

***ASPLENium AURITUM SW. SENSU LATO* (ASPENIACEAE:
PTERIDOPHYTA) - AN OVERLOOKED NEOTROPICAL FERN
NATIVE TO THE AZORES**

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ABSTRACT

Asplenium auritum Sw. *sensu lato* (Eared Spleenwort) is recorded for the Azores and the Macaronesian region for the first time. Misidentified herbarium specimens indicate it to have first been collected on Flores by Drouet in 1857, strongly supporting a native status. A member of a critical species complex of sexual and apogamous lineages of various ploidy levels and widely distributed in Central and Southern America, the Caribbean, Madagascar and eastern Southern Africa, we consider this represents another example of a neotropical element naturally present in the Azorean flora. The taxonomy of this group is far from resolved. It is still unclear whether the Azorean material can be definitely identified with an existing named entity in this group or may be unique and endemic; further molecular work is needed to resolve this issue. Currently fewer than 50 individuals are known from one small area where it is highly vulnerable to both development and collection; we therefore suggest an IUCN category of Critically Endangered – CR (B1,2 a & b, D).

INTRODUCTION

The Macaronesian region, comprising the North Atlantic volcanic, oceanic archipelagos of the Azores, Madeira, Selvages, Canaries and Cape Verdes (Figure 1a) is recognised as a Biodiversity Hotspot with a rich endemic flora (Schaefer, 2003a) and as a globally important centre for pteridophyte diversity. In the Azores, the most northerly and isolated archipelago of the region, comprising nine islands located 1600 km west of the Iberian peninsula, pteridophytes form a notable component of the vegetation. In spite of this interest, the flora remains under-worked and patchily recorded (Schaefer *et al.*, 2011). This is perhaps particularly true of Flores and Corvo (Figure 1b), the two westernmost islands of the Azores, where several previously overlooked pteridophyte taxa, some widely disjunct (Schaefer, 2001, 2003, Rumsey & Schaefer, in prep.), have recently been identified.

During the course of collaborative fieldwork in July-August 2008 between botanists from the Natural History Museum, London (FJR/MC) and those from project “Veronica” at the University of the Azores, a distinctive *Asplenium*, unlike any currently recorded for

Macaronesia (Hansen & Sunding, 1993), or Europe (Tutin *et al.*, 1993), was found in two discrete patches less than 100 m apart. The plants occurred on old walls by tracksides in *Pittosporum*-dominated woodland close to the small village of Cuada on the west coast of Flores (Fig 1c). A return visit to the area by HS in June 2011 detected plants in two patches at another locality, in similar habitats and vegetation, and all within the same square kilometre.

On first sight, the coriaceous texture, channelled rachis and colour suggested a possible hybrid involving *Asplenium marinum* L., of which none are currently known, but the absence of the putative parent, plus the number of individuals of varying age and maturity made this unlikely, and the plant's production of well-developed spores quickly ruled this out. Even though present in small quantity the plants found showed considerable variation in morphology, with the 2011 populations demonstrating that the

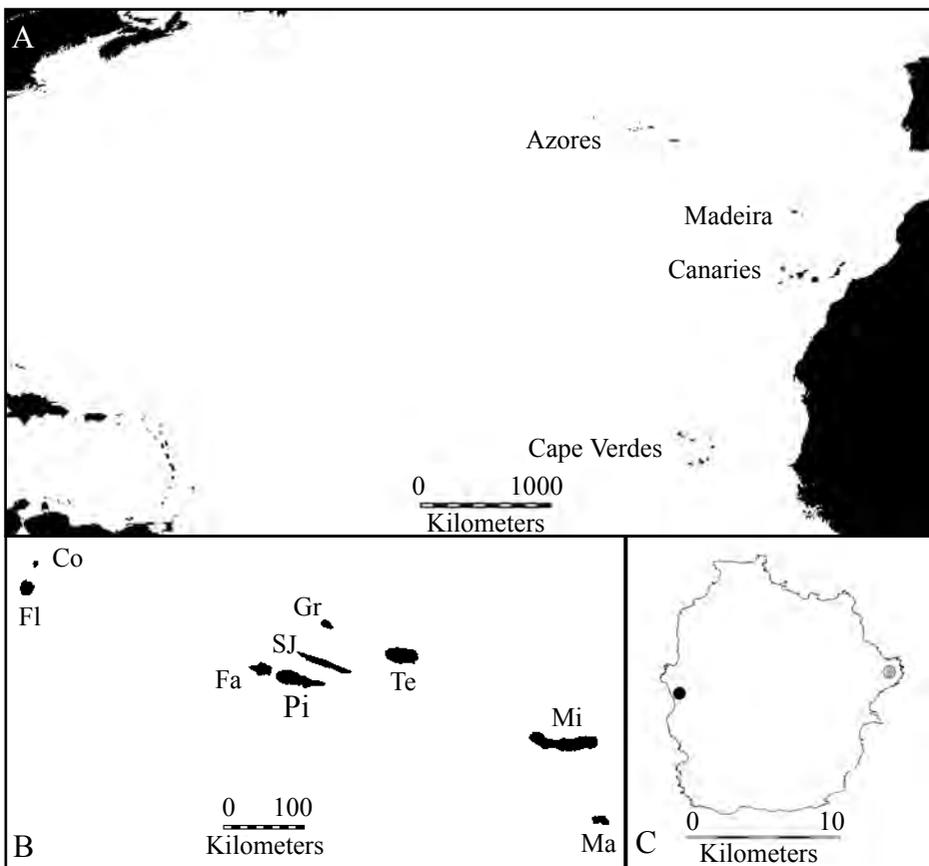


Figure 1. Distribution of *Asplenium auritum* in the Azores. **A.** The location of the Azores in relation to the other Macaronesian archipelagos (Madeira, Canaries, Cape Verdes) and continental landmasses. **B.** The nine islands of the Azorean archipelago. Fl = Flores; Co = Corvo; Fa = Faial; SJ = São Jorge; Pi = Pico; Gr = Graciosa; Mi = São Miguel; Ma = Santa Maria. **C.** The island of Flores showing the location of Aldeia da Cuada (black circle) where all localized collections of *A. auritum* have been made and Santa Cruz das Flores (grey circle) where Drouet probably collected the species on August 3rd 1857 (see text)

juvenile frond form differed significantly in dissection (Figure 2).

Given the floristic links demonstrated by other cryptogamic taxa in the Western Azores (Vanderpoorten *et al.*, 2007) it was considered that related or taxa identical to the novel *Asplenium* should initially be sought from the floras of the Caribbean, Central America and southern North America. Using the keys in Wagner *et al.*, (1993), Adams (1995) and Proctor (1985), the material was quickly identified as belonging to *Asplenium auritum* Sw. *sensu lato*.

The *Asplenium auritum* complex is widely distributed, occurring in both the Neotropics and Palaeo-tropics. The centre of diversity and abundance would appear to be in Central and South America, from Brazil to Bolivia, with populations scattered northwards to southern Mexico, finally reaching a northern limit in Florida, where it is listed as Endangered (E) by the Florida Department of Agriculture. There it occurs primarily as an epiphyte on old oaks (*Quercus virginiana* Miller) in low altitude (<50 m), shady forests (Wagner *et al.*, 1993). It was long thought to be restricted to a single site in Sumter County but has since been detected in small quantities in a further seven counties, although now perhaps extirpated in Dade County (Nelson, 2000). The Florida plants are morphologically dissimilar from the Azorean in their narrower and more acute pinnae. Interestingly, Lakela and Long (1976) regarded the plant as an introduction from Jamaica. *Asplenium auritum sensu stricto* occurs relatively commonly within Jamaica and through the Greater Antilles where it is present at middle elevations (275-945 m), primarily as an epiphyte in humid woodlands, more rarely on banks or humus-filled pockets in rocks (Proctor, 1985). *Asplenium auritum* var. *bipinnatifidum* Kunze (which Proctor (1985) equates with *A. rigidum* Sw.) is also present but additionally distributed through the Lesser Antilles and Trinidad and occurring at higher altitudes (518-1220m). The species aggregate also occurs, but rarely, in La Réunion and Mauritius in the Mascarenes (Autrey *et al.*, 2008) at altitudes up to 1400m, growing in primary woodlands and ravine streambeds. In south-eastern Africa the aggregate is found from 650-1220m in warm, tropical, semi-deciduous woodland and riverine forest along the foot of the eastern escarpment of Zimbabwe, extending into western Mozambique; it is also reported in Malawi and the People's Republic of Congo (Burrows, 1990). Usually plants occur as epiphytes at low altitudes but also as lithophytes, more rarely terrestrial, on earthy banks in light shade. Plants of this aggregate also occur in the forests of Central Madagascar. Christensen (1932) clearly had some doubts about the identity of this material which, although rare, showed considerable morphological variation, with plants being linked to both *A. macilentum* Kunze ex Klotsch and *A. rigidum* Sw. From the limited material initially available and using the concepts and descriptions in Mickel & Smith, (2004) it was considered that the plant more closely approached *A. cuspidatum* Lam. (which those authors synonymised with *A. auritum* var. *bipinnatifidum*), and it was as such that the Flores plant was listed in Silva *et al.* (2010). The later gatherings by HS and the discovery of additional herbarium material has allowed a more considered judgement of the plant's identity to be made. Pending a full revision of the complex necessary to establish the identity of the Azorean material as either endemic to the archipelago or more widespread, we refer it to *A. auritum sensu lato*. In this paper, we provide a description of *A. auritum* in the Azores, together with a key to the species of *Asplenium* in the Azores, to facilitate identification. The status, distribution, ecology and conservation status of Azorean *A. auritum* are also discussed, in light of our collections and those made by earlier collectors.

DESCRIPTION OF AZOREAN MATERIAL

Asplenium auritum Swartz, J. Bot. (Schrader). 1800(2): 52. 1801.

Rhizome erect, unbranched; densely clothed at apex with scales; scales brown throughout, broadly linear, 1-2 × 0.7-1.1 mm, margins shallowly and widely dentate. Petiole green, sometimes blackish brown abaxially, dull, channelled, 2-10(-12) cm, 1/3-1/2 length of frond; indumentum absent. Blade narrowly deltate to lanceolate, degree of dissection variable: juvenile foliage finely 2-pinnate (Figure 2), mature fronds once pinnate-pinnatifid to 2-pinnate (Figure 3), 4-20(-30) × 1.8- 9cm, thick, somewhat coriaceous, glabrous; broadest at base, tapering gradually to apex. Rachis green, dull, channelled, +/- glabrous. Pinnae in 10-18 pairs, linear-deltate, medial pinnae 0.7-4.5 × 0.3-1cm; base with acroscopic auricle or pinnule enlarged, somewhat excavate in proximal 1/5-1/4; margins mostly obtusely lobed to dentate, pinnate proximally or in proximal 2/3; apex obtuse. Sori oblong, 4-9(-12) pairs per pinna, subcostal, nearly parallel to costae on both basiscopic and acroscopic sides, sometimes restricted to distal portion of pinna (Figure 4). Indusium membranous, entire. Spores somewhat variable in shape, reniform-elliptic rarely subglobose, perispore weakly cerebriform-reticulate, obscurely crested, sparsely echinulate, exospores 32-42.5 × 22.5-28(-30) µm.

Asplenium auritum can be discriminated from the other species of *Asplenium* in the Azorean flora by a unique combination of characters. A key to the Azorean taxa is presented below. Twelve species of *Asplenium* have previously been recorded; one, *A. ruta-muraria* L. was presumed to be an introduction that did not persist and it is not treated in the key. Another, the Macaronesian endemic *A. anceps* Hook. & Grev. is also known only from a single gathering, from Pico in 1973 (Lovis *et al.*, 1977). It is implicated in the origin of the Azorean endemic *A. azoricum* Lovis, Rasbach, K.Rasbach & Reichst. (Rumsey *et al.*, 2004) and may be overlooked for that species and so is



Figure 2. *Asplenium auritum* Sw. Cuada, Flores, June 2011 showing dissected juvenile foliage and once pinnate-pinnatifid fronds of young mature plants.

Photo. H. Schaefer



Figure 3. *Asplenium auritum* Sw. Cuada, Flores, June 2011 showing increasing levels of frond dissection on mature plants. Photo. H. Schaefer



Figure 4. *Asplenium auritum* Sw. Coadá, Flores, June 2011 - underside of mature fronds showing indusial arrangement. Photo. H. Schaefer

included. Six hybrids have been reported, a seventh (*A. onopteris* L. × *A. obovatum* Viv. subsp. *lanceolatum* (Fiori) P.Silva) is believed to occur but has yet to be confirmed cytologically (Rumsey, in prep.). Of these six, one has only been found once: *A. azoricum* × *A. scolopendrium* L. (Rumsey *et al.*, 2004), while the majority are apparently very infrequent but perhaps overlooked: *A. azoricum* × *A. trichomanes* subsp. *quadrivalens* D.E.Mey. has been recorded on Terceira and Sao Miguel (Rumsey, in prep.); *A. onopteris* × *A. scolopendrium*, while lost from Faial (Schaefer & Rasbach, 2000) has now been found in several sites on Santa Maria (Schaefer, 2003b). Of the other three hybrids, *A. azoricum* × *A. onopteris* is currently also known only from Santa Maria but again has been found in several sites there (Rumsey *et al.*, 2004), *A. adiantum-nigrum* L. × *A. obovatum* subsp. *lanceolatum* is known from Pico, where first recorded by Bennert *et al.*, (1992) and the last, *A. adiantum-nigrum* × *A. onopteris*, is more widely distributed, overlooked and apparently often more frequent than *A. adiantum-nigrum* itself (Schaefer, 2003c). All hybrids are intermediate between their parents and show high levels of sterility, manifested in the production of misshapen, abortive spores.

Key to the Azorean species of *Asplenium*

1. Fronds entire2
Fronds pinnate-pinnatifid3
2. Frond blade as wide as long, with acute lobes*A. hemionitis* L.
Frond distinctly longer than wide, unlobed*A. scolopendrium* L.
3. Frond simply pinnate4
Frond pinnatifid to twice-pinnate9
4. Rachis with distinct abaxial wing*A. anceps* Lowe
Rachis without distinct abaxial wing5
5. Fronds not coriaceous, rachis without distinct adaxial channel6
Fronds coriaceous, rachis distinctly channelled8
6. Pinnæ entire with single basiscopic sorus*A. monanthes* L.
Pinnæ crenate with >2 sori7
7. Pinnæ >2 × as long as wide, distinctly crenate, glossy
.....*A. azoricum* Lovis, Rasbach, K.Rasbach & Reichst.
Pinnæ <2 × as long as wide, indistinctly crenate, matt
.....*A. trichomanes* L. subsp. *quadrivalens* D.E.Mey.
8. Frond broadest at base, narrowly triangular*A. auritum* Sw.
Frond parallel sided, often widest above middle*A. marinum* L.
9. Basal pinnæ much shorter than those in mid frond
.....*A. obovatum* Viv. subsp. *lanceolatum* (Fiori) P.Silva
Basal pinnæ ± the longest10
10. Frond coriaceous, lower pinnæ with acroscopic auricle*A. auritum* Sw.
Frond not coriaceous, pinnæ never auriculate11
11. Ultimate segments narrowly lanceolate, acute at base, mean exospore length <30 µm
.....*A. onopteris* L.
Ultimate segments lanceolate, somewhat obtuse at base, mean exospore length >30 µm
.....*A. adiantum-nigrum* L.

SPECIMENS SEEN

Asplenium auritum Sw. Azores, Portugal, Flores Island. walls of track leading NE from Casa do Espirito Santo, Aldeia do Quada UTM 0650034/4367245, alt. 146 m asl. Leg.

Carine *et al.*, 58, 8 July 2008. BM

Asplenium auritum Sw. Azores, Portugal, Flores Island. walls of track leading NE from Casa do Espirito Santo, Aldeia do Quada UTM 0650003/4367488, alt. 137 m asl. Leg.

Carine *et al.*, 60, 8 July 2008. BM

Asplenium auritum Sw. Azores, Portugal, Flores Island. *Pittosporum undulatum* forest near the village of Cuada (Fajã Grande). UTM 0650180/4367706, alt. 128 m asl. Leg.

Hanno Schaefer 2011/405, 17 June 2011. BM

Asplenium auritum Sw. Azores, Portugal, Flores Island. *Pittosporum undulatum* forest near the village of Cuada (Fajã Grande). UTM 0650185/4367697, alt. 135 m asl. Leg.

Hanno Schaefer 2011/406, 17 June 2011. BM

Examination of herbarium material at BM revealed two further gatherings of this taxon. One was made in the same area as the recent finds, near the small village of Cuada (Coada/Quada) above Fajã Grande, by C. M. Ward in July 1967 (Figure 5). This specimen (Ward 24) was not mentioned by Ward (1970) in his account of the pteridophyte flora of the island and remained undetermined until incorrectly identified as *A. obovatum* subsp. *lanceolatum* by Ormonde in 1992. The second, much older specimen (Figure 6), was collected by Drouet on 3 August 1857 and is localised only to the island "Flores". Drouet's account of his visit to the Azores (Drouet, 1866) indicates that he was present on Flores from 28th July through to the date on which he collected this specimen (3rd August). His reported itinerary shows he never visited the western coast and the Fajã Grande area in which all recent finds have been made. On 3rd August he was preparing to move on to Faial, and so confined his activities to areas immediately adjacent to Santa Cruz on the east coast, then, as now, the most populous and developed area on the island. He initially labelled the plant as "voisin du *marinum*" (ie *A. marinum*), which in frond texture and colour is indeed the most similar Macaronesian/European species but which never shows the bipinnate dissection of Drouet's plant. Subsequently the specimen was incorrectly labelled as "*Asplenium adiantum-nigrum* L. forma *forsam ad* II. *C. onopteris* Heufl. *A. acutum* (Bory) Milde" [= *A. onopteris* L.]

ECOLOGY

Asplenium auritum is restricted to low-altitude forest within the Azores, the finds near Cuada made between 125 - 200 m. No altitude is given by Drouet but, given his known movements on the day he collected the specimen, the site would be no higher than at Cuada and perhaps much closer to sea-level. This zone has seen the most profound change since the arrival of settlers in the 15th and 16th centuries, with woodland and scrub clearance and the replacement of the dominant species by alien and invasive taxa. Structurally however, this latter-day vegetation may not be entirely dissimilar to the original, and many native cryptogams of the understory appear to have survived in sheltered and ravine sites. For instance, *Culcita macrocarpa* C.Presl recruits abundantly in some areas on the fibrous trunks of the Asian *Cryptomeria japonica* (L.f.) D.Don in old forestry plantations. The species grows in secondary scrubby woodland, dominated by the invasive *Pittosporum undulatum* Vent., and in moderately exposed to rather deeply shaded conditions on dry stone walls made of the local volcanic rock which border the trackways; these are usually free-standing but sometimes soil-backed. Here it occupies the somewhat soil-filled interstices between the blocks, or where soil and humic debris accumulates on the block's pitted oblique and near horizontal surfaces. It is closely associated with very few vascular species, predominantly pteridophytes such as *Polypodium macaronesicum* Bobrov subsp. *azoricum* (Vasc.) F.J.Rumsey, Carine &

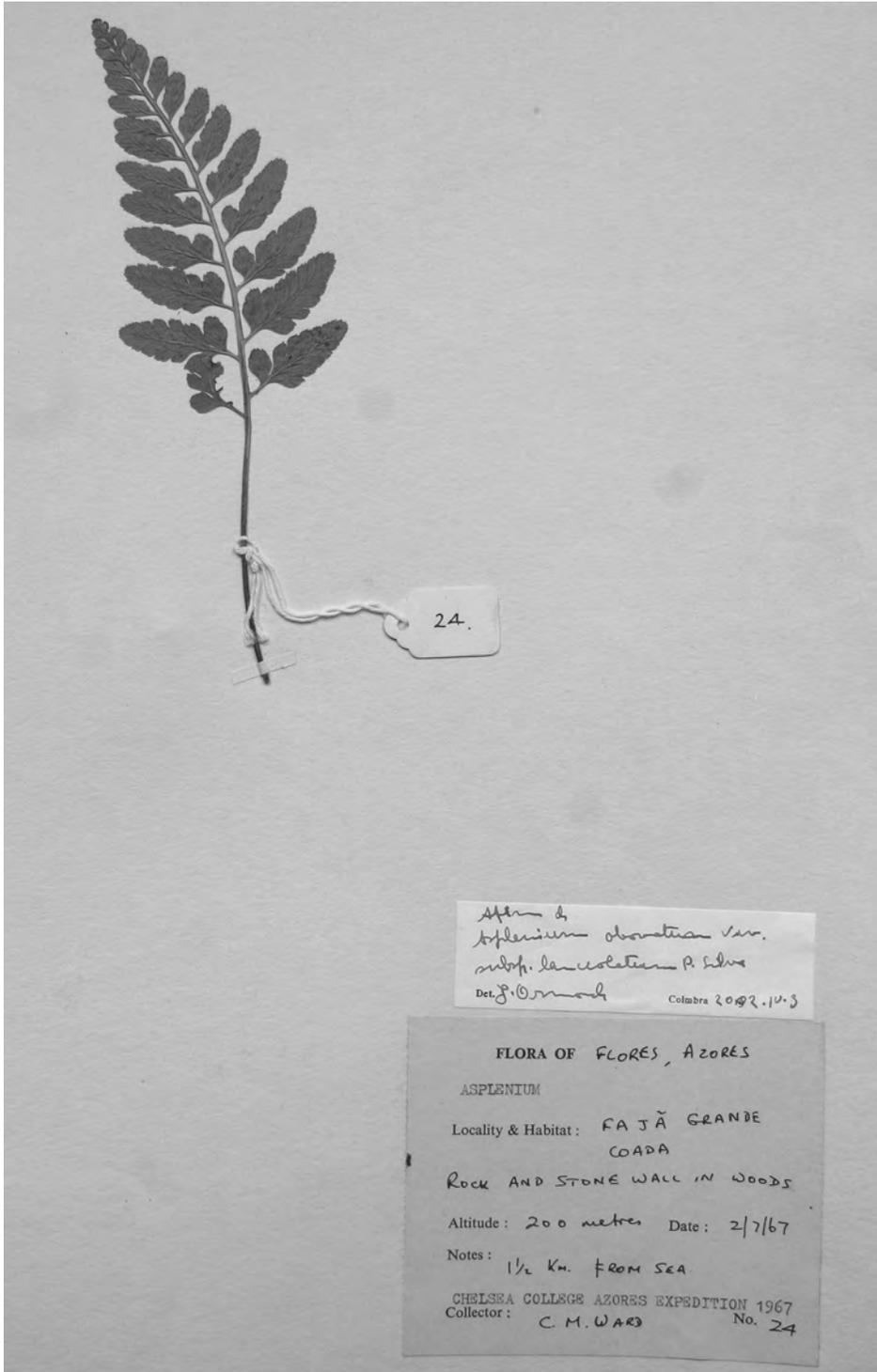


Figure 5. *Asplenium auritum* Sw. – Fajã Grande, Coadã, Flores. C.M. Ward 24, 2/7/1967. (BM)



Figure 6. *Asplenium auritum* Sw. – Drouet, Flores, 3 Aug. 1857 (BM)

Robba, other species of the genus *Asplenium* and usually roots amongst leafy liverworts such as *Frullania* and *Radula* spp. and various foliose lichens. Plants are also to be found on soil banks adjacent to sections of wall, some of which are now in some disrepair, and on thin soils overlying rocks at the base of the walls. In this it shows considerable similarity to *Asplenium azoricum*, another species believed to have Neotropical affinities but which is far more widely distributed in the archipelago, being found on all of the Azorean islands (Rumsey *et al.*, 2004). In the more exposed sections, higher on walls and with less shade, the plant will regularly experience drought stress (Figure 7) and must show a degree of xerophytic tolerance, although high levels of mortality and turnover are to be expected and are reflected in the observation of numerous juveniles.

CONSERVATION

The Drouet specimen indicates that the species was previously more widespread on Flores and we can record a historical decline in area of occupancy and number of sites. The presence of the species in a zone where the vegetation has seen the greatest change and loss offers the possibility that it was once even more widely distributed or, indeed, may remain to be detected elsewhere. Currently it is effectively restricted to a single site (one contiguous area of habitat under single ownership and management) where is a threat of possible development, and has a small population size (less than 50 mature individuals); together these support Critically Endangered status (CR - B1. a,b; B2a,b;



Figure 7. *Asplenium auritum* Sw. Cuada, Flores, July 2008 – appearance of plant when droughted. Photo. F.J.Rumsey

C2a; D) for the species in the Azores, as defined by the I.U.C.N. (2001).

DISCUSSION

Status and relationships

The Macaronesian region is recognised as a globally important centre for pteridophyte diversity not least because of the high levels of endemism; just under 10% of the Azorean pteridophyte species are endemic to the archipelago (Vanderpoorten *et al.*, 2011). The biogeography and origins of the taxa on these remote oceanic islands has been the source of interest since initial considerations by Dansereau (1961). The discovery of additional species, and the use of cytogenetics and latterly molecular studies, have revealed more critical differences and helped elucidate floristic affinities. As a consequence, the pteridophyte flora of the Azores has been shown to have a small but distinctive Neotropical or New World element (Vanderpoorten *et al.*, 2007), with the westernmost islands in the archipelago particularly rich in these species, eg. the Grammitidaceae (Schaefer, 2001) and endemic taxa whose closest relatives have been shown to be New World, eg. *Isoetes azorica* Durieu ex Milde

(Britton & Brunton, 1996) and *Huperzia dentata* (Herter) Holub. The Azorean fern flora shows little affinity to tropical Africa; although some disjunct afro-montane elements are present, these are more of a feature of the more southerly Macaronesian archipelagos (Madeira, the Canaries and Cape Verdes). The endemic taxa are, as with most other described Azorean angiosperm endemics, generally widely distributed across the archipelago (Carine & Schaefer, 2009). The exception, *Marsilea azorica* Launert & Paiva, known only from a single locality, has recently been shown to be synonymous with the Australasian *M. hirsuta* R.Br., a recent invasive weed in tropical North America (Schaefer, Carine & Rumsey, 2011). No single site, or even single island pteridophyte endemic is currently known from the Azorean archipelago, although several non-endemic taxa are restricted to individual sites or islands; this may reflect a comparatively recent arrival, or be as a consequence of ecological (edaphic, biotic or climatic) factors, eg. *Botrychium lunaria* (L.) Sw. recorded only on Pico and restricted to an altitude and environment absent elsewhere in the archipelago.

Biogeographically how should we consider the Azorean *Asplenium auritum*? All evidence points to its being native: restriction to one of the least populous islands, unknown in cultivation and present since some of the earliest periods of exploration of the western islands. While *Asplenium auritum sensu lato* is known from the eastern portion of Southern-most Africa and from Madagascar, the more likely pattern of dispersal is from the Neo-tropics where the species is more abundant. The proof of this assertion will however rely on detailed morphological and molecular studies to elucidate the relationships of these geographically disparate populations. Currently taxonomic treatments and within this group of Spleenworts differ markedly (eg. Proctor, 1985; Adams, 1995; Mickel & Smith, 2004; Roux, 2009; Gabancho, 2011). Many conflicting taxonomic approaches have been taken by recent flora writers working with just a small, local subset of the variation present in the complex. A monographic treatment of the *Asplenium auritum* complex is clearly overdue. Given the wide geographic spread of its occurrences such an undertaking is a challenge to organise and accomplish. Morton & Lellinger (1966) were forced to conclude “until more detailed...studies are made, the division of this complex into taxa based mainly on blade and pinna dissection, blade texture, and spore type will have to stand”. Detailed molecular, genetic and micromorphological data are sadly still largely lacking and the circumscription of taxa

and relationships between them, the genomes they contain and the discrete hybridization and polyploid events which have given rise to them, remain to be resolved.

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REFERENCES

- ADAMS, C.D. 1995. *Asplenium* L. in Davide, G., Mario Sousa, S., Knapp, S., Morran, R.C., Riba, R. (eds.) *Flora Mesoamericana Vol. 1 Psilotaceae a Salviniaceae*. Mexico, Universidad Nacional Autónoma de México.
- AUTREY, J.C., BOSSER, J. & FERGUSON, I.K. 2008. *Flore des Mascareignes: La Réunion, Maurice, Rodrigues. Ptéridophytes* 1-26, Psilotacées à Marsiléacées. Paris, Institut de Recherche pour le Développement.
- BENNERT, H.W., GIERS, A., GULDENPENNING, S., HERBIK, A. & KATHEDER, A. 1992. Some new observations on the fern flora of the Azores. *Fern Gazette* 14: 146-148.
- BRITTON, D.M. & BRUNTON, D.F. 1996. Spore morphology and cytology of *Isoetes azorica* (Pteridophyta, Isoetaceae) and its affinity with North America. *Fern Gazette* 15:113-118.
- BURROWS, J. E. 1990. *Southern African ferns and fern allies*. Sandton, Frandsen.
- CARINE, M.A. & SCHAEFER, H. 2009. The Azores diversity enigma: why are there so few Azorean endemic flowering plants and why are they so widespread? *Journal of Biogeography* 37:77-89.
- CHRISTENSEN, C.F.A. 1932. *Catalogue des plantes de Madagascar, Pteridophyta*. Tananarive, Académie Malgache.
- DANSEREAU, P.M. 1961. Études macaronésiennes. 1. Géographie des cryptogames vasculaires. *Agronomia Lusitanica* 23:151-181.
- DROUET, H. 1866. *Catalogue de la flore des îles Açores, précédé de l'itinéraire d'un voyage dans cet archipel*. Paris.
- GABANCHO, L.R. 2011. The identity of *Asplenium macilentum* Kunze ex Klotsch. *American Fern Journal* 101:206-207.
- HANSEN, A. & SUNDING, P. 1993. Flora of Macaronesia. Checklist of vascular plants. 4th revised edition. *Sommerfeltia*, 17: 9-21.
- I.U.C.N. 2001. IUCN Red List Categories and Criteria: Version 3.1. IUCN Species Survival Commission, Gland Switzerland and Cambridge, UK.
- LAKELA, O. & LONG, R.W. 1976. *Ferns of Florida: an illustrated manual and identification guide*. Miami, Banyan Books.
- LOVIS, J. D., H. RASBACH, K. RASBACH and T. REICHSTEIN. 1977. *Asplenium azoricum* and other ferns of the *A. trichomanes* group from the Azores. *American Fern Journal* 67:81-93.
- MICKEL, J.T. & SMITH, A.R. 2004. The Pteridophytes of Mexico. *Memoirs of the New York Botanic Garden*, Vol. 88. New York, New York Botanic Garden.
- MORTON, C.V. & LELLINGER, D.B. 1966. The Polypodiaceae subfamily Asplenoioideae in Venezuela. *Memoirs of the New York Botanic Garden* 15:1-49.
- NELSON, G. 2000. *The Ferns of Florida*. Sarasota, Pineapple Press.

- PRELLI, R. 2001. *Les Fougères et plantes alliés de France et d'Europe occidentale*. Paris, Editions Belin.
- PROCTOR, G.R. 1985. *Ferns of Jamaica*. London, British Museum (Natural History).
- ROUX, J.P. 2009. Synopsis of the Lycopodiophyta and Pteridophyta of Africa, Madagascar and neighbouring Islands. *Strelitzia* 23: 1-296.
- RUMSEY, F.J., RUSSELL, S.J., SCHÄFER, H. & RASBACH, H. 2004 Distribution, ecology and cytology of *Asplenium azoricum* Lovis, Rasbach & Reichstein (Aspleniaceae, Pteridophyta) and its hybrids. *American Fern Journal* 94: 113–125.
- SCHAEFER, H. 2001. The Grammitidaceae, Pteridophyta, of Macaronesia. *Feddes Repertorium* 112: 509-523.
- SCHAEFER, H. 2003a. Chorology and diversity of the Azorean Flora. *Dissertationes Botanicae* Bd. 374. J. Cramer, Berlin.
- SCHAEFER, H. 2003b. New records of the fern hybrid *Asplenium* × *rouyi* Viane (*A. onopteris* L. × *A. scolopendrium* L.) in the Azores (Aspleniaceae, Pteridophyta). *Arquipélago. Life and Marine Sciences* 20A:55-56.
- SCHAEFER, H. 2003c. Distribution and status of the pteridophytes of Faial island, Azores (Portugal). *Fern Gazette* 16, 213–237.
- SCHAEFER, H., CARINE, M.A. & RUMSEY, F.J. 2011. From European Priority Species to Invasive Weed: *Marsilea azorica* (Marsileaceae) is a Misidentified Alien. *Systematic Botany*, 36(4):845-853.
- SCHAEFER, H. & RASBACH, H. 2000. *Asplenium* × *rouyi* Viane (*A. onopteris* L. × *A. scolopendrium* L.) in the Azores (Aspleniaceae, Pteridophyta). *Willdenowia* 30:219-227.
- SCHNEIDER, H, RUSSELL, S.J. COX, C., BAKKER, F., HENDERSON, S., RUMSEY, F.J., BARRETT, J.A., GIBBY, M. & VOGEL, J.C. 2004. Chloroplast phylogeny of asplenioid ferns based on *rbcL* and *trnL-F* spacer sequences (Polypodiidae, Aspleniaceae) and its implications for the biogeography of these ferns. *Systematic Botany* 29: 260-274.
- SILVA, L., MOURA, M., SCHAEFER, H., RUMSEY, F.J., DIAS, EF. 2010. List of Vascular Plants (Tracheobionta) in Borges, P.A.V., Costa, A., Cunha, R., Gabriel, R., Gonçalves, V., Frias Martins, A., Melo, I., Parente, M., Raposeiro, P., Rodrigues, P., Serrão Santes, R., Silva, L., Vieira, P. & Vieira, V. (eds.) A list of the terrestrial and marine biota from the Azores. *Princípio, Parede*.
- TUTIN, T.G., BURGESS, N.A., CHATER, A.O., EDMONDSON, J.R., HEYWOOD, V.H., MOORE, D.M., VALENTINE, D.H., WALTERS, S.M. & WEBB, D.A. (eds.) 1993. *Flora Europaea Vol. 1 Psilotaceae to Platanaceae*. 2nd. Ed., Cambridge, Cambridge University Press.
- VANDERPOORTEN, A., RUMSEY, F.J. & CARINE, M.A. 2007. Does Macaronesia exist? Conflicting signal in the bryophyte and Pteridophyte floras. *American Journal of Botany* 94: 625-639.
- VANDERPOORTEN, A., LAENEN, B., GABRIEL, R., GONZÁLEZ- MANCEBO, J. M., RUMSEY, F.J. & CARINE, M.A. 2011. Dispersal, diversity and evolution of the Macaronesian cryptogamic floras in Bramwell, D. & Caujapé-Castell, J. (eds.) *The Biology of Island Floras*. Cambridge University Press, Cambridge.
- WAGNER, W.H., MORAN, R.C. & WERTH, C.R. 1993. Aspleniaceae. In *Flora of North America* 6: 228-245. New York, Oxford University Press.
- WARD, C.M. 1970. The Pteridophytes of Flores (Açores): A survey with bibliography. *British Fern Gazette* 10:119-126.