



Molecular and morphological evidence supports the resurrection of a neglected species of *Daucus* (Apiaceae) from North Africa

FERNANDO MARTÍNEZ-FLORES*, ANA JUAN and MANUEL B. CRESPO

CIBIO (Instituto Universitario de la Biodiversidad), Universidad de Alicante, Apdo. 99, E-03080 Alicante, Spain

Received 11 July 2011; revised 7 December 2011; accepted for publication 17 December 2011

A neglected species of *Daucus* (Apiaceae), *D. mauritii*, endemic to northern Morocco, is revived. A full description, illustrations and photographs are provided, and a lectotype is designated. This species has previously been synonymized under *D. muricatus*. However, although *D. mauritii* shares morphological features with *D. muricatus* and *D. aureus*, it shows a unique combination of characters that warrants recognition as a distinct species. Analysis of (internal transcribed spacer, ITS), *trnQ-rps16* intergenic spacer and *rps16* intron sequences indicates that *D. mauritii* is closely related to *D. aureus*. © 2012 The Linnean Society of London, *Botanical Journal of the Linnean Society*, 2012, 169, 320–337.

ADDITIONAL KEYWORDS: Daucinae – nrDNA – plastid DNA – taxonomy.

INTRODUCTION

Daucus L. (Apiaceae) is a genus of wild carrot with at least 20 (Sáenz, 1981) to 60 (Zohari, 1987: 448) species. *Daucus* spp. are distributed throughout most of the world, but the major genetic variability for the genus is found in the Mediterranean basin (14 species), with only one species native to Oceania and three native to America (Sáenz, 1981). The genus is represented in northern Morocco by *D. aureus* Desf., *D. carota* L., *D. crinitus* Desf., *D. durieua* Lange, *D. muricatus* (L.) L. and *D. setifolius* Desf. (Jury, 2002). During fieldwork aimed to increase the floristic knowledge of this area, several *Daucus* populations of unknown identity were found. In the field, these plants superficially resembled *D. aureus*, but the fruits were closer to those of *D. muricatus*. However, the indumentum and bract morphology were not typical of those species.

Further studies, using identification keys for northern Morocco and neighbouring regions, led to inconsistent results. According to Jury (2002) and Pujadas

(2003), our samples approached *D. aureus* and *D. muricatus*, although they appeared to be closer to the former. Following Quézel & Santa (1963), no conclusive results were reached (the plant shared characters with *D. sahariensis* Murb., *D. aureus* and *D. muricatus*). Following Pignatti (1982: 249) and Heywood (1968), our taxon appeared to be *D. broteri* Ten. Finally, according to the global revision keys of Sáenz (1981), our samples were identified, with difficulty, as *D. muricatus*. A subsequent bibliographical search did not allow us to solve the problem as the frequent lack of detailed descriptions and iconography prevented a successful identification of our samples. Therefore, it was necessary to review herbarium material in an attempt to find a solution and to ensure that we were not dealing with a new species. Further research focused on *D. mauritii* (Sennen ex Maire) Sennen, a plant usually included in *D. muricatus* at different ranks (Sennen & Mauricio, 1934: 51; Maire, 1935; Sennen, 1936), which seemingly resembled our collections. The main objective of the present contribution is to explore the taxonomic relationships of *D. mauritii* and to identify the morphological traits warranting its taxonomic independence.

*Corresponding author. E-mail: f.martinez@ua.es

Morphological and molecular evidence is used to confirm the segregation of *D. mauritii* at species rank and to analyse its position and similarities in *Daucus*. A thorough description is also provided to facilitate future comparisons and to avoid misidentifications with related species.

MATERIAL AND METHODS

MORPHOLOGY AND ANATOMY

Morphological observations were based on fresh material collected in Morocco, Portugal and Spain, and herbarium specimens from ABH, B, BOLO, K, MA, MPU, LISI and RNG (abbreviations according to Thiers, 2011). Samples of *D. aureus*, *D. broteri*, *D. mauritii*, *D. muricatus* and *D. sahariensis* were studied. Representative herbarium material examined is listed in the Appendix. Morphological observations were made on flowering and fruiting plants. Measurement of rays, bracts, bracteoles, flowers and fruits were made exclusively on primary and secondary umbels.

MOLECULAR ANALYSES

Silica gel-dried material for the species was used for total DNA extraction employing a modified 2 × cetyltrimethylammonium bromide (CTAB) protocol (Doyle & Doyle, 1987). Total DNA was purified using MOBIO minicolumns and mostly kept in 0.1 × TE buffer [10 mM Tris-HCl, 1 mM ethylenediaminetetraacetic acid (EDTA), pH 8.0]. The internal transcribed spacer (ITS) region of nuclear ribosomal DNA was amplified using the ITS5 and ITS4 primers (White *et al.*, 1990) according to Downie & Katz-Downie (1996). Polymerase chain reaction (PCR) amplifications of the *trnQ-rps16* intergenic spacer (hereafter *trnQ-rps16*) and *rps16* intron were obtained using the primer pairs *trnQ/rps16-1R* and *5'exon(rps16)/3'exon(rps16)*, respectively (Downie *et al.*, 2008).

Sequencer 4.1 (Gene Codes Corp., Ann Arbor, MI, USA) was used to assemble complementary strands and verify software base-calling. All DNA regions were aligned using ClustalW conducted in MEGA 5.02 (Tamura *et al.*, 2011) with minor manual corrections.

Sequence data for 13 accessions were obtained specifically for this study (Table 1). Available sequences for *D. sahariensis*, *D. broteri* [as *D. bicolor* Sibth. & Sm. ssp. *broteri* (Ten.) Okeke] and *Berula erecta* (Huds.) Coville ssp. *erecta* were retrieved from GenBank for comparison and outgroup purposes (AY065320.1 + AY065321.1, AF077783.1 + AF077098.1, AY360231.1 + EF185210.1, respectively).

First, phylogenetic analyses of the ITS, *trnQ-rps16* and *rps16* intron data in combination were obtained

using neighbor-joining (NJ) (Saitou & Nei, 1987), maximum likelihood (ML) (Felsenstein, 1981) and maximum parsimony (MP) (Nei & Kumar, 2000) as implemented in MEGA 5. NJ and ML models with the lowest BIC (Bayesian information criterion) scores were considered to best describe the substitution pattern.

Evolutionary distances for NJ were estimated using the three-parameter method of Tamura (1992), the rate variation among sites was modelled with a Gamma distribution ($G = 0.2411$) and the ambiguous positions were removed for each sequence pair. ML was conducted using the Tamura three-parameter model, a discrete Gamma distribution was used ($G = 0.2413$), all gaps in the matrix were considered and the tree searching strategy was based on nearest-neighbour interchange (NNI). MP was performed without gap exclusion and using the max-mini branch & bound search method. For all methods, support was assessed using the bootstrap (Felsenstein, 1985) with 5000 replicates.

In addition, a pairwise distance estimation was conducted using the Tamura three-parameter model, with $G = 0.2411$, removing all ambiguous positions for each sequence pair and including a standard error estimation (obtained by a 5000 replicate bootstrap procedure).

As a result of the lack of *trnQ-rps16* and *rps16* intron sequences for some species, a second phylogenetic analysis was conducted considering only ITS1 and ITS2 (excluding 5.8S rRNA). As above, NJ, ML and MP were performed. NJ was conducted on the two-parameter model of Kimura (1980), the rate variation among sites was modelled with $G = 0.9517$ and the ambiguous positions were removed for each sequence pair. ML was performed on the Kimura two-parameter model, a 1.7484 Gamma distribution was used, all gaps in the matrix were considered and the tree searching strategy was based on NNI. MP was conducted without gap exclusion using the max-mini branch & bound search method. Again, 5000 bootstrap replicates were used to test topologies.

RESULTS

DESCRIPTION

Daucus mauritii (Sennen ex Maire) Sennen, Diagn. Nouv.: 191 (1936).

Basionym: *D. muricatus* var. *mauritii* Sennen ex Maire in Bull. Soc. Hist. Nat. Afrique N. 26: 206 (1935).

– *D. mauritii* Sennen, Cat. Fl. Rif Orient.: 51 (1934), nom. nud.

Table 1. Data of materials used in the molecular analyses

Label on trees	Taxon	Origin	Voucher	Genbank reference
<i>D. arcanus</i>	<i>Daucus arcanus</i> García-Martín & Silvestre	Spain	ABH 53887	JQ290118
<i>D. aureus</i> ALGERIA	<i>Daucus aureus</i> Desf.	Algeria	ABH 57786	JQ290120
<i>D. aureus</i> SPAIN	<i>Daucus aureus</i> Desf.	Spain	ABH 55117	JQ290119
				JQ290131
				JQ290139
<i>D. carota</i>	<i>Daucus carota</i> L. ssp. <i>hispanicus</i> (Gouan) Thell.	Spain	ABH 53270	JQ290121
				JQ290132
				JQ290140
<i>D. crinitus</i>	<i>Daucus crinitus</i> Desf.	Spain	ABH 52065	JQ290122
<i>D. durieua</i>	<i>Daucus durieua</i> Lange	Spain	ABH 53919	JQ290123
				JQ290133
				JQ290141
<i>D. mauritii</i> 1	<i>Daucus mauritii</i> (Sennen ex Maire) Sennen	Morocco	ABH 55659	JQ290124
				JQ290134
				JQ290142
<i>D. mauritii</i> 2	<i>Daucus mauritii</i> (Sennen ex Maire) Sennen	Morocco	ABH 55656	JQ290125
<i>D. muricatus</i> MOROCCO	<i>Daucus muricatus</i> (L.) L.	Morocco	ABH 55634	JQ290126
				JQ290135
				JQ290143
<i>D. muricatus</i> SPAIN	<i>Daucus muricatus</i> (L.) L.	Spain	ABH 53894	JQ290127
				JQ290136
				JQ290144
<i>D. pusillus</i>	<i>Daucus pusillus</i> Michx.	Argentina	ABH 57683	JQ290128
				JQ290137
				JQ290145
<i>D. setifolius</i>	<i>Daucus setifolius</i> Desf.	Spain	ABH 53906	JQ290129
				JQ290138
				JQ290146
<i>Orlaya grandiflora</i>	<i>Orlaya grandiflora</i> (L.) Hoffm.	Spain	ABH 55673	JQ290130

Ind. loc.: Hab. in arvis Imperii Marocani septentrionali-orientalis prope Dar Kebdani (Sennen et Mauricio).

Type: Plantes d'Espagne 1933 n°8796 – *D. mauritii* ad interim. Maroc: Dar-Kebdani, champs. 14-V. Leg. Sennen et Mauricio (holotype: MPU 009326, photograph!).

= *D. muricatus* forma *macrocarpus* Sennen, Diagn. Nouv.: 125 (1936). *Type*: Plantes d'Espagne 1931 n°7856 – Maroc: Muley-Rechid, talus argilo-schisteux 20-VI. Leg. Sennen & Mauricio (holotype: BC 825997 photograph!).

= *D. muricatus* f. *heterocarpus* Sennen ex Maire in Bull. Soc. Hist. Nat. Afrique N. 26: 206 (1935). *Type*: Plantes d'Espagne 1931 n°7855 – Maroc: El Zaio, coteaux calcaires 28-V. Leg. Sennen & Mauricio (holotype: MPU 018953 photograph!).

The epithet '*mauritii*' honours Hno. Mauricio, colleague and friend of Hno. Sennen.

Typification: The first name applied by Sennen to this entity was *D. muricatus* forma *macrocarpus*, based on collections from Muley-Rechid, about 25 km south of Nador (northeastern Morocco), which were distributed under number 7856 of the exsiccata *Plantes d'Espagne 1931*. Two years later, Sennen applied the name *D. mauritii* for specimens collected with Mauricio at Beni Said, near Dar-Kebdani (about 40 km west of Nador), which were distributed under number 8796 of the exsiccata *Plantes d'Espagne 1933*. Both names were published later by Sennen (1936), although the study of syntypes conserved at BC, MA and MPU reveals that they are conspecific. However, in the meantime, Maire (1935) had previously validated the name *D. muricatus* var. *mauritii* Sennen ex Maire, which was based on materials distributed in the exsiccata of 1933 that are conserved in the Montpellier herbarium (MPU 009326) with Maire's handwriting. This voucher from MPU is to be regarded as the holotype, following recommendation 9A.4 of the

Vienna Code (McNeill *et al.*, 2006). Anecdotally, Sennen himself distributed as *D. mauritii* (cf. MA 89105) plants undoubtedly belonging to *Pseudorlaya pumila* (L.) Grande, under number 9376 of the exsiccata *Plantae d'Espagne 1934*, which were also collected in Dar-Kebdani.

Iconography: Figure 1 (illustration).

Description: Annual, 13–40 cm tall, usually with inflorescence-bearing branches from near the base at fruiting time. Taproot slender, not thickened, yellowish brown. Stem erect (1.0)2.5–5.0 mm in diameter at base, greyish-green, sometimes reddish, mostly densely scabrid-pubescent. Branches alternate, frequently spreading from the stem almost 45–90°. Indumentum of (0.5)1.0–2.0-mm-long hairs mixed with much shorter hairs (usually < 0.2 mm). Indumentum gradually shorter towards the apical half of the stem, but always denser at nodes. Hairs simple, whitish, ± straight, reflexed to patent.

Lower leaves 9–12(20) × 4–7 cm (including petiole), withered at fruiting time. Petiole long, up to 50% of the leaf length, inflated and sheathing at the base. Sheath with indumentum similar to that on the stem nodes, and long ciliate on margins. Rachis canaliculate with involute margins. Lamina ovate-elliptic in outline, four or five decreasingly pinnate, with all divisions ± narrow and similar in shape. Middle and upper cauline leaves becoming gradually smaller upwards, usually 1.0–6.0(10.0) × 0.5–2.5(5.0) cm, with petiole reduced to the sheath, and lamina three or four decreasingly pinnate.

Upper leaves distinctly different from the bracts. Leaf rachis densely scabrid-pubescent, with white patent hairs, even inside the adaxial central groove. Leaf segments sparsely pubescent at the adaxial side, scabrid-pubescent at the abaxial, mainly on veins. Ultimate segments ('leaf lobes') narrow elliptic or oblong-elliptic in outline, acute, mucronate, with distinct marginal short hairs that are slightly curved towards the apex.

Peduncles of umbels densely scabrid-pubescent, 29–105 mm long, those of the secondary umbels usually longer than the primary ones. Peduncle of primary umbels 1.3–2.1 mm in diameter on its central part. Receptacle of primary and secondary umbels thickened, often reddish, hirsute, with erect hairs 0.2–1.4 mm long (Fig. 1B). Umbel flat at anthesis, becoming contracted with straight rays at early fruiting time, and concave with rays curved outwards at late fruiting.

Bracts of umbels of first and second order (6)7–8, 11–27 mm long, much shorter (sometimes slightly shorter) than the longer rays, one or two (three) decreasingly pinnatisect with (one) two to four pairs

of primary divisions (Fig. 1C). Each primary division with zero to two pairs of segments. Ultimate segments 0.5–1.0 mm wide, narrow elliptic (oblong-elliptic), mucronate. Hyaline margin present in lower parts, long-ciliate. Indumentum densely short-scabrid at the abaxial side, with numerous marginal short hairs that are often slightly curved towards the apex. Bracts patent at anthesis, and patent to slightly reflexed at fruiting stage.

Rays (eight) 10–18; the outer ones 20–30 mm long, the inner 12–21 mm. Adaxial and abaxial faces of ray with similar indumentum of dense (100–175 hairs per mm²), short (100–240 µm), slightly recurved hairs (Fig. 1B). Rays subequal at fruiting time, with ratio longer/shorter 54–81%, bearing no fruit in the basal part of umbel.

Bracteoles seven to nine, with a hyaline ciliate margin in lower parts; the outer ones 6–9 mm long with one to four lateral lobes (Fig. 1D); the inner 4–6 mm long, commonly undivided or sometimes with one or two lateral lobes. Umbellules with 20–40 pedicellate flowers. Secondary umbels with umbellules bearing staminate inner flowers, which have the stylopodium but lack the styles; the outer flowers (*c.* 25% of the umbellet) hermaphrodite, producing fruit. Primary umbels apparently with most or all flowers hermaphrodite. Each umbellule ± symmetrically radiate, with all peripheral flowers subequal and distinctly larger than the inner flowers.

Sepals inconspicuous or reduced to a short hyaline point; the outer ones of peripheral flowers ± narrow-conical, green with a hyaline mucro, up to 1.2 mm long. Petals white or slightly pink, up to 3–4 mm long and 5 mm wide, cordate, bilobate, dorsally sparsely hairy. Anthers dark-pinkish, 615–660 µm long. Pollen grains *c.* 43.4–45.9 × 16.7–17.5 µm.

Mericarp (excluding style and spines, including crest) 4.0–5.1 × 3.2–3.7 mm (Fig. 1E). Primary median and lateral ribs prominent, heterotrichous, with several rows of hairs. Hairs white, broadly triangular, 285–430(625) × 85–110 µm, mixed with shorter hairs *c.* 100 µm long. Primary marginal ribs curved, prominent, with one row of unequal hairs which are patent and parallel to the commissural face, and densely arranged (six to eight hairs per millimetre). Surface between ridges elliptic in outline and canaliculate. Spines four to six per secondary rib, glochidiate, up to 2.7–5.0 mm long, straight, patent, lower and upper ones shorter. Basal spines of both mericarps often appressed to the pedicel, resembling a 'reversed crown'.

Base of the spines strongly widened and swollen. Basal crest up to 460–730 µm wide. Glochide with four to nine reflexed points, which are often strongly unequal, 25–90 µm long. Style 1.5–2.4 mm long, swollen at the base to form a conical stylopodium;

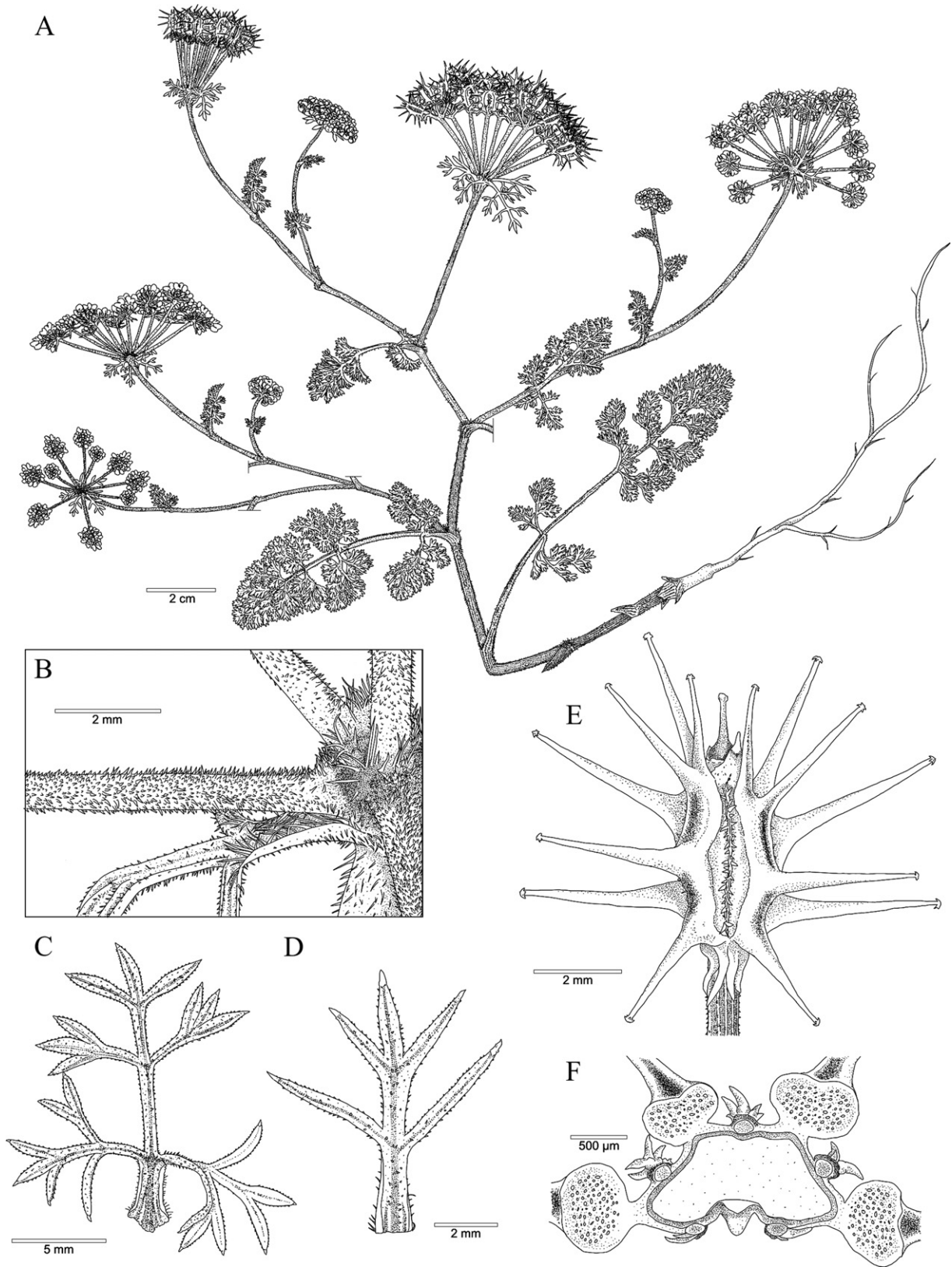


Figure 1. *Daucus mauritii*, near Oued Kert, Morocco (ABH 55658): A, habit; B, primary umbel receptacle; C, bract (adaxial side); D, bracteole (adaxial side); E, mericarp (dorsal face); F, mericarp (median transverse section). Drawing by Fernando Martínez-Flores.

'stylar neck' over the stylopodium erect or slightly recurved, hemicylindrical.

Median transverse section of mericarp showing endosperm slightly dorsally compressed, with subtrapezoid shape. Endosperm 750–900 µm thick and c. 1650–1800 µm wide in marginal face, with compression index (Arenas & García-Martín, 1993) of 2.0–2.2. Base of the spines circular to cordate with mesocarp resembling spongy tissue. Vascular bundle 170–275 µm in diameter (longest axis), elliptical, subequal. Vittae obsolete in mature fruit (Fig. 1F).

Material examined: MOROCCO. Oriental region: El Zaio, coteaux calcaires, 28.v.1931, *F. Sennen et H. Mauricio* [ut *Daucus muricatus* L. forma *heterocarpus*] (BC 825992, MA 89095); Muley-Rechid, talus argilo-schisteux, 20.vi.1931, *F. Sennen et H. Mauricio* [ut *Daucus muricatus* L. forma *macrocarpus*] (BC 825997, MPU 008378, 008379); Dar-Kebdani, champs, 14.v.1933, *F. Sennen et H. Mauricio* [ut *Daucus mauritii* Sennen] (BC 826012, MA 163628, MPU 009326); Dar-Kebdani, sol marneux, 13.v.1934, *F. Sennen et H. Mauricio* [ut *Daucus mauritii* Sennen gr. *muricatus*?] (BC 826013); prox. al Oued Kert, entre campos de cultivo, 30SVD8397, 15 m, 23.iv.2009, Iter Maroccanum 2009: *M.B. Crespo et al.* (ABH 55647, 55648, 55649, 55650, 55659, 55660, 55661, 55662, 55663); prox. al Oued Marracrane, junto a la carretera N-16, 30SVD489967, 23 m, 23.iv.2009, Iter Maroccanum 2009: *M.B. Crespo et al.* (ABH 55655, 55656, 55657, 55658).

Habitat and distribution: The known distribution of *D. mauritii* is restricted to a small area of about 55 km around Melilla, in northeastern Morocco (Fig. 2), in the so-called Gareb area (*sensu* Valdés *et al.*, 2002). It grows on waste ground and roadsides near the coast, where it can be locally abundant as a weed species. As its potential habitat is common, its distribution area may extend to the neighbouring territories of Morocco, northwestern Algeria and possibly southern Spain, where it could have been misidentified as *D. muricatus*. However, our revision of herbarium material has failed to extend the known distribution of the species. Future prospection is needed to throw light on this subject.

DNA ANALYSES

The aligned and combined dataset was 3027 bp. ITS contributed 608 bp, the *trnQ-rps16* intergenic spacer 1547 bp and the *rps16* intron 872 bp of the total number of nucleotides; 4.6% were potentially parsimony informative. Analyses of the combined dataset using NJ (not shown), MP and ML methods yielded trees with the same topology and similar bootstrap

and branch length values (Fig. 3). *Daucus mauritii* and *D. aureus* form a strongly supported clade (bootstrap support, BS = 100%). Although the position of *D. muricatus* is not fully resolved, this species and the two previously mentioned are included in a well-supported subgroup of *Daucus*, with *D. carota* and *D. setifolius*.

Analysis of the same dataset using distance estimation is shown in Table 2. *Daucus aureus* is the closest species to *D. mauritii*, followed by *D. muricatus* and *D. setifolius* with similar values. Divergence between intraspecific sequences (*D. muricatus* M and S) is distinctly lower than the *D. aureus*/*D. mauritii* distance, which is closer to the *D. pusillus*/*D. durieua* distance.

In the aligned sequence comparison (Table 3), the *trnQ-rps16* intergenic spacer shows notable mutations. *Daucus mauritii* and *D. aureus* share a 202-bp deletion which is absent in *D. muricatus* (position 264–456 + 463–473) and partially absent for most of the studied *Daucus* spp. In addition, *D. mauritii* has an additional deletion of 25 bp (position 983–1007) that is unique. These nucleotides are present not only in all other *Daucus* spp. but also in *Berula erecta*.

A second phylogenetic analysis was conducted adding *D. broteri*, *D. crinitus* and *D. sahariensis* accessions and new *D. aureus* and *D. mauritii* specimens (Fig. 4). This analysis only considered ITS1 and ITS2. The aligned matrix was 438 bp, 114 bp (26.0%) of which were potentially parsimony informative sites. MP, ML and NJ (not shown) methods yielded trees with the same topology. The consensus tree shows the existence of two well-supported clades: *D. pusillus*–*D. broteri* and *D. crinitus*–*D. mauritii*. *Daucus mauritii* and *D. aureus* form a strongly supported clade (BS = 99%), sister to *D. carota*–*D. sahariensis*. All these taxa form a larger clade with 60% BS. The phylogenetic position of *D. muricatus* is not resolved by our data and this taxon might not be directly related to *D. mauritii*. Furthermore, other morphologically similar taxa, such as *D. broteri*, appear in the group more closely related to *D. pusillus* and *D. durieua* than to the *D. mauritii* group.

DISCUSSION

Daucus mauritii shows a unique combination of morphological characters (Figs 5A, D, G, 6A, D, G) and a well-supported phylogenetic position which, together, allow its recognition as a distinct species. However, several morphological features connect it to other relatives in the genus.

The large fruits with scarce spines have usually led to its misidentification with *D. muricatus*, although many clear morphological differences exist between the two taxa (Table 4). *Daucus muricatus* has longer

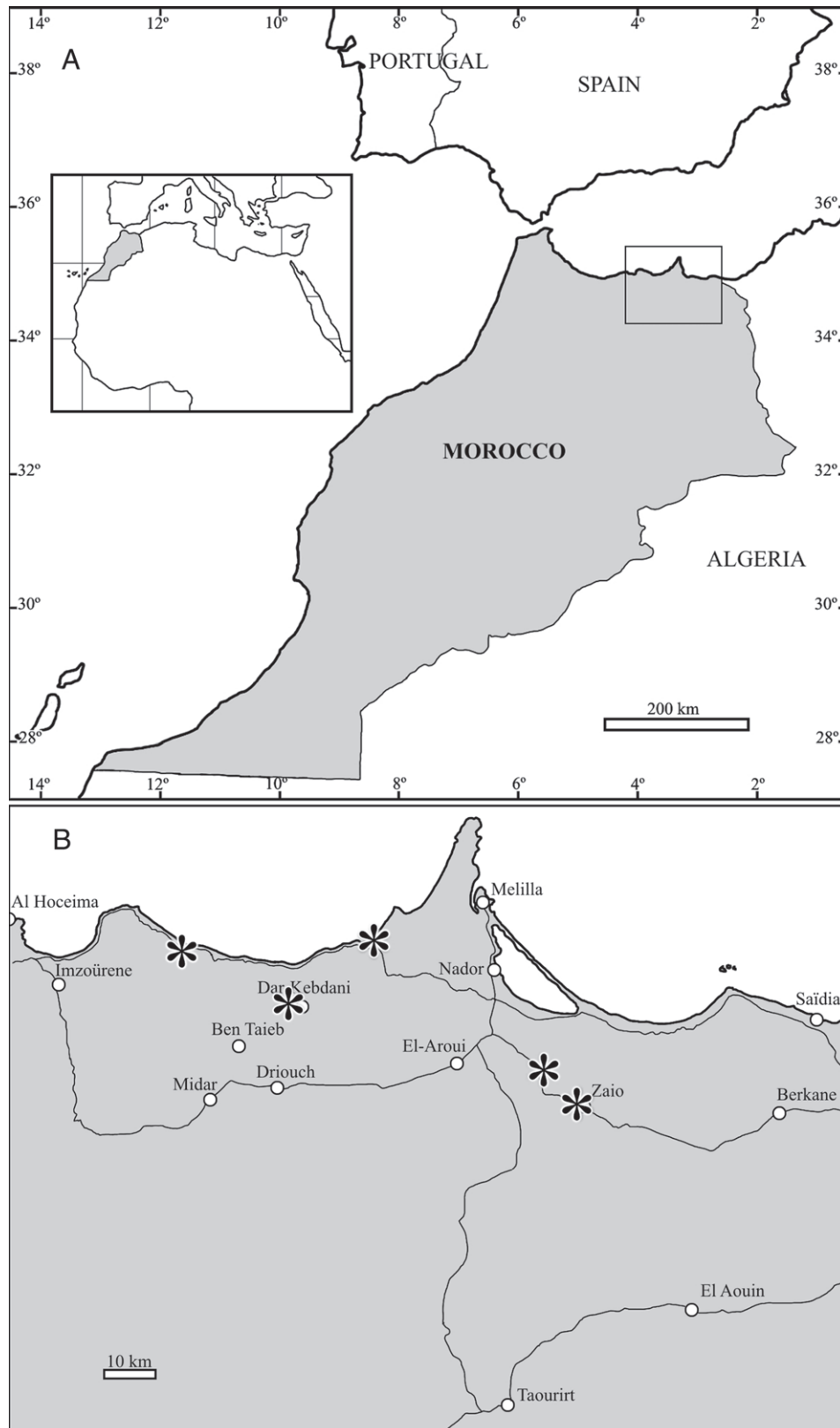


Figure 2. Distribution of *Daucus mauritii* based on field records and herbarium specimens. Each record (*) corresponds to an area of approximately $5 \times 5 \text{ km}^2$.

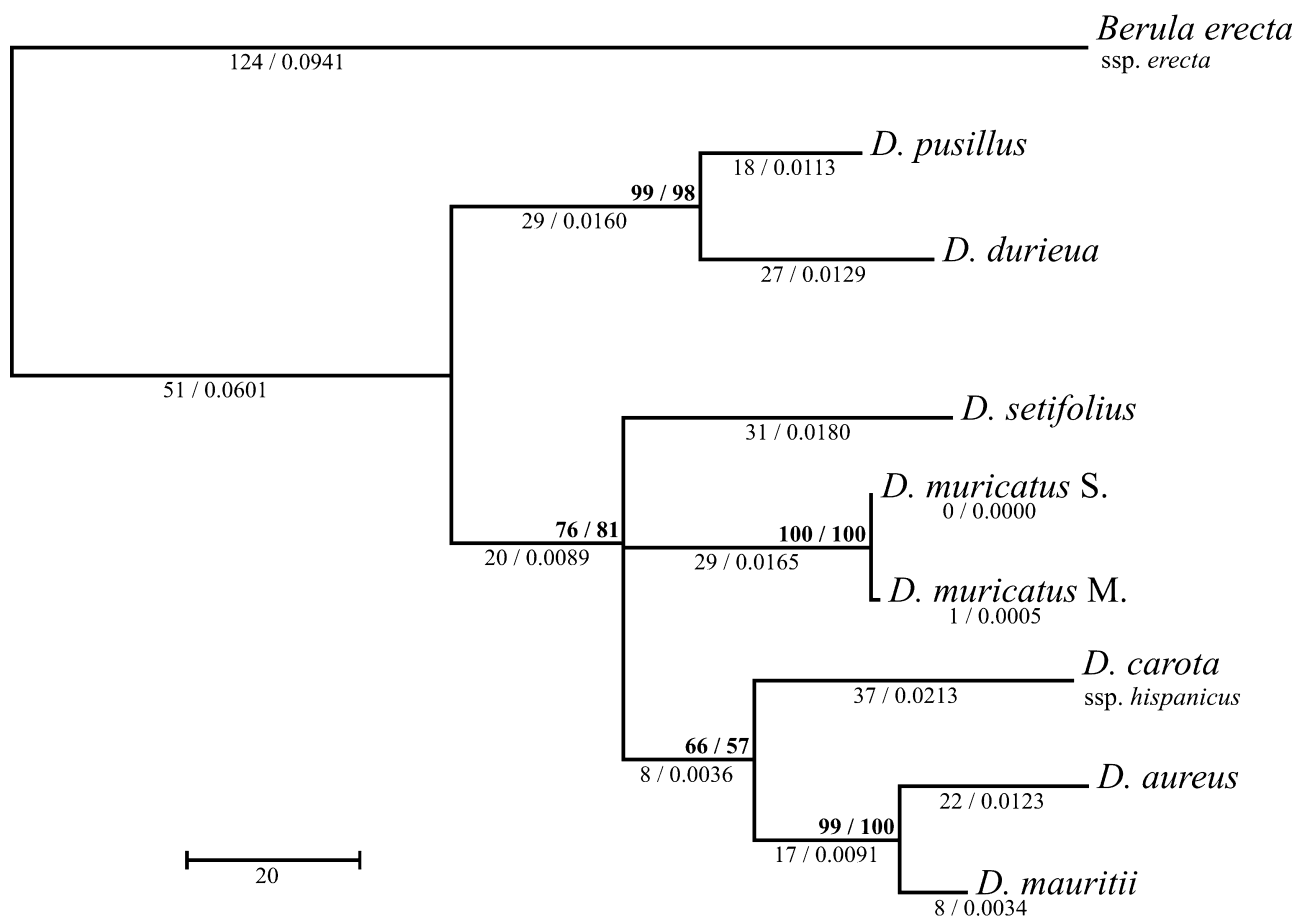


Figure 3. Bootstrap consensus tree from the combined analysis of internal transcribed spacer (ITS), *trnQ-rps16* and *rps16* intron: topology inferred using maximum parsimony (MP). Bootstrap values obtained for MP and maximum likelihood (MP/ML) are shown above the branches. Branch lengths for MP/ML are shown below the branches. Scale units: number of changes over the whole sequence.

hairs on the stem (Fig. 5B), unequal peripheral flowers of each external umbellule (Fig. 5E), mature rays markedly curved inwards, bracts strongly reflexed with linear segments (Fig. 5H), umbel receptacle glabrous to denticulate (Fig. 6B), abaxial hair covering of outer rays glabrescent to sparsely hirsute (Fig. 6E) and fruit with linear hairs at primary ribs, six to eight spines per secondary rib (Fig. 6H) and conspicuous vittae. Moreover, *D. muricatus* is not phylogenetically directly related to *D. mauritii*, as both taxa fall into different clades (Figs 3, 4). The existence of a large deletion in *D. mauritii* also supports the taxonomic segregation of these taxa.

Although previous morphological or taxonomic studies have not indicated any relationship between *D. mauritii* and *D. aureus*, these two taxa show certain morphological similarities. Both plants are easily confused at flowering time (Fig. 5D, F). They produce leaves ovate-elliptic in outline, four or five decreasingly pinnate, all divisions \pm narrow and

similar in shape; external umbellules with all peripheral flowers subequal and radiant at anthesis (Fig. 5D, F); receptacle hirsute, with erect hairs (Fig. 6A, C); umbel rays not markedly unequal at fruiting time (Fig. 5G, I); and fruit vittae obsolete. These morphological similarities are consistent with the molecular studies.

Phylogenetic analysis showed a close relation between these species, as both formed a strongly supported clade (Figs 3, 4). However, *D. aureus* conspicuously differs in its lax indumentum (Fig. 5C), bracts deflexing early, with narrower segments (Fig. 5I), abaxial hair covering of outer rays glabrescent to sparsely hirsute (Fig. 6F), fruit with six to nine spines per secondary rib (Fig. 6I), strongly papillate surface and geniculate hairs on primary ribs, and stylopodium notably thickened at the base (Table 4).

The morphological relationships of *D. mauritii* with other species are quite weak. First, it resembles

Table 2. Estimates of evolutionary divergence using combined dataset of internal transcribed spacer (ITS), *trnQ-rps16* and *rps16* intron. The numbers of base substitutions per site from between sequences are shown below the diagonal. Standard error (SE) estimates are shown above the diagonal

	SE	SE	SE	SE	SE	SE	SE	SE	SE	SE	SE	SE	SE	SE
<i>Daucus aureus</i> SPAIN	0.0144	0.0026	0.0044	0.0044	0.0059	0.0061	0.0050	0.0052	0.0137					
<i>D. mauritii</i> 1	0.0340	<i>D. mauritii</i>	0.0039	0.0039	0.0057	0.0058	0.0039	0.0047	0.0139					
<i>D. muricatus</i> MOROCCO	0.0335	0.0305	<i>D. mur. M.</i>	0.0004	0.0056	0.0055	0.0045	0.0048	0.0133					
<i>D. muricatus</i> SPAIN	0.0555	0.0300	0.0003	<i>D. mur. S.</i>	0.0056	0.0055	0.0046	0.0048	0.0134					
<i>D. durieua</i>	0.0520	0.0508	0.0533	0.0532	<i>D. durieua</i>	0.0033	0.0056	0.0065	0.0125					
<i>D. pusillus</i>	0.0394	0.0477	0.0476	0.0475	0.0217	<i>D. pusillus</i>	0.0056	0.0060	0.0121					
<i>D. setifolius</i>	0.0397	0.0300	0.0376	0.0385	0.0512	0.0481	<i>D. setifolius</i>	0.0051	0.0122					
<i>D. carota</i>	0.1666	0.0335	0.0401	0.0391	0.0565	0.0502	0.0415	<i>D. carota</i>	0.0147					
<i>Berula erecta</i>		0.1675	0.1620	0.1619	0.1647	0.1504	0.1560	0.1639	<i>B. erecta</i>					

D. sahariensis in the annual habit (usually up to 30 cm high), scabrid stems (with short hairs up to 0.37 mm long) and the scabrid bracts not deflexed in fruit (cf. Okeke, 1978; Boulos, 2000). Nonetheless, *D. sahariensis* usually has entire bracts (sometimes three-lobed at the apex); shorter fruits (3–4 mm); oblong-elliptic narrower mericarp; spines numerous (c. 10 on each ridge), shorter (2.0–2.5 mm), 1.0–1.5 times as long as the mericarp width; and the fruit section shows conspicuous triangular vittae, smaller vascular bundles and spines not strongly widened at the base (cf. Maire, 1935; Sáenz, 1981; Boulos, 2000). It grows on stony or rocky ground, in subdesert, arid territories of the northern Sahara and Saharan Atlas (Quézel & Santa, 1963: 663; Ozenda, 1983: 362; Gómiz, 2001: 158), in different ecological and biogeographical conditions. Second, some connections can be found with the central Mediterranean *D. broteri* with regard to the annual, reduced habit; small umbels with outer rays up to 3 cm long; and fruit primary ribs with unequal hairs, some reduced to small denticles among much longer ones (Heywood, 1968; Pignatti, 1982: 249). However, *D. broteri* clearly differs by its long pedunculate umbels, seven to ten times longer than the rays; stem indumentum laxer, mainly composed of long hairs; adaxial sides of rays covered with hairs markedly shorter and more densely disposed than those on the abaxial side; mericarps narrower, with thinner hairs (up to 60 µm in width); and spines not strongly widened at the base, as in *D. sahariensis*. Molecular analysis performed on the ITS1 and ITS2 data revealed that *D. broteri* falls in a different clade (group 1), closer to other species such as *D. pusillus* and *D. durieua*. Conversely, the phylogenetic position of *D. sahariensis* is closer to *D. mauritii*, as both taxa are included within group 2, but *D. sahariensis* is sister to *D. carota* (Fig. 4).

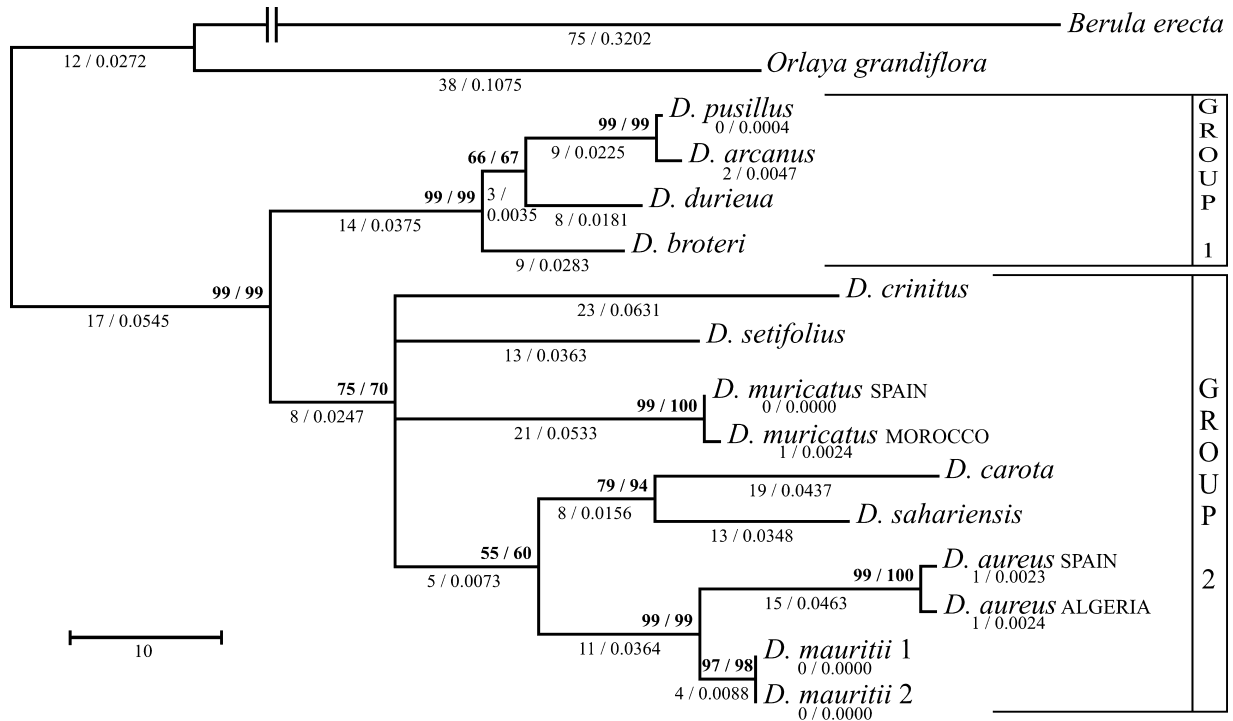
Finally, and despite the frequent misidentification with *D. muricatus*, phylogenetic analyses support a genetic closeness of *D. mauritii* to *D. aureus*. Moreover, according to the evolutionary divergence estimation (Table 2), the genetic distance between *D. mauritii* and *D. muricatus* equals that between *D. mauritii* and *D. setifolius*, the latter pair being morphologically different. This fact supports recognition of *D. mauritii* as an autonomous entity. According to the evidence above, *D. mauritii*, *D. muricatus* and *D. aureus* are clearly different taxa, and, consequently, assignation of the species rank to *D. mauritii* seems to be the most appropriate solution.

ACKNOWLEDGEMENTS

We thank the curators and staff of the herbaria ABH, B, BOLO, K, MA, MPU, LISI and RNG for help with

Table 4. Comparative morphological features of *Daucus* taxa. Asterisks (*) indicate values according to Arenas & García-Martín (1993)

	<i>D. mauritii</i>	<i>D. muricatus</i>	<i>D. aureus</i>
Stem, hair covering	Mostly densely scabrid-pubescent	Mostly hirsute to slightly hispid	Mostly hirsute to slightly hispid
Stem, hair maximum length (mm)	0.5–2.0	2.0–4.0	c. 2.0–2.6
Leaf, primary rachis hair length (µm)	70–500	1000–3000	c. 1100–2400
Umbel, hair covering of receptacle	Hirsute, with erect hairs 0.2–1.4 mm long	Glabrous or denticulate, with minute hairs	Hirsute, with erect hairs 1.2–3.0 mm long
Umbel, morphology at late fruiting	Concave with rays curved outwards	Concave with rays curved inwards	Concave with rays curved inwards
Bracts, position at fruiting	Patent to slightly reflexed	Markedly reflexed	Markedly reflexed
Bracts, ultimate segments	Narrow elliptic (oblong-elliptic)	Linear to oblong-elliptic	Linear to oblong-elliptic
Rays, number in primary umbel	(8)10–18	20–40	18–50
Outer rays, abaxial hair covering	Shortly and densely scabrid	Glabrescent to sparsely hirsute	Glabrescent to sparsely hirsute
Outer rays, adaxial /abaxial indumentum	Equal to subequal	Very unequal	Very unequal
Rays, relative size in fruiting primary umbel	Slightly unequal (shorter/ longer = c. 0.5–0.8)	Very unequal (shorter/ longer = c. 0.05–0.3)	Unequal (shorter/ longer = c. 0.3–0.5)
Flowers, peripheral of an external umbellet	Subequal	Very unequal	Subequal
Peripheral umbellet symmetry	Actinomorph	Zygomorph	Actinomorph
Stylopodium	Not swollen	Not swollen	Swollen
Spines, number per secondary rib	4–6	6–8	6–9
Spines, basal transverse section	Circular to cordate	Oblong	Oblong
Spines surface	Striate (slightly papillate)	Striate (slightly papillate)	Strongly papillate
Fruit vittae	Obsolete	Conspicuous, ovate very small	Obsolete
Vascular bundle, median and lateral (µm)	170–275	100–270*	35–60*
Primary rib hairs	Broadly triangular	Linear	Linear and geniculate

**Figure 4.** Bootstrap consensus tree from internal transcribed spacer 1 (ITS1) and ITS2 sequences. Topology obtained using maximum parsimony (length, 335 steps; consistency index, 0.70; retention index, 0.77). Bootstrap values obtained for maximum parsimony and maximum likelihood (MP/ML) are shown above the branches. Branch lengths for MP/ML are shown below the branches. Scale units: number of changes over the whole sequence.

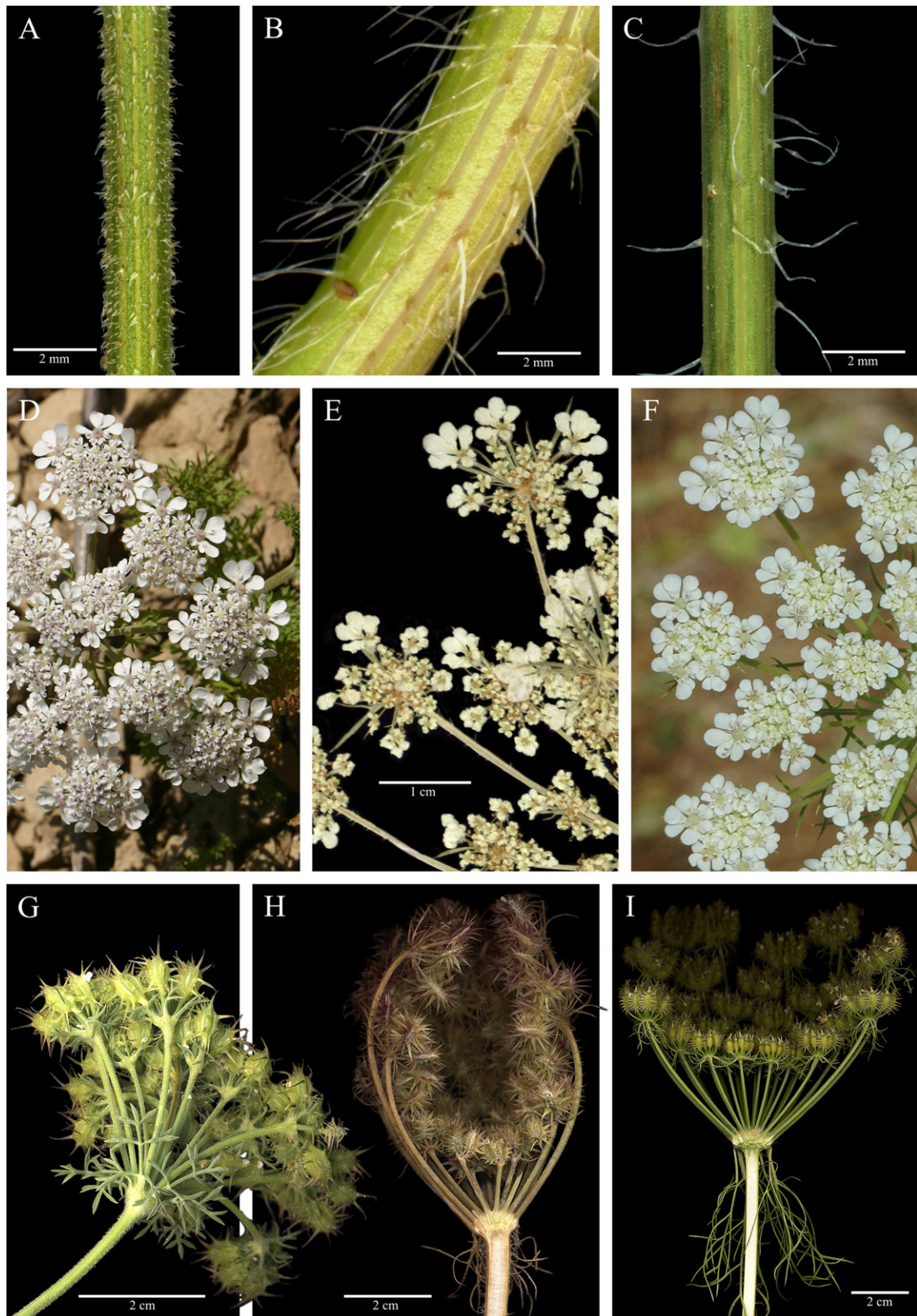


Figure 5. Main distinctive morphological features of *Daucus mauritii* (left column, A, D, G), *D. muricatus* (central column, B, E, H) and *D. aureus* (right column C, F, I): A–C, stem indumentum; D–F, flowering umbel; G–I, fruiting umbel.

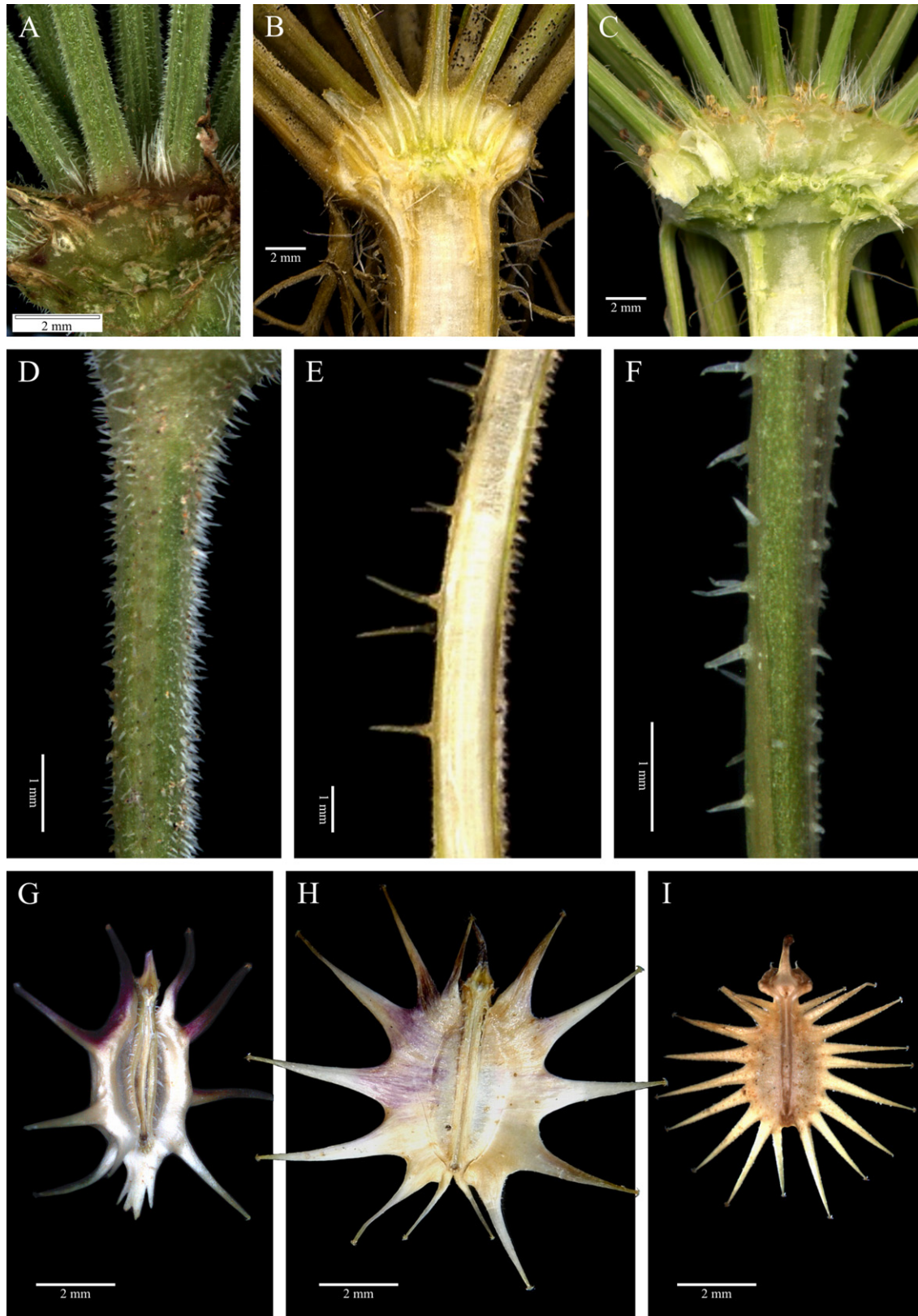


Figure 6. Main distinctive morphological features of *Daucus mauritii* (left column, A, D, G), *D. muricatus* (central column, B, E, H) and *D. aureus* (right column C, F, I): A–C, hair covering of receptacle; D–F, hair covering of outer rays showing abaxial side (left) and adaxial side (right); G–I, mericarp (commissural face).

the studied material. Enrique Triano helped with *Daucus aureus* photographs. Some samples were provided by A. Aparicio, F. Bruno, E. Camadro, A. Castro, F. García-Martín, A. Hipold, J. López-Alvarado, V. Meneses, J. Pastor, L. Sáez and E. Triano. We also thank J.C. Agulló and J.L. Villar for their comments on the manuscript. This research was partly funded by the research grant UA2004-47056131 (University of Alicante) to FMF. Two anonymous reviewers made some interesting comments on the manuscript.

REFERENCES

- Arenas JA, García-Martín F. 1993.** Atlas carpológico y corológico de la subfamilia Apiaceae Drude (Umbelliferae) en España peninsular y Baleares. *Ruizia* **12**: 222–234.
- Boulos L. 2000.** *Flora of Egypt*, Vol. 2. Cairo: Al Hadara Publishing, 182–184.
- Downie SR, Katz-Downie DS. 1996.** A molecular phylogeny of Apiaceae subfamily Apiaceae: evidence from nuclear ribosomal DNA internal transcribed spacer sequences. *American Journal of Botany* **83**: 234–251.
- Downie SR, Katz-Downie DS, Sun FJ, Lee CS. 2008.** Phylogeny and biogeography of Apiaceae tribe Oenantheae inferred from nuclear rDNA ITS and cpDNA *psbI-5'trnK(UUU)* sequences, with emphasis on the North American endemics clade. *Botany* **86**: 1039–1064.
- Doyle JJ, Doyle JL. 1987.** A rapid DNA isolation procedure for small quantities of fresh leaf tissue. *Phytochemistry Bulletin* **19**: 11–15.
- Felsenstein J. 1981.** Evolutionary trees from DNA sequences: a maximum likelihood approach. *Journal of Molecular Evolution* **17**: 368–376.
- Felsenstein J. 1985.** Confidence limits on phylogenies: an approach using the bootstrap. *Evolution* **39**: 783–791.
- Gómez F. 2001.** *Flora selecta marroquí*. Burgos: Amábar, SL., 158.
- Heywood VH. 1968.** *Daucus* L. In: Tutin TG, Heywood VH, Burges NA, Moore DM, Valentine DH, Walters SM, Webb DA, eds. *Flora europaea*, Vol. 2. Cambridge: Cambridge University Press, 373–375.
- Jury SL. 2002.** *Daucus* L. In: Valdés B, Rejdali M, Achhal A, Jury SL, Montserrat JM, eds. *Checklist of vascular plants of north Morocco with identification keys*, Vol. 1. Madrid: Servicio de Publicaciones del CSIC, 467–469.
- Kimura M. 1980.** A simple method for estimating evolutionary rate of base substitutions through comparative studies of nucleotide sequences. *Journal of Molecular Evolution* **16**: 111–120.
- Maire R. 1935.** Contributions à l'étude de la Flore de l'Afrique du Nord. *Bulletin de la Société d'Histoire Naturelle de l'Afrique du Nord* **23**: 184–234.
- McNeill J, Barrie FR, Burdet HM, Demoulin V, Hawksworth DL, Marhold K, Nicolson DH, Prado J, Silva PC, Skog JE, Wiersema JH, Turland NJ, eds. 2006.** *International Code of Botanical Nomenclature (Vienna Code). Adopted by the Seventeenth International Botanical Congress Vienna, Austria, July 2005*. Königstein: Koeltz Scientific Books, [Regnum Vegetabile 146].
- Nei M, Kumar S. 2000.** *Molecular evolution and phylogenetics*. New York: Oxford University Press.
- Okeke SE. 1978.** Morphological variation of bracts, bracteoles and fruits in *Daucus* L. In: Cauwet-Marc AM, Carbonnier J, eds. *Actes du deuxième symposium international sur les ombellifères, Contributions pluridisciplinaires à la systématique*. [Monographs in Systematic Botany from the Missouri Botanical Garden, Vol. 6. Ann Arbor, MI: Braun-Brumfield, 161–174.
- Ozenda P. 1983.** *Flore du Sahara. Ed. 2*. Paris: Centre National de la Recherche Scientifique, 362.
- Pignatti S. 1982.** *Flora d'Italia*, Vol. 2. Bologna: Edagricole, 249.
- Pujadas AJ. 2003.** *Daucus* L. In: Castroviejo S, coord. *Flora iberica*, Vol. X. Madrid: Real Jardín Botánico, CSIC, 97–125.
- Quézel P, Santa S. 1963.** *Nouvelle flore de l'Algérie et des régions désertiques méridionales*, Vol. 2. Paris: Centre National de la Recherche Scientifique, 659–663.
- Sáenz C. 1981.** Research on *Daucus* L. (Umbelliferae). *Anales Jardín Botánico de Madrid* **37**: 481–534.
- Saitou N, Nei M. 1987.** The neighbor-joining method: a new method for reconstructing phylogenetic trees. *Molecular Biology and Evolution* **4**: 406–425.
- Sennen F. 1936.** *Diagnoses des nouveautés parues dans les exsiccata plantes d'Espagne et du Maroc*. Vic: Imprenta Anglada.
- Sennen F, Mauricio F. 1934.** *Catálogo de la flora del Rif oriental y principalmente de las Cabilas limitrofes con Melilla*. Melilla: Gráficas La Ibérica, 51.
- Tamura K. 1992.** Estimation of the number of nucleotide substitutions when there are strong transition–transversion and G + C-content biases. *Molecular Biology and Evolution* **9**: 678–687.
- Tamura K, Peterson D, Peterson N, Stecher G, Nei M, Kumar S. 2011.** MEGA5: molecular evolutionary genetics analysis using maximum likelihood, evolutionary distance, and maximum parsimony methods. *Molecular Biology and Evolution* **28**: 2731–2739.
- Thiers B. 2011.** *Index herbariorum: a global directory of public herbaria and associated staff*. New York: Botanical Garden's Virtual Herbarium. Available at: <http://sweetgum.nybg.org/ih/> [continuously updated; accessed June 2011].
- Valdés B, Rejdali M, Achhal A, Jury SL, Montserrat JM. 2002.** *Checklist of vascular plants of north Morocco with identification keys*, Vol. 1. Madrid: Servicio de Publicaciones del CSIC.
- White TJ, Bruns TD, Lee S, Taylor JW. 1990.** Amplification and direct sequencing of fungal ribosomal RNA genes for phylogenetics. In: Innis M, Gelfand D, Sninsky J, White T, eds. *PCR protocols: a guide to methods and applications*. San Diego, CA: Academic Press, 315–322.
- Zohari M. 1987.** *Flora palaestina*, Vol. 2, Ed. 2. Jerusalem: Israel Academy of Sciences and Humanities, 448.

APPENDIX

LIST OF REPRESENTATIVE HERBARIUM MATERIAL
EXAMINED*Daucus aureus* Desf.

ALGERIA. Oran: Arbal, pres Oran, 100 m, 1.vi.1933, A. Faure (MA 89217); Kristel, 30SYE263640, 125 m, 13.vi.2011, A. Juan (ABH 57786); **Tlemcen:** Maghnia, prope oppidum Lalla, 600 m, 1933, R. Maire (MA 89218); **PALESTINA.** Esdraelon Plain, alrededores de Balfouria, 100 m, 1.vi.1935, N. Feinbrun & M. Zohary (MA 169474); **SPAIN. Córdoba:** Arroyo La Maturra, Baena, 30SUG8070, 250 m, 12.vi.2009, E. Triano & A. Castro (ABH 55117, 55119, 55120); c. Puente San Juan, Luque, 30SUG9660, 400 m, 12.vi.2009, E. Triano & M. Nocete (ABH 55121, 55122, 55123, 55124); Todosaires, Priego, 30SVG0252, 500 m, 29.v.2009, E. Triano & P. Repullo (ABH 53922, 53923, 53924, 53925); Villanueva de San Juan, 30SVG0403, 560 m, 16.vii.1976, S. Castroviejo & E. Valdés-Bermejo (MA 417565); Almedinilla, 30SVG0444, 700 m, 11.vi.1977, Fernández Casas & Muñoz Garmendia (MA 410421); **Cuenca:** Carrascosa del Campo, 870 m, 21.vii.1977, G. López (MA 416972); Las Tinajas, carretera Tarancón a Cuenca km 13, 30TVK9730, 780 m, 21.vii.1977, G. López (MA 417665); **Jaén:** Cortijos Nuevos, salida hacia Beas de Segura, 750 m, 30.vi.1988, A. Aparicio, F. García-Martín & S. Silvestre (MA 504216); Jódar, orilla del Guadalquivir, 350 m, 17.vi.1941, E. Guinea (MA 418307); entre el Guadalquivir y Jimena, 400 m, 3.vi.1927, L. Lacaita (MA 89215); **Málaga:** subida a Ventas de Zafarraya, 30SUF9885, 475 m, 1.vi.1990, S. Silvestre (MA 484338); **Sevilla:** Cuesta de las Doblas, Sanlúcar la Mayor, 29SQB4642, 80 m, 10.ix.2008, F. García-Martín & J. Pastor (ABH 53907).

Daucus broteri Ten.

ITALY. Abruzzo: Caramanico-Abruzzo, vii.1908, M. Guadagno (MA89104); Pescara, Campi sui colli sopra Castellamare, Abruzzo, 6.viii.1910, E. Chiovenda (BOLO25508); **Toscana:** Florencia, iv.1883, S. Summer (RNG); prope Florentiam, viii.1883, S. Sommier (MA89101); prope Florentiam, 60 m, 20.vii.1872, E. Levier (MA89100); Campi a Panzano presso Greve, Firenze, 20.ix.1898, E. Chiovenda (BOLO25501); Paterno, presso Vallombrosa; Firenze, 350 m, viii.1911, A. Fiori (BOLO25504); Chianciano, viii.1983, H. Groves (RNG); Chianciano (prope), viii.1883, H. Groves (MA89102); **Liguria:** Savona, 100 m, 12.xii.1992, G. Galasso (RNG); **Lazio:** Roma, Olevano romano, 7.vii.1908, E. Chiovenda (BOLO25505); Roma, Macchia Mattei, 25.vii.1915, A. Trabalza (BOLO25506); Roma, 10.vii.1895, E. Chiovenda (BOLO25499); Roma, Olevano Romano, 22.vii.1908, E. Chiovenda (BOLO25509); Roma,

presso Marcellina, 29.ix.1895, E. Chiovenda (BOLO25500); Roma, Via Flaminia, 10.vii.1891, E. Chiovenda (BOLO25503); Horcatrano, ix.1985, H. Groves (RNG).

Daucus mauritii (Sennen ex Maire) Sennen

MOROCCO. Oriental: Dar-Kebdani, 14.v.1933, Sennen & Mauricio (BC826012, MA163628, MPU009326); 13.v.1934, Sennen & Mauricio (BC826013); Nador, prox. al Oued Kert, 30SVD8397, 15 m, 23.iv.2009, M.B. Crespo et al. (ABH 55647, 55648, 55649, 55650, 55659, 55660, 55661, 55662, 55663); Nador, prox. al Oued Marracrane, junto a la carretera N-16, 30SVD489967, 23 m, 23.iv.2009, M.B. Crespo et al. (ABH 55655, 55656, 55657, 55658); Muley-Rechid, 20.vi.1931, Sennen & Mauricio (BC825997, MPU008378, MPU008379); El Zaio, 28.v.1931, Sennen & Mauricio (BC825992, MA 89095, MPU 018953), Zaio, Sennen (MPU 018954).

Daucus muricatus (L.) L.

ALGERIA. Donéra, 200 m, 19.v.1929, R. Maire (RNG); Mitidja near El Allia Mitidja, 18.v.1982, W.L. Scott (RNG); Oued Imbert, 500 m, 4.vi.1911, A. Faure (MA 89088); **Aïn Defla:** Hammam-Righa, vi.1920, Ch. Alleizette (MA 89096); v.1920 (MA 89091); J.A. Battandier (MPU007605); **Annaba:** between Annaba (Bone) and El Kala, near Lac des Oiseaux, 30–35 km from Annaba, 2 m, 11.v.1971, Davis (RNG); **Bouira:** Palestro, J.A. Battandier (MPU007606); **Tizi Wezzu:** few km W of Boghni, 250 m, 6.v.1971, Davis (RNG); 35 km W of Tizi-Ouzou, 2 km W of Bordj-Menaïel, 35 m, 29.iv.1976, D.A. & S.J. Sutton 991 (RNG); **ITALY. Sicily:** Agrigento, Montallegro–Sicilia, 50 m, 18.v.1979, D. Davis & S. Sutton (RNG); **MOROCCO. Marrakesch-Tensift-El Haouz:** Oulad Said, Chaouia, 460 m, 29.iv.1929, E. Jahandiez (MA 89094); **Gharb-Chrarda-Beni Hssen:** Sidi Kacem, wilaya de Kenitra, Beni Hassene (à l'W de Ouazzane), 160 m, 31.v.1994, L. Lambinon & G. van den Sande (MA 563959, RNG); WN: 8 km S of Arbaoua, W of road to Kenitra, 250 m, 31.v.1974, Reading Univ. / BM Exped. 35 (RNG); **Oriental:** Mazuza, 30 m, 7.v.1931, Sennen & Mauricio (MA 89097); Melilla, Mazuza, Beni-Sidel, 150 m, v.1934, Sennen & Mauricio (MA 89099); **Tanger-Tetouan:** El Araix, Txumix, 30 m, 18.v.1930, Font Quer (MA 89142); pr. Dar Chaoum, 30 m, 11.vi.1982, J. Fdez. Casas et al. (RNG 18833); inter oppidula Larache (Rhaba el Araich) et El Khemis, 5–10 m, 20.v.1985, C. Blanché et al. (MA 341052, RNG); Laucien, 15 m, 3.v.1921, C. Pau (MA 89093); NE of Meknes, road from Moulay Idriss over Jbel Zerhoun, 870 m, 7.vi.2007, S.L. Jury & R. Shkwa (RNG 33410); Sok et Arbaa, Beni Hasan, 650 m, 7.vi.1928, Font Quer (MA 89090); Tanger, 25 m, v.1921, C. Pau (MA 89092); iv.1921, C. Pau (MA

- 89087); Tetouan, pr. Dar Chaoum, 30 m, 11.vi.1982, *J. Fernandez Casas et al.* (MA 416595, 632491); **Taza-Al Hoceima:** Alhoceima, Taza, 30SVD171115, 769 m, 21.iv.2009, *M.B. Crespo & al.* (ABH 55634); Atlas Rifain, Targuist à Bab-Izugar, 1230 m, 20.vi.1933, *Sennen & Mauricio* (BC825993); Taza. Carretera a Aknoul, a 15 km de Taza, 400 m, 25.v.1994, *M.J. Díez et al.* (RNG); Tsoul, Fes-Taza road, 16 km W of Taza, 1 km W of Bab Merzouka, 30S 392530 3784789, 500 m, 24.iv.1995, *S.L. Jury et al.* (RNG); **Zerhoun:** Jbel Zerhoun; 9 km from Moulay Idriss along road to Nzala-des-Beni-Ammar, 30S 274252 3773290, 540 m, 28.iv.1995, *S.L. Jury et al.* (RNG); ruins of Roman city of Volubilis (3 km NW of Moulay Idriss and 33 km from Meknes along road to Sidi-Kacem and Tanger), 30S 264353 3773005, 390 m, 4.vi.1994, *S.L. Jury 14853 et al.* (RNG); **PORTUGAL. Algarve:** Cálico, 29SPB282166, 70 m, 20.v.2008, *F. Martínez-Flores & C. Flores* (ABH 52555); Quarteira, a Albufeira, 29SNB7607, 50 m, 21.v.2004, *M.B. Crespo, C. Pena & M. Mart. Azorín* (ABH 48987); Zaunva, Pau (MA 89080); **Beja:** Aljustrel, Ervidel, Barragen do Roxo, 5.vi.1972, *A. Leitão* (LISI 33792); Cuba, 2.vi.1972, *A. Leitão* (LISI 33744); Monte das Ametades, entre Moura y Pias, 205 m, 19.v.1981, *Malato-Beliz, H. Franco & J.A. Conerra* (MA 411528); Moura; Póvoa de São Miguel, 12.vi.1972, *J. Monjardino* (LISI 35440); Serpa, Pevide, 17.vi.1970, *J. Franco & M.M. da Fonseca* (LISI 30692); Serpa, Herdade do Pexoto, 17.vi.1970, *J. Franco & M.M. da Fonseca* (LISI 30691); Serpa, Courela de S. Braz, 17.iv.1952, *F. Goinhas* (LISI 13922); **Coimbra:** Lameiros, Antuzide, Coimbra, 325 m, 3.vii.1971, *Rozeira, Barreto, Serra & Araújo* (MA 460473); Torre de Vilela, Sitio das Valas, 50 m, 20.v.1954, *A. Drearte* (LISI 16175); **Évora:** Arraiolos, Vimieiro, Herdade da Tourega, 27.v.1983, *J. C. Costa* (LISI 42626); Monte do Trigo, Evora, Alentejo, 200 m, 17.vi.1972, *Ladero, Rivas Goday & E. Valdés* (MA 310707); Redondo, Montoito, Herdade da Alcoruvisca, 16.v.1956, *J. Chiean* (LISI 18565); Reguengos de Monsaraz, Ferragial de Barro, 16.v.1949, *F. Xarro Guiao* (LISI 12740); Vendas Novas, v.1961, *M. Simoes* (LISI 21178); **Faro:** Albufeira, Guia, 11.v.1991, *M^a D. Espírito Santo* (LISI 48648); Burgau, Vila do Bispo, 29S NB 10, 3.iv.1999, *V.J. Arán & M.J. Tohá* (MA 627931); Estoi, Alcaia Cova – Joao Martins, 31.v.1991, *M. Lousã* (LISI 49357); Lagos, 35 m, 16.v.1853, *Bourgeau* (RNG); Loule, 1.vi.1969, *J. H. Correia* (LISI 28976); Olhao, Moncarapacho, 1 km N of Jordana, 30.v.1991, *M. Lousã* (LISI 49253); Tavira, Conceição, Capelinha, 22.v.1993, *M^a D. Espírito Santo* (LISI 568); Vila Real de Santo António, Cacela Velha, 25.v.1969, *J. Horta* (LISI 28820); **Leiria:** pr. Alvados, Estremadura, Porto de Mós, 370 m, 30.vi.1960, *A.R. Pinto da Silva, B. Rainha & M. da Silva* (MA 310071); Bombarral, Car-
- valhal, 80 m, 31.vii.1984, *M^a D. Espírito Santo* (LISI 48114); Bombarral, 40 m, 22.iv.1983, *M^a D. Espírito Santo* (LISI 42390); Bombarral, Portela, 26.iii.1968, *F. Rebocho* (LISI 26136); Bombarral (junto a vila), 30.v.1968, *F. Rebocho* (LISI 27018); Porto de Mós, S. Pedro, 200 m, 7.v.1980, *M. Lousa & J. Monjardino* (LISI 37634); **Lisboa:** Desvío a Alfragide, Lisboa to Sintra, 5.vi.1975, *M.F. Correia* (LISI 35416); Concelho de Cascais, Tires, 23.v.1964, *J. de Vasconcellos & C.A. da Costa* (LISI 23788); Sierra de Monsanto, 1848, *Welwitsch* (RNG); **Portalegre:** Alto Alentejo, Elvas, Herdade da Alagada, 22.v.1953, *Beliz & Ruiv* (LISI 15281); Aviz, Maranhão, Her de de Margem, 20.vi.1959, *V. Pinto* (LISI 20420); Elvas, Abreu, vi.1936, *J. de Vasconcellos* (LISI 6020); **Santarém:** Várzea, Qta (Quinta) do Mocha, 13.vi.1980, *T. Vasconcelos* (LISI 38784); **Setúbal:** Ferreira do Alentejo, Peroguarda, Serra do Mira, 3.v.1996, *T. Vasconcelos et al.* (LISI 564); Palmela, Barris, Cousela, 120 m, 4.vi.1963, *A. da Cruz* (LISI 22976); **SPAIN. Cáceres:** El Ejido, Saucedilla, 260 m, 7.vi.1982, *D. Belmonte* (MA 341164); **Cádiz:** Alcalá de los Gazules, a 3 km hacia Jerez, 50 m, 22.iv.1993, *J.C. Cristobal* (ABH 5181); Algodonales, Sierra de Lijar, 500–1000 m, 31.v.1980, *A. Aparicio* (MA 504369); Arcos de la Frontera, 28.iv.1951, *C. López & S. Grau* (MA 153270); Benaócaz, 700 m, 23.vi.1925, *P. Font i Quer & E. Gros* (MA 701328, RNG 14343); Cortijo Martineda, pr. Benamahoma, 30STF8072, 450 m, 23.vi.1993, *C. Aedo, C. Navarro & E. Monasterio* (MA 528415); entre S. Martín el Tesorillo y Estación de Castellar, 22.iv.1970, *Heywood et al.* (RNG); El Bosque, 2 km al sur de El Bosque, 400 m, 12.vii.1981, *M.F. & S.G. Gardner* (RNG); Jerez de la Frontera, iv.1961, *J. Borja & A. Rodriguez* (MA 177230, MA 177231, RNG); Prado del Rey, 420 m, 4.vi.1978, *A. Ramos* (MA 311882); Puerto de Santa María, v.1791, *Gutiérrez* (MA 89072); Puerto Real, 10 m, *Jecino* (MA 585340); Puerto Real, 10 m, 19.iv.1895, *C. Pau* (MA 89079); San Roque, entre la Fuente María España y el Arroyo de la mujer, 30STF855111, 25 m, 8.vi.2009, *V. Meneses* (ABH 53890, 53891, 53892, 53893, 53895); Tarifa, 8.v.1966, *Bellot & Casaseca* (MA 197014); Trebujena, 70 m, 16.v.1986, *F.J. Fernández Díez* (MA 487218); Villaluenga del Rosario, Sierra del Caillo, Navazo alto, 1200 m, 30.vi.1983, *A. Aparicio* (MA 469032); **Córdoba:** km 12 de Castro del Río a Bujalance, 8.vi.1980, *M. Ladero & O. Socorro* (MA 416470); Ventas del Río Anzur, Encinas Reales, 350 m, 21.v.1981, *E. Hernández & F. Infante* (MA 771889); **Huelva:** San Juan del Puerto, 10 m, 6.v.1931, *R. Gros* (MA 89076); **Jaén:** Estepa de Úbeda, 17.vi.1941, *E. Guinea* (MA 418318, 423301); Villanueva del Arzobispo, 800 m, vii.1891 (RNG); **Málaga:** Manilva, 30STF9728, 150 m, 21.vi.2007, *F. Martínez-Flores & C. Flores* (ABH 52493, 52492,

52808, 52809); de Marbella a Estepona por la costa, 15.v.1919, *E. Gros* (MA 89073), *Font Quer* (MA 89074); **Sevilla:** Alcalá de Guadaira carretera a Osuna, 21.iv.1973, *V.H. Heywood et al.* (RNG); Aznalcázar, marisma Las Nuevas, Laboratorio de Leo Biaggi, 5 m, 27.iv.1978, *Z. Valdés & S. Castroviejo* (MA 341165); Isla Menor, 2 m, 25.iv.1973, *V.H. Heywood et al.* (RNG); **TUNISIA. Nabeul:** 2.5 km from Soliman; on road to Grombalia, 30 m, 8.v.1990, *P. Wilkin & E.J. Wellens* (RNG).

Daucus sahariensis *Murb.*

ALGERIA. Biskra: prés Biskra, Oued-Biskra, 10.v.1853, *Balansa* (K000313549); Hammam Salahin, prope Biskra; Sahara Alger., 16.iv.1903, *Sv. Murbeck* (MA89241); **MOROCCO. Souss-Massa-Draa:** Ouarzalate, pr. oppidulum Skoura des ahl el Oust, 31.v.1985, *C. Banché et al.* (MA340566).