The genus *Ephedra* (*Ephedraceae*) in Greece

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Abstract. An account of the genus *Ephedra* in Greece is presented. Descriptions of the species with notes on ecology and geographical distribution, illustrations, maps and a key to the taxa are provided. Plants previously identified as *Ephedra nebrodensis* subsp. *procera* in Greece are treated as *E. nebrodensis*.

Key words: *Ephedra*, distribution, flora, Greece, taxonomy

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Introduction

The taxonomically isolated family *Ephedraceae* belongs to an ancient group of gymnosperms (Gnetales) and comprises a single genus *Ephedra* L. which has 55–65 species distributed in the arid and semi-arid regions of the Mediterranean region, Asia, Africa and America (Bolinder & al. 2016). *Ephedra* is monophyletic and sister to a *Gnetum–Welwitschia* clade (Hou & al. 2015). Most of the species are in Central (25 species) and W Asia (17 species). They possess a unique combination of morphological and biochemical characters. In Greece, the genus is represented by three species (Strid & Tan 1997; Strid 2024). These are dioecious, small to medium-sized, much-branched evergreen shrubs with slender, terete, green, *Equisetum*-like branchlets. The leaves are small, scale-like, scarious, brownish- or blackish-grey (non-photosynthetic) or green on outer surface. The reduced flowers are unisexual (male and female strobili). The ovules are naked, i.e., not enclosed in an ovary. The bracts become fleshy during ripening, forming reddish or orange-yellow false berries. Endozoochory is the main mode of dispersal (Lososová & al. 2023).

Ephedrine, pseudoephedrine and related alkaloids are present in varying quantities in the aerial parts of many species, especially those from East Asia, the most well-known being *E. sinica* Stapf (Pellati & Benvenuti 2008; Ibragic & Sofić 2015). They are used in traditional medicine in China and Japan for their stimulative, antitussive and anti-asthmatic properties

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(Sun & al. 2020; Guo & al. 2024). Samples of *E. distachya* L. from Turkey were found to have a low content (0.17%) of these alkaloids (Sticher & al. 2015). The monastery of Timios Prodromos, Serres in northeastern Greece prepares a tincture of *E. foeminea* Forssk. for asthma relief, using material gathered from Mt Menikio (KT obs.).

Ephedra showed a range of somatic chromosome numbers from $2n = 14$ to $2n = 56$ in 47 species studied, based on $n = 7$ (Rastogi & Ohri 2020). The ploidy level goes up to 8*x* (octoploid) which is the highest among gymnosperms.

Material and methods

A comparison of *Ephedra* species in Greece was carried out based on literature and herbarium material as well as studies on living material in their natural habitat. The species are presented in the order adopted in *Flora Hellenica* (Strid & Tan 1997). In the descriptions the diagnostic characters are italicized. The general range within and without Greece is also indicated. For external distribution, reference is made to Floras of the neighbouring countries and *Plants of the World online* (POWO 2024). Descriptive terminology follows that of English language Floras, e.g., *Flora Europaea* (Tutin & al. 1993), *Flora Hellenica* (Strid & Tan 1997).

Taxonomic account

Ephedra L.

Erect, procumbent or scandent much-branched shrubs. Leaves opposite, ± connate, reduced to scarious sheaths. Flowers small, greenish-yellow, in axillary inflorescences. Male flowers with a 2–4-lobed perianth and 2–8 connate stamens (microsporangia) borne in bract axils and forming an ovoid-cylindrical spike. Female flowers 1–3, with 2–4 bracts at base; seed ± enclosed by the fleshy bracts or exserted.

Key to species

1. Scrambling or pendent. Female inflorescence 2-flowered. Seed ± enclosed ……**1. *E. foeminea***
– Erect, ascending or procumbent. Female inflorescence 1–2-flowered. Seed exserted ……**2**
2. Male inflorescence with 4–8 pairs of flowers. Female inflorescence 2-flowered……**2. *E. distachya***
– Male inflorescence with 2–4 pairs of flowers. Female inflorescence 1-flowered……**3. *E. nebrodensis***

1. *Ephedra foeminea* Forssk., Fl. Aegypt.-Arab.: 219 (1775). – Lectotype (Freitag & Maier-Stolte 1989: 552–553): [NW Turkey, Imbros] 'In Insula Imros', Herb. Forsskål no. 774 *Forsskål* (C!).

= *E. fragilis* Desf., Fl. Atlant. 2: 372 (1799) – described from Tunisia and Algeria, 'habitat in montibus ad maris littora'.

= *E. major* Host, Fl. Austriac. 2: 671 (1831), nom. utique rej. prop. – type not designated (Brullo & Del Guacchio 2021).

= *E. campylopoda* C.A. Mey. in Bull. Cl. Phys.-Math. Acad. Imp. Sci. Saint-Pétersbourg 5: 34 (1845) ≡ *E. fragilis* var. *campylopoda* (C.A. Mey.) Stapf in Denkschr. Kaiserl, Akad. Wiss., Wien. Math.-Naturwiss. Kl. 56(2): 56 (1889) ≡ *E. fragilis* subsp. *campylopoda* (C.A. Mey.) K. Richt., Pl. Eur. 1: 8 (1890). – described from Greece, 'Creta, Graecia'.

= *E. gibraltarica* Boiss., Fl. Orient. 5: 714 (1884). – described from Gibraltar, Portugal (Algarve) and Morocco (Mogadur).

= *E. macedonica* Košanin in Glas. Srpske Kral. Akad. 119: 21 (1926). – described from S Serbia and northern Macedonia.

= *E. leptoclados* Heldr., in sched. (1901). – [Greece, Kiklades] 'in lapidosis et rupestribus in Cycladum insula Mykonos, 11 Jul. 1901, *Heldreich* Herb. Gr. Norm. 1700' (WU).

Shrub with *scrambling or pendent branches* to 4(–6) m long, rarely with well-developed stem. Branchlets slender, flexuous, dark green or glaucous, striate-sulcate, papillose-scabrid on the ridges; pith of older branchlets white, composed of thin-walled cells. Leaves 2–3, 1–2.5 (–5) mm long, connate for 2/3, green.

Fig. 1. *Ephedra foeminea* pendent on a small church east of Sofiko, Korinthias (photo G. Zarkos).

Male inflorescence with 4–8 pairs of flowers, sessile or shortly pedunculate. *Female inflorescence 2-flowered*, shortly pedunculate, with 2–3 pairs of bracts, the innermost (upper) pair connate 1/2–2/3. Fruit fleshy, ovoid to subglobose, pruinose, reddish-pink or bright red; *seed* ovoid, 6–8 × 2–4 mm, dark brown to black, *completely enclosed or protruding less than 1 mm from bracts*. — 2*n* = 14 (diploid; Darlington & Wylie 1955; Rastogi & Ohri 2020) – Figs. 1 & 2.

Distribution

Mediterranean area to NE Tropical Africa. Widespread in Greece, reported from all floristic regions in Greece (Fig. 6).

Ecology

Rocky cliffs and gorges, macchie, phrygana, open deciduous and evergreen forest, stone walls, archaeological and coastal sites, on hard limestone, soft conglomerate, schist, ophiolithic substrate, sea level to 1100 m. Flowering April to June, fruits ripening August to late November. During long dry periods the fruits do not become fleshy. The colour of the pith in older branchlets has not been checked for all material examined.

Entomophily and anemophily have been reported for the genus *Ephedra* but anemophily seems to be the norm. However, pollination in *E. foeminea* is noted as by nocturnal insects (*Hemiptera*, *Diptera* and *Lepidoptera*). The production of a glistening pollination droplet is synchronized with the cycles of the full moon, a situation stated to be unique in the plant kingdom (Rydin & Bolinder 2015). It is not known how widespread this phenomenon is.

Fig. 2. *Ephedra foeminea* covering walls between garden terraces below monastery of Simonas Petras, Mt Athos (photo A. Strid).

2. *Ephedra distachya* L., Sp. Pl. 2: 1040 (1753) ≡ *Chaetocladus distachys* (L.) J. Nelson, Pinaceae: 162 (1866) – Lectotype (Nouviant 1996: 132): Herb. Clifford 465, *Ephedra* 1 (BM000647523, BM).

= *E. monostachya* L., Sp. Pl. 2: 1040 (1753) ≡ *E. vulgaris* var. *monostachya* (L.) C.A. Mey., Monogr. Ephedra: 84 (1846) ≡ *E. distachya* subsp. *monostachya* (L.) Riedl in Sci. Pharm. 35: 228 (1967). – Lectotype (Nouviant 1998: 5): Herb Linné *Ephedra minima, flagellis brevioribus* et *tenuioribus* Amman, Stirp. Ruth. ex Gmelin list 17 (1745), ex 1200/4 (Catalog. Linn. Herb. Savage).

= *E. vulgaris* Rich., Comm. Bot. Conif. Cycad.: 26 (1826), nom. superfl. for *E. distachya*.

= *E. minor* Host, Fl. Austriac. 2: 671 (1831). – type not designated. Host saw plants cultivated in Vienna University Botanic Garden but without male or female inflorescences.

= *E. helvetica* C.A. Mey. in Bull. Cl. Phys.-Math. Acad. Imp. Sci. Saint-Pétersbourg 5: 35 (1845) & in C.A. Mey., Monogr. Ephedra: 87 (1846) ≡ *E. distachya* subsp. *helvetica* (C.A. Mey.) Asch. & Graebn., Syn. Mitteleur. Fl. 1: 260 (1897). – described from Helvetia [Switzerland]: Valesia, Tourbillon, Fouly, pont de la Morge, Saillon.

Fig. 3. *Ephedra distachya* (photo A. Strid).

= *E. vulgaris* var. *media* C.A. Mey. in Mém. Acad. Imp. Sci. Saint-Pétersbourg, ser. 6, 7(2): 273 (1846) & in C.A. Mey., Monogr. Ephedra: 83 (1846). – described from Caucasus and Central Asia.

= *E. botryoides* Fisch. & C.A. Mey. in Bull. Cl. Phys.-Math. Acad. Imp. Sci. Saint-Pétersbourg 5: 46 (1845) & in C.A. Mey., Monogr. Ephedra: 99 (1846). – type not designated.

= *E. arborea* Lag. ex Bertol., Fl. Ital. 10: 393 (1857) ≡ *E. vulgaris* var. *arborea* (Lag. ex Bertol.) Nyman, Consp. Fl. Eur.: 677 (1882). – described from plants collected from coastal cliffs of west Sardinia.

= *E. dubia* Regel in Trudy Imp. S.-Peterburgsk. Bot. Sada 6: 482 (1879) – syntypes 'in Turkestania inter Aisi-bulak et Arganaty' (coll. *Kuschakewicz*) and 'ad fluvium Ili prope Suidun' (coll. *A. Regel*).

Erect, ascending or procumbent shrub 20–50 cm tall. Branchlets yellowish-green, papillose-scabrid on the ridges, pith of older branchlets with dark reddish- or blackish-brown deposits. Leaves 1–2 mm long, connate for 1/3–2/3, green, scarious at margin; old leaves greyish-white. *Male inflorescence with 4–8 pairs of flowers*, sessile or shortly pedunculate. *Female inflorescence 2-flowered*, with 3 (-4) pairs of bracts, the innermost (upper) pair connate 1/3–1/2. Fruit fleshy, subglobose, red or orange-red; *seed* ovoid, 4-5 × 2-3 mm, blackish-brown, *protruding almost halfway* from bracts. – $2n$ = 24, 28 (diploid and tetraploid; Amaral Franco 1986, Fu & al. 1999) – Fig. 3.

Distribution

Scattered in S Europe, Anatolia, Caucasia to C Asia, N China and S Russia; introduced in California and

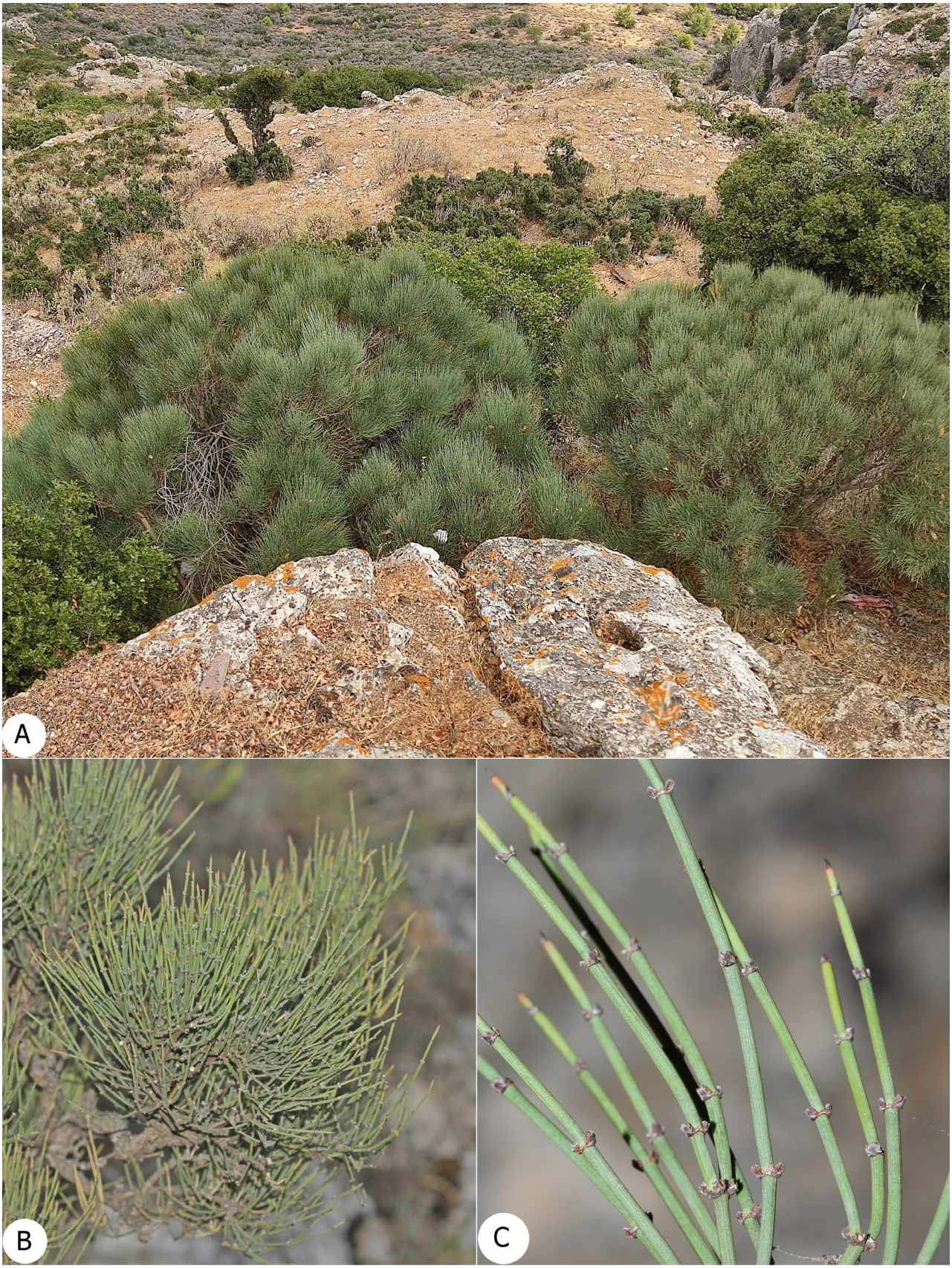

Fig. 4. *Ephedra nebrodensis* from Korinthias: **A**, from Xilokastro; **B** & **C**, from Mikri Ziria (photo G. Zarkos).

Australia. In Greece occurring in W Peloponnisos, W Sterea Ellas, coastal North East and North Central. Reported once from Mt Athos without indication of exact locality or habitat (Sibthorp & Smith 1840) and never recollected. *Ephedra foeminea* however, is very common on Athos. The male plant depicted in *Flora Graeca* (Sibthorp & Smith 1840: tab. 961) is representative of *E. distachya* but the source of the illustration may not have been from Athos but from coastal areas in northeast Greece where *E. distachya* is frequent (Fig. 6).

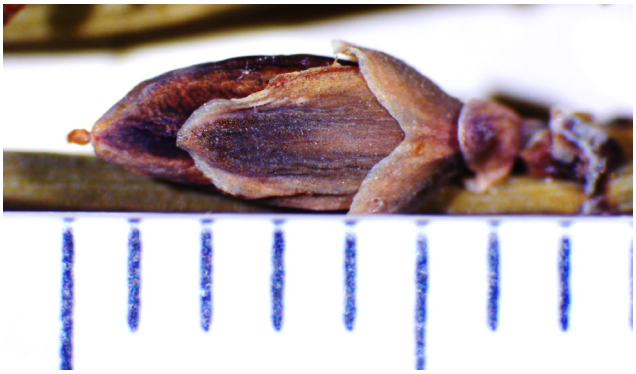

Fig. 5. Seed of *Ephedra nebrodensis* with length to breadth ratio of 2.5 (*Stamatiadou* 9618 from Mt Vourinos).

Ecology

In the Balkans the species has been reported from rocky limestone slopes in inland localities in eastern Serbia, Bulgaria and NE Albania (Niketić 2018). However, in Greece it is predominantly a coastal species and has been used as a sand-binder. Sandy flats and dunes, salines, damp lake shores, river mouths, nitrophilous wasteground, on various substrates of sand, limestone and marl, sea level to 10 (-50) m. Flowering April to June, fruits ripening July to October. Wind pollinated, no insects were observed visiting male or female flowers.

3. *Ephedra nebrodensis* Tineo ex Guss., Fl. Sicul. Syn. 2: 638 (Jul-Oct 1844) ≡ *E. major* var. *nebrodensis* (Tineo ex Guss.) Hayek in Repert. Spec. Nov. Regni Veg. Beih. 30(1): 44 (1924) – Lectotype (Del Guacchio & al. 2021: 91): [Sicily, Madonie, Isnello], 1832, *Tineo* s.n. (NAP-Gussone-Sicilia).

= *E. graeca* C.A. Mey. in Bull. Cl. Phys.-Math. Acad. Imp. Sci. Saint-Pétersbourg 5: 35 (1845) & in Monogr. Ephedra: 93 (1846) – Type: [Greece, Peloponnisos, Mt Parnonas], 'ubi in vertice Stagios Elias jugi Malevi alt. 6000 p', May 1844, *Heldreich* (LE).

= *E. equisetiformis* Webb & Berthel., Hist. Nat. Iles Canaries (Phytogr.) 3: 275 (1847). – described from Canary Islands, Tenerife: Mt Fortaleza (Degollada del Cedro), based on material collected by E. Bourgeau on 19 May 1846.

= *E. villarsii* Godr. & Gren. in Gren. & Godr., Fl. France Corse 3: 161 (1855) – described from SE France: 'sur les murs de la citadelle de Sisteron'.

= *E. scoparia* Lange in Vidensk. Meddel. Naturhist. Foren. Kjøbenhavn 1862: 33 (1862) – described from Spain: Glicia Donińos near Ferrol, Betanzos, Sierra Meirama.

= *E. atlantica* Andr. in Bot. Jahrb. Syst. 64: 265 (1931) – described from Morocco.

= *E. major* auct. non Host (1831: 671).

Erect or ascending shrub to *ca.* 2 m tall. Branchlets whorled or opposite, slender, rigid-fastigiate, dark green, finely striate, smooth or scabrid-papillose; wood of older branchlets reported as reddish- or blackish-brown. Leaves 1-2 (-3) mm, scarious at margin, connate for ¾; old leaves blackish-brown. *Male inflorescences* 1-3, sessile, *with 2(-4) pairs of flowers. Female inflorescences* 1-3, sessile to pedunculate, *1-flowered*, with 2-3 pairs of bracts, the innermost (upper) pair connate to less than 1/2. Fruit fleshy, ovoid, red, orange-red to yellowish; *seed* oblong- to ellipsoid-ovoid, 4.5-6.5 × 2-3 mm, *protruding 1-2(-3) mm from bracts.* – $2n = 14$, $n = 7$ (Amaral Franco 1986) – Figs. 4 & 5.

Distribution

West and Central Mediterranean area to Anatolia. Scattered on mainland Greece (Peloponnisos, Sterea Ellas, East and North Central and North East) and some of the larger Aegean and Ionian islands (Fig. 6).

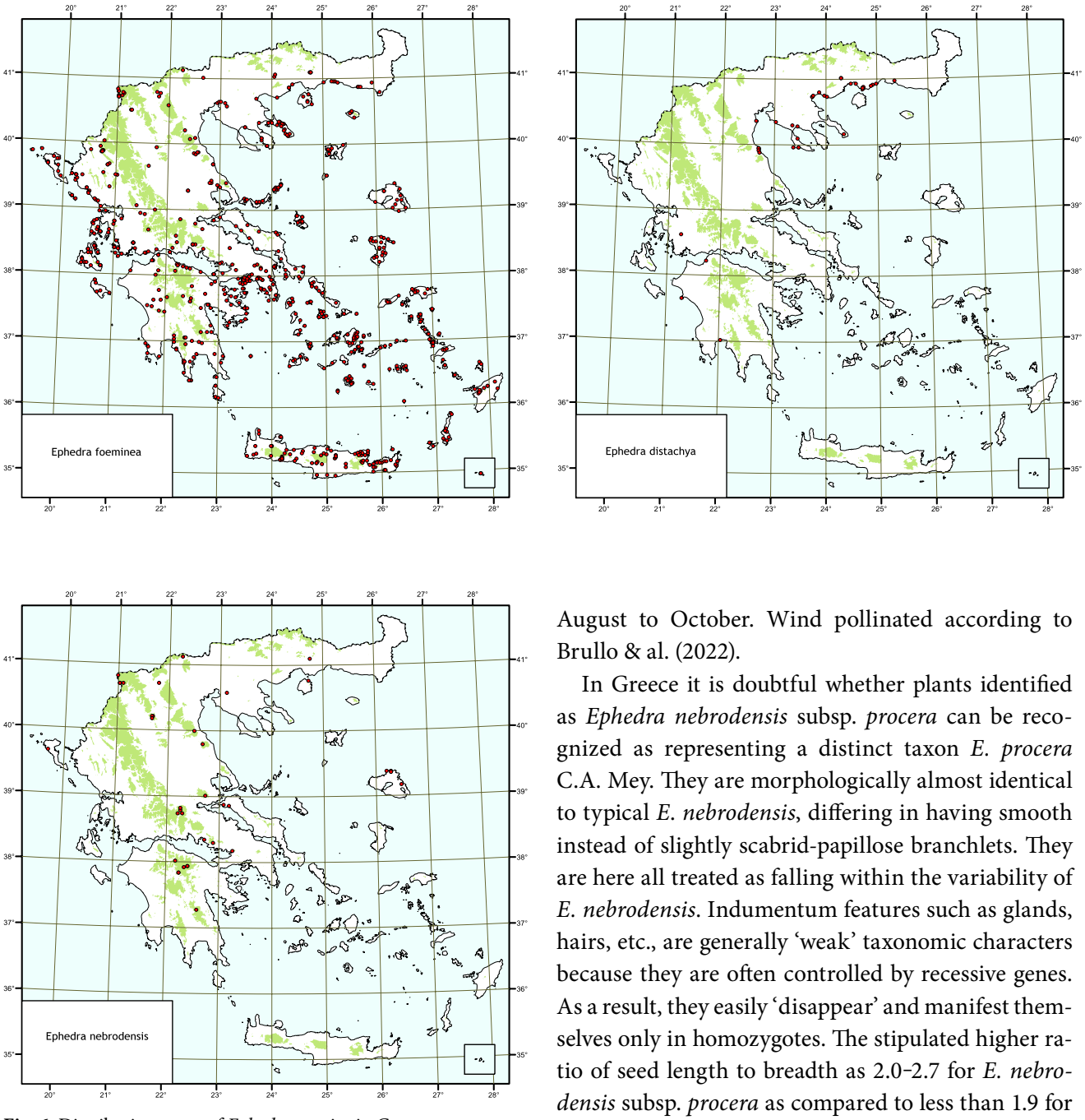

Fig. 6. Distribution maps of *Ephedra* species in Greece.

Ecology

Rocky and gravelly slopes, cliffs, ravines, in *Abies* forest, meadows with rock outcrops, limestone, 50–1975 m. Flowering May to June, fruits ripening August to October. Wind pollinated according to Brullo & al. (2022).

In Greece it is doubtful whether plants identified as *Ephedra nebrodensis* subsp. *procera* can be recognized as representing a distinct taxon *E. procera* C.A. Mey. They are morphologically almost identical to typical *E. nebrodensis*, differing in having smooth instead of slightly scabrid-papillose branchlets. They are here all treated as falling within the variability of *E. nebrodensis*. Indumentum features such as glands, hairs, etc., are generally 'weak' taxonomic characters because they are often controlled by recessive genes. As a result, they easily 'disappear' and manifest themselves only in homozygotes. The stipulated higher ratio of seed length to breadth as 2.0–2.7 for *E. nebrodensis* subsp. *procera* as compared to less than 1.9 for *E. n.* subsp. *nebrodensis* (Christensen 1997) was not demonstrated in material identified by Christensen as subsp. *nebrodensis* (*Stamatiadou* 9618, Fig. 5) where it was 2.5, similar to *E. n.* subsp. *procera*.

Ephedra aurea Brullo & al. was recently described from NW Sicily, with detailed description and good illustrations (Brullo & al. 2022). Its main distinguishing features seem to be the orange-yellow fruits (ripe fleshy bracts), a sea cliff habitat and a pollen-type indicative of insect pollination, while in *E. nebrodensis*,

red and orange-yellow fruits occur, the habitat is inland montane, and the pollen represents a type linked to wind pollination. Its taxonomic status is uncertain but it is probably a local population of *E. nebrodensis*, albeit an interesting one.

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References

Amaral Franco, J. do 1986. *Ephedra* L. – In: **Castroviejo, S. & al.** (eds), Flora Iberica, pp. 191-195. Real Jard. Bot. CSIC, Madrid.

Bolinder, K., Humphreys, A.M., Ehrlén, J., Alexandersson, R., Ickert-Bond, S.M. & Rydin, C. 2016. From near extinction to diversification by means of a shift in pollination mechanism in the gymnosperm relict *Ephedra* (*Ephedraceae*, Gnetales). – Bot. J. Linn. Soc., **180**(4): 461-477.

Brullo, S. & Del Guacchio, E. 2021. (2804) Proposal to reject the name *Ephedra major* (*Ephedraceae*). – Taxon, **70**(2): 431-432.

Brullo, S., Brullo, C., Cambria, S., Ilardi, V., Siracusa, G. & Giusso del Galdo, G. 2022. *Ephedra aurea* (*Ephedraceae*), a new species from Sicily. – Phytotaxa, **530**(1): 001-020.

Christensen, K.I. 1997. *Ephedra* L. – In: **Strid, A. & Tan, Kit** (eds), Flora Hellenica. Vol. **1**, pp. 15-17. Koeltz Sci. Books, Königstein.

Darlington, C.D. & Wylie, A.P. 1955. Chromosome Atlas of Flowering Plants. Ed. **2**. Allen & Unwin, London.

Del Guacchio, E., Cambria, S. & Brullo, S. 2021. Typification of the name *Ephedra nebrodensis* (*Ephedraceae*). – Phytotaxa, **496**(1): 090-092.

Freitag, H. & Maier-Stolte, **M.** 1989. The *Ephedra*-Species of P. Forsskål: Identity and Typification. – Taxon, **38**(4): 545-556.

Fu, L.G., Yu, Y.F. & Riedl, H. 1999. *Ephedraceae*. – In: **Wu, Z. & al.** (eds.), Flora of China. Vol. **4**, pp. 97-101. Sci. Press, Beijing & Missouri Bot. Gard. Press, St. Louis.

Guo, F., Xiao, Y., Makwana, C.N., He, Y., Luo, P., Irfan, M., Xiao, Z., Li, L., Ao, M. & Liu, Q. 2024. The inheritance and development of traditional Chinese medicine formulas in treating childhood asthma based on the perspective of clinical research. – J. Herbal Med., **47**: 1-15.

Hou, C., Wikström, N. & Rydin, C. 2015. The chloroplast genome of *Ephedra foeminea* (*Ephedraceae*, Gnetales), an entomophilous gymnosperm endemic to the Mediterranean area. – Mitochondrial DNA, **28**(3): 1-2.

Ibragic, S. & Sofić, E. 2015. Chemical composition of various *Ephedra* species. – Bosn. J. Basic Med Sci., **15**(3): 21-27.

Lososová, Z., Axmanová, I., Chytrý, M., Midolo, G., Abdulhak, S., Karger, D.N., Renaud, J., Van Es, J., Vittoz, P. & Thuiller, W. 2023. Seed dispersal distance classes and dispersal modes for the European flora. – Global Ecol. Biogeogr., **32**(9):1485-1494.

Niketić, M. 2018. The first record of *Ephedra distachya* L. (*Ephedraceae*, *Gnetophyta*) in Serbia –Biogeography, coenology, and conservation. – Bot. Serbica, **42**(1): 123-138.

Nouviant, J. 1996. Recherches sur *Ephedra* in Europe I: Typification de *Ephedra distachya*. – Bull. Murithienne, **114**: 127-134.

Nouviant, J. 1998. Recherches sur *Ephedra* en Europe V: typification de *Ephedra moostachya*. – Bull. Murithienne, **116**: 1-10.

Pellati, F. & Benvenuti, S. 2008. Determination of ephedrine alkaloids in Ephedra natural products using HPLC on a pentafluorophenylpropyl stationary phase. – J. Pharm. Biomed. Analysis, **48**(2): 254-263.

POWO. 2024. Plants of the World online. Roy. Bot. Gard., Kew.

Rastogi, S. & Ohri, D. 2020. Chromosome numbers in Gymnosperms – an update. – Silvae Genet., **69**: 13-19.

Rydin, C. & Bolinder, K. 2015. Moonlight pollination in the gymnosperm *Ephedra* (Gnetales). –Biol. Lett., **11**(4): 1-4.

Sibthorp, J. & Smith, J.E. 1840. Flora Graeca, **10**(2): tab. 961. Richard Taylor & Sons, London.

Sticher, O., Heilmann, J. & Zündorf, I. 2015. Hänsel / Sticher Pharmakognosie Phytopharmazie. Ed. **10**. Wissenschaft. Verlags. mbH, Stuttgart.

Strid, A. 2024. Atlas of the Hellenic Flora. Broken Hill Publ., Cyprus.

Strid, A. & Tan, Kit (eds). 1997. Flora Hellenica. Vol. **1**. Koeltz Bot. Books, Königstein.

Sun, L., Wang, D., Xu, Y., Qi, W. & Wang, Y. 2020. **Evidence of TCM Theory in Treating the** Same Disease with Different Methods: Treatment of Pneumonia with *Ephedra sinica* and *Scutellariae Radix* **as an Example.** – Evidence-Based Complementary and Alternat. Med.,**1**: 1-23.

Tutin, T.G. & al. (eds.) 1993. Flora Europaea. Ed. **2**, Vol. **1**. Cambridge Univ. Press, Cambridge.