

Distribution, ecology, and population structure of *Senecio lopezii* (Asteraceae) in the Serra de Monchique (SW Portugal)

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Herrn Kollegen Dietmar Brandes mit den besten Wünschen zum 60. Geburtstag und mit herzlichem Dank für das mediterrane Ambiente bei den Braunschweiger Geobotanischen Kolloquien.

Abstract

The Serra de Monchique, a mountain chain in the hinterland of the Algarve Province, is characterized by a remarkable degree of floristic richness and endemism. *Senecio lopezii*, a tall-growing hemicyptophyte, is one of these endemic plants. We studied the local distribution, the ecological requirements, and the size and vitality of the populations in order to evaluate the vulnerability of this species with regard to disturbance by man and landuse changes. Between April and June 2001, populations observed in an area of 84 km² (= the central part of the Serra) were analysed in detail by non-destructive methods. A synopsis of the phytosociology and ecology of the species, based on literature including the Spanish populations in the Campo de Gibraltar (SW Andalusia), is presented.

Senecio lopezii was discovered in the Serra de Monchique at only 5 localities, all in mid altitude (500 to 600 m a. s. l.) in the mesomediterranean bioclimatic belt on the northwestern, windward side of the Serra. The species is associated with the *Sanguisorbo-Quercetum suberis quercetosum canariensis* and its shaded fringes. It persists in *Castanea sativa* coppices, cultivated on sites with semi-deciduous oak forests as climax, when the topsoil remains intact.

Population size ranges from 30 to 350 individuals, the total number is 920 specimens. Plant size and phenological stage were recorded for 258 individuals. Most of them (89 %) are sterile adults, which persist in dark conditions under a closed tree canopy. Flowering starts at a specific plant size and increases with growing rosette diameter, respectively, increasing number of leaves. To get information about the age structure, the life cycle, the role of the seed bank, and the effect of clearings of the shrub layer, further investigations are necessary.

Senecio lopezii is a rare species as regards distribution, habitat specification and population size. It must be considered as a potentially endangered species, because it will not tolerate the transformation of oak forests into *Eucalyptus* plantations.

1. Introduction

MELENDO et al. (2003) compared life forms, the reproductive syndromes and the ecology of the vascular plants which are endemic in the south of the Iberian Peninsula with the characters of the overall flora of this area. They stated that perennial herbs, restricted to mountainous areas, are overrepresented among the endemics. From the fact that most of the endemics are not specialized in pollination and dispersal mode, they conclude that a specialized habitat requirement is the main factor explaining that these species are restricted to a small area.

Senecio lopezii Boiss. (= *S. gibraltarius* Rouy = *S. grandiflorus* Hoffms. & Link non Bergius) is a species that fits into this scheme. It is an insect-pollinated hemicryptophyte with wind dispersal, endemic in mountainous areas. The distribution is disjunct, with a western areal in the mountain chain bordering the northern Algarve and the southern Alentejo Provinces (SW Portugal), and an eastern occurrence in the provinces Cádiz and Málaga in SW Spain. Most of the Portuguese populations are recorded from the Serra de Monchique (MALATO BÉLIZ 1982, SENG & DEIL 1999), most of the Spanish ones from the Aljibe Mountains and the Sierra del Niño near Tarifa (ARROYO et al. 1983).

Because of its restricted distribution, *Senecio lopezii* is listed by IUCN as vulnerable and as one of the target species for the implementation of a Pan European Ecological Network (OZINGA & SCHAMINÉE 2005). Detailed information about the distribution and size of the populations however is missing. A first aim of our study was therefore to get more information about the exact locations of the populations of *Senecio lopezii* in the Serra de Monchique and about the number of individuals growing there. Another objective was to analyse the vitality and life stages (seedlings, juveniles, sterile adults, fertile adults) of the species in relation to environmental conditions.

Besides size, age structure and fecundity of the populations, the habitat specificity of a species is an important parameter to evaluate its vulnerability and its sensitivity towards disturbance and landuse changes. During the last few decades, dramatic land-use changes occurred in the Serra de Monchique (KROHMER & DEIL 2003). Self-sustaining agriculture - applying the traditional shifting cultivation with a rotation system between dry farming and fallowland grazing - has almost disappeared. Cork exploitation is decreasing, the harvest of *Arbutus unedo* fruits is in decline. On the other hand, afforestation with *Eucalyptus globulus* on abandoned arable land and heathland has happened to such an extent, that MALATO BÉLIZ (1982) used the terms Eucalyptization and Eucalyptomania to characterise the trends of landuse.

In comparison to cork oak forests, *Eucalyptus* plantations are exhausting ground water resources. By the enormous litter production, which is decomposed only very slowly, these afforestations change the understorey vegetation (SENG & DEIL 1999). In order to evaluate the risk of this landscape transformation for *Senecio lopezii*, we

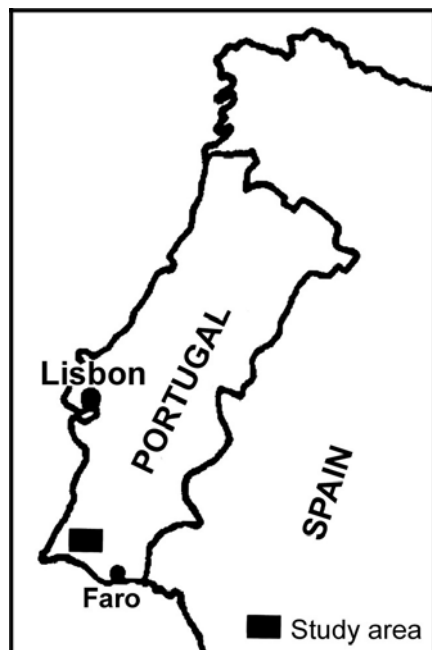
must have a closer look at the ecological requirements and the coenological value of this species.

In a data set of 155 relevés sampled by SENG & DEIL (1999) over the whole range of different forest types in the Serra de Monchique, *Senecio lopezii* was restricted to the most intact forests and to those growing in the most humid conditions of the Serra. It was totally missing in *Eucalyptus*-plantations, but occurred in *Castanea sativa*-coppices, which were planted on sites with *Quercus suber*-*Quercus canariensis*-vegetation as climax. A closed tree canopy does not seem to be a precondition for the occurrence of *Senecio lopezii*. CAPELO (1996) described from the Serra de Monchique the *Senecio lopezii*-*Cheirolophetum sempervirentis*, a plant community characterized by tall-growing hemicryptophytes, which colonize the shaded fringes of *Quercus suber* and *Q. canariensis* forests. An aim of our research was to study whether *Senecio lopezii* is restricted to humid forests as primary habitat, or if it is able to expand its areal under human impact.

Finally, the phytosociology and ecology of the species in the Serra de Monchique will be compared with the situation in the Spanish areal. This comparison is based upon a review of the available literature.

2. The study area

Location and abiotic conditions: The Serra de Monchique is situated in the hinterland of the Algarve coast (District of Faro) (Fig. 1). The area is dominated by two



mountain ridges, running from West southwest to East northeast (Fig. 2). The climate has a Mediterranean precipitation regime (see climatic graphs in Fig. 2, from ROCHA FARIA et al. 1981), with a certain Atlantic character. Due to the proximity to the Atlantic Ocean and the elevation, the amount of rainfall is considerably higher than in the rest of the Algarve region. The central summits Foia (902 m a. s. l.) and Picota (773 m a. s. l.) are responsible for a windward-leeward side effect with the northwestern slope being cooler and more humid than the southeastern one. The central part of the Serra, where most of the populations of *Senecio lopezii* occur, belongs to the humid to perhumid, mesomediterranean bioclimate (RIVAS-MARTÍNEZ et al. 1990).

Fig. 1: Location of the study area in Portugal.

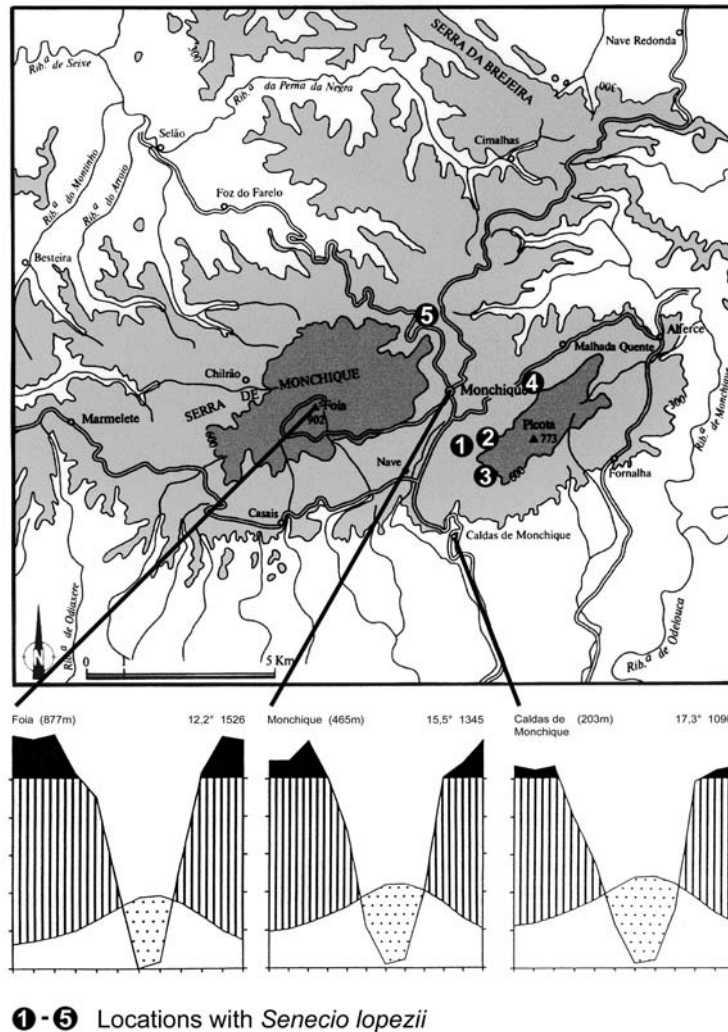


Fig. 2: Locations of the studied populations and climatic graphs of three stations in the Serra de Monchique (climatic data based on ROCHA FARIA et al. 1981).

The bedrock in this central part is a syenitic intrusion (Lakkolith), surrounded by paleozoic schists and graywakes. The weathering of the coarse-grained syenite results in cambisols with a sandy texture, a high water holding capacity and good base saturation (KOPP et al. 1989).

Phytogeography and climax vegetation: In all phytogeographical schemes of the Iberian Peninsula, the Serra de Monchique is considered as a separate unit, characterised by elements restricted to the Serra and its surroundings such as *Euphorbia paniculata* ssp. *monchiquensis*, *Centaurea fraylensis*, *Campanula alata* or by species which occur in the Serras of Southern Portugal and in the Sierras of the Campo de Gibraltar in Spain (COSTA et al. 1998). *Senecio lopesii* belongs to the latter group. It is one representative of a number of vascular plant species which support

the definition of the Gaditano-Onubo-Algarviense Province proposed by PEREZ LATORRE et al. (1996) and by GALÁN DE MERA & VICENTE ORELLANA (1996), including the Monchiquense- and the Aljibico-sector in this province.

The potential natural vegetation in the mesomediterranean belt is dense oak forests with ombrophilous species in the ground floor (*Sanguisorbo-Quercetum quercetosum suberis* in the humid parts, *Sanguisorbo-Quercetum quercetosum canariensis* and *Euphorbio monchiquensis-Quercetum canariensis* in the perhumid parts) (RIVAS-MARTÍNEZ et al. 1990). In small openings and along roadsides and footpaths crossing these forests, the mantle community *Lonicera periclymenum-Rubetum ulmifolii* and herbaceous fringes from the *Origanion virentis* alliance can be observed (CAPELO 1996, CAPELO et al. 2001). Forest clearing and frequent fire result in the *Phillyreo-Arbutetum unedonis* as a first degradation step, further degradation ends in heath-land communities with *Erica australis* and *Cistus populifolius*.

3. Methods

Field data were collected between April and June 2001. We restricted our observations to the Serra de Monchique (an overall area of 84 km²). Populations known from Alentejo and from Spain have not been investigated. We searched for *Senecio lopezii* in all kinds of habitats with preference to those, where the occurrence was documented by earlier studies (SENG & DEIL 1999): *Quercus suber*-forests, *Quercus suber*-*Q. canariensis*-forests and *Castanea sativa*-coppices, but also *Eucalyptus globulus*-afforestations. For all observed populations the following site descriptive parameters have been noted: geographical coordinates according to GPS-data, altitude, aspect, substrate, habitat type and plant community.

Numbers of individuals were counted on a standard plot size of 625 m². The total number of individuals of the population was then estimated from the area covered by the population. *Senecio lopezii* can spread vegetatively by short rhizomes. Subterranean parts were examined only on very few specimens. Rosettes with a distance < 15 cm were treated as one individual. Whether multiplication occurs by self-cloning is unknown.

In order to analyse the population structure of *Senecio lopezii*, vegetative and generative parameters related to vitality were measured for 258 individuals. For this rare species, the observations had to be restricted to non-destructive methods. A starting hypothesis was that there will be a correlation between the size of the basal leaf rosette and the age of the plant and a correlation between the size of the basal rosette, respectively, the photosynthetic active surface and the flowering rate. Therefore, the measured parameters were: number of leaves of the basal rosette, size of longest and largest leaves, rosette diameter and plant height (the latter parameter only

for flowering individuals). To gain information about the generative vitality, we determined the number of flowering individuals and the phenology, and we searched for seedlings and plantlings.

4. Results

4.1. Distribution in Portugal and Spain

Senecio lopezii grows in mountainous areas of mid altitude. It is recorded from forests with acid soils and with subhumid to humid mesomediterranean bioclimatic conditions. In Portugal, *Senecio lopezii* is restricted to the SW part of the country (Serra de Monchique, Serra de Silves, Ribeira de Odelouca, Serra da Vigia, Serra de S. Martinho das Amoreiras) (our own observations and personal communications by F. B. CALDAS and M. J. GONÇALVES PINTO, University of Lisbon). In Spain, it is endemic in SW Andalusia, in the Sierras del Campo de Gibraltar (Province Cádiz) and in the Sierra de la Nieves (Province Málaga).

Tab. 1: Abiotic and biotic data of the 5 populations of *Senecio lopezii*.

	altitude	exposition	inclination	GPS-Data	plant community	population size
1	570m a. s. l.	NW	30°	N 37° 18' 11 W 8° 33' 14	<i>Sanguisorbo-Quercetum quercetosum canariensis</i>	density: 19 individuals per 100m ² total: 120 individuals
2	485m a. s. l.	NW	30°	N 37° 18' 14 W 8° 33' 05	<i>Sanguisorbo-Quercetum quercetosum canariensis</i>	density: 34 individuals per 100m ² total: 250 individuals
3	520m a. s. l.	SW	20°	N 37° 17' 48 W 8° 32' 49	<i>Sanguisorbo-Quercetum quercetosum canariensis</i>	density: 21 individuals per 100m ² total: 150 individuals
4a	490m a. s. l.	NW	20°	N 37° 18' 49 W 8° 32' 35	<i>Castanea sativa</i> coppice	density: 19 individuals per 100m ²
4b	490m a. s. l.	NW	20°	N 37° 18' 49 W 8° 32' 35	<i>Sanguisorbo-Quercetum quercetosum canariensis</i>	density: 12 individuals per 100m ² total: 50 individuals
5	520m a. s. l.	NNW	30°	N 37° 19' 54 W 8° 33' 56	<i>Sanguisorbo-Quercetum quercetosum canariensis</i>	density: 51 individuals per 100m ² total: 350 individuals

4.2. Local distribution and population size in the Serra de Monchique

Senecio lopezii was discovered in the Serra de Monchique at only 5 localities. The sites are mapped in Fig. 2. Some characters of the observed populations like number and density of individuals, altitude, exposition, inclination and GPS-data are given in Tab. 1. Population size ranges from 30 to 350 individuals. The total number of individuals is 920.

Except for population No. 3, all the populations grow in northwestern expositions (Fig. 3). The altitude range is quite restricted (from 500 to 600 m a. s. l.). All the populations occur in the syenitic part of the Serra. *Senecio lopezii* is associated with the *Sanguisorbo-Quercetum quercetosum canariensis* and the replacing *Castanea sativa*-coppices (population No. 4a), and it occurs in the fringes of both forest types.

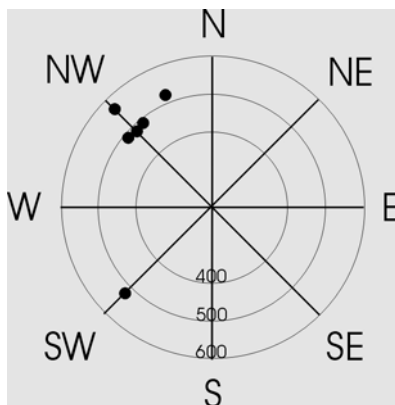


Fig. 3: Distribution of the sites with *Senecio lopezii* in relation to altitude and exposition.

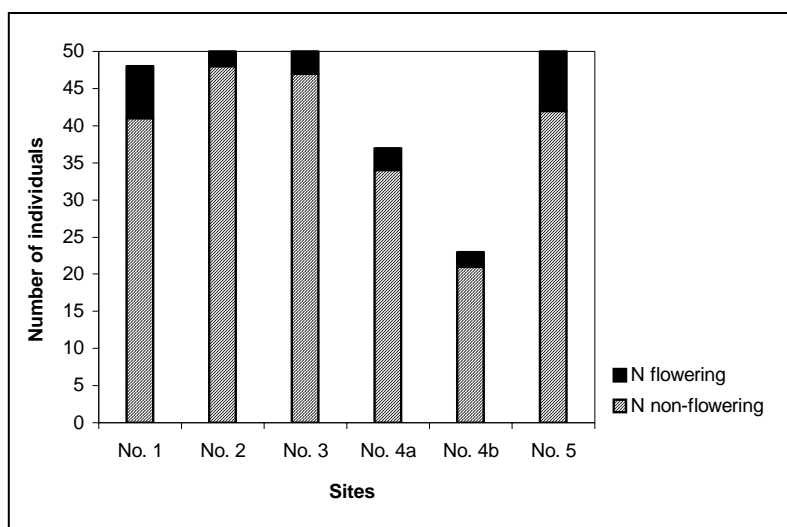


Fig. 4: Number of flowering and non-flowering individuals of *Senecio lopezii* at the particular sites.

4.2. Phenology, flowering rate and correlation with plant size

Senecio lopezii is a hemicryptophyte with a basal rosette. Only occasionally, individuals have two or three rosettes. During the flowering season in late spring, the plant develops a shoot of 100-120 cm height, culminating in a branched inflorescence with several capitula (mean number 7, maximal number 18). Only twice, we registered that

the second rosette of an individual had developed another flowering shoot. Not a single seedling was observed in spring 2001. Germination seems to start during the winter rain period. Juveniles could not be distinguished and are included in the class of sterile adults.

Fig. 4 shows the number of flowering and non-flowering individuals in the studied *Senecio*-populations. At all sites, sterile individuals predominate over fertile ones (mean frequency is 89 versus 11%). A relatively high flowering rate was found in populations No. 1 and 5. Both grow under an open tree layer. Sites 2 and 3 have a closed canopy with *Quercus canariensis*. The density of the species is quite high there, but nearly all the individuals remain in the vegetative phase. Generative reproduction seems to be restricted by insufficient light. *Senecio lopezii* can persist under dark conditions and reproduce by daughter-rosettes.

Another precondition for the transition from the vegetative to the generative stage is a minimum size of the basal rosette, i.e. the size of the photosynthetic active part of the plant. On average, *Senecio lopezii* forms a rosette of 7 leaves, though the number varies considerably (up to 20 leaves). Leaves have a mean length of 35 cm and a width of 5 cm.

According to our studies, the flowering probability depends on the number of leaves, respectively the diameter of the rosette. Both parameters are closely correlated. Only individuals with more than 5-10 leaves (Fig. 5) or a rosette > 40-50 cm in diameter (Fig. 6) were in flower. The low number of flowering individuals did not allow a statistical treatment of the data.

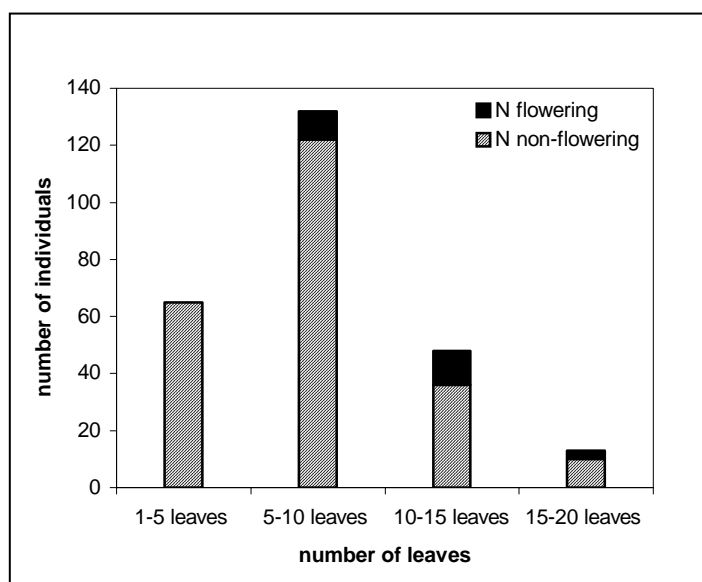


Fig. 5: Number of flowering individuals in correlation to leaf number.

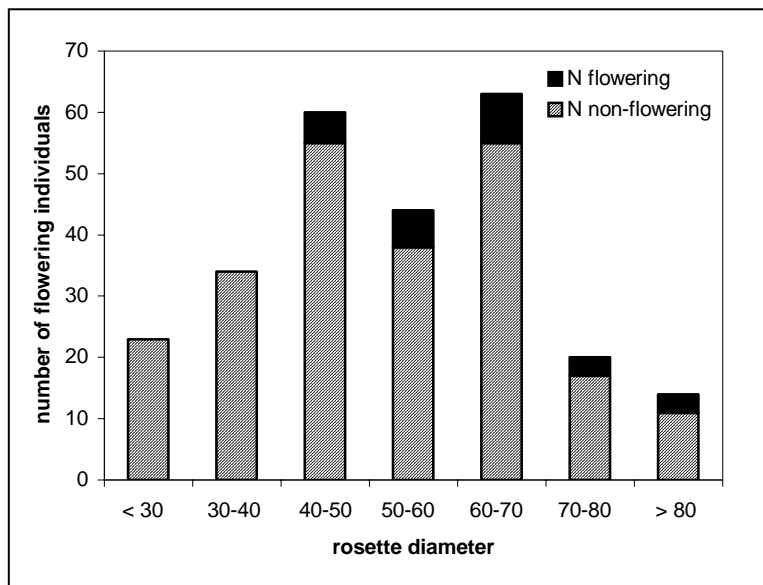


Fig. 6: Number of flowering individuals in correlation to rosette diameter (in cm).

5. Discussion

5.1. Ecology and phytosociology

In the Serra de Monchique, *Senecio lopezii* was recorded in 2001 only at five sites in the central syenite area and under the most humid bioclimatic conditions, on northern and western exposed slopes at mid altitude on the windward side of the Serra. According to MALATO BÉLIZ (1982), RIVAS-MARTÍNEZ et al. (1990), SENG & DEIL (1999) and to our field research, *Senecio lopezii* is restricted in the Serra de Monchique to closed forests with intact topsoil (*Sanguisorbo-Quercetum suberis quercetosum canariensis*) and to *Castanea sativa*-coppices planted on such sites. Also in the Aljibe Mountains in Spain, the species is classified by OJEDA et al. (2000) as an indicator of non-degraded stands of the forest community *Rusco-Quercetum canariensis*. It is considered by RIVAS-MARTÍNEZ et al. (2002), as a character species of deciduous oak forests (*Quercion broteroi*) in Southern Spain and Portugal. It further occurs in pure cork oak forests (*Teucrio scorodoniae-Quercetum suberis*) in the Campo de Gibraltar.

Under perhumid bioclimatic conditions, *Senecio lopezii* is not strictly a forest species. In the Serra de Monchique it can occur along the shaded fringes of *Quercus suber-Quercus canariensis* forests, together with other tall growing hemicryptophytes (*Cheirolophus sempervirens*, *Origanum virens*, *Digitalis purpurea*, *Stachys germanica* a. o.). These stands have been described as *Senecio lopezii-Cheirolo-*

phetum sempervirentis (CAPELO 1996, CAPELO et al. (2001). It is a community endemic in the Serra de Monchique (COSTA et al. 1998).

In the Spanish part of its distribution area *Senecio lopezii* can be found in heathland vegetation, dominated by the shrubby oak *Quercus lusitanica* or by Krummholz-forms of *Quercus pyrenaica*. This is the case on wind-exposed sandstone ridges of the Aljibe Mountains which receive a considerably amount of rainfall and are frequently covered by clouds. Some authors considered *Senecio lopezii* to be a character species of this habitat and even used it as name-giving taxon (*Senecio lopezii-Quercetum lusitanicae* sensu RIVAS-MARTÍNEZ et al. (2002) = *Quercus lusitanica-Ilex aquifolium* community sensu PEREZ LATORRE et al. (1996) = *Phillyreo angustifoliae-Quercetum lusitanicae ulicetosum borgiae* sensu CAPELO et al. (2002). In the Serra de Monchique, *Senecio lopezii* does not enter the heathland community on wind-exposed mountain ridges (*Centaureo crocatae-Quercetum lusitanicae*) (CAPELO et al. 2002, MÜLLER & DEIL 2002).

5.2. Reproductive and dispersal strategy

Concerning the life cycle of *Senecio lopezii* and the age structure of the populations, our non-destructive approach ends up with more open questions than with answers. With the sampled parameters, it was not possible to analyse the age structure of the populations. Conclusions about the age of the individuals from the architecture of the above-ground parts are possible for the nano-phanerophyte *Euphorbia paniculata* ssp. *monchiquensis* (FOX & DEIL 2004), but not for the hemicryptophyte *Senecio lopezii*. Without permanent plot data from the field, a garden experiment of the growth rate or a dendrochronological analysis of cross-sections of the subterranean parts (see SCHWEINGRUBER & POSCHLOD 2005 for other herbaceous plants) we do not know how close the correlations are between the age of a plant and the size of the basal rosette, respectively, the number of leaves. In a general way, the data support the hypothesis that flowering starts at a specific plant size and increases with growing rosette diameter, respectively, increasing number of leaves, corresponding to the amount of biomass. It is unknown whether the same individual can flower in consecutive years or whether a new accumulation of reserve material is starting after generative reproduction. Furthermore, observations over several winter periods are necessary to get information about the germination rate, seedling establishment and the transition from juveniles to the adult sterile life stage.

Also the effect of the PAR for the stimulation to flowering must be studied in the future. There is obviously a positive effect of an opening of the tree layer for the fertility of *Senecio lopezii*. This effect must be evaluated against an increasing risk of desiccation by clearing of the woody canopy or by clearing of the shrublayer before cork-harvesting.

Our observations point out a double strategy of the species. On the one hand, a more or less sterile population can persist in dark conditions. Short-range dispersal by rhizomes and slow vegetative reproduction ensures the survival of the population under undisturbed conditions. This is a sitler strategy. On the other hand, anemochory permits long-distance dispersal and recolonisation of suitable habitats after severe disturbance such as fire or clear-cutting.

Most of the forests where *Senecio lopezii* was recorded in the Serra de Monchique in 2001 have been damaged by a big fire in 2003. The sites should be revisited to study the effect for the plant populations. Also the role of the seed bank for reestablishment after fire has to be studied in the future.

5.3. Conservation aspects

Senecio lopezii is a rare species (see criteria in RABINOWITZ et al. 1986) as regards distribution, habitat specification and population size, and it must be considered as a potentially endangered species. It can withstand an exploitation of the cork oak (profiting from the understorey opening is probable) or a cultivation with *Castanea sativa* instead of deciduous oak trees. An expansion of the *Eucalyptus*-afforestations on these ancient forestry land types however would disturb the natural habitat severely and endanger the survival of the species. Until now, a nature reserve in the Serra de Monchique is still in a planning phase. It will be important to protect ancient land use types, as well as preserving forests stands close to the climax. In a management plan for the National Park “Sudoeste Alentejano e Costa vicentina”, *Senecio lopezii* is listed under the vulnerable species to be considered for protection of its habitats (Ministerio de Agricultura 2002).

Because of its high specificity for humid bioclimatic conditions and intact topsoil, *Senecio lopezii* will be restricted to the small areas in the Serra de Monchique which offer such conditions. The clumped pattern of occurrence makes the species vulnerable to biotic stress, for example to wild boars eating the below-ground parts. Damage by herbivorous insects is less probable, because it produces repellents: A screening of wild plants of the Iberian Peninsula for insecticidal activity resulted in the discovery of new agents for pest control. Like a number of other plants, extracts of the aerial parts of *Senecio lopezii* inhibit larvae growth of the test organism *Tribolium castaneum* (Coleoptera: Tenebrionidae) significantly (PASCUAL-VILLALOBOS & ROBLEDO 1998).

Zusammenfassung

Die Serra de Monchique, eine Bergkette im Hinterland der Algarve, besitzt eine bemerkenswerte floristische Diversität und eine beachtliche Endemitenrate. *Senecio lopezii*, ein hochwüchsiger Hemikryptophyt, ist einer dieser Endemiten. Wir untersuchten die lokale Verbreitung, die ökologischen Ansprüche und die Größe und Vitalität der Populationen, um abschätzen zu können, ob anthropogene Störungen und Landnutzungswandel eine Bedrohung darstellen. Zwischen April und Juni 2001 wurden alle Populationen, die wir in einem Gebiet von 84 km² (= dem zentralen Bereich der Serra) fanden, mit nicht-destruktiven Methoden genauer untersucht. Schliesslich wird die Pflanzensoziologie und Ökologie der Art in einer Übersicht dargestellt. Diese stützt sich auf eine Auswertung der Literatur, die auch die spanischen Vorkommen im Campo de Gibraltar (SW Andalusien) berücksichtigt.

Senecio lopezii wurde in der Serra de Monchique nur an 5 Lokalitäten gefunden, alle in mittlerer Höhenlage (500 to 600 m üNN.) in der mesomediterranen Höhenstufe und auf der nordwestlichen, der Luvseite der Serra. Die Art ist mit dem *Sanguisorbo-Quercetum suberis quercetosum canariensis* vergesellschaftet und tritt auch an den schattigen Rändern dieser halbimmergrünen Waldgesellschaft auf. Wenn der Oberboden intakt ist, kann sie auch in *Castanea sativa* Niederwäldern weiterexistieren, die an Stelle der natürlichen Waldgesellschaft gepflanzt wurden.

Die Populationsgröße variiert zwischen 30 und 350 Individuen. Insgesamt wurden 920 Pflanzen gezählt, bei 258 davon wurden Größe und phänologischer Zustand erfasst. 89% der Pflanzen sind sterile Rosetten, die im Unterwuchs geschlossener Wälder persistieren. Erst ab einer bestimmten Mindestgröße der Grundblattrosette bzw. einer Mindestanzahl von Blättern tritt die Art in die generative Phase ein. Um die Altersstruktur der Bestände, die Lebensdauer, die Rolle der Samenbank und die Auswirkungen einer Auflichtung durch Beseitigung des strauchigen Unterwuchses vor der Korkernte zu kennen, sind weitergehende Untersuchungen nötig.

Senecio lopezii ist eine seltene Art, sowohl was die Gesamtverbreitung als auch die Populationsgröße anbetrifft. Wegen ihrer sehr spezifischen Umweltansprüche (Bindung an naturnahe Eichenwaldgesellschaften) ist sie durch eine Umwandlung dieser Habitate in *Eucalyptus* Pflanzungen potenziell gefährdet.

Acknowledgements

Financial support by the German Research Foundation (DFG) is gratefully acknowledged (Az DE 402/3). We are indebted to Dr. Randy Cassada for linguistic corrections.

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Zeitschrift/Journal: [Braunschweiger Geobotanische Arbeiten](#)

Jahr/Year: 2008

Band/Volume: [9](#)

Autor(en)/Author(s): Hagemann Dorothee, Deil Ulrich

Artikel/Article: [Distribution, ecology, and population structure of *Senecio lopesii* \(Asteraceae\) in the Serra de Monchique \(SW Portugal\) 209-222](#)