Lichens in the upper belt of the Serra da Estrela (Portugal)

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Abstract: A survey is presented of lichens collected in the upper belt of the Serra da Estrela, the highest mountain range of continental Portugal. The upper belt is built up of granite and its altitudes range from some 1600 m s. m. up to the summit (1993 m s. m.). For this area a total number of 250 lichen taxa is listed, including 16 new records for Portugal, of which at the same time five are new to the Iberian Peninsula (marked with *): *Bryoria bicolor*, *Buellia chloroleuca*, *B. hypophana*, *B. longispora*, *Caloplaca tiroliensis*, *Fuscidea praeruptorum*, *Lecanora caesiosora**, *Lecidea porphyrospoda**, *Lepraria borealis**, *Leptogium rivale**, *Melanelia disjuncta*, "*Melanelia sorediella*", *Pyrenopsis* aff. *subareolata*, *Rinodina olivaceobrunnea*, *Tephromela pertusarioides* and *Thrombium thelostomum**. A first attempt is made to describe the preference of epilithic lichens for biotopes like granitic cliffs, tors, screes, and fresh water. In addition preferences of terricolous lichens for major plant formations and Natura 2000 habitats are noted. Epiphytic lichens are related to phorophytes, provisional lichen communities and partly to plant communities in which the phorophytes occur. A previously described variant of a heathland community is typified as a new subassociation: Potentillo herminii-Callunetum pycnothelietosum papillariae JANSEN.

Zusammenfassung: Ein Überblick über Flechten, die in der oberen Zone der Serra da Estrela, dem höchsten Gebirgszug des kontinentalen Portugal, gesammelt wurden, wird gegeben. Die obere Zone ist aus Granit aufgebaut und ihre Höhe erstreckt sich von etwa 1600 m s. m. bis zum Gipfel (1993 m s. m.). Für dieses Gebiet wird eine Gesamtanzahl von 250 Flechtentaxa aufgelistet, einschließlich 16 neuer Nachweise für Portugal, wovon gleichzeitig fünf neu für die Iberische Halbinsel sind (mit * markiert): *Bryoria bicolor*, *Buellia chloroleuca*, *B. hypophana*, *B. longispora*, *Caloplaca tiroliensis*, *Fuscidea praeruptorum*, *Lecanora caesiosora**, *Lecidea porphyrospoda**, *Lepraria borealis**, *Leptogium rivale**, *Melanelia disjuncta*, „*Melanelia sorediella*", *Pyrenopsis* aff. *subareolata*, *Rinodina olivaceobrunnea*, *Tephromela pertusarioides* und *Thrombium thelostomum**. Es wird ein erster Versuch gemacht, die Vorlieben epilithischer Flechten für Biotope wie Granitfelsen, Felstürme, Geröllhalden und frisches Wasser zu beschreiben. Zusätzlich werden die Vorlieben erdbewohnender Flechten für bestimmte Pflanzengesellschaften und Natura 2000 Habitate festgehalten. Epiphytische Flechten sind mit Phorophyten, provisorischen Flechtengesellschaften und zum Teil mit Pflanzengesellschaften, in denen die Phorophyten vorkommen, vergesellschaftet. Eine früher beschriebene Variante einer Heidengesellschaft wird als neue Subassoziation typifiziert: Potentillo herminii-Callunetum pycnothelietosum papillariae JANSEN.

The Serra da Estrela is considered a centre of endemic and narrowly distributed vascular plant taxa (MORENO SAIZ & SAINZ OLLERO 1992, DAVIS & al. 1994, MÉDAIL & QUÉZEL 1997). The massif contains more than 30 biotopes of the "Habitats Directive" (JANSEN 1997), including most of those treated in this paper with respect to terricolous and epiphytic lichens (EUROPEAN COMMISSION 1996). So far epilithic lichen environments have been neglected in that Directive. The present paper is a first contribution to a better knowledge of the lichens from the upper belt of the Serra da Estrela.

According to JANSEN (1997) the flora of Estrela includes about a quarter of the preliminary Portuguese red list of vascular plant species (LOPES & CARVALHO 1990), many of which are confined to the Estrela within Portugal. In the area of the Parque Natural da Serra da Estrela more than 400 bryophyte species could be detected. This is about two-third of the bryophyte flora of Portugal and some 40% of the Iberian Peninsula (GARCIA & al. 1999). A considerable number occurs on the red list of bryophytes from the Iberian Peninsula (SÉRGIO & al. 1994). *Bruchia vogesiaca* NESTL. ex SCHWAEGR. and *Marsupella profunda* LINDB. are even listed as priority species in annex II of Council Directive 92/43/EEC.

From the aforementioned floristic characteristics a rich lichen flora could be suspected. At the time being a red list of lichens does not exist, reason why no assessment of their status can be made in this paper. To show that many interesting species occur we note that of the 250 lichen species presented in this paper 216 are known from Germany of which 128 (= 59%) are occurring on the red list of that country (see WIRTH & al. 1996).

The first list of lichens from the Serra da Estrela is from BROTERO (1804). In the course of the nineteenth century collections have been made by WELWITSCH, NYLANDER, GOMES MACHADO, RICARDO DA CUNHA and HENRIQUES (HENRIQUES 1881). Early in the 20th century PALHINHA and SAMPAIO collected also lichens. However the localities and altitudes (from 800-1750 m s. m.) are not always clear (SAMPAIO 1970). A contribution from the middle of this century is from TAVARES (1945), who listed 124 taxa from all altitudinal belts. After a silence of some decades APTROOT & al. (1992), JANSEN (1993) and BOOM & GIRALT (1996, 1999) recorded lichens from various altitudes and substrata in the Serra da Estrela, including new records for Portugal.

The present paper only deals with own collections, excluding the examination of the historic herbarium collections. It concentrates on the highest altitudinal belt. A number of habitats for lichens are described. The saxicolous species are related to major weathering forms. The terricolous lichens have been linked to the syntaxonomical units and Natura 2000 habitats in which they mostly occur. The epiphytic lichens are as far as possible related to specified phorophytes, which in turn are frequently related to dwarf juniper scrub and heath. A preliminary classification of epiphytic communities is presented.

Study area

Geography, geology, geomorphology and soil

The Serra da Estrela is situated in the central-east of the country and holds by far the highest peak (1993 m s. m.) of continental Portugal (Fig. 1). The study area measures

c. 70 km^2 and is delimited by the 1600 m s. m. contour line. It is situated in the southern part of the mountain range, mainly consisting of plateaus with some deep incisions (most of them glacial troughs), all built up by different types of granites mainly being muscovite and two-mica granites (see FERREIRA 1998).

Fig. 1. Location (asterisk) of the study area (Serra da Estrela) in Portugal.

The general topographical framework is essentially a consequence of Cenozoic tectonics. Being part of the Central Cordillera it is bound by late-Variscan strike-slip faults, which reactivated in reverse faulting during the Alpine compression (RIBEIRO 1984). In the genesis of the main morphological features of the mountain a permanent interaction between tectonics and fluvial erosion took place (FERREIRA 1998). A major part of the study area was covered by an ice-cap and from it several glaciers diverged towards the lower areas (VIEIRA & FERREIRA 1998). It is assumed that glaciation decreased by the end of the Late Glacial. A variety of weathering forms is present in the area, e.g., steep cliffs, gently slope rock knobs, tors, and screes.

Soil development is usually poor, mainly as a result of the extreme weather conditions and the long agro-pastoral tradition of burning and grazing. The slopes experience the strongest erosion. The convex and flat areas of the planes are strongly affected by cryogenic and hydro-aeolian processes and usually carry shallow coarse grained soils. Concave areas have deeper soils in which accumulation of organic matter and humus takes place.

Climate

The climate of the Serra da Estrela may be characterised as a Mediterranean mountain climate with Atlantic influence. The latter increases gradually going from east to west and from low to higher altitudes. The mean annual precipitation in the study area exceeds 2000 mm with a maximum above 2500 mm in the upper Torre plateau (VIEIRA & MORA 1998). The precipitation regime is marked by a minimum during the summer months. Most of the precipitation falls between October and May. The number of days with precipitation easily exceeds a hundred per year with a maximum of more than 150 in the highest area (DAVEAU & al. 1985). The weather station of Penhas Douradas (1380 m s. m.) closely situated to the study area shows an annual average of 33 days with snow fall and 52 days with snow cover. These values are usually irregular and discontinuous and are assumed to be higher in the upper areas. The annual sunshine in Penhas Douradas exceeds 2500 hours and the mean annual temperature there is 8.9 °C with January being the coldest month with 2.4 °C and July the warmest with 17.2 °C (TORMO MOLINA & al. 1992). According to VIEIRA & MORA (1998) the number of days with minima below 0 °C may reflect the number of air frost cycles. This number varies between 67 for Penhas Douradas and 87 for Penhas da Saúde (1510 m s. m.). In July and August it is very rare to have air temperatures below 0 °C in these stations. Monthly mean temperatures at the summit estimated from the regression between data from three weather stations show a mean annual temperature of 3 °C to 4 °C. The coldest month is February with -1.7 °C and July the warmest with 11.8 °C (VIEIRA & MORA 1998). Wind conditions are as precipitation and temperature regimes controlled by the local topography. The mean annual wind velocity at Penhas Douradas is 23.8 km/h (AMORIM FERREIRA 1965). According to VIEIRA & MORA (1998) maximum wind speeds occur during autumn and winter months, especially from November to March when monthly speeds average some 27 km/h.

Vegetation

In the Serra da Estrela three major vegetation belts can be distinguished, the lower belt from the foot of the mountain to ca. 900 m s. m., the middle belt from ca. 900 to ca. 1650 m s. m. and the upper from ca. 1650 m s. m. to the top (RIVAS-MARTÍNEZ 1981). In the Eurosiberian region these belts may be compared with the colline, montane and subalpine belts respectively.

Subjected to a long history of human activities (burning, grazing, cutting) climax forests disappeared from the study area, making way for scrub and grasslands. Convergence of subsequent retrogressional stages in combination with large variation in local topographic conditions make it precarious to determine the upper limits of the middle belt or the lower limits of the upper belt. The transition area between both belts must have carried a major climax vegetation of Pyrenean oak forests (Holco mollis-Quercetum pyrenaicae) or under more humid conditions Birch forests (Saxifrago spathularis-Betuletum celtibericae). The upper belt must have hosted at least some populations of Scots pine (class: Pino-Juniperetea).

To make sure that the present paper shows the most exhausting list of the highest area of Portugal, all lichens found at altitudes over 1600 m s. m. are listed, including those occurring in the transitional zone.

The present-day climax sere of the upper belt is formed by Pino-Juniperetea communities: Dwarf juniper scrub (Lycopodio clavati-Juniperetum nanae, mesosere) and hedgehog or thorn-cushion scrub (Teucrio salviastri-Echinospartetum pulviniformis, xerosere). The former in particular supports a rich terricolous and epiphytic lichen flora, in common with the heathlands (JANSEN 1994 a).

The plant cover of the upper belt consists of a mosaic of plant communities such as the aforementioned climax scrub vegetation, heathlands (Calluno-Ulicetea), open grasslands (mainly Festucetea indigestae), pioneer vegetation on rock surfaces (mainly Sedo-Scleranthetea) (Fig. 4), mat-grass swards (Nardetea), rock fissure, talus and scree vegetation, spring communities, bogs and aquatic communities of rivulets and lakes.

A rich epilithic flora is found on a variety of rock surfaces, e.g., steep cliffs with northern or southern aspect, wet rock outcrops, tors, overhanging rocks, crevices, and block slopes with all kinds of aspect and inclination.

Materials and methods

The present survey is mainly based on collections made by the first author during short visits between 1993 and 1998, and by the second author during phytosociological fieldwork carried out between 1990 and 1998 (JANSEN 1994 a, b, 1997, 1998; JANSEN & SEQUEIRA 1999; JANSEN & SÉRGIO unpubl.). Relevés were made according to the BRAUN-BLANQUET method (BRAUN-BLANQUET 1964, WESTHOFF & MAAREL 1973) and stored in a database with the computer program TURBOVEG (HENNEKENS 1996).

Additional records were obtained from previous publications (APTROOT & al. 1992, JANSEN 1993). Some of the previously recorded specimens have been revised. The following species, earlier published for the study area are not accepted: *Agonimia tristicula* (NYL.) ZAHLBR. (= *Agonimia* spec.), *Biatora pilularis* (KÖRBER) HEPP (= *Lecidea porphyrospoda* or *Biatora vernalis*), *Bryonora castanea* (HEPP) POELT (= *B. curvescens*), *Buellia erubescens* ARNOLD (= *B. chloroleuca*), *Caloplaca cinnamomea* (TH. FR.) OLIVE (= *C. tirolensis*), *Catillaria erysiboides* (NYL.) TH. FR. (= *Mycobilimbia carneoalbida*), *Cladonia macrophylla* (SCHAERER) STENH. (= *C.* cf. *cyathomorpha*), *C. ochrochlora* FLÖRKE (= *C. coniocraea*), *C. scabriuscula* (DELISE) NYL. (= *C. glauca*), *Koerbera sonomensis* (TUCK.) HENSSEN (= *Polychidium muscicola*), *Lecanora bicincta* RAM. (= *L. rupicola* or *L. cenisia*), *Lecidea nylanderi* (ANZI) TH. FR. (= *L. antiloga*), *Lepraria incana* (L.) ACH. (= *Lepraria* spp. because they are not checked by TLC and probably confused with *L. lobificans* or *L. borealis*), *Micarea prasina* FR. (= *M. denigrata*), *Mycobilimbia berengeriana* (MASSAL.) HAFELLNER & V. WIRTH (= *Lecidoma demissum*), *Rhizocarpon simillimum* ANZI (= *Buellia aethalea*), *Scoliciosporum chlorococcum* (GRAEWE ex STENHAMMAR) VĚZDA (= *S. umbrinum*), *Trapeliopsis aeneofusca* (FLÖRKE ex FLOTOW) COPPINS & P. JAMES (= *Japewia subaurifera*), *Usnea subfloridana* STIRTON (= unidentified *Usnea* species), *Xanthoparmelia verrucigera* NYL. (= *X. conspersa*). Older published records for which we were unable to examine any corresponding specimens have not been accepted, except those species that could reasonably expected. These are marked by an o in the list. Not listed are very doubtful species such as *Mycobilimbia hypnorum* (LIBERT) KALB & HAF. [specimen has been lost (A. APTROOT, pers. comm.) and most probably confused with *Lecidea rufofusca*] and *Rinodina exigua* (ACH.) S. F. GRAY (probably confused with *R. archaea* or *R. septentrionalis*, see GIRALT & MAYRHOFER 1995). Specimens from *Rhizocarpon badioatrum* (FLÖRKE ex SPRENGEL) TH. FR., published in JANSEN (1993) from *Cytisus oromediterraneus* RIVAS-MARTÍNEZ, DÍAZ, PRIETO, LOIDI & PENAS are saxicolous and belong to *Schaereria fuscocinerea* and *R.* cf. *polycarpum*. Most complete ecological data were obtained from phytosociological sampling never neglecting terricolous lichens. In 1990 and 1991 phytosociological sampling was also linked with collections of epiphytic lichens from separate phorophytes occurring in the sampled plots (see JANSEN 1993). In 1998 special emphasis was laid on the description of major habitats for epilithic lichens. Therefore intensive sampling took place in some specific rocky locations mentioned in the present paper. Doing so some 300 additional collections could be made. General estimation of abundancy of terricolous and epiphytic lichens is as follows: in less than 5% of the samples: rare; from 5% to 20%: occasional; 20% and more: common. Several epilithic lichens were identified using standard microscopic and thin layer chromatography methods (WHITE & JAMES 1985). The specimens cited have been studied mostly according to PURVIS & al. (1992). Nomenclature of lichens is mainly according to PURVIS & al. 1993 or WIRTH (1995). Nomenclature of lichen syntaxa generally follows WIRTH (1995).

Nomenclature of vascular plants generally follows CASTROVIEJO & al. (1986-1999). Arrangement and nomenclature of vascular plant syntaxa generally follows RIVAS-MARTÍNEZ & al. (1999, 2000). Missing or deviating names of both taxa and syntaxa are written at length, only the first time in the text. Lichen collections are kept in the private herbarium of the first author; several are kept in the private herbarium of Dr ANDRÉ APTROOT (Soest), and some duplicates in LISB.

Results and discussion

1 Saxicolous lichens and their major habitats

Steep S-oriented cliffs. On steep S-oriented cliffs a characteristic photophytic and xerophytic lichen assemblage may develop.

We inspected two sites. The first site is a steep rock wall in the SW-oriented cirque of the Cântaro Raso. Here the following species have been collected: *Brodoa intestiniformis*, *Cornicularia normoerica*, *Dimelaena oreina*, *Leproloma membranacea*, *Massalongia carnosa*, *Melanelia disjuncta*, *M. stygia*, *Neofuscelia pulla*, *N. loxodes*, *Pertusaria corallina*, *Polychidium muscicola*, *Protoparmelia badia*, *Rhizocarpon geographicum*, *Umbilicaria* cylindrica, and *Xanthoparmelia conspersa*. *Leproloma membranacea* and both *Melanelia* species seem to have preference for south-oriented cliffs. The former species and *Melanelia disjuncta* were found in rather small quantities. In Germany the latter is generally known to occur in open and relatively warm biotopes (WIRTH 1995). It was inconspicuous to observe among *Melanelia stygia*. *Melanelia disjuncta* is a new species to Portugal. The species was already known from the Spanish part of the Sistema Central (SANCHO 1986).

A second interesting steep S-cliff has been investigated in Covão do Boeiro, the upper part of the former Loriga glacial trough. There a species-poor lichen assemblage, predominated by *Rhizocarpon lecanorinum* was growing on vertical granite. The following associated species were found in small quantities: *Acarospora* spec., *Ephebe lanata*, *Phylliscum demangeonii*, *Pyrenopsis* aff. *subareolata*, and *Umbilicaria spodochroa*. *Pyrenopsis* aff. *subareolata* was found fertile here. The occurrence of *Ephebe lanata*, *Rhizocarpon lecanorinum* and *Phylliscum demangeonii* is in accordance with observations in Germany, where these species (also *Pyrenopsis* cf. *subareolata*) are known to occur in rather sunny, relatively warm biotopes in rainy mountain areas (WIRTH 1995). Moreover it is noteworthy that in Germany all these species may occur on temporal irrigated rocks.

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Fig. 2. N-oriented cliffs near Cântaro Gordo. Fig. 3. Screes from the area near Cântaro Gordo. Fig. 4. Viev over the Planalto Central from near Curral dos Martins.

S-oriented gentle sloping or horizontal rock surfaces. S-oriented gentle sloping or horizontal rock surfaces often include so-called "roches moutonnées". These outcrops are polished by rocks from the lower surface of the former glacier. In Covão do Boeiro we inspected two of those gently sloped S-oriented outcrops.

Both outcrops were predominated by crustose species from an undescribed community, with mostly *Aspicilia caesiocinerea*, *Rhizocarpon geographicum*, and rarely *Aspicilia epiglypta*. Crevices in these outcrops hosted muscicolous species like *Buellia badia*, *Caloplaca congrediens*, *Catolechia wahlenbergii*, *Lepraria caesioalba*, and *Toninia squalida*. *Caloplaca congrediens* was originally described from Serra da Estrela as *Caloplaca herminica* (SAMPAIO 1970). It has been found in several localities, always in small quantities and mostly in exposed situations.

N-oriented cliffs (Fig. 2). In general, north-facing vertical granite cliffs in the area carry a well-developed lichen vegetation. Macrolichens like *Lasallia pustulata*, *Parmelia omphalodes*, *Platismatia glauca*, *Umbilicaria cylindrica*, and *U. crustulosa* occur in extensive patches throughout the study area. The steep surfaces favour a small number of crustose lichens which are observed on most other N-oriented rocks such as *Lecidea lapicida* var. *pantherina*, *Lopadium pezizoideum*, *Miriquidica nigroleprosa*, *Pertusaria corallina*, *Rhizocarpon geographicum*, and *R. polycarpum*. Of these, *Miriquidica nigroleprosa* has also been found fertile.

One of the most impressive N-cliffs was found nearby Lagoa do Paixão. It is a steep cliff of some 80 m high and a width of more than 100 m. It supports interesting crustose, foliose as well as fruticose lichens. Important and obvious records are from this locality. Here *Alectoria sarmentosa* was present with a few small thalli at the foot of the cliff, but some 50 m higher, on the steep rock-face, much longer thalli of this species were visible. Several species of *Alectoria* are recorded from Serra da Estrela by TAVARES (1945), except this species. It is known from the Sistema Central (Sierra de Tormantos) as a saxicolous species growing at 2200 m s. m. (SANCHO 1986). On aforementioned steep cliff only one single thallus of *Bryoria bicolor* was found, accompanied by *B. fuscescens*. *Bryoria bicolor* is first recorded here for the country. *Cladonia cyathomorpha* was found on protruding ledges with accumulation of soil. *Hypogymnia farinacea*, mainly an epiphytic species common on various trees in the lower belt of the Serra da Estrela, has been found here on steep facing granite. In a deep gorge, S of Lagoa do Paixão on shaded and weakly overhanging granite the following species have been found: *Aspicilia laevatoides*, *Aspicilia subdepressa*, *Lecanora caesiosora*, *Phylliscum demangeonii*, *Rhizocarpon lavatum*, and *Rinodina olivaceobrunnea* (muscicolous). Both *Aspicilia* species were already known from deep shaded gorges elsewhere in the study area (BOOM & GIRALT 1999). Both *Lecanora caesiosora* and *Rinodina olivaceobrunnea* are recorded here as new to Portugal. They where found only in small amounts.

Tors. Rock outcrops that frequently consist of piled and delicately poised logans are known as "tors". The origin of tors is not totally cleared yet. Tors are scattered throughout a large part of the upper belt. They are subjected to a windy climate. Their extensive granite rock exposures provide a great diversity of suitable niches for lichen species, varying from very exposed and sunny sloping surfaces to sheltered and shaded crevices.

For lack of time only three tors have been visited during our survey. An interesting tor was found in the vicinity of Curral do Martins, probably one of the windiest spots of the study area. The following description is mainly based on our observations of this tor. Here some rarities were collected such as *Arctomia delicatula*, *Buellia longispora*, *Catolechia wahlenbergii*, *Lecidea fuliginosa*, *Protoparmelia atriseda*. All these species were encountered in sheltered and shaded crevices on south-facing outcrops. In the same environment we found muscicolous lichens, often growing on moribund bryophytes: *Arctomia delicatula*, *Bryophagus gloeocapsa*, *Caloplaca congrediens*, *Rinodina olivaceobrunnea*, and *Toninia squalida*.

On N-facing outcrops we found interesting species such as *Orphniospora moriopsis*, *Buellia uberior* (this latter species growing on and among *Schaereria fuscocinerea*), *Fuscidea praeruptorum*, *Miriquidica deusta*, *M. leucophaea*, *M. nigroleprosa*, and *Umbilicaria spodochroa*. *Orphniospora moriopsis* is a characteristic species of the Rhizocarpo inarensis-Orphniosporetum atratae, an alpine community described from southern Norway (CREVELD 1981).

Steep SE-oriented rock-faces on this tor supported photophilous and xerophilous species. Most common species were *Buellia aethalea*, *Cornicularia normoerica*, *Lecidea lapicida* var. *panterina*, *Lasallia hispanica*, *L. pustulata*, *Neofuscelia pulla*, *Parmelia omphalodes*, *Pertusaria pseudocorallina*, *Pseudephebe pubescens*, *Rhizocarpon geographicum*, and *Umbilicaria polyrrhiza*. Rare species in this biotope were *Pertusaria melanochroa* and *Tephromela pertusarioides*. This latter species is not mentioned for the oromediterranean belt of the Spanish part of the Sistema Central (SANCHO 1986) and is new to Portugal.

On an underhang, between two outcrops where wind speed must be amongst the highest of the area, *Fuscidea praeruptorum* was found covering at least 1 m². The species was abundantly fertile. It is not rare in Portugal but we never found it in such a perfect condition. It was accompanied by the following species: *Lecanora polytropa*, *Porina chlorotica*, *Porpidia macrocarpa*, *Rinodina interpolata*, and *Scoliciosporum umbrinum*. The latter species may also occur epiphytically on *Cytisus oromediterraneus*, *Juniperus communis* L. subsp. *alpina* (SUTER) ČELAK and *Erica australis* L. In general it is found more often as a saxicolous species and has been found frequently on N-oriented cliffs and at the Cascalvo tor, then also in shady conditions, such as underhangs and stones under overhangs. In the latter situation it grew abundantly together with *Acarospora smaragdula* and *Polysporina simplex*.

Communities from nutrient-enriched sites are rare in the study area, except those from bird-perching rocks. From two tors, the following characteristic species were recorded: *Dimelaena oreina*, *Candelariella vitellina*, *Lecanora polytropa*, *Neofuscelia pulla*, *Platismatia glauca*, *Polysporina simplex*, *Ramalina capitata*, and *Xanthoparmelia conspersa*.

Horizontal to slightly sloping surfaces of boulders are always covered with photophilous species and sometimes with rather nitrophilous lichens like *Aspicilia* spp., *Buellia badia*, *Candelariella vitellina*, *Dimelaena oreina*, *Lecanora polytropa*, *Lepraria caesioalba*, *Massalongia carnosa*, *Rhizocarpon geographicum*, *Rimularia gyrizans*, and *Tephromela atra*. This kind of vegetation is not exclusively restricted to tors, but also occurs on large isolated outcrops or boulders with sloping or more or less horizontal surfaces. *Aspicilia* spp. are often predominate. It is not always possible to identify them, neither in the field nor microscopically, because often, the extensive thalli are sterile, without apothecia or pycnidia. However *Aspicilia caesiocinerea* seems to be the most common species of the genus and occurs in a wider range of habitats than the other *Aspicilia* species. *Aspicilia cinerea* has been found only at one tor (Curral do Martins) on horizontal and steep sunny outcrops. *Aspicilia intermutans* s. l. was found only once, namely on S-sloping granite of the Cascalvo tor. A study exclusively for the genus *Aspicilia* in this area would be useful. Still several collected specimens of *Aspicilia* have not yet been identified.

One of the most important collections is a recently described *Halecania* species, *H. giraltiae* VAN DEN BOOM & ETAYO, which has been found lichenicolous on different hosts, but in optimum conditions, it grows also directly on rock. An accompanying lichenicolous lichen species growing among *H. giraltiae* is *Rinodina parasitica*, which has recently been recorded as new for Portugal by BOOM & GIRALT (1999).

Lichens on rocks are often destroyed by fire, due to burning the surrounding vegetation (JANSEN & al. 1997). Therefore boulders (mostly erratics) and small rock outcrops with recent fire history carry few lichens. However abrasion from wind blown rock particles and ice specules may also be partly responsible, as was suggested by GILBERT & FOX (1985) for the plateau area of the Cairngorns in Scotland.

Erratic boulders and outcrops occur mainly on plateaux and on gentle slopes. In these areas scrub is the main fuel agent. So far we could not detect epilithic lichen species of particular nature on erratic boulders. Steep cliffs and higher parts of tors in the study area are usually not affected by fire. In the lower parts of the mountain where forests occur, high up blazing forest fires do affect high cliffs as well.

Screes (Fig. 3). Good examples of screes or talus slopes can be found in the upper reaches of the glacial troughs of the Zêzere and the Alforfa. These valleys make deep incisions in the higher plateau. The steep cirque walls have shed numerous rock particles under the attack of physical weathering processes, particularly frost shattering. Today still some fresh formed rock debris can be observed, but most of the material must have been formed before (JANSEN & VIEIRA 1998).

Vegetation is very sparse on screes because moving materials inhibit the establishment and growth of plants (JANSEN 1998). Screes include very few terricolous lichens, both in cover and species number. More or less the same applies to the saxicolous lichen cover: a considerable number of unstable rocks on the scree is usually not covered by lichens. However, most of the scarce vascular plant species occurring on screes are endemic taxa and for a major part restricted to this biotope. From a total of 20 characteristic vascular species nine are listed on the preliminary red list of Portugal. Some bryophytes, mostly occurring in screes with large sized rocks are also known as red list species (see JANSEN 1998). Therefore, we expected to find interesting lichen species, too.

Screes consisting of small- to medium-sized blocks are relatively easy transported and carry hardly lichens. Huge boulders of relict blockslopes usually do not carry any vascular plants. Only some bryophytes [e.g., *Racomitrium lanuginosum* (HEDW.) BRID.] cause little competition to lichens. These blockslopes are usually stable and therefore do support a considerable lichen cover. One scree and two blockslopes were visited and all three appeared to have a poorly developed lichen flora.

Most of the encountered lichens are common in the area and not restricted to screes. Relatively rare species collected here are *Cromatochlamys muscorum*, *Peltigera hymenina*, and *Ochrolechia frigida*, a species known from high moors or mountain summits (PURVIS & al. 1992). The most interesting species was found on a blockstream with large boulders. It is *Melanelia sorediella*, a rare species in Portugal, which is only known so far from central Spain and the type locality in Switzerland. This taxon which formerly was described as *Cetraria commixta* (NYL.) TH. FR. f. *sorediella* LETTAU, is presently under investigation by RICO & BOOM (unpubl.).

Irrigated rocks. The Serra da Estrela has a large water storage capacity as a result of the high precipitation. Numerous springs and rivulets exist and some of the largest rivers in Portugal find their off-spring here. Springs and rivulets support an interesting vegetation of vascular plants and bryophytes (JANSEN & MENEZES DE SEQUEIRA 1999, JANSEN & SÉRGIO unpubl.).

Rock seepages and streams were examined at several places in four localities.

The saxicolous flora of inundated rocks in the investigated streams appeared to be poorly developed. In particular streams that are dry during summer, seem to be almost devoid of lichens. Only three lichen species have been frequently found, namely *Hymenelia lacustris*, *Tremolecia atrata*, and *Verrucaria margacea*. In rivulets at Fonte de Luzianos and nearby Lagoa Seca, *Aspicilia epiglypta* was found on horizontal surfaces of submerged stones.

Some topographic favourable rock outcrops receive more frequently run-off than others, due to rain, melt water or seepage from near by. Such outcrops are found in various situations, from exposed sloping or vertical outcrops, to very shaded rock-faces in deep valleys. They seem to be often colonized by *Dermatocarpon luridum*, which is sometimes accompanied by *Ephebe lanata*. In shaded and sheltered habitats, we found more extensive patches of *Dermatocarpon luridum* and *Ephebe lanata*, accompanied by *Polychidium muscicola*, *Porina lectissima*, *Verrucaria margaceum*, and sometimes *Phaeophyscia endococcina*. *Ephebe lanata* and *Polychidium muscicola* are also reported from the Holco gayani-Bryetum alpini JANSEN 1999, an amphibian association from intermittently irrigated rocks (JANSEN & MENEZES DE SEQUEIRA 1999).

In the vicinity of springs, humid outcrops subjected to intermittently trickling drops of water provide conditions suitable for several rarities of the area. Important sheltered and shaded rock faces have been found at the Cântaro Magro, where several springs occur along the rock faces. One of the most impressive records from this site is *Leptogium rivale*. It has been found with fruits on persistently wet vertical to sloping rock in very shaded and sheltered habitats. It was accompanied by *Thrombium thelostomum*. *Leptogium rivale* is a third report for Europe, formerly known from the type locality in Romania (JØRGENSEN 1994) and some localities in central Europe (GUTTOVÁ 2000). *Thrombium thelostomum*, previously known from England and Scotland is also a new record for the Iberian Peninsula. Vertical shaded rocks along the lake Lagoa do Covão das Quilhas carried the rare *Verrucaria praetermissa*, growing with *Ephebe lanata* and *Rhizocarpon lavatum*. On more dry surfaces at the same locality *Verrucaria praetermissa* was accompanied by *Rhizocarpon geographicum* and *Tremolecia atrata*.

2 Terricolous lichens and their major habitats (Fig. 4)

The upper belt of the Serra da Estrela consists of a mosaic of plant communities such as dwarf juniper and thorn-cushion scrub (climax vegetation), heathlands, open grasslands, pioneer vegetation on rock surfaces, mat-grass swards, rockfissure and scree vegetation, spring communities, bogs and aquatic communities of rivulets and lakes. Only the first five groups contain both a considerable terricolous lichen cover and lichen flora. The other communities (Asplenietea, Phagnalo-Rumicetea, Thlaspietea, Oxycocco-Sphagnetea, Scheuchzerietea, Montio-Cardaminetea, Littorelletea, Isoeto-Nanojuncetea) usually host few terricolous lichen species and are not included in this survey.

So far the second author has identified some 250 vascular plant species in the area over 1600 m s. m. This is about the same as the total amount of lichen species identified by the first author. Unpublished data from SÉRGIO & GARCIA show that the number of bryophyte species mounts over 300. This means that cryptogams contribute for a major part to the biodiversity of the upper belt. This can at least partly be explained by the fact that many bryophytes and lichens are able to grow in other biotopes, especially on different substrata (epilithic and epiphytic cryptogams). The number of terrestrial lichen species (some 80) is significantly lower than of vascular plants. Finally we notice the importance of *Cladonia* species representing almost a third of the total number of terrestrial lichen species.

Dwarf juniper, broom and thorn-cushion scrub (Pino-Juniperetea); (Natura 2000 codes: 4060, 4090, 5120). Within the scrub communities of the Pino-Juniperetea quite some variations occur, mainly depending on local climate, topography, soil development and land use (JANSEN & al. 1999). In the scope of this study we do not deal with all these variations. Moreover, both thorn-cushion scrub (Teucrio-Echinospartetum) and post-fire broom scrub predominated by *Cytisus oromediterraneus* are left out of consideration. Such Natura 2000 biotopes (codes 4090 and 5120 respectively) generally include few terricolous lichen species and those that do occur are usually common in the area.

The Lycopodio-Juniperetum nanae has a rich lichen flora, calling up associations with the arctic-alpine wind heaths (Loiseleurio-Vaccinietea). This endemic association forms the climax community of the mesosere. Based on 134 relevés we made an estimation of the degree of occurrence of terricolous lichens.

Common species in the Lycopodio-Juniperetum are: *Cetraria aculeata*, *C. islandica*, *Cladina arbuscula*, *Cladonia cervicornis*, *C. coccifera* s. str., *C. furcata*, *C. gracilis*, *C. phyllophora*, *C. pyxidata*, *Trapeliopsis granulosa*.

Occasional species: *Cladina rangiferina*, *Cladonia crispata*, *C. macilenta* s. l., *C. ramulosa*, *C. subulata*, *C. uncialis*, *Lepraria neglecta*, *Parmelia omphalodes*, *Peltigera malacea*, and *Psoroma hypnorum*.

Rare species: *Baeomyces rufus*, *Cladina portentosa*, *Cladonia carneola*, *C. cornuta*, *C. cyathomorpha*, *C. fimbriata*, *C. floerkeana*, *C. foliacea*, *C. glauca*, *C. merochlorophaea*, *C. pocillum*, *C. rangiformis*, *C. squamosa*, *C. strepsilis*, *Lecidoma demissum*, *Leptogium lichenoides*, *Massalongia carnosa*, *Melanelia commixta*, *Nephroma laevigatum*, *N. resupinatum*, *Ochrolechia androgyna*, *Parmelia saxatilis*, *Parmeliopsis ambigua*, *Peltigera britannica*, *P. canina*, *P. hymenina*, *P. membranacea*, *P. neckeri*, *P. polydactylon*, *Placynthiella icmalea*, *Platismatia glauca*, *Pseudevernia furfuracea*, *Pycnothelia papillaria*, *Spaerophorus globosus*, *Stereocaulon evolutum*, *Trapeliopsis wallrothii*, and *Umbilicaria polyphylla*.

We could identify 25 *Cladonia* species and 7 *Peltigera* species. Within the Lycopodio-Juniperetum, *Peltigera malacea* seems to have preference for the transition to Junipero-Ericetum heathlands in which this species has its optimal occurrence. *Cladina rangiferina* shows preference for cold N-oriented slopes.

Heathlands (Calluno-Ulicetea; Natura 2000 codes: 4010, *4020, 4030). Heathlands from the upper belt mainly include three associations. Both Potentillo-Callunetum and Ericetum tetralicis (Oxycocco-Sphagnetea) occur on hydromorphic soils throughout the upper belt and Junipero-Ericetum aragonensis marks the transition to the middle belt.

In the Ericetum tetralicis no lichens were found, probably because this association is very rare in Estrela; moreover it occurs on peaty soils that are waterlogged during a large part of the year.

In the Potentillo-Callunetum terricolous lichens occur frequently, especially in a variant with *Pycnothelia papillaria* (see JANSEN 1994 a). This variant occurs in wind-exposed sites. The second author proposes here to raise this variant to the rank of subassociation. Lectotype of the **Potentillo-Callunetum pycnothelietosum papillariae subass. nova hoc loco** is relevé 16 from table 2 in JANSEN (1994 a). Common lichen species from this subassociation are *Cetraria aculeata*, *C. islandica*, *Pycnothelia papillaria*, and *Trapeliopsis granulosa*. *Cladonia strepsilis* seems to be one of the differential species of this subassociation. The following lichen species (varying from rare to occasionally) have been found in the Potentillo-Callunetum: *Baeomyces rufus*, *Cladina arbuscula*, *C. portentosa*, *C. rangiferina*, *Cladonia carneola*, *C. cervicornis*, *C. coccifera*, *C. crispata*, *C. fimbriata*, *C. floerkeana*, *C. furcata*, *C. glauca*, *C. gracilis*, *C. macilenta* s. l., *C. phyllophora*, *C. pyxidata*, *C. ramulosa*, *C. subulata*, *C. uncialis*, *Lepraria neglecta*, *Peltigera malacea*, *P. membranacea*, *P. polydactylon*, *Placynthiella icmalea*.

In the lower parts of the upper belt the Lycopodio-Juniperetum transgrades into the Junipero-Ericetum. The latter is generally considered a degraded stage of the Pyrenean oak forest. The Junipero-Ericetum is mostly predominated by *Erica australis* and often accompanied by *E. umbellata* LOEFL. ex L., *E. arborea* L., *Calluna vulgaris* HULL, and occasionally by other dwarf shrubs (e.g., *Juniperus communis* subsp. *alpina*, *Cytisus oromediterraneus*). The association has a rich terricolous and epiphytic lichen flora. Half of the relevés had a lichen cover of 25% or more. *Cladonia uncialis* is a good differential species against the Lycopodio-Juniperetum; *Cladonia cervicornis*, *C. phyllophora* and *Peltigera malacea* are weak differential species. Terricolous lichens include 22 *Cladonia* species and 8 *Peltigera* species. Note that the analysis is based on 69 relevés over 1600 m s. m. A total analysis of the Junipero-Ericetum, including lower altitudes, may give a different picture. Although 10 species of *Peltigera* have already been recorded for Serra da Estrela by VITIKAINEN (1994) and MARTÍNEZ (1999), most of their records are from lower altitudes. Only *P. britannica* and *P. praetextata* are mentioned for the upper belt.

Common terricolous species are: *Cetraria aculeata*, *C. islandica*, *Cladina arbuscula*, *Cladonia cervicornis*, *C. coccifera* s. str., *C. furcata*, *C. gracilis*, *C. macilenta* s. l., *C. phyllophora*, *C. pyxidata*, *C. ramulosa*, *C. subulata*, *C. uncialis*, *Lepraria neglecta*, *Peltigera malacea*, and *Trapeliopsis granulosa*.

Occasional are : *Baeomyces rufus*, *Cladina portentosa*, *C. rangiferina*, *Cladonia* *cornuta*, *C. crispata*, *C. floerkeana*, *C. foliacea*, *C. glauca*, *C. merochlorophaea*, *Lecidoma demissum*, *Massalongia carnosa*, *Parmelia omphalodes*, *Psoroma hypnorum*, and *Pycnothelia papillaria*.

Rare species include: *Cladonia carneola*, *C. fimbriata*, *C. rangiformis*, *C. squamosa*, *C. strepsilis*, *Evernia prunastri*, *Lasallia hispanica*, *Ochrolechia androgyna*, *O. frigida*, *Peltigera britannica*, *P. canina*, *P. didactyla*, *P. hymenina*, *P. membranacea*, *P. neckeri*, *P. polydactylon*, *Placynthiella icmalea*, *Sphaerophorus globosus*, *Stereocaulon evolutum*, *Trapeliopsis wallrothii*, and *Usnea* spp.

Grasslands (Festucetea indigestae, Nardetea, Sedo-Scleranthetea; Natura 2000 codes: 6160, *6230 p.p., 8230). Open grasslands in the Serra da Estrela include communities from four syntaxonomic classes: Festucetea indigestae, Sedo-Scleranthetea, Koelerio-Corynephoretea, and Helianthemetea. The open grasslands mostly occur in convex areas, whereas the more dense grasslands (Nardetea) occur in concave areas. On the basis of 153 relevés from open grasslands we made a general estimation of the distribution status of the occurring lichens.

Common species in these open grasslands are *Cetraria aculeata*, *Cladonia cervicornis*, *C. coccifera* s. str., *C. furcata*, *C. uncialis*, and *Trapeliopsis granulosa*.

Occasional species are: *Cetraria islandica*, *Cladina arbuscula*, *Cladonia gracilis*, *C. pyxidata*, *C. rangiformis*, *C. strepsilis*, *Lecidoma demissum*, *Lepraria caesioalba*, *L. neglecta*, *Melanelia commixta*, *Pycnothelia papillaria*, and *Trapeliopsis wallrothii*.

Rare species are: *Bryonora curvescens*, *Caloplaca nivalis*, *C. tiroliensis*, *Cetraria muricata*, *Chromatochlamys muscorum*, *Cladina portentosa*, *C. rangiferina*, *Cladonia carneola*, *C. crispata*, *C. floerkeana*, *C. foliacea*, *C. glauca*, *C. macilenta* s. l., *C. merochlorophaea*, *C. phyllophora*, *C. ramulosa*, *C. subulata*, *Lasallia pustulata*, *Lecidea rufofusca*, *Massalongia carnosa*, *Neofuscelia loxodes*, *N. pulla*, *Parmelia omphalodes*, *Peltigera malacea*, *P. neckeri*, *Placynthiella icmalea*, *Psoroma hypnorum*, *Trapeliopsis flexuosa*, *Umbilicaria polyphylla*, *Xanthoparmelia conspersa*, and *X. protomatrae*.

Many of the open grasslands are subjected to relatively strong cryogenic forces. The Iberian Festucetea indigestae have close affinities to the Juncetea trifidi from the Alps and other alpine areas. As for Natura 2000 habitats they are included in the "6160 Siliceous Festuca indigesta Iberian grasslands". From all grasslands they host the largest number of lichens. At wind-exposed convex areas these grasslands are sometimes almost entirely covered by *Cladina arbuscula*, or more rarely by *C. rangiferina*. However, both *Cladina* species develop only abundantly in areas in the absence of strong wind abrasion by gravel. An important part of the encountered lichens are typical soil surface species such as *Lecidea rufofusca*, *Lecidoma demissum*, *Pycnothelia papillaria*, *Trapeliopsis granulosa*, *T. wallrothii*, and several *Cladonia* spp. We note that *Cladonia cervicornis*, one of the most frequent species, usually lacks cups in open grasslands. This is in accordance with KETNER-OOSTRA (1999) who made similar observations on soil crusts in Australia. In heathlands and dwarf juniper scrub specimens of *Cladonia cervicornis* usually do have cups, a phenomenon which may be due to the protection of shrubs against wind abrasion by quartz grains.

Perhaps the most species-rich group of open grasslands is those predominated by *Luzula caespitosa* GAY (Sileno elegantis-Luzuletum caespitosae JANSEN, ined.). These grasslands mostly occur as "Treppenrasen" on slopes. They often support a considerable lichen cover. A slope with Sileno-Luzuletum at Cântaro Raso, sheltered by very steep N-facing cliffs, yielded an interesting lichen flora with *Caloplaca nivalis*, *Chromatochlamys muscorum*, *Cladonia phyllophora*, *Lecidea rufofusca*, and *Lepraria neglecta*. The latter species has previously been published from Portugal but without the chemical identity within the "*L. neglecta* group". However we can confirm here the presence of *L. neglecta* s. str., proven by TLC.

Lecidea rufofusca is a terricolous species growing on compact sandy soil. It has recently been reported from the study area (BOOM & GIRALT 1999).

Most of the more dense grasslands are predominated by *Nardus stricta* L., including Galio saxatilis-Nardetum, Genisto anglicae-Nardetum and Campanulo herminii-Festucetum henriquesii. These mat-grass swards usually do not host many lichens. Especially the first two associations are rather heavily grazed and trampled in summer by herds of sheep and goats. This favours *Nardus* making dense carpets. Transition zones to open grasslands offer better conditions for lichens to compete with vascular plants. These zones are mostly situated between concave areas and convex areas. The former are often occupied by Festucetea indigestae grasslands and Pino-Juniperetea scrub, the latter by *Nardus* grasslands and Potentillo-Callunetum heath. Concave areas receive run-off offering vascular plants a better competition position than convex areas. From 38 relevés we conclude the following distribution status of lichens within Nardetea.

Occasional species are: *Cetraria aculeata*, *C. islandica*, *Cladina arbuscula*, *Cladonia cervicornis*, *C. coccifera* s. str., *C. gracilis*, *C. pyxidata*, *C. uncialis*; rare species are: *Cladonia foliacea*, *C. merochlorophaea*, *C. phyllophora*, *Melanelia commixta*, *Parmelia omphalodes*, *Sphaerophorus globosus*, and *Trapeliopsis granulosa*.

3 Epiphytic lichens and their major habitats

The upper belt hosts a rich epiphytic lichen flora, in spite of the fact that no forests occur over 1600 m s. m. A few isolated shrubby trees do occur, but they usually support few lichen species. The richness of the epiphytic flora is almost totally on the account of dwarf juniper scrub and heathlands. We assume that these scrub formations must have inherited an important part of the epiphytic lichen flora of the former climax forests.

The following survey is a synthesis based on earlier findings (see JANSEN 1993) and additional collections made by the first author.

There are more than 15 different possible phorophytes occurring in the upper belt. Some of them have their optimum in the middle belt and are rarely found in the upper belt. Only samples have been taken from the most frequent phorophytes.

The following phorophytes have been sampled (with number of epiphytic lichen species in brackets): *Juniperus communis* subsp. *alpina* (59), *Erica arborea* (47), *E. australis* (44), *E. umbellata* (28), *Calluna* (21), *Cytisus oromediterraneus* (16), *Halimium lasianthum* (LAM.) SPACH subsp. *alyssoides* (LAM.) GREUTER (14), *Genista florida* L. (11), and *Quercus pyrenaica* WILLD. (10).

The first three species have relatively large stems and branches, offering better opportunities for epiphytic lichens to establish. Shrubs from the *Leguminosae* family are usually less woody and carry fewer lichens. *Genista florida* is an exception. It attains more than 4 m, while having arm-sized branches supporting a considerable lichen flora. This species has its optimum in the middle belt. It has been subsequently sampled only twice, explaining the relatively low number of epiphytic lichens reported here.

The corticolous flora of trees is particularly poor, probably because of the lack of mature trees and the lack of diversity in tree species in the study area. In the middle belt various woodland communities exist (RIVAS-MARTÍNEZ & al. 2000). These forests usually support a rich epiphytic flora. So far a large collection has been made and in future a preliminary survey of the epiphytic lichen flora of these forests is foreseen.

The trunks and branches of two inspected *Quercus pyrenaica* trees appeared to be colonized by common macro-lichens like *Hypogymnia tubulosa*, *Melanelia exasperata*, *Parmelia sulcata*, and *Parmelina tiliacea*. Micro-lichens such as *Arthopyrenia punctiformis*, *Lecanora argentata*, *L. carpinea*, and *Rinodina sophodes* point out some affinities to the Lecanoretum subfuscae.

Within the given time it was not possible to collect lichens neither from the bark of the rare *Betula celtiberica* ROTHM. & VASC. nor of *Sorbus aucuparia* L., the most frequent (small) tree species. Collections of these phorophytes should be made in the future.

Epiphytic lichens from the upper belt mainly occur on shrubs. Common epiphytic species on shrubs are: *Bryoria fuscescens*, *Buellia chloroleuca*, *B. griseovirens*, *Cetraria aculeata*, *Hypogymnia tubulosa*, *Lecanora pulicaris*, *L. symmicta*, *Melanelia exasperata*, *Mycobilimbia carneoalbida*, *Parmelia saxatilis*, *Platismatia glauca*, *Pseudevernia furfuracea*, and *Trapeliopsis granulosa*. Occasional species are: *Melanelia subaurifera*, *Parmelia omphalodes*, *Parmelia sulcata*, and *Parmeliopsis ambigua*. Rare epiphytic species are: *Buellia iberica*, *Japewia subaurifera*, *Lecidea antiloga*, *L. porphyrospoda*, *Leptogium lichenoides*, *Massalongia carnosa*, *Melanelia commixta*, *Nephroma resupinatum*, *Ochrolechia androgyna*, *Parmelia saxatilis*, and *Placynthiella icmalea*.

Buellia chloroleuca is a species new to Portugal. So far only one collection was mentioned for Spain (GIRALT & al. 2000).

Hypogymnia tubulosa is the only species that has been found on all phorophytes examined. However, certain lichen species seem to have affinity with specific phorophytes (see also JANSEN 1993). *Brodoa intestiniformis*, *Mycobilimbia carneoalbida*, *Pertusaria albescens*, and *Rinodina archaea* have been exclusively found on *Juniperus*. The same holds for *Biatora vernalis*, *Nephroma resupinatum*, *Peltigera membranacea*, and *Sphaerophorus globosus*, although these species also grow on soil and/or rock. *Juniperus* and *Erica arborea* have some epiphytes in common that do not grow on *Erica australis*, like *Japewia subaurifera*, *Melanelia commixta*, and *Ochrolechia androgyna*. *Usnea* spp. have been found on all three *Erica* species and *Halimium*, but not on *Juniperus*. *Cetraria chlorophylla* has been found on all three *Erica* species and *Calluna*, but not on *Juniperus*. *Melanelia exasperatula* has been found on *Erica arborea* and *E. australis*, but not on *Juniperus*. *Alectoria sarmentosa* has been found exclusively on *Calluna* and *Rhizocarpon geographicum* only on *Cytisus oromediterraneus*; *Ramalina farinacea* and *Xanthoparmelia protomatrae* have only been found growing on *Halimium*, although *X. protomatrae* also occurs on soil. *Caloplaca ferruginea* has only been found on *Quercus pyrenaica*.

A preliminary classification of epiphytic lichen assemblages based on TWINSPAN (HILL 1979) and CEDIT (TONGEREN 1991) resulted in three major types (JANSEN 1993).

The first type has been described as inops-coenon (JANSEN 1993). This species-poor coenon probably represents an initial phase of the other two distinguished coena, because it has been found in all scrub communities. However most frequently it was found in the Junipero-Ericetum. This may be related to fire history and partly also to relative warm environments (S-oriented slopes). The lower parts of the mountain are more frequently subjected to fire than the highest parts and warm environments have higher fire risks. The coenon has one weak differential species namely *Scoliciosporum umbrinum*. According to WIRTH (1995) this is a toxitolerant species.

Common species of the inops-coenon are: *Buellia griseovirens*, *Cetraria aculetea*, *C. sepincola*, *Hypogymnia tubulosa*, *Lecanora pulicaris*, *L. symmicta*, *Parmelia omphalodes*, and *Pseudevernia furfuracea*.

Here it is stressed that the effects of burning on epiphytes should be investigated, preferably on the basis of permanent plots (JANSEN & al. 1997). It is assumed that colonization of scrub by epiphytes may go in several phases: the older the scrub (the longer the fire history) the more mature (and diverse) the assemblage. If our hypothesis is correct then it underlines the necessity for nature management of maintaining all developmental stages of scrub types in time and space in order to have the highest diversity (JANSEN 1994 b).

The second and third type include a large number of lichen species. Common species in both types are: *Buellia griseovirens*, *Cetraria aculeata*, *C. sepincola*, *Hypogymnia tubulosa*, *Lecanora symmicta*, *Parmelia omphalodes*, *Platismatia glauca*, and *Pseudevernia furfuracea*.

The second type has been described as the *Usnea subfloridana-Melanelia exasperatula*-coenon (JANSEN 1993). However after revision of the herbarium material the record of *Usnea subfloridana* cannot be maintained. So far the material includes two unidentified *Usnea* species. From now on the second group will be denominated as *Evernia prunastri-Melanelia exasperatula*-coenon. This coenon may be ranked within the Hypogymnion physodis. The *Evernia prunastri-Melanelia exasperatula*-coenon seems to develop optimally in the Junipero-Ericetum, although some records are known from both Lycopodio-Juniperetum and Potentillo-Callunetum.

Diagnostic species are: *Bryoria fuscescens*, *Buellia disciformis*, *Caloplaca ferruginea*, *Cetraria chlorophylla*, *Evernia prunastri*, *Hypogymnia physodes*, *Melanelia exasperata*, *M. exasperatula*, *M. subaurifera*, *Mycobilimbia carneoalbida*, and *Usnea* spp.

The third type has been described as *Buellia erubescens-Cladonia pyxidata*-coenon (JANSEN 1993). However this name cannot be maintained neither. Revision of the herbarium material revealed that the former name-giving *Buellia* species in question is *B. chloroleuca*. Therefore the name is changed into *Buellia chloroleuca-Cladonia pyxidata*-coenon. This coenon may be ranked within the Cetrarion pinastri. It has affinities with the Parmeliopsidetum ambiguae, the only chionophilous association of the Alectorietalia. The *Buellia chloroleuca-Cladonia pyxidata*-coenon seems to develop optimally in the Lycopodio-Juniperetum, although some records are known from both Junipero-Ericetum and Potentillo-Callunetum.

Diagnostic species are: *Buellia chloroleuca*, *Cladonia furcata*, *C. pyxidata*, *Lepraria neglecta*, *Melanelia commixta*, *Ochrolechia androgyna*, and *Parmeliopsis hyperopta*.

Now that we have a better knowledge of the lichen flora, epilithic and epiphytic communities should be studied more intensively. This would be an important step to establish a complete comprehensive syntaxonomic survey of all the communities of vascular plants, bryophytes, and lichens showing the floristic diversity of the upper belt of the Serra da Estrela.

Phytogeographic notes

The upper belt of the Serra da Estrela supports a rather rich lichen flora. This may be explained by several factors such as its long history, its isolation, the low air pollution, its bioclimatic variation ranging from Temperate to sub-Mediterranean, and the presence of a wide variety of biotopes.

The list includes 250 infrageneric lichen taxa (249 species and one variety). On the whole, crustose lichens make up 60.8% (including lichenicolous lichens), foliose 20.4% and fruticose 18.8%. Most of the species are saxicolous (51.2%), including species growing on saxicolous bryophytes; epiphytic species are 31.6%, and terricolous species include 30.0%.

The species have been subdivided into eight phytoclimatical groups, based on their latitudinal and longitudinal ranges in Europe (WIRTH 1995, NIMIS & TRETIACH 1995). Additional data are obtained from NIMIS (1993), PURVIS & al. (1992), and CLAUZADE & ROUX (1985) (Fig. 5).

The Temperate element is clearly best represented with 38.8% of the total lichen flora. It is formed by wide ranging species that occur from Arctic (or Boreal) to Mediterranean areas. The northern Temperate species count for 9.2%, but the southern Temperate flora element for only 3.2% of the lichen flora. The Arctic-Alpine element is formed by 13.2% and the Boreal-montane element represents about the same: 12.8%. The group consisting of sub-Mediterranean to Mediterranean taxa includes 4.8%. Northern and southern sub-Atlantic taxa constitute 5.2% and taxa with a strictly Atlantic character account for 3.2% of the total lichen flora. Species not belonging to one of the eight phytoclimatical groups are "others" (9.4%). Finally we notice the absence of the Southern European orophytic element that includes upland areas of southern Central and South-Europe (see NIMIS & TRETIACH 1995).

The relatively high annual precipitation and the large number of foggy days are assumed to be the major determinants to explain the absence of xerophytic species that are particularly frequent in lower hilly areas in Portugal (compare CARVALHO 1997).

Strict endemic lichen taxa could not be detected from the study area in contrast to the relatively high proportion of endemics in its vascular flora.

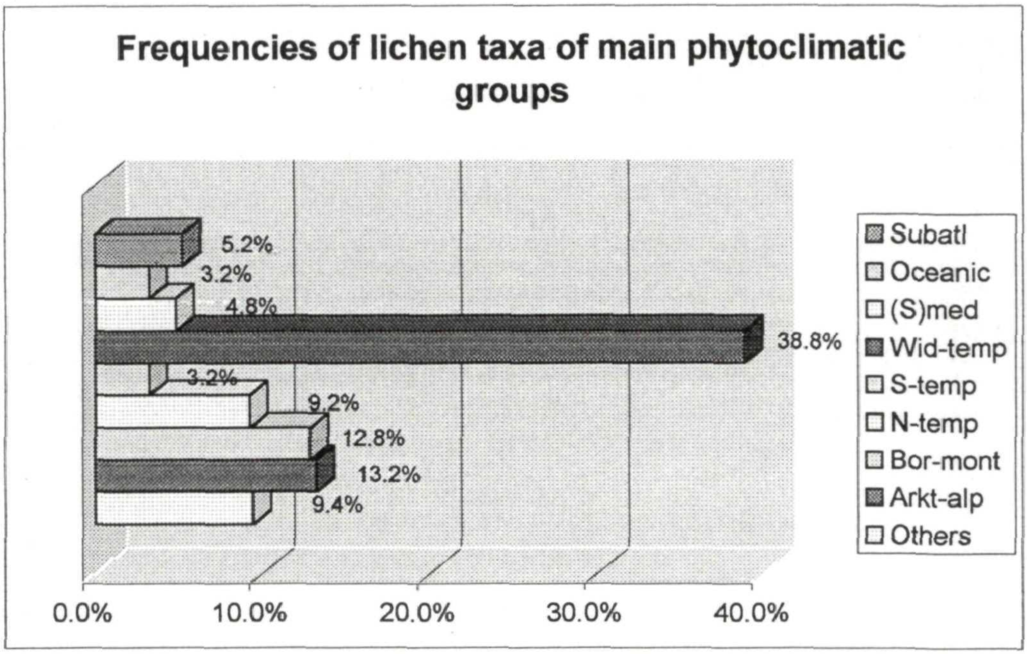

Fig. 5. Frequencies of lichen taxa of main phytoclimatic groups.

In future we intend to study the lower parts of the Estrela. It is expected that the phytogeographic spectrum of the lower parts of the Estrela will be rather different. The Atlantic element for instance is much better represented in the Serra de S. Mamede, a mountain with only a lower and middle belt situated SE of our study area (CARVALHO 1997).

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Appendix 1. Preliminary check-list of lichens from the upper belt (> 1600 m s. m.) of the Serra da Estrela

* new to Portugal
** new to Iberian Peninsula

Abbreviations: AL *Halimium lasianthum* subsp. *alyssoides*, AR *Erica arborea*, AU *Erica australis*, CV *Calluna vulgaris*, E *Erica* spec., GF *Genista florida*, JU *Juniperus communis* subsp. *alpina*, CY *Cytisus* spec., OR *Cytisus oromediterraneus*, Q *Quercus pyrenaica*, UM *Erica umbellata.*

f field observation
o older published record
e epiphytic, s saxicolous, t terricolous

Acarospora smaragdula (WAHLENB.) MASSAL. s 22 med-mieur.mo/alp-med.mo/alp
Adelolechia pilati (HEPP) HERTEL & HAF. s 22 arkt-h'mo/alp
Alectoria sarmentosa (ACH.) ACH. e, s 13 5 36 (CV) bor-smed.mo (med.mo)
Amandinea punctata (HOFFM.) COPPINS & SCHEIDEG. e 36 AU, UM (arkt-)bor-med
Arctomia delicatula TH. FR. s 8 21 bor-mieur
Arthopyrenia punctiformis MASSAL. e 31Q bor-med
Arthrorhaphis citrinella (ACH.) POELT s 5 arkt-med.mo
Aspicilia caesiocinerea (NYL. ex MALBR.) ARNOLD s. l. s 4 6 bor-med.mo
Aspicilia cinerea (L.) KÖRBER s 19 28 bor-med.mo
Aspicilia epiglypta (NORRLIN ex NYL.) HUE s 4 29 (s'bor-)mieur
Aspicilia intermutans (NYL.) ARNOLD s. l. s 22 bor-med
Aspicilia laevatoides (MAGN.) OXNER s 11 12 13 bor-mieur.mo-s'med.mo
Aspicilia subdepressa NYL. s 10 12 22 med?
Baeomyces rufus (HUDSON) REBENT. t 36, 39, bor-smed(-med.mo)
Bellemerea alpina (SOMMERF.) CLAUZ. & ROUX s 11 16 18 23 arkt-alp
Biatora vernalis (L.) FR. e, s 8 18 36 JU 37, 39 bor-mieur.mo-smed.mo, subatl
Brodoa intestiniformis (VILL.) GOWARD e, s 1f 2f 4 6 10 11f 20 21 22 36 (JU) arkt-h'mo/alp
Bryonora curvescens (MUDD) POELT t 8 21 36 43 smed
Bryophagus gloeocapsa NITSCHKE ex ARNOLD s 21 bor-mieur.mo
**Bryoria bicolor* (EHRH.) BRODO & D. HAWKSW. s 13 s'bor.subatl-mieur.subatl
Bryoria fuscescens (GYELNIK) BRODO & D. HAWKSW. e, s 13f 18 22 24 32 E 34 E 36 (AR, AU, JU, UM) bor-med.mo

Buellia aethalea (ACH.) TH. FR. s 21 36 (s')bor-mieur-med
Buellia badia (FR.) MASSAL. s 4 21 (s')bor-med.mo
**Buellia chloroleuca* KÖRBER e 32 AR 36 (AL, AR, CV, JU, OR) mieur.mo-smed.mo, subatl
Buellia disciformis (FR.) MUDD e 36 (AL, AR, AU, JU, UM) bor-med.mo
Buellia griseovirens (TURNER & BORRER ex SM.) ALMB. e 30 GF 36 (AL, AR, AU, CV, JU, UM) s'bor-mieur.subatl-med
**Buellia hypophana* (NYL.) ZAHLBR. t 37 med.subatl?
Buellia iberica GIRALT & LLIMONA e 30 GF smed-med?
**Buellia longispora* SCHEID. s 21 med
Buellia uberior ANZI s 21 arkt-alp
Caloplaca arenaria (PERS.) MÜLL. ARG. s 23 bor-med
Caloplaca cerina (EHRH. ex HEDWIG) TH. FR. s 20 bor-med
Caloplaca congrediens (NYL.) ZAHLBR. s 4 8 21 med.s'atl
Caloplaca crenularia (WITH.) LAUNDON s 22 bor-mieur.subatl-med
Caloplaca ferruginea (HUDS.) TH. FR. e 31 Q bor.subatl-med
Caloplaca nivalis (KÖRBER) TH. FR. s 18 37 arkt-alp
**Caloplaca tiroliensis* ZAHLBR. t 43 arkt-alp
Candelariella vitellina (HOFFM.) MÜLL. ARG. e, s 1f 4f 21f 22f 37 AR arkt-med
Carbonea assimilis (KÖRBER) HAF. & HERTEL s 13 bor.atl-mieur.subatl-smed
Carbonea supersparsa (NYL.) HERTEL s 1 19 bor-med
Catapyrenium cinereum (PERS.) KÖRBER t 39 arkt-med.alp
Catillaria chalybeia (BORRER) MASSAL. s 22 bor(atl)-mieur-med(mo)
Catolechia wahlenbergii (ACH.) KÖRBER s 5 21 arkt-mieur.alp
Cecidonia umbonella (NYL.) TRIEBEL & RAMBOLD s 3 11f 17 25 arkt-alp
Cetraria aculeata (SCHREBER) FR. e, t 35 E 36, 37, 39 (AR, AU, CV, JU, UM) bor-med.mo
Cetraria chlorophylla (WILLD.) VAINIO e 32 E, 36 (AR, AU, CV, UM) bor-smed.mo(-med.mo)
Cetraria islandica (L.) ACH. e, t 36 37, 39 (AR, AU, CA, JU, UM) arkt-mieur(-med.mo)
Cetraria muricata (ACH.) ECKFELDT e, t 1 13 35 E 37 38 42 arkt-bor-med.alp
Cetraria pinastri (SCOP.) GRAY e 32 E 36 (AR, AU, CA, JU) bor-smed.mo(-med.mo)
Cetraria sepincola (EHRH.) ACH. e 32 E 34 E 35 E 36 (AL, AR, AU, CA, JU, OR, UM) bor-mieur.mo (-smed.subalp)
Chromatochlamys muscorum (FR.) MAYRHOFER & POELT t 7 25 37 bor-smed.mo(-med.mo)?
Cladina arbuscula (WALLR.) HALE & CULB. t 36 39 arkt-mieur(-smed.mo)
Cladina portentosa (DUF.) FOLLM. t 36 38 39 mieur-(s)med.subatl
Cladina rangiferina (L.) NYL. t 36 37 38 39 (arkt-)bor-mieur(-smed.mo)
Cladonia carneola (FR.) FR. t 36 38 39 (arkt-)bor-mieur.h'mo
Cladonia cervicornis (ACH.) FLOTOW e, t 36 39 (JU) bor-med.subatl
Cladonia chlorophaea (FLÖRKE ex SOMMERF.) SPRENGEL e 36 (AU, JU) ark-med, o
Cladonia coccifera (L.) WILLD. e, t 36 37 38 39 (AR, AU, JU, UM) (s')bor(subatl)-mieur(subatl)-med.mo
Cladonia coniocraea (FLÖRKE) SPRENGEL e 36 (AR, AU, JU, UM) bor-smed(-med)
Cladonia cornuta (L.) HOFFM. t 36 (arkt-)bor-mieur.mo
Cladonia crispata (ACH.) FLOTOW e, t 36 (JU) arkt-mieur, o
Cladonia cyathomorpha STIRTON ex W. WATSON s, t 13 39 mieur.atl-smed.atl?
Cladonia fimbriata (L.) FR. e, t 36 39 (AR, AU, JU, UM) (arkt-)bor-med, o
Cladonia floerkeana (FR.) FLÖRKE t 36 39 (UM) s'bor-smed
Cladonia foliacea (HUDS.) WILLD. t 36 39 mieur.subatl-med
Cladonia furcata (HUDS.) SCHRAD. e, t 36 39 (AR, JU) bor-med, o
Cladonia glauca FLÖRKE t 36 39 (s'bor-)mieur
Cladonia gracilis (L.) WILLD. t 36 37 38 39 41 arkt-smed.mo
Cladonia macilenta HOFFM. s. l. t 36 s'bor-smed(-med)
Cladonia merochlorophaea ASAH. t 36 arkt-mieur(-smed), o
Cladonia phyllophora HOFFM. e, t 36 37 (JU, UM) bor-mieur
Cladonia pocillum (ACH.) O. J. RICH. t 36 37 arkt-med, o

Cladonia pyxidata (L.) HOFFM. e, t 36 37 (AR, AU, CA, JU, OR) arkt-med, o
Cladonia ramulosa (WITH.) LAUNDON t 36 38 39 (s'bor-)mieur.subatl-smed.subatl(-med)
Cladonia rangiformis HOFFM. t 36 s'bor-med, o
Cladonia squamosa (SCOP.) HOFFM. t 36 arkt-med, o
Cladonia strepsilis (ACH.) GROGNOT t 36 39 41 (bor.atl-)mieur.subatl-smed
Cladonia subcervicornis (VAINIO) KERNST. s 21 bor.atl-med
Cladonia subulata (L.) WEBER ex WIGG. t 36 39 bor-med, o
Cladonia uncialis (L.) WEBER ex WIGG. t 24 36 arkt-mieur(-smed.alp)
Coelocaulon crespoae BARRENO & VASQUEZ e 32 E (JU) smed-med
Cornicularia normoerica (GUNN.) DU RIETZ s 1f 2f 4f 8 9 10f 11f 19 20f 21f arkt-alp,subatl
Cystocoleus ebeneus (DILLWYN) THWAITES s 13 16 17 bor-mieur
Dermatocarpon luridum (WITH) LAUNDON s 7 s'bor-mieur-smed (alp)-(-med.alp)
Dimelaena oreina (ACH.) NORM. s 1f 2f 4f 10f 11f 20f 21 22f arkt-alp/pralp
Enterographa zonata (KÖRBER) KALLSTEN s 16 (bor.atl-)s'bor.subatl-smed.subatl(-med)
Ephebe lanata (L.) VAINIO s, t 7 19 29 bor-smed.mo
Evernia prunastri (L.) ACH. e, t 36 (AL, AR, AU) bor-med
Fuscidea interincta (NYL.) POELT s 8 20 21f bor-atl
Fuscidea kochiana (HEPP) V. WIRTH & VĚZDA s 20 s'bor.atl-mieur.subatl-med(subatl)-mo
**Fuscidea praeruptorum* (DU RIETZ & MAGN.) V. WIRTH & VĚZDA s 20 21 22 s'bor.subatl-med. mo(oz)
Fuscopannaria mediterranea (TAV.) P. M. JØRG. e 36 (JU) bor.atl-med.atl
Halecania giraltiae VAN DEN BOOM & ETAYO s 21 smed.atl?
Halecania viridescens COPPINS & P. JAMES e 36 (AU) mieur.atl-smed.atl ?
Hymenelia lacustris (WITH.) M. CHOISY s 6 26 29 arkt-smed.mo
Hypogymnia farinacea ZOPF s 13 s'bor-med.h'mo
Hypogymnia physodes (L.) NYL. e 36 (AR, AU, CA, JU) arkt-med
Hypogymnia tubulosa (SCHAERER) HAV. e 31 Q, 35 E, 36, (AL, AR, AU, CA, GF, JU, OR, UM) bor-med
Immersaria athroocarpa (ACH.) RAMBOLD & PIETSCHM. e 10 mieur-med.mo
Japewia subaurifera MUHR & TØNSB. e 32 E 36 (AR, JU) bor-mieur
Lasallia hispanica (FREY) SANCHO & CRESPO s, t 1f 9 10 11f 19 20f 21r smed-med?
Lasallia pustulata (L.) MÉRAT s, t 1f 4f 10f 17 20f 21f 22f s'bor-med
Lecanora achariana A. L. SM. s 21 bor-mieur
Lecanora argentata (ACH.) MALME e 31 Q 34 E s'bor-med
***Lecanora caesiosora* POELT s 12 bor.mo-med.mo
Lecanora carpinea (L.) VAINIO e 31 Q 34 CY 35 GF bor-med.mo
Lecanora cenisia ACH. s 5 10 12f 19 21f 22f arkt-mieur-h'mo/alp
Lecanora hageni (ACH.) ACH. e 31 Q bor-med
Lecanora intricata (ACH.) ACH. s 10f 18 19 26f arkt-bor.h'mo/alp
Lecanora muralis (SCHREBER) RABENH. s 2 arkt-med
Lecanora orosthea (ACH.) ACH. s 13 (s'bor-)mieur-med.mo
Lecanora polytropa (HOFFM.) RABENH. s 1f 4f 10f 11f 20 21 22f arkt-med
Lecanora pulicaris (PERS.) ACH. e 30 G 36 (AR, AU, CA, GF, JU, OR, UM) bor-med.mo
Lecanora rupicola (L.) ZAHLBR. s 21 arkt-med
Lecanora strobilina (SPRENGEL) KIEFFER e 35 E mieur-med.subatl
Lecanora symmicta (ACH.) ACH. e 30 GF 32 E 35 CY, E 36 (AL, AR, AU, CA, GF, JU, OR, UM) bor-med
Lecanora varia (HOFFM.) ACH. e 30 GF 36 bor-med.mo
Lecidea antiloga STIRTON e 32 E (AR, AU, CA, JU, UM) bor-med
Lecidea atrobrunnea (LAM. & DC.) SCHAERER s 4 arkt-alp
Lecidea fuliginosa TAYLOR s 21 (bor-)mieur.subatl-smed
Lecidea lapicida (ACH.) ACH. s 7 23 arkt-alp
Lecidea lapicida (ACH.) ACH. var. *panterina* ACH. s 1 11 12 13 20 21 22 5 15 19 arkt-alp
Lecidea luteoatra NYL. s 20 21 22 16 mieur

****Lecidea porphyrospoda* (ANZI) TH. FR. e 33 JU 36 AR bor-mieur
Lecidea rufofusca (ANZI) NYL. t 37 38 mieur.mo
Lecidella carpathica KÖRBER s 2 10 arkt-med
Lecidoma demissum (RUTSTRÖM) G. SCHNEIDER & HERTEL t 39, 40, 41, 43 arkt-alp
****Lepraria borealis* LOHTANDER & TØNSBERG e 33 JU bor-mieur
Lepraria caesioalba (B. DE LESDAIN) LAUNDON t 4 9 13 21 38 s'bor-mieur
Lepraria lobificans NYL. s 21 bor-mieur(subatl)-med
Lepraria neglecta VAINIO t 37 (AR, JU) bor-mieur.mo
Lepraria rigidula (HUE) TØNSB. s 13 16 s'bor-med
Leproloma membranaceum (DICKSON) VAINIO s 2 21 bor-med
Leptogium lichenoides (L.) ZAHLBR. t 36 39 arkt-med
****Leptogium rivale* TUCK. s 13 16 mieur-smed.mo
Lopadium pezizoideum (ACH.) KÖRBER s, t 13 17 37 arkt-bor-mieur.mo
Massalongia carnosa (DICKSON) KÖRBER t 2f 4f 11f 12f 18 19 21f 36 37 43 arkt-mieur.mo(-med.mo)
Melanelia commixta (NYL.) THELL e, s 2 9 10 11f 15 18 19 26 32 E 34 E 36 37 38 (AR, JU) arkt-bor-mieur.alp
**Melanelia disjuncta* (ERICHSEN) ESSL. s 2 (arkt-)bor-mieur(-smed)
Melanelia exasperata (DE NOT.) ESSL. e 31 Q 36 (AR, AU) bor-med
Melanelia exasperatula (NYL.) ESSL. e 32 E 36 (AL, AR, AU, CA, JU, UM) bor-med
**Melanelia sorediella* (LETT.) comb. ined. s 23 smed.subatl-med.subatl
Melanelia stygia (L.) ESSL. s 1 2 4f 19 20f 21f 22f arkt-h'mo/alp
Melanelia subaurifera (NYL.) ESSL. e 36 (AL, AR, AU, CA, JU, UM) bor-smed
Micarea botryoides (NYL.) COPPINS s 16 (s'bor-)mieur.subatl
Micarea denigrata (FR.) HEDL. e 35 E 36 (GF) bor-med
Micarea lignaria (ACH.) HEDL. s 17 bor-med.mo
Miriquidica deusta (STENHAM.) HERTEL & RAMBOLD s 21 (s')bor-med
Miriquidica complanata (KÖRBER) HERTEL & RAMBOLD s 18 20 23 bor-mieur.atl
Miriquidica intrudens (H. MAGN.) HERTEL & RAMBOLD s 4f 11 19 23 mieur.h'mo/alp
Miriquidica leucophaea (RABENH.) HERTEL & RAMBOLD s 20 21 bor-mieur.h'mo
Miriquidica nigroleprosa (VAINIO) HERTEL & RAMBOLD s 8 10 11f 20 21 25 arkt-mieur.alp(-med.alp)
Mycobilimbia carneoalbida (MÜLL. ARG.) e 32 E 34 E 36 (AR, AU, CA) mieur-med
Neofuscelia loxodes (NYL.) ESSL. t 2f 4 s'bor-med
Neofuscelia pulla (ACH.) ESSL. t 2f 20f 21f 22f s'bor-med
Nephroma laevigatum ACH. t 36 (s')bor.atl-mieur.atl-med(subatl), o
Nephroma resupinatum (L.) ACH. e, t 36 (JU) bor-med.mo, o
Ochrolechia androgyna (HOFFM.) ARNOLD e, t 10f 15 21f 22f 35 E 36 (AR, JU) bor-med.mo
Ochrolechia frigida (SWARTZ) LYNGE e, t 25 43? (AR) arkt-mieur.mo
Ochrolechia szatalaensis VERS. e 30 JU 36 (AR, CA, JU) bor-mieur.pralp-med.mo
Ochrolechia tartarea (L.) MASSAL s 1 12f 13 8 bor.subatl-mieur.subatl(-smed),oz
Ophioparma ventosum (L.) NORMAN s 10f 15 20f 21f arkt-bor-mieur.h'mo/alp-med.alp
Orphniospora moriopsis (MASSAL.) D. HAWKSW. s 13 bor-alp
Parmelia omphalodes (L.) ACH. t 1 4f 10 11f 12f 15 20f 21f 22f 25 36 37 (AL, AR, AU, CA, JU, OR, UM) arkt-smed.mo/alp
Parmelia saxatilis (L.) ACH. e, s, t 10f 12f 36 (AR, AU, JU) arkt-mieur-med.mo
Parmelia sulcata TAYLOR e 31 Q 36 (AU, GF, JU) arkt-med
Parmelina tiliacea (HOFFM.) HALE e 30 GF (s'bor-)mieur-med
Parmeliopsis ambigua (WULLF.) NYL. e, t 33 JU 36 (AR, AU, JU) bor-smed.h'mo(-med.mo)
Parmeliopsis hyperopta (ACH.) ARNOLD e 36 (AR, AU, JU) bor-mieur.h'mo(-smed.h'mo)
Peltigera britannica (GYELN.) HOLT.-HARTW. & TØNSBERG t 36 45 bor-mieur.subatl
Peltigera canina (L.) WILLD. t 36 39 bor-smed(-med)
Peltigera didactyla (WITH.) LAUNDON t 36 arkt-med, o
Peltigera hymenina (ACH.) DELISE ex DUBY t 24 28 36 39 bor.atl-smed, o
Peltigera malacea (ACH.) FUNCK e, t 13 37, 39 (JU) arkt-smed.mo

Peltigera membranacea (ACH.) NYL. e, t 36 39, 46 (JU) (s'-)bor-smed(-med)
Peltigera neckeri HEPP ex MÜLL. ARG. t 36 39 arkt-med, o
Peltigera polydactylon (NECK.) HOFFM. t 36 arkt-mieur-med.mo
Peltigera praetextata (FLÖRKE ex SOMMERF.) s 12f bor-med
Peltigera rufescens (WEIS) HUMB. t 36 arkt-med, o
Pertusaria albescens (HUDS.) CHOISY & WERNER e 36 (JU) (s')bor-med, o
Pertusaria amara (ACH.) NYL. s.1. (s')bor-med
Pertusaria corallina (L.) ARNOLD s 2f 11f 12f 20f 21f 22f 18 (s')bor-mieur.mo-med.mo(alp)
Pertusaria melanochlora (DC.) NYL. s 20 21 mieur-med
Pertusaria pseudocorallina (LILJ.) ARNOLD s 13 21f 22f mieur(subatl)-med(mo)
Pertusaria pupillaris (NYL.) TH. FR. e 36 (AR, AU, JU) s'bor-smed, o
Pertusaria pustulata (ACH.) DUBY e 31 Q (s')mieur(atl)-med.subatl
Phaeophyscia endococcina (KÖRBER) MOBERG s 3 14 arkt-med.mo
Phylliscum demangeonii (MOUG. & MONT.) NYL. s 5 12 16 18 bor-mieur.mo
Placynthiella icmalea (ACH.) COPPINS & P. JAMES e, t 18 36 39, 43 (AR, AU, JU) bor-med
Platismatia glauca (L.) CULB. & C. CULB. e, t 1f 12f 13 19 20f 21f 22f 31 Q 35 E 36 (AR, AU, CA, JU, OR, UM) bor-mieur-med.mo
Polychidium muscicola (SWARTZ) GRAY e, s 2f 7 13f 16 17 28 (JU) (arkt-)bor-med.(h)mo
Polysporina simplex (DAVIES) VĚZDA s 22 arkt-med
Porina chlorotica (ACH.) MÜLL. ARG. s 7 21 s'bor.subatl-med.mo
Porina lectissima (FR.) ZAHLBR. s 13 16 s'bor.subatl-smed.mo
Porpidia macrocarpa (DC.) HERTEL & SCHWAB s 5 6 11 21 29 ('s)bor-med
Porpidia speirea (ACH.) KREMPELH. s 19 arkt-bor-alp
Porpidia tuberculosa (SM.) HERTEL & KNOPH s 21 (arkt)bor-smed
Protoblastenia lusitanica RÄS. e 36 (AR, AU, CA, JU, UM) med.atl, o
Protoparmelia atriseda (FR.) R. SANT. & V. WIRTH s 21 (s'bor-)mieur(-med)
Protoparmelia badia (HOFFM.) HAFELLNER s 1f 2f 11f 12f 20f 21f 22f 23f arkt-med.mo
Protothelenella sphinctrinoidella (NYL.) MAYRHOFER & POELT s 18 arkt-mieur.alp(smed.alp)
Pseudephebe pubescens (L.) M. CHOISY e, s 11f 13 20f 21f 22 4f 6 15 9 19 (AR, AU, JU) arkt-(mo) alp
Pseudevernia furfuracea (L.) ZOPF e, s, t 10f 12f 20f 21f 22f 36 (AL, AR, AU, CA, GF, JU, OR, UM) bor-med.mo
Psoroma hypnorum (VAHL) S. GRAY e, t 12 16 18 37 38 39 (AR, AU, JU) arkt-alp
Pycnothelia papillaria DUF. t 36 39 43 bor-mieur(-smed)
**Pyrenopsis* aff. *subareolata* NYL. s 5 s'bor-med
Ramalina capitata (ACH.) NYL. s 22 arkt-mieur(-mo/alp)-med.mo/alp
Ramalina farinacea (L.) ACH. e 36 (AL) bor-med
Rhizocarpon geographicum (L.) DC. s 1f 2f 4f 5 6 10f 11f 12f 13 16 19 20f 21f 22f 23f arkt-med
Rhizocarpon lavatum (FR.) HAZSL. s 10 11 19 arkt-mieur.mo/alp(-smed.mo/alp)
Rhizocarpon lecanorinum ANDERS s 5 6 (s')bor-med.mo
Rhizocarpon polycarpum (HEPP) TH. FR. s 10 11 13 21 22 17 arkt-med.mo
Rimularia furvella (NYL. ex MUDD) HERTEL & RAMBOLD s 19 20f 21f bor-mieur.h'mo(-smed. h'mo)
Rimularia gyrizans (NYL.) HERTEL & RAMBOLD s 21 bor-smed.h'mo
Rinodina archaea (ACH.) ARNOLD e 36 JU bor-mieur(?-med)
Rinodina confragosa (ACH.) KÖRBER s 3 bor-med.mo
Rinodina interpolata (STIRTON) SHEARD s 10 21 22 bor.subatl-mieur.subatl
Rinodina milvina (WAHLENB.) TH. FR. s 12 21 arkt-med.alp/h'mo
**Rinodina olivaceobrunnea* DODGE & BAKER s 2 13 arkt-alp
Rinodina parasitica MAYRH. & POELT s 13 16 29 bor-smed.mo, o
Rinodina septentrionalis MALME e 30 GF 32 E 35 E bor-mieur
Rinodina sophodes (ACH.) MASSAL. e 31 Q 36 (AU) s'bor-med.mo
Schaereria fuscocinerea (NYL.) CLAUZADE & ROUX s 2 12 20 21 4 8 25 (arkt-)bor.h'mo/alp
Scoliciosporum umbrinum (ACH.) ARNOLD e, s 10 12 21 22 15 36 (GF) bor-med
Sphaerophorus globosus (HUDS.) VAINIO e, s 10 20f 22f 15 17 36 (JU) (arkt.atl-)bor.subatl-mieur.

subatl-med.mo, oz
Stereocaulon alpinum LAURER s 8 arkt-mieur-alp
Stereocaulon evolutum GRAEWE e, t 3 36 bor.atl-mieur(atl)-med(atl)
Tephromela atra (HUDS.) HAFELLNER ex KALB. s 5 10f 20f 21f 22f arkt-med
**Tephromela pertusarioides* (DEGEL.) HAFELLNER & ROUX s 21 mieur-smed-alp
***Thrombium thelostomum* (ACH. ex HARRIMAN) A. L. SM. s 13 mieur.atl
Toninia squalida (ACH.) MASSAL. s 5 21 bor-mieur.mo/alp-med.mo/alp
Trapeliopsis flexuosa (FR.) COPPINS & P. JAMES e, t 36 (JU) bor-med, o
Trapeliopsis granulosa (HOFFM.) LUMBSCH e, t 36 37 38 39 41 42 43 44 (AR, AU, CA, JU, UM) arkt-smed.mo(-med.mo)
Trapeliopsis wallrothii (FLÖRKE ex SPRENGEL) HERTEL & G. SCHNEIDER t 36 39, 41 mieur.subatl-med
Tremolecia atrata (ACH.) HERTEL s 5 6 11 19 28 arkt-mieur.mo/alp-med.alp
Umbilicaria cf. *cinerascens* (ARNOLD) FREY s 9 mieur.mo-smed.mo?
Umbilicaria crustulosa (ACH.) FREY s 8 9 13 19 20 21 22 25 arkt-alp/pralp
Umbilicaria cylindrica (L.) DELISE ex DUBY s 1f 2f 4f 9 10 11f 12f 20f 21f 22f 23f arkt-mieur-hmo/alp-med-alp
Umbilicaria deusta (L.) BAUMG. s 19 (arkt-)bor-mieur.mo/alp-med.alp
Umbilicaria polyphylla (L.) BAUMG. t 36 bor-mieur.mo-alp, o
Umbilicaria polyrrhiza (L.) FR. s 1 9 23 24 (bor.atl)s'bor-med.mo, subatl
Umbilicaria spodochroa (EHRH. ex HOFFM.) DC. s 1 19 20 21 bor-mieur.atl-med.atl?
Umbilicaria torrefacta (LIGHTF.) SCHRADER s 8 15 bor-mieur.mo/h'mo-med.alp
Usnea glabrescens (NYL. ex VAINIO) VAINIO e 35 E bor-mieur.mo
Usnea hirta (L.) WIGG. e 35 E (AU) bor-mieur(med.mo)
Usnea spec. e, t (AL, AR, AU, UM)
Verrucaria cf. *aethiobola* WAHLENB. s 6 arkt-mieur-smed.mo
Verrucaria margacea (WAHLENB.) WAHLENB. s 28 6 29 bor-mieur.h'mo/alp
Verrucaria praetermissa (TREVISAN) ANZI s 16 19 mieur.subatl
Xanthoparmelia conspersa (EHRH. ex ACH) ACH. s, t 1f 2f 21f 22 4 23f 36 bor-med
Xanthoparmelia protomatrae GYELNIK e, t 36 (AL) bor-mieur(-smed)

Localities of saxicolous lichens:

S-oriented cliffs and S-oriented sloping and horizontal surfaces: 1 S-cliff, Covão do Boi, UTM 199-649; **2** S-cliff, Cântaro Raso, UTM 195-647 (1998); **3** S-cliff, Cântaro Margo, UTM 189-652 (1995); **4** S-oriented ± horizontal surface, Covão do Boeiro, UTM 170-660 (1998); **5** S-oriented ± horizontal surface, Covão do Boeiro, UTM 169-662 (1998); **6** S-oriented ± horizontal surface, Fte. dos Perús, 7°37.5'W-40°22.0'N (1997); **7** Open area, low outcrops, Rodeio Grande, 7°39.0'W-40°22.0'N (1997); **8** Open area, low outcrops, Lagoa Redonda, UTM 169-699 (1995); **9** Open area, exposed outcrops, Covão do Meio, 7°37.0'E-40°19.5'N (1993).

N-oriented cliffs: 10 N-cliff, Cântaro Raso, UTM 193-650; **11** N-cliff, Cântaro Raso, UTM 194-649; **12** N-cliff, Lagoa do Paixão, UTM 183-667; **13** N-cliff, Lagoa do Paixão, UTM 185-667; **14** N-cliff, Lagoa do Paixão, UTM 187-667 (1998); **15** N-cliff, Penha do Gato, 7°40.0'W-40°20.5'N (1997); **16** NE-cliff, Cântaro Margo, UTM 189-653 (1995); **17** N-cliff, Lagoa Redonda, UTM 169-699 (1995); **18** N-cliff, Cântaro Gordo, UTM 191-664 (1995); **19** N-cliff, Lagoa do Covão, 7°37.5'E-40°19.3'N (1993).

Tors: 20 Tor, Penha do Gato, UTM 135-671; **21** Tor, Curral do Martins, UTM 204-707; **22** Tor, Cascalvo, UTM 209-634 (1998).

Screes and blockstreams: 23 Scree, Cântaro Raso, UTM 194-649; **24** Blockstream, Lagoa do Paixão, UTM 188-667 (1998); **25** Blockstream, Cântaro Gordo, UTM 191-664 (1995).

Irrigated rocks: 26 Brooklet, Lagoa do Paixão; **27** Brooklet, Fonte de Luzianos, UTM 142-679; **28**

Brooklet, Covão do Curral, UTM 157-701 (1998); **29** Brooklet, Lagoa Seca, UTM 164-689 (1995).

Localities of epiphytic lichens: 30 Lagoa Comprida, Fonte de Luzianos, shrubs along stream, UTM 142-679; **31** S-cliff, S of Cântaro Raso, Quercus pyrenaica, UTM 195-647; **32** Lagoa Comprida, shrubs along Pragueira, UTM 143-685 (1998); **33** S of Lagoa Comprida, Rodeio Grande, open field, UTM 145-677; **34** S of Lagoa Comprida, near Penha do Gato, UTM 133-671 (1997); **35** SW of Lagoa Comprida, shrubs among boulders, UTM 195-679? (1993); **36** refer to JANSEN (1993) or APTROOT & al. (1992) (1988-1992).

Localities of terricolous lichens: 37 Treppenrasen (Cântaro Raso) (1998); **38** Treppenrasen (Cântaro Gordo); **39** Lycopodio-Juniperetum (JANSEN 1993); **40** Rodeo Grande; **41** Area of Poios Brancos; **42** Covão do Boi (S slope); **43** Summit area (open vegetation); **44** Corvo de Talada; **45** Cântaro Magro; **46** Lagoa Redonda. [nr **40** t/m **46** are from JANSEN (1993) and APTROOT & al. (1992)].

Localities refer to UTM grid '29TPE' from maps 223 and 224 (INSTITUTO GEOGRÁFICO DO EXÉRCITO 1993). Data from relevés refer to more than 700 localities and are omitted for shortage of space. These data are kept in an adapted database programm of TURBOVEG (HENNEKENS 1996).