



The recognition of infraspecific taxa in *Juniperus brevifolia* (Cupressaceae)

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Abstract

Based on morphological, genetic and ecological data, we describe new infraspecific taxa of the Azorean endemic *Juniperus brevifolia*. *J. brevifolia* subsp. *maritima* is an erect shrub or small tree, found in Flores, Terceira, Pico and São Jorge, in coastal scrubs below 100 m. *J. brevifolia* subsp. *brevifolia* occurs in all islands of the archipelago except Graciosa, between 300 and 1500 m. *J. brevifolia* subsp. *brevifolia* var. *brevifolia* is a small to medium tree found between 300 and 1000 m. *J. brevifolia* subsp. *brevifolia* var. *montanum* is a small prostrate shrub, common in mountain scrubs and blanket bogs, between 850 and 1500 m. The most striking morphological differences of subsp. *maritima* are the larger leaves, seed cones and seeds. Phenological patterns of the subspecies also differ, notably in the periods of seed maturation and pollination. The distribution of taxa within islands is peripatric. Coastal populations (subsp. *maritima*) are small and isolated from the usually much larger subsp. *brevifolia* populations, above 300 m. In subsp. *brevifolia* the varieties are parapatric, since their ranges are adjacent to each other, occurring together in narrow contact zones.

Keywords: Azores, Geographical patterns, Morphological characters, Short leafed juniper, Subspecies, Varieties

Introduction

Juniperus brevifolia (Seubert 1844: 26) Antoine (1857: 16) is the dominant tree species in most of the remaining Azorean native forests, especially above 500 m (Dias 1996; Dias *et al.* 2004, 2007; Elias & Dias 2009a; Elias *et al.* 2011). Its importance is recognized by several authors due to the presence of many endemic arthropods, bryophytes and vascular plants, including rare species, in native *J. brevifolia* dominated communities (e.g. Gabriel & Bates 2005; Homem & Gabriel 2008; Elias & Dias 2009b, 2009c; Cardoso *et al.* 2010; Gaspar *et al.* 2011). In fact, *Juniperus brevifolia*, protected by law since 1989, is considered a top priority for conservation in Macaronesia, based on a global set of criteria ranging from ecological value to social importance (Elias & Silva 2008).

Sequences from nuclear and chloroplast DNA (trnC-trnD spacer) have placed *J. brevifolia* in a clade with *J. navicularis* Gandoger (1910: 55), that is endemic to western coastal areas of mainland Portugal and it has been proposed that seeds of *J. navicularis*-like plants or their ancestor were brought to the Azores by birds from the Iberian Peninsula (Adams, 2008). A recent study, based on the analysis of five plastid DNA regions, by Rumeu *et al.* (2011), also found a close relation between *J. brevifolia* and *J. navicularis*. The results suggested that a single introduction event likely occurred from Europe and that genetic differentiation of *J. brevifolia* postdated the emergence of the oldest island (Santa Maria, 8.12 Ma, França *et al.* 2003).

In the study of Rumeu *et al.* (2011), the pre-Pleistocene (> 2.5 Ma, França *et al.* 2003) islands of São Miguel and Terceira were found to harbor the highest diversity levels and are the source of seven different haplotypes, thus playing a significant role in the diversification of the species. The results also highlight the importance of Terceira as a stepping-stone island within the Azores, fostering genetic connectivity in the archipelago. Equally important could have been the oldest island of Santa Maria, where it is possible that *J. brevifolia* first originated. However, the near-extinction of the species on that island enables only a glimpse of its potential genetic diversity. The results of Rumeu *et al.* (2011) also show that Graciosa (the fourth oldest island, with 2.5 Ma, França *et al.* 2003) could also have played a central role in the stepping-stone colonization of younger islands such as São Jorge, Faial and Pico. This is however impossible to confirm since this species is now extinct in Graciosa.

Caldeira da Aqualva, 650 m, 28 May 1988, *D. Silva 30* (AZU); Terceira, Caldeira da Aqualva, 650 m, 26 June 1988, *G. Madruga 10* (AZU); Terceira, Malha Verde, 515 m, June 1988, *J. Adriano 27* (AZU); Terceira, Biscoitos, 500 m, 18 June 1988, *A. Rino 5* (AZU); Terceira, Malha Verde, 515 m, June 1988, *Duarte 27* (AZU); Terceira, Biscoitos, 500 m, 27 June 1988, *Margarida 26* (AZU); Terceira, Malha Verde, 515 m, June 1988, *A. Raposo 27* (AZU); Terceira, Caldeira da Aqualva, 650 m, 28 May 1988, *J. Penacho 10* (AZU); Pico, Calheta Nesquim, 550 m, 24 April 1992, *T. Vieira 5* (AZU); Pico, Práinha, 550 m, 7 April 1992, *M. J. Silva 4* (AZU); Pico, Cabecinhos, 505 m, 11 June 2004, *R. B. Elias 16* (AZU); Faial, 750 m, 11 October 1998, *H. Schäfer 36* (AZU); São Miguel, Tronqueira, 651 m, 22 March 2005, *R. B. Elias 14* (AZU). Santa Maria, Almagreira, 190 m, 24 August 2001, *H. Schäfer* (AZU)

var. **montanum** R.B.Elias & E.Dias, var. nov.

Type:—PORTUGAL. Azores: Terceira, Santa Bárbara, Serra, 986 m a.s.l., 38° 43' 51.8" N, 27° 19' 42.8" W, 9 October 2002, *R. B. Elias 3* (AZU holotype and isotype).

Small prostrate shrub. Branches level with patent to erecto-patent branchlets. Leaves acuminate, patent to erecto-patent in whorls of 3 (5–7/cm), overlapping by 65%. Seed germination: April–June. Male cones 2.8–3.6 × 1.9–2.5 mm, with 9 microsporophylls. Pollination: April–June. Distribution: Flores, Terceira, Pico, São Jorge, Faial and São Miguel, between 850 and 1500 m a.s.l.

Other specimens seen: PORTUGAL. Azores: Flores, Morro Alto, 914 m, 15 October 2003, *R. B. Elias 10* (AZU); São Jorge, Pico dos Frades, 885 m, 8 August 2003, *R. B. Elias 7* (AZU); Pico, Montanha, 1225 m, 13 June 2004, *R. B. Elias 17* (AZU); São Miguel, Graminhais, 986 m, 23 March 2005, *R. B. Elias 18* (AZU).

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References

- Adams, R. P. (2008) *Junipers of the world: the genus Juniperus, 2nd edition*. Trafford Publishing Co., Vancouver, Canada, 402 pp.
- Antoine, F. (1857) *Die Kupressineengattungen Arceuthos, Juniperus, und Sabina*. Wien, 16 pp.
- Azevedo, E.B. (1996) *Modelação do clima insular à escala local – Modelo CIELO aplicado à ilha Terceira*. Ph.D. Dissertation, Universidade dos Açores. Angra do Heroísmo. Azores, Portugal.
- Cardoso, P., Borges, P.A.V., Dinis, F. & Gaspar, C. (2010). Patterns of alpha and beta diversity of epigeal arthropods at contrasting land-uses of an oceanic island (Terceira, Azores). In: Serrano, A.R.M., Borges, P.A.V., Boieiro, M. & Oromí, P. (Eds.) *Terrestrial arthropods of Macaronesia – Biodiversity, Ecology and Evolution*. Sociedade Portuguesa de Entomologia, Lisboa, pp. 73–88.
- Christensen, K.I. (1987) Taxonomic revision of the *Pinus mugo* complex and *P. × rhaetica* (*P. mugo* × *sylvestris*) (Pinaceae). *Nordic Journal of Botany* 7: 383–408.
<http://dx.doi.org/10.1111/j.1756-1051.1987.tb00958.x>
- Dias, E. (1996) *Vegetação natural dos Açores*. PhD thesis, University of the Azores.
- Dias, E., Elias, R.B. & Nunes, V. (2004) Vegetation mapping and nature conservation: a case study in Terceira island (Azores). *Biodiversity and Conservation* 13: 1519–1539.
<http://dx.doi.org/10.1023/b:bioc.0000021326.50170.66>
- Dias, E., Elias, R.B., Melo, C. & Mendes, C. (2007) Biologia e ecologia das florestas das ilhas - Açores. In: Silva, J.S. (Ed.) *Árvores e florestas de Portugal – Vol. 6*. Público, Comunicação Social, SA/ Fundação Luso-Americana/ Liga para a Protecção da Natureza, pp. 51–80.
- Elias, R.B. (2007) *Ecologia das florestas de Juniperus dos Açores*. PhD thesis, University of the Azores.
- Elias, R.B. & Silva, L. (2008) *Juniperus brevifolia* (Seub.) Antoine. In: Martín, J.L., Arechavaleta, M.J., Borges, P.A.V. & Faria, B. (Eds.)

Top 100 Las cien especies amenazadas prioritarias de gestión en la región europea biogeográfica de la Macaronesia. Consejería de Medio Ambiente y Ordenación Territorial, Gobierno de Canarias, pp. 182–183.

- Elias, R.B. & Dias, E. (2009a). Gap dynamics and regeneration strategies in *Juniperus-Laurus* forests of the Azores islands. *Plant Ecology* 200: 179–189.
<http://dx.doi.org/10.1007/s11258-008-9442-x>
- Elias, R.B. & Dias, E. (2009b). Cyclic patch dynamics in a Macaronesian island forest. *Community Ecology* 10: 25–34.
<http://dx.doi.org/10.1556/ComEc.10.2009.1.4>
- Elias, R.B. & Dias, E. (2009c) The effects of landslides on the mountain vegetation of Flores island, Azores. *Journal of Vegetation Science* 20: 706–717.
<http://dx.doi.org/10.1111/j.1654-1103.2009.01070.x>
- Elias, R.B., Dias, E. & Pereira, F. (2011) Disturbance, regeneration and the spatial pattern of tree species in Azorean mountain forests. *Community Ecology* 12: 23–30.
<http://dx.doi.org/10.1556/ComEc.12.2011.1.4>
- França, Z., Cruz, J.V., Nunes, J.C. & Forjaz, V.H. (2003) Geologia dos Açores: uma perspectiva actual. *Açoreana* 10: 11–140.
- Gabriel, R. & Bates, J.W. (2005) Bryophyte community composition and habitat specificity in the natural forests of Terceira, Azores. *Plant Ecology* 177:125–144.
<http://dx.doi.org/10.1007/s11258-005-2243-6>
- Gandoger, M.M. (1910) Notes sur la flore hispano-portugaise. Quatrième voyage en Portugal. *Bulletin de la Société Botanique de France* 57: 55.
<http://dx.doi.org/10.1080/00378941.1910.10832175>
- Gaspar, C., Gaston, K.J., Borges, P.A.V. & Cardoso, P. (2011) Selection of priority areas for arthropod conservation in the Azores archipelago. *Journal of Insect Conservation* 15: 671–684.
<http://dx.doi.org/10.1007/s10841-010-9365-4>
- Homem, N. & Gabriel, R. (2008) *Briófitos raros dos Açores*. Principia, Oeiras, 94 pp.
- IUCN (2012) *IUCN Red List of Threatened Species. Version 2012.2*. Available from: www.iucnredlist.org (accessed 14 February 2013).
- Monteleone, I., Ferrazzini, D. & Belletti, P. (2006) Effectiveness of neutral RAPD markers to detect genetic divergence between the subspecies *uncinata* and *mugo* of *Pinus mugo* Turra. *Silva Fennica* 40(3): 391–406.
<http://dx.doi.org/10.14214/sf.476>
- Rumeu, B., Nogales, M., Elias, R.B., Padilla, D.P., Resendes, T., Rodríguez, A.F. & Dias, E. (2009) Contrasting phenology and female cone characteristics of the two Macaronesian island endemic cedars (*Juniperus cedrus* and *J. brevifolia*). *European Journal of Forest Research* 128: 567–574.
<http://dx.doi.org/10.1007/s10342-009-0304-4>
- Rumeu, B., Caujapé-Castells, J., Blanco-Pastor, J. L., Jaén-Molina, R., Nogales, M., Elias, R.B. & Vargas, P. (2011) The colonization history of *Juniperus brevifolia* (Cupressaceae) in the Azores islands. *PLoS ONE* 6: e27697.
<http://dx.doi.org/10.1371/journal.pone.0027697>
- Seubert, M. (1844) *Flora Azorica: quam ex collectionibus schedisque Hochstetteri patris et filii*. Apud Adolphum Marcum. Bonnae.
<http://dx.doi.org/10.5962/bhl.title.60217>
- Silva, L., Elias, R.B., Moura, M., Meimberg, H. & Dias, E. (2011) Genetic variability and differentiation among populations of the Azorean endemic gymnosperm *Juniperus brevifolia*: Baseline information for a conservation and restoration perspective. *Biochemical Genetics* 49: 715–734.
<http://dx.doi.org/10.1007/s10528-011-9445-5>
- Stuessy, T.F. (2009). *Plant taxonomy: The systematic evaluation of comparative data, 2nd edition*. Columbia University Press. New York, USA, 539 pp.
- Ter Braak, C.J.F. & Šmilauer, P. (2002) *CANOCO Reference Manual and CanoDraw for Windows User's Guide: Software for Canonical Community Ordination (version 4.5)*. Microcomputer Power. Ithaca, NY, 500 pp.
- Turra, A. (1764) Dei vegetabili di Monte Baldo. *Giornale italiano di Scienze Naturali* 1: 117–120.