

Full Length Research Paper

A taxonomic study of the genus *Fibigia* Medik. (Brassicaceae)

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In this study, *Purpureae* A.Duran and Ö.Çetin sect. nov. is described under the genus *Fibigia* Medik. The taxa of the genus were revised under the sections *Fibigia* and *Purpureae*. *Fibigia clypeata* (L.) Medik was classified as *F. clypeata* (L.) Medik subsp. *clypeata* and subsp. *anatolica* A.Duran & Tuştaş subsp. nov., and *Fibigia eriocarpa* (DC.) Boiss. was rearranged as *F. clypeata* (L.) Medik subsp. *clypeata* var. *eriocarpa* in Turkish Flora. The infrageneric and subgeneric keys were revised. Seed and pollen surface ornamentations were studied by scanning electron microscopy (SEM). The pollens examined have tricolpate aperture type and reticulate surface ornamentation. Seed surface ornamentation was reticulate. The taxa of the genus *Fibigia* have a diploid chromosome number of $2n=16$. Karyotype analyses of the taxa were carried out for the first time. It was found that each taxon differed in chromosome morphology.

Key words: *Fibigia*, morphology, pollen, scanning electron microscopy (SEM), new taxa, Turkey.

INTRODUCTION

The Brassicaceae (Cruciferae) or mustard family, is a monophyletic group of about 338 genera and some 3709 species distributed worldwide (Al-Shehbaz et al., 2006). It is a natural family easily distinguished by floral and fruit morphology, that is, cruciform corolla, tetradynamus stamens, and characteristic siliques (Warwick et al., 2008). They show a worldwide distribution on all continents except Antarctica. Most of the taxa are found in temperate regions of the northern hemisphere. However, numerous genera are also found in the southern hemisphere (such as *Draba*, *Lepidium* and *Cardamine*), and some of them are even endemic to southern regions (South African genera: *Heliophila*, *Silicularia*, *Brachycarpa*, *Chamira*, *Schlechteria*) (Koch and Kiefer, 2006). Turkey is one of the richest countries in the world in terms of the number of species of the Brassicaceae (Cruciferae), and with its 571 species it is second only to the United States, where there are 653 native species in 61 genera, a country nearly ten times

the size of Turkey (Al-Shehbaz et al., 2007).

The genus *Fibigia*, which includes 13 species is distributed in southern Europe, Caucasus, middle East and Egypt (Appel and Al-Shehbaz, 2003; Warwick et al., 2006; Warwick et al., 2008). *Fibigia* is represented by five species in Flora of Iraq, of which the species of *F. suffruticosa* (Vent.) Sweet, *Fibigia clypeata* (L.) Medik., *F. thesigeri* Rech.f. are included in the section *Fibigia*, and the species of *F. multicaulis* (Boiss. & Hohen.) Boiss, *F. umbellata* (Boiss.) Boiss. are included in the section *Edmondia* (Townsend and Guest, 1980). The genus *Fibigia* is represented by four species; *F. suffruticosa*, *F. clypeata*, *F. eriocarpa*, *F. macrocarpa* (Boiss.) Boiss. (as *F. macroptera* Boiss. in Russian Flora), in Russian Flora (Bush, 1939), by eight species in Iranian Flora (Rechinger, 1968), and by three species in European Flora (Tutin and Heywood, 1964). In Egyptian, Flora and Flore du Liban and De La Syrie include only the species of *F. clypeata* (Bouloumoy, 1930; Tackholm, 1974), while only the species of *F. eriocarpa* is included in Flora of Cyprus (Meikle, 1977), and two taxa of the genus in Palaestianian Flora (Zohary, 1966). *Fibigia* was revised by Cullen (1965) for the 'Flora of Turkey' in which five

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species were accepted.

The genus *Fibigia* was studied in terms of morphology, floristic features, palynology, molecular characteristics, anatomy and chemotaxonomy (Vaughan and Whitehouse, 1971; Matvejeva, 1978; Moussavi, 1985; Al Shehbaz and Al Shammari, 1987; Garraud, 1990; Takhtajan, 1992; Damjanovic and Stevanovic, 1993; Erbar and Leins, 1997; Avetisyan, 1999; Kostovic et al., 1999).

In this study, the taxa of *Fibigia* growing naturally in Turkey were studied in relation to morphologic, cytotaxonomic features and pollen and seed surface characteristics. In addition, *F. clypeata* subsp. *anatolica* was introduced as a new taxon, for the first time.

MATERIALS AND METHODS

In 2007, during one of the field trips in the Mediterrean region of Turkey, an unusual specimen of *Fibigia* was collected. A study of the descriptions in Flora of Turkey and the East Aegean Islands (Davis, 1965 to 1985; Davis et al., 1988; Güner et al., 2000), Flora Iranica (Rechinger, 1968), Flora of Iraq (Townsend and Guest, 1980), Flore du Liban and De La Syrie (Bouloumoy, 1930), Flora Palaestina (Zohary, 1966), Flora of USSR (Bush, 1939), Flora of Cyprus (Meikle, 1977), Flora Europae (Tutin and Heywood, 1964) and student Flora of Egypt (Tackholm, 1974) as well as a comparison with materials in GAZI, HUB, ISTF, KNYA, ANK, VANF, B and W herbaria showed that the specimen represented a new taxon. In particular, the new taxon was compared with specimens of the closely similar taxa of the genus *Fibigia*. In the morphological description below, each numerical value is the average of ten measurements from different specimens. *Fibigia lunarioides* (Willd.) Sibth. and Sm. fell outside the scope of this study because the species is distributed in East Aegean Islands in Greece (Davis, 1965).

Cytotaxonomic methods

All the materials investigated were collected from different parts of Turkey, as given in Table 1. Voucher accessions have been deposited at the herbarium Ahmet Keleşoğlu Education Faculty Selcuk University. In karyological studies were made on metaphase cells of root tips obtained from germinated mature seeds which were pretreated in α -monobromonaphthalene for 16 h, then fixed in Carnoy's solution for at least 24 h, hydrolyzed in 1N HCl for 12 min at room temperature, and stained with 2% aceto-orcein for 2 h. Permanent slides were made by using the standard liquid nitrogen method. They were then examined under olympus BX50 photomicroscope using an oil immersion objective (x100). Photographs were taken by the same microscope. Karyotype analyses were made by the use of an image analysis software (BAB Bs200Pro Image Analysis Software, BAB Müh, Turkey). At least five metaphase plates were measured for each species. Chromosomes were classified using the nomenclature of Levan et al. (1964). Ideograms were arranged in order of decreasing lengths.

Micromorphological methods

Materials used for this study were collected from wild populations. Collectors and localities are shown in Table 1. The specimens of the plants were deposited in the A. Keleşoğlu Education Faculty Herbarium. For SEM studies, pollen grains and seed samples were

mounted on SEM stubs using double-sided adhesive tapes and coated with gold. Coated seeds and pollen grains were examined and photographed by scanning electron microscopy.

RESULTS

The systematic positions of *Fibigia* taxa were revised in the light of morphological, micromorphological, and cytotaxonomical data. The species *Fibigia suffruticosa* (Vent.) Sweet was transferred to the new section *Purpureae* sect. nov. The key for *Fibigia* taxa were rearranged according to the latest systematic arrangements. The sections of the genus *Fibigia* and the taxa of these sections are as follows:

Fibigia Medik. in Pflanzengatt., 1: 90, t. 2, fig. 23 (1792).

Section: *Fibigia*

Syn. Sect. *Eufibigia* Boiss., Fl. Or. 1: 257 (1807).

Fibigia clypeata

Fibigia macrocarpa

Section: *Purpureae* sect. nov.

Fibigia suffruticosa

Identification key for the species of the genus *Fibigia*

1. Petals violet; siliqua glabrous, inflated
..... **suffruticosa**
1. Petals yellow; siliqua tomentose, compressed
2. Siliqua elliptical to circular, at least 14 mm wide; seed wing broader than seed
..... **macrocarpa**
2. Siliqua oblong-elliptical to oval-oblong; seed wings equal to seed or less than seed width
..... **clypeata**

Purpureae A. Duran & Ö. Çetin sect. nov.

Foliis integris; petiolo foliis basalibus longis, 2.5–9 cm; petalis violaceis; siliculis inflatis et glabris.

Type: *Fibigia suffruticosa* (Vent.) Sweet

Fibigia suffruticosa (Vent.) Sweet

Syn: *Lunaria suffruticosa* Vent. Hort. Cels. 19 (1800). Ic.: Flora Azerbaidzhana 4: t. 34 (1953); *Fibigia suffruticosa* var. *macrostyla* Bornm., Fedde Rep. Beih. 89: 45 (1836); Blakelock in Kew Bull. 10: 540 (1955); Rawi in Dep. Agr. Iraq Tech. Bull. II 287 (1821) *Farsetia suffruticosa* DC., Syst. II (1821) 287; *Brachypus asper* Ldb., Fl. Ross. I 133 (1842).

Fibigia suffruticosa is distributed in Caucasus, C. Asia (Turkmenia), Iran, Iraq, Turkey. The species seems to be a very distinct species of the genus *Fibigia* without any close relatives. The characters are given in the key.

Table 1. The localities of studied specimens in *Fibigia* taxa.

Vouchers number	Taxa	Locality
A.Duran 5300	<i>F. clypeata</i> subsp. <i>clypeata</i> var. <i>clypeata</i>	C6 Hatay: Dört Yol, Topaktaş, in alpine zone, stony places, 2200 m, 18.06.2000
S.Tuştaş 1006	<i>F. clypeata</i> subsp. <i>clypeata</i> var. <i>eriocarpa</i>	C6 Adana: Saimbeyli, Yardibi village, roadside, 31.07.2006
M.Ünal 5195	<i>F. macrocarpa</i>	B9 Van: Erek Mountain, south of hillside, steppe, 2600 m 18.05.2007
A.Duran 5195	<i>F. suffruticosa</i>	B9 Muş: between Malazgirt-Mezra village, 10 km, igneous places, 1640 m, 26.05.2000
A.Duran 7643	<i>F. clypeata</i> subsp. <i>clypeata</i> var. <i>eriocarpa</i>	C5 Niğde: Ulukışla, between Çiftelhan-Pozantı, 2. km, 1000 m, 01.08.2007
A.Duran 7509	<i>F. clypeata</i> subsp. <i>clypeata</i> var. <i>clypeata</i>	B1 Balıkesir: Edremit, Kazdağı, Kızılkeçili village, open <i>Pinus nigra</i> , 740 m, 39°39.473'N, 26°54.375'E, 06.07.2007
S.Tuştaş 1007	<i>F. clypeata</i> subsp. <i>anatolica</i>	C6 Hatay: Arsuz. Gözcüler, serpentine stony slopes, 1350 m, 07.07.2007.
A.Duran 7672	<i>F. macrocarpa</i>	B6 Kayseri: Sarız-Yalak (Yeşilkent), Binboğa Mountain, 1850 m, steppe, 07.08.2007
S.Tuştaş 1003	<i>F. suffruticosa</i>	B9 Van: Erek Mountain, 2200 m, 09.08.2006
S.Tuştaş 1004	<i>F. macrocarpa</i>	B9 Van: Erek Mountain, 2200 m, 09.08.2006
A.Duran 7718	<i>F. clypeata</i> subsp. <i>clypeata</i> var. <i>clypeata</i>	C6 Osmaniye: between Osmaniye-Yarpuz, roadside, 750 m, 18.06.2007

Section: *Fibigia****Fibigia macrocarpa*** (Boiss.) Boiss.

Syn: *Farsetia macrocarpa* Boiss. in Ann. Sci. Nat. 17: 89 (1842); *Farsetia macroptera* Kotschy & Boiss. ex Fourn. in Bull. Soc. Bot. Fr. 11: 60 (1864); *Fibigia macroptera* (Kotschy & Boiss. ex Fourn.) Boiss., Fl. Or. 1: 257 (1867); *Fibigia clypeata* (L.) Medik subsp. *macroptera* (Kotschy et Boiss. ex Fourn.) Bornm. in Beih. Bot. Centralbl. 28(2): 112 (1911); *Fibigia clypeata* (L.) Medik. subsp. *macroptera* (Kotschy et Boiss. ex Fourn.)

Bornm. **syn. nov.** in Fl. Iraq 4: 951-958 (1980).

Fibigia macrocarpa is distributed in Syrian Desert, Iran, Iraq, Caucasus, Turkey and is related to *Fibigia clypeata*. The different characters between them are given in the key.

Fibigia clypeata (L.) Medik.

F. clypeata is separated into two subspecies. These subspecies and identification key as follows;

1. Stem taller than 30 cm; with or without

bracteate; silique oblong-elliptical to ovate-oblong, up to 12 mm wide

subsp. *clypeata*

1. Stem shorter than 30 cm; without bracteate; silique slightly ovate, at least 13 mm wide

subsp. *anatolica****F. clypeata*** (L.) Medik. subsp. ***clypeata***

F. clypeata subsp. *clypeata* is separated into two varieties. These varieties and identification key as

follows;

1. Siliqua stellate hairy
 var. **clypeata**
 1. Siliqua stellate and bifurcate hairy.....
 var. **eriocarpa**

F. clypeata subsp. *clypeata* var. *clypeata*

Syn: *Alyssum clypeatum* L., Sp. Pl. 651 (1753); *A. cheiranthifolium* Willd., Sp. Pl. 3: 468 (1800); *Fibigia rostrata* (Schenk) Boiss., l.c. *Farsetia rostrata* Schenk, Pl. Specim. Aeg. 42 (1840). *Farsetia clypeata* R.BR. in APTON, Hort. Kew, ed. 2, 4 :96 (1812); *Farsetia clypeata* Ldb., Fl. Ross. I (1842) 134.

F. subsp. *clypeata.*, *clypeata* var. *clypeata* is widespread in central Europe, Austria, Bulgaria, Greece, France, former Yugoslavia, the Balkan Peninsula, N. & C. Italy, W. Syria, N. Iraq, C. & W. Iran, Transcaucasia, Crimea, Egypt, Russia, and Turkey. Most features of this taxon are the same as in *F. clypeata* subsp. *clypeata* var. *eriocarpa* (DC.) Post. It differs from *F. clypeata* subsp. *clypeata* var. *eriocarpa* because it has siliquae with stellate hairs (not stellate and bifurcate hairs).

F. clypeata subsp. *clypeata* var. *eriocarpa* (DC.) Post

Syn: *Farsetia eriocarpa* DC. System. Veg. 2: 288 (1821); *Fibigia eriocarpa* (DC.) Boiss. Fl. Orient. 1: 258 (1867); Fl. Pal. ed. 2, 1: 82 (1932); N. Busch in Fl. U.R.S.S. 8: 337 (1939); Cullen in Fl. Turkey 1: 357 (1965); Nouv. Fl. Syr. 2: 161 (1970).

F. clypeata subsp. *clypeata* var. *eriocarpa* is distributed in C. & S. Greece, W. Syria, Iraq, Caucasus, Palaestina, Cyprus, Turkey, and is related to *Fibigia clypeata* subsp. *clypeata* var. *clypeata*.

F. clypeata subsp. *anatolica* A.Duran & Tuştaş **subsp. nov.** (Figures 3 to 5)

Plantis 10 to 30 cm *elatis*, *foliis basalibus* 20 - 30 x 4 - 9 mm, *Siliquis Leviter ovatis*, 30 - 34 x 13 - 17 mm.

Type: Turkey. C6 Hatay: Iskenderun, Arsuz, above Gözcüler town, serpentine stony places, 1350 m, 07.07.2007, S.Tuştaş 1007 (holotype: KNYA, isotypes: ANK, GAZI, HUB, Selçuk Üniv. Eğitim Fak. Herb.).

Paratype: Turkey. C6 Hatay: Iskenderun, Arsuz, above Gözcüler town, serpentine stony places, 1350 m, 21.07.2006. S.Tuştaş 1001 (KNYA, Selçuk Üniv. Eğitim Fak. Herb.); Hatay: Iskenderun, Arsuz, above Gözcüler town, serpentine stony places, 1350 m, 31.05.2008, S.Tuştaş 1009 (KNYA, Selçuk Üniv. Eğitim Fak. Herb.); Hatay: Iskenderun, Arsuz, above Gözcüler town, serpentine stony places, 1350 m, 36°20.380'N, 35°58.978'E, 06.08.2001, N.Adıgüzel 4069 (GAZI).

Distribution and suggested conservation status: *F. clypeata* subsp. *anatolica* appears to exist in only the

present locality (Hatay province), and its estimated area of occupancy is less than 5 km² with a population of less than 200 mature individuals. Because of its localized distribution and small population size, the new species should be considered as critically endangered (CR) according to IUCN red list criteria (IUCN, 2001).

Habitat ecology: *F. clypeata* subsp. *anatolica* grows in the mediterranean phytogeographical region on serpentine stony places and in open *Pinus brutia* Ten forest with *Iberis taurica* DC., *Alyssum murale* Waldst & Kit, *Phlomis pungens* Wild., *Orobanch* sp., *Piptathelum* sp., *Quercus cerris* L., *Ferulago cassia* Boiss. and *Anthemis cretica* L.

F. clypeata subsp. *anatolica* is closely related to *F. clypeata* subsp. *clypeata* but differs in stem 10 to 30 cm tall, (not 25 to 90 cm), siliqua wide 13 to 17 mm (not 8 to 12 mm), siliqua slightly ovate (not oblong-elliptical to ovate-oblong) (Table 3).

Chromosome morphology of this taxon could not be studied because its seeds could not be germinated. It was determined that *F. clypeata* subsp. *anatolica* has pollens and seeds with reticulate ornamentation, and its pollen aperture type is tricolpate (Figures 3 and 4).

F. clypeata subsp. clypeata var. clypeata

Somatic chromosome number in *F. clypeata* subsp. *clypeata* var. *clypeata* is 2n = 16. The karyotype formula is n=8=6m+2sm (Figure 1). The chromosome morphology was reported for the first time. Metaphase chromosome lengths range from 1.76 to 0.94 µm, total haploid chromosome length is 10.05 µm (Table 2). The ideogram is given in Figure 2.

Pollen grains of *F. clypeata* subsp. *clypeata* var. *clypeata* are tricolpate and exine ornamentation is reticulate (Figure 3).

The seeds of *F. clypeata* subsp. *clypeata* var. *clypeata* were studied by SEM and LM. Seeds were large; 5 x 5 mm, with marginal wings, and also smooth and brown. SEM showed that the seed surface sculpture is reticulate (Figure 4).

F. clypeata subsp. clypeata var. eriocarpa

Somatic chromosome number in *Fibigia clypeata* subsp. *clypeata* var. *eriocarpa* is 2n = 16. The karyotype formula is n=81m+7 sm (Figure 1). The chromosome morphology is reported for the first time. Metaphase chromosome lengths range from 1.74 to 0.87 µm, total haploid chromosome length is 10.61 µm. The ideogram is given in Figure 2.

The pollen of *F. clypeata* subsp. *clypeata* var. *eriocarpa* was studied by SEM. The ornamentation types of pollen

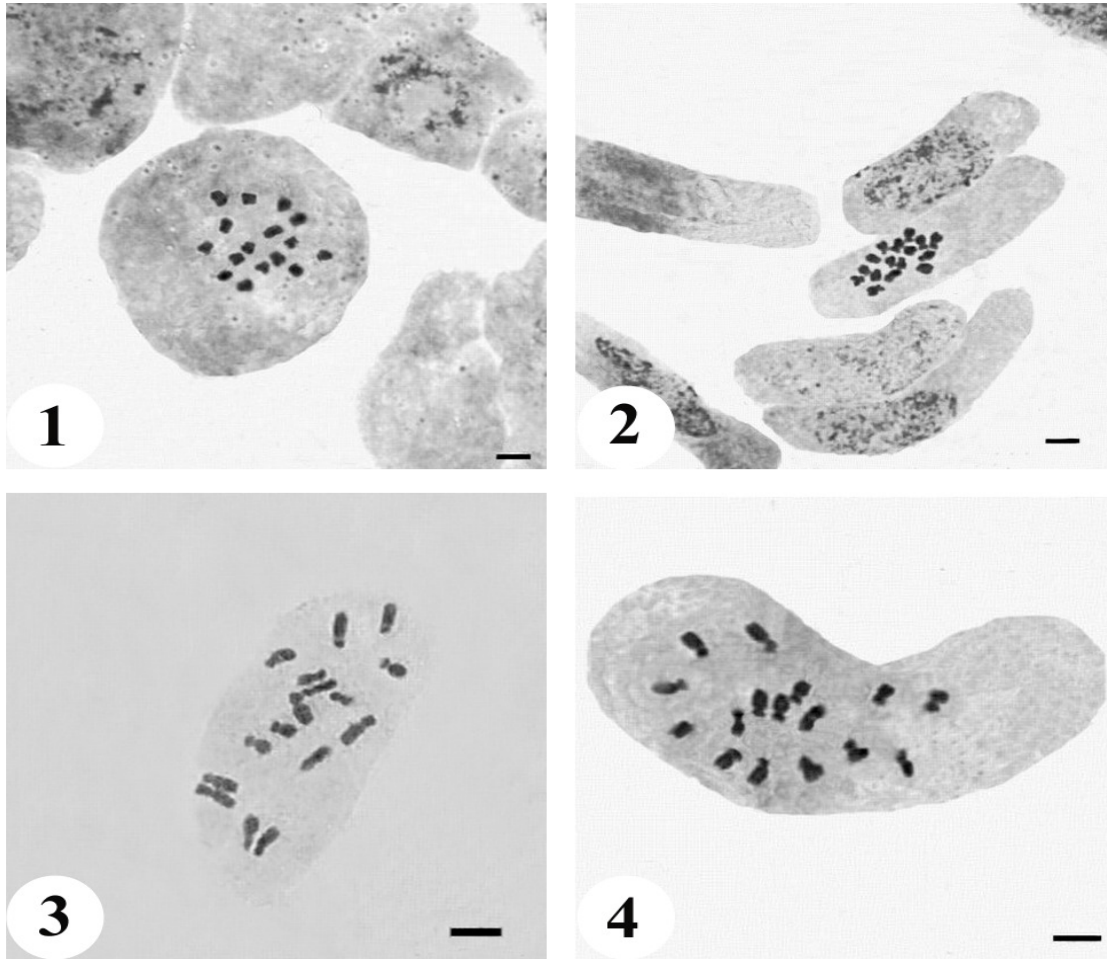


Figure 1. Metaphase chromosomes of *Fibigia* taxa. 1, *F. clypeata* subsp. *clypeata* var. *clypeata*; 2, *F. clypeata* subsp. *clypeata* var. *eriocarpa*; 3, *F. macrocarpa*; 4, *F. suffruticosa*. scale bar: 5 μ m.

grains are reticulate and pollen grains are tricolpate (Figure 3).

The seed of *F. clypeata* subsp. *clypeata* var. *clypeata* was studied by SEM and LM. Seeds were large; 5 x 5 mm. Seeds are smooth with marginal wings. SEM showed that the seed surface pattern is reticulate (Figure 4).

Fibigia macrocarpa

Somatic chromosome number in *F. macrocarpa* is $2n = 16$ (Figure 1). The karyotype formula is $n = 8 = 8 sm$. The chromosome morphology was reported for the first time. Metaphase chromosome lengths ranging from 2.40 to 1.34 μ m, total haploid chromosome length is 14.96 μ m. The ideogram is given in Figure 2.

The pollen of *F. macrocarpa* was studied by SEM and LM. Pollen grains are tricolpate. The pollen surface is reticulate (Figure 3). The seed of *F. macrocarpa* was studied by SEM and LM. Seeds are relatively large, 12 x 11 mm. Seeds are smooth with relatively large wings. The

seed surface ornamentation is reticulate (Figure 4).

Fibigia suffruticosa

Somatic chromosome number in *F. suffruticosa* is $2n = 16$. The karyotype formula is $n = 8 = 3m + 4sm + 1st$ (Figure 1). The chromosome morphology was reported for the first time. Metaphase chromosome length ranging from 3.07 to 1.45 μ m, total haploid chromosome length is 18.37 μ m. The ideogram is given in Figure 2.

The samples of seeds were investigated under SEM and LM. The mature seeds of *F. suffruticosa* are 8 mm long and 8 mm wide. Seeds are smooth with marginal wings. SEM indicated that the seed surface is reticulate. The pollen of *F. suffruticosa* was studied by SEM. The ornamentation types of pollen grains are reticulate and pollen grains are tricolpate (Figure 3).

DISCUSSION

Represented by 13 species in the world, the genus

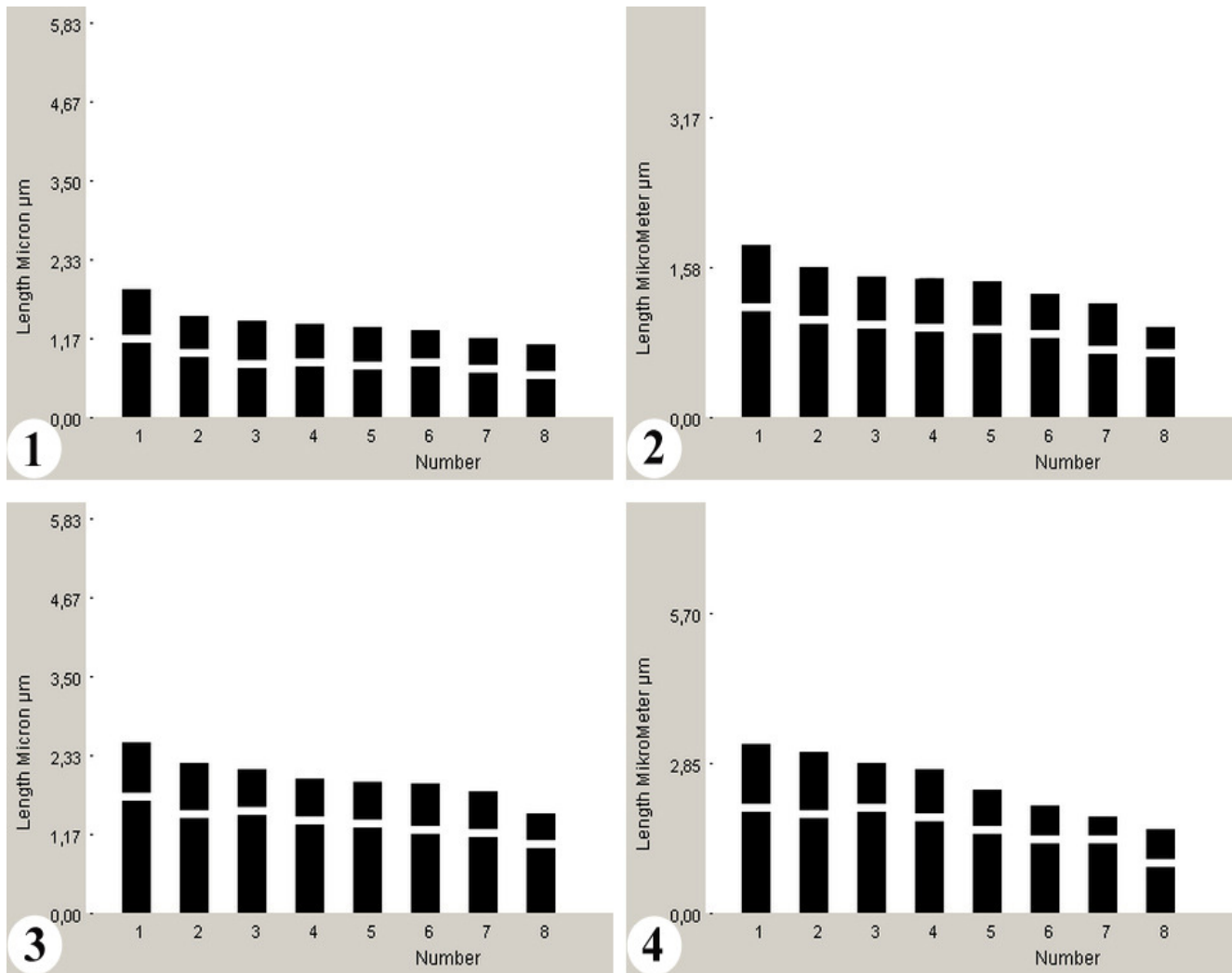


Figure 2. Ideogram of *Fibigia* taxa. 1, *F. clypeata* subsp. *clypeata* var. *clypeata*; 2, *F. clypeata* subsp. *clypeata* var. *eriocarpa*; 3, *F. macrocarpa*; 4, *F. suffruticosa*.

Fibigia was determined having somatic chromosome number of $2n = 16$ (Baltisberger, 1991; Kostovic-Vranjies et al., 1999; Warwick and Al-Shehbaz, 2006). In our study, it is stated that the examined taxa have the same somatic chromosome number of $2n = 16$, while those differ from each other in terms of karyotype formulas. The karyotype formula is $6m+2sm$ for the taxon *F. clypeata* subsp., *clypeata* var. *clypeata*, $1m + 7sm$ for the taxon *F. clypeata* subsp. *clypeata* var. *eriocarpa*, 8 sm for the species *F. macrocarpa* and $3m+4sm+1st$ for the species *F. suffruticosa*. It is confirmed that chromosome morphologies among species are peculiar to examined taxa. The taxon *F. clypeata* subsp. *clypeata* var. *eriocarpa* has the shortest chromosome length of $0.87 \mu\text{m}$, while *F. suffruticosa* has the longest of $3.07 \mu\text{m}$. *F. clypeata* has the haploid chromosome length of $10.05 \mu\text{m}$ (the shortest) while *F. suffruticosa* has the length of $18.37 \mu\text{m}$

(the longest). In terms of arm length ratios, *F. clypeata* subsp. *clypeata* var. *clypeata* has the smallest arm ratio (1.54), and *F. macrocarpa* has the largest (2.22).

According to centromeric indices of the taxa, the lowest value was obtained from the species *F. macrocarpa* (3.91), and the highest was calculated for the taxon *F. clypeata* subsp. *clypeata* var. *clypeata* (4.94). Total lengths of mitotic metaphase chromosomes are 0.94 to $1.76 \mu\text{m}$ for the taxon *F. clypeata* subsp. *clypeata* var. *clypeata*, and 1.45 to $3.07 \mu\text{m}$ for the species *F. suffruticosa*. Both taxa considerably differ from each other in chromosome morphologies. The karyotype formula of *F. clypeata* is $6m+2sm$ while that of *F. suffruticosa* is $3m+4sm+1st$. The species *F. macrocarpa* which is distinct from the other taxa in terms of chromosome morphology consists of only submedian chromosome pairs. It is obvious even in other karyological measurements that

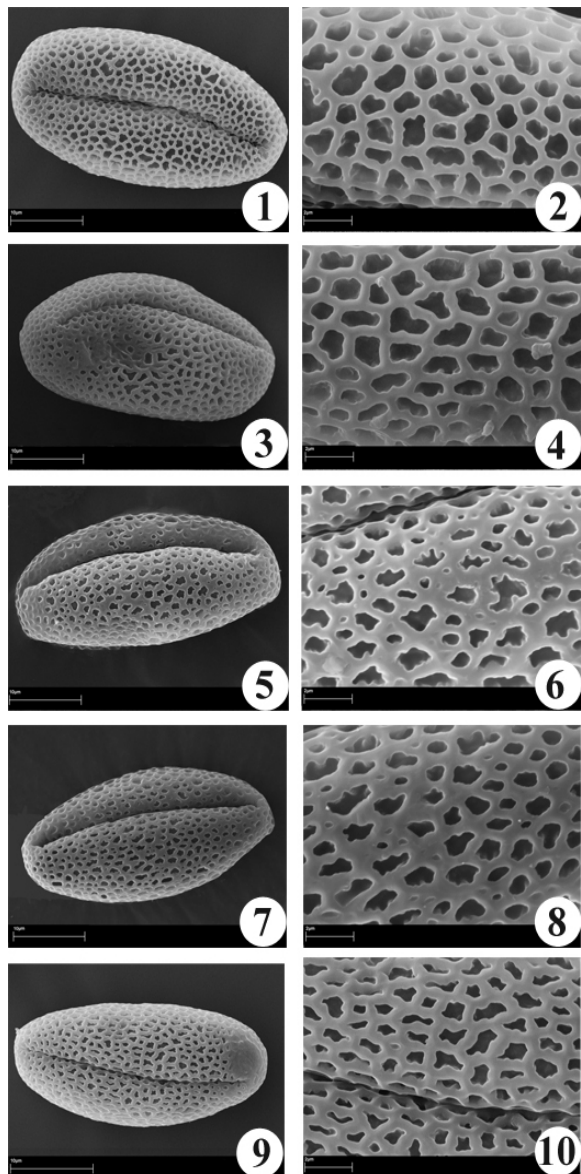


Figure 3. SEM micrographs of the pollen grains of *Fibigia* taxa, *F. clypeata* subsp. *clypeata* var. *eriocarpa*. 1, general view; 2, detail view; *F. clypeata* subsp. *clypeata* var. *clypeata*; 3, general view; 4, detail view; *F. clypeata* subsp. *anatolica*; 5, general view; 6, detail view; *F. macrocarpa*; 7, general view; 8, detail view; *F. suffruticosa*; 9, general view; 10, detail view.

chromosome lengths are different. In *F. clypeata* subsp. *clypeata* var. *clypeata*, for instance, haploid chromosome length is 10.05 μm ; the lowest rate to examined *Fibigia* taxa, is 18.37 μm in *F. suffruticosa*.

Analyzing the taxa of *Fibigia* in relation to karyological characteristics, the somatic chromosome morphologies of the taxa differ from each other considerably. Metaphase chromosome pairs are median or submedian type in general, whereas a pair of subterminal chromosome type was observed in the species *F. suffruticosa*. This

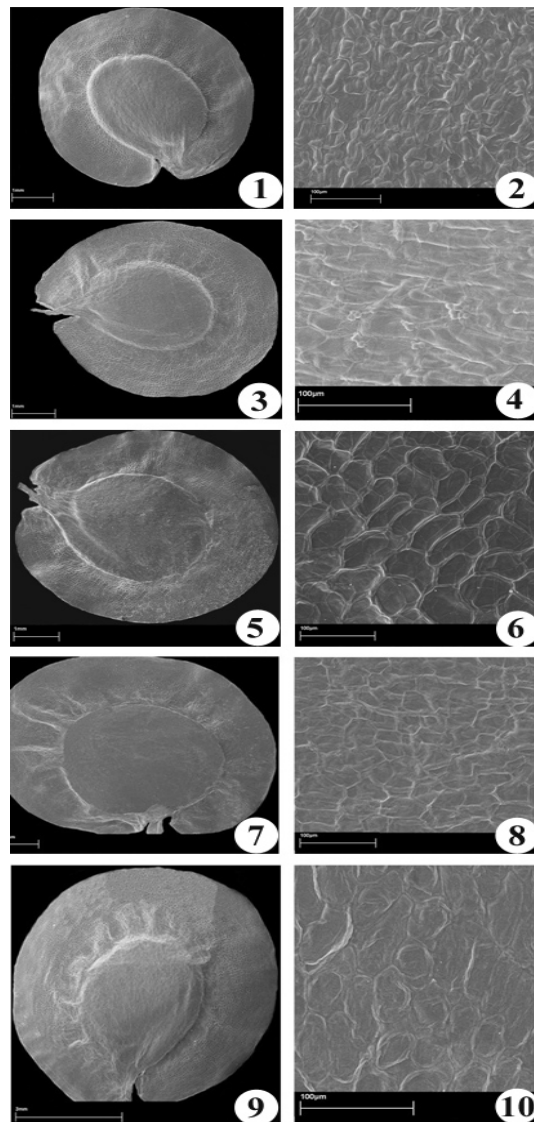


Figure 4. SEM micrographs of the seed coat surfaces of *Fibigia* taxa. *F. clypeata* subsp. *clypeata* var. *eriocarpa*. 1, general view; 2, detail view; *F. clypeata* subsp. *clypeata* var. *clypeata*; 3, general view; 4, detail view; *F. clypeata* subsp. *anatolica*; 5, general view; 6, detail view; *F. suffruticosa*; 7, general view; 8, detail view; *F. macrocarpa*; 9, general view; 10, detail view.

species is quite distinct from the other taxa both morphologically (flower colour) and genetically. Karyotypes of taxa were made using an image analysis system. Chromosome numbers, chromosome morphologies, total chromosome lengths, arm ratios and centromeric index are summarized in Table 2.

The somatic chromosome morphology of the *Fibigia* taxa differs from each other considerably. Chromosome morphology was defined for the first time in four taxa of *Fibigia* namely; *F. clypeata* subsp. *clypeata* var. *clypeata*, *F. clypeata* subsp. *clypeata* var. *eriocarpa*, *F. macrocarpa* and *F. suffruticosa*. All taxa contained somatic chromosome number of $2n = 16$.

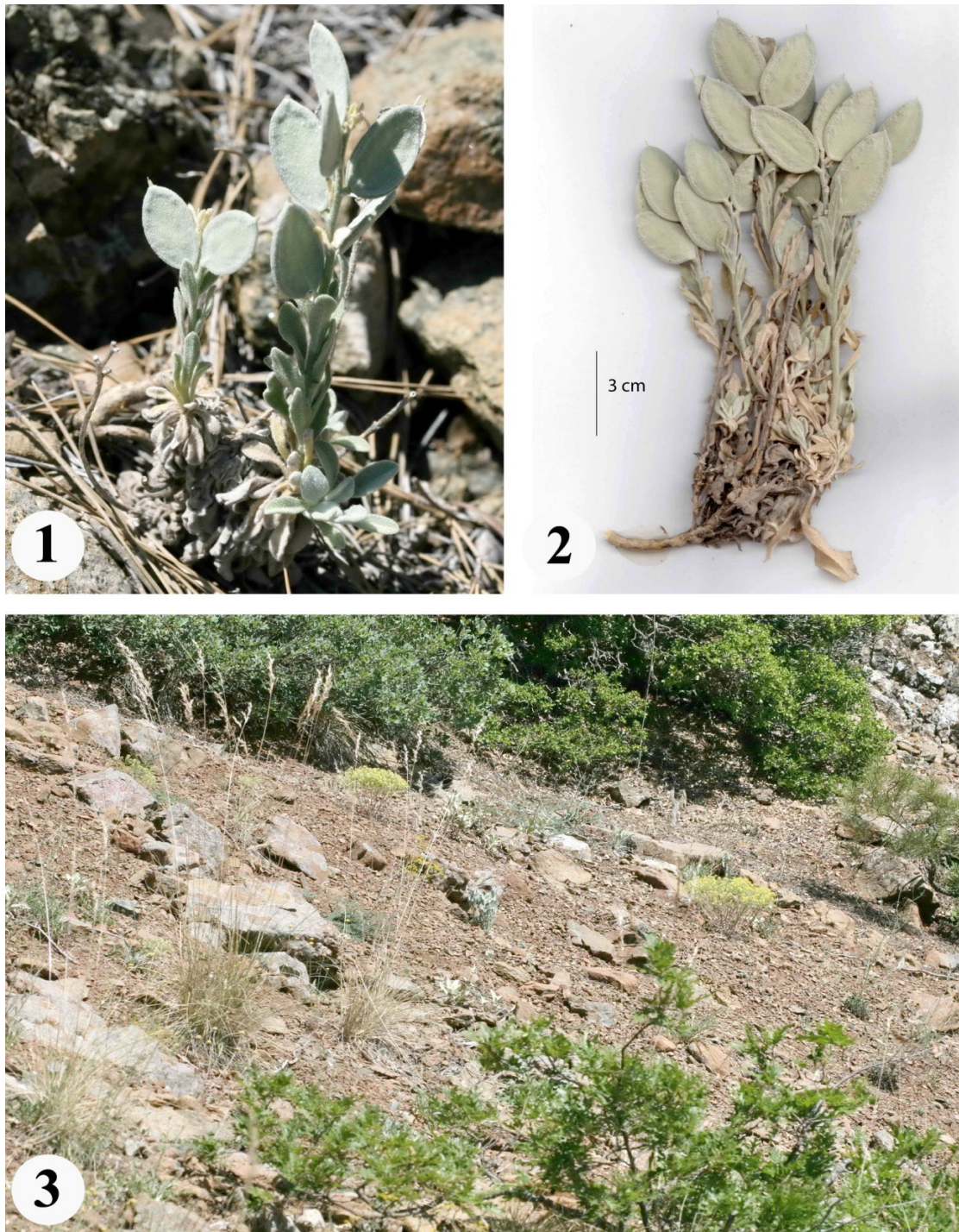


Figure 5. 1, General aspects of *F. clypeata* subsp. *anatolica*; 2, the habit of *F. clypeata* subsp. *anatolica* (from isotype); 3, habitat and general view of the type locality of *F. clypeata* subsp. *anatolica*.

The chromosome count for the species of *Fibigia* is not a distinguishable character to identify species. The somatic chromosome numbers obtained from this study show parallelism with literature (Warwick and Al-Shehbaz, 2006).

In this study, pollen and fruit morphology of the genera *Fibigia* were examined by using scanning electron microscope (SEM). The seed coat ornamentation is reticulate. *F. macrocarpa* is remarkably different from the other *Fibigia* species with its broadly winged seeds.

Table 2. Measurements of somatic chromosomes of *Fibigia* taxa.

Fibigia suffruticosa										
Chromosome pair no	Long arm (L)	Short arm (S)	Total length	Arm (L/S)	ratio	Centromeric index	Relative length	Chromosome type		
1	1.93	1.15	3.07	1.68	6.25	16.73	m			
2	1.80	1.10	2.90	1.63	5.99	15.76	m			
3	1.91	0.77	2.68	2.46	4.22	14.59	sm			
4	1.73	0.83	2.56	2.08	4.52	13.91	sm			
5	1.49	0.68	2.17	2.19	3.70	11.81	sm			
6	1.32	0.56	1.88	2.36	3.05	10.23	sm			
7	1.31	0.36	1.67	3.63	1.96	9.06	st			
8	0.88	0.57	1.45	1.52	3.13	7.89	m			
Total length of haploid complement:18.37 µm										
Fibigia macrocarpa										
1	1.65	0.75	2.40	2.21	5.00	16.04	sm			
2	1.41	0.70	2.11	2.00	4.71	14.13	sm			
3	1.45	0.55	2.00	2.61	3.71	13.40	sm			
4	1.30	0.56	1.86	2.33	3.74	12.46	sm			
5	1.25	0.55	1.80	2.24	3.71	12.03	sm			
6	1.16	0.62	1.78	1.86	4.14	11.86	sm			
7	1.11	0.55	1.67	2.00	3.71	11.13	sm			
8	0.96	0.39	1.34	2.48	2.57	8.95	sm			
Total length of haploid complement:14.96 µm										
Fibigia clypeata subsp. clypeata var. eriocarpa										
1	1.12	0.61	1.74	1.84	5.77	16.36	sm			
2	0.99	0.51	1.50	1.93	4.81	14.10	sm			
3	0.90	0.51	1.41	1.76	4.81	13.30	sm			
4	0.94	0.47	1.41	1.97	4.48	13.30	sm			
5	0.89	0.47	1.36	1.89	4.43	12.82	sm			
6	0.84	0.39	1.22	2.17	3.63	11.50	sm			
7	0.67	0.45	1.11	1.49	4.20	10.47	m			
8	0.64	0.23	0.87	2.76	2.17	8.16	sm			
Total length of haploid complement: 10.61 µm										
Fibigia clypeata subsp. clypeata var. clypeata										
1	1.09	0.67	1.76	1.63	6.66	17.52	m			
2	0.89	0.49	1.38	1.84	4.83	13.69	sm			
3	0.72	0.59	1.31	1.21	5.92	13.09	m			
4	0.74	0.51	1.26	1.46	5.08	12.49	m			
5	0.69	0.51	1.20	1.35	5.08	11.95	m			
6	0.74	0.43	1.17	1.73	4.28	11.70	sm			
7	0.65	0.39	1.03	1.68	3.83	10.25	m			
8	0.55	0.39	0.94	1.43	3.83	9.31	m			
Total length of haploid complement:10.05 µm										

Pollens of all species have tricolpate aperture. Pollen ornamentation is similar for all taxa and determined as reticulate.

Brassicaceae is a stenopalynous family, the pollen grains are usually reticulate and tricolpate (Erdtman,

1952; Reile, 1992; El Ghazali, 1993, Khalik et al., 2002). Pollen grains are generally prolate to subprolate, spheroidal 3-colpate often four to six colpate as *Atlanthera perpusilla* 6-colporate pollen; tectum reticulate to granulated (Khan, 2005). *Alyssum obtusifolium* was

Table 3. A comparison between the diagnostic characters of *F. clypeata* subsp. *anatolica* and *F. clypeata* subsp. *clypeata*

Diagnostic character	<i>F. clypeata</i> subsp. <i>anatolica</i>	<i>F. clypeata</i> subsp. <i>clypeata</i>
Plant	10-30 cm tall	25-90 cm
Basal leaves	20-30 x 4-9 mm	40-55 x 8-10 mm
Stem leaves (lower and middle)	25-30 x 3-5 mm	30-60 x 4-12 mm
Siliqua	siliqua slightly ovate	oblong-elliptical to ovate-oblong
Siliqua size	30-34 x 13-17 mm	15-25 x 8-12 mm
Seed number per locus	at least 10	6-8

studied anatomically and palynologically. It was found that *A. obtusifolium* pollens are prolate and tricolpate (Orcan and Binzet, 2003). The pollen of *Hesperis turkmendaghensis* and *H. matronalis* ssp. *matronalis* was studied by SEM. *H. turkmendaghensis* and *H. matronalis* are very similar in their pollen characteristics. The pollen grains exine ornamentation is reticulate and pollen grains are prolate-spheroidal (Duran and Ocak, 2005).

In this study, the taxa of the genus *Fibigia* growing naturally in Turkey; *F. clypeata* subsp. *clypeata* var. *clypeata*, *F. clypeata* subsp. *clypeata* var. *eriocarpa*, *F. macrocarpa*, *F. suffruticosa*, were examined by determining somatic chromosome numbers, chromosome morphologies, and pollen and seed surface characteristics. Section *Purpureae* and *F. clypeata* subsp. *anatolica* was introduced as new taxa for the first time.

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