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The genus *Huperzia* (Lycopodiaceae) in the Azores and Madeira

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The taxonomy and nomenclature of the genus *Huperzia* Bernh. in the Azores and Madeira have been reviewed. Plants collected in the Azores and Madeira were characterized morphologically. The independence between two endemic species common to Madeira and the Azores Islands – *Huperzia suberecta* (Lowe) Tardieu and *Huperzia dentata* (Herter) Holub – is clearly shown. A clear-cut morphological separation between these taxa and *Huperzia selago* (L.) Bernh. ex Schrank & Mart. of continental Europe is established. © 2008 The Linnean Society of London, *Botanical Journal of the Linnean Society*, 2008, **158**, 522–533.

ADDITIONAL KEYWORDS: bulbil – *Huperzia dentata* – *Huperzia selago* – *Huperzia suberecta* – nomenclature – spore – stoma – taxonomy.

INTRODUCTION

Lycopodiaceae P.Beauv. ex Mirb. *sensu lato* is a family with a cosmopolitan distribution, consisting of between 200 and 500 species according to Øllgaard (1987), although other authors, including Wagner & Beitel (1993+), recognised approximately 350–400 species. Some authors have proposed the division of the family, recognising the family Huperziaceae Rothm. (Salvo, 1990); however, most researchers support the maintenance of Lycopodiaceae *sensu lato* (Rothmaler, 1964, 1993; Villar, 1986; Øllgaard, 1987, 1992; Wagner & Beitel, 1992, 1993+).

With regard to the systematics of Lycopodiaceae, some North American flora specialists (Wagner & Beitel, 1992, 1993+) have considered many genera: *Phlegmariurus* Holub, *Huperzia* Bernh., *Lycopodium* L., *Diphasiastrum* Holub, *Palinhae* Vasc. & Franco, *Pseudolycopodiella* Holub and *Lycopodiella* Holub. Most authors have accepted this systematic treatment of Lycopodiaceae in Europe, including the genera *Huperzia*, *Lycopodium*, *Diphasiastrum* and *Lycopodiella* (Rothmaler, 1964, 1993; Villar, 1986). However, Øllgaard (1987) suggested a more synthetic treatment for the whole family, with *Huperzia*, *Lycopodium*, *Lycopodiella* and *Phylloglossum* Kunze.

The diversity of Lycopodiaceae in continental Europe (Rothmaler, 1993) is quite low when compared with the diversity described on other continents (Wagner & Beitel, 1992), or even when compared with other Holarctic regions, such as North America (Wagner & Beitel, 1993+) (Table 1). The diversity in the Macaronesian archipelagos is also low, and the highest value is found in the Azores and Madeira, the only areas in which plants of the genus *Huperzia* grow (Hansen & Sunding, 1993) (Table 1).

Plants of *Huperzia* with leaves without teeth in the margin (entire margin) are frequent in Madeira, where plants with these characteristics (Benl, 1971) were described by Lowe (1831) as *Lycopodium*

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Table 1. Diversity of Lycopodiaceae. Genus classification according to Wagner & Beitel (1992). Diversity (number of species per genus) and distribution according to Wagner & Beitel (1993+). Continental Europe (CE) diversity following Rothmaler (1964); Macaronesian diversity (Az, Md, Ca, Cv: number of species per genus in the Azores, Madeira, Canaries and Cape Verde, respectively) according to Hansen & Sunding (1993); North American (NA) diversity following Wagner & Beitel (1993+)

				Macaronesia				
Genus	Diversity	Distribution	CE	Az	Md	Ca	Cv	NA
Phlegmariurus	300	Tropical areas worldwide	0	0	0	0	0	1
Huperzia	10–15	Temperate, alpine and arctic regions, and tropical Asian mountains	1	1*	1*	0	0	7
Lycopodium	15–26	Mainly temperate and subarctic	3	0	0	0	0	6
Diphasiastrum	15–20	Mainly north temperate and subarctic	4	1	1	0	0	5
Lycopodiella	8–10	North temperate region and tropical America	1	1	1†	0		6
Palinhae	10–15	Mainly pantropical and subtropical	1	1	1	0	1‡	1
Pseudolycopodiella	12	Widespread	0	0	0	0	0	1
Phylloglossum	1	Australia, Tasmania and New Zealand	0	0	0	0	0	0

*Hansen & Sunding (1993) accepted the presence in the Azores and Madeira of only one species of the genus *Huperzia*, distinguishing two subspecies.
†Hansen & Sunding (1993) accepted the presence on Madeira of *Lycopodiella veigae*, despite the fact that other authors included this plant within the same species growing in the Azores: *L. inundata*.
‡Hansen & Sunding (1993) identified, on Cape Verde, one variety (*Palinhae cernua* var. *caboverdeana*) that differs from the typical form growing in the Azores and Madeira.

suberectum [= *Huperzia suberecta* (Lowe) Tardieu]. Conversely, these plants are less frequent in the Azores. Nevertheless, Watson (1843, 1844, 1870) noted the existence of plants with these characteristics on the islands of Pico and Terceira; this author identified such plants as *Lycopodium selago* L. [= *Huperzia selago* (L.) Bernh. ex Schrank & Mart.], and this classification was accepted by Drouet (1866) and Trelease (1897). This same treatment was accepted by more recent authors, such as Rothmaler (1964), Franco (1971), Jalas & Suominen (1972), Wilmanns & Rasbach (1973), Ormonde & Fernandes (1980a) and Rothmaler (1993). In the same way, Benl (1971), Ormonde (1990), Salvo (1990) and Hansen & Sunding (1993) identified as *H. selago* the plants of the Azores and Madeira with leaves with entire margin.

Baker (1887) proposed that such plants leaves with entire margins in Madeira and the Azores should be identified as *L. suberectum*. However, this author believes that *L. suberectum* should be systematized as a variety of *L. selago*; this systematic treatment was formalized by Trelease (1897) and accepted by de Menezes (1914).

Moreover, plants of the genus *Huperzia* with a denticulate margin are extremely rare on Madeira (two known locations; R. Jardim, Jardim Botânico da Madeira, pers. comm.), but are common in the Azores. Many authors (Seubert & Hochstetter, 1843; Watson, 1843, 1844, 1870; Seubert, 1844; Drouet, 1866; Trelease, 1897) mistakenly identified the Azorean plants with such characteristics as '*L. suberectum* Lowe'.

Later, Herter (1909) described the Azorean plants with denticulate margins as *Lycopodium dentatum* [= *Huperzia dentata* (Herter) Holub] [= *H. selago* subsp. *dentata* (Herter) Valentine]; this latter treatment was accepted by Rothmaler (1964) and Palhinha (1966), although Palhinha was unsure of the identity of *L. suberectum* and *L. dentatum*.

Benl (1971) proposed that the name *L. suberectum* should be applied to Azorean and Madeiran plants of the genus *Huperzia* with entire margins. As a result, many authors (Jalas & Suominen, 1972; Sjögren, 1973, 1979; Wilmanns & Rasbach, 1973; Ormonde & Fernandes, 1980b; Ormonde, 1990; Hansen & Sunding, 1993; Rothmaler, 1993) identified them as *H. dentata* plants with denticulate margins. However, other authors (Vasconcellos & Franco, 1967; Franco, 1971; Salvo, 1990) continue to accept the synonymy of *L. suberectum* and *L. dentatum*, and therefore Azorean plants with denticulate margins are identified as *H. suberecta*.

Not all authors agree about the presence in the Azores and Madeira of two different taxa in the genus *Huperzia*; in this regard, Ward (1970) doubted this taxonomic segregation on the grounds that the shape of the leaf margin was highly variable.

Finally, Schäfer (2001, 2002, 2003) and Silva *et al.* (2005) systematized the Azorean and Madeiran plants

of the genus *Huperzia* into two different species: plants with denticulate margins were identified as *H. dentata* and plants with entire margins were identified as *H. suberecta*. The same treatment was applied (Press & Short, 1994; Costa *et al.*, 2004) to Madeiran plants.

Thus, it can be deduced that the current systematic treatment of the genus *Huperzia* in the Azores and Madeira is still not based on precise criteria, and their systematic nomenclature and chorology remain unclear and imprecise. This article attempts to clarify both the systematics and nomenclature of plants of the genus *Huperzia* in the Azores and Madeira through a comparative morphological study of plants collected in both archipelagos and in continental Europe.

MATERIAL AND METHODS

Leaves, bulbils and spores were extracted from plants of the genus *Huperzia* collected by the authors in the Azores and from preserved specimens in herbaria (MAD and FCO).

Morphological characters studied in this work were the presence/absence of bulbils, the shape of the leaf margins, the distribution of stomata in the epidermis of the leaves and the form and ornamentation of the spores.

Observation of the epidermis extracted from the leaves and cleaned with lactophenol was carried out using an optical microscope (OM). Using the methodology proposed by Wodehouse (1935) and observation by OM, the sizes of 30 spores collected from each sample were measured: the length of the polar axis (P) and the equatorial diameters (E_1 and E_2) were measured, and the ratio P/E_1 was calculated. For each sample, the arithmetic means of these three variables were calculated. An analysis of variance was performed (general univariant linear model) in order to establish whether there were significant differences for each of these variables between the three taxa considered. To perform this analysis, each sample was assigned to one of the three species considered (*H. selago*, *H. suberecta* and *H. dentata*), and this was the only fixed factor. In the case of statistically significant differences between the three taxa, a *post hoc* test (Duncan test) was carried out in order to evaluate these differences; all tests were conducted taking into account the value $\alpha = 0.05$.

The outline of the morphology of the spores was observed by OM. The external morphology and ornamentation of the spores were studied by scanning electron microscopy (SEM), with the treatment of the spores proposed by Bueno & de Llanos (1991) for pollen grains.

RESULTS

All the samples studied were perennial, terricolous, erect herbs which formed small, isolated tufts without horizontal stems. The stems had a circular cross-section and dichotomous branching. The leaves were monomorphic, triangular, wider at the base, to lanceolate, not in distinct ranks, and spreading-ascending (in shade) to appressed-ascending (in sun).

The leaves had entire margins in all samples from continental Europe, in two samples from the Azores (AZO 1 and AZO 2) and in all samples from Madeira, with the exception of MAD 3B (Table 2). Moreover, the margin of the leaf was denticulate in most samples from the Azores (AZO 3–7) and in a sample collected on Madeira (MAD 3A) (Table 2) (Fig. 1).

All samples having leaves with denticulate margins had stomata only on the underside (abaxial side); they were hypostomatic (Table 2) (Figs 1, 2). By contrast, all Madeiran and Azorean samples with leaves with entire margins, as well as all samples from continental Europe, had stomata on both the upper and lower sides (adaxial and abaxial sides): they were amphistomatic (Table 2) (Figs 3–6).

No sample from the Azores or Madeira with denticulate margin leaves produced bulbils. The presence of bulbils was detected in all Madeiran and Azorean samples with entire margin leaves and in most samples from continental Europe with the same characteristic (Table 2) (Fig. 7). Only two samples from Picos de Europa (ESP 2 and ESP 3) showed no such reproductive structures; in both cases, the plants were immature.

All samples had free, anisopolar, radially symmetrical, tetrahedral, trilete, medium-sized spores. The data obtained with OM are presented in Table 3. The analysis of variance showed significant differences to specific level in three of the four variables considered:

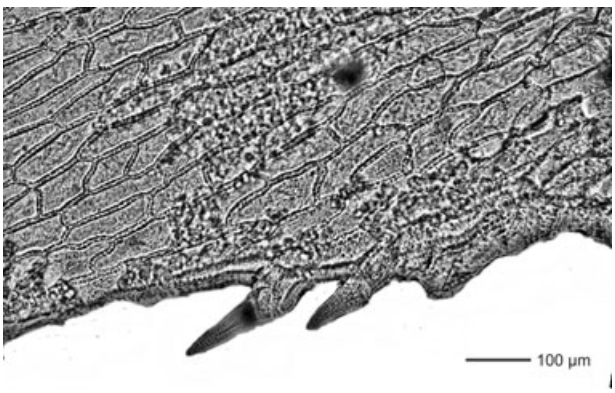

Figure 1. Epidermis of adaxial side, without stoma, of denticulate margin leaf of *Huperzia dentata* (sample AZO 4).

Table 2. Characterization of studied *Huperzia* samples: leaf margins, position of stomata, presence (+) or absence (–) of bulbils and ornamentation of spores (distal and proximal poles)

					Spore ornamentation	
Taxon	Sample	Leaf margins	Position of stomata	Bulbils	Distal pole	Proximal pole
H. dentata	AZO 3	Denticulate	Hypostomatic	–	Foveolate	Psilate
H. dentata	AZO 4	Denticulate	Hypostomatic	–		
H. dentata	AZO 5	Denticulate	Hypostomatic	–	Foveolate	Psilate
H. dentata	AZO 6	Denticulate	Hypostomatic	–	Foveolate	Psilate
H. dentata	AZO 7	Denticulate	Hypostomatic	–	Foveolate	Psilate
H. dentata	MAD 3A	Denticulate	Hypostomatic	–	Foveolate	Psilate
H. suberecta	AZO 1	Entire	Amphistomatic	+	Foveolate	Psilate
H. suberecta	AZO 2	Entire	Amphistomatic	+		
H. suberecta	MAD 1	Entire	Amphistomatic	+	Foveolate	Psilate
H. suberecta	MAD 2	Entire	Amphistomatic	+	Foveolate	Psilate
H. suberecta	MAD 3B	Entire	Amphistomatic	+	Foveolate	Psilate
H. suberecta	MAD 4	Entire	Amphistomatic	+	Foveolate	Psilate
H. suberecta	MAD 5	Entire	Amphistomatic	+		
H. suberecta	MAD 6	Entire	Amphistomatic	+		
H. suberecta	MAD 7	Entire	Amphistomatic	+		
H. suberecta	MAD 8	Entire	Amphistomatic	+		
H. suberecta	MAD 9	Entire	Amphistomatic	+		
H. suberecta	MAD 10	Entire	Amphistomatic	+		
H. suberecta	MAD 11	Entire	Amphistomatic	+		
H. suberecta	MAD 12	Entire	Amphistomatic	+		
H. suberecta	MAD 13	Entire	Amphistomatic	+		
H. selago	AND 1	Entire	Amphistomatic	+	Foveolate	Foveolate
H. selago	ESP 1	Entire	Amphistomatic	+	Foveolate	Foveolate
H. selago	ESP 2	Entire	Amphistomatic	–	Foveolate	Foveolate
H. selago	ESP 3	Entire	Amphistomatic	–		
H. selago	ESP 4	Entire	Amphistomatic	+	Foveolate	Foveolate
H. selago	ESP 5	Entire	Amphistomatic	+	Foveolate	Foveolate

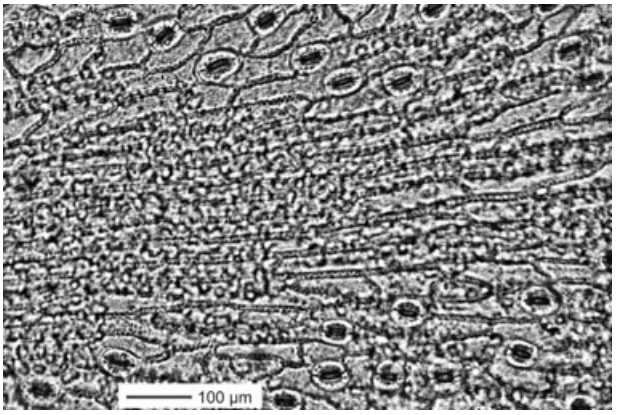

Figure 2. Epidermis of abaxial side, with stomata, of leaf of *Huperzia dentata* (sample AZO 4).

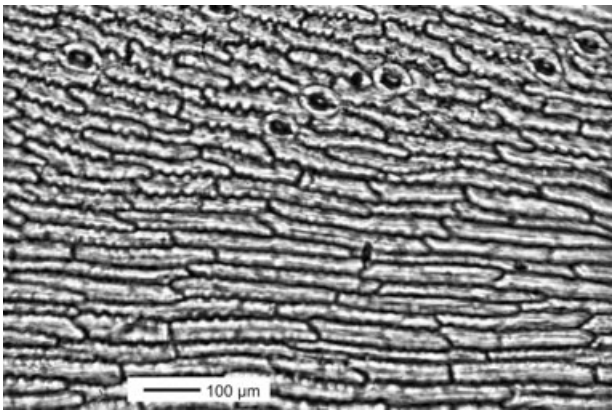

Figure 3. Epidermis of adaxial side, with stomata, of leaf of *Huperzia suberecta* (sample MAD 4).

length of the polar axis P ($F = 10.32$, $P < 0.01$), length of the equatorial diameter E_2 ($F = 11.03$, $P < 0.01$) and P/E_1 ratio ($F = 8.17$, $P < 0.01$). Differences in the equatorial diameter E_1 were not significant ($F = 3.42$, $P = 0.06$) (Fig. 8). The results of Duncan's test showed that, in *H. dentata*, the average values of the variables P and E_2 were significantly different from those of the spores of the other two species.

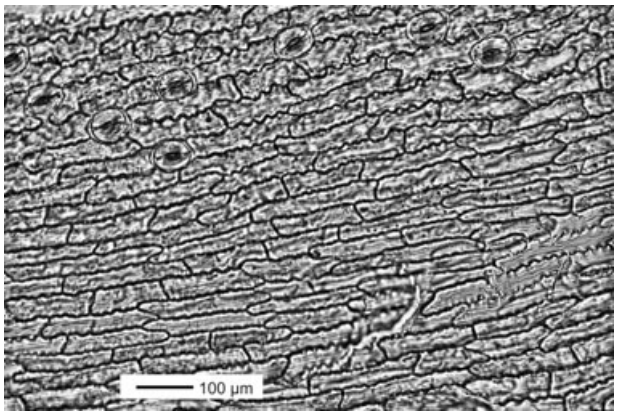

Figure 4. Epidermis of abaxial side, with stomata, of leaf of *Huperzia suberecta* (sample MAD 4).

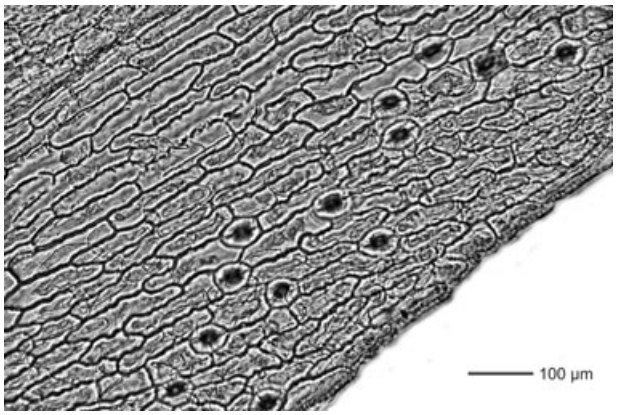

Figure 6. Epidermis of abaxial side, with stomata, of entire margin leaf of *Huperzia selago* (sample ESP 2).

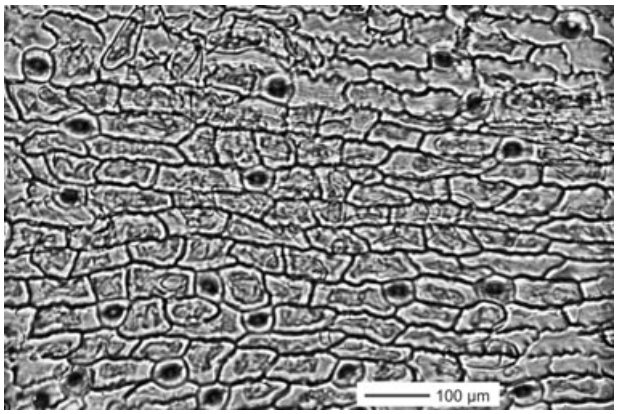

Figure 5. Epidermis of adaxial side, with stomata, of leaf of *Huperzia selago* (sample ESP 2).

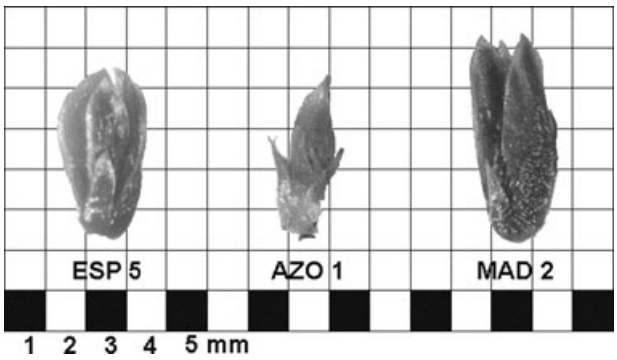

Figure 7. Bulbils of *Huperzia selago* (sample ESP 5) and *Huperzia suberecta* (samples AZO 1 and MAD 2).

Table 3. Size (µm) of spores: *Huperzia dentata* (samples AZO 3–7 and MAD 3A), *H. suberecta* (AZO 1–2, MAD 1–2, 3B and 5–8) and *H. selago* (AND 1 and ESP 1–5)

	Huperzia dentata	*Huperzia suberecta*	*Huperzia selago*
P	x = 28.75;	x = 32.29;	x = 31.43;
	I: (22.80) 26.34–31.73 (55.10)	*I*: (26.60) 29.57–35.79 (43.70)	*I*: (24.50) 28.46–33.86 (39.90)
E_1	x = 38.50;	x = 41.69;	x = 41.99;
	I: (32.40) 36.29–41.04 (47.50)	*I*: (28.00) 39.90–46.61 (51.30)	*I*: (34.20) 39.84–43.92 (49.40)
E_2	x = 35.84;	x = 38.04;	x = 39.85;
	I: (30.40) 33.63–38.86 (39.90)	*I*: (34.20) 36.29–40.47 (43.70)	*I*: (34.10) 36.57–43.16 (47.25)
P/E_1	x = 0.74;	x = 0.77;	x = 0.74;
	I: (0.56) 0.68–0.84 (1.00)	*I*: (0.58) 0.74–0.80 (0.90)	*I*: (0.57) 0.71–0.78 (0.90)

P, length of polar axis; E_1 and E_2, equatorial diameters; x, arithmetic average; I, interval: (absolute minimum value) minimum population average–maximum population average (absolute maximum value).

The spores of *H. suberecta* showed an intermediate value of the P/E_1 ratio in comparison with the values of the other two species studied (*H. dentata* and *H. selago*), which were markedly different from each other (Fig. 8).

In equatorial view with OM, the spores of samples with entire margin leaves [from both continental Europe (*H. selago*) and the Azores and Madeira (*H. suberecta*)] had a triangular outline with straight to concave sides and truncate angles (Figs 9, 10). By

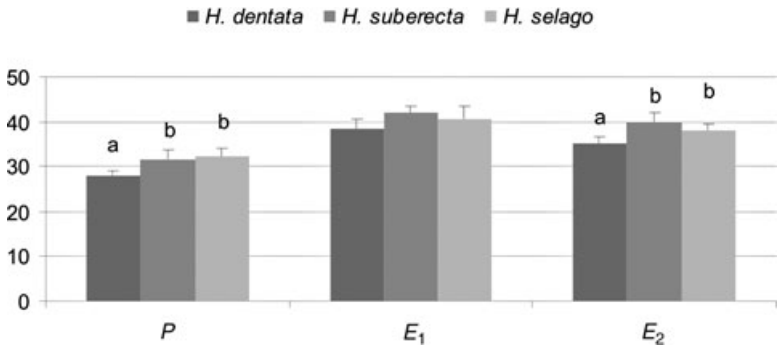

Figure 8. Average (μm) and standard deviation of the spore variables P (length of the polar axis), E_1 and E_2 (equatorial diameters), according to species. Different letters (a and b) indicate distinct subgroups, according to Duncan's test ($\alpha = 0.05$).

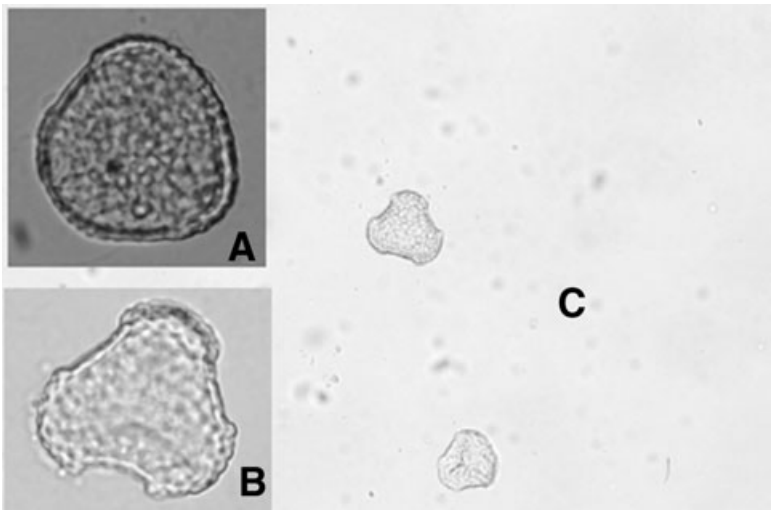

Figure 9. Spore morphology (optical microscope) of *Huperzia selago*: A, sample ESP 3; B, C, sample ESP 5.

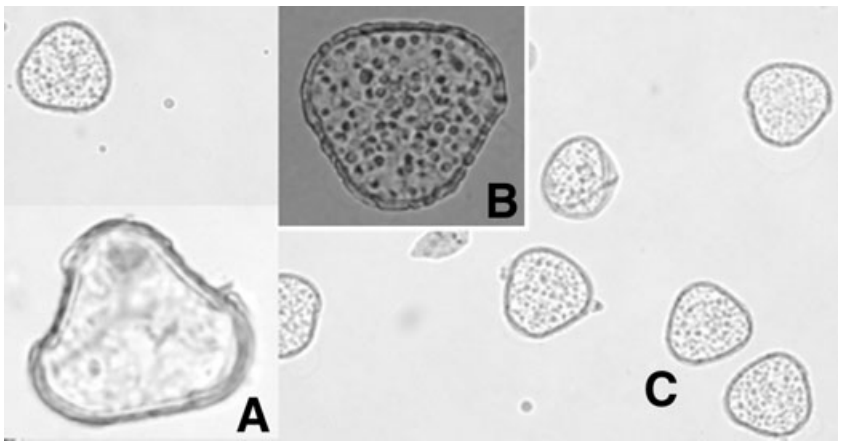

Figure 10. Spore morphology (optical microscope) of *Huperzia suberecta*: A, sample AZO 1; B, C, sample MAD 9.

contrast, samples with denticulate margin leaves (*H. dentata*) (collected in both Madeira and the Azores) had spores with a subtriangular outline, with straight to somewhat convex sides and rounded to angular angles (Fig. 11).

The observation of spores by SEM showed that those from all the samples from the Azores and Madeira, with either entire (*H. suberecta*) or denticulate (*H. dentata*) margin leaves, were irregularly foveolated on the distal face and psilate on the

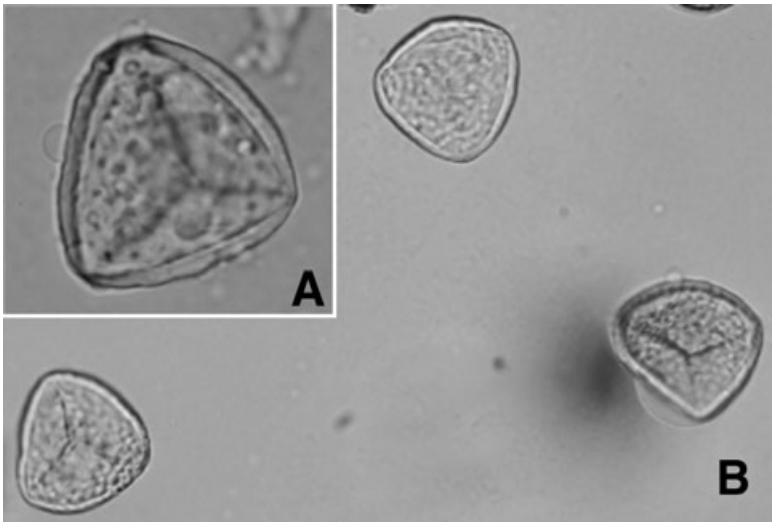

Figure 11. Spore morphology (optical microscope) of *Huperzia dentata*: A, sample AZO 6; B, sample AZO 7.

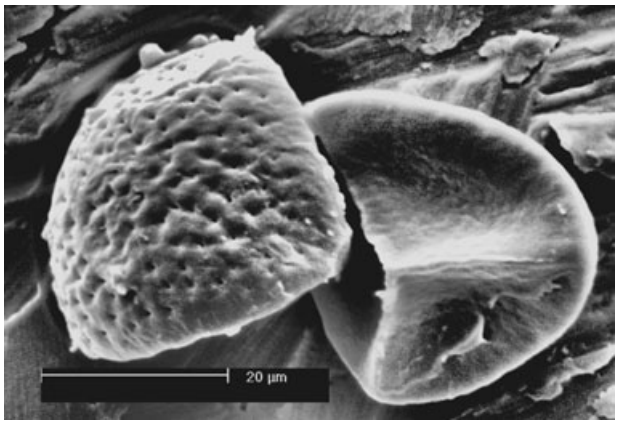

Figure 12. Spore morphology (scanning electron microscopy) of *Huperzia dentata* (sample AZO 5) showing proximal and distal poles.

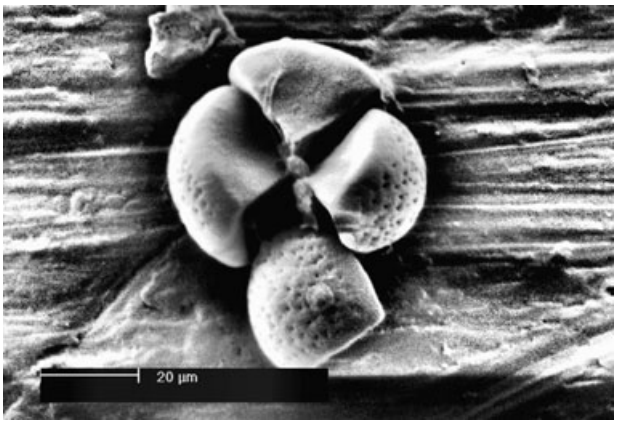

Figure 13. Spore tetrade morphology (scanning electron microscopy) of *Huperzia suberecta* (sample MAD 3B) showing proximal and distal poles.

faces of the proximal pole (Table 2) (Figs 12, 13). By contrast, in all the continental samples studied (*H. selago*), the spores were irregularly foveolated on all faces, and the foveolae on the distal face showed a higher density than those for species from the Atlantic archipelagos (Table 2) (Figs 14, 15).

DISCUSSION AND CONCLUSIONS

All consulted authors (Baker, 1887; Rothmaler, 1964, 1993; Villar, 1986; Salvo, 1990) considered *H. selago* to be the only species of the genus *Huperzia* present in continental Europe. The characteristics of the studied samples from this region coincide with those described by these authors for *H. selago*, mainly in terms of habit, foliar characteristics, phyllotaxis, size, position of the bulbils etc. All samples have leaves with entire margins and with stoma on both faces (amphistomatic), as previously indicated by Wagner & Beitel (1993+) for North American plants identified as *H. selago*.

In equatorial view, the form of the spores of North American plants identified as *H. selago* agrees with previous data supplied by many authors (Wilson, 1934; Wilce, 1972; Beitel & Mickel, 1992; Wagner & Beitel, 1992, 1993+): spores with straight to concave sides and truncated angles. This morphology of the spores has not been described previously for mainland European plants, and it is difficult to analyse the images obtained by OM (Hooker, 1861; Villar, 1986; Salvo, 1990), or by SEM (Ferrarini *et al.*, 1986). It is also not easy to infer the morphology of the spores from our images obtained by SEM.

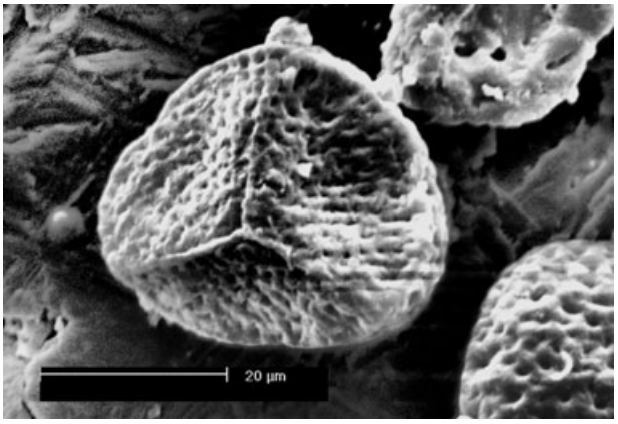

Figure 14. Spore morphology (scanning electron microscopy) of proximal pole of *Huperzia selago* (sample ESP 1).

Figure 15. Spore morphology (scanning electron microscopy) of distal pole of *Huperzia selago* (sample ESP 1).

Plants of *H. selago* collected in continental Europe show irregularly foveolated spores on all faces. This agrees with the observations of Villar (1986) in plants of *H. selago* collected in Girona (Spain). However, our results differ from those published by Ferrarini *et al.* (1986), who reported that the spores of *H. selago* are exine psilate on the proximal face; nevertheless, the image contained in this work shows spores with clearly foveolated proximal faces. The foveolated ornamentation of these spores agrees with the observations of Wilce (1972), who included the '*selago* type' in the 'foveolate-fossulate group'. According to this author, the spores are characterized by 'pits or grooves which occur on both proximal and distal surfaces'; Wilson (1934) described *H. selago* spores in North America as 'papillation of exine uniform, evenly distributed'. Similarly, Wilce (1972) specified that, in the spores from the '*selago* type', 'the prominence of the proximal pitting' could vary.

Concerning Azorean and Madeiran plants, usually included in the genus *Huperzia*, our results show the existence of two different forms: the first with entire margin leaves, identified as *H. suberecta*, and the second with denticulate margin leaves, identified as *H. dentata*. This systematic treatment is accepted by most modern authors (Press & Short, 1994; Schäfer, 2001, 2002, 2003; Costa *et al.*, 2004; Silva *et al.*, 2005).

Our results indicate that Macaronesian plants identified as *H. suberecta* have bulbils, whereas such reproductive structures do not appear in plants of the same origin identified as *H. dentata*; these results are in line with those of Ormonde & Fernandes (1980a, b). Bulbils appear in all Holarctic species of the genus, in both European species and those growing in North America (Wagner & Beitel, 1992, 1993+). Nevertheless, and according to Øllgaard (1987, 1992), this characteristic is exclusive to plants belonging to the '*H. selago* group', and this author included *H. dentata* in the '*Huperzia reflexa* group', composed of erect and homophyllous plants, usually with denticulate leaves, which mainly grow in open habitats of mountain forests. Conversely, Herter (1909) included *H. dentata* and *H. selago*, in the 'Series (Gruppe) Selagina' from 'Sectio I. Selaginurus', instead of including it in the 'Series Reflexa' from 'Sectio II. Crassistachys', also described in the same work (Herter, 1909).

Leaves of plants from the Azores and Madeira treated as *H. suberecta* are amphistomatic, whereas plants of *H. dentata* from the same geographical origin have hypostomatic leaves.

According to Wagner & Beitel (1993+), all North American plants from the genus *Huperzia* are characterized by amphistomatic leaves with entire margins; an exception to this rule is *H. lucidula* (Michx.) Trevis., in which the leaves are hypostomatic with denticulate margins.

Pita, de Menezes & Prado (2006), studying species of the genus *Huperzia* in Brazil, concluded that most have amphistomatic leaves; those with hypostomatic or epistomatic leaves are less frequent; hypostomatic leaves were exclusively detected in *H. hemleri* (Nessel) B.Øllg., included in the '*H. reflexa* group' (Øllgaard, 1987, 1992).

Spores from *H. suberecta* and *H. dentata* are homogeneous in their external ornamentation; in both cases, they are irregularly foveolated on the distal face and psilate on the faces of the proximal pole. Observations by SEM of plants from the Azores and Madeira agree, broadly speaking, with those of Ormonde & Fernandes (1980a, b). However, we did not observe, in any of our samples, the papillae described by Ormonde & Fernandes (1980a) in the spores of the Azorean plants with entire leaf margins; according to these authors, these structures are lacking in Azorean plants with denticulate leaf margins (Ormonde & Fernandes, 1980b).

The presence of papillae in spores was considered by Salvo (1990) as a relevant character of Azorean and Madeiran plants with entire leaf margins, as they are absent in plants of the same origin identified as *H. dentata*.

In equatorial view, differences were found in the external shape of the spores of *H. suberecta* and *H. dentata*; the spores of plants identified as *H. suberecta* were similar to those of *H. selago*. As postulated by Øllgaard (1987), the presence of bulbils in plants of the genus *Huperzia* is found in plants with '*selago* type' spores (Wilce, 1972). In agreement with this criterion and in response to the characterization of the '*H. selago* group' (Øllgaard, 1987), *H. suberecta* can be included in this group.

Given the shape of the outline of *H. dentata* spores, this species should be included in the '*phlegmaria* type', described by Wilce (1972). As a result, Wagner & Beitel (1992, 1993+) included this species in *Phlegmariurus*, a diverse tropical genus with a broad distribution (Table 1).

The characteristics attributed to the plants of the genus cited above (epiphytes, pendulum, without bulbils) are different from those found in European plants identified as *H. selago*. Øllgaard (1987) suggested a broader interpretation of the genus *Huperzia*, including it in the genus *Phlegmariurus*. The same author (Øllgaard, 1987) agreed with Wilce (1972), noting the presence of spores of the '*phlegmaria* type' in plants of the genus *Huperzia* that should not be included in the '*Huperzia phlegmaria* group'; indeed, he noted the presence of such spores in *H. reflexa* (Lam.) Trevis., included in the '*Huperzia reflexa* group', the same group in which this author included *H. dentata*. Pita *et al.* (2006) indicated the same morphology of the spores in *H. treitubensis* (Silveira) B. Øllg., a '*Huperzia brongniartii* group' of plants, which, like the previous group, is basically neotropical (Øllgaard, 1987, 1992).

The results of this study call into question the use of the shape of the spores as a criterion to discriminate between plants of the genera *Phlegmariurus* and *Huperzia*, as proposed by Wagner & Beitel (1992, 1993+) for North American plants. In summary, our results are in agreement with those of Øllgaard (1987) in terms of the systematic treatment of the family Lycopodiaceae and the characterization of the genus *Huperzia*. According to the systematic treatment of the genus *Huperzia* established by the same author (Øllgaard, 1987), the plants studied in this work should be classified into three different taxa, systematized into two infrageneric groups: *H. selago* and *H. suberecta* in the '*H. selago* group' and *H. dentata* in the '*H. reflexa* group.'

For the identification of the plants of the genus *Huperzia* studied in this work, we propose the following key:

1. Plants without bulbils and with hypostomatic leaves with denticulate margins……*H. dentata*
1′. Plants with bulbils and amphistomatic leaves with entire margins……2
2. Plants up to 40 cm high, with irregularly foveolated spores on the distal face and psilate spores on the faces of the proximal pole……*H. suberecta*
2′. Plants usually shorter than 25 cm, with irregularly foveolated spores on all faces……*H. selago*

HUPERZIA SELAGO (L.) BERNH. EX SCHRANK & MART., *HORTUS REGIUS MONACENSIS*: 3 (1829)

= *Lycopodium selago* L., *Species plantarum*: 1102 (1753) [basion.].
= *Selago vulgaris* Schur, *Enumeratio plantarum Transsilvaniae*: 825 (1866).
= *Plananthus selago* (L.) P.Beauv., *Prodrome des Cinquième et Sixième Familles de l'Aethéogamie*: 112 (1805).
= *Urostachys selago* (L.) Herter, *Philippine Journal of Science* 22: 180 (1923).
= *Mirmau selago* (L.) H.P.Fuchs, *Verhandlungen der Naturforschenden Gesellschaft in Basel* 66: 43 (1955).

Huperzia selago is found in cold temperate areas of the boreal hemisphere, but its presence has also been noted in the austral hemisphere (Villar, 1986). In southern Europe, it grows only in mountainous areas, and, in the Iberian Peninsula, it reaches its southern border at the Sistema Central (Rico & Romero, 1983).

Studied samples: ANDORRA. AND 1 – Por encima del Lago Tristania (Andorra). Leg.: S.R. Martínez-Costa. [FCO 00004]. SPAIN. ASTURIAS: ESP 1 – ASTURIAS: Base del Cornón (Somiedo; Asturias) 29TQH26; matorrales ligeramente higrófilos de *Juniperus nana*, *Vaccinium uliginosum* y *Erica tetralix*. Leg.: J.A. Fedz. Prieto. 15.vii.1979 [FCO 09652]. ESP 2 – ASTURIAS: Vega Redonda, Picos de Europa, Cangas de Onís. Nardeta húmeda y sombría; 1770 m.s.n.m. Leg.: H.S. Nava. 27.vii.1982. [FCO 10544]. ESP 3 – ASTURIAS: Las Campizas; de Vega las Fuentes a

Ario; Picos del Cornion; 1500 m.s.n.m. Talud rezumante. Leg.: H.S. Nava. 12.viii.1981. [FCO 10538]. CANTABRIA: ESP 4 – Pico Tresmares (Santander); fisuras de las rocas silíceas; alt. 2080 m.s.n.m. Leg. M. Mayor & Col. 13.vii.1977 [FCO 07059]. RIOJA: ESP 5 – Viniegra de Abajo, Sierra de la Demanda, umbría del Cerro Gomare, taludes en las cabeceras del río Valvanera, fuertes pendientes del NW, sustrato ácido, 1680–1720 U.T.M.: 30TWM0873. Leg.: M.L.Gil Zúñiga & J.A. Alejandre. 22 de Agosto de 1991 (Herb. MA ex duplis n° 1026–91) [FCO 21296].

HUPERZIA SUBERECTA (LOWE) TARDIEU, *ADANSONIA* 10: 20 (1970)

= *Lycopodium suberectum* Lowe, *Transactions of the Cambridge Philosophical Society* 4: 9 (1930) [basión.].
= *Lycopodium selago* subsp. *suberectum* (Lowe) Romariz, *Revista da Facultade de Ciencias, Universidade de Lisboa,* Sér. 2a, C, Ciências Naturais 3: 71 (1953).
= *Lycopodium selago* var. *suberectum* (Lowe) Trel., *Report (Annual) of the Missouri Botanical Garden* 8: 176 (1897).
= *Lycopodium selago* var. *suberectum* (Lowe) C.Chr., *Dansk Botanisk Arkiv Udgivet af Dansk Botanisk Forening* 7: 188 (1932).
= *Huperzia selago* subsp. *suberecta* (Lowe) Franco & Vasc., *Boletim da Sociedade Broteriana, Ser. 2*, 41: 23 (1967), excl. *Lycopodium dentatum* Herter.
= *Lycopodium selago* sensu auct. pl. azoriensis et madeiresis, non L., *Species plantarum*: 1102 (1753).
= *Urostachys suberectus* (Lowe) Herter ex Nessel, *Barlappgewachse (Lycopodiaceae), eine beschreibende Zusammenstellung mit besonder Berucksichtigung ihrer Varietaten und Formen*: 42 (1939).

Endemic to the Azores and Madeira. It is the most common species of the genus on Madeira (Press & Short, 1994); it is rare in the Azores, where it grows in the higher zones of San Miguel, Terceira, San Jorge, Pico, Faial and Flores Islands (Hansen & Sunding, 1993; Schäfer, 2003).

Studied samples: PORTUGAL. AZORES. AZO 1 – PICO: Subida para o Pico, desde Madalena, com *Calluna vulgaris* y *Daboecia azorica*. 780 m. Leg. C. Aguiar & F. Prieto. 24.vii.2003. AZO 2 – PICO: Subida para o Pico. 1345 m. Leg. C. Aguiar & F. Prieto. 31.vii.2002. MADEIRA. MAD 1 – Sopé do Pico Ferreiro – São Vicente. 26.v.1982. Leg. Nóbrega, Pita, Noia. [MADJ. 03293]. MAD 2 – A 3 km do Ribeiro Frio e Santo da Serra, na levada. 23.xi.1982. Leg. Nóbrega, Pita, Noia. [MADJ. 03294]. MAD 3B – Caramujo- Rib^{io} do Inferno ao largo da lev^{da} do Norte. 24.vii.1985. Leg. Nóbrega. [MADJ. 03304]. MAD 4 – Riberiro Frio – Santo da Serra. 3.iv.1990. Leg. Paulo-Fernancas. [MADJ. 02877]. MAD 5 – Casa Florestal da Encumada, Vereda para a Ribeira Grande – São Vicente. Leg. Nobrega (a) (a) Eng^{a} Gloria, Rui Santos, Domingos Noia e Isidoro. 14.x.1981. [MADJ. 03292]. MAD 6 – Encumada – Ribeira Grande São Vicente. Leg. Nobrega. 20.viii.1985. [MADJ. 03296]. MAD 7 – Bica da Cana. Leg. Nóbrega. 13.viii.1986. [MADJ. 03297]. MAD 8 – Ribeira da Ponte dos Ganchos no Urzal de Boaventura. Leg. Nóbrega. 7.vi.1988. [MADJ. 06408]. MAD 9 – Fanal – Ribeira da Janela. Leg. Nóbrega. 26.vii.1988. [MADJ. 06376]. MAD 10 – Caramujo São Vicente, Levada Nova. Leg. Nóbrega. 13.xii.1988. [MADJ. 02930]. MAD 11 – Atrás das rochas da Carapitar, na Serra do Urzal Boaventura em abundancia. Leg. Nóbrega. 21.iv.1992. [MADJ. 06950]. MAD 12 – Encumada de São Vicente. Leg. Nóbrega. 26.v.1992. [MADJ. 09886]. MAD 13 – Rib^{a} da Janela – Fanal. Leg. Nóbrega, Pita, Costa. 10.x.1984. [MADJ. 03295].

HUPERZIA DENTATA (HERTER) HOLUB, *FOLIA GEOBOTANICA ET PHYTOTAXONOMICA BOHEMOSLOVACA* 20: 72 (1985)

= *Lycopodium dentatum* Herter, *Botanische Jahrbücher für Systematik, Pflanzengeschichte und Pflanzengeographie* 43(98): 41 (1909) [basion.].
= *Huperzia selago* subsp. *dentata* (Herter) Valentine, *Feddes Repertorium Specierum Novarum Regni Vegetabilis* 69: 44 (1964).
= *Lycopodium suberectum* sensu auct. pl. azorianos, non Lowe, *Transactions of the Cambridge Philosophical Society* 4(1): 9 (1931).

Endemic to the Azores and Madeira; nevertheless, Øllgaard (1987, 1992) indicated the presence of this plant on Reunion. It is common in the Azores and grows in San Miguel, Terceira, San Jorge, Pico, Faial, Flores and Corvo Islands (Hansen & Sunding, 1993; Schäfer, 2003). On Madeira, it is the less common of the two species of the genus *Huperzia* (R. Jardim, Jardim Botânico da Madeira, pers. comm.).

Studied samples: PORTUGAL. AZORES. AZO 3 – S. Miguel: Furnas, talude da estrada para a Rubiera Grande. Leg. C. Aguiar & F. Prieto. 23.vii.2003. AZO 4 – Terceira: Serra de St^{a} Bárbara. *Calluneta* instalada sobre solo com horizonte orgânico parcialmente mineralizado. Leg. C. Aguiar & F. Prieto. 24.vii.2002. AZO 5 – S. Jorge: Serra do Topo, Pedra Vermelha. Leg. C. Aguiar & F. Prieto. 18.vii.2003. AZO 6 – S. Miguel: Nordeste, caminho florestal para os Graminhais; Calluneta. Leg. C. Aguiar & F. Prieto. 23.vii.2003. AZO 7 – S. Miguel: entre Miradouro do Rei e Pico do Carvao. Leg. C. Aguiar & F. Prieto. 24.vii.2003. MADEIRA:

MAD 3A – Caramujo- Rib^{io} do Inferno ao largo da lev^{da} do Norte. 24.7.1985. Leg. Nóbrega. [MADJ. 03304].

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