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Revision of the genus *Anethum* (*Apiaceae*) in North Africa, with the rediscovery of two little-known species

Abstract

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The rediscovery of two little-known species, *Foeniculum subinodorum* and *Anethum theurkauffii* in Morocco and Mauritania has led us to revise the taxonomy of the genus *Anethum*, with support of molecular data (nrDNA ITS and plastid rps16 sequences). Our phylogenetic analyses and morphological observations confirm that these two taxa are the same species to be renamed under *Anethum subinodorum*. Moreover, the phylogenetic analysis of the whole genus *Anethum* led us to recognize the close relationship between *A. subinodorum* and *A. foeniculoides*; and confirm that *Foeniculum scoparium* from Chad should be treated as a synonym of *A. foeniculum*. We recognize eight taxa (seven species and one subspecies) in *Anethum*, for which we propose an identification key and finally we here propose one new combination and design two lectotypes. These results confirm that Morocco is the center of diversity of *Anethum* with two strict sub-Saharan endemic species and a Mediterranean one.

Key words: *Anethum theurkauffii*, *Anethum subinodorum*, *Foeniculum*, *Ridolfia*, phylogeny, ITS, mericarp morphology, Maghreb, taxonomy.

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Introduction

Anethum L. sensu Frankiewicz & al. (2021), includes seven species distributed in the Iberian Peninsula (4 spp.) and the north-western region of Africa (5 spp.). *Anethum* species are perennial to annual plants characterized by leaves 2–4(–5) divided-pinnate with fine segments, a lack of bracteoles and sepals, and flowers with yellow petals often indented. Fruit morphology in the genus is highly heterogenous with strong differences in mericarp size and rib morphology among species (Jimenez-Mejías & Vargas 2015) (Fig. 1). Phylogenetic analyses based on molecular data have shown that taxa currently included in *Anethum* form a monophyletic lineage that has been previously recognized as the *Anethum* alliance (Reduron & al. 2009; Downie & al. 2010; Jimenez-Mejías & Vargas 2015;

Frankiewicz & al. 2021). Until recently (Frankiewicz & al. 2021), taxa of this alliance were recognized as distinct genera characterized by carpological and biological features. This narrow circumscription has led to the creation of several monotypic genera such as *Pseudoridolfia* Reduron, Mathez & S.R. Downie (Reduron & al. 2009), *Schoenoselinum* Jim.-Mejías & P. Vargas (Jimenez-Mejías & Vargas 2015) to fulfill the monophyly criterion. Merging *Anethum*, *Foeniculum* Mill. and other genera into a broader morphological definition of *Anethum* has been discussed for a long time by Drude (1898), Maire (1936), Jansen (1981), Badoc (1986), Reduron (2007) and Jimenez-Mejías & Vargas (2015), but it is only recently that Frankiewicz & al. (2021) simplified the systematics of the *Anethum* alliance, recombining all monospecific genera of the alliance (i.e., *Foeniculum*, *Pseudoridolfia*, *Ridolfia*, *Schoenoselinum*) under the genus *Anethum*.

Until now, the knowledge of the *Anethum* diversity was still incomplete and needed a revision, with three taxa still not included in any phylogenetic work: *A. theurkauffii* Maire, *A. subinodorum* (Maire, Weiller & Wilczek) C. Chatel. & Chamboul., and *A. scoparium* Quézel. Furthermore these three taxa differ from the definition of the genus *Anethum* by presence of small sepals (accrescent) and bracteoles that fall off quickly. We used new collections and molecular data to improve the descriptions of the six species occurring in the Maghreb and clarify their phylogenetic relationship. Description and delimitation of the two species restricted to Southern Morocco (*A. foeniculoides* Maire & Wilczek, *A. theurkauffii*) was particularly unclear in the literature (Maire 1936; Badoc & Lamarti 1997). Although *A. foeniculoides* is well characterized and frequently collected along the coastal region of the Atlantic Sahara, *A. theurkauffii* is only known from three specimens, one collected by Theurkauff (*n*°28 MPU) and one by Maire & Wilczek *s.n.* (P) and one by Larribaud (MPU) more than seventy years ago between the Atlantic Sahara and the Anti-Atlas. The poor quality of these fragmented specimens both collected in 1935 strongly limits the morphological description of these species and the chance to obtain DNA suitable for phylogenetic analysis. Fortunately, populations of *A. theurkauffii* have been rediscovered in 2017 and 2018. Here we described the morphology of these new collections, including fruit anatomy, and resolved the phylogenetic placement of *A. theurkauffii* within the genus *Anethum* using molecular data (ITS and *rps16* DNA sequences). Likewise, the phylogenetic position of a second inland species, *A. subinodorum*, very close to *A. theurkauffii*, which was only known from three herbarium specimens with only immature fruits, was not known. But a recent collection of the latter species in the Anti-Atlas has allowed to clarify its position, thanks to genetic analysis. We added in this analysis a sample from *A. scoparium* from Tibesti (Chad), which was also ignored from all previous studies.

These results are integrated in a new revision of the genus *Anethum*.

Material and Methods

A revision of North African taxa of *Anethum* is presented including synonyms, types, description, ecology, distribution and conservation status, specimens examined and a dichotomous key. New specimens of *Anethum theurkauffii*, well developed and in fruit, were collected during fieldwork carried out in Morocco in 2017 and in northern Mauritania in 2018, and deposited in G herbarium (herbarium acronyms according to Thiers 2026).

The description and analysis of this species were based on fresh and dried specimens. Data for comparison with other species were taken from previous floristic and taxonomical treatments (Maire 1936; El Alaoui Faris & Ibn Tattou 2007) and directly from herbarium specimens mostly at G, MPU and P. To try resolving all these poorly known species, we added recent specimens identified as *A. subinodorum* from Morocco (ECWP).

To assess the phylogenetic position of *Anethum theurkauffii*, we performed a phylogenetic analysis based on DNA nucleotide sequences data. Two newly collected samples of *A. theurkauffii* (Chatelain 4382 and 5138) and one of *A. subinodorum*, all deposited in G, were analyzed with 10 other samples of *Anethum* (10 new and 8 taken from GenBank, Table 1), representing all the known species in this genus. Four species representing different lineages in the tribe *Apieae* were selected as outgroups according to previous phylogenetic analyses (Jiménez-Mejías & Vargas 2015). Total DNA of the newly included plant materials was extracted from silica dried-material using the SILEX method (Vilanova & al. 2020). We amplified and sequenced the ribosomal internal transcribed spacer (ITS) and the plastid *rps16* region following the procedure described in Perret & al. (2013). Other sequences not generated in this study were obtained from GenBank. Voucher information and GenBank accession number for each sequence used in this study are provided in Table 1.

DNA sequences were manually aligned in Mesquite 3.51 (Maddison & Maddison 2017). Maximum likelihood (ML) and maximum parsimony (MP) analyses were performed on individual and combined datasets. ML analyses were conducted using the software RAXML v.8.2.10 (Stamatakis 2014) with a rapid bootstrap analysis followed by the search of the best-scoring ML tree in one single run. The model GTR was used for the ML analysis. MP analyses were carried out in PAUP 4.0a build 169 (Swofford 2002). Heuristic searches were performed with tree-bisection-reconnection (TBR) branch swapping algorithm, retaining a maximum of 10,000 trees. Branch support was estimated by full-heuristic bootstrapping with 1000 replicates using TBR branch swapping.

Results

Phylogenetic analyses

The ITS matrix had a total length of 603 characters, of which 121 were variable and 62 parsimony informative. The *rps16* matrix had a total length of 909 characters, of which 45 were variable and 17 parsimony informative. ML and MP analyses of *rps16* retrieved only a poorly resolved tree showing no supported incongruences with the ITS ML and MP trees. ML and MP analyses of the combined matrix ITS and *rps16* were fully congruent and only ML tree is shown in Figure 1. In agreement with previous results of Frankiewicz & al. (2021), the monophyly of *Anethum* is strongly supported (BS 89%).

A. theurkauffii (BS 100%) and *A. foeniculoides* (BS 96%), restricted to Morocco and northern Mauritania, are monophyletic and form a clade (BS 94%) sister to all other *Anethum* species. We found that the ITS sequence obtained from the ECWP specimen of *A. subinodorum* is highly similar and clustered within the sequences of *A. theurkauffii* (Fig. 1); as well as the type specimen of *F. scoparium* (Quézel s.n.) is highly similar and clustered with the sequences of *A. foeniculum* (BS 88%, Fig. 1).

Table 1. Sequences of *Anethum* and outgroups used for the phylogenetic analysis. Species names and their authors, herbarium vouchers, and GenBank accession numbers are provided. In bold sequences realized for this study.

Species	Locality	Voucher	ITS	rpl16
<i>Ammi majus</i>	Spain, Sevilla	Jiménez-Mejías 54PJM06, (UPOS)	KJ473864	KJ473901
<i>Anethum fennanei</i> (cultivated)	Morocco, Plateau Central	Mathez 6979ter, (MPU)	KJ473884	KJ473924
<i>Anethum foeniculoides</i>	Morocco, Mechbour	Chatelain cc4493, (G)	OM337865	OM319487
<i>Anethum foeniculoides</i>	Morocco, vers Tantan, Tafnidilt	Fischer Nina 89, (G)	OM337866	OM319488
<i>Anethum foeniculoides</i>	Morocco, Tarfaya	Podlech 48741, (MSB)	KJ473870	KJ473906
<i>Anethum foeniculoides</i>	Morocco, Tarfaya	Schuhwerk 90/297, (M)	KJ473869	KJ473905
<i>Anethum foeniculum</i>	Morocco, Guelmim	Buira & Calvo s.n., (MA)	KJ473897	KJ473920
<i>Anethum foeniculum</i>	Morocco, Tantan	N. Fischer Nina 64 (G, G00611482)	OM337867	OM319489
<i>Anethum foeniculum</i>	Spain, Seville	Silvestre-Alsina & al. 38ASA10, (UPOS)	KJ473896	KJ473919
<i>Anethum foeniculum</i> subsp. <i>piperitum</i>	Morocco, Missour	Chambouleyron s.n. (ECWP)	PQ659288	NA
<i>Anethum graveolens</i>	Spain, Valencia	Leadlay & Petty 89, (MO)	GQ148794	AF110542
<i>Anethum ridolfia</i>	Spain, Granada	Morales & al. s.n., (MA)	KJ473895	KJ473925
<i>Anethum sanguineum</i>	Spain, Cádiz, El Bosque, Sierra de Grazalema	Triano & R. Hinojosa COA45977 (COA)	GQ162781	NA
<i>Anethum subinodorum</i> [<i>Anethum theurkauffii</i>]	Morocco, Zemmour, Agalmim Al Maghdar	Chatelain cc4382, (G)	OM337868	NA
<i>Anethum subinodorum</i> [<i>Anethum theurkauffii</i>]	Morocco, Guelta Zemmour	Dobignard AD16898 (G)	PQ659287	NA
<i>Anethum subinodorum</i>	Morocco, Akka	Chambouleyron sn, (ECWP)	PQ659289	NA
<i>Anethum subinodorum</i> [<i>Anethum theurkauffii</i>]	Mauritania, Oummat el ham, Aguelte Bou Habeio	Chatelain cc5138, (G)	OM337869	OM319490
<i>Apium annuum</i>	Australia, Victoria	Walsh 5239, (MEL)	KJ473892	KJ473907
<i>Apium graveolens</i>	Spain, Seville	García-Nogales & al. 548AGN09, (UPOS)	KJ473893	KJ473908
<i>Deverra intermedia</i>	Morocco, Errachidia	Jury & al. 9231, (MA)	KJ473874	KJ473943
<i>Anethum foeniculum</i> [Type <i>Foeniculum scoparium</i>]	Chad, Emi Koussi	Quézel [Aix 00026]	PQ659290	NA

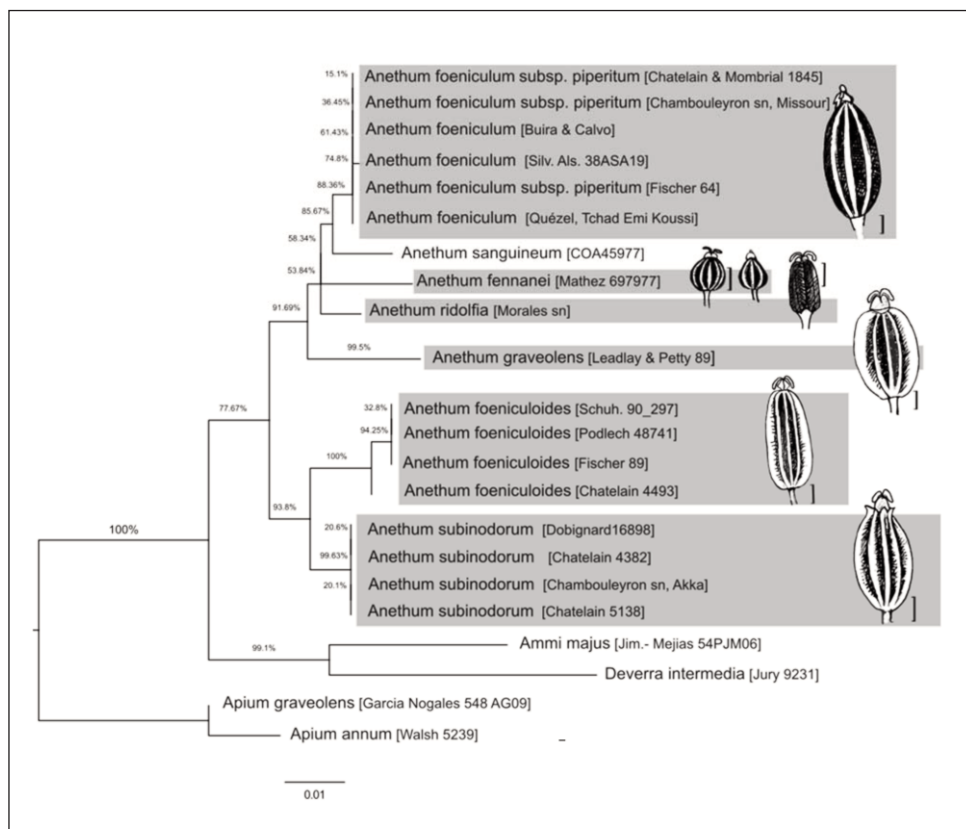


Fig. 1. Maximum likelihood tree inferred from combined sequences of nrDNA ITS and plastid rps16 intron. Bootstrap supports for nodes are given along the branches. The scale bar represents the mean number of nucleotide substitution per site. Mericarp morphology of each *Anethum* species are illustrated with a scalebar of 1mm (drawn by Chatelain).

Taxonomy

The North African *Anethum* taxa are described below:

1. *Anethum foeniculoides* Maire & Wilczek in Bull. Soc. Hist. Nat. Afrique N. 27: 66. 1936. $\equiv$ *Schoenoselinum foeniculoides* (Maire & Wilczek) Jim.-Mejías & P. Vargas in Phytotaxa 212(1): 76. 2015. Lectotype (designated by Jiménez-Mejías 2015: 76): Morocco: In rupestribus arenaceis secus flumen Noun infra Abouda, 4.IV.1935, *Maire & Wilczek* 2556 (P00084296 photo!). iso: (MPU003621, MPU003622!).

Plant clumpy perennial. *Stems* many, up to 80 – 180 cm tall, fennel-smelling. *Leaves* bi-tripennate with thin segments (< 2 mm wide), the basal ones are rapidly deciduous, the cauline ones with a sheath terminating in a very short blade ($\pm$ 2 – 8 cm) (Fig. 2), the terminal ones reduced to a sheath. *Umbels* without bracts and bracteoles absent; rays 2.3 – 5



Fig.2. *Anethum foeniculoides* and detail of a very reduced stem leaf (Photo: Fischer n89).

cm of unequal length in a same umbel; raylets 0.4 – 0.6 cm long. *Flowers* yellow; calyx teeth absent; petals slightly emarginate. *Mericarps* 3.5 – 4 × 1.8 – 1.9 mm, 3-ribbed, cumin-scented, lemon-tasting (Fig. 2).

Ecology. – *Anethum foeniculoides* occurs on rocky soils, wadi banks and drainage lines, and in littoral and sublittoral areas.

Distribution and Status. – [Saharo-mediterranean SW] Endemic to the areas of Tekna and Zemmour (northern part of Atlantic Sahara – Morocco and Mauritania) (Fig. 3).

Conservation status in Morocco – VU(e) according to Fennane (2021).

Additional specimens examined. – MOROCCO – Laâyoune: Seguiet el Ahmra, 21.VII.1938, Murat 2485 (MPU004122); Tekna, lit de l'O. Aoreora aux env. d'El-Ketoua, 12.IV.1970, Mathez 5329 (RAB); Tekna litt., 18km W de Goulimine, O. Noun-Assaka à Abouda, 21.IV.1986, Dobignard AD4357 (G) (immature fruits); Littoral, kreb de la Hamäidia Et Talia, 14km W de Tantan, 18.IV.1988, Dobignard AD6162 (G) (det. by Reduron 2010); Tekna litt., Oued Noun-Assaka au gué d'Abouda, 18km W de Goulimine, 10.IV.2009, Dobignard AD15212 (G) (immature fruits); 120km S de Layoune, littoral, 20.III.2017, Dobignard AD16841 (G); Mechbour, bord de l'oued, 5.IV.2017, Chatelain cc4493 (G); Vers Tantan, Tafnidilt, 22.IV.2020, Fischer 89 (G).

2. *Anethum subinodorum* (Maire, Weiller & Wilczek) C. Chatel. & Chamboul., comb. nov.
 ≡ *Foeniculum subinodorum* Maire, Weiller & Wilczek in Bull. Soc. Hist. Nat. Afrique N. 26: 121. 1935. Lectotype (designated here): Morocco: Anti-Atlantis inter Imiteq et Tatta, 8.IV.1934, Maire & Wilczek s.n. (P00084295 photo!); iso-: (MPU007759 photo!, RAB061216!).

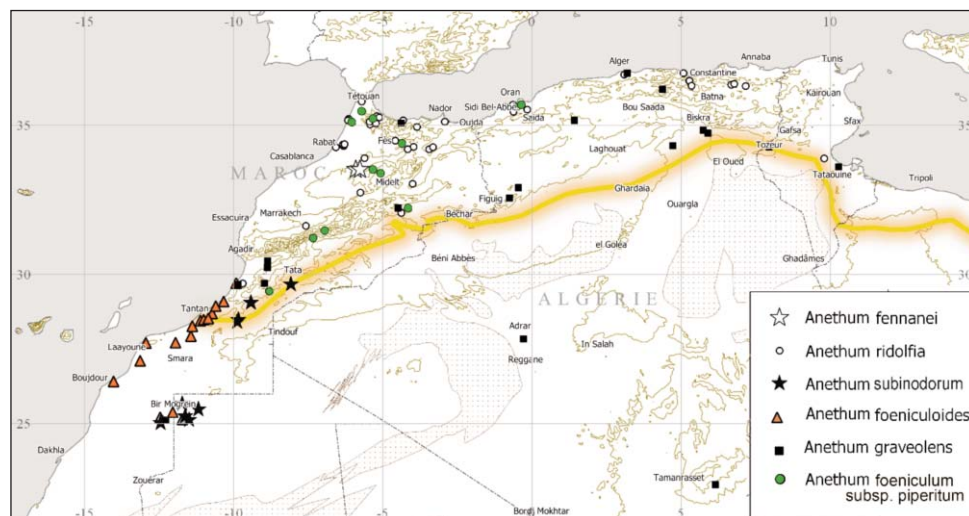


Fig. 3. Distribution map of the *Anethum* species in Maghreb. Yellow line is the north Sahara limit.

≡ *Foeniculum vulgare* var. *subinodorum* (Maire, Weiller & Wilczek) Maire in Cat. Pl. Maroc 4: 1087. 1941.

≡ *Foeniculum vulgare* subsp. *subinodorum* (Maire, Weiller & Wilczek) Ibn Tattou in Bocconea 8: 184. 1998.

= *Anethum theurkauffii* Maire in Bull. Soc. Hist. Nat. Afrique N. 27: 226. 1936, syn. nov. Lectotype (designed here): Mauritania, Zemmour: Bir Moghein, IV.1935, Theurkauff 28 (MPU003624!). (Very fragmentary type specimen, consisting of one mature fruit and fragments of a single leaf; the umbel bears filiform bracts, unlike our specimens).

Biennial (perennial?) plant, 50 – 200 cm. *Stems* up to 0.8 cm diameter ridged stems. *Leaves* 15 – 40 cm long, 3 – 4 pinnate with flat linear segments 0.5 mm wide, tips triangular to lanceolate (Fig. 4). *Umbels* with linear bracts soon caducous; involucre of 25 – 30 rays, 4 – 6 cm long, on a broad base, involucre 0.3 – 0.4 cm long; *Flowers* yellow with calyx teeth acuminate and short (Fig. 4); styles recurved on the stylopode. *Mericarps* 5 × 2.7 – 3 mm with 3 dorsal ribs and 1 marginal rib (ribs are absent in immature state) (Fig. 5), with camphorate taste.

Distribution and Ecology. – [Saharo-mediterranean SW] Endemic to southern Anti-Atlas and Zemmour (Morocco and North Mauritania), in arid to saharan areas. It occurs on sand or gravel between rocks of the rocky outcrops locally known as ‘guelbs’ (Zemmour) and in talwegs of the Anti-Atlas (Fig. 3).

Conservation status in Morocco. – The few known populations are small in number, and gaps in their distribution make a reliable evaluation difficult. Although Fennane (2021) did not assign a conservation status, we recommend Designation of Data Deficient (DD) to encourage further field surveys that could clarify the species’ range and population trends.



Fig. 4. *Anethum subinodorum*. Leaves and umbel, Akka (Photo: Chambouleyron)

Notes. – Clearly distinguished from *A. foeniculoides* which is a perennial plant (vs. biennial?), by numerous clumpy stems which can reach 150 – 200 cm high (vs. 50 – 80 cm for *A. foeniculoides*); by the leaves 3- or – 4-pennate with thin segments, less than 2 mm wide (vs. < 0.5 mm), anise-scented (vs. lemon-scented for specimens collected by Chambouleyron from Akka); without triangular acute tips on the calyx (vs. with these tips) (but impossible to observe on unripe fruits), fruit with a taste of anise (vs. strongly camphorated-scented specimens collected by Chatelain cc5138).

The type specimen of *A. theurkauffii* bears only fragmentary fruits, but they are enough distinct from all other species, contrary to the undeveloped fruits of the type of *F. subinodorum* collected by Maire.

Additional specimens examined. – MOROCCO – Anti-Atlas, Tarhijicht, 24.IV.1939, Gattefossé 39219 (MPU070728 photo!); Zemmour, Agalmim al Maghdar, 2.IV.2017, Chatelain cc4382 (G); Environs de Guelta Zemmour, 02.IV.2017 Dobignard AD16898 (G); Akka, 6.II.2019 Chambouleyron s.n. (ECWP). MAURITANIA: Bou Cheb Chou, 8.II.1954, Sougy 360 (P); Bir Moghreïn, 31.X.1942, Sauvage 17 (P02518197] photo!); Tamreikat, I.1951, Larribaud s.n., Herb. Weiller (P04349609) photo!); Oummat el Ham, Aguelt Bou Habeio, 1.XII.2018, Chatelain cc5138 (G) (Fig. 5).

3. *Anethum foeniculum* L., Sp. Pl. 1: 263. 1753.

≡ *Foeniculum vulgare* Mill., **Lectotype** (designated by Jansen & al. 1981: 24): Herb. Cliff 106, *Anethum* no. 2 (BM000558385).

= *F. officinale* All., Fl. Pedem. 2: 25. 1785.

– *F. capillaceum* Gilib. Fl. Lit. Inch. 2: 40.1782. (nom. illeg.)

= *F. dulce* Mill., Gard. Dict., ed. 8. n. 2. 1768.

= *F. vulgare* var. *inodorum* Maire in Bull. Soc. Hist. Nat. Afrique N. 26: 205. 1935.

Lectotype (designated here): Morocco. Kheneg Lekhal près Aflou, 14.VIII.1888, Clary 647 (MPU010117 photo!).

= *F. scoparium* Quézel in Bull. Soc. Hist. Nat. Afrique N. 48: 91. 1957, syn. nov. Holotype: Chad: Emi-Koussi, IV.1961, Quézel s.n. (AIX000026!).

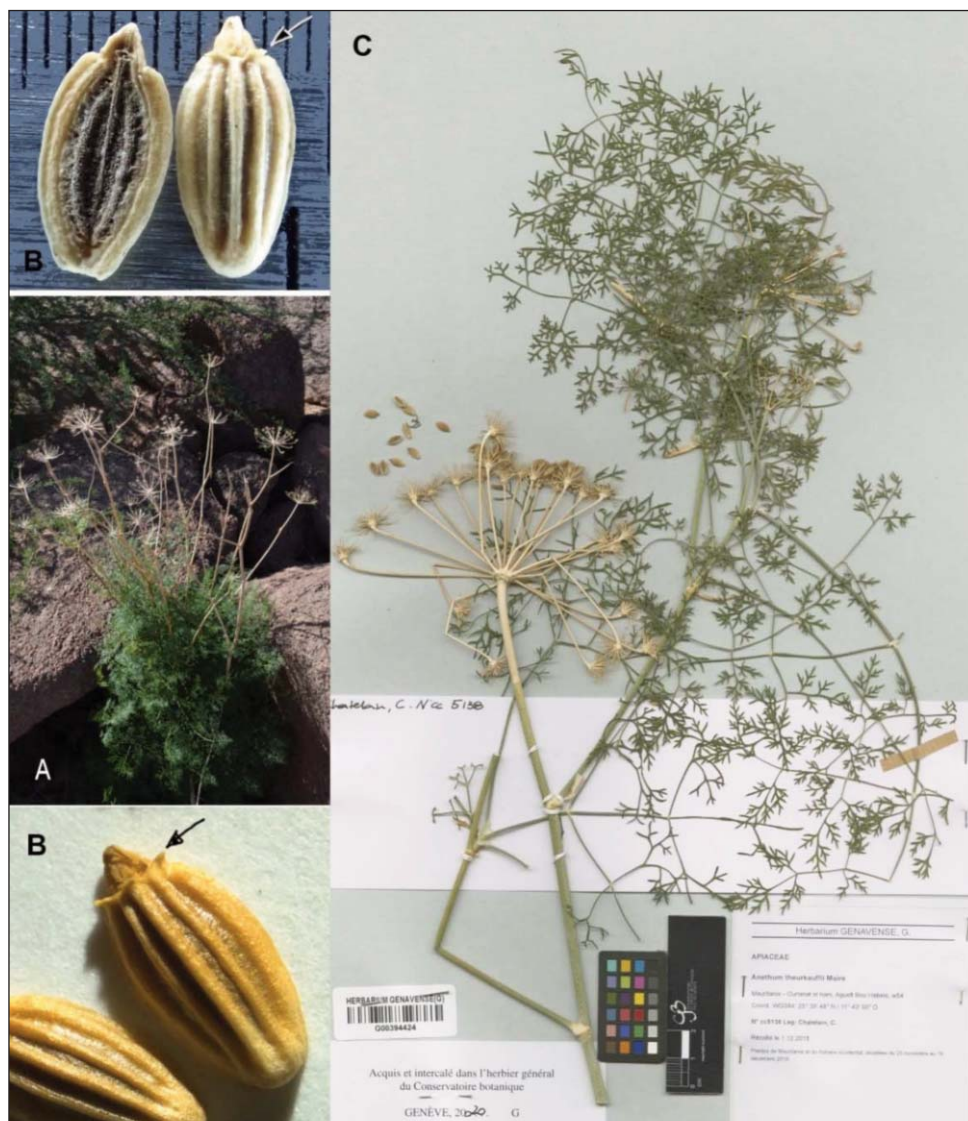


Fig. 5. *Anethum subinodorum* A. Plant growing between the rocks at Bir Moghreïn; B. mericarps, arrow showing sepals. C. Voucher from Bir Moghreïn collected by Chatelain cc5138, (G00394424) used for analysis [photo: Chatelain].

subsp. *foeniculum*

Perennial plant 1 – 2.5 m tall. *Stems* striated, glabrous. *Leaves* 3– or 4– pinnate, with narrowly linear to narrowly acicular segment. *Umbels* without bracts, nor bracteoles. *Fruit* narrowly ovoid, with prominent ridges at maturity. Glabrous. *Mericarps* anise-scented.

Distribution and Ecology. – Stenomediterranean? unknown, due to historical cultivation and propagation throughout the world by humans its difficult to propose a map close to reality. Widely distributed around the Mediterranean and introduced and cultivated in the north. In wasteland, cultivated fields, fallows, roadsides.

Additional specimens examined. ALGERIA – Alger, 1868, *Durando s.n.* (G00614519). MAURITANIA – Bir Moghreïn, IV.1961, *Quézel s.n.* (MARS76470). MOROCCO – Larache, 7.VIII.1923, *Caballero s.n.* (G00614518). TUNISIA – Gabès, III.1909, *Pitard s.n.* (G00614520).

subsp. ***piperitum*** (Ucria) Reduron & Spalik in Bot. J. Linn. Soc. 198(1): 19. 2021.
 ≡ *Anethum piperitum* Ucria, Pl. Linn. VI: 250. 1793 (reprint 1959).

Lectotype (designated by Ilardi & Troia 2021: 202): Italy. Illustration in Cupani, Panphyt. Sicul. 1: t. 117. 1713.

Epitype: (designated by Ilardi & Troia 2021: 202) Italy. Sicily, massif of Rocca, Busambra, s.d., *Troia & Ilardi s.n.* (PAL109712).

Perennial *plant* 0.8–1.5 m tall. Stems glaucous green, without anise-scented; stem striate-ridged. *Leaves* 3- or 4-pinnate, green-glaucous, with ultimate segments filiform, short (3 – 8 mm long). *Umbel* without bracts nor bracteoles, of 3 – 10(– 15) rays and umbellules with (3–) 5 – 10 raylets. *Flowers* with style short (0.2 – 0.5 mm) < stylopode. *Fruits* with a spicy taste.

Distribution and Ecology. – [Stenomediterranean] Exact distribution difficult to establish due to numerous confusions with the true cultivated taxon (see Ilardi & Troia 2021). Ecology similar to that of subsp. *foeniculum*.

Additional specimens examined. – ALGERIA – Oran, fort Santa Cruz, 24.IX.1930, *Faure s.n.* (G00382266). MOROCCO – Moyen Atlas, Ras el Ma, 11.IX.1924, *Jahandiez 924* (G00382265); Azrou, Bois de Tioumliline, 9.VIII.1924, *Litardière s.n.* (G00385100); Tighfist, 28.VII.1926, *Maire s.n.* (RAB39314); Gorges Ait Mansour, 16.III.2015, *Chatelain cc3182* (G); Oued Mekhazen, à l'ouest de Beni Arouss, 24.X.2016, *Chatelain & Mombrial cc3924* (G); Assif Lakhdar, non-loin d'Agouti, 9.XII.2018, *Chatelain & Guenat cc4993* (G). CHAD – Emi Koussi, IV.1961 *Quézel s.n.*, Typus of *F. scoparium* (AIX000026). TUNISIA – Zaghouan, 26.VII.1834, *Kralik s.n.* (G00382263).

Notes. – The distinction of infraspecific taxa is sometimes doubtful, because the ray number is highly variable, the glaucous epidermis is not visible on old specimens, and the flavour is difficult to discern in herbaria. The samples we used in this study are all grouped under the species *A. foeniculum*. Following Ilardi & Troia (2012), who confirm the distinction of subspecies *piperitum*, we consider that the mentions of this subspecies in North Africa are questionable.

4. *Anethum ridolfia* Spalik & Reduron in Bot. J. Linn. Soc. 198(1): 19. 2021.

≡ *Meum segetum* Guss., Fl. Sic. Prodr. 1: 346 (1827).

≡ *Ridolfia segetum* (Guss.) Moris in Ind. Sem. Hort. Taur. 43. 1841.

Lectotype (designed by Santangelo & al. 2022: 206): Italy. Sicily, VI-V 1827?, *Gussone, s.n.* (NAP).

Annual *plant* 0.4 – 1 m high. *Stem* finely striate. Basal and cauline *leaves* 3 – 5 pinnate, with filiform segments, acute-mucronate at apex, the upper ones reduced to a sheath. *Umbels* 8 – 15 cm wide each with 25 – 50 rays, without involucre, umbellules with 15 – 30 raylets without involucre; carpophore divided and persistent after the fruit has dehiscent. *Flowers* yellow, regular, sepals not visible, petals emarginate, incurved; styles diverging, very short, but longer than the stylopode. *Fruit* ovoid-subcylindrical 1.7 – 2.5 mm long, glabrous and smooth; mericarps with 5 inconspicuous fine primary ribs, one rib per vallecule, and 2 commissural ones.

Distribution and Ecology. – [Stenomediterranean] All the countries bordering the Mediterranean Sea (except Egypt), and Saudi Arabia. Cultivated fields, fallows.

Additional specimens examined. – ALGERIA – Alger, 1838, *Bové 129* (G00382260); Ferme de l'Union du Sig, 1885, *Durando 62* (G00408416); Oran, 16.VI.1852, *Balansa 692* (G00408422); Constantine, 1.VII.1875, *Reboud 794bis* (G00408418); Djebel Ouach à Constantine, VII.1888, *Girod s.n.* (G00408420); Bougie, VII.1896, *Reverchon s.n.* (G00610509); Kerrata, VI.1897, *Reverchon 187* (G00382259); Kerrata, lieux incultes sur le calcaire, 800m, 1.VII.1897, *Reverchon 184* (G00610503); Arbali (domaine d'Arbal), près d'Oran, V.1918, *d'Alleizette s.n.* (G00382258). MOROCCO – Larache, 7.VI.1923, *Caballero s.n.* (G00408417); Moyenne Moulouya, Missouri, 13.VIII.1924, *Litardière s.n.* (G00610506); Kenitra, VI.1925, *Humbert s.n.* (G00408419); Xauen, 24.VI.1928, *Font Quer 298* (G00408424); Rif NE. col entre l'O. Segouenaoua et l'O. Ibouharene, 18.VI.1964, *Mathez 2113* (RAB090894); Haut-Atlas oriental, env. 12-15 km au sud du "Tunnel du Légionnaire" et 1 km au nord du pont sur le Ziz, 7.VI.1997, *Jacquemoud & Jeanmonod 97/287* (G00403774); Marrakech, 45 km à l'Est de Marrakech, 2.VI.1997, *Jacquemoud & Jeanmonod 3* (G00403786). TUNISIA – Gabès, El Hamdor, III.1907, *Pitard 3065* (G00382256).

5. *Anethum fennanei* (Reduron, Mathez & S.R. Downie) Reduron & Spalik in Bot. J. Linn. Soc. 198(1): 19. 2021.

≡ *Pseudoridolfia fennanei* Reduron, Mathez & S.R. Downie in Acta Bot. Gallica 156(3): 496. 2009.

Holotype (designated by Reduron & al., 2009: 496): Morocco: Plateau central au sud-ouest de Meknès, 11.VI.1973, *Mathez 6941* (RAB 77687).

Description. – Annual herb 30–50 cm, glabrous. Basal and stem *leaves* similar, 2–3 – pinnately divided with filiform segments, narrow sheaths with white margins; umbels with 5–10 subequal rays, no involucre, nor involucre. *Flowers* yellow, petals ovate, coiled, sepals absent. *Fruit* ovoid 2 × 2 – 4 mm, smooth; styles reflexed, as long as the stylopode; mericarps 1.2 mm wide, oval curved and not joined at maturity, with 5 equal ribs.

Distribution and Ecology. – [Stenomediterranean SW] Endemic to the Oulmès mounts (Morocco), growing in *Tetraclinis* forests (Fig. 3).

Specimens examined. – MOROCCO – Aïn Karouba, Oulmès, 9.VI.1931, *Emberger s.n.* (MPU014215); Entre El-Hammam et Ouljètes-es-Soltane, 14.VI.1973, *Mathez 6973* (MPU019745).

6. *Anethum graveolens* L. in Sp. Pl.: 263. 1753.

Lectotype (designated by Jansen & al., 1981: 30): Portugal-Spain: Habitat inter Lusitaniae & Hispaniae segetes, s.d., Anon. (LINN-HL371.1).

= *Anethum graveolens* var. *chevallieri* Maire in Bull. Soc. Hist. Nat. Afrique N. 17: 114. 1926. **Holotype**: Algeria: Biskra, entre l'oued Abdi et l'oued Biskra au col des Chiens, 30.VI.1902, *Battandier s.n.* (P00084298).

Annual herb 30 – 50 cm high, all parts glabrous. *Stem* striate, branched from base. *Leaves* embracing the stem at base, 1 – 3(– 5) cm long, white with scarious margins, pinnately divided into c. 2 – 6 pairs, with linear segments. *Inflorescences* in umbel 4 – 16 cm in diam.; bracts and bracteoles usually absent; 5 – 7(– 35) rays, 9 – 15 secondary rays. *Calyx* vestigial, sometimes 5 very small teeth adnate to the ovary. *Petals* yellow, strongly inflexed. *Fruit* lens-shaped, 4 – 4.5–5 × 2 – 3 mm; mericarp flat or slightly concave, with 3 prominent ribs and two lateral whitish flat marginal wings; strong smelling.

Distribution and Ecology. – [Mediterranean S-Arabic-Irano-Turanian] N. Africa to Chad, Iran to Arabian Peninsula, introduced and cultivated in many countries. Rocky areas, wasteland, fields, gravels, roadside, (cultivated).

Additional specimens examined.: MOROCCO – Taroudant, 8.VI.1888, *Ibrahim s.n.* (G00382262); Oum-Djerid, 20.VI.1888, *Ibrahim s.n.* (G); Grand Atlas: Tizi-n-Jir au-dessus de Rich., s.d., *Humbert s.n.* (MPU335354); Torres de Alcala, 4.VI.1927, *Font Quer 458* (G00382264); Tafraoute, 16.VI.1939, *Maire & Weiller 108* (MPU070726); Carretera de Tiznit à Souk el Arba du Sahel, à 38 km de Mirleft, 16.IV.1989, *Jacquemoud 3996* (G00382261); Guelta Zemmour, 6.I.2018, *Garcin s.n.* (G). ALGERIA – Kosni, au sud de Tiaret, s.d., *Pomel s.n.* (MPU335342); Hoggar, s.d., *Lhote s.n.* (MPU335347); Portes de Fer, s.d., *Battandier s.n.* (MPU335349); Biskra, s.d., *Chevallier s.n.* (MPU001649); Biskra, 4.VI.1904, *Chevallier 577* (G00385134); Sud Oranais, Mir-el-Djebel, 30.VI.1913, *Maire s.n.* (MPU335356); Djebel Aïssa, 10.VII.1913, *Maire s.n.* (MPU335344); Assekrem, 20.III.1928, *Maire 598* (MPU335350); Adrar (Algérie), 17.IV.1958, *Simonneau s.n.* (MPU346699); Sidi-Okba, Biskra, 25.IV.1987, *Dubuis s.n.* (MPU346697).

7. *Anethum sanguineum* (Triano & A.Pujadas) Spalik, Banasiak & Frank, in Bot. J. Linn. Soc. 198(1): 19 (2021).

≡ *Foeniculum sanguineum* Triano & A.Pujadas in Acta Botanica Malacitana 40: 75.

Holotype: Spain. Sierra de Grazalema, 19.XI.2006, *Triano & Pujadas s.n.* (COA 44204).

Plant herbaceous perennial. *Stems* 50-160(190) cm, striate, green-glaucous colour. Lower *leaves* 9 – 22 × 2.5 – 5 cm, 3 – 5 pinnatisect; ultimate lobes (0.4)0.6 – 4.5 × 0.2 – 0.4 mm, filiform. Upper leaves like the lower leaves. the uppermost leaves reduced to a sheath. *Umbels* without bracts and bracteoles, with (2)3 – 5(6) primary rays, ultimate

umbels with 10 – 18 secondary rays, 2 – 5 mm. *Calyx* inconspicuous. *Petals* red, sometimes with a tinged yellow margin. *Anthers* yellow; red deciduous *Styles*, red stylopodes. *Mericarps* (4)4.5 – 6(7) × 1-2.2 mm, oblong to elliptical, pentagonal section, 5 prominent primary ridges, ridges; 4 vallecular vittae and 2 commissural vittae; aromatic (limonene and piperitene).

Distribution and Ecology. – Spain, Morocco. From the sea level till 1500 m, primary on sandy soils, weakly nitrified areas, common in wetlands, streams margin and gutters.

Additional specimens. – MOROCCO – Casablanca, Bouazza 18.XI.1987, *Lewalle s.n.*, (MA510450); Meknès-Tafilatet, Azrou, 9.VIII.1924, *Jahandiez 924*, (MA88102); Rif Oriental, Benibruifur, 20.IX.1920, *Vicioso* (MA88105); Larache, Telazta de Reixona, 11.VI.1923, *Caballero* (MA88106); Agadir, Oulad-Teima, 7.VII.1987, *Jury 9083 et al.* (MA391454); Er-Rachidia, Gorge du Ziz, 12.VII.1997, *Jury 17522 et al.* (MA616094). SPAIN – See Triano & A. Pujadas 2015.

Key to the *Anethum* taxa occurring in North Africa

Common characters: mericarps with 3 central ribs, leaves divided into narrow segments (very thin in *A. fennanei*), smelling of fennel (though sometimes very faint); petals yellow, except for *A. sanguineum*.

1. Mericarps without marginal ribs or indistinct, sepals absent 2
- 1a. Mericarps with distinct marginal ribs, like small wings (visible only on ripe fruits).. 3
2. Fruit elongated-ovoid, mericarp c. 1.25 mm large, length/width ratio c. 0.5, without prominent ribs, petals emarginate, umbels 5 – 10 rays curved inwards when fruiting, grows in cultivated fields or fallows..... *A. ridolfia*
- 2a. Fruit ovoid, mericarp 0.7 – 0.9 mm large, length/width ratio c. 1, with prominent ribs, umbels 5 – 10 rays spread out, grows in natural habitats (forests) *A. fennanei*
3. Annual 0.2 – 0.50 m; fruits ovoid 4 – 5.5 mm long, with large marginal ribs *A. graveolens*
- 3a. Perennial 0.5 – 2 m tall, clumpy with numerous stems 4
4. Bracts, bracteoles and sepals (accrescent) presents, taste camphorate *A. subinodorum*
- 4a. Bracts, bracteoles and sepals absents 5
5. Petals red and red deciduous styles and stylopodes , *A. sanguineum*
- 5a. Petals yellow and long-lasting stylopode 6
6. Mericarps mature 5 mm long, section little convex, marginal small but larger than the dorsals, lemon-tasting and fennel-scented stem *A. foeniculoides*
- 6a. Mericarps mature 6 – 7 mm, section circular, marginal ribs like the dorsal 7
7. Dark green plant; umbel (7)12 – 30 (50), rays; anise-scented leaves, mericarp variable in taste, but not pickly *A. foeniculum* subsp. *foeniculum*
- 7a. Glaucous plant; umbel 3 – 10 (15) rays; mericarps with a pickly taste *A. foeniculum* subsp. *piperitum*

Conclusion

Our phylogenetic analyses clearly support the monophyly and the close relationships of the species forming the *Anethum* alliance in agreement with the results of Jiménez-Mejías & Vargas (2015) and Frankiewicz & al. (2021), which merges *Foeniculum*, *Ridolfia*, and *Pseudoridolfia* into *Anethum*. The addition of *A. subinodorum* in this phylogenetic analysis, based on new collections, shows for the first time that it represents a monophyletic lineage within *Anethum* closely related to *A. foeniculoides*, despite it can be distinguished from congeneric species by its accrescent sepals, its mericarps with similar lateral and central ribs and the presence of umbel bracts and bracteoles (Fig. 1, 3 and 4). The results support our decision to sink *A. theurkauffii* into *A. subinodorum*, following Maire (1936). Finally, we demonstrate that *F. scoparia*, known only by the type specimen from Tibesti mountains, is a synonym of *A. foeniculum*: the analyses of a partial ITS sequence obtained from this specimen fully matches with ITS sequences of *A. foeniculum* accessions (Fig. 1). Altogether, this revision of the North African taxa of *Anethum* recognizes eight taxa (seven species and one subspecies) and provides an expanded description of these taxa that will facilitate their identification.

Biogeographically it is interesting to note that the sister species *A. foeniculoides* and *A. subinodorum* grow in $\pm$ similar habitats (wadi banks, drainage lines, talwegs), and are restricted to two neighbouring disjunct areas (between the Sahara, the Anti-Atlas and the Souss plain, Fig. 5), which is part of the probable place of origin of the genus (Frankiewicz & al. 2021): *A. foeniculoides* from the Souss to the Tekna in Morocco, an area benefitting from the Atlantic fogs suitable conditions (Chatelain & al. 2024), *A. subinodorum* from the Anti-Atlas (Morocco) to the Zemmour (Morocco and northern Mauritania), a dryer area, more inland and eastern.

We have previously resolved the confuse taxonomy of *Ammodaucus* sp.pl. (Chatelain & al. 2021), present in Atlantic Sahara, Anti-Atlas and Macaronesia, an area recognized to have an important rate of endemism (Médail & Quézel 2018; Chatelain & al. 2024), but still insufficiently explored. This work and the rediscovery of *A. subinodorum* in the wild confirm again the absolute necessity to promote fieldwork and collecting campaigns in North-West Africa, in order to answer the countless questions raised by our predecessors concerning the taxonomy and diversity of this poorly documented flora.

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