



## Typification of the Iberian endemic Juniper *Juniperus navicularis* Gand. (Cupressaceae)

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### Abstract

The typification of the name *Juniperus navicularis* (Cupressaceae) is provided, based on a thorough literature review and examination of original herbarium material deposited in the Gandoger collection (LY). In addition to discussing the historical background of the name and various assignments by different authors, we further studied additional types from Portuguese collections (LISU, COI, and PO) and other historical herbaria (H and P), cited in the species protologue.

**Key words:** Lectotype, nomenclature, *Juniperus oxycedrus*, taxonomy, type, Gandoger

### Introduction

*Juniperus* Linnaeus (1753: 1038) (Cupressaceae) is a phanerophytic genus with a continuous distribution across the northern hemisphere, where it is an important component in semi-arid and mountain ecosystems. Within the genus, three sections were recognized by Adams (2004): 1- Sect. *Caryocedrus* Endlicher (1847: 2); 2- Sect. *Juniperus*, and 3—Sect. *Sabina* (Miller 1754: 412) Spach (1841: 291). This division has been later supported by molecular studies (Adams 2008, Mao *et al.* 2010). Yang *et al.* (2022), in a recent gymnosperm classification, treated the sections as three different genera, i.e., *Arceuthos* Antoine & Kotschy (1854: 249), *Sabina* Miller (1754: 412) and *Juniperus*, respectively. *Juniperus s. str.* comprises about 13 dioecious species (Adams 2014) that occur from the Mediterranean and Macaronesian regions to East Asia with one circumboreal species, i.e., *J. communis* Linnaeus (1753: 1040), distributed also in North America (Caudullo *et al.* 2017). Characteristic features of this group are the linear-acicular leaves in whorls of three with whitish stomatal bands on the upper side and articulated at the base, and mature cones varying in size, ranging from 8 to 18 mm, and bluish or reddish in color, usually including three seeds. Within this group, there is a Mediterranean-Macaronesian species aggregate that includes *J. oxycedrus* Linnaeus (1753: 1038) and six allied species characterized by leaves with two stomatal bands and red-orange mature seed cones (Adams 2014): *J. badia* (Gay 1889: 501) Rivas-Martínez, Molero Mesa, Marfil & G.Benítez (2020: 119), *J. brevifolia* Antoine (1857: 16), *J. cedrus* Webb & Berthelot (1847: 277), *J. deltoides* Adams (2004: 47), *J. macrocarpa* Smith (1816: 263), *J. navicularis* Gandoger (1910: 55), and *J. maderensis* (Menezes 1908: 227-228) Adams (2010b: 53) (Adams *et al.* 2010a-b, Adams & Schwarzbach 2012, Díez-Garretas *et al.* 2017). Among these, the sea sands juniper (*J. navicularis*) was

initially described by Gandoger (1910) as a putative new species, based on samples collected from different localities in Portugal. These included Extremadura (surroundings of the village of Coína), and Alentejo Litoral (surroundings of the villages of Tróia, Alcácer do Sal and Grândola). The species was included in the variability of *J. oxycedrus* var. *brachyphylla* Loret (1865: 282) in Billot (1865) by Coutinho (1909) or *J. macrocarpa* by Sampaio (1910).

The range of *J. navicularis* comprises Portugal and Spain, mostly across the acidic and sandy coastal areas of the Coastal Lusitanian and West Andalusian biogeographical province (Rivas-Martínez *et al.* 2017). The species grows both in the understory of psamphilic cork oak forests and Montado (*Aro neglecti-Quercetum suberis*) and inland dunes (palaeodunes of Plio-Quaternary origin). It can thrive also in podzolized soils with a clay bedrock, often with a deep water table, where microphanerophytic communities develop (Rivas-Martínez 1990, Neto 2002, Neto *et al.* 2007, Rivas-Martínez *et al.* 2011, Costa *et al.* 2012, García *et al.* 2014). The sea sands Juniper is a Near Threatened species following IUCN criteria (NT), and has the same status at the Portuguese national level, being severely threatened by land use change and ageing of its populations (Farjon 2013, Castro *et al.* 2016, Carapeto *et al.* 2020).

Different studies have been conducted about the putative phylogenetic relationships of *J. navicularis* and the rest of the taxa within *Juniperus* sect. *Juniperus*. Historically, there has been ambiguity regarding its placement, usually associating it alternatively either with the *J. oxycedrus* group or with the Azorean species *J. brevifolia* (Adams 2014). A preliminary approach to these relationships was proposed by Adams *et al.* (1998, 2000), by analyzing essential oils, concluded that *J. brevifolia* had a divergent evolutionary pathway, while *J. navicularis* resulted more closely related to *J. oxycedrus* and *J. communis*. Nevertheless, a phylogenetic tree based on the Internal Transcribed Spacer (ITS) region of nrDNA and one plastid DNA region pointed otherwise, suggesting sister relationships for *J. navicularis* and *J. brevifolia* (Adams 2008, Adams *et al.* 2010a). Rumeu *et al.* (2011), although based on two plastid regions only, confirmed such a sister relationship, which was recovered in a well-supported clade. Shortly afterwards, Adams & Schwarzbach (2012) based on nrDNA ITS and five plastid DNA regions, recovered *J. navicularis* in a well-supported clade with *J. brevifolia* and *J. deltoides*, while *J. oxycedrus* and allies, including the Macaronesian taxa *J. cedrus* and *J. maderensis*, were clustered in another well-supported clade. Later, Boratyński *et al.* (2014) explored the biogeography and genetic relationships of *J. oxycedrus* and related taxa, using SSR loci, concluding that *J. navicularis* is genetically quite different from its relatives. Finally, Adams *et al.* (2014) combined integrative information and confirmed the already stated relationship between *J. navicularis*, *J. brevifolia*, and *J. deltoides* (Adams *et al.* 2014), although uncertainties regarding the evolutionary relationships of several lineages and taxa within the *J. oxycedrus* group remain (Rumeu *et al.* 2014). The separation between *J. deltoides* and *J. oxycedrus* s.l. (including *J. badia*) was also confirmed by Roma-Marzio *et al.* (2017), through analysis of essential oils and comparison of morphometric data. *Juniperus navicularis* was reported as a diploid species by Romo *et al.* (2013) and Farhat *et al.* (2019). A morphological and ecological/chorological analysis was also performed by Díez-Garretas *et al.* (2017) to distinguish this species from *J. oxycedrus* and *J. macrocarpa*. These authors found support for the morphological distinctiveness of *J. navicularis*, reinforcing its taxonomic status as distinct species within the Mediterranean Junipers group. Whilst different phylogenetic approaches consistently relate this juniper to the Macaronesian-Azorean *J. brevifolia*, the biogeographical and ecological hypothesis is also supported, since *J. brevifolia* occurs in mesic habitats (Elias 2007) and *J. navicularis* grows normally in areas with a higher water table content, or edaphic compensation due to the existence of clayed bedrock (podzols). This ensures higher levels of soil moisture, in thermomediterranean Atlantic areas (Rivas-Martínez *et al.* 2017), confirming the biogeographic connection of lineages that links the Macaronesian archipelagos to the Iberian Southwest, already suggested by different works (De Mera *et al.* 1997, Latorre & Cabezudo 2006, Vila-Viçosa *et al.* 2020, Vila-Viçosa & Arsénio 2021, Vila-Viçosa 2023). Overall, congruence between biogeography, ecology and phylogenetics suggests that *J. navicularis* and *J. brevifolia* belong to a Macaronesian-Iberian disjunct lineage having higher soil moisture and low temperature sensitivity, therefore with relict environmental features.

Because of the taxonomic and phylogenetic uncertainty regarding *Juniperus* sect. *Juniperus*, and lacking a proper typification of *J. navicularis*, a review including the historical study of specimens cited by all authors involved in its adscription to different taxonomic ranks is necessary. Thus, this paper aims to correctly identify, by the typification of the name, this Iberian endemic and threatened micro-tree (Diez-Garretas *et al.* 2017) and contribute to future studies that will help to unveil the taxonomic and phylogenetic relationships among this cryptic and important group of conifers from the Macaronesian-Mediterranean Macro-Region.

## Materials and methods

The designation of the lectotype is based on the study of Gandoger's specimens, kept in the herbarium of the Université Claude Bernard in Lyon (LY) and the literature cited in the protologue (Gandoger 1910). Supplementary specimens that were mentioned in the protologue and deposited at LISU, COI, PO and H, were also studied. The typification follows the International Code of Nomenclature for algae, fungi, and plants (Turland *et al.* 2018).

Author names and abbreviations follow IPNI ([www.ipni.org](http://www.ipni.org)) or Phytotaxa guidelines, when necessary and the codes of consulted herbaria are indicated according to Index Herbariorum (Thiers, B. M., updated continuously, <http://sweetgum.nybg.org/science/ih/>).

## Results and discussion

### *Background and typification of the name*

*Juniperus navicularis* was described by Gandoger (1910) after a second trip to Portugal and Spain to explore inaccessible Atlantic regions in 1905. Notably, the author suggested a putative relationship of his new species with *J. brevifolia* in the labels of the studied specimens (LY0772612! and LY0772611!) (Figures 1 and 2). This was stated *in schedulis*: “*An species nova prope J. brevifoliam Ant. (e Madera)*” and “*Affinis J. brevifoliae Ant. (e Madera et Azor)*” (Figures 1 and 2). The author had first labeled the specimens as *J. umbilicata* and acknowledged in the protologue that the plant was reported by other Portuguese botanists as *J. macrocarpa*. Previously, Coutinho (1909) identified these plants as *J. oxycedrus* var. *brachyphylla* Loret in Billot (1861: 282), as populations possessing mostly non-pruinose cones with 6–12 mm in diameter and occurring from coastal Alentejo to near Setúbal, including specimens collected by Welwitsch and reported by Parlatore (1864). In the same work, Coutinho (1909) identified the junipers from the Tagus River, with pungent and larger leaves (18 × 10 mm wide) as *J. macrocarpa* (Coutinho 1909). On the other hand, Sampaio (1910, 1913) initially identified the specimens from Coastal Alentejo as *J. macrocarpa* due to their habitat and the shorter leaves, when compared with those from the Douro basin (Northeast Portugal). However, the author (Sampaio 1910, 1913) gave an erroneous cone size of 12–15 mm, which he later decreased into 6–9 mm, when referring to the coastal Alentejo populations (Sampaio 1922). Here, the author stated for the first time that these populations could be a geographical “race” of *J. macrocarpa* (Sampaio 1922), but he did not publish validly any new combination (art. 36.1). Instead, he listed the southwestern Portuguese populations under the name *J. rufescens* Link (nom. illeg., Art 38.1) in Kunze (1846: 579), based on the work of Endlicher (1847). Coutinho (1926) was aware of Gandoger's name and refuted that the plants from Alentejo belonged to *J. oxycedrus* var. *brachyphylla*, although he later proposed the combination *J. oxycedrus* subsp. *rufescens* (Link) Coutinho in his *Flora de Portugal* (Coutinho 1939). This name was already validly published by Debeaux (1894), based on specimens from Kabylia (Algeria), turning Coutinho's combination illegitimate as a later homonym of the former name. The name *J. rufescens* itself is illegitimate, as it was meant to be a replacement name for *J. oxycedrus* to prevent further confusions with *J. macrocarpa*, thus becoming a superfluous synonym. Nevertheless, *J. oxycedrus* subsp. *rufescens* (Link) Debeaux is not illegitimate, as it has a different type than *J. oxycedrus* L.

Later, Franco (1963) formalized a proposal to classify this taxon (*J. navicularis* Gand.) at the subspecific rank with a new name, *J. oxycedrus* subsp. *trastagana* Franco (1963: 166). This proposal was done disregarding Gandoger (1910) and was supported by specimens cited by Coutinho (1909) (Figure 3). The subspecific status was chosen because of the similarity of the cones to those of *J. oxycedrus*, although its quite specific ecology was recognized, related to Pleistocene sands from the Tagus-Sado Cenozoic basin (Carvalho *et al.* 1983, Neto *et al.* 2007). Later, Silba (1984) proposed the combination *J. oxycedrus* var. *trastagana* (Franco) Silba (1984: 35), and finally, Franco (1986, 1993) recognized *J. navicularis* in both *Flora Iberica* and *Flora Europea* as a southwestern Iberian endemic juniper.



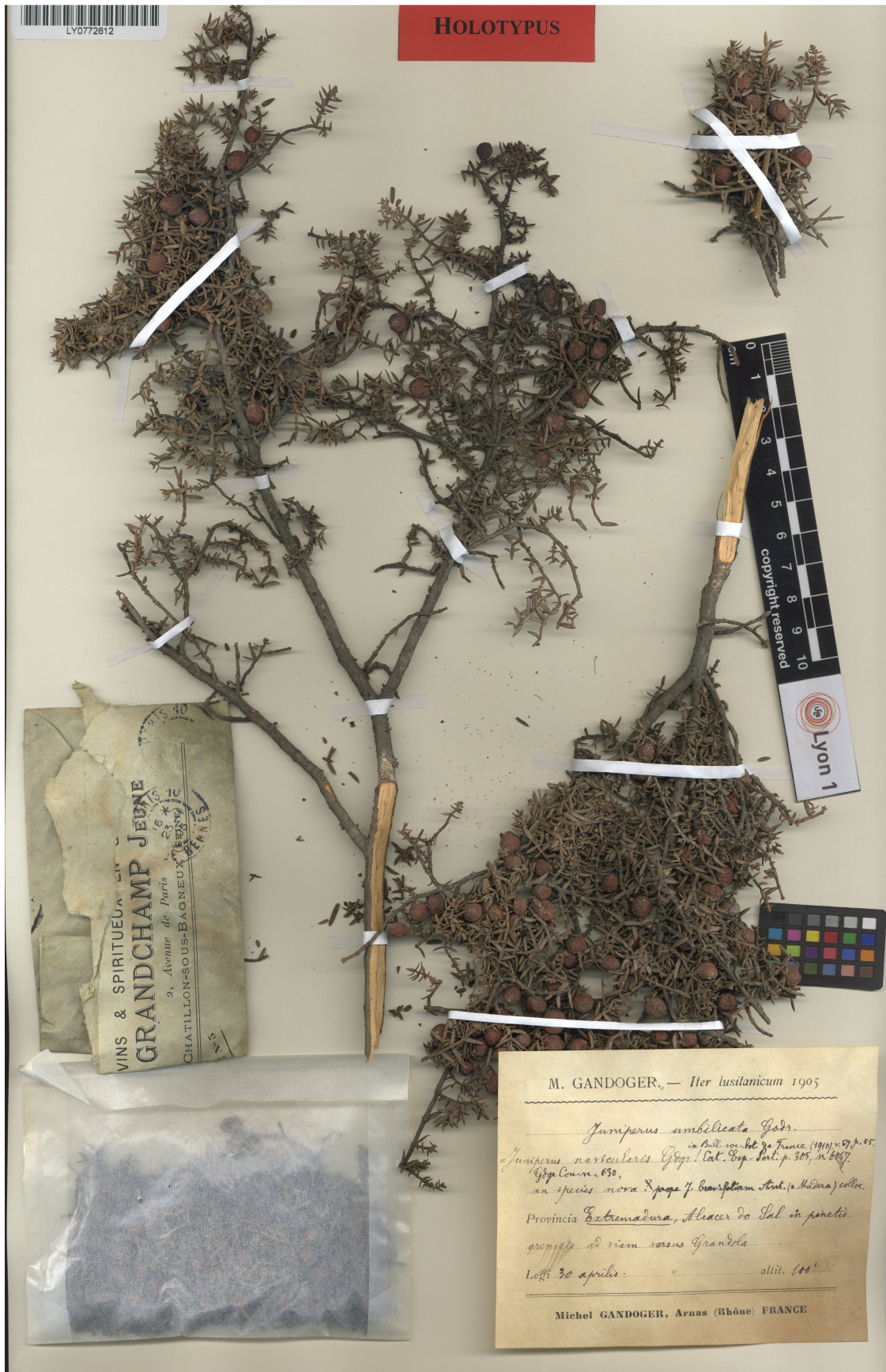


FIGURE 1. Lectotype of *Juniperus navicularis* Gand. (1910: 55) LY0772612!, Herbar LY, Fr BioEEnVis, UCB Lyon 1.



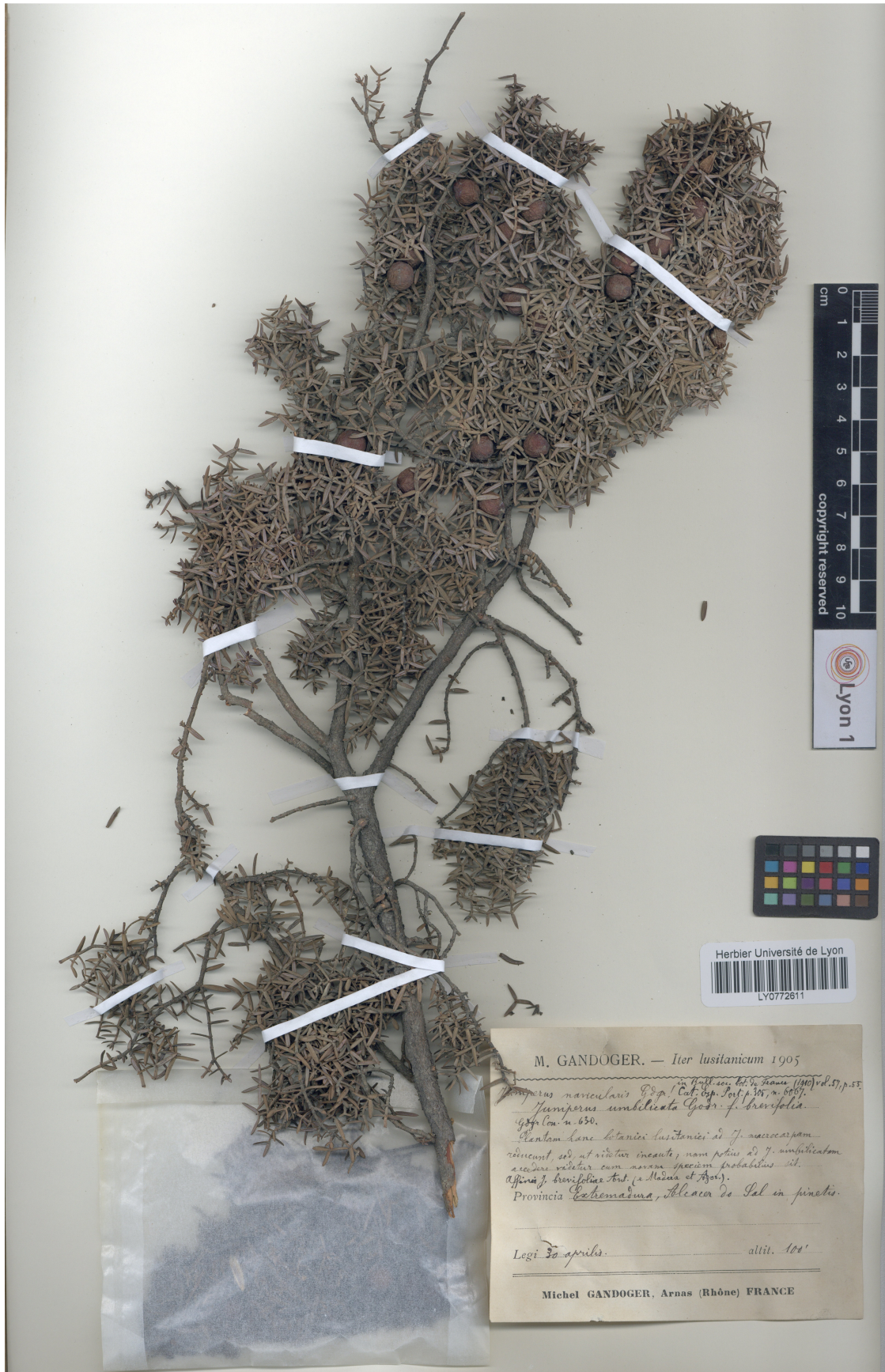


FIGURE 2. Isolectotype of *Juniperus navicularis* Gand. (1910: 55) LY0772611!, Herbier LY, Fr BioEEnVis, UCB Lyon 1.



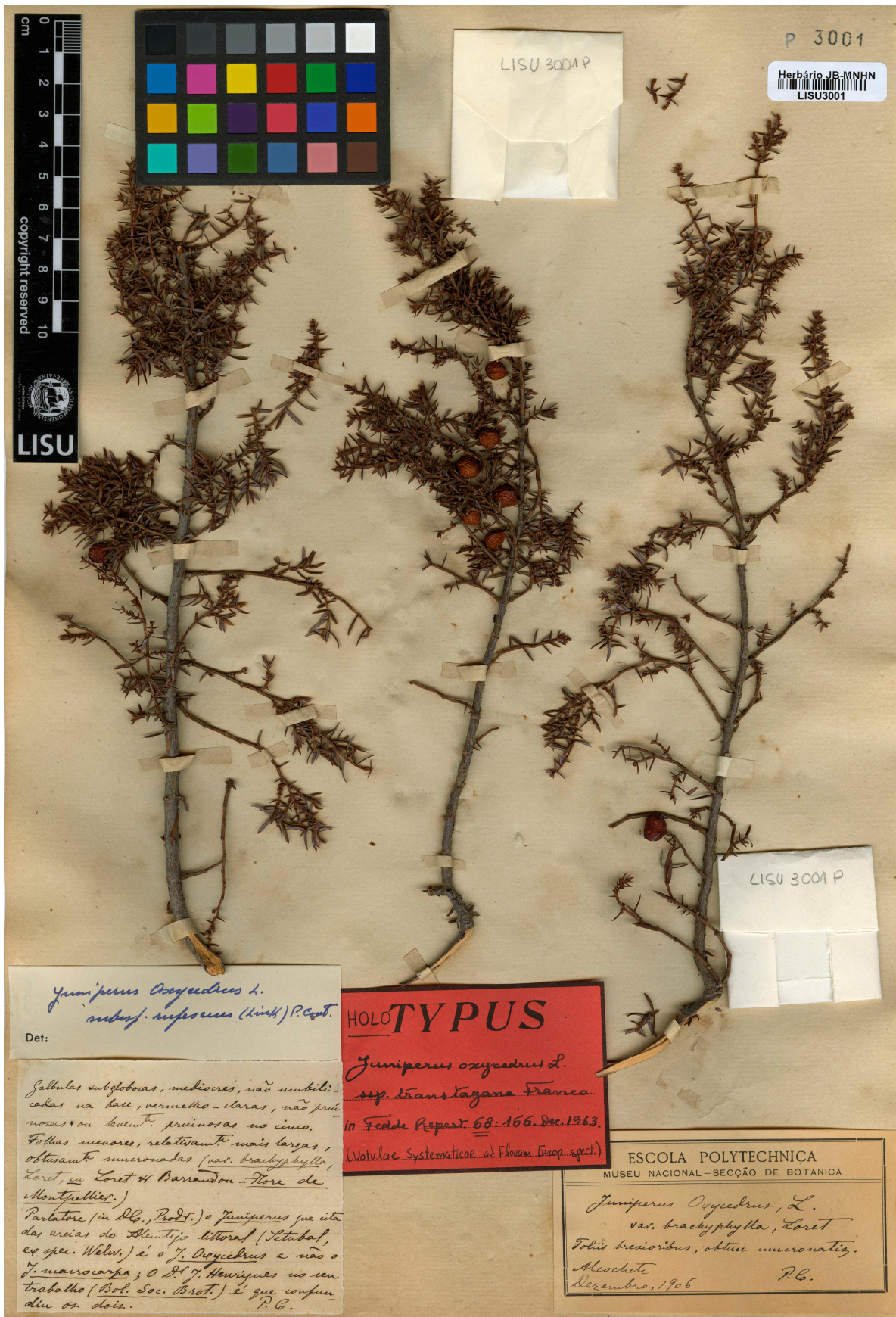


FIGURE 3. Holotype of *Juniperus oxycedrus* subsp. *transtagana* Franco (1963: 166) (LISU3001!).



## Description

*J. navicularis* has leaves of 4–12 × 1–1.5 mm, which are patent, lanceolate, concave (navicular), attenuated from the middle, sometimes mucronated, with stomatal bands wider than the central green band and round cones up to 10–12 mm with three seeds, very rarely 4 or 5. It can thus be readily separated from *J. oxycedrus* s. str., which also has cones up to 10–12 mm (but generally smaller), because the leaves of the latter are longer, 8–20(–25) × 1–1.5 mm, with a pungent mucron in all stages of development and stomatal bands as wide as the central green band, which is prominent. The cones very often have more than three larger seeds (ca. 6 × 5 mm). As was pointed out above, it can be distinguished from *J. macrocarpa* because this one has cones (10) 12–18 mm wide, often pruinose, with a foul smell, and leaves 20–25 × 2–2.5 mm, lanceolate in shape, with the widest point towards the middle and attenuated into a pricy mucron, more evident in young trees. The seeds are quite distinct, generally ovate, longer but narrower (7 × 4.6 mm) (Franco 1986, pers. obs.).

*Juniperus navicularis* is a name that needs to be typified. As stated above, Gandoger did not cite any specimens, nor any herbarium, but three collections near Lisbon, done by Moller (Coína), Daveaux (Troia) and Gandoger himself (between Alcácer do Sal and Grândola). Following the art. 7.11 example 13 and note 1 of art. 40, we proposed all specimens of those collections as syntypes. While we have been able to locate several specimens belonging to those collections, among them, the specimens from LY are the best preserved original materials. We designate LY0772612 as the lectotype, as this specimen mirrors the species morphological description, based in the leaf and fruit dimensions. Moreover, the label explicitly mentions *In Scheda “Extremadura, Alcacer do Sal in pinetis arenosis ad viam versus Grandola*, which is congruent with the original protologue (Gandoger 1910).

*Juniperus navicularis* Gandoger (1910: 55) = *Juniperus macrocarpa* subsp. *rufescens* (Link) Samp. (1922: 124) = *Juniperus oxycedrus* subsp. *transtagana* Franco (1963:166) ≡ *Juniperus oxycedrus* var. *transtagna* (Franco) Silba (1984: 35).

Type (Lectotype, designated here):—PORTUGAL, Extremadura: Alcácer do Sal, *In pinetis arenosis ad viam versus Grandola*, 30 April 1905, Gandoger, s.n. (LY0772612!); Isolectotype—(LY0772611!); Syntypes—PORTUGAL, Extremadura: Entre Azeitão e Coína, April 1887, A. Moller s.n. (LISU1735!; POV195 G.S!; COI82002!; H1504182!); PORTUGAL, Extremadura: Arredores de Setúbal, Tróia, Jules Daveaeu s.n. February 1888 (LISU2995!; 2996!); PORTUGAL, Extremadura: Península de Tróia, April 1881, Jules Daveau s.n. (LISU3005!); PORTUGAL, Extremadura: Tróia, February 1888, Jules Daveau s.n., (LISU3002!; 3003!); PORTUGAL, Extremadura: Tróia, Praia da Malha da Costa, April 1879, Jules Daveau s.n. (LISU3008!; COI-82003!); Portugal, Extremadura: Tróia, Sables de la Peninsule de Troia, May 1879, Jules Daveau s.n. (LISU3009!).

*Juniperus oxycedrus* subsp. *transtagana* Franco (1963: 166)

Type (Holotype, Franco (1963)):—PORTUGAL, Extremadura: Alcochete, August 1906. António Pereira Coutinho s.n. (LISU-3001!).

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