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Bryophyte diversity and impact of land-use in semi-natural grasslands in the Serra da Estrela (Portugal)

Abstract

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The aims of this study are the description of the bryophyte diversity on representative grasslands in Serra da Estrela (Portugal) and their dependence relative to different management actions and vegetation types. The inventory of bryophytes from major grassland assemblages was carrying out from 1992 to 2000. The identification of all taxa and the registration of quantitative data, of the most important meadow communities of Natural Park of Serra da Estrela, will contribute to monitor future alterations in such communities.
A list of 109 bryophyte taxa (27 hepatics and 92 mosses) from 52 plots is presented and percentage of occurrence of each species is given for each type and subtype of grassland. Bryofloristic survey and species preferences were analyzed using TWINSPAN analysis.

Introduction

The Serra da Estrela constitutes the western part of the Iberian Sistema Central, in the east-central Portugal between 40° 15' and 40° 17' N and 7° 15' and 7° 50'W. The Natural Park of Serra da Estrela (PNSE) covers about 1000 Km^2. The summit area is a biogeographic reserve, approved by the Council of Europe in 1993, and holds the highest peak (1993 m) of continental Portugal. The precipitation regime is marked by a Mediterranean influence in the annual rhythm. The vegetation of the Serra da Estrela reveals the presence of 5 or 6 altitudinal bioclimatic variants. As knowledge of the vegetation of the Serra da Estrela is not sufficient to distinguish and attribute all stages of the climax series, it is decided to use the more general terms for the five or six belts including them in one lower, one middle and one upper belt. The Serra da Estrela mountain range consists mainly of granite rocks in its central part and schists on its periphery. Many geomorphological structures have glacial and periglacial origin (Vieira 1998).

Jansen (1997, 1999, 2002) has distinguished different types of grasslands in the Estrela Mountains, based on a phytosociological classification and characterized by vascular plant composition and in part, by some representative bryophytes. There is very little information available on bryophyte composition of grasslands in Portugal, particularly in the Serra da Estrela.

The aims of this study are to describe the present status of grassland bryophytes on representative sites and to relate this to different management procedures and vegetation types.

An inventory of bryophytes from major grassland assemblages was performed in the Serra da Estrela from 1992 to 2000. The present paper is the result of a PAMAF project about pasture management for the production of the famous Serra da Estrela cheese and based in part on vegetation survey of all biotopes developed by the third author (Jansen 2002).

Methods

Relevés were made according to the French-Swiss school of phytosociology (Braun-Blanquet 1964; Westhoff & Van Der Maarel 1973). Quantative occurrence was estimated according to the nine-fold scale of Barkman & al. (1964), transformed to nine Arabic numerals, 1 up to and including 9. The relevés were stored in a database with the computer program TURBOVEG (Hennekens 1996). In the synthetic phase TWINSPAN (Hill 1979) was used for arranging the relevés into more or less homogeneous clusters. SHIFTTAB (Hennekens 1996) has been used for obtaining an optimal classification by relocating relevés and species based both on field knowledge and the literature involved.

Species nomenclature of vascular plants follows *Flora Iberica* as far as issued (Castroviejo & al. 1986-1999), Nova Flora de Portugal as far as issued (Franco 1971, 1984; Franco & Afonso 1994-1998), otherwise Flora Europaea 5 (Tutin & al. 1980). Nomenclature of syntaxa generally follows Rivas-Martínez & al. (1999).

An inventory of plant communities including vascular plants and cryptogams was made from 1992 to 2000 by the third author in the framework of his thesis on the vegetation ecology of the Serra da Estrela. In grassland communities more than a hundred sample plots were made. Easy recognizable bryophyte species were identified in the field, but the rest were identified after they had been collected and stored in the Lisbon Herbarium (LISU).

For this study 52 sample plots were performed in selected grassland assemblages (Fig. 1 and Annex 1). All sites lie between 500 and 1840 m.

The studied areas belong to two main different grassland types: mat-grass swards (*Nardetea*-**Na**) and meadows (*Molinio-Arrehenatheretea*-**Mo**). Pasture areas (**Pa**), some with a rotation system of rye fields, were also considered for comparison with the different practices and management procedures.

The nomenclature generally follows Corley & al. (1981) and Corley & Crundwell (1991) for the mosses and Grolle & Long (2000) for the hornworts and liverworts.

Bryophyte taxa abundances were subjected to a TWINSPAN analysis (Hill 1979). Data from all relevés were used in a first analysis, and then relevés 49 and 2 were down weighted as both correspond to particular conditions or diverse microhabitat situations.

For each taxon (Annex 2) we mention the status in the Red List of Iberian Bryophytes according Sérgio & al. (1994).

General description of the grasslands

The Serra da Estrela may have hosted natural grasslands in a few restricted places with favorable site conditions. Grasslands that now occur in the Estrela are all more or less semi-natural. Their variation depends not only on climate, soil, altitude and topography, but also on the agro-pastoral system. In fact this system has brought about a rich variety of grasslands, some of which have a high species diversity. Grazing influences the structure and composition of the vegetation, depending on the intensity, the rhythm and kind of livestock.

The present study involves two main semi-natural grassland types: mat-grass swards (*Nardetea*-**Na**) and meadows (*Molinio-Arrehenatheretea* **Mo**), as well as three pasture areas (**Pa**) with different agro-pastoral use. Flooded grassy banks of rivers, intensive pastures and resting places for cattle or other animals were not treated in the present study, neither the xerophytic summit grasslands that are hardly grazed.

We have assumed that the relevés made represent an adequate cross-section of the Estrelean grasslands and their management practices.

Characterization of vascular and bryophyte vegetation

Mat-grass swards (Nardetea)-Na

Mat-grass swards (Portuguese: cervunais) are nutrient-poor grasslands on organic soils. The European range of Mat-grass (*Nardus stricta*) attains its southwestern limits in the Serra da Estrela.

In the Estrela, according to Jansen (1999), three types of Mat-grass swards occur: 1 - Mat-grass swards predominated by *Festuca henriquesii* (Na1 in Annex 2); 2 - species-poor Mat-grass swards of the upper belt (Na2 in Annex 2); 3 - species-rich Mat-grass swards of the middle belt (Na3 in Annex 2).

The first type is probably of primary origin, but the other two are assumed to develop to scrub or woodland if grazing stops. The more representative species are: *Nardus stricta, Festuca henriquesii, Campanula herminii, Narcissus bulbocodium* subsp. *nivalis, Galium saxatile* subsp. *saxatile, Ranunculus bulbosus* subsp. *alae*, etc.

Festuca henriquesii grasslands-**Na1**

It is assumed that areas with prolonged snowcover must have functioned as a source from which this strictly endemic grass once originated. *Festuca henriquesii* is the third fescue species occurring in the Estrela that is mentioned under Annex II of the European Council Directive 92/43/EEC.

These vulnerable grasslands prefer relatively well-drained soils in shaded situations below sheer north-facing cliffs or in other places with prolonged snowcover and with around 70% grass cover. Soil-filled rock-fissures (Jansen 2002) provide miniatures of this format.

Some important bryophyte species can appear in small pastures to build a unique population including: *Bruchia vogesiaca, Rhizomnium magnifolium, Polytrichum alpinum, Bartramia ithyphylla, Pleurozium schreberi* and *Sanionia uncinata.*

Good examples can be observed below sheer cliffs, especially in the vicinity of the Cântaros, Chancos and Rua de Mercadores (see studied localities in annex 1 and Fig. 1).

Biodiversity is higher in this Mat-grass community with a total of 56 species (12 hepatics and 44 mosses).

Bryophyte composition of some *Nardus* communities, especially where *Festuca* *henriquesii* is less frequent, shows affinities with the scrub vegetation of *Juniperus communis* L. subsp. *alpina*. Here bryophyte species like *Bartramia ithyphylla*, *Kiaeria starkei*, *Pleurozium schreberi* and *S. uncinata* were not recorded. However, other species are

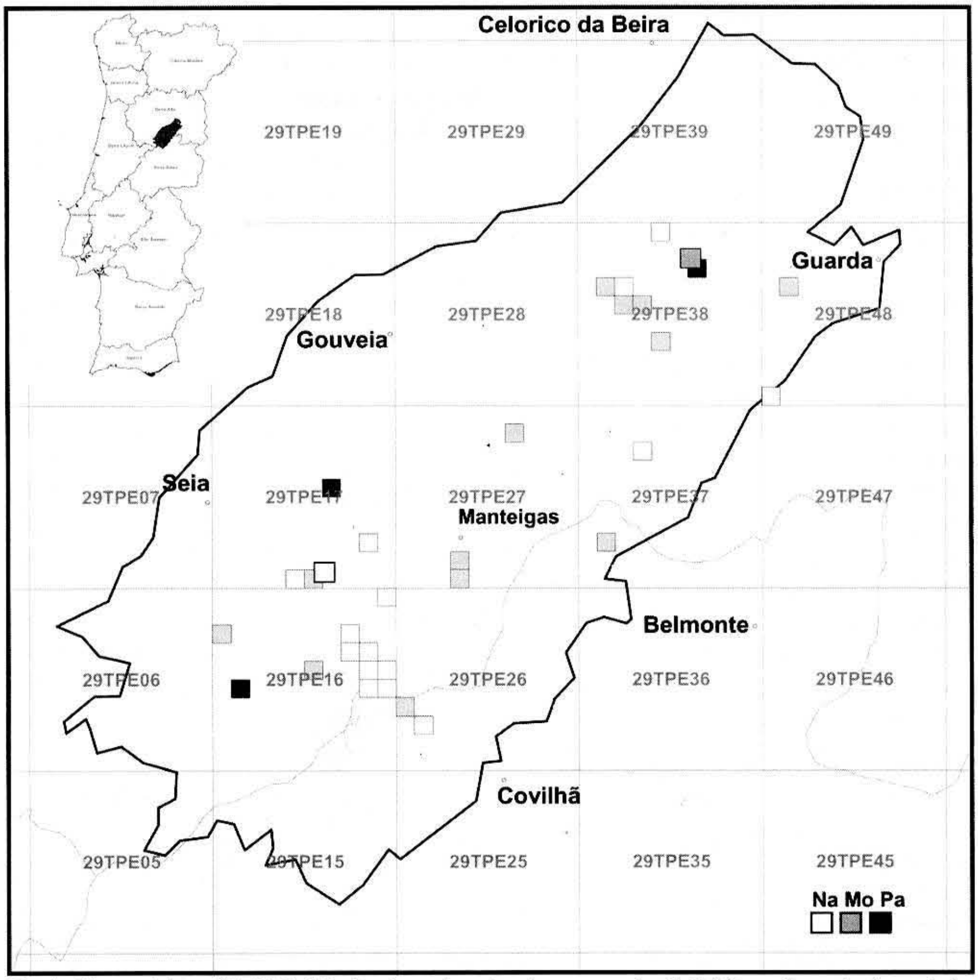

Fig. 1. Site positions (UTM 1x1 km) where the relevés were made. Solid lines show the boundaries of the Natural Park of the Serra da Estrela.

frequent like *Polytrichum piliferum, Dicranum scoparium* and *Brachythecium dieckii.* These last two are also frequent in scrub vegetation composed of *Juniperus* (Sergio & Jansen 2000).

It is interesting to refer the presence of *Ceratodon purpureus, Brachythecium rutabulum* and *Polytrichum juniperinum* in the relevés where they are more common with open or disturbed soil as a positive response to the nutrient enrichment of the substrate.

Nardus grasslands of the upper belt- **Na2**

(*Galio saxatilis-Nardetum, Genisto anglicae-Nardetum*)

The relative species-poor mountain pastures dominated by Mat-grass (*Nardus stricta*) occur in the higher middle and upper belt. *Nardus stricta* is well adapted to grazing and trampling and consequently most successful in the summer pastures of the Estrela. These pastures are generally found in concave areas such as small depressions and extended valleys. In the depressions there is a general accumulation of materials washed down and as a result the plants usually grow better. The soils are usually humid to wet as their organic nature raises their water-holding capacity. This is especially important during the dry summer period. Species-poor Matt-grass swards are clearly semi-natural grasslands with more or less 70 % cover of herbaceous species, They can develop under a high precipitation regime on relatively deep and poorly drained soils through a long tradition of pastoralism (cutting, burning, summer-grazing). On organic hydromorphic soils (peats) these pastures transgrade into bog vegetation, while on drier soils (plateaux, convex areas) they become open xerophytic summit grasslands (Jansen 1999).

Depending on the environmental humidity, soil nutrient concentration and *Nardus* cover, the bryophyte communities are often poor with a total of only 24 species (8 hepatics and 16 mosses). It is only close to small watercourses, on patches of bare ground and open turf that some hygrophytic species, like *Aneura pinguis* can occur.

In several localities, as in the Vale de Rossim and Fontes, where the amount of water in the substrate is higher, some *Sphagnum* species can be found: as *Sphagnum auriculatum* (*S. denticulatum*), *S. tenellum, S. palustre and S. compactum* associated with species like *Aulacomnium palustre*, *Calliergon stramineum, Jungermannia gracillima* and *Cephaloziella elachista*. The latter was found for the first time in Portugal in similar conditions (Sérgio & al. 2000).

Nardus grasslands of the middle belt-**Na3**

Small species-rich Matt-grass swards from lower altitudes might have evolved through extensive year-round grazing and perhaps a touch of occasional mowing, irrigation, and organic fertilization. They are found occasionally in the agricultural landscape of the middle belt, often in contact with meadows (see localities studied in Videmonte). With the breakdown of the traditional agro-pastoral system, these species-rich Matt-grass swards will disappear, because in order to maintain them, they need to be used in the traditional way. Such a breakdown is expected to lead to abandonment (invasion of scrub), in some cases to intensive husbandry (eutrophication, drainage) or conversion into woodland plantations (Jansen 1999). These grasslands include a mix of vascular species, some of which are typical for Mat-grass swards; others have their climax in heaths or meadows.

No bryophytes have been recorded in grasslands that have not been grazed in the past, apparently because of competition with vascular plants, particularly grasses which occupy the bare ground where the bryophytes could have established. On the other hand, some grasslands may have been grazed in recent years but still have a dense layer of grasses, perhaps due to a substrate eutrophication related to soil fertilization. In fact, the herbaceous cover is almost 100% in all studied relevés.

Meadows (*Molinio-Arrhenatheretea*)-Mo

To supply his livestock with extra fodder, man invented mowing and the practice of irrigation. As a result of this, the irrigated meadows were created.

Meadows are cut in the growing season and may be grazed outside it, while pasture is usually open to grazing all year round.

Under natural conditions, the meadows are enriched by an input of minerals from deposited silt or moving water. In addition, they may be supplied with organic manure. The long history of traditional use has led to high species diversity. Species from biotopes irrigated under natural conditions such as floodplain pastures, fringes of riparian forests, Mat-grass swards, wet heaths, bogs or other (sub-) humid vegetation were able to invade this new biotope.

Fortunately, in the Estrela many meadows still have a high species diversity and merit to be maintained. Good examples can be observed in the plateau areas of Folgosinho and Videmonte (see localities studied in Annex 1, Fig. 1).

Castillean Bent (*Agrostis castellana*) dominates a special group of these grasslands. These are not, or scarcely, mowed nor actively irrigated. They constitute pastures on relative deep soils that are submitted to brief flooding, poor drainage, and relatively rapid desiccation in the early season.

It is impossible to describe all kinds of meadows here. For a more extended, though not exhausting description, we refer to Jansen (2002). To give an idea, two major types are distinguished, namely those which vary from dry to humid and those which vary from wet to very wet.

The vascular plants present around 80% of total cover and the species more frequent or characteristic of these grasslands are: *Festuca ampla, Agrostis castellana Holcus lanatus, Lotus pedunculatus, Dactylorhiza caramulensis, Plantago lanceolata, Molinia caerulea,* etc.

Grasslands of the *Molinio-Arrenatheretea* do not seem to include a characteristic bryophyte flora since most of the occurring bryophytes are found in other communities. However, the biodiversity is considerable (55 including 11 hepatics and 44 mosses).

Within *Molinio-Arrenatheretea* meadows the bryophyte flora is of low interest and is often found in other habitats. Species composition of meadows varies mainly depending of nutrient status, mowing regime, grazing and trampling, and hydrology. Some bryophytes species are rheophytic species, *Racomitrium aciculare, Racomitrium lamprocarpum, Marsupella emarginata, Scapania undulata*, and other elements more common in turf like *Aulacomnium palustre* and *Sphagnum* species (*S. auriculatum, S. subnitens*). However, some robust species such as *Calliergonella cuspidata* and the mesophytic *Brachythecium albicans, Bryum alpinum, B. pseudotriquetum* and *Philonotis fontana* are able to persist in patches on small soil elevations in pastures.

Others bryophytes species can develop in small micro-habitats as pioneers communities of cultivated soils (*Stellarietea, Isoeto-Nanojuncetea*), between grasses (**Mo** in Annexe 2). In specific temporal inundated gaps in these grasslands an interesting bryophyte flora of high interest may develop (see **Pa3**).

These natural pastures are generally rich in edaphic humidity and develop in areas with deficient drainage. The vegetation cover is dominated by species of *Molinio-Arrenatheretea.* However, in some areas of Serra da Estrela, where the humidity of the substrate is lower, *Agrostis castellana* dominates.

Pasture areas

Most of the so-called 'outfields' have been used as pastures for a long time. Only some have been subjected to agricultural improvement, e.g. the irrigated terraced slopes or the plateaux with the rotation system of rye fields. As an example, we have studied 3 areas with different management procedures (**Pa** in Annex 2: Pa1, Pa2 and Pa3).

This type of community is poor concerning bryophyte diversity and only a total of 14 taxa were identified in the three studied areas.

Bryophytes form an important part of the structure of grasslands and the disappearance of the bryophyte layer can reduce the biological complexity as well as the biodiversity of the community. One of the reasons for this reduction is the increase of atmospheric nitrogen deposition (Carroll & al. 2002). This is particularly important in central Europe as Dutch grasslands (During & Willems 1986). However, atmospheric deposition of nitrogen in the Serra da Estrela is negligible except perhaps shortly after heavy wildfires.

It is accepted that vascular plant competition will be reasonably enhanced by fertilizer addition. However, studies have indicate that increase of nutrients do lead to a loss of certain bryophytes (Brown 1992).

Rotation system, Sabugueiro - **Pa1**

One study area is situated north of Sabugueiro at an altitude around 1200 m. The landscape here is frequently subjected to fire. The drier slopes are largely covered by shrub formations (mostly broom: *Cytisus multiflorus* and *C. striatus*); the more humid slopes are sometimes covered with *Genista florida* shrub. Some of the broom shrubs are sometimes cut and mixed with dung from the stable. The mix is used to fertilise the arable lands and horticultures. The shrub lands are extensively grazed. The shrubs often form mosaics with pioneer communities, including annual herbs and grassland species, with about 80% of total cover (mostly belonging to *Helianthemetea* and *Stellarietea*). The pioneer species also invade the areas that are part of the rotation system of rye fields, fallow lands (pousio) and broom scrub. This rotation system is mostly applied on relatively well-drained gentle slopes and plateaux. In a subsequent phase some bryophyte species of these fallow lands will succumb to taller vascular plants, particularly grasses (e.g. *Holcus mollis, Agrostis castellana, Festuca rubra s.l.*). The area can be seen, as an example of a landscape typical for the northwestern part of the middle belt of the Serra da Estrela.

The rye fields include acrocarpic and pioneer species as *Bryum radiculosum, B. torquescens, B. elegens, Ceratodon purpureus, Funaria hygrometria, Pleuridium acuminatum*. These species are very short lived above ground but maintain themselves by subterranean tubers (rhizoidal gemmae and bulbils) often forming a considerable diaspore bank in the soil. They are able to colonize new cultivated areas. However, the most common species found in these pastures are *Bryum alpinum* and *Polytrichum juniperinum,* mosses also frequent in all other types of grasslands. Nowadays, in similar humid depressions, generally at lower altitudes, the practice of irrigated pastures is nowadays abandoned, but these fields are still used as passing pastures.

Irrigated hay-meadow, Videmonte - **Pa2**

The area around Videmonte is a good example of the landscape of the northern plateau in the Estrela. The agro-pastoral system here shows strong affinity with the northern

Portuguese mountain areas. Vineyards and maize are not common in the Videmonte area.

The low nutrient level of the meadow in combination with active irrigation, create the ideal preconditions for *Isoeto-Nanojuncetea* communities that occupy micro-sites within the meadows (Jansen & Sequeira 1999). These small biotopes are considered priority Natura 2000 priority habitats.

In our relevés the herbaceous vegetation presents about 95% of cover, the bryophyte layer is also high 70-80%, integrating only six species.

Important bryophytes of these micro-sites are: *Philonotis tomentella,* as well as *Fossombronia wondraczekii* and *Cephaloziella stellulifera*, showing Mediterranean-Atlantic affinities.

Terraced landscape, The Loriga Valley - **Pa3**

The studied area around the Loriga Valley is a good example of the terraced landscape of the southern slopes of the Estrela (Fig. 2). The location is in the southern part of the Estrela and the altitudes are lower, providing a milder climate compared to the other areas treated in this study. The relative steep slopes could only be used for agriculture after

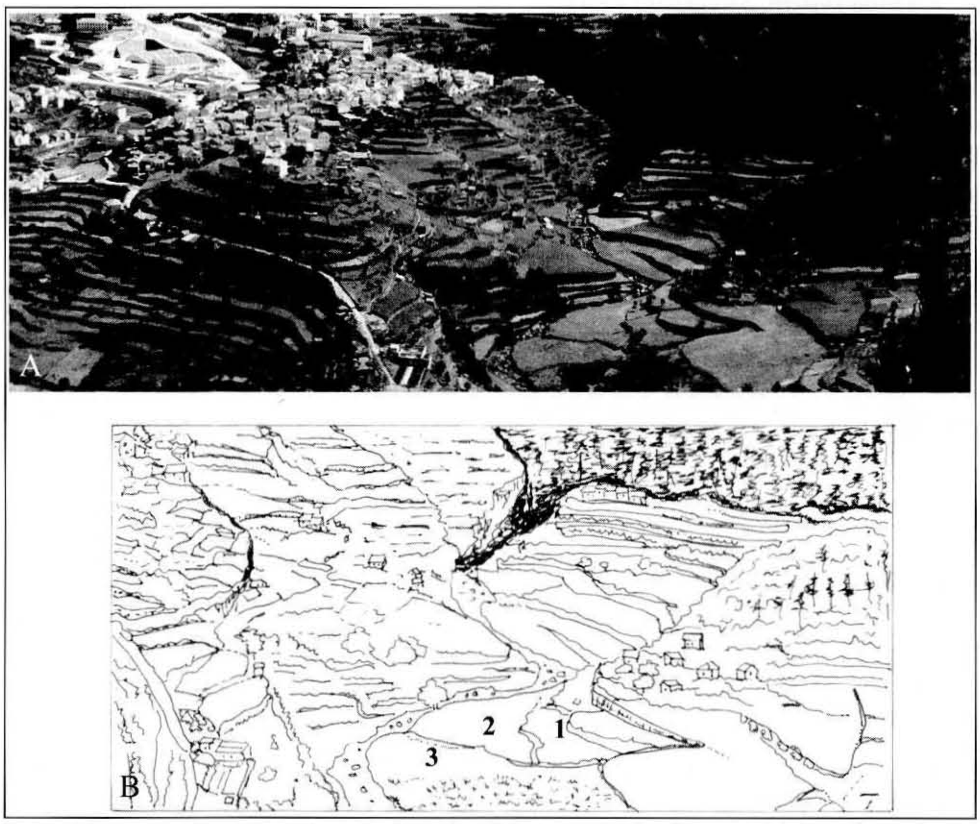

Fig. 2. The Loriga Valley is a good example of the terraced landscape of the southern slopes of the Estrela

terraces had been constructed. On the terraces you may find vineyards and small olive groves (both facilitated by a suitable climate), the latter often with grassy undergrowth that can be used whole year round as pasture areas for livestock. Horticulture is frequently practiced in the vicinity of the villages and as in Sabugueiro and Videmonte. A rotation system of arable lands (mostly rye and oat), fallow lands and scrub is applied here too in combination with grazing (mainly sheep and goats). A brilliant irrigation system guarantees enough water supplies.

The different relevés made in this area present a total cover of 91% grasses, but in some terraces it was observed that communities dominated by scrub occupy progressively the abandoned fields (Fig. 2 B).

Only seven species have been observed here, but including *Rhynchostegium megapolitanum, Brachythecium rutabulum, Hypnum cupressiforme* (all pleurocarpous species) and *Ceratodon purpureus* and *Bryum rubens* (both acrocarpous). This last species is exclusive of this area and the first locality of the Serra da Estrela (Sérgio & al. 2001).

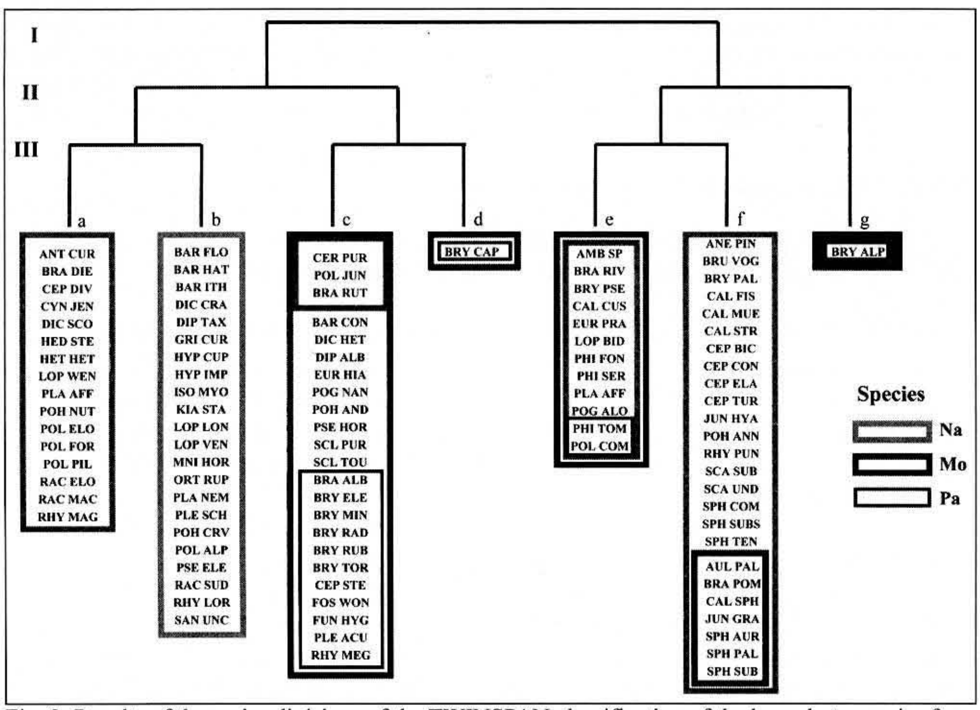

Fig. 3. Results of the major divisions of the TWINSPAN classification of the bryophyte species from the pasture communities in the Serra da Estrela, based on species abundance in each relevé. Light grey: Mat-grass (*Nardus stricta*), Dark grey: Meadows (*Molinio-Arrehenatheretea*), and black: Pasture areas.

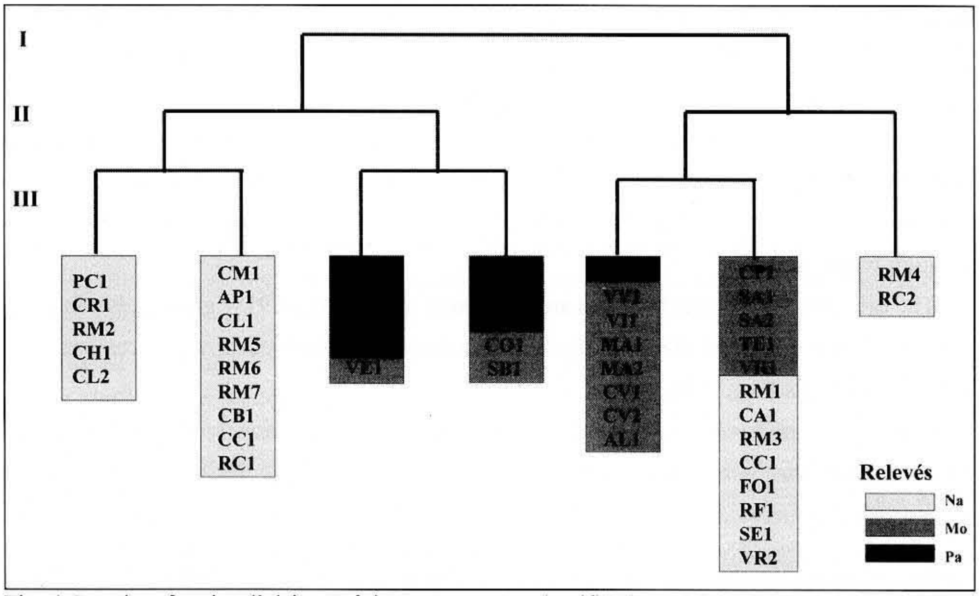

Fig. 4. Results of major divisions of the TWINSPAN classification of the different pasture types in the Serra da Estrela, according to their localisation in the areas studied (49 sites, Annex 1). Light grey: Mat-grass (*Nardus stricta*), Dark grey: Meadows (*Molinio-Arrehenatheretea*) and black: Pasture areas. 49 relevés were used in a first analysis and then two relevés (**CF1** and **CN1**) were down weighted as both correspond to particular conditions or diverse microhabitats situations.

Bryofloristic analysis and species preferences

A list of 109 bryophyte taxa (27 hepatics and 92 mosses) from 52 plots is presented in Annex 2. The percentage occurrence of each species is given for each type and subtype of grassland.

For all species the status in the red list of Iberian Bryophytes is indicated (Sérgio & al. 1994).

The two dendrograms (Figs 3 and 4) represent the results using analysis for all relevés and all species. Figure 4 in the first and second major TWINSPAN divisions, separating the 109 taxa and 49 relevés into four major groups based in species abundance within each relevé. The first dendogram shows the division until the 3rd level, along with the indicator species for each group.

The species groups a and b indicate the elements exclusive to Mat grass. However, the more frequent species and those exclusive to Na1 are in the b group, e.g. *Kiaeria starkei*, *Polytrichum alpinum*, *Bartramia ithyphylla* and *Sanionia uncinata*.

The species from c group and the out-layer d group, with *Bryum capillare*, correspond to taxa that can be found in all type of grasslands (semi-natural and pastures). The analysis also shows that the higher bryophyte diversity is found in Mat-grass (Na) areas, although, some affinities with meadows (Mo) in the c group were observed. In this group, some species are not exclusive but typical of nutrient enriched open soils and disturbed places or are frequent in burnt sites, like *Brachythecium rutabulum*, *Ceratodon purpureus*, *Funaria hygrometrica*, *Polytrichum juniperinum*, *Rhynchostegium megapolitanum*.

We can also note that the first two taxa are bryophytes that are common throughout agricultural landscapes in Danish semi-natural grasslands (Ejrnaes & Poulsen 2001).

It is interesting to note, that the other groups (e, f, g) include elements characteristic of wet conditions: *Sphagnum* species, *Aulacomnium palustre, Philonotis seriata* and *Brachythecium rivulare*. These were all abundant. However, species of group e are mainly from dripping rocks or rheophilous conditions (*Brachythecium rivulare, Bryum pseudotriquetrum, Philonotis fontana* and *P. seriata*), and those from the f group are from soils rich in humus or peat (*Aneura pinguis, Bruchia vogesiaca, Aulacomnium paluste* and *Sphagnum* spp.). In contrast, *B. alpinum* was observed in all types of pastures. This last species shows a considerable tolerance to drought stress and is characteristic of seasonal-inundated vegetation, e.g. open sandy soil (Jansen & Sequeira 1999).

The dendrogram (Fig. 4), represents the major divisions of the TWINSPAN classification of the different pasture types, according to their places in the areas studied (49 relevés).

The results show that, in general, there is a correspondence between the three types of vascular communities and the biodiversity of bryophyte assemblages associated. In fact, it is in *Nardus* grasslands that the bryodiversity is higher with the shoot density of vascular plants favouring bryophyte colonization. It is also clear that there is an important relation between meadows of the *Molinio-Arrenatheretea* and pastures with occasional mowing, irrigation and organic fertilization. These harbour bryophytes tolerant to soil improvement like those relevés in the centre of dendrogram (Fig. 4). Indeed, some pastures subjected to a natural agricultural improvement are located in the vicinity of *Molinio-Arrehenatheretea* areas. Here the same species are growing as in the irrigated terraced slopes or in the rye fields with rotation system.

Evaluation of the status of threatened and rare species

Bryophyte species reflect the biodiversity richness of a given region; as they are the best elements that can be used as bioindicators (Sérgio & al. 2000).

Figure 5 represents the ecological value of each pasture type, considering the species included in the Red List (Ex, E, V and R) of bryophytes from the Iberian Peninsula (Sérgio & al. 1994). The more important grasslands for conservation actions are theMat-grass (*Nardus stricta*) where threatened bryophytes are better represented. In fact, *Bruchia vogesiaca*, may be considered the most important bryophyte (Sérgio & al. 1998), from the conservation point of view as it, is a vulnerable/endangered and priority species in Europe (ECCB, 1995) and the Iberian Peninsula.

In general, the bryophyte flora of *Molinio-Arrenatheretea* and *Nardetea* pastures include a considerable number of species, although some of them are not exclusive of these communities. In reality, the bryophyte species, besides those of the aforementioned meadows, are also important in pioneer communities of cultivated soils (*Stellarietea, Isoeto-Nanojuncetea*), or turf soils (*Oxycocco-Sphagnetea*), or humid pastures (*Scheuchzerio-Caricetea fuscae*) and other types of vegetation related to pastures, such as shallow water and other seasonally-inundated habitats.

An important part of the grasslands has not yet been analysed. From the grasslands mentioned by Jansen (1997, 2002), at least the following have not been studied: therophytic

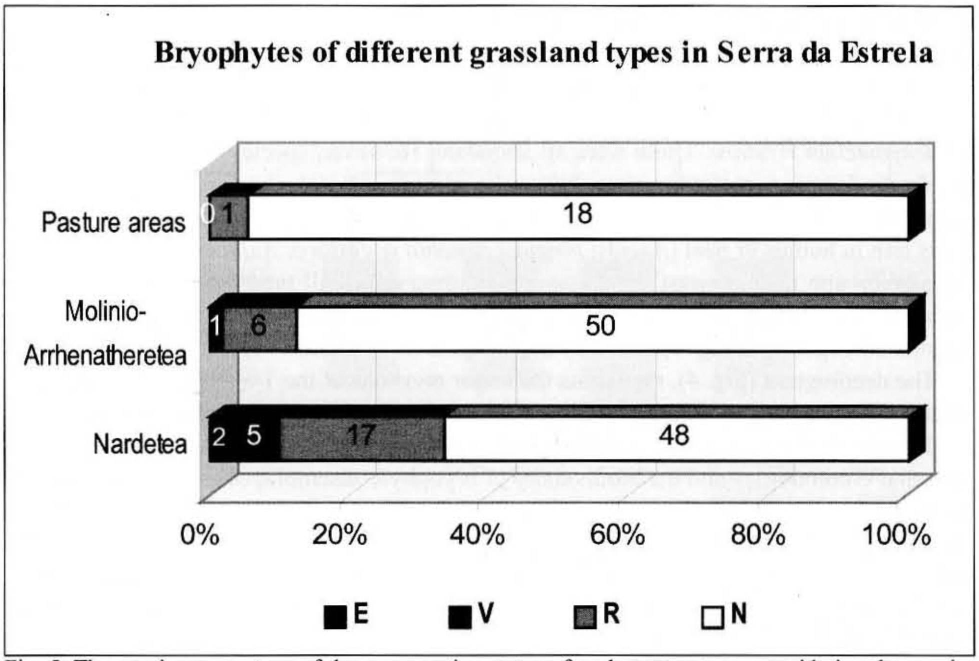

Fig. 5. The species percentage of the conservation status of each pasture type, considering the species included in the Red List (Ex, E, V and R) of bryophytes from the Iberian Peninsula (Sérgio & al. 1994).

grasslands, xerophytic perennial grasslands of slopes and xerophytic summit grasslands. We stress the importance of continuing the investigations of grasslands in order to assess their contribution to the biodiversity and unique ecological position of the Estrela. In the last few years, a considerable number of new plant species have been reported from this area, some of which were found in xerophytic grasslands (Jansen & al. 1999; Jansen 2002).

Conclusions and measures to protect bryodiversity in grasslands

Grasslands that now occur in the Estrela are all more or less semi-natural. Their variation depends not only on climate, soil, altitude and topography, but also on the agro-pastoral system. In fact, this system has brought about a rich variety of grasslands, some with a high species diversity.

Unfortunately, there are insufficient data to permit an analysis of how species response is affected by trampling at different seasons or intensity, but for bryophytes it seems essential to produce new open spaces in the grasslands.

On the other hand, the different practices of land use and management procedures have a considerable impact on plant biodiversity. Although same of them are, at least locally, creating areas where bryophytes diversity is maintained, other actions may have contributed to the decline of the plant communities. As referred above, the natural pastures are absent and the semi-natural cultivated pastures may represent important habitats to preserve biodiversity. However, neglect of the traditional agricultural practices leads to a negative impact in these communities.

The pastures of the Serra da Estrela are a good example of this situation. From the floristic analysis and the environmental quality of the sites (in the Natural Park of Serra da Estrela) under different management procedures, we can conclude:

- The changes in land-use and cultivation practices often result in an increase of grass density with a negative impact on the diversity and richness of the vascular and bryophyte floras.
- The stability of some of the open habitats referred in the Habitats Directive (92/43/CEE) depends on the intensity and type of grazing. Apparently, through competition with vascular plants, bryophytes species can disappear, as in some *Nardetea* grasslands.
- The meadow communities include special sensitive vegetation units. Any change in their management may contribute to a decline in their diversity and the communities related to them.
- The use of a rotation system is important to preserve some pioneer communities. The wet heaths and meadows should be considered similar.
- Grazing is important to preserve grasslands, heathlands and other 'matos'.
- Mowing (sometimes in combination with irrigation) is important to preserve some *Molinio-Arrhenatheretea* grasslands.

The present study provides a reference point from which future changes in the flora can be assessed. The identification of all taxa and the registration of quantitative data, as a result of the phytossociological study of the most important meadow communities of PNSE, will contribute to monitor future changes. These include plans to raise public awareness on conservation matters, to promote regional development, to create nature conservation/education actions and to foster the development of environmentally tourism as a major future economic feature of the region. The development of a strategy for sustainable traditional agro-pasture management and the creation of an advisory service for product diversification, processing, quality improvement of regional products mainly for Serra da Estrela cheese.

In general, and according to the conclusions of this work, the grass communities, including the pastures with strong human influence, show a great ecological interest from the biodiversity conservation viewpoint. This is important support to improve the quality of life in the region and the amenity of the landscape for locals and visitors.

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References

Barkman, J. J, Doing, H. & Segal, S. 1964: Kritische Bemerkungen und Vorschläge zur quantitativen Vegetationsanalyse. — Acta Bot. Neerl. **13**: 394-419.

Braun-Blanquet, J. 1964: Pflanzensoziologie. - 3. Aufl. — Wien & New York.
Brown, D.H. 1992: Impact of agriculture on bryophytes and lichens. — Pp. 259-283 in: J. W. Bates and A. M. Farmer (eds), Bryophytes and Lichens in a Changing Environment.
Carroll, J. A., Johnson, D., Morecroft, M., Taylor, A., Caporn, S. J. M. & Lee, J. A. 2000: The effect of long-term nitrogen additions on the bryophyte cover of upland acidic grasslands. — J. Bryol. **22**: 83-89.
Castroviejo, S., & al. 1986-1999: Flora Iberica. Plantas vasculares de la Península Ibérica e Islas Baleares, **1-8**. — Madrid.
Corley, M. F. & Crundwell, A. C. 1991: Additions and amendments to the mosses of Europe and the Azores. — J. Bryol. **16**: 337-356.
— , —, Düll, R., Hill, M. O. & Smith, A. J. E. 1981: Mosses of Europe and the Azores: an annotated list of species, with synonyms from recent literature. — J. Bryol. **11**: 609-689.
During, H. J. & Willems, J. H. 1986: The impoverishment of the bryophytes and lichen flora of the Dutch chalk grasslands in the thirty years 1953-1983. — Biol. Conserv. **36**: 143-158.
ECCB 1995: Red Data Book of European bryophytes. European Committee Conservation of Bryophytes ECCB (eds). — Trondheim.
Ejrnaes, R. & Poulsen, R. S. 2001: Trends in the bryophyte and lichen flora of Danish semi-natural grasslands over the last 50 years. — Lindbergia. **26**: 115-120.
Franco, J. A. 1971-1984: Nova Flora de Portugal (Continente e Açores), **1-2**. — Lisboa.
— & Rocha Afonso, M. L. 1994-1998: Nova Flora de Portugal (Continente e Açores), **3(1-2)**. — Lisboa.
Grolle, R. & Long, D. 2000, An annotated check-list of *Hepaticae* and *Anthocerotae* of Europe and Macaronesia. — J. Bryol. **22**: 103-140.
Hennekens, S. M. 1996: Turboveg. Software package for input, processing, and presentation of phytosociological data. Users guide. — Wageningen, Lancaster.
Hill, M. O. 1979: Twinspan-A FORTRAN program for arranging multivariate data in an ordered two-way table by classification of the individuals and attributes. — New York.
Jansen, J. 1994: Heide-und Zwerg-Wacholdervegetation in den höheren Stufen der Serra da Estrela (Portugal), unter besonderer Berücksichtigung des *Potentillo-Callunetum*. — Ber. d. Reinh.-Tüxen-Ges. **6**: 279-303.
— 1997: A survey of habitats and species occurring in the Parque Natural da Serra da Estrela. — Final report for the Natura 2000 project. Museu e Jardim Botânico, Universidade de Lisboa. — Lisboa.
— 1999: Matt-grass swards (*Nardetea strictae*) in the Serra da Estrela, Portugal. Symposium International Association of Vegetation Science. — 26-30 July. Bilbao (abstract) Vitorio-Gasteiz.
— 2002: Geobotanical guide of the Serra da Estrela. Parque Natural da Serra da Estrela. Instituto da Conservação da Natureza. — Lisboa.
— & Sequeira, M. P. S. M. 1999: The vegetation of shallow waters and other seasonally-inundated habitats (*Littorelletea* and *Isoeto-Nanojuncetea*) in the higher parts of the Serra da Estrela, Portugal. — Mitt. Bad. Landesvereins Naturk. Naturschutz. Freiburg **17(2)**: 449-462
Rivas-Martínez, S., Fernández-González, F. & Loidi, J. 1999: Checklist of plant communities of Iberian Peninsula, Balearic and Canary Islands to suballiance level. — Itinera Geobotanica **13**: 353-451.
Sérgio, C., Casas, C., Brugués, M. & Cros, R. M. 1994: Lista Vermelha dos Briófitos da Península Ibérica/Red List of Bryophytes of the Iberian Peninsula: 1-50. — Lisboa.
— , Garcia, C., Jansen, J. & Sim-Sim, M. 2001: Novos dados para a brioflora da Serra da Estrela ou de Portugal. in Notulae Bryoflorae Lusitanicae VII. 5. — Anuário Soc. Brot. "1999" **65**: 99-104.
— & Jansen, J. 2000: On the presence of *Brachythecium dieckii* Roell (*Brachytheciaceae, Musci*)

in Portugal and Morocco. — J. Bryol. **22**: 241-242.

— , — & Séneca, A. 1998: *Bruchia vogesiaca* Schwaegr. (Musci, *Dicranales*) in Portugal. New remarks on morphology, ecology, distribution and conservation. — Lindbergia **23**: 55-61. Lund.

Tutin, T. G., Heywood, V. H., Burges, N. A., Valentine, D. H., Walters, S. M., Moore, D. M. & Webb, D. A. 1980: Flora Europaea, **5** — Cambridge.

Vieira, G. T. (eds) 1998: Glacial and Periglacial Geomorphology of the Serra da Estrela. — Guidebook for the field-trip, IGU Commission on Climate Change and Periglacial Environments, 26-28 August 1998, CEG and Department of Geography, University of Lisbon — Lisboa.

Westhoff, V. & Der Maarel, E. Van 1973: The Braun-Blanquet approach. — Pp. 617-726 in: Ordination and classification of vegetation. Handbook of Vegetation Science, **5** — The Hague.

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Annex 1

Different grassland types, localities and relevées (Na, Mo and Pa). (All in Beira Alta: Serra da Estrela, with locality, UTM 1x1 km, altitude, author, date, nº relevée). The locality abbreviations (in bold) correspond to the use in the TWINSPAN analysis. From a total of 52 relevés, only 49 (in bold) included bryophytes.

Na1- **RC1**- Malhadas do Cume, Ribeiro do Cume, 29TPE1767, 1790 m, Jansen 1991, 91-029, Rel. 67.
Na1- **RC2**- Ribeira do Cume, 29TPE1767, 1800 m, Sérgio, Séneca and Jansen 1992, 8210-8212.
Na1- **PC1**-Fragão do Poio dos Cães, 29TPE1767, 1790 m, Jansen 1992, 92-172, Rel. 187
Na1- **CR1**- N of Cântaro Raso, 29TPE1964, 1840 m, Jansen 1992, 92-191, Rel. 203.
Na1- **CA1**-S do Cântaro Magro, 29TPE1965, 1790 m, Jansen 1992, 92- Rel. 222.
Na1- **RM1**-Rua dos Mercadores, 29TPE1864, 1870 m, Sérgio and Jansen 1995, 10174-10180.
Na1- **RM2**-Rua dos Mercadores, 29TPE1965, 1810 m, Jansen 1992, 92-245, Rel. 239.
Na1- **RM3**-Rua dos Mercadores, 29TPE1865, 1870 m, Sérgio and Jansen 1995, 10164-10173, Rel. 379.
Na1- **RM4**-Rua dos Mercadores, 29TPE1864, 1870 m, Jansen 1995, Rel. 380.
Na1- **RM5**- Rua dos Mercadores, 29TPE1965, 1815 m, Jansen 1996, 96-127, Rel. 586.
Na1- **RM6**- Rua dos Mercadores, 29TPE1965, 1790 m, Jansen 1996, 96-129, Rel. 588.
Na1- **RM7**-Rua dos Mercadores, 29TPE1965, 1790 m, Jansen 1996, 96-130, Rel. 589.
Na1- **CH1**-Chancas, 29TPE1866, 1650 m, Jansen 1995, 95-064, Rel. 417.
Na1- **CL1**-Clareza, 29TPE1866, 1860 m, Jansen 1996, 96-110, Rel. 567.
Na1- **CL2**- Clareza, 29TPE1866, 1850 m, Jansen 1996, 96-170, Rel. 630.
Na1- **CB1**- Covão Boieiro, 29TPE1766, 1850 m, Jansen 1996, 96-156, Rel. 616.
Na1- **CM1**- Curral do Martins, 29TPE1969, 1720 m, Jansen 1992, 92-138, Rel. 170.
Na1- **AP1**- Alto da Pedrice to Cascalvo, 29TPE2162, 1650 m , Jansen 1992, 92-280, Rel. 262.
Na2- **CC1**-N of Barragem do Covão do Curral, 29TPE1570, 1510 m, Jansen 1996, 96-072, Rel.

530.

Na2- **FO1**-Fontes, 29TPE1470, 1430 m, Jansen 1996, 96-074, Rel. 532, 533.

Na2- **VR2**- Vale de Rossim, 29TPE1872, 1470 m, Jansen 1997, 97-234, Rel. 881.

Na2- **RF1**- Ribeira do Forno, 29TPE3286, 1190 m, Jansen 1997, 97-158, Rel. 803.

Na2- **SE1**- S of Seixo, 29TPE3489, 1230 m, Jansen 1997, 97-160, Rel. 805.

Na3- **QF1**- Quinta da Fragusta, 29TPE3377, 980 m, Jansen 1997, 97-111, Rel. 762.

Na3- **QF2**-Quinta da Fragusta, 29TPE3377, 980 m, Jansen 1997, 97-113, Rel. 764.

Na3- **AV1**- Alvarrões, 29TPE4080, 1090 m, Jansen 1997, 97-252, Rel. 900.

Mo- **CP1**-Covão da Ponte, 29TPE2678, 895 m, Jansen 1996, 96-065, Rel. 523.

Mo- CF1-Barragem Covão do Ferro, 29TPE1570, 1480 m, Jansen 1996, 96-081, Rel. 539.

Mo- **SA1**-S-slope of Salgadeira, 29TPE3385, 1100 m, Jansen 1996, 96-086, Rel. 544.

Mo- **SA2**-S of Salgadeira, 29TPE3285, 1100 m, Jansen 1996, 96-088, Rel. 546.

Mo- **AL1**-Vale de Alforfa, 29TPE2063, 1460 m, Jansen 1996, 96-116, Rel. 575.

Mo- **SB1**- Estrada de São Bento, 29TPE1067, 1080 m, Jansen 13.5.97, 97-026, Rel. 664.

Mo- **TE1**- Termos, 29TPE3186, 1180 m, Jansen 1997, 97-167, Rel. 812.

Mo- **VR1**-Videmonte, Quinta da Veleda, 29TPE3483, 845 m, Jansen 1997, 97-217, Rel. 864.

Mo- CN1- Covão da Nave, 29TPE1565, 1600m, Jansen 1997, 97-246, Rel. 894.

Mo- **VV1**-NE of Casal da Vargem de Vide, 29TPE2678, 950 m, Jansen 1996, 96-014, Rel. 467.

Mo- **VI1**- Videmonte, 29TPE3687, 1040 m, Jansen 1996, 96-023, Rel. 476.

Mo- **CO1**- N of Corujeira, 29TPE4186, 700 m, Jansen 1997, 97-020, Rel. 659.

Mo- **MA1**- Caldas de Manteigas, 29TPE2371, 800 m, Jansen 1997, 97-038, Rel. 677.

Mo- **MA2**- Caldas de Manteigas, 29TPE2371, 800 m, Jansen 1997,97-039, Rel. 678.

Mo- **CV1**- Vale de Zêzere, Covais, 29TPE2371, 890 m, Jansen 1997, 97-131, Rel. 776.

Mo- **CV2**- Vale de Zêzere, Covais, 29TPE2370, 890 m, Jansen 1997, 97-132, Rel. 777.

Mo- **VE1**- Verdelhos, 29TPE3172, 540 m, Jansen 1997, 99-003, Rel. 642.

Pa1- **PS1** to **PS4** -Fraga da Varanda to Sabugueiro, 29TPE1675, 1300-1400 m, Sérgio, Garcia &Jansen, 2000, Rel. P1, P2, P3, P4.

Pa2- **PV1** to **PV2**- Videmonte. Lameiros a seguir à povoação, sentido S-N, 29TPE3687, 1040-1050 m, Sérgio, Garcia & Jansen 2000, Rel. P 1, P 2.

Pa3- **PL1, PL2**- Loriga. Ribeira de Loriga a jusante da povoação, 29TPE1164, 650m, Sérgio, Sim-Sim & Garcia 1998, 2000. Rel. P1, P2/P3.

Annex 2

List of bryophytes present in the grassland types studied in the Serra da Estrela, with reference to their endangered status according to the Iberian Red List (Ex, E, V and R) (Sérgio & al. 1994). The species abbreviations correspond to the ones used in the TWINSPAN analysis. Percentage of species occurrence in the different grassland types is shown.

Red List	Abbrev.	Taxa	Na1	Na2	Na3	Mo	Pa1	Pa2	Pa3	Total
		Number of relevés	18	5	3	17	4	2	3	52
			%	%	%	%	%	%	%	%
		Hepatics								
R	ANEPIN	Aneura pinguis (L.) Dumort.		20						1.9
R	BARFLO	Barbilophozia floerkei (F. Weber & D. Mohr) Loeske	5.6							1.9

Annex 2. (continued).

	BARHAT	Barbilophozia hatcheri (A. Evans) Loeske	11.1						3.8
V	**CALFIS**	Calypogeia fissa (L.) Raddi		40					3.8
R	**CALMUE**	Calypogeia muelleriana (Schiffn.) Müll. Frib.	11.1	20					5.8
	CALSPH	Calypogeia sphagnicola (Arnell & J. Perss.) Warnst. & Loeske			5.9				1.9
V	**CEPBIC**	Cephalozia bicuspidata (L.) Dumort.	5.6	20					3.8
	CEPCON	Cephalozia connivens (Dicks.) Lindb.		20					1.9
	CEPDIV	Cephaloziella divaricata (Sm.) Schiffn.	16.7						5.8
	CEPELA	Cephaloziella elachista (Jack ex Gott. & Rabenh.)Schiffn.		40					3.8
	CEPSTE	Cephaloziella stellulifera (Taylor ex Spruce) Schiffn.			5.9				1.9
	CEPTUR	Cephaloziella turneri (Hook.) Müll. Frib.		20					1.9
R	**DIPALB**	Diplophyllum albicans (L.) Dumort.			11.8				3.8
	DIPTAX	Diplophyllum taxifolium (Wahlenb.) Dumort.	5.6						1.9
	FOSWON	Fossombronia wondraczekii (Corda) Lindb.					50		1.9
	FRUTAM	Frullania tamarisci (L.) Dumort.			5.9				1.9
	JUNGRA	Jungermannia gracillima Sm.		20	5.9				3.8
	JUNHYA	Jungermannia hyalina Lyell	5.6						1.9
E	**LOPBID**	Lophocolea bidentata (L.) Dumort.			5.9				1.9
R	**LOPLON**	Lophozia longiflora (Nees) Schiffn.	5.6						1.9
R	**LOPVEN**	Lophozia ventricosa (Dicks.) Dumort.	5.6						1.9
	LOPWEN	Lophozia wenzelii (Nees) Steph.	5.6						1.9
V	**MAREMA**	Marsupella emarginata (Ehrh.) Dumort.			5.9				1.9
R	**PLAPOR**	Plagiochila porelloides (Torrey ex Nees) Lindenb.			5.9				1.9
	SCASUB	Scapania subalpina (Nees ex Lindenb.) Dumort.	5.6						1.9
	SCAUND	Scapania undulata (L.) Dumort.	5.6		5.9				3.8
	TRIQUI	Tritomaria quinquedentata (Huds.) H. Buch			5.9				1.9
		Mosses							
	AMPMOU	Amphidium mougeotii (B. & S.) Schimp.			5.9				1.9
	ANTCUR	Antitrichia curtipendula (Hedw.) Brid.	5.6						1.9
	AULPAL	Aulacomnium palustre (Hedw.) Schwaegr.	5.6	100	17.6				17.3
R	**BARCON**	Barbula convoluta Hedw.			5.9				1.9
	BARITH	Bartramia ithyphylla Brid.	27.8						9.6
	BARPOM	Bartramia pomiformis Hedw.	5.6	20	5.9				5.8
R	**BRAALB**	Brachythecium albicans (Hedw.) B., S. & G.			23.5				7.7
	BRADIE	Brachythecium dieckii Roell	22						7.7
	BRARIV	Brachythecium rivulare B., S. & G.			5.9				1.9
V	**BRARUT**	Brachythecium rutabulum (Hedw.) B., S. & G.	5.6					66.7	5.8
	BRUVOG	Bruchia vogesiaca Schwaegr.	22						7.7
	BRYALP	Bryum alpinum With.		20	35.3	25	50	66.7	21
R	**BRYCAP**	Bryum capillare Hedw.			11.8			33.3	5.8
	BRYELE	Bryum elegans Nees in Brid.				25			1.9
R	**BRYMIN**	Bryum minii Podp.			5.9				1.9
	BRYPAL	Bryum pallescens Schleich. ex Schwaegr.	5.6						1.9
	BRYPSE	Bryum pseudotriquetrum (Hedw.) Gaertn., Meyer & Scherb.		20	41.2				15.4
K	**BRYRAD**	Bryum radiculosum Brid.				25			1.9
	BRYRUB	Bryum rubens Mitt.						66.7	3.8
	BRYTOR	Bryum torquescens B. & S.				25			1.9
	CALSTR	Calliergon stramineum (Brid.) Kindb.		20					1.9

Annex 2. (continued).

	CALCUS	Calliergonella cuspidata (Hedw.) Loeske			29.4				9.6
	CERPUR	Ceratodon purpureus (Hedw.) Brid.	55.6		11.8	100		100	31
V	**CYNBRU**	Cynodontium bruntonii (Sm.) B., S. & G.			5.9				1.9
	CYNJEN	Cynodontium jenneri (Schimp.) Stirt.	11.1						3.8
R	**DICHET**	Dicranella heteromalla (Hedw.) Schimp.			11.8				3.8
	DICCRA	Dicranum crassifolium Sérgio, Ochyra & Séneca	11.1						3.8
	DICSCO	Dicranum scoparium Hedw.	33.3						1.5
	EURSWA	Eurhynchium aff. hians			5.9				1.9
	EURPRA	Eurhynchium praelongum (Hedw.) B., S. et G.		20	17.6				7.7
	FUNHYG	Funaria hygrometrica Hedw.				25			1.9
	GRICUR	Grimmia curvata (Brid.) De Sloover	16.7		5.9				7.7
	HEDSTE	Hedwigia stellata Hedenäs	11.1						3.8
R	**HETHET**	Heterocladium heteropterum B., S. & G.	5.6		5.9				3.8
	HYLSPL	Hylocomium splendens (Hedw.) B., S. & G.			5.9				1.9
	HYPCUP	Hypnum cupressiforme Hedw.	16.7		5.9			33.3	9.6
R	**HYPCUPL**	Hypnum cupressiforme (Hedw.) var. lacunosum Brid.	5.6						1.9
	HYPIMP	Hypnum imponens Hedw.	5.6						1.9
	ISOHOL	Isothecium holtii Kindb.			5.9				1.9
R	**ISOMYO**	Isothecium myosuroides Brid.	16.7						5.8
	KIASTA	Kiaeria starkei (Heb. & Mohr) I. Hag.	38.9						13.5
	MNIHOR	Mnium hornum Hedw.	5.6		5.9				3.8
	ORTRUP	Orthotrichum rupestre Schleich. & Schwaegr.	5.6						1.9
	PHIFON	Philonotis fontana (Hedw.) Brid.			35.3				11.5
	PHISER	Philonotis seriata Mitt.	5.6		5.9				3.8
	PHITOM	Philonotis tomentella Mol.					100		3.8
	PLAAFF	Plagiomnium affine (Bland.) T. Kop.			5.9				1.9
	PLADEN	Plagiothecium denticulatum var. obtusifolium (Turn.) Moore	5.6						1.9
	PLANEM	Plagiothecium nemorale (Mitt.) Jaeg.	5.6						1.9
	PLEACU	Pleuridium acuminatum Lindb.			5.9	50	50		7.7
	PLESCH	Pleurozium schreberi (Brid.) Mitt.	11.1						3.8
	POGALO	Pogonatum aloides (Hedw.) P. Beauv.			5.9				1.9
	POGNAN	Pogonatum nanum (Hedw.) P. Beauv.			5.9				1.9
	POHAND	Pohlia aff. andalusica (Höhn) Broth.			5.9				1.9
	POHANN	Pohlia annotina (Hedw.) Lindb. (sensu Shaw)	11.1	20					3.8
	POHCRU	Pohlia cruda (Hedw.) Lindb.	5.6						1.9
R	**POHELO**	Pohlia elongata Hedw.	5.6		5.9				3.8
R	**POHNUT**	Pohlia nutans (Hedw.) Lindb.	5.6						1.9
	POLALP	Polytrichum alpinum Hedw.	50		11.8				21.1
	POLCOM	Polytrichum commune Hedw.	5.6	40	29.4		100		19.2
	POLFOR	Polytrichum formosum Hedw.	5.6						1.9
	POLJUN	Polytrichum juniperinum Hedw.	22		11.8	50		33.3	17.3
	POLPIL	Polytrichum piliferum Hedw.	38.9	20	11.8				19.2
	PSEHOR	Pseudocrossidium hornschuchianum (K. F. Schultz) Zander			5.9				1.9
	PSEELE	Pseudotaxyphillum elegans (Brid.) Iwats.	11.1						3.8
	RACELO	Racomitrium elongatum (Ehrh.) Frisvoll	11.1	80	5.9				11.5
R	**RACLAM**	Racomitrium lamprocarpum (C. Muell.) Jaeg.			5.9				1.9
R	**RACMAC**	Racomitrium macounii Kindb. ex Kindb. ssp. macounii	5.6		5.9				3.8

Annex 2. (continued).

V	**RACSUD**	Racomitrium sudeticum (Funck) B., S. & G.	5.6							1.9
	RHIMAG	Rhizomnium magnifolium (Horik.) T. Kop.	5.6							1.9
	RHIPUNC	Rhizomnium punctatum (Hedw.) T. Kop.	5.6							1.9
	RHYLOR	Rhytidiadelphus loreus (Hedw.) Warnst.	16.7			5.9				7.7
	SANUNC	Sanionia uncinata (Hedw.) Loeske	50							17.3
	SCLPUR	Scleropodium purum (Hedw.) Limpr.				5.9				1.9
	SCLTOU	Scleropodium touretii (Brid.) L. Koch				5.9				1.9
	SPHAUR	Sphagnum auriculatum s.lat.	5.6	80		17.6				15.4
R	**SPHCOM**	Sphagnum compactum Dc. ex Lam. & Dc.		20						1.9
	SPHPAL	Sphagnum palustre L.		20						1.9
	SPHSUB	Sphagnum subnitens Russ. & Warnst. ex Warnst.		20		17.6				7.7
	SPHSUBS	Sphagnum subsecundum Nees ex Sturm.		20		5.9				3.8
R	**SPHTEN**	Sphagnum tenellum Ehrh. ex Hoffm.		40						3.8
	WARFLU	Warnstorfia fluitans (Hedw.) Loeske				5.9				1.9
	Total number		**56**	**24**	**0**	**55**	**8**	**5**	**8**	