Karyotype Analyses of the Genus *Matthiola* (Brassicaceae) in Turkey

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Summary In the present paper, karyotype analyses are reported for 12 taxa of *Matthiola* from Turkey. *Matthiola trojana* Dirmenci, Satıl & Tümen, *M. odoratissima* (Pall.) R.Br., *M. anchonifolia* Hub.-Mor., *M. montana* Boiss., *M. fruticulosa* (L.) Maire ssp. *fruticulosa* and *M. ovatifolia* (Boiss.) Boiss. counted $2n=12$ chromosomes, and *M. incana* (L.) R.Br., *M. longipetala* (Vent.) DC. ssp. *bicornis* (Sibth. et Smith) P. W. Ball, *M. longipetala* (Vent.) DC. ssp. *longipetala*, *M. longipetala* (Vent.) DC. ssp. *pumilio* (Sibth. & Smith) P. W. Ball, *M. sinuata* (L.) R.Br., and *M. tricuspidata* (L.) R.Br. showed $2n=14$ chromosomes. The idiograms and karyomorphometric data obtained by using Image Analysis System (Bs200Pro). The chromosome number of *M. montana* was determined for the first time. Also, karyotype asymmetry index such as M_{CA}, CV_{CL} and CV_{CL} were measured for the reconstruction of karyological relationships.

Key words Karyotype asymmetry, *Matthiola*, PCoA, Chromosome number.

The genus *Matthiola* Aiton belonging to the tribe Anchonieae of the family Brassicaceae consists of *ca.* 50 woody and herbaceous species in the world (Al-Shehbaz 2012, Ranjbar and Karami 2013). It is a widespread genus distributed throughout Macaronesia, the Mediterranean basin, the Saharo–Sindian region and Northeast Africa and Asia, and it exhibits two centers of taxonomic diversity in Turkey and the Irano–Turanian region (Cullen 1965, Heywood 1993, Al-Shehbaz *et al.* 2006, Warwick *et al.* 2006, Ranjbar and Karami 2013). The genus *Matthiola* is represented by approximately 50 species in the world, with 12 taxa in Turkey (Cullen 1965, Heywood 1993, Dirmenci *et al.* 2006, Martin *et al.* 2013).

Karyological research showed that somatic chromosome numbers were $2n=10$, 12, 14 and 16 in *Matthiola* (Maassoumi 1980, Strid and Franzen 1981, Magulaev 1984, Tammaro 1985, Tiniakou 1996, Khosravi and Maassoumi 1998, Ghaffari 2006, Ranjbar and Karami 2013, Martin *et al.* 2013). The karyotype asymmetry is a good expression for the chromosome morphology, so it is very important to have a uniform system to compare karyotypes on correct statistical grounds (Paszko 2006). Researchers proposed a lot of parameters for this aim,

but we used only quantitative parameters that are correct on statistical grounds: $2n$, x, THL, M_{CA}, CV_{CL} and CV_{CL} (Peruzzi and Eroğlu 2013, Peruzzi and Altınordu 2014). TF%, AsK%, AsI%, Syi, A1, CG, Rec, DI, AI and other characters like karyomorphometric measurements of single chromosome pairs were not considered (for details see Peruzzi and Eroğlu 2013).

This research presents karyomorphometric data based on karyotype analyses for 12 *Matthiola* taxa from Turkey. Within this context, our objectives are to (1) determine the number of somatic chromosomes of the genus and to compare it to previous studies, (2) perform karyotype analyses on the taxa of the genus, (3) assist in the revision of *Matthiola* found in Turkey by providing cytogenetic comparison of the taxa, (4) determine the karyotype asymmetry indices and demonstrate the karyologic relationships among *Matthiola* taxa.

Materials and methods

All samples were collected from wild populations and then germinated in Necmettin Erbakan University, Faculty of Science. Samples of the studied taxa were collected from different localities of Turkey (Table 1).

All karyological observations were carried out on root tips. Root tip meristems were provided from seeds by germinating them on wet filter paper in Petri dishes at

Table 1. Localities, voucher and herbarium numbers.

Taxon	Localities, voucher and herbarium numbers
Matthiola trojana	B1: Balıkesir, Edremit, Kaz mountain, Nanekırı vicinity, 1594 m, 39°41′899″, 26°53′106″D, 08.09.2012, MUASEF 10207, VANF 164034
Matthiola odoratissima	A8: Artvin, Yusufeli, between Olur and Yusufeli, 757 m, 40°45′558″K; 30°46′282″, 31.08.2013, MUASEF 10189, VANF 164030
Matthiola anchoniifolia	B6: Sivas, Gürün, Gökpınar village road, 4. km, 1474 m, 38°39′215″K; 37°18′164″D, 21.07.2013, ASEFMU 10201, VANF 164023
Matthiola montana	A2: Bursa, Uludağ, between Kuşaklı and Şahinkaya hill, 2153 m, 40°05′230″K, 29°09′230″D, 07.09.2012, MUASEF 10208, VANF 164029
Matthiola fruticulosa ssp. *fruticulosa*	A2: İstanbul, Sarıyer, Kumköy (Kilyos), sandy areas, 4 m, 41°14′415″K; 29°00′554″D, 18.06.2012, ASEFMU 10202, VANF 164024
Matthiola ovatifolia	B6: Sivas, between Gürün- and Darende arası 3. km, steppe, 1447 m; 38°41′339″K; 37°23′147″D, 20.08.2013, ASEFMU 10209, VANF 164031
Matthiola incana	A5: Sinop, Sinop castle, above rampart, 10 m, 42°01′468″K; 35°08′704″D, 30.08.2013, MUASEF 10188, VANF 164025
Matthiola longipetala ssp. *bicornis*	C8: Mardin, Savur, from Sürgücü village to Savur 5. km, steppe, 918 m, 37°30′159″K; 40°38′238″D, 15.05.2013, MUASEF 10204, VANF 164027
Matthiola longipetala ssp. *longipetala*	C5: Niğde, from Konya to Ulukışla, 15. km, steppe, 1281 m, 37°36′284″K; 34°24′146″D, 14.05.2013, MUASEF 10203, VANF 164026
Matthiola longipetala ssp. *pumilio*	C3: Antalya, Murat Paşa, Lara, 25 m, 36°50′558″K; 30°46′282′, 06.04.2013, ASEFMU 10205, VANF 164028
Matthiola sinuata	A1: Çanakkale, Seddülbahir (Helles), sandy areas, 14 m, 40°02′342″K; 26°11′112″D, 06.05.2012, ASEFMU 10210, VANF 164032
Matthiola tricuspidata	B1: İzmir, Çeşme, Çiftlik village, Altınkum seaside, 13 m, 38°16′207″K; 26°15′639″D, 10.04.2013, MUASEF 10206, VANF 164033

room temperature. Firstly, root tips were pretreated for 16 h in α-monobromonaphthalene at 4°C and fixed in 3 : 1 absolute alcohol–glacial acetic acid. Then the root tips were hydrolyzed with 1 N HCl for 12 min at 60°C and stained with 2% aceto orcein for 2 h at room temperature. Stained root tips were squashed in a drop of 45% acetic acid, and permanent slides were made by mounting in DPX (Martin *et al.* 2013). For karyotype analysis, the photographs enlarged 10×100 were taken using an OLYMPUS BX51 microscope with camera Pixera PVC 100C attachment. The classification of chromosomes, the length of long and short arm, arm ratio, centromeric index and relative chromosomal length were measured by Software Image Analyses (Bs200Pro) loaded on a personal computer. Chromosomes were classified using the nomenclature of Levan *et al.* (1964) in Table 2. Idiograms of these taxa were arranged in decreasing length (Martin *et al.* 2007). Chromosome number ($2n$), basic chromosome number (x), total haploid length of the chromosome set (THL), M_{CA} (Mean Centromeric Asymmetry), CV_{CL} (Coefficient of Variation of Chromosome Length) and CV_{CI} (Coefficient of Variation of Centromeric Index) were used as characters to determine the karyological relationships (Table 3) (Paszko 2006, Peruzzi and Eroğlu 2013, Peruzzi and Altınordu 2014). To perform multivariate ordination approach, PCoA and PCA, a similarity matrix was created using Gower's (1971) general coefficient similarity to summarize the relationship among accessions (Sneath and Sokal 1973). Therefore, the software Past 3.03 (Hammer *et al.* 2001) was used along with Minitab 17.

Table 2. Levan *et al.* (1964) nomenclature method.

Term	Location	r (Arm ratio)
M	Median point	1.0
m	Median region	1.0–1.7
sm	Submedian region	1.7–3.0
st	Subterminal region	3.0–7.0
t	Terminal region	7.0–∞
T	Terminal point	∞

Results

The karyotype analyses were studied for all taxa. All observations showed that *Matthiola trojana*, *M. odoratissima*, *M. anchonifolia*, *M. montana*, *M. fruticulosa* ssp. *fruticulosa*, and *M. ovatifolia* have a somatic number of $2n=12$; *M. incana*, *M. longipetala* ssp. *bicornis*, *M. longipetala* ssp. *longipetala*, *M. longipetala* ssp. *pumilio*, *M. sinuata*, and *M. tricuspidata* have a somatic number of $2n=14$.

Matthiola trojana

The taxon, which was introduced to the scientific world from Balıkesir Kaz Mountains, is markedly distinct from *M. fruticulosa* due to its short stature, pinnatifid leaves and ascendant and falcate fruit. The somatic chromosome number of *Matthiola trojana* was determined to be $2n=12$ (Fig. 1A). The total chromosome length is between 2.22–3.81 μm. The total length of the haploid set is 18.98 μm. Chromosome arm ratios are measured as 1.34–2.00. As a classification result, the karyotype formula is 4m+2sm. The idiogram was drawn based on centromeric index and arranged in decreasing size order (Fig. 2A).

Table 3.   Values of asymmetry indices in studied taxa.

| Taxon	CV_{CI}	CV_{CL}	M_{CA}	THL	$2n$	x
M. trojana	10.2	18.38	22.17	18.98	14	7
M. odoratissima	20.18	28.46	18.31	26.43	12	6
M. anchonifolia	10.49	19.05	17.02	36.81	12	6
M. montana	8.93	24.88	15.89	31.29	12	6
M. fruticulosa ssp. *fruticulosa*	18.47	25.24	18.8	21.11	12	6
M. ovatifolia	13.8	29.06	21.08	19.34	12	6
M. incana	4.69	10.69	16.49	17.9	14	7
M. longipetala ssp. *bicornis*	9.89	28.29	14.56	18.31	14	7
M. longipetala ssp. *longipetala*	24.19	23.62	23.19	22.84	14	7
M. longipetala ssp. *pumilia*	18.98	17.24	18.18	26.23	14	7
M. sinuata	11.57	15.47	18.7	15.6	14	7
M. tricuspidata	5.77	20.6	10.76	24.88	14	7
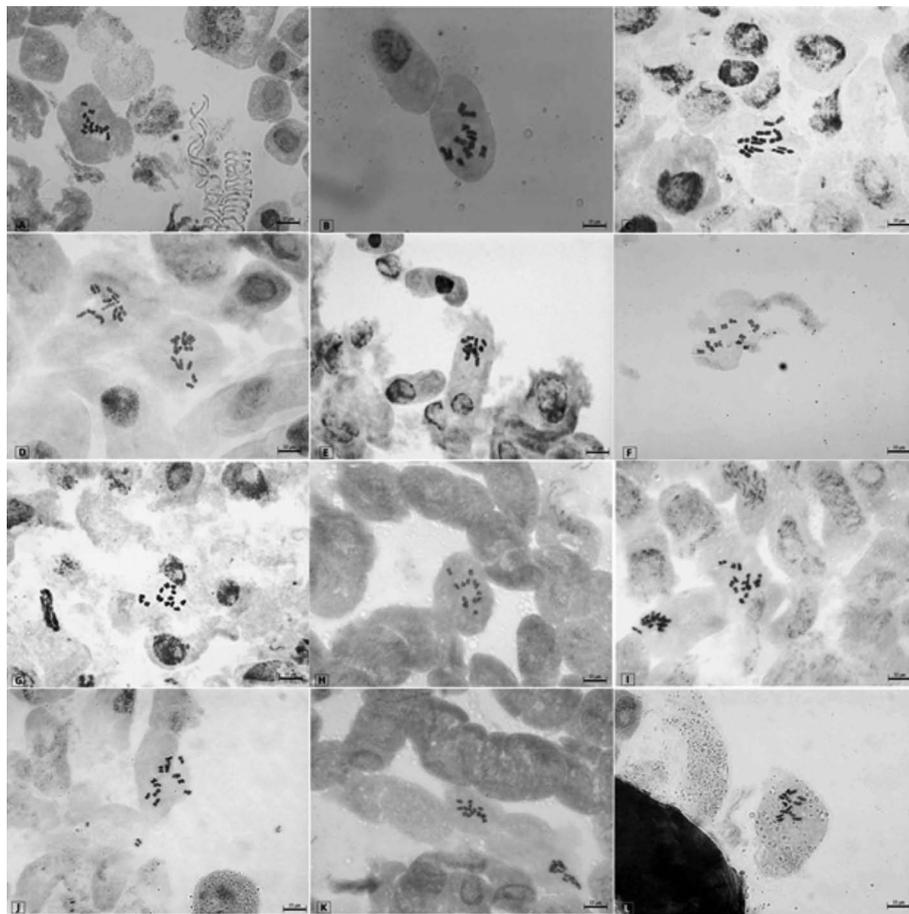
Fig. 1.   Somatic chromosome of *Matthiola* taxa. (A) *M. trojana*, (B) *M. odoratissima*, (C) *M. anchonifolia*, (D) *M. montana*, (E) *M. fruticulosa* ssp. *fruticulosa*, (F) *M. ovatifolia*, (G) *M. incana*, (H) *M. longipetala* ssp. *bicornis*, (I) *M. longipetala* ssp. *longipetala*, (J) *M. longipetala* ssp. *pumilia*, (K) *M. sinuata*, (L) *M. tricuspidata*. Scale bar: 10 µm.

Matthiola odoratissima

One of the most typical attributes of the species is that its leaves can go up to pinnatifid split. The somatic chromosome number of *Matthiola odoratissima* was determined to be $2n=12$ (Fig. 1B). The total chromosome length is between 2.61–5.94 µm. The total length of the haploid set is 26.43 µm. Chromosome arm ratios are measured as 1.10–2.45. As a classification result, the karyotype formula is 4m+2sm. The idiogram was drawn based on centromeric index and arranged in decreasing size order (Fig. 2B).

Matthiola anchoniifolia

It is an endemic species introduced to the scientific world from the area around Sivas. It is typical due to concentration of leaves in the base and its leaves lacking gland hairs. The somatic chromosome number of *Matthiola anchonifolia* was determined to be $2n=12$ (Fig. 1C). The total chromosome length is between 4.56–7.74 µm. The total length of the haploid set is 36.80 µm.
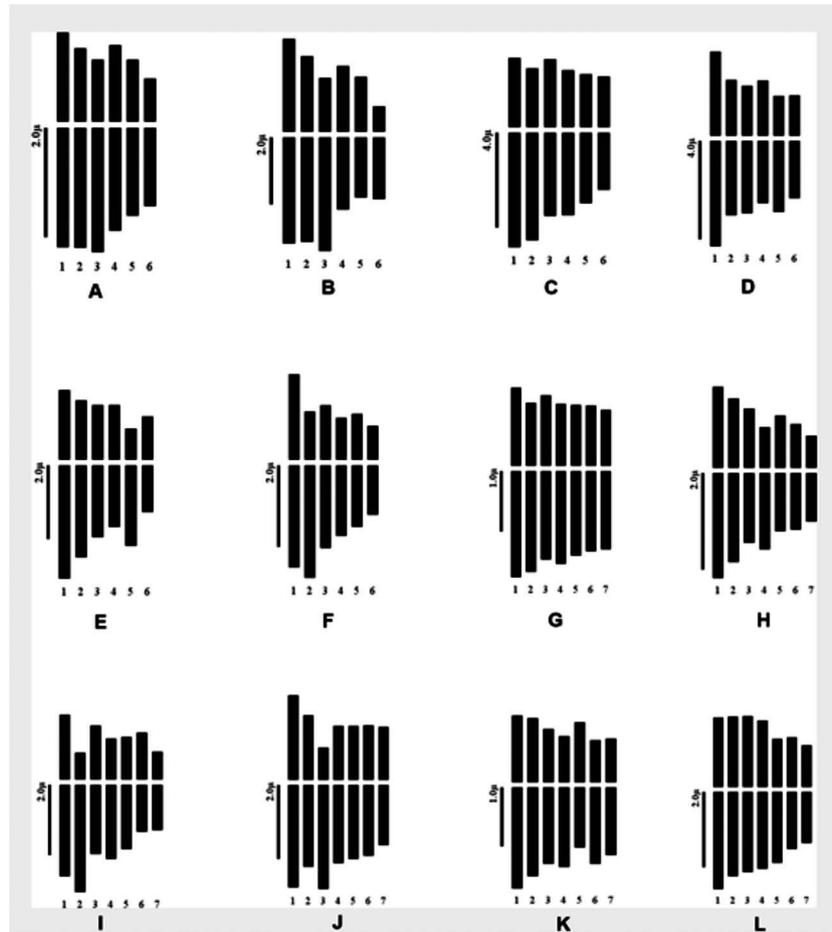
Fig. 2. Idiograms of *Matthiola* taxa. (A) *M. trojana*, (B) *M. odoratissima*, (C) *M. anchonifolia*, (D) *M. montana*, (E) *M. fruticulosa* ssp. *fruticulosa*, (F) *M. ovatifolia*, (G) *M. incana*, (H) *M. longipetala* ssp. *bicornis*, (I) *M. longipetala* ssp. *longipetala*, (J) *M. longipetala* ssp. *pumilia*, (K) *M. sinuata*, (L) *M. tricuspidata*.

Chromosome arm ratios are measured as 1.14–1.82. As a classification result, the karyotype formula is 5m+1sm. The idiogram was drawn based on centromeric index and arranged in decreasing size order (Fig. 2C).

Matthiola montana

The endemic species which propagates in the southwest region of our country and whose type specimen was collected from Malatya is typical in the hornless and flat fruit group due to its smooth leaf edges and flat and hairless fruit. The somatic chromosome number of *Matthiola montana* was determined to be 2*n*=12 (Fig. 1D). The total chromosome length is between 3.98–7.70 µm. The total length of the haploid set is 31.28 µm. Chromosome arm ratios are measured as 1.13–1.79. As a classification result, the karyotype formula is 5m+1sm. The idiogram was drawn based on centromeric index and arranged in decreasing size order (Fig. 2D).

Matthiola fruticulosa *subsp.* fruticulosa

When we evaluate the taxon in regard to having a flat fruit or not, which is a basic character in the *Matthiola* key, and also carrying a horn over 2 mm or not, it is found to be in the group with terete fruit and horn over

2 mm. However, even though the whole group consists of annual plants, this taxon is perennial with a ligneous structure. Medit Element found in the genus is one of the taxa. The somatic chromosome number of *Matthiola fruticulosa* ssp. *fruticulosa* was determined to be 2*n*=12 (Fig. 1E). The total chromosome length is between 2.44–4.94 µm. The total length of the haploid set is 21.11 µm. Chromosome arm ratios are measured as 1.07–2.60. As a classification result, the karyotype formula is 5m+1sm. The idiogram was drawn based on centromeric index and arranged in decreasing size order (Fig. 2E).

Matthiola ovatifolia

It is the taxon that was sampled in the city of Sivas in Turkey. The species *Matthiola odoritissima* is also among the synonyms. The somatic chromosome number of *Matthiola ovatifolia* was determined to be 2*n*=12 (Fig. 1F). The total chromosome length is between 2.05–4.60 µm. The total length of the haploid set is 19.34 µm. Chromosome arm ratios are measured as 1.19–2.34. As a classification result, the karyotype formula is 5m+1sm. The idiogram was drawn based on centromeric index and arranged in decreasing size order (Fig. 2F).

Matthiola incana

The taxon, which is known to be from the western-most part of our country, is typical with its glandular leaves and with seed size no more than 3 mm. The somatic chromosome number of *Matthiola incana* was determined to be 2*n*=14 (Fig. 1G). The total chromosome length is between 2.22–3.04 μm. The total length of the haploid set is 17.89 μm. Chromosome arm ratios are measured as 1.25–1.59. As a classification result, the karyotype formula is 7m. The idiogram was drawn based on centromeric index and arranged in decreasing size order (Fig. 2G).

Matthiola longipetala *subsp.* bicornis

Its propagation overlaps with that of subspecies *longipetala*, which has a broad propagation area in and around Central Anatolia. The somatic chromosome number of *Matthiola longipetala* ssp. *bicornis* was determined to be 2*n*=14 (Fig. 1H). The total chromosome length is between 1.68–3.85 μm. The total length of the haploid set is 18.31 μm. Chromosome arm ratios are measured as 1.11–1.88. As a classification result, the karyotype formula is 6m+1sm. The idiogram was drawn based on centromeric index and arranged in decreasing size order (Fig. 2H).

Matthiola longipetala *subsp.* longipetala

Fruit size, orientation and the tip and size of the horn are presented as the main features used for the differentiation of subspecies. Subspecies *longipetala*, which is similar to subspecies *bicornis* in its geographical propagation, is differentiated by the width and color of its petal lip and also by the upswept orientation of the horn. The somatic chromosome number of *Matthiola longipetala* ssp. *longipetala* was determined to be 2*n*=14 (Fig. 1I). The total chromosome length is between 2.08–4.46 μm. The total length of the haploid set is 22.84 μm. Chromosome arm ratios are measured as 1.01–4.03. As a classification result, the karyotype formula is 5m+1sm+1st. The idiogram was drawn based on centromeric index and arranged in decreasing size order (Fig. 2I).

Matthiola longipetala *subsp.* pumilio

The subspecies, which is differentiated from other subspecies with its typically small fruits and is known solely from within and near Antalya, is endemic. The somatic chromosome number of *Matthiola longipetala* ssp. *pumilio* was determined to be 2*n*=14 (Fig. 1J). The total chromosome length is between 3.05–5.08 μm. The total length of the haploid set is 26.23 μm. Chromosome arm ratios are measured as 1.14–3.21. As a classification result, the karyotype formula is 6m+1st. The idiogram was drawn based on centromeric index and arranged in decreasing size order (Fig. 2J).

Matthiola sinuata

It is the most easily identified taxon of the genus due to the presence of visible glands on the fruit. The somatic chromosome number of *Matthiola sinuata* was determined to be 2*n*=14 (Fig. 1K). The total chromosome length is between 1.88–2.83 μm. The total length of the haploid set is 15.60 μm. Chromosome arm ratios are measured as 1.00–1.84. As a classification result, the karyotype formula is 1M+4m+2sm. The idiogram was drawn based on centromeric index and arranged in decreasing size order (Fig. 2K).

Matthiola tricuspidata

The taxon, which is known from the western part of our country, is distinctly differentiated in the genus with its terete fruit and the typical presence of three equal horns in the fruit. The somatic chromosome number of *Matthiola tricuspidata* was determined to be 2*n*=14 (Fig. 1L). The total chromosome length is between 2.48–4.44 μm. The total length of the haploid set is 24.88 μm. Chromosome arm ratios are measured as 1.13–1.48. As a classification result, the karyotype formula is 7m. The idiogram was drawn based on centromeric index and arranged in decreasing size order (Fig. 2L).

We analyzed 12 taxa by PCoA (cumulative variance explained by the first two axes: 71, 9%) and PCA (cumulative variance explained by the first two axes: 76, 72%). Our results are congruent with the current systematic knowledge of the genus. According to Jaén-Molina *et al.* (2009), *Matthiola incana* was in a strongly supported (100% PP, 89% BS) sister position to a mostly Madeiran clade (100% PP, 100% BS), where the samples of *M. sinuata* were in a derived position, and *M. tricuspidata* is sister to these species. We predict that, as has been reported by Jaén-Molina *et al.* (2009), the subspecies of *M. longipetala* are in the same clad. Indeed, *Matthiola incana*, *M. sinuata* and *M. tricuspidata* are karyologically closely related species. Moreover, *M. longipetala* ssp. *bicornis* and *M. longipetala* ssp. *pumilia* are karyologically closely related species, and this is supported by available phylogeny of Jaén-Molina *et al.* (2009). As to other species, although we do not know more about phylogeny, *M. montana* and *M. anchonifolia* are karyologically similar and distinct from others. *M. ovatifolia*, *M. odoratissima* and *M. fruticulosa* ssp. *fruticulosa* show similar karyologic features (Figs. 3 and 4). Variabilities in CV_{CL}, CV_{CI} and THL values for each taxon are illustrated by the boxplots shown in Fig. 5.

Discussion

Karyotype characteristics are distinctive features in the classification of *Matthiola* taxa. The karyotype formula of the taxa *Matthiola trojana* and *M. odoratissima* is 4m+2sm, yet the chromosome morphology measurements are different as expected for the different taxa.
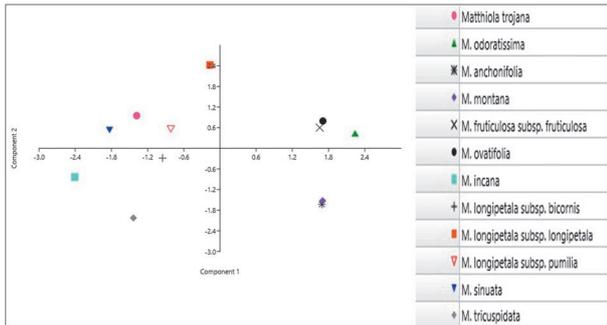
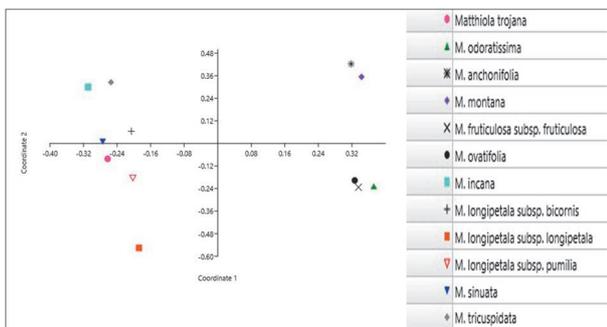**Fig. 3.** PCA for *Matthiola* based on six quantitative karyological parameters (Axis 1 *vs.* Axis 2).

Fig. 4. PCoA for *Matthiola* based on six quantitative karyological parameters (Axis 1 *vs.* Axis 2).
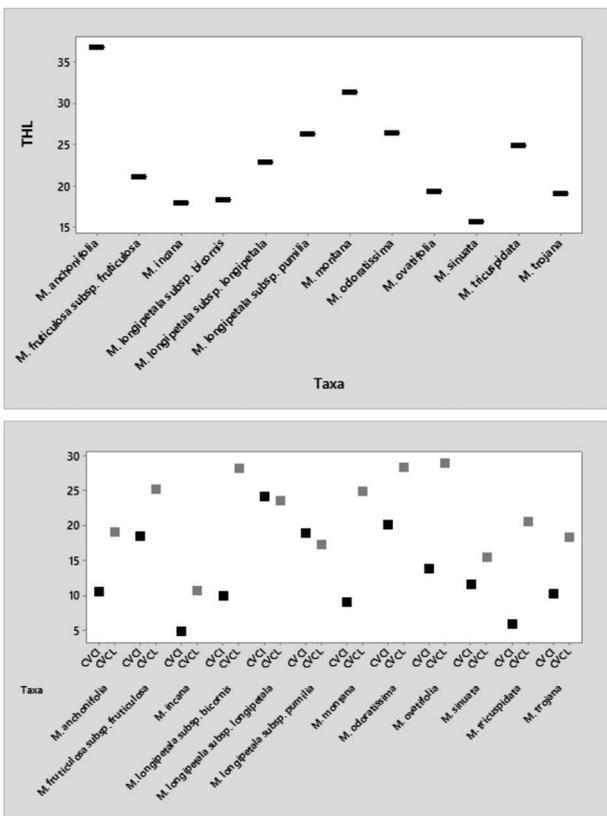

Fig. 5. Variabilities in CV$_{CL}$, CV$_{CI}$ and THL values for *Matthiola* taxa.

The calculated karyotype formula is 5m+1sm in the taxa *M. anchonifolia*, *M. montana*, *M. fruticulosa* ssp. *fruticulosa* and *M. ovatifolia*. In the *Matthiola* taxa, in which the somatic chromosome number is $2n=14$, the karyotype formula is 7m for *M. incana* and *M. tricuspidata*, whereas they are quite different from each other in the other four taxa. *Matthiola longipetala* is represented by three subspecies. The somatic chromosome number of these three subspecies is $2n=14$, but karyotype formulas are different in all three. It is 6m+1sm in *M. longipetala* ssp. *bicornis*, 5m+1sm+1st in *M. longipetala* ssp. *longipetala* and 6m+1st in *M. longipetala* ssp. *pumilio*.

Metacentric, submetacentric and subtelocentric chromosome pairs are found in the karyotype formulas of the studied taxa. Among the studied taxa, the shortest chromosome length, 1.68 μm, is observed in the taxon *Matthiola longipetala* ssp. *bicornis*. The longest chromosome length, 7.74 μm, is present in *M. anchonifolia*. The smallest value of total haploid chromosome length is seen in *M. sinuata* (15.60 μm) and the largest is seen in *M. anchonifolia* (36.80 μm). When the arm ratios were considered, *M. sinuata* had the smallest (1.00) and *M. longipetala* ssp. *longipetala* had the largest (4.03). Total length of the somatic chromosomes were measured as 2.22–3.81 μm in *M. trojana*, 2.61–5.94 μm in *M. odoratissima*, 4.56–7.74 μm in *M. anchonifolia*, 3.98–7.70 μm in *M. montana*, 2.44–4.94 μm in *M. fruticulosa* ssp. *fruticulosa*, 2.05–4.60 μm in *M. ovatifolia*, 2.22–3.04 μm in *M. incana*, 1.68–3.85 μm in *M. longipetala* ssp. *bicornis*, 2.08–4.46 μm in *M. longipetala* ssp. *longipetala*, 3.05–5.08 μm in *M. longipetala* ssp. *pumilio*, 1.88–2.83 μm in *M. sinuata* and 2.48–4.44 μm in *M. tricuspidata*. The total haploid chromosome length varies between 15.60 and 36.80 μm in all studied taxa.

Different karyotype formulas were obtained for *M. longipetala* ssp. *bicornis*, *M. longipetala* ssp. *longipetala*, and *M. longipetala* ssp. *pumilio* subspecies, although they have the same number of chromosomes. Moreover, chromosome morphology measurements were also markedly different in each subspecies. Among these studied sub-taxa, the shortest chromosome length is observed in *Matthiola longipetala* ssp. *bicornis* taxon with 1.68 μm, whereas the longest chromosome length is observed in *M. longipetala* ssp. *pumilio* taxon with 5.08 μm. The smallest value of total haploid chromosome length is seen in *M. longipetala* ssp. *bicornis* taxon (18.31 μm) and the largest is seen in *M. longipetala* ssp. *pumilio* taxon (26.23 μm). Considering the arm ratios, *M. longipetala* ssp. *longipetala* taxon has the smallest (1.01) and *M. longipetala* ssp. *longipetala* taxon has the largest (4.03). The total length of somatic chromosomes was measured as 1.68–1.81 μm in *M. longipetala* ssp. *bicornis*, 2.08–4.46 μm in *M. longipetala* ssp. *longipetala* and 3.05–5.08 μm in *M. longipetala* ssp. *pumilio*.

Cytogenetic studies aiming to determine the chromosome numbers in taxa belonging to *Matthiola* genus are presented in Table 4.

Somatic chromosome numbers of *Matthiola fruticulosa* (L.) Maire and *M. fruticulosa* ssp. *perennis* P. W. Ball are 2*n*=12, whereas that of *M. fruticulosa* ssp. *valesiaca* P. W. Ball subspecies is 2*n*=12 and 24 (Djerdjour and Guittonneau 1977, Ančev 1981, Strid and Franzen 1981, Polatschek 1983, Papanicolaou 1984, Tammaro 1985, Izuzquiza 1989). Previous studies have reported the presence of polyploidy in ssp. *valesiaca*. In our country, *Matthiola fruticulosa* species is known as a subspecies as *M. fruticulosa* ssp. *fruticulosa*. Taking the findings we obtained into account, the somatic chromosome number of this subspecies is 2*n*=12, which is consistent with the literature.

Diploid chromosome number of *Matthiola incana* (L.) W. T. Aiton, *M. incana* ssp. *incana*, *M. incana* ssp. *pulchella* (Tineo ex Guss.) Brullo & F. Furnari taxa were reported as 2*n*=14 (Tiniakou 1996, Lan *et al.* 1999). While sub-taxa of the species *Matthiola incana* are not found in our country, the diploid chromosome number is 2*n*=14, consistent with the literature.

Somatic chromosome numbers of *Matthiola longipetala* (Vent.) DC., *M. longipetala* ssp. *bicornis* (Sibth. & Sm.) P. W. Ball, and *M. longipetala* ssp. *pumilio* P. W. Ball are reported to be the same, 2*n*=14 (Maassoumi 1980, Al-Shehbaz and Al-Omar 1982, 1983, Ghaffari 1988, 2006, Tiniakou 1996). The chromosome numbers of the three sub-taxa of *Matthiola longipetala*, which were studied in our research, are in parallel with the literature.

Matthiola odoratissima R.Br. was reported to have the chromosome number 2*n*=12 by two different studies performed in 1981 and 1984 by two different researchers (Ančev 1981, Magulaev 1984). We obtained the same result for this species, which naturally grows in our country.

The species *Matthiola ovatifolia* Boiss. was reported to have the chromosome number 2*n*=12 by different cytologic studies performed in different years (Maassoumi 1980, Soliman and Parker 1986). The chromosome number obtained in this study is consistent with these literature reports.

The species *Matthiola sinuata* R.Br. was reported to have the chromosome number 2*n*=14 by different cytologic studies performed in different years (Montmollin 1986, Tiniakou 1996, Runemark 2000). The chromosome number obtained in this study is consistent with these literature reports.

Two different numbers of somatic chromosomes (2*n*=14 and 16) have been reported for *Matthiola tricus-*

Table 4. Some cytogenetic studies in the genus *Matthiola*.

Taxon	Chromosome number (2*n*)	References
M. afghanica Rech. fil. & Koie	12	Khosravi and Maassoumi 1998
M. alyssifolia Bornm.	14	Khosravi and Maassoumi 1998
M. aspera Boiss.	14	Díaz Lifante *et al.* 1992
M. bicornis (Sibth. & Sm.) DC.	14	Soliman and Parker 1986
M. carnica Tammaro	12	Tammaro 1985
M. caspica Grossh.	12	Magulaev 1984
M. daghestanica N. Busch	12	Magulaev 1984
M. farinosa Bunge ex Boiss.	12	Maassoumi 1980
M. flavida Boiss.	12	Khatoon and Ali 1993
M. fruticulosa (L.) Maire	12	Tammaro 1985, Ančev 1981, Djerdjour and Guittonneau 1977
M. fruticulosa ssp. *perennis* P. W. Ball	12	Polatschek 1983
M. fruticulosa ssp. *valesiaca* P. W. Ball	12, 24	Izuzquiza 1989, Papanicolaou 1984, Strid and Franzen 1981
M. incana (L.) W. T. Aiton	14	Lan *et al.* 1999
M. incana (L.) W. T. Aiton ssp. *incana*	14	Tiniakou 1996
M. italica Tammaro	12	Tammaro 1985
M. longipetala (Vent.) DC.	14	Al-Shehbaz and Al-Omar 1982, Al-Shehbaz and Al-Omar 1983, Ghaffari 1988, Maassoumi 1980
M. longipetala ssp. *bicornis* (Sibth. & Sm.) P. W. Ball	14	Ghaffari 2006
M. longipetala ssp. *pumilio* P. W. Ball	14	Tiniakou 1996
M. lunata DC.	10, 11, 26	Soliman and Parker 1986, Djerdjour and Guittonneau 1977
M. maderensis Lowe	14	Soliman and Parker 1986
M. maroccana Coss.	14	Soliman and Parker 1986
M. odoratissima R.Br.	12	Magulaev 1984, Ančev 1981
M. ovatifolia Boiss.	12	Soliman and Parker 1986, Maassoumi 1980
M. perennis Conti	12	Galland 1984, Galland 1988
M. revoluta Bunge ex Boiss.	12	Maassoumi 1980
M.sinuata R.Br.	14	Montmollin 1986, Tiniakou 1996, Runemark 2000
M. tenera Rech. f.	12	Polatschek 1983
M. tricuspidata (L.) R.Br.	14, 16	Brullo and Pavone 1977, Runemark 2000
M. valesiaca Boiss.	12	Tammaro 1985
M. valesiaca var. *pedemontana* Gremli	12	Tammaro 1985

pidata (L.) R.Br. (Brullo and Pavone 1977, Runemark 2000). This species, which grows in our country as well, was determined to have only $2n=14$ chromosomes in this study, unlike these literature reports.

We believe that identification of chromosome numbers of the taxa in *Matthiola* genus will light the way for the further studies to be performed on this topic. Since *Matthiola* is used as a decoration plant, the results will facilitate reclamation studies of this species. In this sense, the lack of information regarding karyotype for this genus has been addressed.

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