



## Rediscovery of *Ferula anatolica* and *Ferula drudeana* (Apiaceae) from Turkey

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### Abstract

*Ferula anatolica* Boiss. was first collected from West Anatolia by Boissier and *F. drudeana* Korovin from South Anatolia by Siehe. No specimens belonging to those species have been collected since type specimens. In this paper, diagnostic morphological characters were discussed. In addition to their description, illustration, conservation status, ecology, SEM photographs surface of mericarp and pollen, chromosomes numbers of *F. anatolica* were presented.

**Key words:** *Apiaceae*, Pollen, Ecology, *Ferula*, Chromosome number

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### Türkiyeden *Ferula anatolica* ve *F. drudeana*'nın yeniden keşfi

### Özet

*Ferula anatolica* Boissier tarafından ilk kez batı Anadolu'dan ve *F. drudeana* Siehe (ki bu bitkiler Anadolu'da Çakşır, Çakşır olarak bilinir) tarafından güney Anadolu'dan toplandı. Tip örneklerinden bu zamana kadar bu türlere ait hiçbir örnek toplanamadı. Bu makalede bu türler yeniden toplanarak, bu türlerin ayırt edici morfolojik karakterleri, tanımları, resimleri, koruma statüleri, ekolojileri, meyve ve pollen SEM fotoğrafları ve *F. anatolica*'nın kromozom sayısı ve fotoğrafları verildi.

**Anahtar kelimeler:** *Apiaceae*, Polen, Ekoloji, *Ferula*, Kromozom sayısı

### 1. Introduction

Turkey has the richest flora in the temperate zone, with approximately 10,000 vascular plants. Along with its rich flora, it also has a wide diversity of habitats; however, the unique flora and habitats of Turkey are threatened and have rapidly declined during the last 40 years (Özhatay, 2006).

The genus *Ferula* L. (*Apiaceae*) contains 180–185 species (Pimenov & Leonov 2004) with the most diversity found in Central and Southwest Asia. Here about 130 species occur, of which approximately 100 are endemic (Korovin 1951, Chamberlain & Rechinger 1987). In Turkey, the first revision of *Ferula* was prepared by Peşmen (Peşmen, 1972), in which he recognized 18 species; one of them was incompletely known and nine of them were endemic. Four new species have since been added to the Flora of Turkey, and we collected and described one incompletely known species (Duman & Sağiroğlu, 2005; Sağiroğlu & Duman, 2007a; Sağiroğlu & Duman 2007b; Sağiroğlu & Duman 2010c).

The first samples belonging to *F. anatolica* Boiss. were collected in 1844 by Boissier in two different localities during one of his botanical trips through West Anatolia at the first time. These localities are B2 Alaşehir (Tmolus Supra Philadelphium) and B2 Denizli Honaz (Cadmus) mountain. After then, this species have not been collected until 2001. We have collected the specimens of these species from Alaşehir in 2001, however we could not collect from Honaz mountain. During our further investigations in 2002 and 2007, first author collected flowering and fruiting materials of *F. anatolica* (çakşır) from Alaşehir.

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Also, the specimens of *Ferula drudeana* were collected in 1904 by Siehe from South Anatolia C5 Adana inter Farasch et Jagaly at the first time. These specimens were identified as *F. ovina* by Siehe. When the monograph of *Ferula* was being prepared by Korovin, he described this specimens as *F. drudeana*. After then, this species have not been collected until the time of 2003. Pimenov collected to *F. drudeana* from Arslanköy (Mersin), and he presented to its chromosome number as  $2n=22$  (Güner et al., 2000). This region is close to the area where Siehe's lived. He had lived Fındıklı (Mersin) at that time. We not collected this species, despite all our investigations in the area.

During the further investigations in 2003-2008, first author collected adequate flowering and fruiting materials of *F. drudeana* (Çakşır) from South Anatolia C5 Adana inter Farasç (Farasch) et Çakallı (Jagaly).

It was observed that animals would prefer to eat fresh leaves and fruits of *F. anatolica* and *F. drudeana*. And this inhibits growth and reproduction individuals. In addition to that, *F. anatolica* and *F. drudeana* are represent with very few individuals because of over used of *F. anatolica* and *F. drudeana* fresh leaves and roots by people.

Measuring the level of threat to plant species is very important at conservation works. The IUCN Red list categories and criteria, which were designed by The World Conservation Union (IUCN 20001), are used to classify plant species. In the present study, *F. anatolica* Boiss. and *F. drudeana* Korovin, which were reported as (DD) data deficient and (VU) vulnerable ( Ekim et al. 2000), were recollected.

The results obtained in this study are in the following order: general descriptions and distribution, habitat and ecology, conservations status, SEM images showing the micromorphological features of the mericarps surface and pollens, and chromosomes number of *F. anatolica*.

## 2. Materials and methods

Samples belonging to *F. anatolica* and *F. drudeana* were collected from two localities. Each locality visited at least 5 times during the flowering and fruiting periods of the plant, and the population state of the species in these localities was determined. With the examinations conducted on the preparations of root tips, chromosomes of the cells in the metaphase stage were counted and their photographs were taken. Mericarps representing the general fruit structure were selected from the samples with fruits. Appropriate mericarps and pollens belonging to *F. anatolica* and *F. drudeana* were placed on prepared stubs; surface photographs of the mericarps were taken with a JSM 5600 SEM. Voucher specimens, collected during the flowering and fruiting periods, are deposited in GAZI herbarium.

## 3. Results

**3.1. *F. anatolica*** Boiss. in Ann. Sci. Nat. Ser. 3, 1: 317 (1844). Map 60, p. 451 (Fig.1).

**Syntypes:** Turkey B2 Manisa; Tmolus supra Philadelphiam (Alaşehir) Boissier G; C2 Denizli Cadmus (Honaz Da.) supra urbem Denisleh, Boissier G.

Polycarpic, perennial herbs. Rootstock thick, dense fibrous collar present up to 10 cm. Stem 100- 230 cm, terete, sulcate, glaucous, glabrous, 0.5-1.5 cm diameter at base. Basal leaves triangular-ovate in outline, 30-50 x 20-30 cm; petioles 3-10 cm; lamina 6-7 pinnate, glabrous, ultimate segments filiform, (5-)10-18(-27) x 0.2-0.4 mm, acute-mucronate. All sheaths amplexicaul, coriaceous, sulcate, sometimes glaucescent, glabrous; lower sheaths oblong, 4-8 cm, weakly inflated, lamina conspicuous, 5-6 pinnate; middle sheaths ovate-lanceolate 3-7 x 1.5-3 cm, broadly inflated, lamina 4-5 pinnate; upper sheaths ovate-lanceolate, 5-7 x 2.5-4 cm, lamina 1-3 pinnate, 1.5-4 cm. Inflorescence paniculate-corymbose; central umbels long peduncled 4-7 cm; rays (5-) 9-18, 3-6 cm, lateral umbels usually 2, long peduncled, usually fertile; per umbellules 10-18 flowered, fruiting pedicels 10-15 mm. Bracteoles linear-lanceolate, 5-7, 1-4 mm, caducous, rarely 1-2 persistent. Sepals minute, 0.2-0.7 mm, triangular-lanceolate to subulate. Petals glabrous, 1.5-2.5 mm, deflexed. Mericarps oblong-elliptic, 10-15 x 4-6 mm, dark brown when ripe; dorsal ridges filiform, lateral wings 0.5-1 mm wide; stylopodium short cylindrical; style usually persistent; dorsal vittae vittae per vallicule 2-3, commissural vittae (4-) 6.



Figure 1. Generally view of *Ferula anatolica* .

**Flowering time:** May-June

**Habitat:** Calcareous rocky places 900-1000 m.

**Distribution:** West Anatolia.

**Chromosome number:**  $2n=22$  (M.Sağiroğlu 2238 Fig.2).

**Specimens examined**

-B2 Manisa: Alaşehir, above Kozluca village, Tilki hill, 950-1000 m, 13-07-2001, *M.Sağiroğlu* 1801 & *A.Duran* (GAZI); *ibid.*, 24-05-2002, *M.Sağiroğlu* 1867 (GAZI); *ibid.*, 19-07-2002, *M.Sağiroğlu* 2150 (GAZI); *ibid.*, 22-08-2002, *M.Sağiroğlu* 2238 (GAZI). *İbid.*, 04-06-2007, *M.Sağiroğlu* 2707 (GAZI).

#### Conservation status

*F. anatolica* is classified as ‘data deficient (DD)’ in endemic rare plants in according to the recent “ Türkiye Bitkileri Kırmızı Kitabı” by Ekim et al. (Ekim et al. 2000). This species is known from two locations, so that it could be evaluated as “Endangered” (criterion B1 a) in this respect. In the meantime, it could also be categorized as “Critically Endangered” (criterion B2) for its known “area of occupancy” which is not more than 1 km<sup>2</sup> and population size estimated to fewer than 100 mature individuals (criterion C). We think that *F. anatolica* must be classified as “Critically Endangered (CR)” based on its “area of occupancy”, although it is known from two locations.

#### Ecology

*F. anatolica* is one of the highly local endemic species of genus *Ferula* in Turkey. According to our observations, it grows at the altitude of 1000 m on calcareous rocks in Alaşehir (Manisa) mountainous areas where woody *Pinus nigra* Arn., *Juniperus communis* subsp. *nana* Syme, *Jurinea consanguinea* DC., *Opopanax hispidus*, *Ferulago trachycarpa*, *Pimpinella tragium* subsp. *polyclada* (Boiss. & Heldr) Tutin, *Pimpinella tragium* subsp. *lithopgila* (Schischkin) Tutin, *Malabaila secacul* Banks & Sol., *Sideritis lanata* L., *Salvia aethiopsis* L., *Dianthus anatolicus* Boiss., *Silene splendens* Boiss., *Ajuga chamaepitys* subsp. *mesogitana* (Boiss.) Bornm., *Alkanna tubulosa* Boiss., *Scrophularia scopoli* var. *smyrnaea* (Boiss.) Boiss., *Campanula* sp, *Centaurea* sp, *Sedum* sp and *Orchis* sp.

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#### Cytology

In the chromosome study, mature mericarps were washed with water and kept in a freezing compartment for 7-15 days. They taken out of the freezing compartment, placed in petri dishes and kept in a refrigerator. They were left to

sprout at + 4 °C for 15-30 days. With the examinations conducted on the preparatons of root tips, chromosomes of the cells in the metaphase stage were counted and photographed.

The chromosome number of *F. anatolica* are presented for the first time. The species is diploid with  $2n= 22$  (Figure 2).

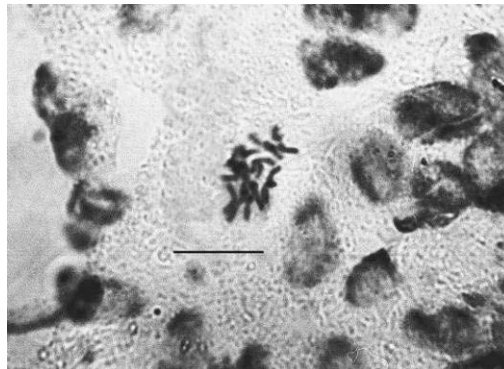


Figure 2. Somatic metaphase chromosome of *F. anatolica*. Scale bar, 10  $\mu$ m.

### Pollen Characteristics

*F. anatolica*: Polen grains radially symmetrical, tricolporate pollen tricolporate prolate P/E= 2.17  $\mu$ m, ornamentation is regulate, por oblate whose calpus is narrow and long borders are obvious, oblate pig/ plt= 0.72  $\mu$ m (Fig.3).



Figure 3. SEM image pollen of *F. anatolica*.

### 3.2. *Ferula drudeana* Korovin, monogr. 38 (1947).

**Type:** Türkiye C5 Adana inter Farasch (Faraşa) et Jagaly (Çakallı), Siehe 403 (holo. LE, iso. E!).

Perennial, Monocarpic herbs. Rootstock oblong, 3-8 cm diam.; fibrous collar dense. Stem 90-250 cm, terete, sulcate, sometimes angled at upper parts, glabrous, (2-) 3-8 cm diam at the base. Basal leaves triangular-ovate in outline, 35-60  $\times$  20-40 cm, puberulent, basal leaves less when constitute the flowering stem; petioles 8-15 (-20) cm long; lamina 6-7 pinnate, densely puberulent; ultimate segments, linear-setaceous, 0.5-2  $\times$  0.2-0.5 mm, acute. All sheaths papery, inflated, amplexicaul, semiamplexicaul, lanceolate; completely soft densely puberulent at lower part sheaths, sparsely puberulent on dorsal side of middle and upper sheaths. Inflorescence panikulate-corymbose, central umbels short peduncled (0.2-0.5 cm), lateral umbels 3-9, fertile; rays 10-22, 2-8 cm (central umbel 10-18 rays and 6-8 cm, lateral umbel 16-22 rays and 2-4 cm), erect or ascending; central umbel 20-34 and 12-25 flowered, fruiting pedicels 5-10 mm. Bracteoles usually absent, rarely 1-2, caducous. Sepals obsolete. Petals glabrous 1-1.5 mm, deflexed. Mericarps elliptic-oblong, 8-15  $\times$  4-6 mm, brown when ripe, dorsal ridges filiform, lateral wings 0.5-0.7 mm wide; stylopodium cylindric and undulate at base, conical at upper; dorsal vittae 2-3 per vallecule, commissural 6-10 (Figure 4).

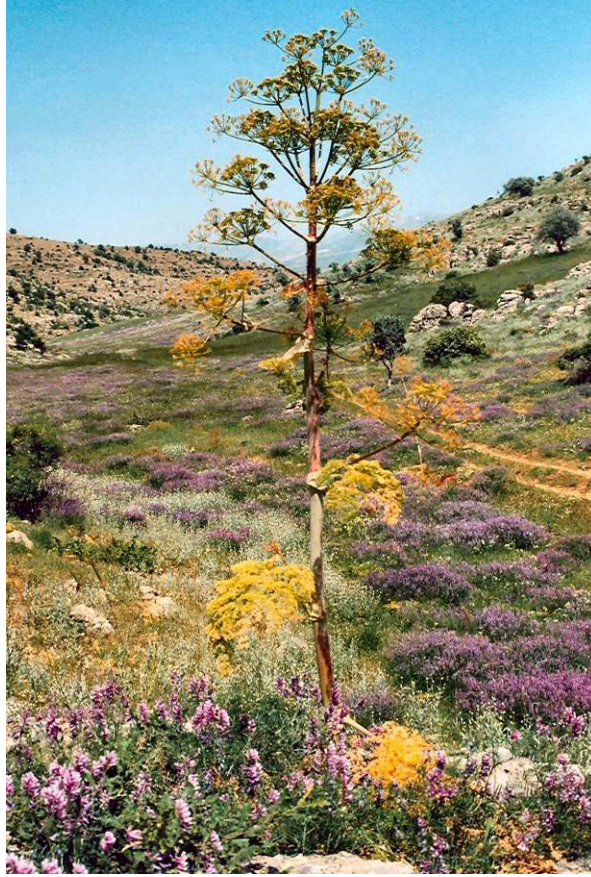


Figure 4. Generally view of *F. drudeana*.

**Flowering time:** May-June

**Habitat:** Stony places, clearing forest, 1500-1550m.

**Distribution:** South Anatolia.

**Specimens examined:**

-C5 Kayseri: Yahyalı-Çamlıca köyü 27. km, 1500-1550 m, 4.7.2003, *M.Sağiroğlu* 2366 (GAZI); İbid., 18.6. 2004, *M.Sağiroğlu* 2459 (GAZI); İbid., 16.8.2004, *M.Sağiroğlu* 2525 (GAZI ); İbid., Adana: İnter Farasch (Faraşa) et Jagaly ( Çakallı ), Siehe 403 (İso. E).

**Conservatio status:** It is narrow endemic to South Anatolia. This species is known from two locations, so that it could be evaluated as “Endangered” (criterion B1 a) in this respect. In the meantime, it could also be categorized as “Critically Endangered” (criterion B2) for its known “area of occupancy” which is not more than 1 km<sup>2</sup> and population size estimated to fewer than 250 mature individuals (criterion C). We think that *Ferula drudeana* must be classified as “Critically Endangered (CR)” based on its “area of occupancy”, although it is known from two locations.

### Ecology

*F. drudeana* is one of the highly local endemic species of genus *Ferula* in Turkey. According to our observations, it grows at the altitude of 1500 m on calcareous rocks in Yahyalı (Kayseri) mountainous areas where woody *Centaurea huber-morathii* Wagenitz, *Dianthus strictus* var. *subnervis* (Boiss.) Reeve, *Iberis aucheri* Boiss., *Michauxia tchihatchewii* Fis. & Mey., *Nepeta caesarea* Boiss., *Salvia heldreichiana* Boiss. Ex Benth, *Stachys sparsipilosa* Bhattacharjee & Hub.-Mor., *Scutellaria orientalis* subsp. *pinnatifida* Edmondson, *Marrubium cephalanthum* Boiss. & Noe, *Alkanna kotschyana* DC., *Acyonema michauxioides* (Boiss.) Damboldt, *Prangos uechritzii* Boiss., *Tordyllum elegans* (Boiss. & Bal.) Alava & Hub.-Mor., *Hordeum murinum* L., *Quercus cerris* L. var. *cerris* L., *Pistacia terebinthus* L. subsp. *terebinthus* L., *Paliurus sipina-christi* Miller, *Astragalus* sp., *Hypericum* sp., *Veronica* sp., *Campanula* sp., *Verbascum* sp.

### Pollen Characteristics

*F. drudeana*: Pollen grains radially symmetrical, tricolporate pollen tricolporate perprolate P/E= 2.09 µm, ornamentation is regulate, por suboblate whose calpus is narrow and long borders are obvious, oblate plg/ plt= 0.79 µm (Fig.5).

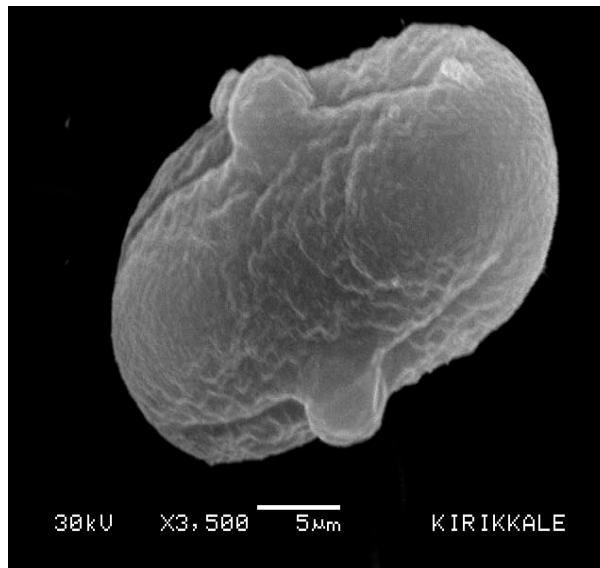


Figure 5. SEM image pollen of *F. drudeana*.

#### 4. Discussion

*F. anatolica* from 1844 to 2001 and *F. drudeana* from 1904 to 2003 had not been collected. During this time, these two areas had been observed by some collectors but these species couldn't be recorded because of these narrow and limiting areas. *F. anatolica* which is distributed at West Anatolia and *F. drudeana* which is distributed at South Anatolia has been managed to collect. Therefore, *F. anatolica* was listed at DD and *F. drudeana* was listed at VU in the Turkish Red Data Book, these have recollected from the areas (type locality) and *F. anatolica* was decided to be CR instead of DD and similarly *F. drudeana* to be CR instead of VU.

*F. anatolica* is a very distinct species, with no obvious allies in Turkey, Europae, Iran, and U.S.S.R. due to its peduncle of central umbel 4-7 cm, evident ovate sheaths, upper sheaths distinctly leafy at apex (Fig 1), dorsal vittae 2-3.

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*F. anatolica* has a somatic chromosome number of  $2n=22$  (Figure 3). and surface of mericarps contains scales (Figure 6). The mericarp surface of *F. anatolica* contains scales, whereas that of *F. drudeana* is reticulate and verrucate (Figure 6-7).

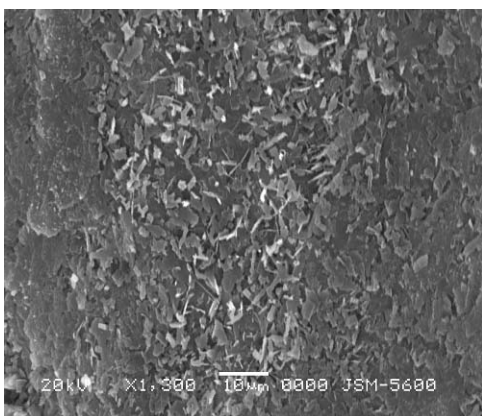


Figure 6. Scanning electron micrograph of surface of *F. anatolica* valecula.

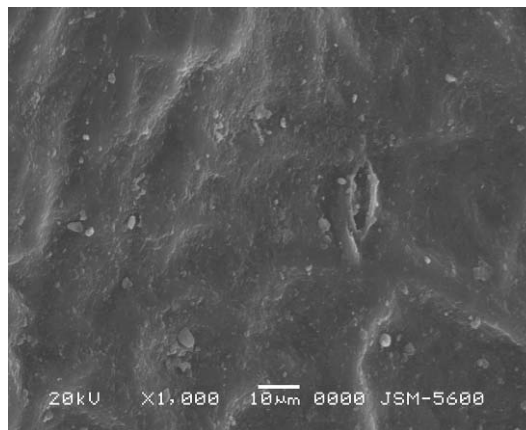


Figure 7. Scanning electron micrograph of surface of *F. drudeana* valecula.

*F. drudeana* is a very distinct species, with no obvious allies in Turkey and Europae due to its monocarpic features, evident papery sheaths, 6-7 pinnate and puberulent of basal leaves, commissural vittae 6-10.

*F. anatolica* and *F. drudeana* are enigmatic species because they were not collected so far from the date of the first collection. The most important reason for reduced populations of these species are affected anthropogenic. As a result, in Turkey, there are 22 *Ferula* species and those which *F. anatolica* and *F. drudeana* are exposed too much damage.

Turkey has a rich floral diversity as expected. Most species in Anatolia are confined to rather restricted areas of distribution. Some areas and valleys in Turkey can be determined as diversity centres for *Ferula* genus. For example, Salt Lake (Tuz Gölü) area has three species from *Ferula* genus (*F. halophila*, *F. caspica*, *F. szowitsiana*).

Moreover, Farasa (Çakallı) region and the surrounding (Bani et al., 2010) is a floristically interesting area, in that it lies between the Mediterranean phytogeographical region and the Anatolian diagonal. Palaeopalynological data show that Anatolia had a dense vegetation cover during the last interglacial period. The topography of Turkey has since changed many times, introducing different microclimates in the tectonic valleys (Gemici 1993). The phytogeographical distribution of *F. drudeana* was found to be related to the Anatolian Diagonal. The Diagonal is an interesting biodiversity area and is rich in local endemic plants, the most in any Mediterranean region (Duran et al. 2005).

*Ferula drudeana* grows up at Zamantı valley (1500 m) which is affected by the Mediterranean phytogeographic region (Figure 2). *Pinus brutia* forest is dominating on both sides of the Zamantı valley, which are effected by the Mediterranean Sea.

With this study, problems related to the taxonomy of this species were solved. But these species in the future will be faced with the danger of extinction, because the living areas as a result of anthropogenic effects is narrow and limited.

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