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Evaluation of the Conservation Status of Threatened Lichens List from Coastal areas of the Valencian Community (Eastern Spain)

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Résumé – L'état actuel de conservation des populations de onze espèces de lichens menacées, des zones côtières de la Communauté de Valence, est analysé. Les cartes et l'aire de distribution actuellement connue sont aussi présentées. Des populations de lichens menacés ont été sélectionnées au hasard et ont été quantitativement étudiées par un comptage du nombre d'individus et une estimation de la surface du substrat colonisé pour de futurs suivis. Le déclin actuel, projeté ou suspecté des populations de ces espèces de lichens est discuté en fonction de leurs habitats. La plupart des menaces rencontrées sont dues à des activités humaines telles que l'urbanisme et le feu. A partir de cette information, les catégories et critères de l'IUCN ont été revus pour ces espèces de lichens. Les perspectives futures pour ces populations sont envisagées en fonction de l'état de conservation actuel de leur habitat et leur gestion.

Lichens côtiers menacés / Conservation / Valencia / IUCN categories / Espagne

Abstract – The current conservation status of populations of eleven threatened lichens from coastal areas of the Valencian Community is analysed. Maps and current known distribution are also provided. Randomly selected threatened lichen populations have been quantitatively studied by counting the number of individuals and estimating the area of substrate colonisation for future surveys. Present, projected or suspected decline in populations of these lichen species is noticed by inspection of their habitats. Most of the threats found are due to human activity in the form of urbanism and fires. With this information in mind, the IUCN categories and criteria were reassigned to the lichen species. Future perspectives of these populations are speculated according to present day habitat conservation and management.

Threatened coastal lichens / Conservation / Valencia / IUCN categories / Spain

INTRODUCTION

Although many strategies have been successfully applied to vascular plant conservation in Spain (see review in Laguna-Lumbreras, 1998), cryptogams have been omitted because of the lack of information of their conservation status therefore being other organism prioritised over them. However, during the past decade, there has been increased interest on lichen conservation in the Iberian Peninsula resulting on the first production of species catalogues, for several territories (Carballal *et al.*, 1995; Atienza & Segarra, 1999a; Llimona & Hladún, 2001). A second step forward resulted on the tentative inclusion of certain species in Red Lists (Carballal *et al.*, 1999; Atienza & Segarra, 2000; Martínez *et al.*, 2003) based on the modification of the criteria applied to vascular plants to accommodate cryptogams (Church *et al.*, 1996; Hodgetts, 2000).

Nevertheless there are some lichen taxa that appear to be naturally rare. Most endangered lichen species face the risk of population decline, even global extinction, because of several factors derived from human activity. The sensitivity exhibited by many lichens to environmental pollution (Richardson, 1992), because the increase of habitat alteration due to fires, forestry management and urbanism (Thor, 1995). These factors added to the unsuitability of the *ex situ* conservation strategies used for plants (i.e. germplasm collections, cultivation in botanical gardens) for these symbiotic organisms, makes that conservation of lichens still remains a matter of concern. All this indicates that the maintenance of populations of a certain lichen species, can only be ensured by the conservation of the habitat and community in which it develops. Thus one can expect that lichen species occurring within the perimeter of Natural Parks and other protected areas are better preserved; however, this is not the case for many endangered lichen taxa which inhabit small areas in non-protected areas.

Although a number of species were included in the preliminary Red List of the Valencian Community (Atienza & Segarra, 2000), this study has focussed on a smaller sample of species that are confined to coastal habitats because of: (i) conversely to other areas, these ones have been subjected to intense lichen surveys (Alonso & Egea, 1989; 1994a; 1994b; Alonso *et al.*, 1989; Egea, 1989; Egea & Llimona, 1984; Egea & Torrente, 1985; Llimona, 1980) and consequently large data-sets are available, and (ii), these habitats have declined exponentially in Valencian Community territory during the past years due to man activity. In addition the Mediterranean vegetation of coastal rocky shores have been listed as a Priority Habitat (annex I) by the European Union Habitats Directive 92/43/CEE, since they house the only extant populations of many rupicolous endemic plants world-wide. With this in mind, the goal of the present work is evaluate the conservation status of the endangered lichens populations inhabiting coastal areas; so that a methodology can be developed to monitor lichen populations for conservation and management tasks.

MATERIAL AND METHODS

The Valencian region (Spain) includes three provinces (Alicante, Valencia and Castellón), covering about 24.000 km^2 which are located along the Eastern coast of Spain. In this study populations of eleven regional Red-list lichens (Atienza & Segarra, 2000) found along the coastal areas were studied. Seven of these taxa

Table 1. Location and ecological data of the sites studied.

N°	*Site*	*Province*	*UTM grid*	*Altitude m*	*Substrate*	*Vegetation*
1	La Caleta	Alicante	31SBC5794	50	Limestone rocks	Rupicolous plants
2	Cabo S. Antonio	Alicante	31SBC555997	130	Limestone rocks	Rupicolous plants
3	Cabo de la Nao	Alicante	31SBC5991	170	Limestone rocks	Rupicolous plants
4	Illa Grossa	Castellón	31SCE022193	60	Basaltic rocks	Rupicolous plants
5	Massenes	Alicante	31SBC5294	60	*Pinus halepensis*	*P. halepensis* stands
6	La Granadella	Alicante	31SBC5591	150	*Quercus coccifera*	*Q. coccifera* forest
7	La Guardia	Alicante	31SBC5792	140	*Pinus halepensis*	*P. halepensis* stands
8	Puebla de Benifassar	Castellón	31TBF695043	750	*Quercus ilex*	*Q. ilex* forest
9	La Murta	Valencia	30SYJ2834	50	*Quercus coccifera/ Olea europaea*	*Q. coccifera* forest
10	El Marenyet	Valencia	30SYJ3836	10	*Cupressus sempervirens*	*C. sempervirens* stands

are saxicolous: *Anema suffruticosum*, *Arthonia meridionalis*, *Dirina immersa*, *Dirina paradoxa* subsp. *africana*, *Ingaderia troglodytica*, *Lecanographa subgrumulosa*, *Opegrapha lutulenta*; the remaining four are epiphytes: *Parmotrema hypoleucinum*, *Ramalina lacera*, *Ramalina pusilla*, *Schismatomma albocinctum*.

Several sites were selected (Table 1) on the basis of previous studies such as the check-list of the area in Atienza & Segarra, 1999a, and other following addenda (Atienza & Segarra 1999b, 2000, Atienza *et al.,* 2001). At each site the habitat of the species was re-inspected and the populations of each species located by using square quadrats/grid of 10 cm^2 randomly. The total number of squares established varied according to the population size of the species considered. For each quadrat the average cover was estimated following Puche & Gimeno (2000) and Atienza & Segarra-Moragues (2002); also the number of thalli were counted to conduct a census. Thus, for well-delimited crustaceous, fruticulose and foliose lichens, continuous and conspicuous thalli were assumed to belong to a single individual. However, for certain cases, as previously acknowledged for bryophytes (Hallingbäck *et al.*, 1998), it is impossible to determine what constitutes an individual. In order to overcome this, therefore we have considered each separate area occupied by lichen thalli in each quadrat as a single individual.

Number of thalli and percentage of substrate colonization is given in Figs 1 to 3, also mean percentage values of lichen taxa in each studied locality are given in Table 2.

The conservation status of the species was classified using the IUCN (1994) and the IUCN (2001, revised version) guidelines. Threat categories were assigned to the selected lichen taxa at regional scale within The Valencian Community. These categories were interpreted according to Hodgetts (2000) and comply with the modifications of Church *et al.* (1996). Only three categories were considered for the taxa studied: **CR**, for Critically Endangered; **EN**, for Endangered and **VU** for Vulnerable. Because of the unavailability of previous surveys on the population dynamics of these taxa the criteria **A**, **C** and **E** (as in Church *et al.*, 1996) were not used. Criterion **B** is applied to taxa with a narrow distribution area, which are present in few localities (no

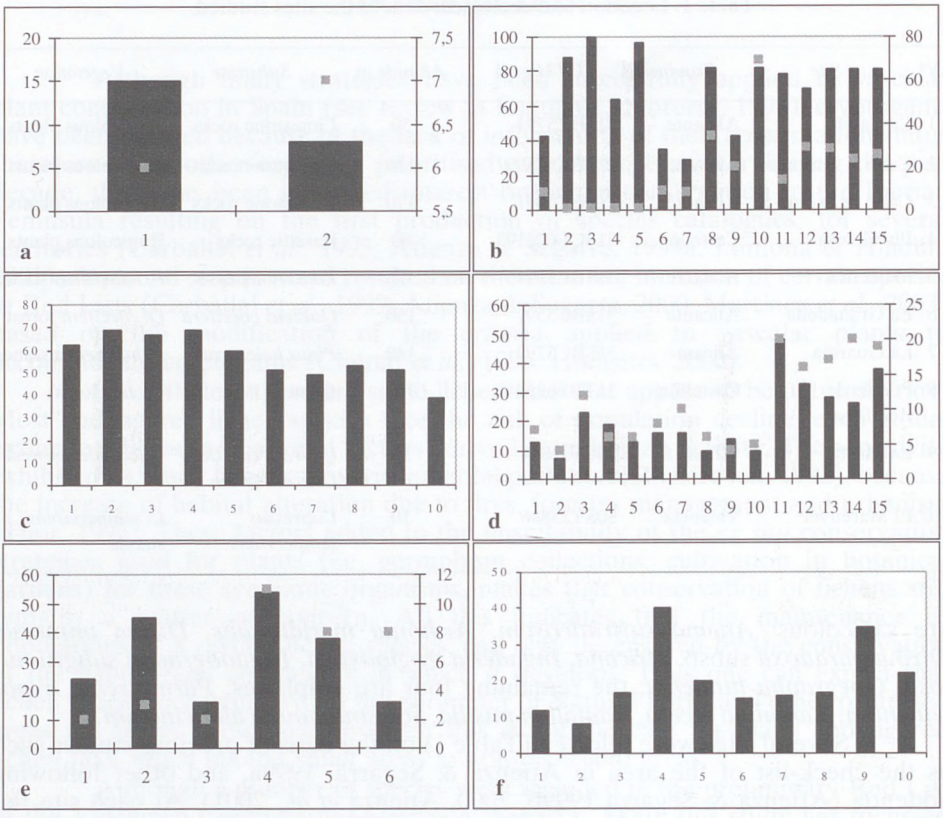

Fig. 1. Number of thalli (grey squares, right axis) and percentage of substrate colonisation (black bars, left axis) for the lichen taxa surveyed in each plot. a) *Arthonia meridionalis*, plots 1-2, site 1; b) *Dirina immersa*, plots 1-5, site 2; plots 6-10, site 1; plots 11-15, site 3; c) *Dirina paradoxa* subsp. *africana*, plots 1-10, site 4; d) *Ingaderia troglodytica*, plots 1-10, site 2; plots 11-15, site 1; e) *Lecanographa subgrumulosa*, plots 1-6, site 2; f) *Opegrapha lutulenta*, plots 1-10, site 4.

more than one hectad for CR, two to five for EN and six to ten for VU) and whose population are declining or prone to decline in the near future. Criterion **D** was applied to taxa with small population sizes (< 50 mature individual for CR, < 250 mature individuals for EN, and < 1000 mature individuals for VU D1 and with restricted habitat or known from up to four localities for **VU D2**). Total number of 10 × 10 Km squares in Valencian Community is given in Table 3. Threats that affect selected taxa are indicated by numbers (Table 3) following the system set up by IUCN to species proposal red-list questionarie assessment (see http://iucn.org/themes/ssc/redlist/RLcats2001booklet.html). Threats can be due to intrinsic factors (i.e. low densities, poor recruitment, small number of known populations or small population size, for "naturally rare" species) but more often they are extrinsic and mainly derived from human disturbance or are human induced (infrastructure development due to tourism/recreation activities and fires). These threats were encoded by the numbers: **1**, restricted range/poor recruitment; **2**, forest management activities/agriculture crops; **3**, tourism/recreation; **4**, fires; **5**, urbanism infrastructure development; **6**, habitat loss/degradation and **7**, deforestation.

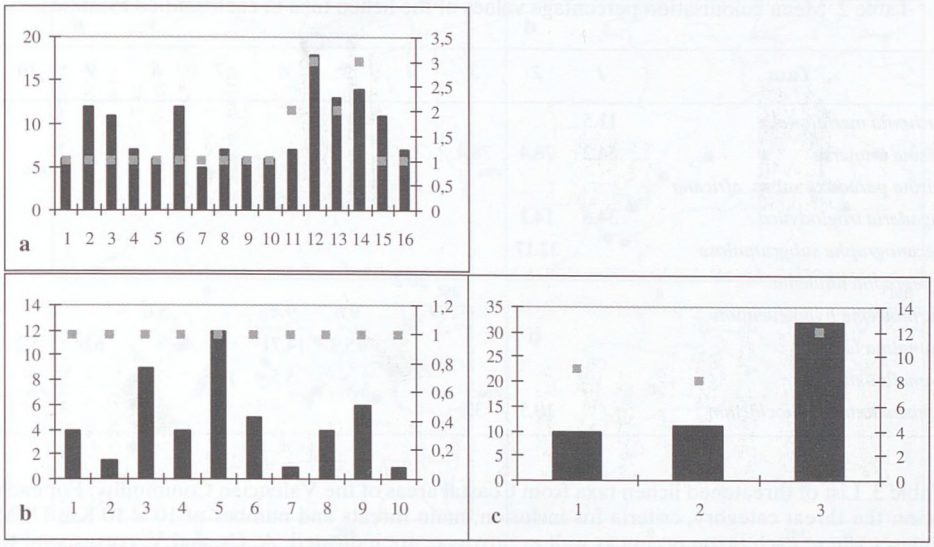

Fig. 2. Number of thalli (grey squares, right axis) and percentage of substrate colonisation (black bars, left axis) for the lichen taxa surveyed in each plot. a) *Parmotrema hypoleucinum*, plots 1-5, site 5; plots 6-15, site 6; plot 16, site 7; b) *Ramalina pusilla*, plot 1, site 5; plots 2-6. site 7; plots 7-9, site 6; plot 10, site 9. c) *Schismatomma albocinctum* plots 1-2 site 2. plot 3 site 3.

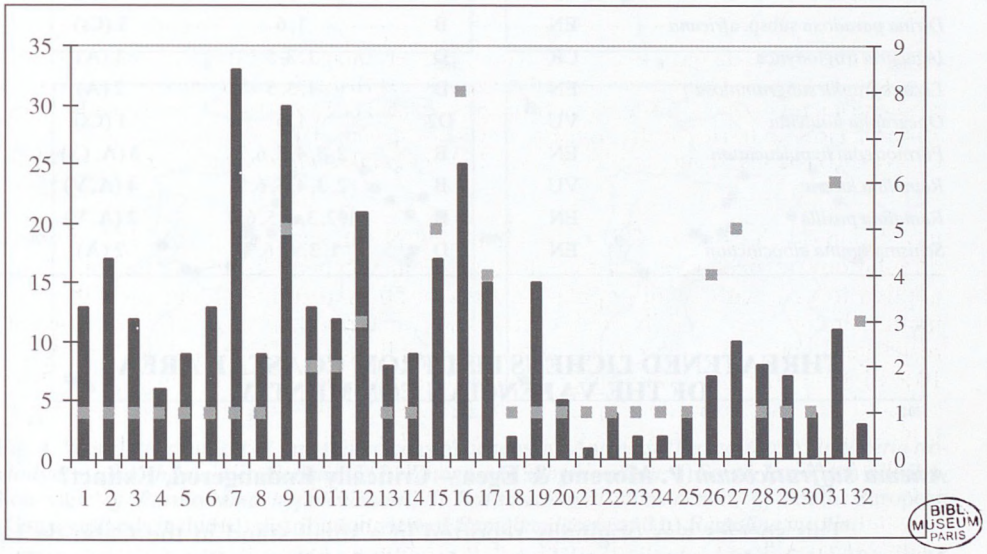

Fig. 3. Number of thalli (grey squares, right axis) and percentage of substrate colonisation (black bars, left axis) of *Ramalina lacera* in each plot. Plots 1-7, site 5; plots 8-17, site 6; plots 18-27, site 10; plots 28-32, on *Olea europaea*, site 9.

Table 2. Mean colonisation percentage values of the lichen taxa in each studied localities.

Taxa	*1*	*2*	*3*	*4*	*5*	*6*	*7*	*8*	*9*	*10*
Arthonia meridionalis	11.5									
Dirina immersa	54.2	78.4	78.4							
Dirina paradoxa subsp. *africana*				57						
Ingaderia troglodytica	34.6	14.1								
Lecanographa subgrumulosa		32.17								
Opegrapha lutulenta				20.2						
Parmotrema hypoleucinum					9.6	9.4		5.6		
Ramalina lacera					15.9	14.71			6.6	5.2
Ramalina pusilla					-	5.5	12.5		-	
Schismatomma albocinctum		10.5	32							

Table 3. List of threatened lichen taxa from Coastal areas of the Valencian Community. For each taxon the threat category, criteria for inclusion, main threats and number of 10 × 10 Km UTM squares where each taxon occurs as well as province, are indicated. A, Cs, and V, correspond to Alicante, Castellón and Valencia provinces respectively.

Taxa	*Category*	*Criteria*	*Threats*	*Total number of 10 Km² squares*
Anema suffruticosum	CR, EX?	D	1, 3	1 (A)
Arthonia meridionalis	VU	D2	1, 3, 5	2 (A)
Dirina immersa	VU	D2	3, 5	3 (A)
Dirina paradoxa subsp. *africana*	EN	B	1, 6	1 (Cs)
Ingaderia troglodytica	CR	D	1, 3, 5	1 (A)
Lecanographa subgrumulosa	EN	D	1, 3, 5	2 (A)
Opegrapha lutulenta	VU	D2	1, 6	1 (Cs)
Parmotrema hypoleucinum	EN	B	2, 3, 4, 5, 6, 7	3 (A, Cs)
Ramalina lacera	VU	B	2, 3, 4, 5, 6, 7	4 (A, V)
Ramalina pusilla	EN	B	1, 2, 3, 4, 5, 6, 7	2 (A, V)
Schismatomma albocinctum	EN	D	1, 3, 4, 6, 7	2 (A)

THREATENED LICHENS LIST FROM COASTAL AREAS OF THE VALENCIAN COMMUNITY

Anema suffruticosum P. Moreno & Egea – Critically Endangered, Extinct?

This species was originally reported in a small stand in the Cabo de La Nao a frequented tourism recreation area located in Alicante Province coast. The type locality is the only site known in the Iberian Peninsula for this species. In this area a population not bigger than 50 thalli of *A. suffruticosum* was reported from calcareous rocks of the coastal cliff at 150 m. a. s. l. in ornithocoprophyle lichen communities that are exposed to high light and temperature conditions during

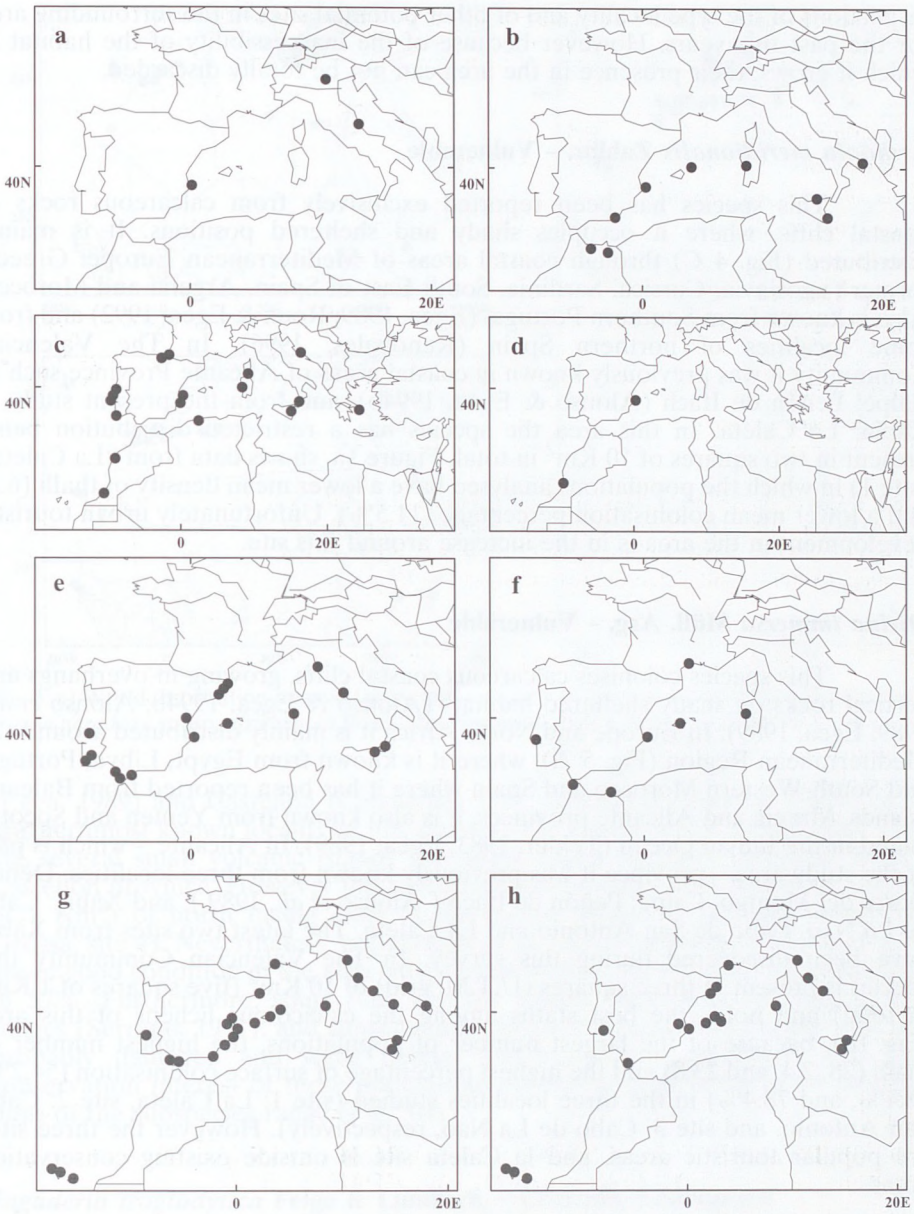

Fig. 4. World distribution of threatened coastal lichens: a) *Anema suffruticosum*; b) *Ingaderia troglodytica*; c) *Arthonia meridionalis*; d) *Lecanographa subgrumulosa*; e) South European distribution view of *Parmotrema hypoleucinum*; f) *Schismatomma albocinctum*; g) South European (Canary islands included) distribution view of *Ramalina lacera* and h) *Ramalina pusilla*.

summer (Moreno & Egea, 1992). Recently it has been discovered in two Italian localities (Nascimbene, 2002), being this its whole world distribution (Fig. 4A). The existence of the only known Iberian population of *A. suffruticosum* has not been confirmed in the area since its description in spite of several carefull

inspections of the type locality and of other potential sites in the surrounding area for the past five years. However because of the inaccessibility of the habitat in which it grows, their presence in the area can not be totally discarded.

***Arthonia meridionalis* Zahlbr. – Vulnerable**

This species has been reported exclusively from calcareous rocks of coastal cliffs, where it occupies shady and sheltered positions. It is mainly distributed (Fig. 4 C) through coastal areas of Mediterranean Europe: Greece, formerYugoslavia, Corsica, Sardinia, South East of Spain, Argelia and Morocco. Also is known from Southern Portugal (Egea, 1989; Roux & Egea, 1992) and from some localities of northern Spain (Renobales, 1996). In The Valencian Community it was previously known in coastal areas of Alicante Province such as Calpe: Peñón de Ifach (Alonso & Egea, 1994b), and from the present study in Xàbia: La Caleta. In this area the species has a restricted distribution being present in two squares of 10 Km^2 in total. Figure 1a, shows data from "La Caleta" (site 1) in which the populations analysed have a lower mean density of thalli (6.5) and a lower mean colonisation percentage (11.5%). Unfortunately urban touristic development in the area is in the increase around this site.

***Dirina immersa* Müll. Arg. – Vulnerable**

This species colonises calcareous coastal cliffs, growing in overhangs and vertical rocks on shady sheltered habitats (Alonso & Egea, 1994b; Alonso *et al.*, 1989; Egea, 1989). In Europe and North Africa it is mainly distributed around the Mediterranean Region (Fig. 5 A), where it is known from Egypt, Libya, Portugal and South-Western Morocco and Spain where it has been reported from Balearic Islands, Murcia and Alicante provinces, it is also known from Yemen and Socotra Island in the Indian Ocean (Tehler, 1983, Egea, 1989). In Alicante – which is part of the study area – province it was previously known from three localities: Dènia: Sierra del Montgó, Calpe: Peñón de Ifach (Alonso *et al.*, 1989), and Xàbia: Cabo de La Nao, Cabo de San Antonio and La Caleta. The latest two sites from Xàbia have been discovered during this survey. In The Valencian Community this species is present in three squares (U.T.M. grid) of 10 Km^2 (five squares of 1 Km^2 in total) and holds the best status among the calcicolous lichens of this area (Fig. 1b), because of the largest number of populations, the highest number of thalli (28, 2.4, and 23.8) and the highest percentage of surface colonisation (54.2%, 78.4%, and 78.4%) in the three localities studied (site 1: La Caleta, site 2: Cabo San Antonio, and site 3: Cabo de La Nao, respectively). However the three sites are popular touristic areas, and la Caleta site is outside existing conservation areas.

***Dirina paradoxa* subsp. *africana* (Fée) Tehler – Endangered**

This saxicolous species occurs in basaltic rocks in vertical coastal cliffs in Northern exposures directly influenced by the sea water spray. The subspecies *africana* has its core distribution (Fig. 5B) in the Mediterranean (incl. Northern Africa), The Canary Islands and Atlantic coast of Northern Africa. It is also known from Cabo Verde, Senegal, Yemen and Socotra Island (Tehler, 1983). In Spain it has been reported from four coastal provinces: Almería, Cádiz, Murcia

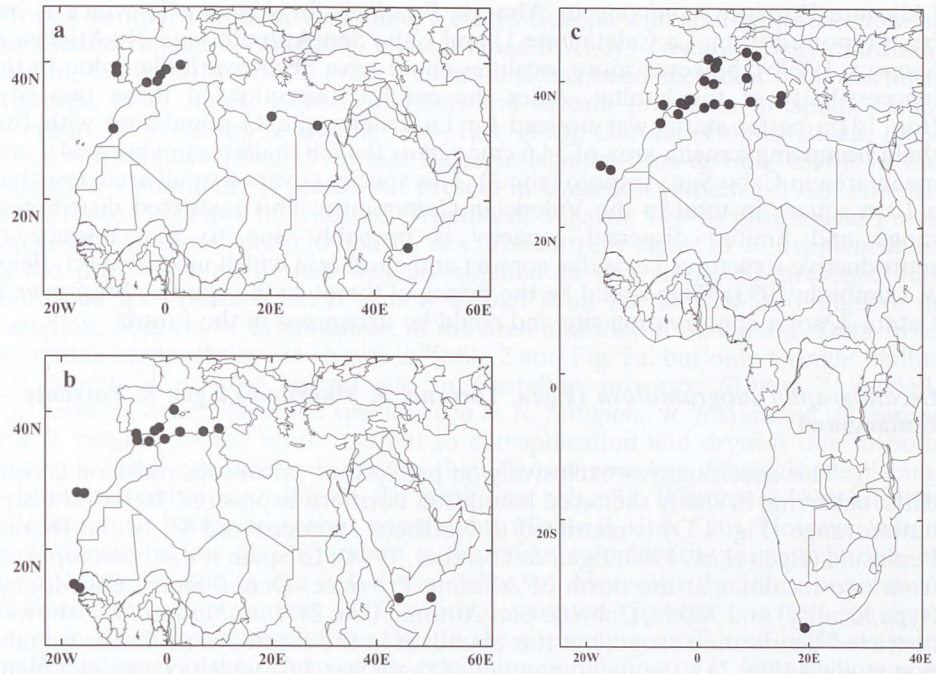

Fig. 5. a) World distribution map of *Dirina immersa*; b) Europe and North Africa distribution of *Dirina paradoxa* subsp. *africana*. c) World distribution map of *Opegrapha lutulenta*.

(Egea, 1989) and Castellón (Calatayud, 1998, Atienza & Segarra, 1999b) as the northernmost known locality of this taxon in The Columbretes archipelago. These are several small volcanic islands and islets, about 30 miles from the coast of Castellón province. However this taxon colonizes a small area (less than a square of 1 Km^2) of north facing cliffs in the biggest island of the archipelago (Illa Grossa, site 4). Nevertheless, populations of *D. paradoxa* subsp. *africana* (Fig. 1c) are in good condition in the area with a mean percentage of substrate colonisation of 57%. Furthermore, some time ago the islands were used for marine firing ranges (Serrano, 1991), and subsequently both cliffs and lichen populations were probably damaged and some habitat loss could have occurred. The main conservation interest of these populations resides in their being at the northern limit of the subspecies range (Fig. 5B).

Ingaderia troglodytica Feige & Lumbsch. – Critically Endangered

This is the only Mediterranean species of the genus *Ingaderia* which includes two more species with a disjunct distribution in South America (Feige & Lumbsch, 1993). *I. troglodytica* grows exclusively on calcareous vertical rocks and overhangs of coastal cliffs in shady and sheltered habitats. Its world distribution (Fig. 4 B) encompasses four sites in Italy, including Sicily and Sardinia Islands (Nimis & Tetriach, 1999; Obermayer, 1994), Morocco and Spain where is known from the type locality in Minorca (Balearic Islands; Feige & Lumbsch, *opus cit.*) and three mainland localities, two of them in the Valencian Community area

(Alicante Province) and one in Almería Province. In Alicante Province it has been reported from: La Caleta (site 1) and Cabo San Antonio (site 2) (Atienza & Segarra, 1999b); however more localities could have been overlooked due to the inaccessibility of the habitat. After the careful inspection of these two sites (Fig. 1d) a better status was noticed for La Caleta (site 1) population with 18.4 thalli occupying a mean area of 34.6 cm^2 *versus* the 6.8 thalli occupying a 14.1 cm^2 mean area in Cabo San Antonio (site 2). This species covers a small area, less than a 10 m square in total in the Valencian Community. This restricted distribution range and limited dispersal capacity is probably due to the absence of reproductive structures i.e. isidia, soredia and apothecia which unknown (cf. Feige & Lumbsch, 1993). This would be the principal threat to the species. Moreover la Cateta is not a conservation site and could be urbanized in the future.

***Lecanographa subgrumulosa* (Egea, Torrente & Manrique) Egea & Torrente – Endangered**

This species grows exclusively on precipitous calcareous rocks on coastal cliffs, occurring in shady sheltered habitats in northern exposures. Its world distribution range (Fig. 4 D) is restricted to Northern Morocco and SE of the Iberian Peninsula (Egea *et al.*, 1993; Egea & Torrente, 1994). In Spain it has been reported from two localities at the north of Alicante Province: Denia, Sierra del Montgó (type locality) and Xàbia, Cabo de San Antonio (site 2). *L. subgrumulosa*, shows a restricted distribution range, but it is abundant in the studied area. In the population studied (Fig. 1e), the mean number of thalli was 5.67 which occupied a mean area of 32.17 %. This species is often accompanied by *Dirina immersa* and *Ingaderia trogloditica* populations. In The Valencian Community this species is known of two squares of 10 Km^2 in total. Restricted range coupled with tourism impact on the environment are the mean threats to this species.

***Opegrapha lutulenta* Nyl. – Vulnerable**

This saxicolous species grows on crevices and vertical acid rocks in rather shaded habitats in coastal areas of the Western Mediterranean and Macaronesia (Canary Islands) regions. It is known (Fig. 5 C) from Algeria, France (Eastern Pyrenees), Italy (Liguria, Toscana, Sardinia and Sicily) and Morocco (Torrente, & Egea, 1989). In mainland Spain it spreads through several provinces: Almería, Cádiz, Murcia, Catalonian coasts and also in Mallorca (Balearic Islands). In the Valencian Community it has a restricted distribution range in the Columbretes archipielago (Castellón province), where it colonises basaltic substrata in northern cliffs of the Illa Grossa (site 4). As in the case of *Dirina paradoxa* subsp. *africana*, the populations of *O. lutulenta* were affected in the past by marine fire practices. The damage caused by such activities to the populations is uncertain but the fact is that *O. lutuenta* (Fig. 1f) is not abundant, colonising only an average 20.2%, so the habitat of this species could have well been damaged. Although the species is also known from north of the Iberian Peninsula coasts and coast of North Africa, the rarity of coastal acid rocks in the Valencian Community makes its future uncertain.

***Parmotrema hypoleucinum* (J. Steiner) Hale – Endangered**

This epiphytic species occurs on bark of conifer and deciduous trees in temperate shaded areas with high atmospheric humidity. It spreads (Fig. 4 E)

through Southern Atlantic areas and Western Europe with spotted distribution in the Mediterranean region (e. g. coastal areas of Italy: Toscana, Sicily, Sardinia, Latium, Calabria). In the Iberian Peninsula it has been recorded from Portugal (Tavares, 1945; Jones, 1980; Fos, 1998) and several provinces of Spain: Cádiz (Werner, 1975; Crespo & Bueno, 1984; Fos, 1998), Gerona (Gómez-Bolea, 1985; Fos, 1998), Huelva (Fos, 1998) and Balearic Islands (Mus & Fiol, 1990). In the Valencian Community is scarce but present in Castellón (Atienza, 1990; Atienza & Barreno, 1991) and in Alicante (Atienza & Segarra, 1999b) growing on *Pinus halepensis*, *Quercus coccifera* and *Q. ilex*. The current status of *P. hypoleucinum* in the previously cited sites was investigated in this study. Its presence was confirmed for Alicante but it is now extinct from the locality of Traiguera in Castellón, because of urbanisation in the area and loss of its habitat. Data from the remaining localities are shown in Table 2 and Fig. 2a, but only a single thallus was found in a more inland site in Castellón province (Table 2, site 8). Furthermore other *Ramalina* species such as *R. fastigiata, R. fraxinea, R. farinacea* and *R. canariensis* are more tolerant to eutrophication and dryness due to both inorganic fertilisers and cattle grazing than *Parmotrema hypoleucinum*, displacing it from its habitat e.g.: Puebla de Benifassar (site 8). Fortunately the sites in Alicante have better preserved populations (Table 2, sites 5, 6). However mean thalli density is low (1-1.6) and so is the mean colonisation percentage, 9.6, in site 5: Massenes and in site 6, la Granadella, 9.4. Moreover the latter population survived the fire in summer 2000 which devastated *Quercus* coccifera garrigue forest in the surroundings of the site. In the site only a small area of 50 m^2 with unaffected trees is the refuge of the remaining population of *P. hypoleucinum*. A decline of the phorophyte population is going to have a direct impact on the expansion of *P. hypoleucinum* and other associate lichen species as *Ramalina pusilla* and *R. lacera*. The habitat loss by development due to increased tourism is also evident in La Guardia and Massenes (sites 7 and 5 respectively).

P. hypoleucinum has been mentioned in the first European Red-List of macrolichens as Vulnerable (Serusiaux, 1989). In the Valencian area the habitat loss or deterioration due to urban development, and fires is the clearest cause of the decline of the species. The total number of sites in the Community is three.

***Ramalina lacera* (With.) J.R. Laundon – Vulnerable**

This is an epiphytic species like the previous taxon grows on bark of several conifer and deciduous trees on rather shaded sheltered habitats with high atmospheric humidity. It is present in Atlantic and Mediterranean areas from southern Scandinavia, Scotland, Portugal (Estremadura, Algarve) and Macaronesia (The Canary Islands) (Werner, 1975; Krog & James, 1977; Jones, 1980; Krog & Osthagen, 1980; Hernandez-Padrón, 1987; Arroyo, 1991) to Mediterranean coast of Italy (Sardinia and Sicily) (Nimis, 1993) and south- and eastern coasts of Spain. It has also been reported from North America (California) (Brodo *et al.*, 2001). In Spain (Fig. 4 G), it is restricted to some coastal localities of Cádiz, (Fos, 1998) Gerona, Tarragona (Gómez-Bolea, 1985), Huelva, Murcia, Almería, Balearic Islands (Mallorca, Menorca, Ibiza and Formentera) (Arroyo, 1991), Alicante and Valencia (Atienza, 1990, Atienza & Barreno, 1991; Atienza & Segarra, 1999a). In the two latest provinces belonging to the Valencian Community, *Ramalina lacera* grows on *Pinus halepensis*, *Quercus coccifera* and *Q. ilex* where it is often accompanied by *Parmotrema hypoleucinum* and *Ramalina pusilla*. In the studied sites (Fig. 3) it is abundant with mean thalli density of

1-3.2, and the populations are healthy. Nevertheless the populations (sites 5, 6) of Alicante are in a better conservation status, as the thalli are bigger (15.9%-14.71% of mean substrate colonisation) than those in sites 9 and 10 of Valencia (6.6%-5.2% of mean substrate colonisation), probably because of the better conservation of the tree canopy and general habitat conditions. Moreover its endangered status is evidenced because in some of the studied sites (9, 10) it grows on cultivated phorophytes and consequently more prone to alterations due to human agricultural activities; e.g. the lower branches of the trees in which *R. lacera* grows are removed in El Marenyet (site 10). The main threats to this species range from eutrophication caused by inorganic fertilisers used in agriculture to fires (summer 2000 fire in la Granadella site). Also the habitat is being lost to urban development due to increased tourism; e.g. La Guardia and Massenes sites. Fos (1998) pointed out the absence of this species in some localities of Gerona where it was previously known. Total number of sites occupied by *R. lacera* in the Valencian Community is four.

***Ramalina pusilla* Le Prév. *ex* Duby – Endangered**

This epiphytic species has similar ecological requirements to those of *R. lacera* and *Parmotrema hypoleucinum* but a much more restricted distribution area. Its worldwide distribution (Fig. 4 H) ranges from the Mediterranean coast of France, West of Italy, and Spain, to the coasts of Algeria, Portugal, The Canary Islands and the Azores (Harmand, 1909, Abbayes, 1954, Werner, 1975; Krog & Osthagen, 1980; Hernandez-Padrón, 1987, Clauzade & Roux, 1985, Nimis, 2003). In the Iberian Peninsula it has been reported from Cádiz, Gerona (Fos, 1998), the Balearic Islands (Llimona, 1976; Tonsberg, 1980; Hoffman, 1990) Alicante (Atienza & Segarra, 1999b) and Valencia (the present). It has been collected on bark of *Olea europaea*, *Pinus halepensis* and *Quercus coccifera*. *R. pusilla* (Fig. 2b) forms low density populations in the south of Valencia (site 9) and the north of Alicante (sites 5, 6, 7). The number of thalli per site was very low with only one thallus found per site. Its mean percentage of colonisation is also low (1%-6.3%) because of the small size of its thallus and the competition for the habitat with other, more invasive, *Ramalina* species such as *R. calicaris* (L.) Fr., *R. canariensis* J. Steiner, *R. farinacea* (L.) Ach. *R. fastigiata* (Pers.) Ach. and *R. fraxinea* (L.) Ach.). The later *Ramalina* species tolerates eutrophication and dryness due to both inorganic fertilisers and cattle grazing better than *R. pusilla* displacing it from its habitat. Habitat loss due to touristic development is also evident in La Guardia and Massenes (sites 7 and 5 respectively). As in the case of *Parmotrema hypoleucinum*, the populations of *R. pusilla* were affected by a fire in summer 2000 which devastated the populations of a *Quercus coccifera* garrigue forest in the surroundings of the Granadella (site 6). Fire could cause the extinction of this rare species in the provinces of Valencian and Alicante. Presently the total number of 10 km^2 sites of this species is two.

***Schismatomma albocinctum* (Nyl.) Zahlbr. – Endangered**

This is an epiphyte species that grow on dense garrigues of shaded and humid coastal areas. It has a restricted world distribution in the coast of the Western Mediterranean region (Fig. 4 F). It is known only from Morocco, Italy (Sardinia), south of France and Portugal (Torrente & Egea, 1989; Letrouit-Galinou *et al.*, 1994; Boom & Giralt, 1996; Boissiere & Montavont, 2000, Nimis,

2003). In Spain it is restricted to the eastern coast of the Balearic Islands (Mallorca) and Alicante province (Torrente & Egea *opus cit.)*, where it colonises the bark of *Pinus halepensis* and *Pistacia lentiscus* in habitats subject to sea-water spray. Coastal areas of Alicante shelter the only known populations of *Schismatomma albocinctum* in the Valencian Community, where it is known from two sites (Fig. 2c). In spite of the small size of the thallus of this species the mean number of thalli is relatively high (8.5 for Cabo San Antonio and 12 for Cabo La Nao) and also is mean percentage of colonisation (10.5% and 32% respectively). However its restricted Iberian distribution in the Iberian Peninsula makes it vulnerable to extinction in case of habitat changes. Its substract is sensitive to fires, deforestation, degradation and touristics recreation activities.

CONSERVATION OF COASTAL THREATENED LICHENS AND THEIR HABITATS IN THE VALENCIAN COMMUNITY

The Valencian Community shelter a high biodiversity of lichen flora. From the species catalogue eleven taxa were selected because of their urgent need of protection (Table 3). All the taxa studied have a restricted distribution range in the Valencian Community. Four of them: *Dirina paradoxa* subsp *africana*, *Ingaderia trogloditycа*, *Opegrapha lutulenta*, and *Anema suffruticosum* are only present in one 10 Km^2 square. Another group of four: *A. meridionalis, Lecanographa subgrumulosa Ramalina pusilla* and *Shismatomma albocinctum* have been reported from two 10 Km^2 squares. *Anema suffruticosum* and *Lecanographa subgrumulosa* have been recently found in this area, and have been scarcely reported elsewhere. The remainder are distributed mainly in Mediterranean and Macaronesian areas of southern Europe and northern Africa. Other species: *Dirina immersa, Parmotrema hypoleucinum* and *Ramalina lacera* have a wider distribution and in the Valencian Community have been reported from three and four 10 Km^2 squares. Moreover all of the taxa considered are species with restricted ecology, which can become extinct because they might have difficulties re-colonizing the fragmented and damaged remaining habitat.

It is widely assumed that lichen species become endangered because of human activity (Hawksworth & Rose, 1976; Thor, 1995; Atienza & Segarra-Moragues, 2002 and this paper; Martínez *et al.*, 2003). Moreover, the biological characteristics of the lichens make that *ex situ* conservation strategies are unsuitable for these organisms. Hence, conservation of endangered lichen populations strictly depends on the conservation of the habitat in which they occur and the maintenance of the micro-ecological conditions necessary for their development. Immediate consequences of habitat deterioration, deforestation or habitat loss are the fragmentation of lichen populations which is a matter of concern especially for those with small distribution range. This implies that the more distant the populations are the lower like possibility to buffer against local extinctions.

Many of the species treated here develop in habitats that are subjected to certain degree of legal protection. The populations of *D. immersa*, *I. trogloditycа*, *L. subgrumulosa* and *S. albocinctum* in Cabo de San Antonio, are included in the Montgó Natural Park; those of *D. immersa* and *S. albocinctum* in Cabo de La Nao, are protected by a "Microreserve", which represent a network of protected sites (with an extension < 20Ha each) intended to preserve a

representation of the plant biodiversity (and their habitats) of the Valencian Community, with special emphasis on rare, endemic or endangered vascular flora (Akeroyd, 1998; Laguna-Lumbreras, 1998), but recently included populations of bryophytes (Gimeno *et al.*, 2001) and lichens (Atienza *et al.*, 2001). Moreover in the Columbretes archipielago, the populations of *D. paradoxa* subsp. *africana* and *O. lutulenta*, and those of *P. hypoleucinum*, *R. lacera* and *R. pusilla* in La Granadella, are protected by Natural Reserves. It needs to be mentioned that some of the sites, e.g. Cabo San Antonio and Cabo de la Nao are touristic centres due to the pleasant soft climate, landscape and their beautiful beach. Subsequently the tourism impact due to urban development in the surroundings of the Natural Parks (i.e. La Guardia and Massenes sites) makes difficult their conservation tasks and yet despite legal protections some sites would still be subject to catastrophic damages incurred in the past, and probably to new ones such as fires especially when they occur frequently and are not due to natural causes. Additionally, when trying to prevent fires, lichens are not taken into consideration, and forest conservation management activities usually clash with the ecological requirements of these species (i.e. lower branches of trees in which epiphytic lichens develop are removed).

There are other lichens populations in this study which are found in habitats outside existing conservation areas, e.g. the populations of *Ramalina pusilla* and *R. lacera* in La Murta, the populations of *A. meridionalis* and *I. trogloditycа* in La Caleta and those of *P. hypoleucinum*, *R. lacera* and *R. pusilla* in Puebla de Benifassar, Massenes and "La Murta" lack of any legal protection. Particularly it is great concern the problem of eutrophication from agricultural practices and cattle grazing affecting the sites of La Murta and Puebla de Benifasar; both factors encourage the growth of tolerant species, which are members of the Theloschistaceae (e.g. *Caloplaca* species, *Xanthoria parietina* and *Theloschistes chrysophthalmus*), and replace the other non tolerant species from the habitat.

At the present it seems that many special lichen sites are excluded from legal protection. Therefore future perspectives in lichen conservation in the Valencian Community must include protection measures to both lichen phorophyte habitats and to special lichen sites, either within or excluded from legal protection areas.

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REFERENCES

ABBAYES H. des, 1954 — Le chêne-vert (*Quercus ilex* L.) et son cortège floristique méditerranéen sur le littoral sub-ouest de Massif Armoricain. *Vegetatio* 5-6: 1-5.

AKEROYD J., 1998 — Microrreserves "capture" Valencia special flora. *Plant Talk* 14: 20-23.

ALONSO F. L. & EGEA J. M., 1989 — Notas sobre líquenes calcícolas del litoral de Alicante. *Folia Botanica Miscellanea* 6: 49-59.

ALONSO F. L. & EGEA J. M., 1994a — Sobre las comunidades de líquenes calcícolas de zonas costeras del sur de la Península Ibérica y Marruecos. *Studia Geobotanica* 14: 3-25.

ALONSO F. L. & EGEA J. M., 1994b — Algunos líquenes interesantes de áreas costeras del Sur de la Península Ibérica y Marruecos. *Cryptogamie, Bryologie Lichénologie* 15(3): 225-238.

ALONSO F. L., EGEA J. M. & MORENO P. P., 1989 — Flora liquénica, calcícola, del litoral de la provincia de Alicante. *Acta Botánica Malacitana* 14: 59-71.

ARROYO R., 1991 — *El género* Ramalina *Ach. En la Península Ibérica: química, quimiotaxonomía, morfología, anatomía y distribución.* Ph.D. Thesis. University Complutense of Madrid. 369 pp.

ATIENZA V., 1990 — *Flora y vegetación liquénica epifítica de las comarcas de Els Ports y Baix Maestrat (Castellón) y territorios próximos.* Ph.D. Thesis. University of València. 438 pp.

ATIENZA V. & BARRENO E., 1991 — Fragmenta Chorologica Occidentalia, Lichenes, 3285-3432. *Anales del Jardin Botanico de Madrid* 49(1): 100-110.

ATIENZA V. & SEGARRA, J.G., 1999a — A first approximation check-list of the lichens of the Valencian Community. *Flora Mediterranea* 9: 235-272.

ATIENZA V. & SEGARRA, J. G., 1999b — Fragmenta Chorologica Occidentalia, Lichenes, 7040-7082. *Anales del Jardin Botanico de Madrid* 57(1): 148-151.

ATIENZA V. & SEGARRA, J.G., 2000 — Preliminary Red List of the lichens of the Valencian Community. *Forest Snow and Landscape Research* 75(3): 391-400.

ATIENZA V. & SEGARRA-MORAGUES, J.G., 2002 — Estado de conservación de algunos líquenes epífitos amenazados en la Comunidad Valenciana (España). *Butlletí de la Societat Micològica Valenciana* 7: 35-48.

ATIENZA V., SEGARRA, J.G. & LAGUNA E., 2001 — Propuesta de microrreservas vegetales. Una alternativa para la conservación de líquenes en la Comunidad Valenciana. *Botanica Complutensis* 25: 115-128.

BOISSIERE J.C. & MONTAVONT J.P., 2000 — Lichens de France (XVI): *Schismatomma albocinctum* (Nyl.) Zahlbr. et *Umbilicaria decussata* (Vill.) Zahlbr. - *Bulletin d'Informations de l'Association Française de Lichénologie* 25(2): 1-6.

BOOM P.P.G.Van den, GIRALT M., 1996 — Contribution to the flora of Portugal, Lichens and lichenicolous fungi I. *Nova Hedwigia* 63: 145-172.

BRODO I., SHARNOFF S. D. & SHARNOFF, S., 2001 — *Lichens of North America.* Yale University Press. 795 p.p.

CALATAYUD V., 1998 — *Líquenes y hongos liquenícolas de rocas no carbonatadas en el Sistema Ibérico Oriental e Islas Columbretes.* Ph.D. Thesis. University of València.

CARBALLAL R., LÓPEZ de SILANES M.E., BAHILLO L. & ÁLVAREZ J., 1995 — Recopilación bibliográfica de citas liquénicas de Galicia (1851-1993). *Nova Acta Científica Compostelana (Bioloxia)* 5: 49-134.

CARBALLAL R., PAZ-BERMÚDEZ G. & VALCÁRCEL C.P., 1999 — Datos para una "Lista Roja" de macrolíquenes en Galicia. *Libro de resúmenes, XIII Simposio de Botánica Criptogámica*, pp. 118.

CHURCH J.M., COPPINS B.J., GILBERT O.L., JAMES P.W. & STEWART N.F., 1996 — *Red data books of Britain and Ireland: Lichens, Volume 1: Britain.* Peterborough, Joint Nature Conservation Committee. 84 pp.

CLAUZADE G. & ROUX C., 1985 — Likenoj de Okcidenta Europo. Illustrita determinlibro. *Bulletin de la Société Botanique du Centre-Ouest: Nouvelle Serie: Numero Special* 7: 1-893.

CRESPO A. & BUENO A., 1984 — Flora liquénica epifítica de Cádiz I. Los alcornocales de las sierras de Algeciras. *Anales de Biología, Universidad de Murcia 1,* (sección especial, 1*)*: 219-231.

EGEA J.M., 1989 — Las comunidades liquénicas saxícolas, ombrófobas, litorales del Suroeste de Europa y Norte de África (*Roccelletea phycopsis Classis prov.*). *Studia Geobotanica* 9: 73-152.

EGEA J.M. & LLIMONA X., 1984 — Las comunidades liquénicas saxícolas ombrófobas de la costa del S.E. de España comprendidas entre el Penyal d'Ifach (Alicante) y Almería. *Collectanea Botanica* 15: 205-219.

EGEA J.M. & TORRENTE P., 1985 — Aportación al conocimiento de los líquenes calcícolas del litoral del S.E. de España. *International Journal of Mycology and Lichenology* 2(1): 31-38.

EGEA J.M. & TORRENTE P., 1994 — El género de hongos liquenizados *Lecanactis* (Ascomycotina). *Bibliotheca Lichenologica* 54: 1-205.

EGEA J.M., TORRENTE P. & MANRIQUE E, 1993 — The *Lecanactis grumulosa* group. (Opegraphaceae). *Plant Systematics and Evolution* 187: 103-114.

FEIGE G.B. & LUMBSCH H.T., 1993 — A European species of the genus *Ingaderia* and comments on the relationship of the genera *Darbishirella* and *Ingaderia* (Roccellaceae). *Mycotaxon* 48: 381-387.

FOS S., 1998 — Líquenes epífitos de los alcornocales ibéricos. Correlaciones bioclimáticas, anatómicas y densimétricas en el corcho de reproducción. *Guineana* 4: 1-507.

GIMENO C., PUCHE F., SEGARRA J.G. & LAGUNA E., 2001 — Modelo de conservación de la flora briológica en la Comunidad Valenciana: microrreservas de flora criptogámica. *Botanica Complutensis* 25: 221-231.

GÓMEZ-BOLEA A., 1985 — *Líquenes epifíticos en Cataluña.* Resumen de la tesis presentada para aspirar al grado de Doctor en C.C. Biológicas. Barcelona. 54 pp. Centre de Publicacions, Intercanvi Cientific i Extensió Universitaria.

HALLINGBÄCK T., HODGETTS N., RAEYMAEKERS G., SCHUMACKER R., SÉRGIO C., SÖDERSTRÖM L., STEWART N. & VÁNA J., 1998 — Guidelines for application of the revised IUCN threat categories to bryophytes. *Lindbergia* 23: 6-12.

HARMAND J., 1909 — Notes relatives à la Lichenographie du Portugal. *Bulletin de la Société Botanique de France* 56: 7-14.

HAWKSWORTH D.L. & ROSE F., 1976 — Lichens as Pollution Monitors. *Studies in Biology* 66. Arnold, London.

HERNANDEZ-PADRÓN C.E., 1987 — Flora y vegetación liquénica de los sabinares Herreños. *Bibliotheca Lichenologica* 27: 1-317.

HODGETTS N.G., 2000 — Interpreting the IUCN Red List categories and criteria for cryptogams. *Forest Snow and Landscape Research* 75 (3): 293-302.

HOFMANN P., 1990 — Beitrag zur Flechten flora von Mallorca (Spanien). *Bericht des Naturwissenschaftlich- Medizinischen Vereins Innsbruck* 77: 21-29.

IUCN 1994 — *IUCN Red List Categories.* Prepared by the IUCN Species Survival Commission. IUCN, Gland, Switzerland.

IUCN 2001 — *The IUCN Red List of Threatened Species. 2001 Categories and Criteria. Version 3.1.* Gland, Switzerland and Cambridge, UK.

JONES M.P., 1980 — Epiphityc macrolichens of the Algarve, Portugal. *Lichenologist* 12: 253-265.

KROG H. & JAMES P.W., 1977 — The genus *Ramalina* in Fennoscandia and the British Isles. *Nordic Journal of Botany* 24: 15-43.

KROG H. & ØSTHAGEN H., 1980 — The genus *Ramalina* in The Canary Islands. *Norwegian Journal of Botany* 27: 255-296.

LAGUNA-LUMBRERAS E., 1998 — La conservación de la flora silvestre en la Comunidad Valenciana. *In*: Laguna & *al.*, *Flora rara endémica o amenazada en la Comunidad Valenciana, Colección Biodiversidad n° 1*, pp. 37-58.

LETROUIT-GALINOU M-A., BELLEMÈRE A. & TORRENTE P., 1994 — Études ultrastructurales d'asques et d'ascospores chez quelques Opegraphaceae, Roccellaceae et Arthoniaceae. – *Bulletin de la Société Linnéenne de Provence* 45: 389-416.

LLIMONA X., 1976 — Impresions sobre la vegetació de la Illa de Cabrera IV.Vegetació liquenica. *Treballs de la Institucio Catalana d'Historia Natural* 7: 123-137.

LLIMONA X., 1980 — La vegetació liquènica de les illes Columbretes. *Bulletí de la Societat Catalana de Biología* 3-4: 146-147.

LLIMONA X. & HLADÚN N., 2001 — Checklist of the lichens and lichenicolous fungi of the Iberian Peninsula and Balearic Islands. *Bocconea* 14: 5-581.

MARTÍNEZ I., ARAGÓN G., SARRIÓN F.J., ESCUDERO A., BURGAZ A.R. & COPPINS B.J., 2003 — Threatened lichens in central Spain (saxicolous species excluded). *Cryptogamie, Mycologie* 24(1): 73-97.

MORENO P.P. & EGEA J.M., 1992 — Estudios sobre el complejo *Anema-Thyrea-Peccania* en el Sureste de la Península Ibérica y Norte de África. *Acta Botanica Barcinonensia* 41: 1-66.

MUS M. & FIOL L. A., 1990 — Fragmenta chorologica occidentalia lichenes 2557-2565. *Anales del Jardin Botanico de Madrid* 47(2): 472-473.

NASCIMBENE J., 2002 — Segnalazioni lichenologiche per le Alpi sud-orientali. *Lavori Societa Veneziana Siences Naturale* 27: 149-150.

NIMIS P.L., 1993 — *The lichens of Italy an annotated catalogue.* Monogr. Mus Reg. Sc. Nat. Torino 12. 860 pp.

NIMIS P.L. & TETRIACH M., 1999 — Itinera Adriatica. Lichens from the eastern side of the Italian Peninsula. *Studia Geobotanica* 18: 51-106.

NIMIS P.L., 2003 — TSB Lichen Herbarium 3.0, University of Trieste, Dept. of Biology, IH3.0/02 (http://dbiodbs.univ.trieste.it/global/italic_tsb1).

OBERMAYER W., 1994 — Lichenotheca Graecensis Fasc. 1 (Numbers 1-20). *Fritschiana* 1: 1-7.

PUCHE M.F. & GIMENO C., 2000 — Dynamics of the early stages of bryophyte colonization of burnt Mediterranean forest (E Spain). *Nova Hedwigia* 70: 523-536.

RENOBALES G., 1996 — Contribución al conocimiento de los líquenes calcícolas del occidente de Vizcaya y parte oriental de Cantabria (N-España). *Guineana* 2: 1-310.

RICHARDSON D.H.S., 1992 — *Pollution monitoring with lichens.* Naturalist's Handbooks 19. Richmond Publishing Co. Ltd., Slough.

ROUX C. & EGEA J.M., 1992 — L'*Opegraphetum durieui* Egea & Cl. Roux Ass. Nov., une association lichénique saxicole-calcicole, halophile. *Cryptogamie, Bryologie Lichénologie* 13: 105-115.

SERRANO R., 1991 — Historia de los asentamientos humanos en las Columbretes. In: Alonso, L.A., Carretero, J.L. & Garcia-Carrascosa, M.G., 1991 — Islas Columbretes: contribución al estudio de su medio natural. *Monografies* 5: 13-18.

SÉRUSIAUX E., 1989 — *Liste Rouge des macrolichens dans la Communauté Européene.* Liège. Centre de Recherches sur les Lichens.

TAVARES C., 1945 — Contribuçao para o estudo das Parmeliaceas portuguesas. *Portugalia Acta Biologica* 1: 1-210.

TEHLER A., 1983 — The genera *Dirina* and *Roccellina* (Roccellaceae). *Opera Botanica* 70: 1-86.

THOR G., 1995 — Red Lists – Aspects of their compilation and use in lichen conservation. *Mitt. Eidgenöss Forsch. Anst. Wald Schnee Landsch.* 70: 29-39.

TORRENTE P. & EGEA J.M., 1984 — Aportación al conocimiento de los líquenes epífitos del S.E. de España: líquenes con *Trentepohlia. Folia Botanica Miscellanea* 4: 81-89.

TORRENTE P. & EGEA J.M., 1989 — La familia Opegraphaceae en el área Mediterránea de la Península Ibérica y Norte de África. *Bibliotheca Lichenologica* 32: 1-282.

TØNSBERG T., 1980 — Contribution to the lichen flora of Majorca (Spain) *Norwegian Journal of Botany* 28:193-198.

WERNER R. G., 1975 — Etude écologique et phytogeographique sur les lichens del'Espagne méridionale. *Revue Bryologique et Lichenologique* 41(1): 55-82.