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***Fritillaria* species (*Liliaceae*) with yellow or yellowish-green flowers in Greece**

Abstract

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There are 7 yellow- or yellowish-green-flowered *Fritillaria* species in Greece, 4 of which are endemic. *F. conica* and *F. euboica*, endemic to mainland Greece and Evvia, are distinct by their 3-fid styles. *F. rhodia* is restricted to the island of Rodos. *F. pelinaea*, here described as a new species from Mt Pelineo on the island of Hios, was previously confused with *F. carica* and *F. bithynica*, found both on the East Aegean islands and in Asia Minor. The presence on the island of Samos of *F. forbesii* is reported, which is a new record for Greece. The main morphological features of the seven species are described and compared with those of related species. The karyotypes of *F. rhodia* and *F. pelinaea* are presented for the first time, that of *F. bithynica* was studied on a newly discovered population. Some differences in karyotype morphology are reported, especially in the marker and SAT chromosomes. The occurrence of yellowish-green variants in normally purplish-flowered *Fritillaria* species is discussed.

Introduction

The yellow or green colour exists in the flowers of most *Fritillaria* species as tessellations or fascia, or on the inner side of the tepals. Old World *Fritillaria* species with purely yellow or yellowish-green flowers (outside and within) are so far known from Iran (3 out of 15 species), Turkey (8 out of 30 species), and Greece (7 out of 23 species). Two of them are endemic to Iran (Rix 1977), four to Turkey (Rix 1984), and four to Greece.

Almost all *Fritillaria* species with a yellow or yellowish-green perianth have conical to narrowly campanulate, non-tessellated flowers. About half of them have undivided styles, and about one third have winged capsules.

Rix (1975), the principal investigator of the genus *Fritillaria* in the eastern Mediterranean region, clarified the taxonomy of most of the yellow-flowered species occurring in Turkey and Greece. He restricted application of the specific epithet *sibthorpiana* to a local, two-leaved endemic of SW Anatolia (Marmaris peninsula), and described other material previously named *F. sibthorpiana* as two new species: *F. euboica* from the

island of Evvia, Mt Dirfis, and *F. carica* from the Izmir area (Samsun Dağ). However he failed to appreciate the taxonomic significance of winged vs. non-winged capsules, nor did he have sufficient material from Samos and Hios with unwinged capsules at his disposal. Therefore, some problems remain with respect to the yellow-flowered *Fritillaria* species of the East Aegean islands.

In this paper, we try to clarify the taxonomy of all yellow-flowered *Fritillaria* species occurring in Greece.

Material and methods

For our study, we used both live and dried material from all over Greece (Fig. 1). The herbarium material was sent on loan from the following herbaria: ATH, ATHU, B, C, G, G-BOIS, Herb. Ganiatsas (Thessaloniki), HUTH, K, LD, M, Herb. Pinatzi (Athens), UPA, W, and WU-Halácsy. Greek specimens seen by us are listed under each taxon. Plants representing 21 populations of all seven yellow-flowered Greek *Fritillaria* species are cultivated in the experimental garden of the Botanical Institute, University of Patras (Fig. 1).

The method used for karyological investigation has been described in a previous paper (Kamari 1984).

Taxonomy

Key to the yellow or yellowish-green flowered Fritillaria species occurring in Greece

1. Capsules winged 1. *F. bithynica*
- Capsules unwinged 2.
2. Style undivided, or divided for up to 1 mm 3.
- Style divided for more than 1 mm 6.
3. Lower leaves \pm linear, up to 1.2 cm wide 4.
- Lower leaves \pm lanceolate to ovate, more than 1.2 cm wide 5.
4. Inner tepals narrower than the outer; style papillose, clavate 3. *F. forbesii*
- Inner tepals broader than the outer; style glabrous, slender 4. *F. rhodia*
5. Stem usually slender, often papillose at the base; lower leaves lanceolate to oblanceolate, up to 1.8 cm wide; nectaries dark brown to almost black 2. *F. carica*
- Stem usually robust, glabrous; lower leaves broadly-elliptic to ovate-lanceolate, more than 1.8 cm wide; nectaries yellowish-green 5. *F. pelinaea*
6. Leaves bright to deep green, usually opposite; style glabrous, its branches 2.5-5 mm long; capsule cylindrical to broadly cylindrical 6. *F. conica*
- Leaves glaucous, usually alternate; style \pm papillose, its branches 0.1-4 mm long; capsule subglobose 7. *F. euboica*

1. *Fritillaria bithynica* Baker in J. Linn. Soc., Bot. **14**: 264. 1874. – Lectotype (Rix 1984: 294): [Turkey, Bursa] “Bithynia in Monte Olympo” (Ulu Dağ), c. 1850, Noë (K!).

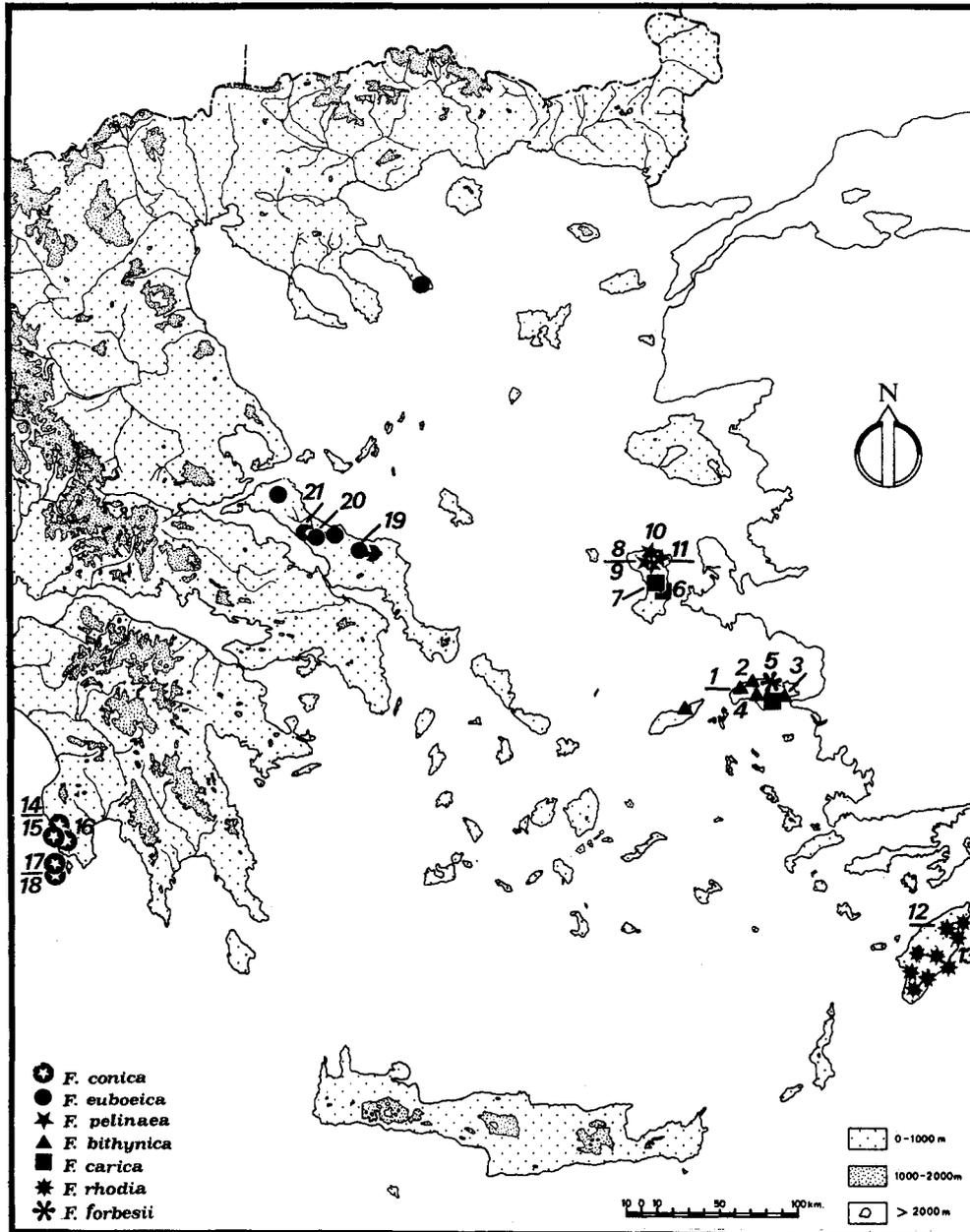


Fig. 1. Map of the known Greek distribution of seven yellow-flowered *Fritillaria* species. Numbers indicate populations that were cultivated for karyosystematic studies.

= *Fritillaria dasyphylla* Baker in Gard. Chron., ser. 2, **3**: 653. 1875.

= *Fritillaria schliemannii* Sint. ex Rodigas in Ill. Hort. **31**: 106. 1884.

= *Fritillaria pineticola* O. Schwarz in Repert. Spec. Nov. Regni Veg. **36**: 69. 1934.

Stem 7-25 cm, glabrous. Leaves (5-)7-10(-13), glaucous green, usually oblong-lanceolate to narrowly ovate, usually alternate but the lowermost often subopposite or opposite; the uppermost usually up to 3.5 cm, often single, sometimes in a whorl of 3. Flowers 1-2(-4), narrowly campanulate, usually greenish-yellow, sometimes glaucous green outside, greenish yellow inside; outer segments 17-20(-25) × 5-8 mm, usually oblong, acute; inner segments 8-10(-11) mm wide, obovate, acute. Nectaries 2-3 mm, linear-lanceolate, dark to yellowish green. Style 7-10 mm long, undivided, glabrous, slender. Capsule subglobose to shortly cylindrical, with 6 wings (Fig. 3c). $2n = 24$, 48 chromosomes.

In openings of *Pinus brutia* woodland or *Quercus coccifera* scrub, from 250 to 1140 m of altitude, chiefly on limestone substrate. Flowering from the end of March to April.

E Mediterranean element. In Greece, it occurs only on the islands of Samos and Ikaria (Fig. 1), in Asia Minor it is more widely distributed (Rix 1979, 1984), from NW to SW Anatolia.

Island of Samos: Apr 1953, *Goulimis* (Herb. Pinatzi); 10 May 1954, *Goulimis*, (Herb. Pinatzi); mons Kerkis, ad monasterium, supra pagum Kosmadei, 37°45'N, 26°39'E, c. 600 m, in pinetis, 27 Apr 1975, *Tzanoudakis 2183* (UPA); Mt Kerkis, above the village Drakei, 37°45'N, 26°37'E, 900-1100 m, 14 Jun 1979, *Christodoulakis & al. 329* (UPA); *ibid.*, 600-700 m, in *Pinus brutia* forest, 30 Jun 1980, *Christodoulakis & al. 1041* (UPA); *ibid.*, 800-1000 m, 7 Jun 1981, *Christodoulakis & Georgiadis 1428* (UPA); Mt Kerkis, SE foothills, E-NE of the Evangelistria Monastery along the path to the chapel Profitis Ilias, 750-850 m, in *Pinus nigra* woodland and rocky places, limestone, 1 May 83, *Stamatiadou 22749* (ATH); Mt Kerkis, 1 km SW of the village Kosmadei, 750 m, pine forest, 9 Apr 1985 *Zaharof F-115* (C); mons Ambelos, supra pagum Ambelos, 500-700 m, 25 Apr 1975, *Tzanoudakis 2189* (UPA); *ibid.*, 900 m, 25 Apr 1975, *Tzanoudakis 2190* (UPA); W summit of Mt Ambelos (Profitis Ilias), 900-1140 m, 3 Jun 1981, *Christodoulakis & Georgiadis 1365* (UPA); Mt Ambelos, c. 700 m, in *Pinus* woodland, 17 Aug 1982, *Christodoulakis 1728* (UPA); Mt Ambelos, c. 700 m, 5 Oct 1983, *Christodoulakis & Georgiadis 1780* (UPA); Pirgos, 300 m, 1934, *Rechinger 3853* (G) & *21360* (W); place called "Koutsi", close to Pirgos, 8 Apr 1984, *Christodoulakis 1824* (UPA); Mt Bournias, 1.5 km before the village Spatharei, 650 m, pine forest, 8 Apr 1985, *Zaharof F-028* (W); prope urbem Samos (Vathi), in ditone Zervou, 37°43'N, 26°54'E, 250 m, 30 Apr 1977, *Iatrou 183* (UPA).

Island of Ikaria: Mt Atheras, SW of the village Mileopon, 300-600 m, rocky schist with macchie and abundant *Pteridium*, damp sandy areas, 2 May 1976, *Stamatiadou 18913* (ATH).

Fritillaria bithynica is the most easily distinguished among yellow-flowered *Fritillaria* species occurring in Greece, owing to its characteristic winged capsules. Rix (1979, 1984), who did not consider this feature as significant, included in *F. bithynica* speci-

mens with both winged and unwinged capsules. As reported by Rix (1979) and Zaharof (1987), and as we could observe ourselves on the island of Samos, *F. bithynica* forms mixed populations with *F. forbesii* or *F. carica*, in which intermediate plants can be found – likely a recurrent situation in W and SW Anatolia wherever these species co-exist. *F. bithynica* varies to some extent in features such as size of stems, leaves and tepals, but, disregarding putative hybrids, it is stable in its winged capsule. The record (Rix 1979, 1984) of *F. bithynica* from the island of Hios, at Karies, is certainly due to confusion with *F. carica* which alone occurs there.

2. *Fritillaria carica* Rix in Kew Bull. **30**: 156. 1975. – Type: [Turkey] “Izmir, Samsun Dağ above Guzelcamli, 800 m, summit ridge in *Pinus brutia* forest”, 24 Apr 1965, Davis 41737 (holo- E).

= *Fritillaria tulipifolia* var. *dasyphylla* Baker in J. Linn. Soc., Bot. **14**: 266. 1874 [non *F. dasyphylla* Baker 1875].

– “*Fritillaria chia* Boiss.” ex Nyman, Consp. Fl. Eur.: 722. 1882, pro syn.

– “*Fritillaria sibthorpiana*” sensu Boiss., Fl. Orient. **5**: 187. 1884, pro parte (specimina ex Nymph Dağ) [non Baker 1874].

Stems up to 10(-12) cm, sometimes papillose at the base. Leaves 3-6(-8), glaucous, lanceolate to oblanceolate, often wavy-edged or with short papillae at the base, alternate, usually acute, the uppermost up to 4 cm, linear. Flowers 1-2, narrowly campanulate, yellowish-green or yellow; outer segments up to 18 × 7(-8) mm, lanceolate to narrowly oblong, usually obtuse; inner segments up to 8 mm wide, spatulate to oblanceolate, obtuse. Nectaries 2-4 mm, linear to lanceolate, dark brown to almost black, rarely dark green. Style 6-9 mm, undivided or 3-fid for up to 1 mm, papillose, ± stout. Capsule subglobose, unwinged (Fig. 3b). $2n = 24$ chromosomes.

In openings of *Pinus brutia* forests or in rocky places with phrygana, from 600-900 m of altitude, chiefly on limestone substrate. Flowering in April.

E Mediterranean element, is distributed mainly in W and SW Anatolia. In Greece, it occurs only on the islands of Hios and Samos (Fig. 1).

Island of Samos: Apr 1953, *Goulimis* (Herb. Pinatzi); Apr 1959, *Pinatzi 16100* (Herb. Pinatzi).

Island of Hios: in monte Provatas, supra Nea Moni (rarissima), 3000', 12/24 Apr 1886, *Orphanidis 847* (G-BOIS, WU-Halácsy) & *Orphanidis 3230* (G-BOIS); pr. Nea Moni, Apr 1931, *Pinatzi 4214* (Herb. Pinatzi); Mt Provatas, rocky slopes, 38°23'N, 26°04'E, 650-750 m, in *Pinus* woodland, 19 Apr 1990, *Phitos & al. 20829* (UPA); Mt Oros, 900 m, 1 Apr 1951, *Pinatzi 36* (Herb. Pinatzi); S slopes of Mt Oros, 2 km N of the village Pitius, 1000 m, open stony places, limestone, 11 Mar 1969, *Stamatiadou 4494* (ATH); Mt Oros, SW-facing rocky slopes, 38°30'N, 36°00'E, 750-870 m, 24 Apr 1990, *Phitos & al. 21223* (UPA).

Fritillaria carica has previously been confused under the name *F. sibthorpiana* (Sm.) Baker. Indeed some plants from the island of Hios, like *F. sibthorpiana*, have only 2-3 leaves, but they are much smaller in size. Additionally, they have very short stems and

rather slender, shortly papillose styles, two features that characterize *F. carica* subsp. *serpenticola* Rix (1983, 1984), which grows on serpentine substrate in SW Anatolia.

Plants from the island of Hios, Nea Moni (*Orphanidis 847*, G-BOIS!, WU-Halácsy!), were labelled "*Fritillaria chia* Boiss." and are mentioned as such in the synonymy of *F. pinardii* Boiss. by Nyman. *F. pinardii*, a very variable species with a wide distribution (from Armenia through Asia Minor to Lebanon, Syria, and eastwards to W Iran) has perianth segments that are purplish to greyish outside. As in all yellow-flowered *Fritillaria* species, the tepals of *F. carica* often change colour at maturity or when dried, becoming orange or fading to purple, especially at the edges or along the veins. For this reason, the two species are often confused.

Fritillaria carica is closely related to *F. forbesii*, which differs mainly in the shape of its flowers (inner tepals broader than the outer) and in the broader cauline and radical leaves.

3. *Fritillaria forbesii* Baker in Linn. Soc., Bot. 14: 264. 1874. –Type: [Turkey] "In dumetis rupestribus ad Macri" (Fethiye), Mar 1842, *Forbes 626* (holo- K!).

Stem usually up to 10(-15) cm, sometimes minutely papillose at the base. Leaves 5-10(-12), glaucous, linear-lanceolate to linear, often wavy-edged or with short papillae at the base, all alternate or rarely the lowermost subopposite to opposite, the middle and upper linear and usually twisted. Flowers 1-2, conical-campanulate to narrowly campanulate, often wide open at the mouth, greenish-yellow becoming orange or fading to purple at maturity; outer segments 15-22 × 4.5-8 mm, narrowly elliptic to rhomboidal, acute to obtuse but not rounded; the inner similar but usually narrower, or at most equaling the outer. Nectaries 2-5 mm, lanceolate, dark green to almost black. Style 4.5-7 mm, undivided or 3-fid for up to 1 mm, papillose, clavate. Capsule subglobose to cylindrical, unwinged. $2n = 24$ chromosomes.

Rocky slopes covered with spiny cushions of *Astragalus ptilodes* and *Atraphaxis billardieri*, above *Pinus nigra* woodland, at 650 to 1000 m of altitude, on schist. Flowering in April.

Mainly in SW Anatolia. In Greece, it occurs only on the island of Samos (Mt Ambelos).

Island of Samos: E summit of Mt Ambelos, above the place called "Lazaros", 27°45'N, 26°50'E, 900-1000 m, 4 Jun 1981, *Christodoulakis & Georgiadis 1314* (UPA).

Fritillaria forbesii was previously thought to be endemic to SW Anatolia (Marmaris peninsula), growing at low altitudes on serpentine substrate, together with *F. sibthorpiana* and *F. carica*. It is closely related to the latter species, with which it has often been confused.

We had noted previously (Kamari 1991b) that some plants from the island of Samos remind *Fritillaria forbesii*, and Zaharof (1987) had also mentioned that in these plants the inner tepals are narrower than the outer. After a detailed study of herbarium material of *F. forbesii* from Turkey (unfortunately, no live plants were available), we conclude that the population of Mt Ambelos does indeed belong to *F. forbesii* rather than to its

close relative, *F. carica*. More material is needed, both from Samos and Anatolia, before we can be certain on the status of *F. carica*.

4. *Fritillaria rhodia* Hansen in Notes Roy. Bot. Gard. Edinburgh **29**: 329. 1969. – Type: [Greece, Dodekanisos, Rodos]: “N-exposed limestone slope of the Attaviros-Massif, NE of the town of Ag. Isidoros, open stony ground, c. 500 m, in flower”, 27 Apr 1965, *A. Hansen* (holo- C!).

Stem up to 30 cm, glabrous. Leaves 7-13, glaucous, linear, somewhat canaliculate, alternate, usually twisted, often waxy or papillose along the margins at the base. Flowers 1-2, narrowly campanulate, usually strongly flared at the mouth; outer segments up to 18 × 6(-7) mm, oblong, usually obtuse; inner segments up to 8 mm wide, always wider than the outer, obovate, obtuse or rounded. Nectaries very small (1-2 mm), yellow to greenish yellow. Style 4-6 mm, undivided, glabrous, slender. Capsule subglobose to spherical, unwinged. $2n = 24$ chromosomes.

On open stony ground or under shrubs at (50-)150-500 m of altitude, on limestone substrate. Flowering in April.

Endemic to the island of Rodos. At first it was known from a few localities only (Hansen 1969), but it has since been found to occur all over the island (Carlström 1987, H. Kalheber & K. Baumann, pers. comm.).

Island of Rodos: near the bridge outside of Lindos, 150'-200', 2 Jun 1963, *Hodgkin 6* (K); N-exposed slope of the Attaviros massif, 500 m, 27 Apr 1965, *Hansen* (C) & 10 May 1966, *Hansen* (C); Loutanis valley NW of Afandou, 36°18'N, 28°09'E, 28 Apr 1986, *Tzini & Tseroni 23343* (UPA); N-facing slopes of Mt Tsambikos close to the Loutanis valley, NW of Afandou, 36°18'N, 28°09'E, 150 m, 28 Apr 1986, *Tzini & Tseroni 23344* (UPA).

Fritillaria rhodia is easily distinguished thanks to its very narrow, somewhat canaliculate, alternate, usually twisted leaves and its small, narrowly campanulate flowers, usually flared at the mouth. In leaf characters it is similar to *F. forbesii* (which occurs in the adjacent Marmaris peninsula and on the island of Samos), but differs in some floral characters such as flower shape and style.

5. *Fritillaria pelinaea* Kamari, **spec. nova** – Type: [Greece] “Island of Hios: Mt Pelineo, W-facing slopes, above Spartounda, 38°32'N, 26°00'E, under *Acer* sp.”, 760 m, 22 Apr 1990, *Phitos & al. 22122* (holo- UPA!; iso- B!, C!, G!). – Fig. 2, 3a.

Bulbus ad 2 cm diametro. Scapus ad 20(-25) cm altus, glaber, robustus. Folia 7-10(-12), atroviridia, glauca, carnosula; inferiora late elliptica vel late ovato-lanceolata, opposita; superiora lanceolata, ± alterna vel in verticillum 3-foliatum disposita. Flores 1-2, anguste campanulati; tepala haud tessellata, lutea vel aurea; externa late oblonga, obtusa, 17-22 × 6-9 mm; interna 8-12 mm lata, late obovata, obtusa vel rotundata. Nectaria lanceolata, luteo-viridia, 2-3 mm longa. Stylus tenuis, indivisus, laevis vel breviter papillosus. Capsula late cylindrica, c. 2 cm diametro, exalata.

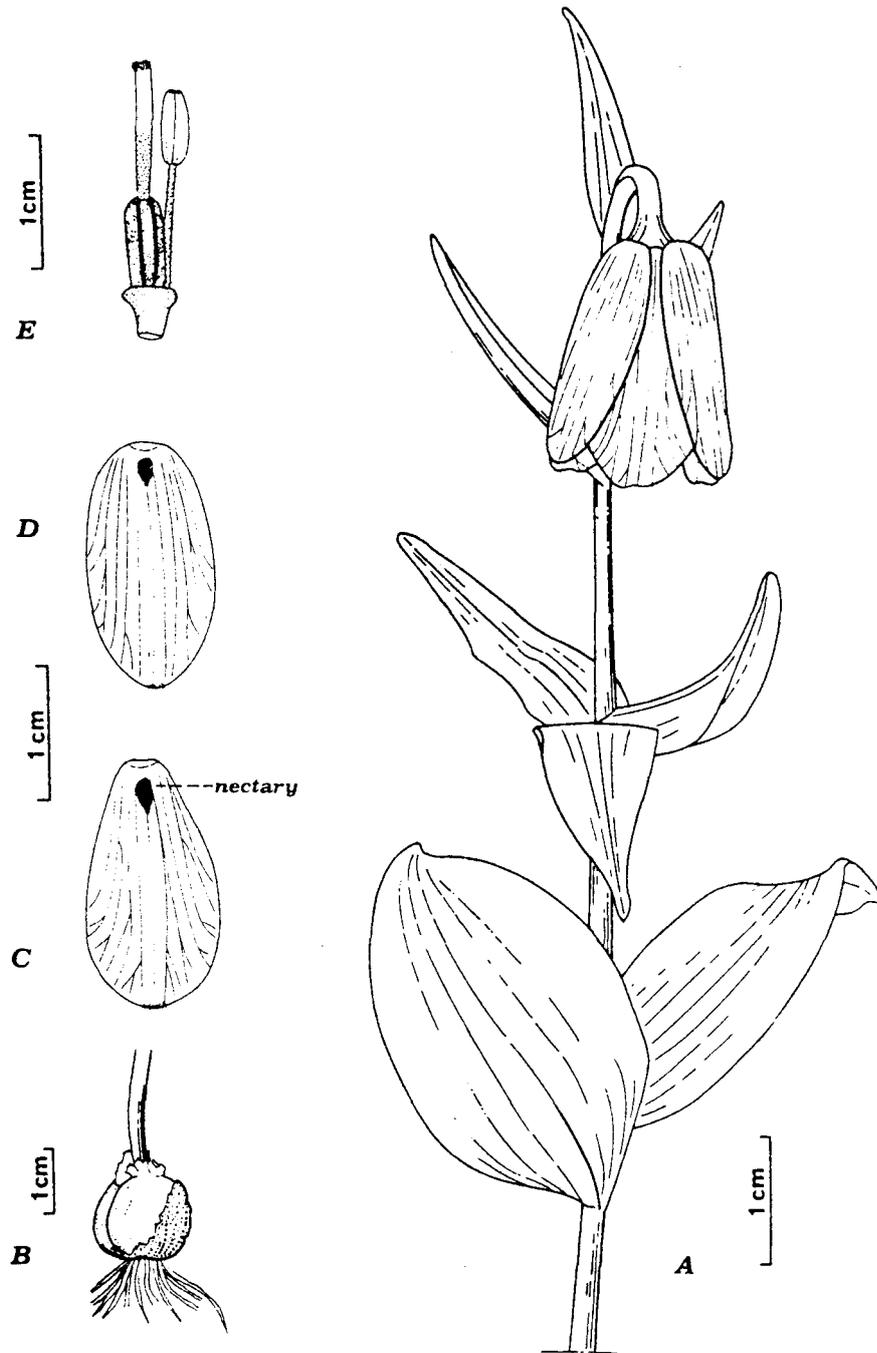


Fig. 2. *Fritillaria pelinaea* Kamari. A, habit; B, bulb; C, inside of the inner tepal; D, inside of the outer tepal; E, ovary, style and stamen.



Fig. 3. Capsule and upper part of stem of: a, *Fritillaria pelinaea* from the island of Hios (pop. n° 9); b, *F. carica* from the island of Hios (pop. n° 6); c, *F. bithynica* from the island of Samos (pop. n° 2).

Rocky slopes under *Acer*, *Pinus brutia* or in scrub, (350-)500-1000 m alt., on limestone substrate. Flowering from March to April.

Endemic. Restricted to Mt Pelineo on the island of Hios (several populations).

Island of Hios: Mt Pelineo, W-facing slopes, above Spartounda, 38°32'N, 26°00'E, 800-1000 m, under *Acer* sp., 23 Feb 1979, *Kamari & Christodoulakis 15833a* (UPA); Mt Pelineo, W-facing rocky slopes, above Spartounda, 38°32'N, 26°00'E, 760 m, under *Acer* sp., 22 Apr 1990, *Phitos & al. 21122* (UPA); Mt Pelineo, NW-facing slopes above Vikio, 38°34'N, 26°01'E, 480 m, in *Pinus brutia* woodland, 26 Jul 1992, *Phitos & Kamari 23096* (UPA); Mt Pelineo, N-facing slopes above Amades, 38°34'N, 26°02'E, 350-550 m, in scrub, 26 Apr 1990, *Anagnostopoulos & Athanasiou 3634* (UPA).

Fritillaria pelinaea was discovered fifteen years ago, on Mt Pelineo, above the village of Spartounda, growing together with *Galanthus elwesii* under *Acer* trees, at c. 900 m of altitude. A few immature plants were collected, which appeared to differ from all known yellow-flowered *Fritillaria* species. A few years ago, we found it again in the same locality and in two new ones, all on the W-, NW- and N-facing slopes of Mt Pelineo. All previous *Fritillaria* records for Hios (see Rix 1975, 1979, and 1984, for references) were from Mt Provatas or Mt Oros, where *F. carica* alone occurs, except for a single specimen from Mt Pelineo, *Platt 118* (K; Meikle 1954, as *F. sibthorpiana*), which I have not seen. As far as we know, *F. pelinaea* is restricted to Mt Pelineo. Its lower cauline leaves are often similar to those of *F. sibthorpiana*, which, however, has only two leaves.

Fritillaria pelinaea can be easily distinguished from all other yellow-flowered *Fritillaria* species by its robust stem and broadly ovate-lanceolate to broadly elliptic, somewhat fleshy, green to deep glaucous-green, amplexicaul leaves, as well as by its broadly cylindrical, non-winged capsule (Fig. 3a). In addition, the cauline leaves are usually opposite, subopposite or sometimes in a group of three, broadly lanceolate; the uppermost are like the middle ones, often in a whorl of three.

6. *Fritillaria conica* Boiss., *Diagn. Pl. Orient.* 7: 105. 1846. Type: [Greece, Peloponnisos] "In Peloponneso prope Navarin", 1845, *Bory* (holo- G-BOIS!; iso-TCD)

Stem up to 33 cm, glabrous. Leaves 5-8(-9), bright green, usually opposite or subopposite but the uppermost often alternate, lanceolate to ovate-lanceolate, usually acute. Flowers 1-2, conical-campanulate, often wide open at the mouth, yellow; outer segments up to 26(-28) × 8(-10) mm, narrowly elliptic to rhomboidal, acute to obtuse; the inner similar but somewhat wider, up to 11(-12) mm wide. Nectaries 1-2 mm, lanceolate to ovate, green or yellowish-green. Style 7-11 mm, 3-fid to halfway, glabrous, slender. Capsule subglobose to broadly cylindrical, unwinged. $2n = 24$ chromosomes.

On rocky hills covered with scrub of *Quercus coccifera*, *Pistacia lentiscus*, and *Phlomis fruticosa*, or in clearings of *Quercus coccifera* woodland, from near sea level to 350 m of altitude, on limestone substrate. Flowering mainly from March to mid-April.

Endemic to SW Peloponnisos (between Pilos and Methoni) and the small island of Sapienza, where it was rediscovered in 1991. Previous records by Halácsy (1904) from

the NW Peloponnisos (near Patras) are dubious or may refer to populations that have become extinct.

Nomos Messinia: prope Agios Nikolaos, Mar 1897, *Zahn* (UPA); in colle Agios Nikolaos inter Pilos et Methoni, rarissima, 23 Mar 1898, *Zahn 1584* (G-BOIS); in collibus saxosis inter Methoni et Pilos, 20 Mar 1899, *Zahn 15* (WU-Halácsy); Messenia Mar 1951, *Goulimis & Pinatzi 5397* (Herb. Pinatzi); in ditone vici Pilos, ad Agios Nikolaos, 350 m, in declivibus nanofruticetosis, 6 Apr 1983, *Phitos & Kamari 19130* (UPA); slope of Agios Nikolaos, close to Pilos, 39°55'N, 21°42'E, in scrub, 6 Apr 1985, *Phitos & Kamari 23341* (UPA); inter vicus Pilos et Methoni, in nanofruticetosis, c. 200 m, solo calcareo, 12 Mar 1988, *Phitos & Kamari 19962* (UPA).

Island of Sapienza: NE part of the island, 36°47'N, 21°42'E, in macchie, 24 Mar 1991, *Phitos & al. 23340* (UPA); central part of the island, 36°46'N, 21°42'E, in woodland of *Quercus coccifera*, *Acer* sp., etc., 24 Mar 1991, *Phitos & al. 23339* (UPA).

Fritillaria conica is a distinctive species, differing from all other yellow-flowering *Fritillaria* species not only by its isolated geographical position (Fig. 1), but also by its bright green leaves and glabrous style divided down to the middle. In leaf shape and colour, and in the shape of its capsule, it somewhat resembles *F. davisii* Turrill which grows on the neighbouring Mani peninsula.

7. *Fritillaria euboica* Rix in Kew Bull. **30**: 158. 1975. – Type: [Greece] Ins. Evvia: “In cacumine montis Delphi Euboeae, alt. 5500’”, 30 Apr 1865, *Orphanidis 470* (holo- G-BOIS!; iso- ATHU!).

= *Fritillaria rixii* Zaharof in Nordic J. Bot. **6**: 727. 1986.

– “*Fritillaria sibthorpiana*” auct. balcan. [non (Sm.) Baker 1874].

Stem up to 25 cm, glabrous. Leaves 5-10, glaucous, lanceolate to linear, all alternate or the lower subopposite to opposite; the uppermost up to 5 cm, linear. Flowers 1-2 (in cultivation up to 4), conical-campanulate to narrowly campanulate, yellow, often with reddish veins at maturity; outer segments 16-26(-28) × 4-7(-8) mm, narrowly obovate, subacute to obtuse; inner segments 5-8(-9) mm wide, obtuse but not rounded. Nectaries 2-4 mm, green to yellowish brown. Style 7-11 mm, 3-fid, with branches 1-4 mm, glabrous or papillose, slender. Capsule subglobose, unwinged. $2n = 24$ chromosomes.

Rocky places or open coniferous woodland and macchie, 700-1750 m of altitude, on limestone or ophiolitic substrate. Flowering from mid-April to May.

Endemic to Greece: central and N Evvia, and Mt Athos.

Island of Evvia: in regione superiore montis Delphi, planta rarissima, Apr 1864, *Orphanidis* (ATHU); in cacumine montis Delphi Euboeae, 5500', 30 Apr 1865, *Orphanidis 470* (G-BOIS, ATHU); in cacumine Mt Dirfis, 5500', rara, 30 Apr 1865, *Orphanidis 1107* (G, WU-Halácsy); Mt Dirfis, 38°38'N, 23°50'E, 1500 m, 3 Aug 1976, *Phitos & Kamari 13120a* (UPA); Mt Dirfis, SE ridge, by the path from the katafigion to the summit, 1050-1700 m, limestone rocks and screes, 19 May 1980, *Hartvig & Franzén 9285* (C); Mt Dirfis, S side, rocky limestone screes, 1500 m, 5 Apr 1984, *Zaharof F-116* (C); Mt Pixaria, forest road from the village of Markates, large clearing in *Abies* forest, 900 m, rocky calcareous area with *Juniperus oxycedrus* and *Buxus sempervirens*, 5 Apr

1985, Zaharof F-195 (C); Mt Kandili, 15 Apr 1956, Pinatzi (Herb. Pinatzi); Mt Kandili, 38°41'N, 23°27'E, 1000 m, in scrub, 18 Apr 1983, Phitos & Kamari 19163 (UPA); Mt Kandili, around Moni Sotiros above Prokopi, 38°42'N, 23°26'E, 700-750 m, 23 Mar 1984, Phitos & Kamari 23342 (UPA); Mt Xiron, by the road from the village Kerasia to Kokkinomilia, 750 m, *Pinus halepensis* woodland, ophiolitic substrate, 6 Apr 1984, Zaharof F-095 (C).

Nomos Halkidiki: Mt Athos, Ganiatsas 1282 (HUTH).

The plants from the summit area of Mt Dirfis (locus classicus) and Mt Athos are small, with relatively few and broad leaves. *Fritillaria euboica*, however, varies even in the type collection, not only in stature, number and width of the leaves, but also in the surface and branches of the styles (Kamari 1991a). Plants from fairly low altitudes have been described by Zaharof (1986) as a separate species, *F. rixii*, which falls within the range of variation of *F. euboica*. The main morphological feature that distinguishes *F. euboica* from the yellow-flowered *Fritillaria* species of the E Aegean is its slender style that is divided for at least one sixth, or up to halfway down. This feature is shared by *F. conica*, which differs from *F. euboica* in its bright green, usually opposite leaves.

Some individuals of *Fritillaria euboica*, especially those from lower altitudes, are also similar to *F. drenovskii* Degen & Stoj. which, however, has tepals that are deep purplish- to reddish-brown outside.

Karyology

The chromosomes of *Fritillaria* are among the largest in the plant kingdom, varying from 10 to 22 μm in length. For this reason, the genus has been used extensively in detailed cytological studies by many research workers (Darlington 1930, 1936, La Cour 1951, 1978a-c, Koul & Wafai 1980, Kamari 1984, 1991b, Zaharof 1987, 1989).

For yellow-flowered species in particular, karyotype morphology was studied as follows: for *Fritillaria bithynica*, *F. conica*, *F. forbesii*, and *F. rhodia*, by La Cour (1978), using the Giemsa technique; for *F. bithynica*, *F. conica*, and *F. carica*, by Zaharof (1987 & 1989), using the Feulgen technique; for *F. euboica* and *F. conica*, by Kamari (1991b), also using the Feulgen technique, and with some additional remarks concerning *F. carica*, *F. bithynica*, and *F. rhodia*. Here, we present for the first time the karyotype morphology of *F. pelinaea*, and the Feulgen-stained karyotype of *F. rhodia*. We also compare their karyotypes with that of *F. bithynica*. A detailed karyological study of all the above taxa will be presented in a forthcoming paper.

Fritillaria bithynica: $2n = 24 = 4m + 16st + 4t$ (Fig. 4a)

The karyotype of *Fritillaria bithynica* consists of two pairs of *m* chromosomes, eight pairs of *t*-chromosomes and two pairs of *st*-chromosomes. Zaharof (1989) remarks that "secondary constrictions and SAT-chromosomes are not evident in the karyotype of *F. bithynica*". We observed, on the contrary, many secondary constrictions in the majority of its chromosomes (especially in those of the *m*-type), and often 5-6 very small satellites were visible; 3 or usually 2 of them were located on the shorter arms of *m*-chromosomes, which also had secondary constrictions close to the centromere; 3 or rarely 4

were observed on the short arms of *st*-chromosomes (2 are about 12-13 μm long and 2 about 15-17 μm long). *F. bithynica* is considered to have the most symmetric karyotype among the species examined here.

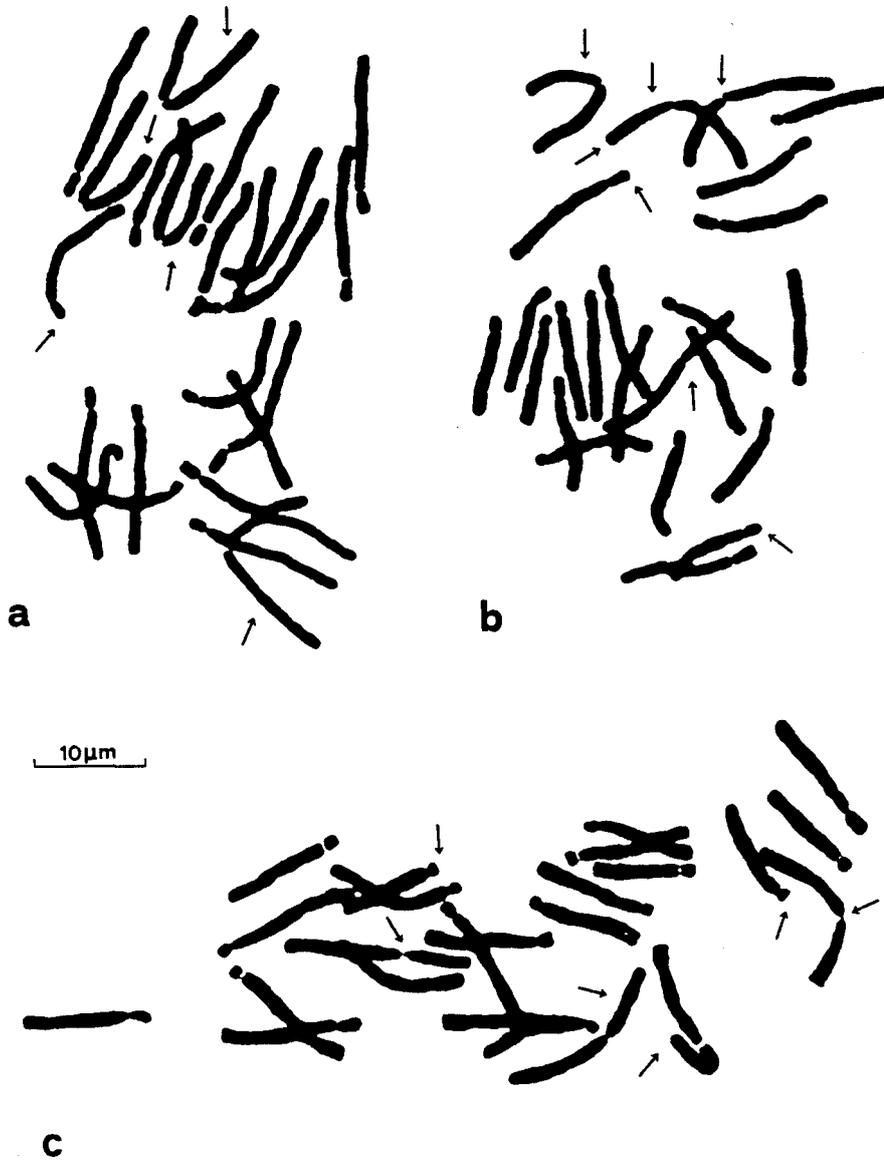


Fig. 4. Feulgen-stained somatic metaphase plates of: **a**, *Fritillaria bithynica*, $2n = 24$ chromosomes (one chromosome missing), from the island of Samos (pop. n° 2); **b**, *F. rhodia*, $2n = 24$ chromosomes, from the island of Rodos (pop. n° 12); **c**, *F. pelinaea*, $2n = 24$ chromosomes, from the island of Hios (pop. n° 8). Arrows indicate the marker m, sm, and SAT chromosomes.

Fritillaria rhodia: $2n = 24 = 4m + 14st + 6t$ (Fig 4b)

The karyotype morphology of *Fritillaria rhodia*, presented here for the first time, is very similar to that of *F. bithynica*, and mainly differs in the number of *t*-chromosomes (6, not 4 as in *F. bithynica*), which are more strongly of the *t*-type (having much shorter arms). Satellites were observed on the shorter arms of the two longest chromosomes, as well as in 1-2 of the *t*-chromosomes, which are nearly the shortest within the complement. The satellites are always very small, and may occasionally escape notice because of their minute size. It is likely that the observed presence of small satellites and secondary constrictions correlates with the terminal and some intercalary bands observed by La Cour (1987c) in all chromosomes of *F. rhodia* when using the Giemsa technique.

Fritillaria pelinaea: $2n = 24 = 2m + 2sm + 8st + 12t$ (Fig. 4c)

The karyotype of *Fritillaria pelinaea*, presented here, is more similar to those of *F. carica* and *F. conica* than of *F. bithynica* with which the species is sometimes confused. It consists of 2 *m*-chromosomes and 12 *t*-chromosomes, while in *F. bithynica* 4 *m*-chromosomes and only 4 *t*-chromosomes occur. The 2 symmetrical *sm*-chromosomes of *F. pelinaea*, have a very small satellite, as is common in yellow-flowered *Fritillaria* species. Its asymmetrical *st*-chromosomes vary from 8 to 10, and the *t*-chromosomes from 12 to 10, respectively. However, such minor differences in the number of the *st*- and *t*-chromosomes may be insignificant, since the arm ratios range within narrow deviations of around 7, the conventional limit value (Levan & al. 1965) between the *st*- and *t*-chromosome types. 3 *t*-chromosomes and one *st*-chromosome possess small satellites on the short arms. From the above 6 SAT-chromosomes, usually 3 to 4 were visible in each metaphase plate.

Conclusions

From the morphological (Tables 1-2) and karyological (Fig. 4) observations presented here, it is possible to draw the following conclusions.

The most variable among the yellow-flowered *Fritillaria* species examined here, in morphological terms, are *F. carica* and *F. euboica*.

Fritillaria carica is morphologically close to *F. forbesii*, with which it is sometimes confused, and also to *F. rhodia*, which however has a different karyotype, resembling that of *F. bithynica* (Fig. 4).

Fritillaria bithynica always has winged capsules. The karyotypes of *F. bithynica* and *F. rhodia* both have four metacentric chromosomes but differ in the number of strongly anisobrachial (*t*-) chromosomes (4 rather than the 6 of *F. rhodia*).

Fritillaria pelinaea is a very distinct species, differing from all the others examined here in several morphological features (Tables 1-2). From *F. bithynica*, with which it is usually confused, it differs not only morphologically (unwinged capsules, shape of flowers, tepals and leaves), but also in its karyotype (Fig. 4): *F. pelinaea* has 2 metacentric and 2 submetacentric chromosomes, while *F. bithynica* has 4 metacentric chromosomes; they also differ in the number of anisobrachial chromosomes.

Table 1. Differences in stem and leaf characters among the seven yellow-flowered *Fritillaria* species occurring in Greece. All measurements are in cm.

<i>Fritillaria</i>	stem height	stem pilosity	leaf number	lowest leaf length × width	uppermost leaf, length	leaf shape	leaf colour
<i>bithynica</i>	(7-)10-20(-25)	–	5-10(-13)	3-6(-8) × 1.5-2(-2.5)	2-3.5	oblong-lanceolate to narrowly ovate	glaucous-green
<i>carica</i>	(3-)5-10(-12)	±	3-6(-8)	3-5(-8) × 0.7-1.8	3-4	lanceolate to oblanceolate	glaucous
<i>forbesii</i>	(6-)8-10(-15)	±	5-10(-12)	4-8(-11) × 0.5-1.2(-1.4)	3.5-6	linear-lanceolate to linear	glaucous
<i>rhodia</i>	(6-)10-25(-30)	±	(7-)9-13	3-6(-7) × 0.6-0.7	2-3	linear to linear-lanceolate	glaucous
<i>pelinaea</i>	(7-)10-20(-25)	–	7-10(-12)	4-9(-12) × 1.8-4	3-3.5	broadly elliptic to broadly ovate-lanceolate	deep glaucous-green
<i>conica</i>	(7-)10-25(-33)	=	5-8(-9)	5-8(-10) × 1.2-2	3-5	lanceolate to ovate-lanceolate	bright green
<i>euboeica</i>	(3-)5-20(-25)	–	5-8(-10)	4-7.5(-8) × (0.6-)0.8-2.5	2-5	lanceolate to linear	glaucous

The occurrence on the island of Samos of *Fritillaria forbesii*, which was considered endemic to SW Anatolia (Rix 1975, 1984), confirms once more the floristic links between Samos and SW Anatolia (Hristodoulakês 1986).

Fritillaria conica and *F. euboeica*, the two yellow-flowered species occurring in mainland Greece and on the adjacent islands of Evvia and Sapientza, differ from the related taxa mainly by their divided styles. They both show many similarities with *F. ehrhartii* Boiss. & Orph. and *F. obliqua* Ker-Gawl., two related species that occur on Evvia and the Kiklades and which we found to sporadically include yellowish-green-flowered individuals in their populations.

Most yellow-flowered *Fritillaria* species studied here have one or sometimes two close relatives differing mainly in their tepals which are dark purplish to purple (usually only outside), and growing in more or less adjacent geographical areas.

The close relationship of *Fritillaria euboeica* with *F. drenovskii* and of *F. conica* with *F. ehrhartii* is confirmed by the results of the numerical phenetic study performed by Zaharof (1988) on some Greek *Fritillaria* species. Whereas phenetic analysis does not necessarily produce results that are compatible with phylogenetic conclusions, these results may, if they are supported by phytogeographical data, lead to a better understanding of relationships in a polymorphic genus such as *Fritillaria*.

Remarkably, two populations of *Fritillaria ehrhartii* on the island of Tinos were found to include some plants with yellowish-green flowers, like *F. bithynica*, which we considered as a separate variety, *F. ehrhartii* var. *prasinantha* Kamari (Kamari 1991b). It differs from *F. bithynica* mainly by its unwinged capsules, and from *F. conica* and *F. euboeica*, by its undivided style. *F. ehrhartii* var. *prasinantha*, in the central Aegean, may be interpreted as forming a phylogenetic link and stepping-stone between the yellowish-green-flowered *Fritillaria* species of the E Aegean and Turkey and those of the W Aegean and SW Peloponnisos. May we add that even among plants of *F. obliqua*

Ker-Gawl., a species with dark purplish flowers both outside and within, and of *F. rhodokanakis* Orph., completely yellow-flowered individuals occur sporadically.

From the information presented here, it becomes clear that not only morphological, but karyological (obtained by the application of Feulgen and Giemsa techniques) and phytogeographical data are necessary for an adequate understanding of the taxonomy and evolution of that variable and attractive genus, *Fritillaria*.

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Table 2. Differences in floral characters of the seven yellow-flowered *Fritillaria* species occurring in Greece. All measurements are in mm.

<i>Fritillaria</i>	outer tepals length × width	inner tep. width	inner tep. apex	nectary length	nectary colour	style length × width
<i>bithynica</i>	17-20(-25) × 5-8	8-10(-11)	acute	2-3	dark to yellowish green	7-10 × 0.5-0.9
<i>carica</i>	13-18 × 4-7(-8)	5-7(-8)	obtuse	2-4	dark brown to blackish	6-9 × 1.0-2.1
<i>forbesii</i>	15-22 × 4.5-7(-8)	4-7	acute to subacute	2-5	dark green to blackish	4.5-7 × 1.5-2.2
<i>rhodia</i>	10-17(-18) × 4-6(-7)	5-7(-8)	obtuse	1-2	yellow to greenish yellow	4-6 × 0.8-0.9
<i>pelinaea</i>	17-20(-22) × (6-)7-9	8-11(-12)	obtuse to rounded	2-3	yellowish green	7-10 × 0.7-1.1
<i>conica</i>	16-26(-28) × 6-8(-10)	7-11(-12)	acute to obtuse	1-2	green to yellowish green	7-11 × 0.8-1.1
<i>euboeica</i>	16-26(-28) × 4-7(-8)	5-8(-9)	acute to obtuse	2-4	green to yellowish green	7-11 × 0.7-1.0

<i>Fritillaria</i>	style branch length	style surface	style shape	capsule shape
<i>bithynica</i>	0	glabrous	slender, entire	subglobose to shortly cylindrical, winged
<i>carica</i>	≤ 1	papillose	stout, ± 3-fid	subglobose to subcylindrical, unwinged
<i>forbesii</i>	≤ 1	papillose	clavate, ± 3-fid	subglobose to subcylindrical, unwinged
<i>rhodia</i>	0	glabrous	slender, entire	subglobose to spherical, unwinged
<i>pelinaea</i>	0	smooth to ± papillose	slender, entire	cylindrical to broadly cylindrical, unwinged
<i>conica</i>	2.5-5	glabrous	slender, 3-fid	cylindrical to broadly cylindrical, unwinged
<i>euboeica</i>	1-4	glabrous to papillose	slender, 3-fid	subglobose, unwinged

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