

ECOLOGY AND STRUCTURE OF *DROSOPHYLLUM LUSITANICUM* (L.) LINK POPULATIONS IN THE SOUTH-WESTERN OF THE IBERIAN PENINSULA

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ABSTRACT. *Ecology and structure of Drosophyllum lusitanicum (L.) Link populations in the south-western of the Iberian Peninsula.* The population size and the demographic structure of the autogamous and nautochoric *Drosophyllum lusitanicum* were studied in two areas in the South-western Iberian Peninsula. Its coenological character is documented by a synoptic phytosociological table, based upon the published relevés and new data. In the Serra de Monchique (Portugal), the distribution was mapped. 21 populations are growing there with an average size of 165 individuals. In the Campo de Gibraltar (Spain), the biggest population with several thousands of individuals occurs in the Sierra del Aljibe. Plant size, rosette diameter and lignification rate from 700 measured individuals are used as indirect indicators for the age-structure in 19 populations.

Drosophyllum has a certain pioneer character. It occurs mostly in open *Ericion umbellatae*-heathland communities (*Stauracantho-Drosophylletum*, *Quercus lusitanicae-Stauracanthetum*, *Genisto tridentis-Stauracanthetum* etc.). It is able to colonize disturbed habitats like roadside verges and fire prevention strips and is an apophyt in the *Drosophyllo-[Stauracanthenion]*-basal community. As a re-seeder the species is favoured by fire events of medium frequency. In open *Myrto-Quercetum suberis*-woodland and in dense *Erica australis*-heathland, large and tall-growing specimens predominate; there the populations are over-aged. Some deficits in the knowledge of its reproductive biology and further research topics are outlined and the needs for conservation efforts in the Portuguese study area are strengthened.

Key words. Heathland vegetation, *Ericion umbellatae*, Portugal, Serra de Monchique, Spain, phytosociology, endemism.

RESUMEN. *Ecología y estructura de poblaciones de Drosophyllum lusitanicum (L.) Link en el suroeste de la Península Ibérica.* *Drosophyllum lusitanicum* es una planta autógena y nautocórica cuyo tamaño y estructura de población han sido estudiados en dos áreas del suroeste de la Península Ibérica. Su carácter cenológico se documenta mediante una tabla fitosociológica sintética basada en inventarios ya publicados y datos nuevos. En la Sierra de Monchique (Portugal) se cartografiaron 21 poblaciones cuyo tamaño medio es de 165 individuos. Sin embargo, en el Campo de Gibraltar (España), se encontró la población de mayor tamaño, con varios miles de individuos en la Sierra del Aljibe. Aquí se estudió el tamaño de las plantas, el diámetro de la roseta basal y el grado de lignificación de 700 individuos, lo que se utilizó como indicador indirecto de la estructura de edades de 19 poblaciones.

Drosophyllum lusitanicum tiene un cierto carácter pionero. Se presenta mayoritariamente en los brezales aclarados de *Ericion umbellatae* (*Stauracantho-Drosophylletum*, *Quercus lusitanicae-Stauracanthetum*, *Genisto tridentis-Stauracanthetum*, etc.). Es capaz de colonizar medios alterados, como cunetas de carreteras y cortafuegos, y es un apófito en las comunidades basales de *Drosophyllo-[Stauracanthenion]*, siendo además esta especie favorecida por los frecuentes incendios de la zona. En los alcornocales abiertos de *Myrto-Quercetum suberis* y en los brezales densos de *Erica australis* predominan

los individuos grandes, siendo éstas poblaciones maduras. Finalmente, se aportan algunos datos poco conocidos de su reproducción y ecología que indican la necesidad de un mayor esfuerzo para la conservación del área portuguesa estudiada.

Palabras clave. Brezales, *Ericion umbellatae*, Portugal, Serra de Monchique, España, fitosociología, endemismos.

INTRODUCTION

Unlike the *Calluno-Ulicetea*-heathland in the perhumid climate of Western Europe, dominated by eurychorous taxa, the heathland associations of the suballiance *Stauracanthion boivinii* (*Ericion umbellatae*, *Calluno-Ulicetea*), distributed in the mountainous arc from the Serra de Monchique in Southern Portugal via the Sierras de Algeciras (SW Spain) to the Western Rif Mountains (Morocco), are characterized by a remarkable degree of endemism and species richness (Arroyo & Marañón, 1990; Galán de Mera & Vicente Orellana, 1996; Ojeda *et al.*, 1995, 1996a). One reason might be that this southwestern part of the Mediterranean region is a centre of origin of this type of vegetation. The occurrence of heliophilous low shrub endemics like *Drosophyllum lusitanicum*, *Nothobartsia aspera*, *Odontites foliosa*, *Teucrium afrum* ssp. *rubriflorum* etc. indicate that there exist – at least in small areas – primary habitats for those characteristic heathland species.

In their area of distribution, however, *Calluno-Ulicetea*-communities must be considered as secondary (man-made) communities in most cases, replacing acidophilous forests (mostly cork-oak forests) after cutting and burning. During the last few decades, the heathlands in Southern Portugal and in Andalusia were affected by severe land-use changes. Some major trends are the decline or even the total abandonment of traditional rotating cultivation practises, a decreasing grazing impact, the afforestation with

allochthone taxa like *Eucalyptus* and *Pinus* and the change of fire frequency and intensity (Krohmer & Deil, 1999). Are the *Stauracanthion*-species threatened or favoured by these current land-use trends ?

A first step to answer this question is to have a closer look upon the ecological requirements and coenological value of keystone species in primary and secondary habitats, and to study their life cycle and population structure in different situations. One of those southwest-Iberian-northwest-Moroccan elements, upon which the phytogeographical province Tingitano-Onubo-Algarviense within the superprovince Iberomarroquí-atlántica (Galán de Mera & Vicente Orellana, 1996; Pérez Latorre *et al.*, 1996) is based, is *Drosophyllum lusitanicum* (L.) Link. It is a carnivorous, low growing perennial plant, lignified in its basal shoots (half shrub, chamaephytic growth form). This monotypic genus has quite an isolated position within the *Droseraceae*-family and is sometimes even separated from *Droseraceae* as the monospecific family *Drosophyllaceae* (Williams *et al.*, 1994). It shares its distribution, sociology, life form, and isolated taxonomic position with the still rarer *Nothobartsia aspera* (for the latter species see Galán de Mera *et al.*, 1996).

Most of the populations of *Drosophyllum lusitanicum* are located near the sea (fig. 1). They range from Northern Portugal along the Atlantic coast to the Serra de Monchique in the Algarve Hinterland. In Spain, the highest density of populations can be found in the Campo de Gibraltar (Aljibian sector of the

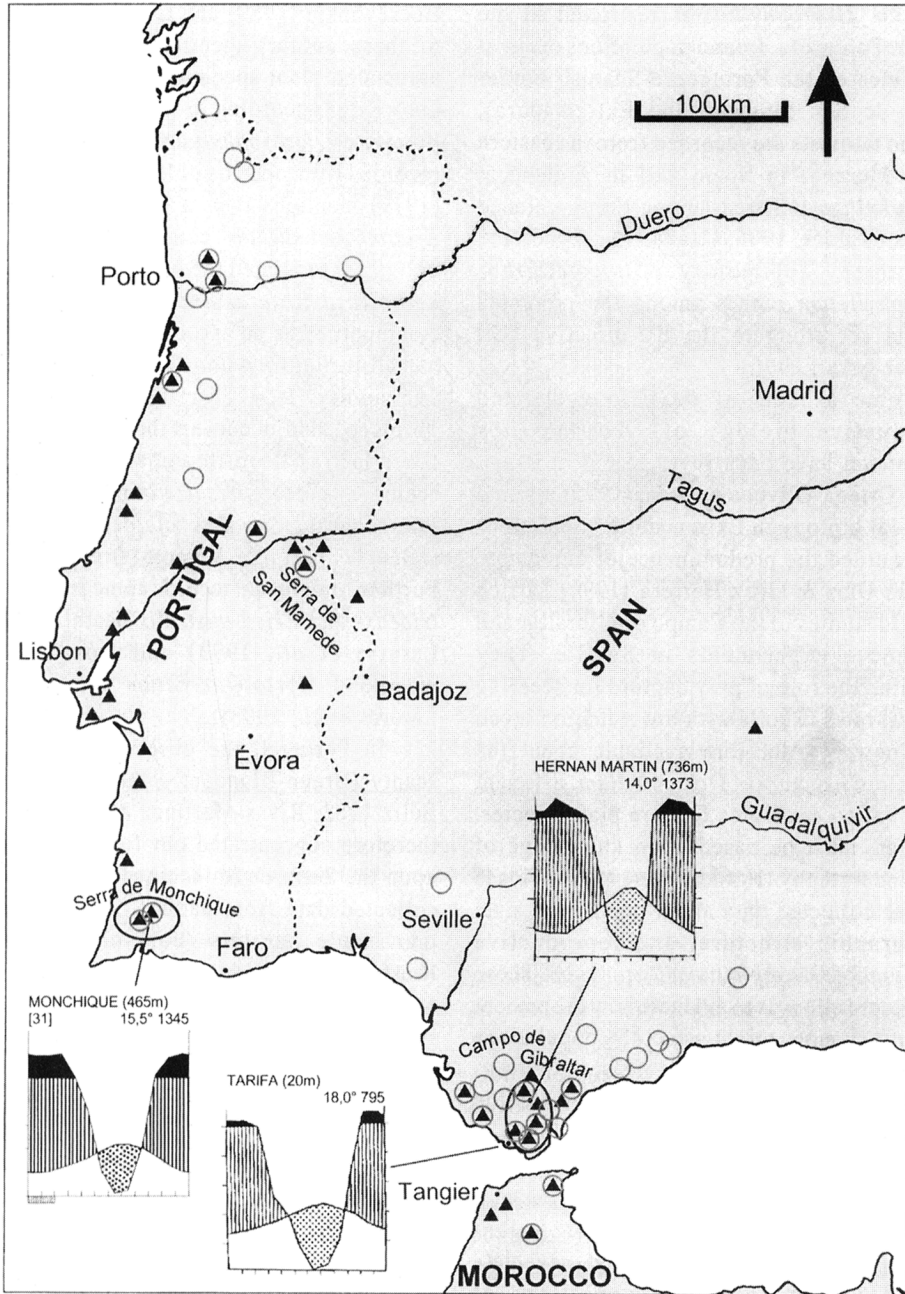


Figure 1. Study areas (black ellipses), distribution of *Drosophyllum lusitanicum* (▲), and locations of phytosociological relevés (○) (after our own data and various authors).

Tingitano-Onubo-Algarvian province). In Morocco, *Drosophyllum* is restricted to the Tangier Peninsula. Inland populations occur at both sides of the Portuguese-Spanish border (Serra de San Mamede and Extremadura), isolated outposts are recorded from the eastern Sierra Morena. In Spain and in Andalusia, *Drosophyllum* is listed among the threatened species (Valdés, 1996; Ocaña *et al.* 2000) and the plant community *Stauracantho-Drosophylletum* ranges among the protected habitats according to the EU-directive (Gil Jiménez *et al.*, 1996).

Some aspects of the life cycle and reproductive biology of *Drosophyllum lusitanicum* have been investigated in recent years. Ortega Olivencia *et al.* (1995) studied the floral biology in Extremadura populations and recorded the predominance of autogamy. Garrido Díaz & Ortiz Herrera (1996) carried out field studies in the Campo de Gibraltar and glasshouse experiments in Seville. They underline the role of prey capture for seedling survival rates in soils with low nutrition level. Until now, no data are available about the population structure of *Drosophyllum*. Efficient conservation strategies for rare plant species, however, must be based upon knowledge of their demography (Holderregger, 1996). This is why we collected data about population size, demographic structure, and reproductive behaviour of *Drosophyllum lusitanicum*. These data should allow us to evaluate how the present land-use changes might affect the populations of this species in the future.

To answer the questions, what are the primary respectively the secondary habitats of *Drosophyllum lusitanicum* and in which plant communities does it occur, we present a synoptic view of the available plant sociological studies and gathered new data from Southern Portugal. Populations of *Drosophyllum* in pine and cork-oak woodlands are recorded by Ortega Olivencia *et al.* (1995); herbarium records from clearings and in coastal

rock communities are presented by Boesewinkel (1989) and Cheers (1992). None of these authors mention the whole set of associated plant species. What is the state of knowledge according to the plant sociological literature? *Drosophyllum lusitanicum* is often recorded from open heathland: Rivas-Martínez (1979) mentions it as a character species of *Ericion umbellatae*-communities. Quézel *et al.* (1988) separated the open type of the *Erica umbellata-Stauracanthus boivini*-communities as an association of its own and named it *Stauracantho-Drosophylletum*. This community, first described from Northern Morocco, also occurs in the Cádiz Peninsula (Deil, 1997a). It is differentiated in the Aljibian sector by *Satureja salzmanii* (*Drosophyllo-Stauracanthetum saturejetosum salzmanii*, Galán de Mera & Vicente Orellana, 1996). Further Andalusian records come from *Genista tridens*- and *Erica australis*-heathland (Pérez Latorre *et al.*, 1993) and from cork-oak woodland *Myrto-Quercetum suberis* (Pérez Latorre *et al.*, 1993).

In Portugal, the observations are quite scanty (Braun-Blanquet *et al.*, 1964; Malato Béliz 1982; Rivas-Martínez *et al.*, 1990). We therefore concentrated our field observations upon the Serra de Monchique in Portugal and collected data from natural, seminatural and man made habitats (cork-oak woodland, heathland, roadside verges, fire prevention strips etc.).

THE STUDY AREAS

Field studies were carried out in two regions located in the southwestern part of the Iberian Peninsula (fig.1): the first study area, the Serra de Monchique, is situated in a mountainous region of mid altitude (902m a.s.l. at Foia) in the Algarve Hinterland (District of Faro, Portugal). The second study area are the Sierras of the Campo de Gibraltar (Cádiz and

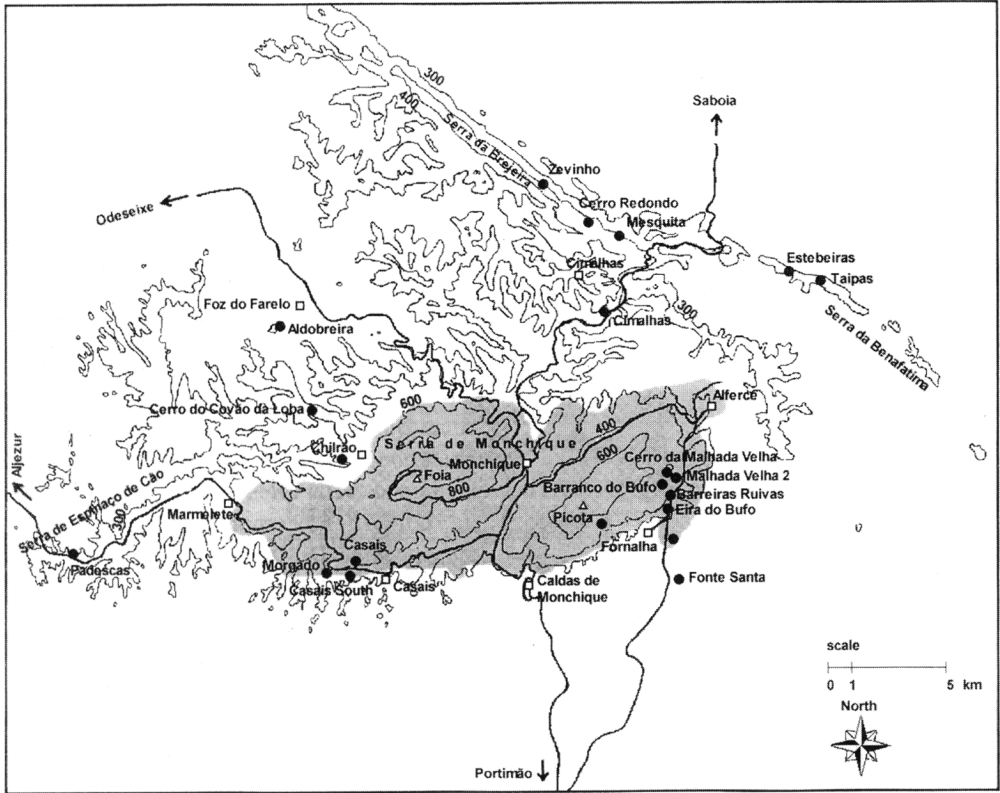


Figure 2. Distribution of *Drosophyllum lusitanicum* (●) in the Serra de Monchique. The syenite area is marked with grey colour.

Málaga provinces, Andalusia, Spain). Both areas have been selected because they shelter important populations of *Drosophyllum lusitanicum*, they offer quite similar physical conditions and they are subjected to different trends in land-use changes (Deil, 1997a).

The study areas have a Mediterranean climate with Atlantic character (see climatic graphs in figure 1). Westerly winds, high air humidity and frequent clouds in the summit parts reduce the severity of summer drought. The central part of the Serra de Monchique consists of a syenite intrusion, surrounded by Palaeozoic schists and greywakes. The

weathering of the coarse-grained syenite results in cambisols with a sandy texture and a high water holding capacity, whereas on the schists stony leptosols with low nutrient content develop. The Sierras of the Campo de Gibraltar are part of the betic-riphaean mountain ridge, consisting of several Cretaceous and Tertiary flysch layers. Most of the *Drosophyllum*-populations there grow on sandy soils over Aljibe-sandstone.

The climax community in the thermomediterranean part of the Serra de Monchique is an open cork-oak woodland (*Myrto-Quercetum suberis*), followed in the

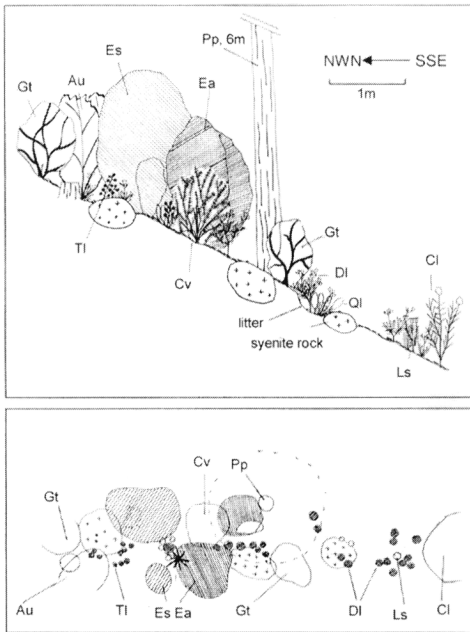


Figure 3. *Erico australis-Cistetum populifolii* with *Drosophyllum lusitanicum*. Vertical and horizontal structure of this tall-growing heathland community on a rocky slope near Cerro da Malhada Velha in the Serra de Monchique. Abbreviations: Au: *Arbutus unedo*, Cl: *Cistus ladanifer*, Cv: *Calluna vulgaris*, Dl: *Drosophyllum lusitanicum*, Ea: *Erica australis*, Es: *Erica scoparia*, Gt: *Genista tridentata*, Ls: *Lavandula stoechas*, Pp: *Pinus pinaster*, Ql: *Quercus lusitanica*, TI: *Tuberaria lignosa*.

mesomediterranean by dense oak forests (*Sanguisorbo-Quercetum suberis typicum* in the humid parts and *quercetosum canariensis* in the hyper-humid parts) (Malato B eliz, 1982; Rivas-Mart inez *et al.*, 1990; Seng & Deil, 1999). The *Phillyreo-Arbutetum unedonis* as the first degradation step of *Quercus suber*-forests is widespread and traditionally and currently used to harvest fruits from the strawberry tree. Further degradation results in heathland communities. They have expanded under human impact (fire, grazing, cutting) from a few original sites (mountain ridges heavily exposed to wind, rocky outcrops with

superficial soils, hyperhumid sites with stagnant water and pseudogley) and currently cover vast areas. The *Erica*-heathlands and *Cistus*-shrublands show a clear bioclimatic zonation. There is a transition from *Cisto-Lavanduletea* in the thermomediterranean, dry and subhumid zone to *Calluno-Ulicetea* in the mesomediterranean, humid and hyperhumid zone. The altitudinal series is *Genisto hirsutae-Cistetum ladaniferi*, *Cisto ladaniferi-Ulicetum argentei*, *Quercus lusitanicae-Stauracanthetum boivinii*, *Erico australis-Cistetum populifolii* to *Cisto salvifolii-Ulicetum minoris*. On syenite outcrops at mid-altitude, the altitudinal zonation starts with *Halimio calycini* and *Ericetum australis-Rosmarinus* community ined. and with *Silene mellifera-Ranunculus bupleuroides* community, goes on to *Stauracantho-Drosophylletum* and ends up with the *Osyrio quadripartitae-Juniperetum turbinatae*.

The altitudinal zonation of the original forests and the secondary heathland in the Spanish part of the study area is very similar to Portugal: *Myrto-Quercetum suberis* is followed by *Teucrio-Quercetum suberis* and *Rusco-Quercetum canariensis*. The heathland communities are to some extent identical, to the other replaced by corresponding communities: *Quercus lusitanicae-Stauracanthetum boivinii* in the Monchique Mountains has the same matrix species like *Genista tridentis-Stauracanthetum quercetosum lusitanicae* in the Aljibe Mountains. They differ by the Aljibian-Tingitanian endemics *Genista tridens*, *Satureja salzmanii*, *Klasea alcalae* etc. and the Monchique endemics *Centaurea crocata* and *C. fraylensis*. Further details to the heathland communities of the Sierras of the Campo de Gibraltar can be taken from the abundant literature (Asensi & D iez Garretas, 1987; Nieto Caldera *et al.*, 1990; P erez Latorre *et al.*, 1993; P erez Latorre *et al.*, 1994; Nezaal *et al.*, 1994; Deil, 1997a; P erez Latorre *et al.*, 1999).

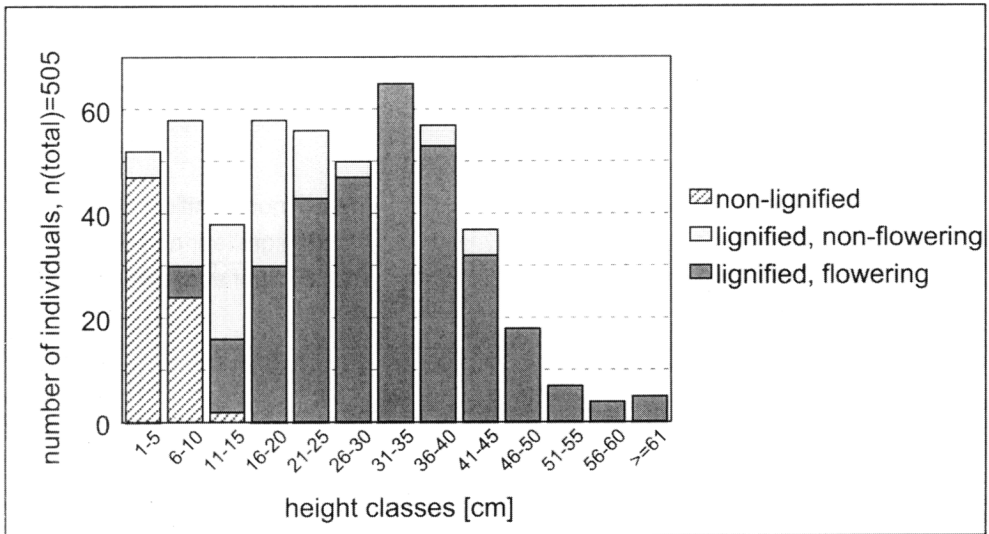


Figure 4. Height classes, lignification and flowering rate in Portuguese populations of *Drosophyllum lusitanicum*

METHODS

Field data were collected between April and July 1998. In the Serra de Monchique, the local distribution of *Drosophyllum lusitanicum* was mapped (fig. 2) and the number and size of all populations was documented. Additional data were collected in the Sierra del Aljibe and in other mountains of the Campo del Gibraltar. In total, 700 individuals in 19 different populations were measured. Table 1 shows the sample sizes per population and per study area. All studies have been restricted to non-destructive observations. Subterranean parts were not investigated; every shoot rooting independently was treated as an individual. Small sample sizes are due to a low number of individuals in the respective population.

To analyse the population structure of *Drosophyllum*, vegetative morphometric parameters, which can be interpreted as age-states or life-states (Barkham, 1980;

Holderegger, 1997), were measured. These parameters are plant height, rosette diameter and degree of lignification in the basal parts of the specimen. To get an insight into the generative reproduction strategy, the following data were noted: number of buds, flowers, fruits, seeds per fruit and seedling occurrence and establishment.

Phytosociological relevés were made in all kind of habitats (primary and secondary) where *Drosophyllum lusitanicum* occurred. To see whether *Drosophyllum* exhibits an apophytic character even impoverished stands at roadside verges and on fire-prevent strips were sampled. In the Serra de Monchique, structural transects of several meters length with exact position and size of *Drosophyllum* and its neighbouring specimens were taken to describe the spatial pattern in selected habitats. To study the sociological amplitude of *Drosophyllum lusitanicum*, the available data from the literature and our own new data are

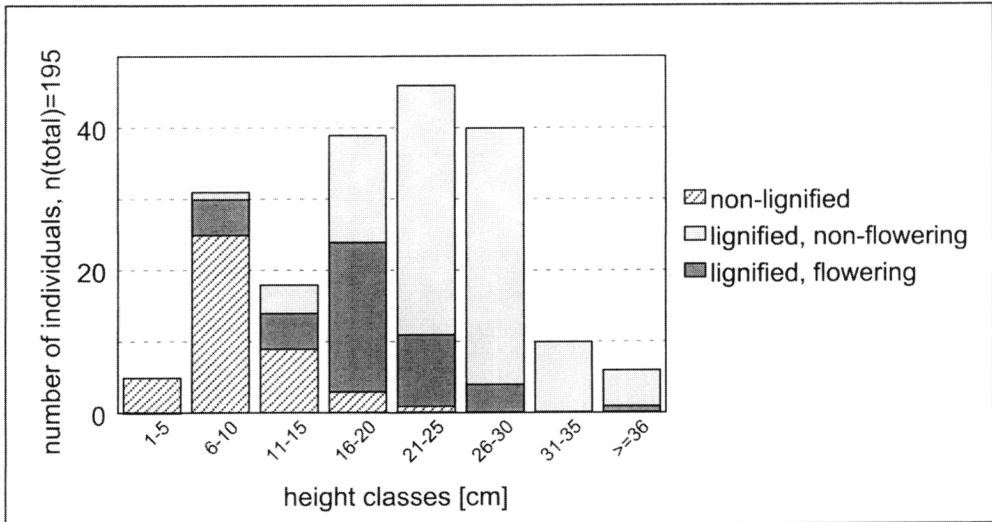


Figure 5. Height classes, lignification and flowering rate in Spanish populations of *Drosophyllum lusitanicum*

presented in a constancy table (tab. 3), which is reduced to the diagnostic and frequent species. The locations of the relevés are documented in figure 1. Classification and nomenclature of the plant communities are according to the Zurich-Montpellier school (Braun-Blanquet, 1964; Dierschke, 1994). Impoverished stands are typified following the concept of basal communities according to Kopecky & Hejny (1974). Plant communities are typified and named according to Rivas-Martínez *et al.* (1990) in Portugal, and Deil (1997a) and Pérez Latorre *et al.* (1999) in Spain. In both countries nomenclature of plant species follows Valdés *et al.* (1987).

RESULTS

Local distribution and size of the populations: In the Serra de Monchique, 21 populations have been found (tab. 2). The altitudes of the localities range between 290m

and 560m a.s.l., i.e. from the thermo- to the mesomediterranean bioclimatic level. A higher density of the populations can be stated in the leeward, southern and southeastern parts of the Serra (fig. 2). 10 populations occur on syenite, 11 on schists and greywakes. The average population size (statistical mean) is about 165 individuals. The most important population with about 800 specimens is near Chilrão. In the Sierras of the Campo de Gibraltar, the studied populations of *Drosophyllum lusitanicum* are all growing on Aljibe-sandstone. The biggest population with several thousands of individuals occurs near the summit of Picacho in the Sierra del Aljibe at an altitude of about 830m a.s.l. in the mesomediterranean bioclimatic level.

Sociology and autecology of *Drosophyllum lusitanicum*: *Drosophyllum lusitanicum* has its highest frequency and abundance in very open *Erica umbellata*-*Stauracanthus boivinii*-heathlands on sandstone, syenite ridges and on steep loamy,

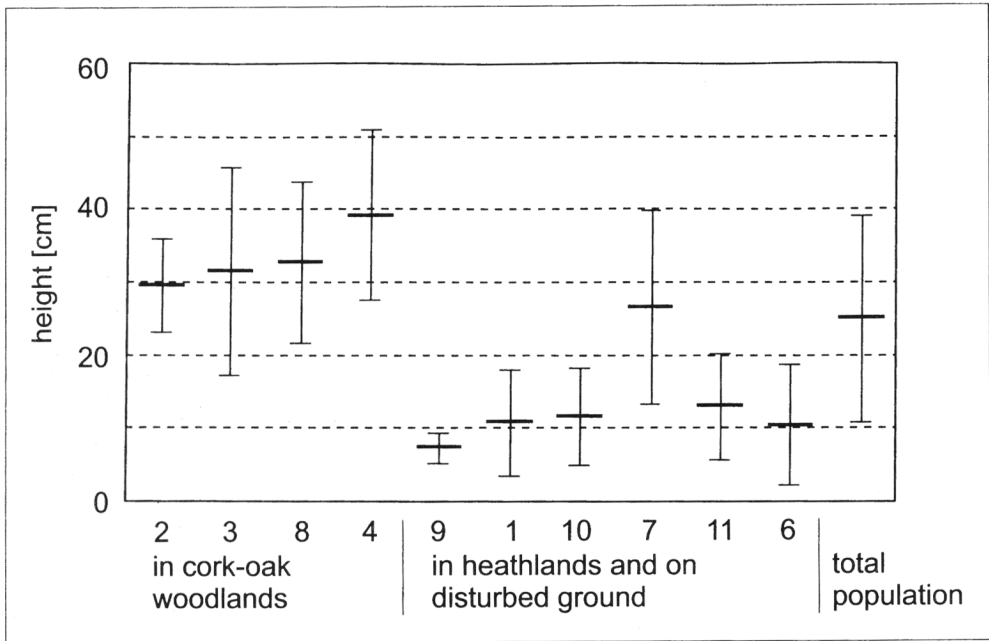


Figure 6. Mean height and height variability (standard deviation) of nine *Drosophyllum* populations in Portugal (numbers of populations like in table 1)

silty slopes on Aljibe-clay. This vegetation type was first described by Quézel *et al.* (1988) from the Tingitanian sector in northern Morocco as *Stauracantho-Drosophylletum*, based upon *Drosophyllum lusitanicum* as the only character species. In the type relevé, *Cistus monspeliensis* is very abundant, indicating the high fire frequency at this site in the Tangier area. The association also occurs in the Aljibian sector (Nezadal *et al.*, 1994; Pérez Latorre *et al.*, 1996; Deil, 1997a). Besides the typical subassociation (tab. 3, column 1), the subassociation *saturejetosum salzmanii* (tab. 3, column 2) with a high frequency of *Satureja salzmanii* was stated for the Gaditanian Peninsula by Galán de Mera & Vicente Orellana (1996).

If the fire frequency is lower and the relief moderate, surface runoff decreases and soils are deeper. At such sites, the *Erica*

umbellata-heathlands have a dense vegetation canopy and *Drosophyllum* occurs in low frequency and with only some scattered individuals. These habitats can be enclosed in the Sierras of the Campo de Gibraltar into the *Genisto tridentis-Stauracanthetum* in its typical subassociation and into the subassociation with *Quercus lusitanica* on profound, podsolic soils (tab. 3, columns 3 and 4). In Morocco, the succession advances from the *Drosophyllo-Stauracanthetum* to the *Erica umbellata-Cistus crispus*-community (Deil, 1997a). The investigated populations in the Campo de Gibraltar can be assigned to *Drosophyllo-Stauracanthetum* and to *Genisto tridentis-Stauracanthetum*.

The community corresponding to the *Genisto-Stauracanthetum* in the Aljibian sector is the *Quercus lusitanicae-Stauracanthetum* in the Monchiquense sector. The latter community

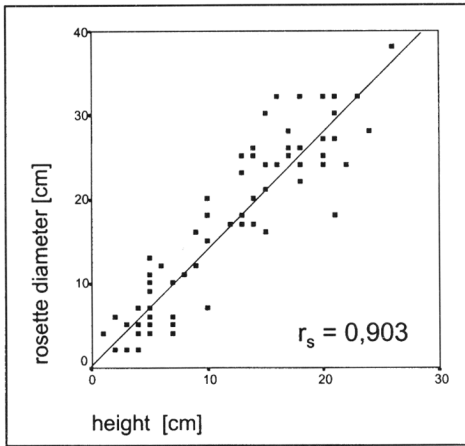


Figure 7. Correlation between rosette diameter and height in the population Mesquita in Portugal ($n = 75$, Spearman's correlation coefficient r_s)

is endemic in the Serra de Monchique. It is concentrated in the western and northwestern schistous parts of the Serra and occurs exclusively on wind exposed mountain ridges with stony soils with a shallow or even completely missing humus layer. From these sites, which seem to be original heath habitats, the heathlands have been expanded under human impact to *Phillyreo-Arbutetum*-climax sites and to originally open *Quercus suber*-woodland sites. Today, the traditional land-use (burning and pasturing) is abandoned and high growing shrubs are invading the secondary *Erica umbellata*-heathlands. Like in the closed *Genisto-Stauracanthetum*, *Drosophyllum lusitanicum* occurs in the dense and intact *Quercus-Stauracanthetum* only with low frequency and very limited numbers of individuals (tab. 3, column 5).

In the Serra de Monchique, the former secondary heathlands have been transformed to a large extent into *Eucalyptus*-plantations within the last few decades (Malato Béliz, 1982; Krohmer & Deil, 1999). In the ground layer of these forests, the floristic composition

is very similar to the non-reforested sites. Character species of *Quercus-Stauracanthetum*, like *Centaurea crocata* and *C. fraylensis*, are still occurring, but with lower frequency and abundance (tab. 3, column 6). The plant cover, however, is much more open, the sites are often terraced before planting. This vegetation type was called "matas artificiais" by Malato Béliz (1982). It is identical with type 10 (*Eucalyptus* afforestations in *Quercus lusitanica* heathland) in Seng & Deil (1999). According to the nomenclature of Kopecky & Hejny (1974), it can be named *Drosophyllo*-[*Stauracanthenion*]-basal community. *Drosophyllum lusitanicum* has a good capability of recolonizing these terraced *Eucalyptus*-forests if the tree layer remains open and if vital populations of *Drosophyllum* are nearby. It can even expand to sites with high disturbance like roadside verges, timber storage areas and firebreak strips. The apophytic character of *Drosophyllum* is indicated by its higher frequency in disturbed (tab. 3, column 6) than in undisturbed (tab. 3, column 5) sites of the *Quercus-Stauracanthetum*.

Most of the 21 populations of *Drosophyllum* found in the Serra de Monchique occurred in the *Quercus-Stauracanthetum* or in [*Drosophyllo*]-*Stauracanthenion*-basal communities. In higher altitudes and at northern slopes, *Quercus-Stauracanthetum* respectively *Genisto tridentis-Stauracanthetum* is replaced by *Erica australis-Cistetum populifolii*. The *Erica australis*-heathland is taller and growing more densely than *Erica umbellata*-dominated heathland; *Drosophyllum lusitanicum* becomes less frequent (tab. 3, column 7). Populations with high numbers of individuals occur at disturbed sites (*Eucalyptus*- and *Pinus pinaster*-plantations), where the plant canopy is open (fig. 3).

The occurrence of *Drosophyllum lusitanicum* in *Ericion umbellatae*-communities in Portugal outside the Serra de

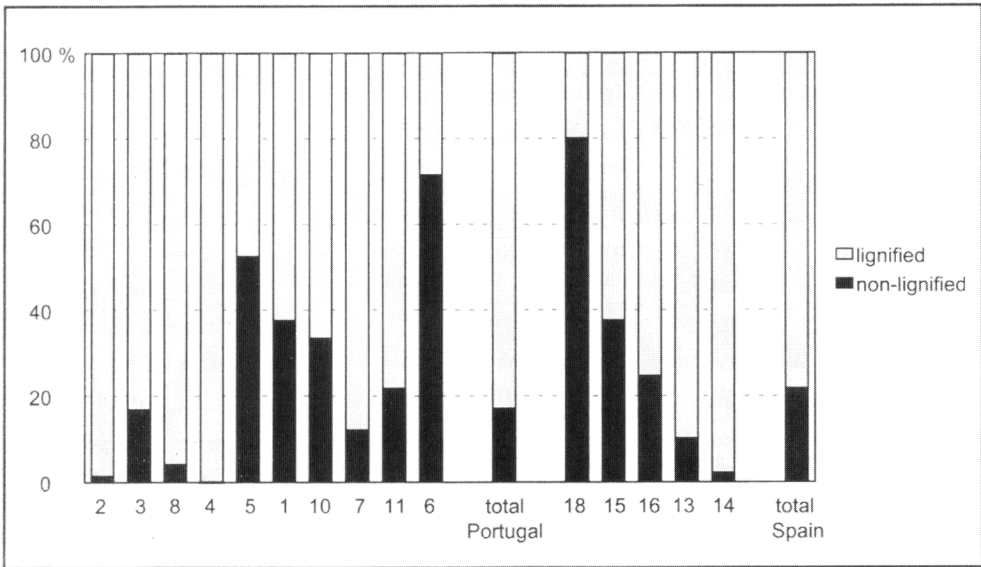


Figure 8. Lignification rate in different populations of *Drosophyllum lusitanicum* (for localities see table 1)

Monchique was documented by Braun-Blanquet *et al.* (1964). In the heavily grazed *Erico umbellatae-Ulicetum micranthi* (tab. 3, column 10) as well as in the *Ulici minoris-Ericetum umbellatae* from the Serra de San Mamede (tab. 3, column 9) *Drosophyllum lusitanicum* appears with low frequency.

In cork-oak woodland, *Drosophyllum lusitanicum* remains restricted to the *Myrto-Quercetum suberis* (thermomediterranean subhumid bioclimate) (tab. 3, column 8) where it prefers small disturbed areas, resulting from digging animals or from ploughing. *Drosophyllum lusitanicum* does not occur in closed thermo- and mesomediterranean humid cork-oak woodlands with dense litter (*Teucrio-Quercetum suberis* in Spain respectively *Sanguisorbo-Quercetum suberis* in Portugal).

Population structure: Plant height, lignification rate and rosette diameter are parameters which can be easily measured in a non-destructive way and are indirect parameters of the age of the individuals. Figures 4 and 5

show the correlation between height classes, lignification in the basal parts and flowering rate in all measured specimen in Portugal respectively Spain. In Portugal (fig. 4, 505 individuals measured in total), the proportion of the non-lignified individuals decreases continuously in the first three height classes, whereas the proportion of flowering individuals increases in the same way. > 6cm is the minimum size for flowering, individuals > 25cm are nearly all flowering. A maximum height of 72cm was stated in Portugal. All flowering specimen are lignified in the basal parts of the shoots. The Spanish populations (fig. 5, 195 individuals measured in total) show similar tendencies. > 5cm is the minimum size for flowering, all flowering individuals are lignified. In contrast to the Portuguese populations, the specimen are dwarfishly growing (> 40cm) and the rate of flowering is during flowering peak much lower.

To see how the density of the plant canopy and the co-occurring species affect the vitality

population	localities	number of sampled individuals
Study area Serra de Monchique (Algarve, Portugal)		
1	Barranco do Bufo	16
2	Casais	75
3	Casais South	30
4	Cerro da Malhada Velha	75
5	Cerro Redondo	42
6	Cimalhas	7
7	Eira do Bufo	75
8	Fornalha	75
9	Malhada Velha 2	3
10	Mesquita	75
11	Padescas	74
Study area Sierras del Campo de Gibraltar (Cádiz, Spain)		
12	Cerro de las Callejuelas	5
13	El Picacho 1	50
14	El Picacho 2	50
15	Puerto de Gáliz 1	16
16	Puerto de Gáliz 3	49
17	Sierra de Ojen 1	2
18	Sierra de Ojen 2	20
19	Sierra del Niño	3

Table 1: Location of the studied populations and number of sampled individuals of *Drosophyllum lusitanicum*

and the competitiveness of *Drosophyllum*, populations in different communities have been studied. fig. 6 shows the mean height and height variability of nine populations in Portugal (no data available from Spain). The average height (statistical mean) is about 25cm, individuals in opened cork-oak woodlands (populations 2, 3, 4 and 8) and tall-growing heathland (population 7) being significantly taller than those in low-growing heathland and in open areas. Height class distribution is different: in open areas low classes predominate, populations in cork-oak woodlands have a balanced distribution, tall specimens dominate in heathlands of the *Erico australis-Cistetum populifolii*.

The parameter rosette diameter confirms these results. The mean rosette diameter for all measured individuals is about 21cm. There are no significant differences between all

Portuguese and all Spanish populations and between the different Spanish populations ($p = 0,165$, Kruskal-Wallis H-test, (Sachs 1993)). A comparison of the Portuguese populations, however, shows significant differences between the studied populations (tab. 4). Individuals in the cork-oak woodlands and tall-growing heathland have significantly larger rosette diameters (about 30cm) than those in low-growing heathland and open habitats (about 23cm, $p < 0,001$, Mann-Whitney U-test, Sachs 1993). The measured parameters plant height and rosette diameter are significantly correlated to each other in almost all populations in Portugal and Spain (tab. 5). A correlation diagram of the population 10 "Mesquita" is shown as an example (fig. 7).

Clearer than plant height or rosette diameter, lignification of the basal shoot can

	population / locality	altitude m a.s.l.	aspect	substrate	number of individuals
Portugal	Aldobreira	250	NE, E	schist	450
	Barranco do Bufo	450	S	syenite	50
	Barreiras Ruivas	325	E	syenite	85
	Casais	420	S, SW	syenite	265
	Casais South	385	SSE	syenite	32
	Cerro da Malhada Velha	560	SE	syenite	80
	Cerro do Covao da Loba	415	SE	schist	121
	Cerro Redondo	460	S	schist	42
	Chilrão	460	NE, E	schist	800
	Cimalhas	430	NW	schist	7
	Eira do Bufo	390	SE	syenite	450
	Estebeiras	330	SE	schist	1
	Fonte Santa	270	NE	schist	87
	Fornalha	290	SE	syenite	95
	Malhada Velha 2	515	SW	syenite	3
	Mesquita	490	S, E	schist	165
	Morgado	415	S	syenite	205
	Padescas	335	S, SSE	schist	80
	Picota	400	SSW	syenite	20
Taipas	340	SE	schist	44	
Zevinho	440	NE, SE	schist	385	
Spain	Cerro de las Callejuelas 4	590	SW	Alljibe-sandstone	117
	Cerro de las Callejuelas 5	570	SW	Alljibe-sandstone	8
	Cerro de las Callejuelas 6	550	S	Alljibe-sandstone	2
	Cerro de las Callejuelas 7	540	SE	Alljibe-sandstone	45
	El Picacho 1	690	SE	Alljibe-sandstone	187
	El Picacho 2	770-830	SE	Alljibe-sandstone	8000
	Puerto de Gáliz 1	420	SW	Alljibe-sandstone	16
	Puerto de Gáliz 2	470	NW	Alljibe-sandstone	24
	Puerto de Gáliz 3	610	S	Alljibe-sandstone	91
	Sierra de Ojén 1	450	S	Alljibe-sandstone	2
	Sierra de Ojén 2	450	SE	Alljibe-sandstone	51
Sierra del Niño	240	SE	Alljibe-sandstone	3	

Table 2. Environment and size of the studied populations of *Drosophyllum lusitanicum*

Column	1	2	3	4	5	6	7	8	9	10
Number of relevés	14	5	32	26	32	10	23	35	15	21
Stauracantho-Drosophylletum lusitanici CS										
<i>Drosophyllum lusitanicum</i>	V	V	I	II	I	III	I	I	I	I
Stauracantho-Drosophylletum satirejetosum DS										
<i>Satureja salzmanii</i>	I	V	II	III	.	.	.	.	.	.
Genisto tridentis-Stauracanthetum boivinii CS										
<i>Genista tridens</i>	III	.	IV	V	.	.	.	.	.	.
<i>Klasea alcalae</i>	III	II	III	IV	.	.	.	.	.	.
<i>Bupleurum foliosum</i>	I	I	I	I	.	.	.	.	.	.
Quercu lusitanicae-Stauracanthetum boivinii CS										
<i>Lavandula stoechas</i> ssp. <i>luisieri</i>	.	.	.	.	IV	.	III	I	II	.
<i>Centaurea crocata</i>	.	.	.	.	III	III	II	I	.	.
<i>Centaurea fraylensis</i>	.	.	.	.	II	IV	.	.	.	.
<i>Klasea monardii</i>	.	.	.	.	II	I	.	I	.	.
<i>Lavandula viridis</i>	.	.	.	.	I	.	I	I	.	.
Stauracanthenion boivinii DS										
<i>Stauracanthus boivinii</i>	V	V	V	V	V	IV	I	.	.	.
<i>Avenula sulcata</i> s.l.	III	II	III	III	IV	IV	II	I	I	I
Ulici minoris-Ericetum umbellatae CS										
<i>Ulex minor</i>	.	.	.	.	.	.	I	I	II	I
Erico umbellatae-Ulicetum micranthi CS										
<i>Ulex micranthus</i>	.	.	.	.	.	.	.	.	.	V
Ericion umbellatae CS										
<i>Erica umbellata</i>	II	IV	III	III	V	II	I	.	V	V
<i>Genista triacanthos</i>	II	II	II	I	III	I	III	I	III	III
<i>Genista tridentata</i>	II	.	III	II	V	V	II	I	V	IV
<i>Erica australis</i>	II	.	II	IV	IV	III	V	I	II	I
Halimium alyssoides ssp. lasianthum										
<i>Thymus villosus</i>	III	I	IV	II	II	I	.	.	.	.
<i>Polygala microphylla</i>	I	I	II	II	.	.	.	.	I	I
<i>Quercus lusitanica</i>	II	.	II	V	V	IV	II	.	.	.
<i>Halimium ocymoides</i>	.	.	.	.	IV	III	I	.	III	I
<i>Ornithogalum broteroi</i>	.	.	.	.	IV	II	I	I	II	.
<i>Erica cinerea</i>	.	.	.	.	.	.	.	.	IV	IV
Calluno-Ulicetea CS										
<i>Calluna vulgaris</i>	III	III	IV	V	V	V	IV	I	IV	V
<i>Agrostis curtisii</i>	II	I	IV	IV	IV	III	I	.	V	V
<i>Simethis planifolia</i>	II	.	I	I	II	II	I	I	IV	IV
<i>Erica scoparia</i>	III	I	IV	IV	II	II	I	I	.	.
Cisto-Lavanduletea, Lavanduletalia CS										
<i>Tuberaria lignosa</i>	III	III	III	III	III	IV	II	I	I	I
<i>Cistus salvifolius</i>	II	I	IV	III	III	II	V	III	.	.
<i>Cistus crispus</i>	III	I	II	I	I	.	II	I	.	.
<i>Lavandula stoechas</i>	IV	I	IV	III	I	II	I	II	.	.
<i>Halimium halimifolium</i>	III	.	II	I	I	.	.	I	.	.
<i>Cistus populifolius</i> ssp. <i>major</i>	.	I	I	III	II	I	III	I	.	.
<i>Cistus ladanifer</i>	.	.	I	II	V	IV	V	I	.	.
<i>Helichrysum stoechas</i>	.	.	.	.	III	II	I	I	.	.

Quercetea ilicis CS

Quercus suber	I	.	II	I	I	.	II	V	I	.
Arbutus unedo	I	.	I	II	IV	III	IV	II	.	.
Erica arborea	I	.	I	I	II	.	II	III	II	.
Daphne gnidium	II	.	II	II	.	.	II	IV	I	.
Scilla monophyllos	I	.	I	.	II	III	I	.	.	.
Carex depressa	IV	.	III	.	II	.	.	.	.	.
Crepis tingitana	II	.	II	I	.	.	.	.	.	.

CS: character species, DS: differential species

1: Stauracantho boivinii-Drosophylletum (Quezel *et al.*, 1988 Morocco; Deil, 1997a Spain and Morocco); 2: Stauracantho-Drosophylletum saturejetosum salzmanii (Galán de Mera & Vicente Orellana, 1996 Spain); 3: Genisto tridentis-Stauracanthetum (Rivas-Martínez, 1979 Spain; Galán de Mera & Vicente Orellana 1996 Spain; Deil, 1997a Spain and Morocco and own material); 4: Genisto tridentis-Stauracanthetum quercetosum lusitanicae (Pérez Latorre *et al.*, 1993 Spain; Galán de Mera & Vicente Orellana, 1996 Spain and own material); 5: Querco lusitanicae-Stauracanthetum (Malato Béliz, 1982 Portugal; Galán de Mera & Vicente Orellana 1996 Spain; Deil *et al.*, *in prep.* Portugal and own material); 6: [Drosophyllo]-Stauracanthenion basal community (own material) 7: Erico australis-Cistetum populifolii (Braun-Blanquet *et al.*, 1964 Portugal; Malato Béliz, 1982 Portugal; Pérez Latorre *et al.* 1993 Spain; Deil *et al.*, *in prep.* Portugal and own material); 8: Myrto-Quercetum suberis (Rivas-Martínez *et al.*, 1990 Portugal; Nieto Caldera *et al.*, 1990 Spain; Pérez Latorre *et al.*, 1993 Spain and own material); 9: Ulici minoris-Ericetum umbellatae (Braun-Blanquet *et al.*, 1964 Portugal); 10: Erico umbellatae-Ulicetum micranthi (Braun-Blanquet *et al.*, 1964 Portugal)

Table 3. Sociology of *Drosophyllum lusitanicum* in the South-western Iberian Peninsula and in Northwest Morocco (constancy table, reduced to frequent and diagnostic species)

be used as a differentiating character of adult versus juvenile plants. On average, the proportion of juvenile plants is about 20% in Portuguese as well as in Spanish populations (fig. 8). We can however state an enormous variability of the rate of juveniles from one population to the other. Some populations in Portuguese cork-oak forests are nearly without any juvenile plants (populations 2 and 8). They must be interpreted as over-aged. Population 4 is too small to be significant. A very low rate of non-lignified specimens was further stated in the mass population (> 8000 individuals) near Picacho summit in Spain. This population has re-established itself after a fire event. It has a strong cohort structure and nearly the whole cohort is already in the lignified stage. Since this event, new seedling establishment seems to be extremely rare.

In both study areas, *Drosophyllum*

lusitanicum flowers from April to July. Most of the rosettes develop one, seldom two, flowering shoots. The flowering rate ranges between 13 and 96%, depending on the habitat and the age, as determined by the size-structure (height, rosette diameter, lignification) of the population (fig. 4 and 5). With increasing plant size, the flowering rate increases (tab. 5). In the cork-oak woodlands and in the tall-growing *Erica australis*-heathlands, the flowering rate was constant during the observation period from April to June, in open *Erica umbellata*-heathland it increased with a flowering peak end of June.

Ortega Olivencia *et al.* (1995) stated that seed number per fruit is quite a constant parameter throughout the populations in Spain. We counted 3839 seeds (397 fruits) in Portuguese and 1155 seeds (81 fruits) in Spanish populations and can confirm the

	2	3	8	4	9	1	10	7	11
3	ns								
8	**	ns							
4	***	*	**						
9	***	*	***	***					
1	***	***	***	***	ns				
10	***	***	***	***	ns	ns			
7	ns	ns	**	***	**	***	***		
11	***	***	***	***	ns	ns	ns	***	
6	***	***	ns	***	ns	ns	ns	**	ns

ns = not significant, * = $p < 0,05$, ** = $p < 0,01$, *** = $p < 0,001$ (Mann-Whitney-U-test)

Table 4. Significance test of the parameter “rosette diameter” related to populations in Portugal.

constant number within the populations of both study areas. There is however a significant difference ($p < 0,001$, Mann-Whitney U-test) between both study areas with about 10 seeds per fruit in Portugal and 14 in Spain. Because of its constancy, seed number per fruit is not a suitable character to measure vitality.

The observations about seedling density and seedling patterns are very preliminary; data about seedling survival rates in the field are still missing. Most of the seedlings have been observed on open sites with shallow soils and without any litter. Within those habitats, seedlings are mostly established in the shadow of dwarf shrubs, which seem to offer safe sites for seedling survival. In cork-oak woodlands, seedlings are very rare and appear only in places where the humus layer is disturbed by animal activity or by ploughing.

The generative strategy of *Drosophyllum lusitanicum* is supported by vegetative sprouting. In *Quercus suber*-forests we observed a few specimens with long superficial creeping shoots (up to 40cm). These shoots are able to develop adventitious roots and daughter rosettes.

DISCUSSION AND CONCLUSIONS

Drosophyllum lusitanicum occurs in several acidophilous heathland communities

in the southwestern part of the Iberian Peninsula and in northwestern Morocco. The species is most frequent in low growing and open heathland and can – in accordance with Rivas-Martínez (1979) – in a broader sense be evaluated as a character species of *Ericion umbellatae*. The highest densities and the most numerous populations occur in the *Drosophyllo-Stauracanthetum* where this heathland is original: wind exposed mountain ridges in the mesomediterranean belt and stony/loamy slopes in the thermo- and mesomediterranean belts. In both situations, periodical fire is an intrinsic factor of the ecosystem. The community can expand to less shallow soils, favoured by a higher, man-made fire-frequency and by clearing of the forests.

Beside *Drosophyllum lusitanicum*, other heliophilous dwarf shrubs, which are endemic in the southwestern Mediterranean and must have evolved in an open heathland of *Ericion umbellatae*-type, are *Nothobartsia aspera* (Galán de Mera *et al.*, 1996) and *Teucrium salviastrum* ssp. *rubriflorum* (Deil, 1997b). These dwarf shrubs can also exist under a very open *Quercus suber* tree layer. In the Sierras del Campo de Gibraltar, sometimes native *Pinus pinaster* populations grow within this vegetation (Pérez Latorre *et al.*, 1999). *Drosophyllum* occurs with low frequency and low individual numbers in open cork-oak forests on shallow rocky soil in the

thermomediterranean bioclimate (*Myrto-Quercetum suberis*). This is not obvious in so far as Pérez Latorre *et al.* (1993) placed the *Stauracantho-Drosophylletum* in the *Teucrio-Querceto suberis* S. series. Nieto *et al.* (1990) did not mention *Drosophyllum lusitanicum* in Spanish *Myrto-Quercetum suberis*-communities.

Drosophyllum lusitanicum can be considered as a potentially endangered species. It occurs in isolated populations and often in small individual numbers. In Spain, most of the populations are situated within the Natural Park "Los Alcornocales" and their protection status is sufficient. In the Serra de Monchique, there exists not a single nature reserve at the moment. Apart from the extremely rare *Rhododendron*-ravines, the most interesting places in the Serra from the botanical point of view are some mountain ridges in the schistous part of the Serra with *Quercus-Stauracanthetum* and its endemics *Centaurea crocata* and *C. fraylensis* and some rocky outcrops in the central syenite area. In the latter sites, *Drosophyllum* occurs in a vegetation complex with some other communities like *Halimio calycinii-Ericetum australis rosmarinetosum* ined., *Sileno melliferae-Ranunculetum bupleuroidis* ined., *Osyrio quadripartitae-Juniperetum turbinatae*, *Laurentio-Juncetum*, *Isoeto histricis-Radioletum linoidis*, *Loto subbiflori-Chaetopogonetum fasciculati*, *Arenaria conimbricensis-Sedum andegavense*-community etc. (Rudner *et al.*, 1999). These sites should be protected from *Eucalyptus*-plantations, changes to the hydrological system and from the direct destruction by syenite exploitation.

Open soil seems to facilitate the establishment and the regeneration of *Drosophyllum*. Opening of the plant canopy can either occur by human or animal activities or be induced by natural disturbance (erosion, fire). The species has a certain pioneer character. It can recolonize burned sites,

terraced slopes and disturbed roadsides. Its strategy reacting to disturbance is that of a re-seeder (Ojeda *et al.*, 1996b). This is supported by the fact that autogamy is prevailing (Ortega Olivencia *et al.*, 1995). Autogamy is widespread in species with a pioneer character at extreme habitats.

The current land-use trends can affect the populations in different and contradicting ways. A diminishing anthropo-zoogenic disturbance in oak forests will reduce the germination niches, but favour the life span and the vegetative regeneration. The abandonment of the traditional pasture use and the burning management of secondary *Ericion umbellatae*-heathland in Spain and Portugal will allow the regrowth of dense *Erica australis*-heathland and of the tall-growing *Phillyreo-Arbutetum* and *Cytiso-Arbutetum*-Maquis. This will reduce the area of the *Drosophyllo-Stauracanthetum* to its original sites. The effect of land-use in Morocco is opposite of that in Portugal and Spain. In Morocco, the populations of endemic *Ericion umbellatae*-heathland taxa are threatened by a very high fire frequency and by an ongoing rotating cultivation even on steep slopes.

To define age-states, Holderegger (1997) recommends using only vegetative parameters. The vegetative parameters "plant height" and "rosette diameter" are almost always significantly correlated with each other. They permit a description of the population structure and can be interpreted as age-states or life-states (Barkham, 1980; Holderegger, 1997). In most species, reproductive capability, growth and survival probability are strongly correlated with their size respective their age-states (Werner & Caswell, 1977; Silvertown *et al.*, 1993). The older an individual is, the more rosettes, flowers and seeds does it produce. Big individuals should be older and will have a higher reproductive capability. When low sizes dominate, the populations can be interpreted as young. This is the case for

Portugal population		rosette diameter	sum of individuals in every height class	Spain population		rosette diameter	sum of individuals in every height class
total				total			
height	0,704**	n = 505		height	0,710**	n = 194	
proportion of flowering individuals	0,863**	n = 61		proportion of flowering individuals	0,924**	n = 38	
proportion of non-lignified individuals	-0,689**	n = 61		proportion of non-lignified individuals	-0,809**	n = 38	
cork-oak woodlands				El Picacho 1			
height	0,549**	n = 178		height	0,379**	n = 50	
proportion of flowering individuals	0,802**	n = 47		proportion of flowering individuals	0,682**	n = 22	
proportion of non-lignified individuals	-0,604**	n = 47		proportion of non-lignified individuals	-0,693**	n = 22	
Barranco do Bufo				El Picacho 2			
height	0,814**	n = 16		height	0,521**	n = 50	
proportion of flowering individuals	0,725*	n = 9		proportion of flowering individuals	0,585*	n = 18	
proportion of non-lignified individuals	-0,730*	n = 9					
Casais				Puerto de Gáliz 1			
height	0,307**	n = 74		height	0,901**	n = 16	
proportion of flowering individuals	0,613**	n = 21		proportion of flowering individuals	0,857**	n = 12	
proportion of non-lignified individuals	-0,354n.s.	n = 23		proportion of non-lignified individuals	-0,819**	n = 12	
Casais South				Puerto de Gáliz 3			
height	0,676**	n = 29		height	0,785**	n = 49	
proportion of flowering individuals	0,806**	n = 19		proportion of flowering individuals	0,595*	n = 12	
proportion of non-lignified individuals	-0,707**	n = 19		proportion of non-lignified individuals	-0,778**	n = 25	
Cerro da Malhada Velha				Sierra de Ojen 2			
height	0,170n.s.	n = 74		height	0,796**	n = 20	
proportion of flowering individuals	0,498**	n = 37		proportion of flowering individuals			
proportion of non-lignified individuals				proportion of non-lignified individuals			
Cimalhas							
height	0,973**	n = 7					
proportion of flowering individuals	0,828*	n = 6					
proportion of non-lignified individuals	-0,828*	n = 6					
Eira do Bufo							
height	0,692**	n = 75					
proportion of flowering individuals	0,862**	n = 38					
proportion of non-lignified individuals	-0,694**	n = 38					
Fornalha							
height	0,421**	n = 75					
proportion of flowering individuals	0,742**	n = 36					
proportion of non-lignified individuals	-0,450**	n = 36					
Mesquita							
height	0,903**	n = 75					
proportion of flowering individuals	0,860**	n = 23					
proportion of non-lignified individuals	-0,758**	n = 23					
Padescas							
height	0,844**	n = 73					
proportion of flowering individuals	0,649**	n = 24					
proportion of non-lignified individuals	-0,682**	n = 24					

Table 5. Correlations between vegetative and generative parameters in 14 populations of *Drosophyllum lusitanicum* (rosette diameter – height; height – flowering rate, height – rate of non-lignified individuals)(Spearman's correlation coefficient r_s ; n.s. = not significant, * = $p < 0,05$, ** = $p < 0,01$, . = no data available)

Drosophyllum lusitanicum populations in open habitats. This interpretation is supported by the flowering behaviour which is significantly correlated with height and lignification. In a further research study it would be an interesting question whether the differences between Portuguese and Spanish populations, for example the different seed numbers per fruit, are phenotypic modifications or are based upon a genetic separation. In a gardening experiment, the correlation between age, lignification, basal shoot diameter, plant height and rosette diameter should be investigated in a planted population to get better data about the age structure of the field populations.

Following the age-state-concept, the populations in *Myrto-Quercetum* and in *Erico australis-Cistetum populifolii* are over-aged. A further reason for the occurrence of large and rich flowering plants in cork-oak woodland could be the better nutritional situation at those sites. Seedling survival should be better than in open heathlands because nutrient supply from the soil or from prey capture favour germination and seedling survival (Garrido Díaz & Ortiz Herrera, 1996). Seed rain should be sufficient in cork-oak forest populations of *Drosophyllum* but hard data are still missing. The insufficient regeneration might be due to the rarity of germination niches. The continuous litter and the undisturbed soil might be responsible for the over-aging of those populations. The low generative regeneration in *Quercus suber*-forests is, to some extent, compensated by vegetative regeneration. Further studies should include investigations about germination and seedling establishment under field conditions. Especially, the influence of chamaephytes and litter for the germination should be a topic in further research.

For the moment it is unknown to what extent *Drosophyllum lusitanicum* is able to tolerate or recover from heavy disturbances like terracing for *Eucalyptus*-plantations or after forest harvesting. *Drosophyllum* is

nautochoric and its seeds can be transported by runoff. Exact data about other dispersal agents (ants ?), the dispersal efficiency and distance are missing. We also do not know whether it performs a transient or permanent seed bank.

SYNTAXONOMICAL CONSPECTUS

QUERCETEA ILICIS Br.-Bl. ex A. & O. Bolòs 1950 + *Quercetalia ilicis* Br.-Bl. ex Molinier 1934 em. Rivas-Martínez 1975

* *Quercus rotundifoliae-Oleion sylvestris* Barbero, Quézel & Rivas-Martínez in Rivas-Martínez, Costa & Izco 1986

Teucro baetici-Quercetum suberis Rivas-Martínez ex Díez Garretas, Cuenca & Asensi 1988 [dense cork-oak woodland, in subhumid, humid and hyperhumid climate, mainly on sandy soils, typical for the Aljibico sector]

Myrto communis-Quercetum suberis Barbéro, Quézel & Rivas-Martínez 1981 [silicicolous cork-oak woodland with south-west Ibero-Atlantic distribution, thermomediterranean, subhumid-humid bioclimate]

Rusco hypophylli-Quercetum canariensis Rivas-Martínez 1975 [silicicolous cork-oak woodland, thermo- and mesomediterranean, humid and hyperhumid bioclimate, Aljibico sector]

* *Quercion broteroi* Br.-Bl., Pinto da Silva & Rozeira 1956 em. Rivas-Martínez 1975 corr. V. Fuente 1986
Sanguisorbo hybridae-Quercetum suberis Rivas Goday 1959 em. Rivas-Martínez 1975

typicum [mesomediterranean cork-oak woodland, subhumid-humid bioclimate, west-Iberian distribution]

quercetosum canariensis Rivas-Martínez, Lousa, Díaz, Fernández González & Costa 1990 [mesomediterranean cork-oak woodland with *Quercus canariensis*]

+ *Pistacio lentisci-Rhamnetalia alaterni* Rivas-Martínez 1975

* *Juniperion turbinatae* Rivas-Martínez 1975 corr. 1987

Osyrio quadripartitae-Juniperetum turbinatae (Rivas-Martínez 1975) Rivas-Martínez, Lousa, Díaz, Fernández-González & Costa 1990 [thermomediterranean shrubland in coastal areas of the Gaditano-Onubo-Monchiquense-Sadense sectors]

* *Ericion arboreae* Rivas-Martínez (1975) 1987

Phillyreo angustifoliae-Arbutetum unedonis Rivas Goday & F. Galiano in Rivas Goday & cols. 1959 [thermo-mesomediterranean *Arbutus unedo*-shrub in the south-western Iberian Peninsula]

Cytiso baetici-Arbutetum unedonis Nieto Caldera, Pérez Latorre & Cabezudo 1990 [thermo-mesomediterranean *Arbutus unedo*-*Cytisus-Genista* shrub in the Aljibian sector]

CALLUNO-ULICETEA Br.-Bl. & R. Tx. ex Klika & Hadac 1944

+ Calluno-Ulicetalia (Quantin 1935) R. Tx. 1937 *em.* Rivas-Martínez 1979

* *Ericion umbellatae* Br.-Bl., Pinto da Silva, Rozeira & Fontes 1952 *ampl.* Rivas-Martínez 1979

- *Ericenion umbellatae* Rivas-Martínez 1979

Cisto salvifolii-Ulicetum minoris Br.-Bl., Pinto da Silva, Rozeira 1964 [endemic heathland in Portugal (Bajo Alentejano-Monchiquense subsector), humid to hyperhumid bioclimate]

- *Stauracanthion boivinii* Rivas-Martínez 1979

Quercus lusitanicae-Stauracanthetum boivinii Rothmaler 1954 *ex Malato Beliz* 1982 [low-growing heathland only on schists, degradation community of the *Myrto communis-Quercetum suberis*, endemic in Portugal, humid and hyperhumid bioclimate]

Genisto tridentis-Stauracanthetum boivinii Rivas-Martínez 1979

typicum [silicolous, low-growing heathland in the Aljibico sector]

quercetosum lusitanicae Pérez Latorre, Nieto Caldera & Cabezudo 1993 [subassociation with high frequency of *Quercus lusitanica* on deeper soils]

Stauracantho boivinii-Drosophylletum lusitanici Quézel, Barbero, Benabid, Loisel & Rivas-Martínez 1988 [open, low-growing, silicolous scrub on sandy soils, Aljibico and Tangerino sector]

saturejetosum salzmanii Galán de Mera & Vicente Orellana 1996 [differs by the high frequency of *Satureja salzmanii*, Aljibico sector]

Drosophyllo-[Stauracanthenion]-basal community [floristically impoverished Stauracanthenion-community on habitats which are heavily disturbed by man, mainly in the Monchiquense sector]

Erica umbellata-Cistus crispus-community Deil 1997 [fire-promoted heathland community in the Tangerino sector]

Halimium calycinum-Erica australis-Rosmarinus community [dwarf heathland on syenit outcrops in the Monchiquense sector, mesomediterranean, subhumid bioclimate, transitional association between the *Ericion umbellatae* and the *Ulici-Cistion*]

Silene mellifera-Ranunculus bupleuroides community [in crevices and between consolidated sandstone and syenit boulders, endemic in the Monchiquense sector, mesomediterranean, a dynamic transition from *Asplenietea* to *Calluno-Ulicetea*]

CISTO-LAVANDULETEA Br.-Bl. in Br.-Bl., Molinier & Wagner 1940

+ Lavanduletalia stoechadis Br.-Bl. in Br.-Bl., Molinier & Wagner 1940 *em.* Rivas-Martínez 1968

* *Ulici argentei-Cistion ladaniferi* Br.-Bl., Pinto da Silva & Rozeira 1964

Cisto ladaniferi-Ulicetum argentei Br.-Bl., Pinto da Silva & Rozeira 1964 *em.* Rivas-Martínez 1979

[thermo- and mesomediterranean *Cistus*-shrubland with Mediterranean and Ibero-Atlantic distribution]

Genisto hirsutae-Cistetum ladaniferi Rivas Goday 1954 *em.* Rivas-Martínez 1979 [*Cistus*-shrubland on relatively nutrition-rich, siliceous soils, Luso-Extremadurese province]

Erico australis-Cistetum populifolii Rivas Goday 1954 [Bajo-Alentejano-Monchiquense sectors, mesomediterranean, subhumid bioclimate, transitional association between the *Cisto-Lavanduletea* and the *Calluno-Ulicetea*]

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