

**A revision of *Fibigia* sect. *Purpureae* (Brassicaceae, *Alysseae*) in Iran, and the description of three new species**Massoud RANJBAR ^{*1}, Somayeh KARAMI ¹, Mahnaz ROSTAMI ¹¹ Department of Biology, Faculty of Science, Bu-Ali Sina University, P. O. Box 65175/4161, Hamedan, Iran**Abstract**

The present study is focused on the cytogenetic and morphological criteria for distinguishing new taxa belonging to *Fibigia* sect. *Purpureae*. This section in Iran is revised, and three new species (*F. kermanshahensis* Ranjbar & Karami, *F. khoshyelaqensis* Ranjbar & Rostami, and *F. tabriziana* Ranjbar & Karami) are described and illustrated from Kermanshah, Gorgan and Azarbaijan Sharqi Provinces. These are closely related to *F. suffruticosa* (Vent.) Sweet. but differs from it in morphological characters such as plant indumentums, fruits size and shape, lateral sepals saccate at base and stigma size and shape. The meiotic chromosome number and behavior were studied in *F. kermanshahensis* and *F. suffruticosa*. *F. kermanshahensis* is a diploid plant and possesses the chromosome number $2n = 2x = 14$, inconsistent with the base number of *F. suffruticosa* which shows $2n = 2x = 16$. The general meiotic behavior in both species was regular, with bivalent pairing and normal chromosome segregation at meiosis. However, some meiotic abnormalities were observed including varied degrees of sticky chromosomes with laggards, a precocious division of centromeres in metaphase I and metaphase II, bridges in anaphase II, laggard chromosomes, micronucleus, asynchronous nucleus and cytotoxicity. Finally, a key to all four species of this section is presented.

Key words: Brassicaceae, cytogenetic, *Fibigia*, Iran, new species, Sect. *Purpureae***1. Introduction**

Fibigia Medik. is a genus of 14 species that belongs to the Brassicaceae (Cruciferae), an economically important family with 321 genera and 3660 species (Al-Shehbaz, 2012). It is a member of the *Alysseae*, a tribe characterized by having stellate or sometimes dendritic trichomes, usually latiseptate or terete, few-seeded silicles, appendaged filaments, and usually winged seeds (Dudley and Cullen, 1965; Al-Shehbaz et al., 2006). *Fibigia* is not a large genus, but from the point of view of taxonomy and nomenclature it is very complex (Rechinger, 1968). The genus is distributed in Afghanistan, Armenia, Azerbaijan, Austria, Bulgaria, Bosnia & Herz, Cyprus, Caucasus, Egypt, France, Greece, Georgia, Iran, Iraq, Italy, Macedonia, Syria, Spain, Turkmenistan, Turkey, Yugoslavia and Ukraine (Appel and Al-Shehbaz, 2003; Warwick et al., 2008; Busch, 1939; Rechinger, 1968). Iran has seven species of *Fibigia* (Rechinger, 1968; Moussavi, 1985), of which *F. suffruticosa* (Vent.) Sweet. is cultivated as ornamental. This species have recently been placed in the monotypic sect. *Purpureae* A. Duran and Ö. Çetin (Çetin et al., 2012), which differs from the other sections of the genus by characters discussed below *Fibigia*. Members of the section generally are distinguished from other *Fibigia* species by having purple flowers and fruits glabrous (Rechinger, 1968; Çetin et al., 2012). Cytological studies on genus *F. suffruticosa* is a diploid species with the base chromosome number of $2n = 2x = 16$. Our results agree with the report by Maassoumi (1980) and Ghaffari (2006) from Iran. Nazarova (1984) also has reported the chromosome number $2n = 2x = 16$ for this species from Armenia. Two basic chromosome numbers ($x = 7$ and $x = 8$) are present in the section.

During field work in 1997 to 2012 by the herbarium staff of Bu-Ali Sina University (BASU) in northern and western Iran, several collections of *Fibigia* did not fit in any of the currently recognized taxa. Their identification necessitated a close examination of all species known to grow in the country. As a result, three new species are described below and compared with their closest relatives. This article follows previous studies conducted on flora of Iran (Ranjbar et al., 2010a, b; Ranjbar et al., 2011a, b, c; Ranjbar et al., 2012a, b; Ranjbar and Negaresh, 2013).

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2. Materials and methods

2.1. Plant material

This study is based on plants were collected mainly from several localities of Iran, plants of *Fibigia* from different parts such as Hamedan, Kermanshah, Azarbaijan Sharqi and Gorgan Provinces. Their vouchers are currently deposited in BASU, and these were closely compared with various collections housed in the B, FUMH, G, E, LE, P, W and WU herbaria (acronyms follow <http://sweetgum.nybg.org/ih/>). All collections were critically studies for characters taxonomically important in the genus, including indumentums, stem length, leaf shape and color, flower color, development of sac at the base of lateral sepals, stigma shape and color, style length, gynophore length, appendage shape of lateral filaments, fruit size and shape, and seed shape, color, hairs and width of wing.

2.2. Cytogenetic

For cytogenetic study, 15 flower buds from at least 5 plants were fixed in modified Carnoy's solution in ethyl alcohol (96 %), chloroform and propionic acid (6:3:2) for 24 h at room temperature and then stored in 70 % ethyl alcohol at 4 °C until used. Anthers were squashed and stained with 2 % (w/v) acetocarmine. All slides were made permanent using Venetian turpentine. Photographs of chromosomes were with an Olympus BX-51 photomicroscope at an initial magnification of 1000×. Chromosome counts were made from well-spread metaphases in intact cells, by direct observation and from photomicrographs.

3. Results

3.1. Taxonomical notes on *Fibigia* sect. *Purpureae*

All three novelties described herein belong to the sect. *Purpureae*, and their recognition introduced certain characters (e.g., 2-lobed stigmas, obovate fruits, poorly saccate lateral sepals, pubescent seeds) not previously known in this section. This necessitated expanding the sectional limits as follows.

Fibigia sect. *Purpureae* A. Duran and Ö. Çetin, Afr. J. Biotech. 11: 110. 2012.

Type: *Fibigia suffruticosa* (Vent.) Sweet. Hort. Brit [Sweet.] 467. 1826.

Fibigia sect. *Purpureae* is easily distinguished from both sects. *Fibigia* and *Edmondia* Bunge ex Boiss. by its purple (vs. yellow) flowers and saccate (vs. non-saccate) lateral sepals. It further differs from sect. *Fibigia* by having glabrous (vs. pubescent) fruits equaling or shorter (vs. much longer) than fruiting pedicels, and from sect. *Edmondia* by having appendaged (vs. unappendaged) lateral filaments and winged (vs. wingless) seeds. The sectional type, *F. suffruticosa*, has recently been transferred by Dorofeyev (2012) to the monotypic genus *Brachypus* Ledeb. solely on morphological grounds, a position with which we disagree. Retention of the species in *Fibigia* would maintain the integrity of genus as recognized in most of recent and past works and would agree with the molecular studies on the tribe (Warwick et al., 2008; German et al., 2009).

3.2. Key to the species of sect. *Purpureae* in Iran

- 1a. Stem > 30 cm; leaves > 5 cm long; lateral sepals strongly saccate, seeds two in each locules2
- 1b. Stem < 30 cm; leaves < 3.5 cm long; lateral sepals only slightly saccate, seeds two or three in each locules3
- 2a. Fruits suborbicular; appendage of lateral filaments acute at apex; stigma entire, yellow.....*F. suffruticosa*
- 2b. Fruits obovate; appendage of lateral filaments obtuse at apex; stigma minutely 2-lobed, violet.....
.....*F. kermanshahensis*
- 3a. Fruits obovate; seeds glabrous; appendage of lateral filaments subacute at apex; stigma green and entire.....*F. khoshyelaqensis*
- 3b. Fruits orbicular; seeds hairy; appendage of lateral filaments rounded at apex; stigma coarsely papillate, violet.....*F. tabriziana*

3.3. Description

F. kermanshahensis Ranjbar & Karami, **sp. nov.** (Figure 1)

Type: Iran. Province Kermanshah, Ouraman neck, 2198 m, 26.4.2012, Ranjbar & Karami 33006 (holotype: BASU!)

Stems 65 - 75 cm tall, branched at base and middle, loosely covered with dendritic and rarely stellate hairs ca. 0.3 mm long. Basal leaves oblanceolate, 13.5-15.5 × 2.5 - 3.2 cm, with a loose mixture of dendritic and stellate hairs ca. 0.5 mm long, base attenuate, apex rounded, petioles 4.5 - 6.5 cm long; cauline leaves sessile or subsessile, oblanceolate or uppermost linear, 6.5 - 9.3 × 0.5 - 1 cm, subacute to acute at apex. Racemes 7.5 - 10.5 cm long, 14 - 16 flowered, with dendritic hairs 0.3 - 0.5 mm long; fruiting pedicels 9 - 10 mm long. Sepals greenish violet, overlapping at base, shape and size dimorphic, with stellate and loosely dendritic hairs 0.3 - 0.5 mm long; median pair linear to oblong, 8.5 -

9 × 2 - 2.7 mm; lateral pair strongly saccate, oblong, 9.5 - 10 × 3.2 - 3.5 mm. Petals purple, 14 - 15 mm long; blade obovate, 5.5 - 6 × 2.8 - 3 mm, slightly retuse at apex; claw well differentiated from blade, 8 - 10 mm long. Stamens included, markedly tetradynamous, erect; median filament pairs yellow, 9.5 - 10 mm long, wingless, anthers ca. 1.8 mm; lateral filament pair 7 - 7.2 mm long, anthers 2 - 2.2 mm long, tooth 4.7 - 5 × 0.3 mm, obtuse. Fruit sessile, obovate, 15 - 18 × 11 - 13 mm; residue style 1 - 1.5 mm long; style yellow, 6.5 - 9 mm long; stigma violet, minutely 2 - lobed, lobes free. Seeds 4, greenish brown, 6 - 6.2 mm in diam.; wing 1.7 - 2 mm wide, membranous, brownish yellow.

3.4. *paratypes*

Iran: Province Kermanshah: 35 km to Kamyaran, 2210 m, 29.5.2012, Ranjbar & Karami 29631 (BASU!). Province Kurdistan: ca. 100 km N of Kermanshah by the last pass before Sanandaj, 1750 m, 16.6.1959, Wendelbo 1970 (E!); 48 km NW of Sanandaj towards Marivan, 2290 m, 17.5.1966, Aeehltoid 1967 (E!); Salavatabad, 25 km from Sanandaj to Hamedan, 2300 m, 3.7.1971, Lamond 4481 (E!), Sanandaj, 25 km to Sanandaj Salavat Abad neck, 2129 m, 21.6.2009, Ranjbar 18497 (BASU!).

3.5. *Taxonomic and distribution remarks*

Fibigia kermanshahensis is similar in leaf indumentum and shape and winged seeds to *F. suffruticosa*, a species with a much wider distribution in western Iran (Fig. 2A). However, *F. kermanshahensis* differs by having stem indumentum of dendritic and rarely stellate (vs. only dendritic) hairs, wider (2.5 - 3.2 vs. 1.4 - 1.6 cm wide) basal leaves, shape (oblanceolate vs. oblong to oblanceolate) basal leaves, shape (oblanceolate or uppermost linear vs. mostly linear) cauline leaves, smaller racemes (7.5 - 10.5 vs. 17 - 20 cm long), wingless (vs. distinctly winged) median filament pairs (Fig. 6A), longer (8 - 10 vs. up to 6 mm long) claw, obtuse (vs. acute) lateral stamens teeth (Fig. 6a), minutely 2 - lobed (vs. entire) stigmas (Fig. 7A), slightly retuse (vs. rounded) petals, fruits 15 - 18 × 11 - 13 mm (vs. ca. 13 × 9) size, obovate (vs. suborbicular) fruits, seeds 6 - 6.2 mm (vs. ca. 9 mm) in diam. and basic chromosome number ($x = 7$ vs. $x = 8$) (Fig. 7a) (Table 1).

3.6. *Etymology*

The specific epithet refers to Kermanshah Province, where the new taxon is found.

Fibigia khoshyelaqensis Ranjbar & Rostami, **sp. nov.** (Figure 3)

Type: Iran. Province Gorgan: Shahrud to Khoshyelaq, 1965 m, 1.7.2007, Ranjbar 15008 (holotype: BASU!)

Stems 13 - 24 cm tall, branched at base, densely covered with dendritic hairs 0.2 - 0.6 mm long. Basal leaves oblanceolate to spatulate, 4.5 - 5.5 × 0.5 - 1 cm, with a dense mixture of dendritic and loosely stellate hairs 0.1 - 1.2 mm long, apex rounded, petiole 1.3 - 2 cm long; cauline leaves linear, 2 - 3.2 × 0.2 - 0.5 cm, apex acute. Raceme 6 - 11.5 cm long, 8 - 12-flowered, with dense dendritic hairs ca. 3 mm long; fruiting pedicels 9 - 10 mm long, with dense hairs to 0.7 mm long. Sepals pale violet, overlapping at base, shape dimorphic, with dendritic hairs 0.5 - 1.5 mm long; median pair linear to oblanceolate, 7 - 8 × 1.5 - 2 mm; lateral sepals slightly saccate at base, oblong, 7.5 - 8 × 2 - 2.5 mm. Petals violet, flaring, 11 - 13 mm long; blade oblanceolate, 6 - 7 × 1.5 - 2 mm, apex rounded, claw slightly differentiated from the blade. Stamens erect, markedly tetradynamous; median filament pairs 7.8 - 10 mm long, obscurely winged, anthers 1.2 - 1.4 mm long; lateral filament pair 5.5 - 6 mm long, anthers 1.2 - 1.5 mm long; teeth subacute, 1.2 - 1.4. Fruit short stipitate, obovate to elliptic, 13 - 19 × 10 - 12 mm; residue style 1.5 - 2 mm long; style 5 - 7 mm long; stigma green, entire. Seeds 4 - 6, green, entire, 5.5 - 6 × 3 - 5 mm wide, mm long; wing ca. 1.25 mm wide, membranous, green to yellowish.

3.7. *paratypes*

Iran: Province Khorasan: 40 km to Sabzevar, 1375 m, 16.5.2009, Ranjbar 22879 (BASU!), Almehr, 1500 m, 30.4.1972, Kukkonen 5727 (E!); Gorgan: Shah Passand to Shahroud, Gardaneh KoshYeilagh, 1800 m, 22.7.1974, Wendelbo & Foroughi 12877 (E!).

3.8. *Taxonomic and distribution remarks*

Fibigia khoshyelaqensis is a rare species endemic to the Gorgan Province in northern Iran (Fig. 2B), where it grows on stony places at 1375 - 1965 m elevations. It was previously misidentified as *F. suffruticosa*, but the two are quite distinct. From this, *F. khoshyelaqensis* differs by having shorter stems (to 24 vs. 50 - 65 cm), smaller basal leaves (4.5 - 5.5 vs. 9 - 11 cm long) with shorter petioles (1.3 - 2 vs. 6 - 7 cm long), with shape (oblanceolate to spatulate vs. oblong to oblanceolate), smaller cauline leaves (2 - 3.2 vs. 5.2 - 9.7 cm long), smaller racemes (to 11.5 vs. 17 - 20 cm long), shorter lateral sepals (7 - 8 vs. ca. 11.5 mm long), with slightly (vs. distinctly) saccate at base, shorter median sepals (7 - 8 vs. 10 - 12 mm long), obscurely (vs. distinctly) winged median filament pairs (Fig. 6B), appendages of lateral stamens subacute (vs. acute at apex) (Fig. 6b), green (vs. yellow) stigma (Fig. 7B), obovate to elliptic (vs. suborbicular) fruit 13 - 19 × 10 - 12 mm (vs. ca. 13 × 9 mm long), 2 - 3 - seeded (vs. 2 - seeded) locules, seed (incl. wing) 3 - 5 mm (vs. ca. 9 mm long) in diameter (Fig. 7b) (Table 2).

3.9. Etymology

The specific epithet is named after the village Khoshyelaq in Gorgan Province, Iran.

Fibigia suffruticosa (Vent.) Sweet. Hort. Brit [Sweet.] 467. 1826 (Figure 4)

Basionym: *Lunaria suffruticosa* Vent. Descr. Pl. Nouv. 19. 1800.

Type: Iran. Province Hamedan, Alvand mountain, 1500-1600 m, Olivier & Bruguère s.n. (holotype: P!).

Stems 50 - 65 cm tall, mostly branched from the base and sometime from the middle, covered with dendritic hairs 0.1 - 0.3 mm. Basal and lowermost leaves oblong to oblanceolate, 9 - 11 × 1.4 - 1.6 cm, with a dense mixture of stellate and dendritic hairs 0.1 - 0.3 mm long, apex rounded, petiole 6 - 7 cm long; cauline leaves sessile, mostly linear, 5.2 - 9.7 × 0.5 - 0.7 cm, apex acute. Racemes 17 - 20 cm long, 6 - 20-flowered, with dense dendritic hairs 0.1 - 0.4 mm long; fruiting pedicels 10 - 11 mm long. Sepals violet greenish, overlapping at base, shape and size dimorphic, densely covered with dendritic and loosely stellate hairs ca. 0.5 mm long; median pair linear to oblanceolate, 10 - 12 × 1 - 3 mm; lateral pair distinctly blade at base, oblong to linear or sometime lanceolate, ca. 11.5 × 2.2 mm. Petals flaring, purple, 12 - 13 mm long; blade oblanceolate, 6 - 6.5 × 1.8 - 2 mm, apex rounded; claw differentiated from the blade. Stamens included, markedly tetradynamous, erect; median filament pairs 8.5 - 9 mm long, distinctly winged, anthers ca. 1.8 mm; lateral filament pair 7 - 7.2 mm long, anthers ca. 2 mm long; teeth acute, ca. 4.2 × 0.3 mm. Fruits suborbicular, ca. 13 × 9 mm, sessile; residue style 1 - 2 mm long; style yellow, ca. 8 mm long; stigma yellow, entire. Seeds 4, yellow, glabrous, winged ca. 9 mm in diam.; wing ca. 2 mm wide, membranous.

3.10. Specimens seen

Iran: Province Ardabil: Khalkhal to Hashtgin Tarak village, 1865 m, 25.6.2012, Ranjbar & Karami 30461 (BASU!). Province Azarbaijan Gharbi: Oshnavieh to Uromiyeh: The first neck before Sekani village, 1635 m, 13.5.2008, Ranjbar 16353 (BASU!); Oshnavieh to Uromiyeh, Ganj Abad, 1730 m, 25.6.2012, Ranjbar & Karami 32393 (BASU!); Movana toward Salmas, 40 km to Salmas, 1405 m, 19.5.2011, Ranjbar & Karami 25689 (BASU!); Salmas to Uromiyeh: Qushchi neck, 1180 m, 4.7.2007, Ranjbar 15907 (BASU!); Uromiyeh: Sekani village 5 km before Sekani village, 1686 m, 13.5.2008, Ranjbar 16336 (BASU!). Province: Bakhtiari: Gahar, Koelz 17997 (W!); Kuh-e Safid, Chehel Dokhtaran Kuh, Wendlbo 1756 (W!). Province Esfahan: Esfahan, Aucher-Eloy 1631, 4084 (G!). Province Fars: Kuh-e Barfi prope Shiraz, Stapf 260 (W!); Inter Abadeh and Dowlatabad, 1500-2000, Schmid 5315 (W!); Sabz Pushan prope Shiraz, Kotschy 415 (W!). Province Hamedan: Tuyserkan, Khangormaz, protected area, 2853 m, Ranjbar 8524 (BASU!); Avaj, 1800 - 2000 m, 14.5.1997, Ranjbar 114 (BASU!); Gogh Tappeh, 2050 m, 13.5.2011, Ranjbar 33007 (BASU!); 52 km to Avaj, 1985 m, 12.5.2010, Ranjbar 21024 (BASU!); Kand Tappeh, 2072 m, 7.6.2011, Ranjbar 26262 (BASU!); before Gonbad village, 1905 m, 10.6.2012, Ranjbar & Karami 29505 (BASU!); Alvand mountain, 2650 m, 14.5.1999, Ranjbar 771 (BASU!); Hamedan to Qeydar, after Shirin Su, Agh Dagh, 1700 m, 25.5.2007, Ranjbar 14608 (BASU!). Province Kermanshah: Ouraman neck, 2198 m, 26.4.2012, Ranjbar & Karami 33006 (BASU!). Province Kurdistan: Divandarreh toward Saqqez, 1850 m, 17.5.2011, Ranjbar 24941 (BASU!); 44 km from Tekab to Bijar, 1860 m, 13.6.2012, Ranjbar 30515 (BASU!). Province Khorasan: Bar, 1780 - 2530 m, Schmid 6298 (W!); Kopet Dagh: Alam Ali, 2000 m, Rechinger 4828 (W!); Province Lurestan: Nurabad, 2000 m, Koeie 1426 (W!); Khoramabad, 2200 m, Koeie 508 (W!). Province Qazvin: 50 km to Moallem Kalayeh, 1967 m, 25.6.2012, Ranjbar 30086 (BASU!); Kharzan, 1800 m, Bornmuller 6226 (B!); Pich Kuh Prope Karaj, 1600 - 2200 m, Rechinger 568 (W!); Kuh Dashteh Prope Karaj, Rechinger 315 (W!); Inter Karaj and Gachsar, 1200 - 2500 m, Schmid 5687 (W!); Karaj, Gauba. Province Zanjan: The road Qeydar to Zanjan, 55 km Zanjan, 10 km to Soltaniyeh, 2100 m, 25.5.2007, Ranjbar 14645 (BASU!). Province Tehran: Darband, Kotschy 155 (W!); Tuchal, Sharestanak, Bornmuller 6221 (B!), 6222 (B!), 6223 (B!); Emamzadeh Dawud, 3000 m, Bornmuller 6224 (B!); Ab Ali, 3000 m, Furse 2560 (W!); Supra Ab Ali, Wendelbo 751 (W!); Tehran, 2300 m, Furse 1709 (W!).

3.11. Taxonomic and distribution remarks

Fibigia suffruticosa only grows in clay stone and rocky slopes. Flowering and fruiting from April to August. According to Flora Iranica Iran and Iraq are of the most important centers of diversity of the genus in the old world. This genus grows at 1000–2300 m elevations in C, W and NW Iran and N Iraq. *Fibigia* is distributed at higher elevations in Iraq. In addition, some other plants that occurred in this area were *Astragalus parrowianus*, *Alyssum szowitsianum*, *Euphorbia cheiradenia*, *Medicago sativa*, *Phlomis olivieri*, *Salvia multicaulis*, *Stachys lanvandulifolia*, *Silene albescens* and *Onosma microcarpum*. *F. suffruticosa* is an ornamental plant which is distributed in W to NW of Iran especially in Hamadan Province (Fig. 2C). It grows on dry rocky slopes, forests and clay stony slopes, at 700 - 2600 m elevation. It is an Irano-Turanian element. It is widely distributed in comparison to other species of section *Purpureae*.

3.12. Phenology

Flowering from April to May and fruit ripening from June to July.

Fibigia tabriziana Ranjbar & Karami, **sp. nov.** (Figure 5)

Type: Iran. Province Azarbaijan Sharqi: Ahar to Varzaqan, 28 km to Varzaqan, 1550 m, 7.6.2010, Ranjbar 22147 (holotype: BASU!).

Stems 13 - 17 cm tall, branched at the base, covered with dendritic hairs, 0.2 - 0.7 mm long. Basal leaves oblanceolate to linear, 2.5 - 5 × 0.4 - 0.7 cm, ± densely grey-tomentose hairs 0.3 - 0.4 mm, apex rounded to acute, petiole 1.6 - 2.5 cm long; cauline leaves linear, 1.5 - 3 × 0.3 - 0.4 cm, apex acute to acuminate. Racemes 3.5 - 9.5 cm long, 3 - 13-flowered, with dense dendritic hairs ca. 3 mm long; flowering pedicels 4 - 6 mm long, with hairs 0.3 - 0.8 mm long; fruiting pedicels 6 - 10 mm long. Sepals green, overlapping at base, shape and size dimorphic, covered with dendritic hairs, 0.3 - 0.8 mm long; median pair linear to oblanceolate, 6 - 7 × 1.2 - 1.5 mm; lateral pair subsaccate, oblong, 6 - 6.5 × 2 - 2.5 mm. Petals purple, flaring, 8 - 10 mm long; blade oblanceolate, 4 - 4.2 × 1.8 - 2 mm, apex retuse; claw subdifferentiated from the blade. Stamens only slightly tetradynamous; median filament pairs 5 - 5.2 mm long, slightly winged, anthers ca. 1.3 mm long; lateral filament pair 4.5 - 5 mm long, anthers ca. 1.2 mm long; teeth rounded, ca. 1.8 × 0.7 mm. Fruit orbicular, 8 - 11 × 8 - 11 mm, sessile; residue style ca. 4 mm long; style 2.5 - 2.8 mm long; stigma violet, coarsely papillate. Seeds 6, green, ovate, ca. 5 mm in diam., covered with arachnoid hairs; wing membranous, ca. 1 mm wide, brownish yellow.

3.13. Taxonomic and distribution remarks

Fibigia tabriziana is a rare endemic to NW Iran and known only from the dry - steppe zones of mountain area between Ahar and Varzaqan in Azarbaijan Sharqi Province, NW Iran. The new species can be expected to grow on clay hills, at elevations of 1600 - 1850 m. It is similar to *F. suffruticosa*, in W Iran (Fig. 2D) in some important characters such as altitude of habit, trichome structure and petal color. From the latter species, *F. tabriziana* differs by having leaves ± densely grey-tomentose (vs. dense mixture of stellate and dendritic hairs), shorter stems (to 20 vs. 50 - 65 cm long), smaller basal leaves (2.5 - 5 vs. 9 - 11 cm long) with shorter petioles (1.6 - 2.5 vs. 6 - 7 cm long), smaller cauline leaves (to 3 vs. 5.2 - 9.7 cm long), smaller racemes (3.5 - 9.5 vs. 17 - 20 cm long), shorter lateral sepals (6 - 6.5 vs. ca. 11.5 mm long) slightly (vs. distinctly) saccate at base, shorter median sepals (6 - 7 vs. ca. 10 - 12 mm long), slightly (vs. distinctly) winged median filament pairs (Fig. 6D), shorter flowering pedicels (4 - 6 vs. 10 - 11 mm long), shorter (8 - 10 vs. 12 - 13 mm long) and retuse (vs. rounded) petals, rounded (vs. acute) lateral stamens teeth (Fig. 6d), shorter style (2.8 vs. 8 mm long), fleshy stigma, violet (vs. entire, yellow) (Fig. 7D), smaller fruit (8 - 11 vs. ca. 13 mm long), longer residue style (4 vs. ca. 2 mm long), 3 - seeded (vs. 2 - seeded), seed wing ca. 5 mm in diameter, covered with arachnoid hairs (vs. ca. 9 mm long, glabrous) (Fig. 7d) (Table 3).

3.14. Etymology

The specific epithet is named after the city Tabriz in Azarbaijan Sharqi Province, Iran.

3.15. Cytogenetics

Chromosome numbers and meiotic behavior were studied in *Fibigia kermanshahensis* and compared with the *F. suffruticosa* (Table 4, Figs. 8A-O & 9A - L). A wide range of meiotic stages was observed in anthers within the same flower. A total of 615 diakinesis/metaphase I (D/MI) (Figs. 8A, C; 9A, D), 376 anaphase I/telophase I (AI/TI) (Figs. 8E, F; 9F, G, H), 91 metaphase II (MII) (Figs. 8H, 9I) and 290 anaphase II/telophase II (AII/TII) (Figs. 8K, M, O; 9J, K, L) cells were analysed in both species. The D/MI cells were usually regular with predominant bivalent (II) pairing.

However, varied degrees of meiotic irregularity included chromosome laggard D/MI, chromosome bridges resulting from stickiness, micronucleus and laggard chromosomes in AI/TI were observed. Micronucleus is another abnormality that was found in *F. suffruticosa* 8.2% and 2.56% in AI/TI and AII/TII cells, respectively (Figs. 8G, L.) Chromosomes that produced micronuclei during meiosis were eliminated from microspores as microcytes. The micronucleus reached the microspore wall and formed a kind of bud, separated from the microspore. The eliminated microcytes gave origin to small and sterile pollen grains (Ranjbar et al., 2011a, b, c).

Chromosome stickiness may be caused by genetic and environmental factors, and several agents have been reported to cause chromosome stickiness (Pagliarini, 2000). A precocious division of centromeres is an abnormality that was found in 20.32% and 13.550% of *F. suffruticosa* and *F. kermanshahensis* metaphase I and anaphase cells, respectively (Figs. 8D, 9F). Precocious along with were found in 34.02% of *F. suffruticosa* metaphase II cells (Fig. 8I). Chromosome bridges observed in 0.51% of anaphase II/telophase II cells in *F. suffruticosa* (Fig. 8N). Cytomixis that was found in 4.888% of *F. kermanshahensis* diakinesis cells (Figs. 9B, 9C). Stickiness and laggard along with were found in 34.37% of *F. suffruticosa* diakinesis cells (Figs. 8B). The stickiness of bridges and the number of chromosomes involved in their formation varied among different meiocytes. Genetic as well as environmental factors have been considered as the reason for chromosome stickiness in different plant species (Nirmala and Rao, 1996). This phenomenon was not observed in the new species. Asynchrony in the nucleus was observed in 7.22% of *F. suffruticosa* at metaphase II (Fig. 8J).

Results from cytogenetic studies also showed that both *F. suffruticosa* and *F. kermanshahensis* are diploid, but they do not have the same basic chromosome number. The basic chromosome number of *F. suffruticosa* is $2n = 16$, while the new species show $2n = 14$ (Figs. 8A, 9A). The members of the genus are diploid with $2n = 2x = 16$ chromosome numbers, whereas those of species are diploid with $2n = 2x = 14$ chromosome numbers. The results from the present study increase our knowledge about the basic chromosome number of the genus *Fibigia*. This can be helpful in taxonomic delimitation by establishing relationships between cytogenetic and morphological criteria.

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Table 1. Morphological comparison of *Fibigia kermanshahensis* and *F. suffruticosa*.

Taxa characters	<i>F. kermanshahensis</i>	<i>F. suffruticosa</i>
Stems length (cm)	65 - 75	50 - 65
Stem indumentum	dendritic and rarely stellate	dendritic
Racemes length (cm)	7.5 - 10.5	17 - 20
Basal and lowermost leaves (cm)	13.5-15.5 × 2.5 - 3.2	9 - 11 × 1.4 - 1.6
Basal leaves shape	oblanceolate	oblong to oblanceolate
Cauline leaves	oblanceolate or uppermost linear	mostly linear
Sepals median length (mm)	up to 9	up to 12
Petals apex	slightly retuse	rounded
Petals claw(mm)	8 - 10	up to 6
Petals length (mm)	up to 15	up to 13
Median filaments	wingless	distinctly winged
Lateral stamens teeth	obtuse	acute
Stigma	minutely 2 - lobed	entire
Stigma color	violet	yellow
Fruits shape	obovate	suborbicular
Fruits size (mm)	15 - 18 × 11 - 13	ca. 13 × 9
Seeds diam. (mm)	6 - 6.2	ca. 9
n	7	8

Table 2. Morphological comparison of *Fibigia khoshyelaqensis* and *F. suffruticosa*.

Taxa characters	<i>F. khoshyelaqensis</i>	<i>F. suffruticosa</i>
Stem length (cm)	13 - 24	50 - 65
Stem branches	branched at the base	mostly from the base and sometime from the middle
Basal leaves shape	oblanceolate to spatulate	oblong to oblanceolate
Basal leaves length (cm)	up to 5.5	9 - 11
Petiole basal leaves length (cm)	up to 2	6 - 7
Cauline leaves length (cm)	2 - 3.2	5.2 - 9.7
Racemes length (cm)	up to 11.5	17 - 20
Median sepals length (mm)	7 - 8	10 - 12
Lateral sepals length (mm)	7 - 8	ca. 11.5
Lateral sepals saccate at the base	slightly	distinctly
Median filaments	obscurely	distinctly winged
Appendages of lateral stamens	subacute at the apex	acute at the apex
Stigma color	green	yellow
Fruits shape	obovate to elliptic	suborbicular
Fruits size (mm)	13 - 19 × 10 - 12	ca. 13 × 9
Seeds winged (mm)	3 - 5	ca. 9

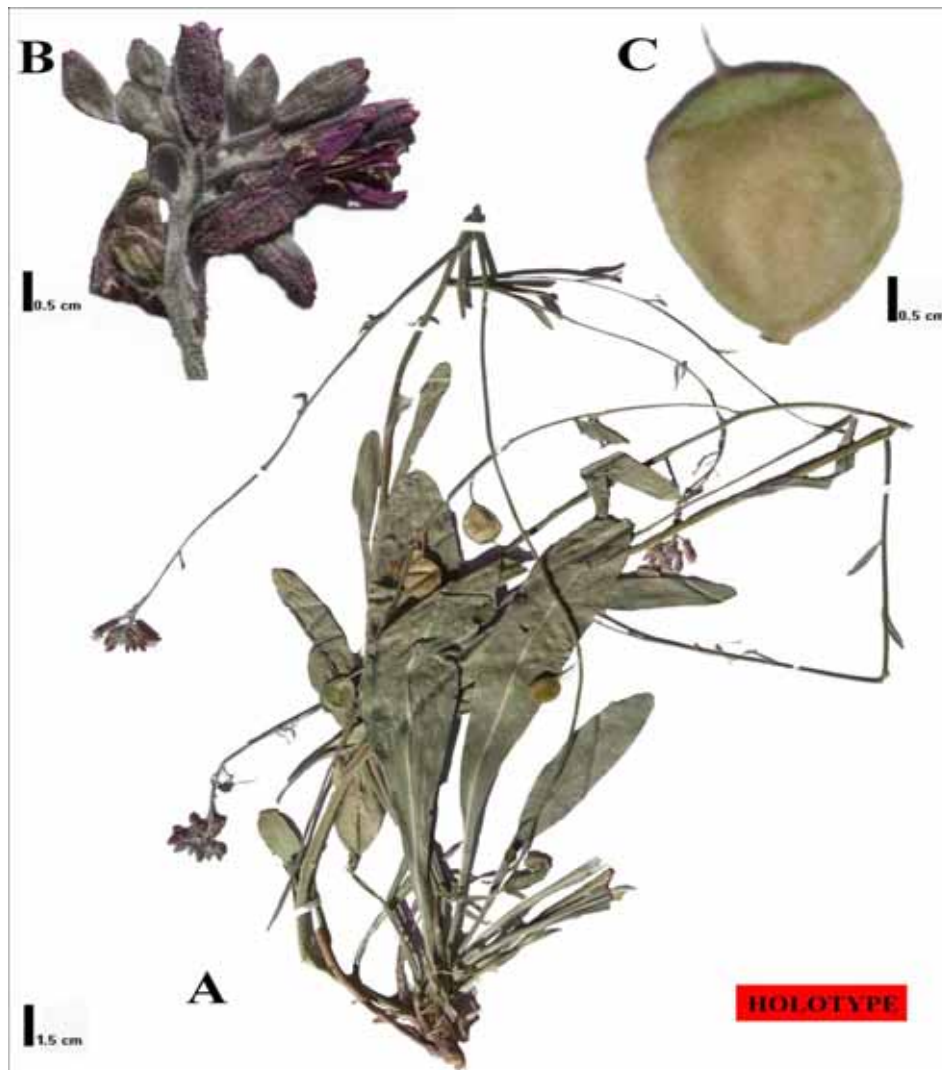
Table 3. Morphological comparison of *Fibigia tabriziana* and *F. suffruticosa*.

Taxa characters	<i>F. tabriziana</i>	<i>F. suffruticosa</i>
Stem length (cm)	13 - 17	50 - 65
Basal leaves length (cm)	2.5 - 5	9 - 11
Indumentum basal leaves	± densely grey-tomentose	dense mixture of stellate and dendritic hairs
Petioles length (cm)	1.6 - 2.5	6 - 7
Cauline leaves length (cm)	up to 3	5.2 - 9.7
Racemes length (cm)	3.5 - 9.5	17 - 20
Pedicels length (mm)	4 - 6	10 - 11
Median sepals length (mm)	6 - 7	10 - 12
Lateral sepals length (mm)	6 - 6.5	ca. 11.5
Lateral sepals saccate at base	subsaccate	distinctly saccate
Petals length (mm)	8 - 10	12 - 13
Petals apex	retuse	rounded
Median filaments	slightly winged	distinctly winged
Lateral stamens teeth	rounded	acute
Stigma	coarsely papillate	entire
Stigma color	violet	yellow
Style length (mm)	2.5 - 2.8	ca. 8
Residue style length (mm)	ca. 4	1 - 2
Fruit length (mm)	8 - 11	ca. 13
Number of seeds locules	3	2
Seeds winged length (mm)	ca. 5	ca. 9
Indumentum seed	covered with arachnoid hairs	glabrous

Table 4. Number of pollen mother cells (PMCs) analyzed and percentage of PMCs meiotic behavior in *Fibigia suffruticosa* and *F. kermanshahensis*.

Meiotic characters	<i>F. kermanshahensis</i>	<i>F. suffruticosa</i>
Total cell number	946	722
D/MI	369	246
% D/MI	57.476	34.07
% Stickiness & Laggard	0	34.37
% Precocious segregation	13.550	20.32
% Cytomixis	4.888	0
AI/TI	193	183
% AI/TI	30.062	25.35
% Micronucleus	0	8.2
MII	1	90
% MII	0.155	14.43
% Precocious segregation	0	7.22
% Asynchronous nuclei	0	34.02
AII/TII	59	195
% AII/TII	9.190	27.008
% Micronucleus	0	2.56
% Bridge	0	0.51
n	7 (5II, 4I)	8 (6II, 4I)

D/MI = Diakinesis/Metaphase I; AI/TI = Anaphase I/Telophase I; MII = Metaphase II; AII/TII = Anaphase II/Telophase II; II = bivalent; I = univalent.

Figure 1. *Fibigia kermanshahensis* sp. nov., A - habit, B - close up flowers, C - close up of fruit.

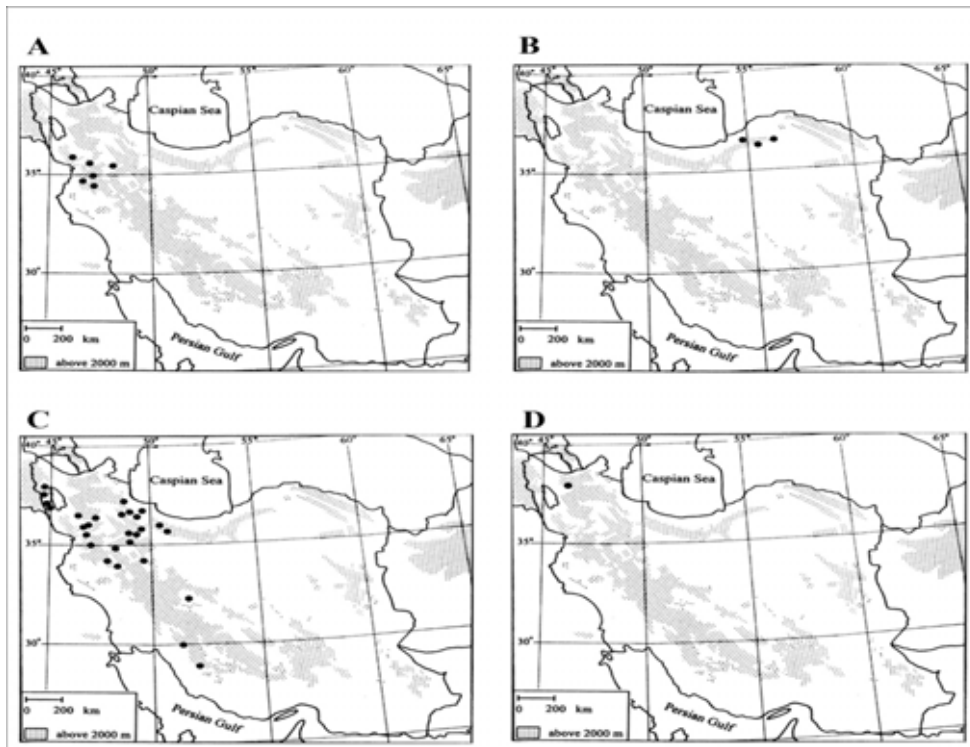


Figure 2. Distribution of *Fibigia* sect. *Purpureae* in Iran, A - *F. kermanshahensis*, B - *F. khoshyelaqensis*, C - *F. suffruticosa*, D - *F. tabriziana*

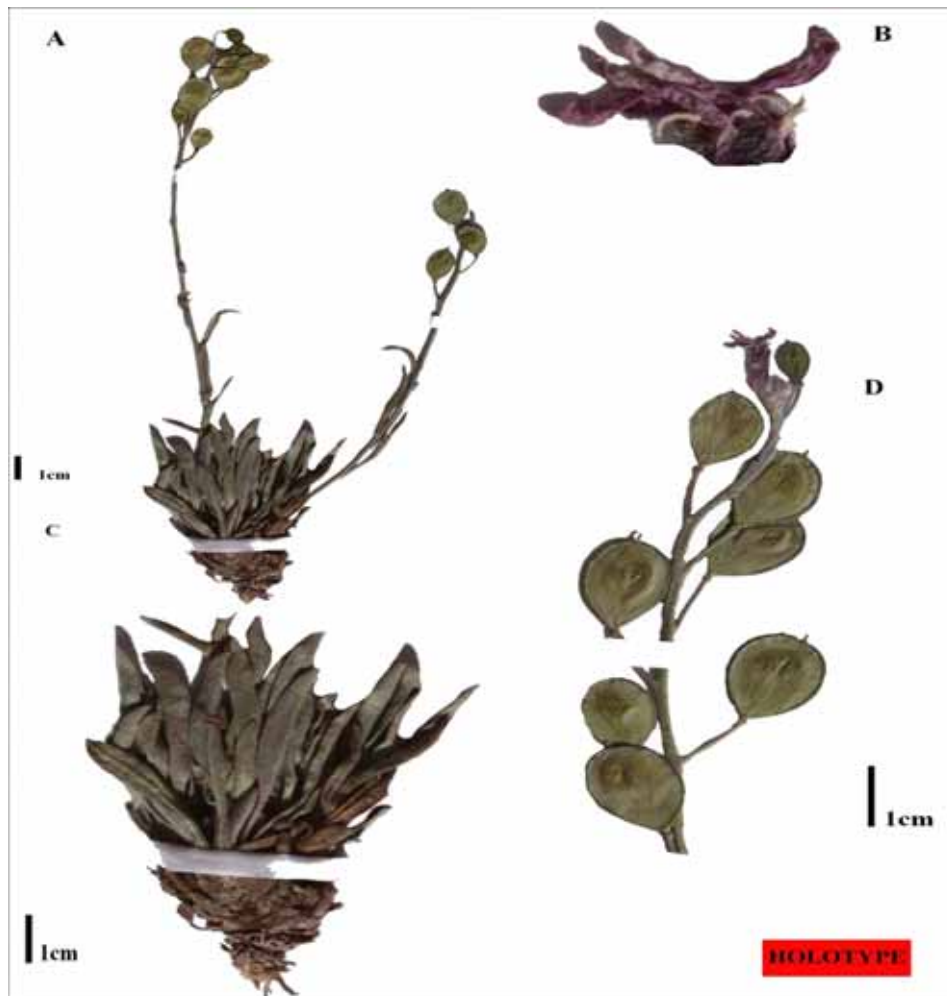


Figure 3. *Fibigia khoshyelaqensis* sp. nov., A - habit, B - close up flower, C - close up basal leaves, D - inflorescence.



Figure 4. *Fibigia suffruticosa* (Vent.) Sweet., photograph provided from P.

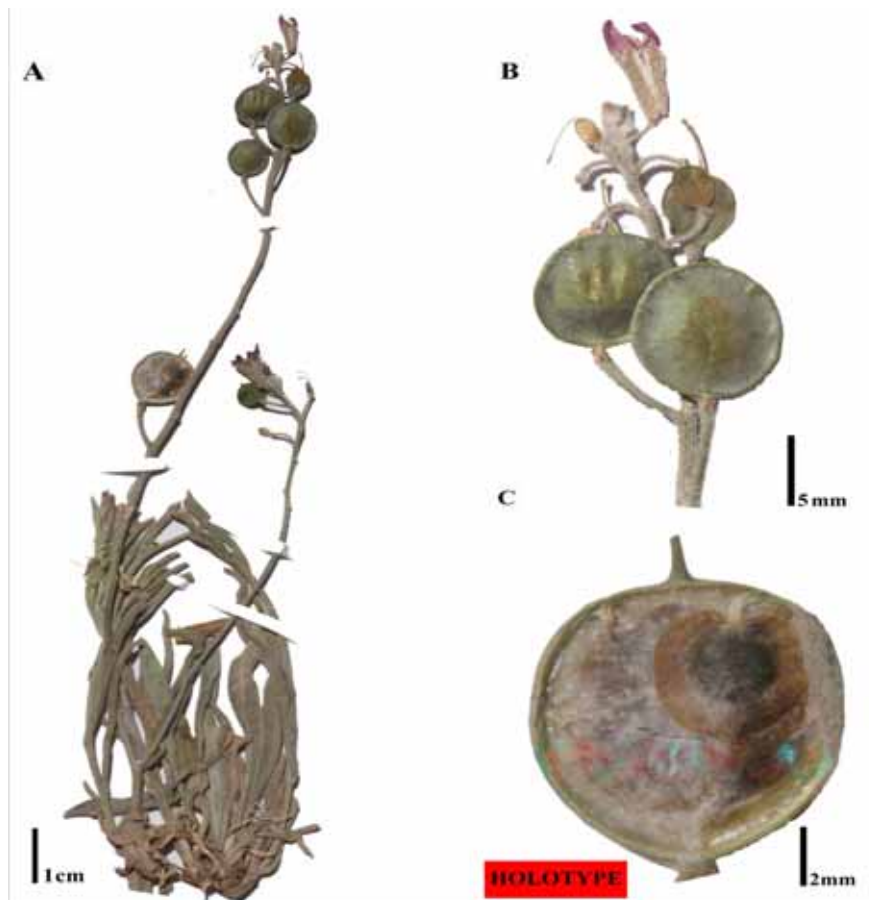


Figure 5. *Fibigia tabriziana* sp. nov., A - habit, B - close up flower and fruits and inflorescence, C - close up of fruit.

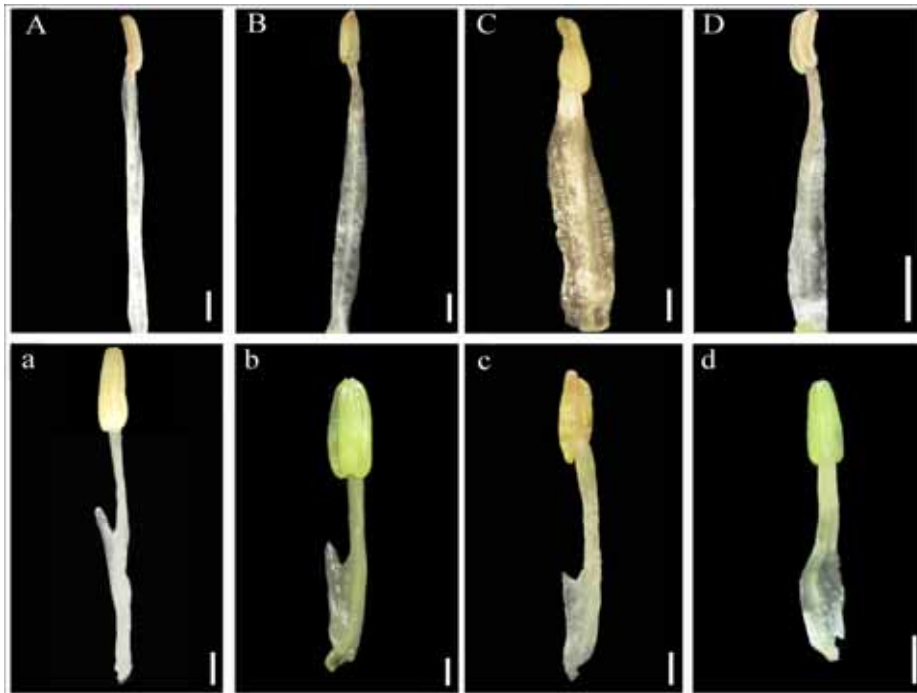


Figure 6. Shape of wings in stamens median filament and appendages in lateral filaments of the *Fibigia* sect. *Purpureae* species, respectively. A, a - *F. kermanshahensis*, B, b - *F. khoshyelaqensis*, C, c - *F. suffruticosa*, D, d - *F. tabriziana*. Scale bar: 1 mm

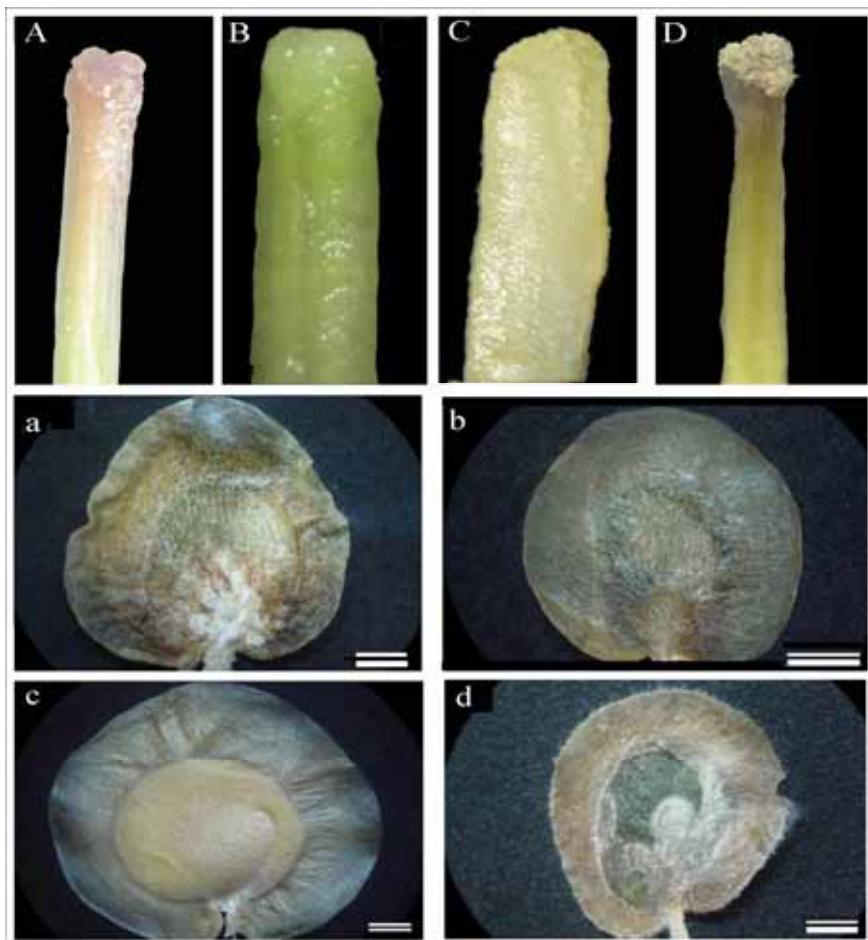


Figure 7. Stigmas and seed wings of *Fibigia* sect. *Purpureae* species, respectively. A, a - *F. kermanshahensis*, B, b - *F. khoshyelaqensis*, C, c - *F. suffruticosa*, D, d - *F. tabriziana*. Scale bar: 1 mm.

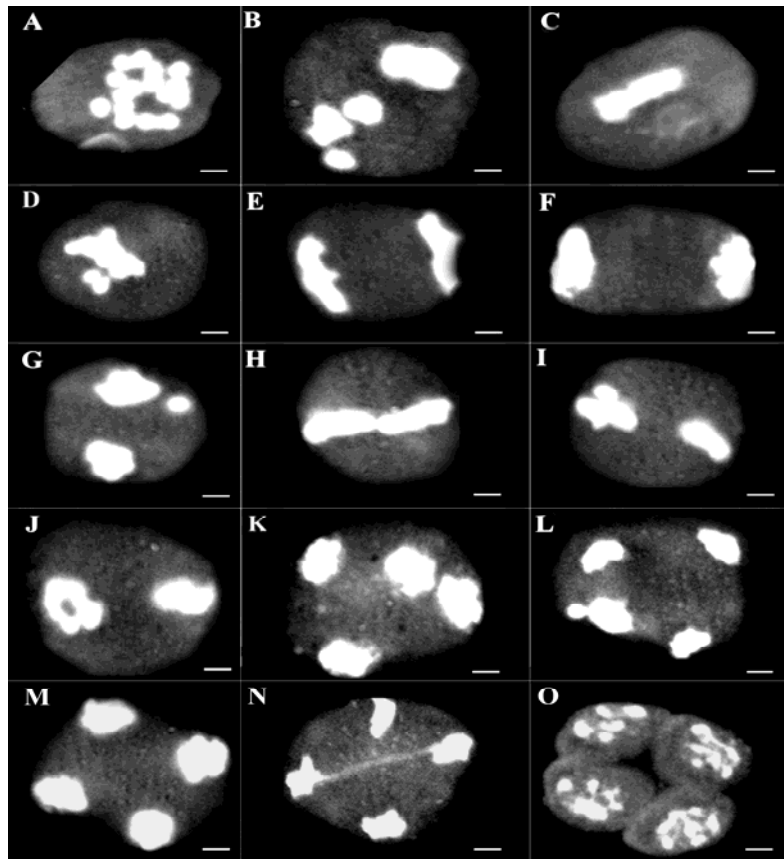


Figure 8. Representative meiotic cells in *Fibigia suffruticosa*, A - diakinesis ($2n = 2x = 16$), B - laggard in diakinesis, C - metaphase I, D - precocious segregation in metaphase I, E - anaphase I, F - telophase I, G - micronucleus telophase I, H - metaphase II, I - precocious segregation in metaphase II, J - asynchronous nuclei, K - anaphase II, L - micronucleus in anaphase II, M - anaphase II, N - bridge in anaphase II, O - telophase II. Scale bar: 2 μ m.

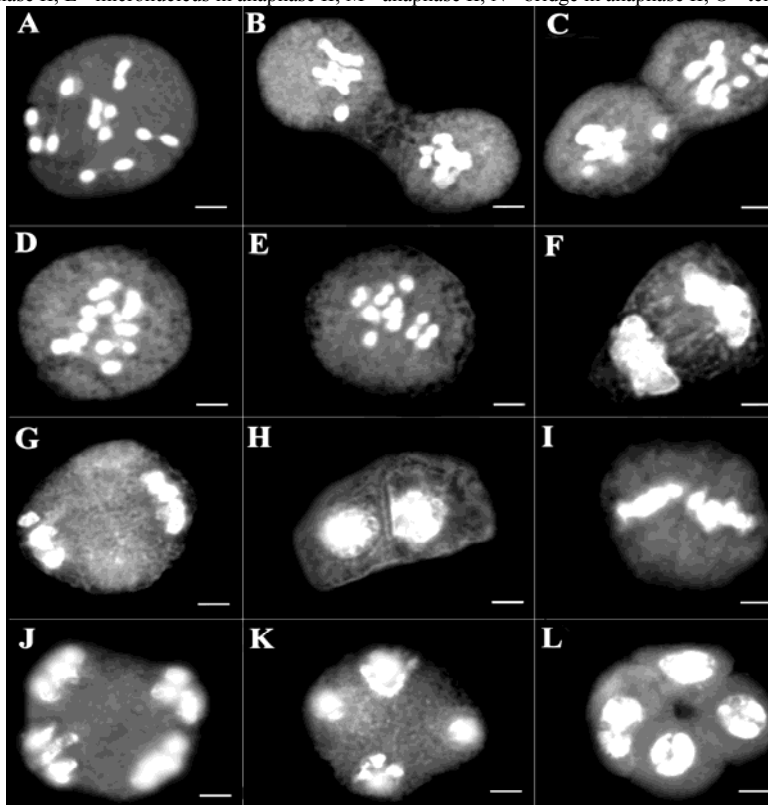


Figure 9. Representative meiotic cells in *Fibigia kermanshahensis*, A - diakinesis ($2n = 2x = 14$), B, C - cytomixis in diakinesis, D - metaphase I, E - precocious segregation in metaphase I, F, G - anaphase I, H - telophase I, I - metaphase II, J, K - anaphase II, L - telophase II. Scale bar: 2 μ m.

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