	7	13	8	7	3	5	43
9420	Alpine *Larix decidua* and/or *Pinus cembra* forests	3	5	8	8	10	2	5	38
9430[a]	Subalpine and montane *Pinus uncinata* forests (if on gypsum or limestone)[a]	–	–	–	1	–	–	1	2
9510[a]	Southern Apennine *Abies alba* forests	–	7	14	13	24	6	4	68
9530[a]	(Sub-) Mediterranean pine forests with endemic black pines	–	1	3	2	7	3	1	17
9540	Mediterranean pine forests with endemic Mesogean pines	–	2	2	2	3	–	1	10
95A0	High oro-Mediterranean pine forests	–	–	2	–	4	–	2	8

Notes: In the last column, the number of EN species, including those assigned to CR, EN and VU categories, is reported.
[a] Prioritary habitats according to the Habitat directive.
[b] Declining habitats according to Petrella et al. (2005) and MATTM (2008).

as RE, but further research should better clarify their status.

Two hundred and thirteen species, corresponding to 27% of the epiphytic lichens of Italy, are included among threat categories: 64 are listed as CR, 75 as EN and 74 as VU. Most of CR species are also likely to have a declining trend and/or are associated with a declining habitat and/or are extremely sensitive to human disturbance.

Fifty-eight species are listed as NT, including lichens that are still relatively common but likely to be declining since information is missing from more than 50 years for some of the Italian regions where they were formerly found or since they are associated with declining habitats.

Twenty species are listed as LC (still relatively common and not experiencing decline).

Fifty-four species are listed as DD requiring further information for their red listing evaluation.

Most species (330) were found to occur in Natura 2000 habitats. Data on the correspondence between species and habitats are not presented here due to space constraint and will be published in a forthcoming paper. A synthesis is presented in Table I where for 44 Natura 2000 habitats the number of species in each IUCN category is reported: 12 habitats, mainly including beech, silver fir, spruce, larch, chestnut, oak forests and riparian forests host more than 50 EN species.

4. Discussion

The red list proposed in this paper condenses the best available knowledge in a form useful for considering epiphytic lichens in the national conservation framework. It represents a compromise between the rigorous application of IUCN (2001) criteria and the need to provide a reliable tool for practical use in conservation policies, providing a basis for further, indispensible and advancements (Dahlberg & Mueller 2011).

For Italy, there was a huge gap between the four epiphytic species assessed for their conservation status (Ravera & Giordani 2008a, 2008b; Nascimbene & Tretiach 2009; Benesperi & Ravera 2011) and the c. 800 epiphytic lichens known from the country. This was likely to give a distorted picture of the relevance of this guild for biodiversity conservation, and of its threats. Our results indicate that more than one-fourth of the epiphytic lichens of Italy are likely to be threatened, so that further research and effort are needed to include lichens in the main national conservation plans. Recently, this process was encouraged by the Important Plant Areas project (Blasi et al. 2011; Ravera et al. 2011), where a list of lichens of conservation concern was used for site selection, together with plants, bryophytes and non-lichenized fungi. The evaluation of the importance of Natura 2000 habitats for lichen conservation is rapidly increasing as well, covering a wide range of environments, including Alpine ecosystems (Nascimbene et al. 2012), riparian forests (Nascimbene et al. 2008), dunal habitats (Potenza et al. 2010) and chestnut woods (Matteucci et al. 2012).

Habitat protection is one of the main strategies in biodiversity conservation, and the habitat-based approach is so far considered as the most effective conservation practice for lichens (Hallingbäck 2007). For this reason, in preparing this contribution, we dedicated relevant effort to supply up-to-date information on the occurrence of species in Natura 2000 habitats. This information, combined with the assessment of the conservation status of the species, provides a practical basis to include lichens in management plans of Natura 2000 sites.

This work highlights the lack of information which still hampers the detailed, rigorous, evaluation of lichen species against IUCN criteria. This gap should be addressed with further research, to considerably increase the number of species which are evaluated in detail, in order to provide a solid basis for monitoring lichen trends in the future and supporting science-based conservation actions.

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