

Taylor & Francis
Taylor & Francis Group

Caryologia

International Journal of Cytology, Cytosystematics and Cytogenetics

ISSN: 0008-7114 (Print) 2165-5391 (Online) Journal homepage: https://www.tandfonline.com/loi/tcar20

Karyomorphological studies on section *Bucerates* Boiss. of *Trigonella* L. (Leguminosae) from Turkey

Martin Esra , Hasan Akan , Murat Ekici & Zeki Aytaç

To cite this article: Martin Esra , Hasan Akan , Murat Ekici & Zeki Aytaç (2008) Karyomorphological studies on section *Bucerates* Boiss. of *Trigonella* L. (Leguminosae) from Turkey, Caryologia, 61:3, 225-236, DOI: 10.1080/00087114.2008.10589634

To link to this article: https://doi.org/10.1080/00087114.2008.10589634

Published online: 04 Feb 2014.

Submit your article to this journal

Article views: 156

View related articles

Citing articles: 8 View citing articles

Full Terms & Conditions of access and use can be found at
https://www.tandfonline.com/action/journalInformation?journalCode=tcar20

CARYOLOGIA Vol. 61, no. 3: 225-236, 2008

Karyomorphological studies on section *Bucerates* Boiss. of *Trigonella* L. (Leguminosae) from Turkey

Martin[1] Esra, Hasan Akan[2*], Murat Ekici[3] and Zeki Aytaç[3]

[1] Selçuk University, Education Faculty, Department of Biology Education, Konya, Turkey.
[2] Harran University, Faculty of Science and Arts, Department of Biology,Şanlıurfa, Turkey.
[3] Gazi University, Faculty of Science and Arts, Department of Biology, Ankara, Turkey.

Abstract — The Karyomorphology of all taxa of section *Bucerates* Boiss. genus *Trigonella* L. (Leguminosae) were made using Image Analysis System. The chromosome numbers of 14 taxa of *Trigonella* (2*n*=16), *T. fischeriana* Ser. and *T. monantha* C.A.Meyer subsp. *noeana* (Boiss.) Hub.-Mor. (2*n*=14), *T. monantha* C.A.Meyer subsp. *monantha* Verz. (2*n*=16, 28, 30) and *T. orthoceras* Kar. & Kir. (2*n*=16, 46) were counted. B chromosomes were observed on *T. arcuata* C.A.Meyer. and there were two chromosomes with a satellite in *T. crassipes* Boiss. In the section *Bucerates*, 12 taxa of *Trigonella* showed tetraploidy, with 2*n*=32 and two taxa of *Trigonella* had hexaploidy (2*n*=48). The range of chromosome length ranged from 3.26 µm to 0.56 µm. Whereas *T. orthoceras* had the longest chromosome length, *T. monantha* subsp. *monantha* had shortest.

Key words: *Bucerates*, *Fabaceae*, Image Analysis System, karyotype, *Trigonella*, Turkey.

INTRODUCTION

Trigonella L. (Leguminosae) is represented worldwide with about 100 species. In Turkey there are 13 sections and 50 taxa localized in different phytogeographical regions. The taxa number of the genus endemic in Turkey is 21, with a 42 % endemism (Davis *et al*. 1970; Akan *et al*. 2005; Akan *et al*. Unpl. data 2006).

Bucerates Boiss. section of *Trigonella* in Turkey is represented with 14 endemic species and 2 subspecies. The phytogeographical distribution of the members of the section is as follows: 10 taxa in the Irano-Turanian and 6 taxa in the East Mediterranean region. The morphological characteristics of section *Bucerates* is as follows; annual, stipules at least in part dentate or incised, keel and wings tightly joined, and the legumes are erect or spreading, linear, reticulate or transversely-nerved, and their sutures thickened.

There are some previous studies focusing on the *Trigonella* species (Small *et al*. 1981; Brookes and Small 1988; Small *et al*. 1990; Alhabori *et al*. 1998; Pandita *et al*. 1999; Murakami *et al*. 2000; Kabilan *et al*. 2002). The cytological information of *Trigonella* consists of chromosome counts of approximately hundred species. Chromosome numbers of some taxa belonging to the section were determined previously (Darlington and Wylie 1955; Bidak and Amin, 1996; Martin *et al*. 2006a; Yilmaz, Unpl. data, 2006).

Except *T. fischeriana* and *T. astroites*, the chromosome numbers and karyotypes of *Bucerates* section are presented here for the first time. The significance of the results is discussed with regard to their systematic position and their relationship among each of these taxa.

MATERIAL AND METHODS

All the material investigated was collected from different part of Turkey, as given in Table 1. Voucher accessions have been deposited at the herbarium of Gazi University (GAZI) and Harran University.

Karyological studies were conducted with metaphase cells obtained from the root tips of germinated mature seeds. The root tips' pretreatment was conducted in α-monobromonaphthalene for 16 hours; afterwards they were fixed in Carnoy for 24 hours; their hydrolysis was done in 1N HCl for 13 minutes at room temperature and staining with 2 % aceto-orcein for 2 hours. The karyotype analyses were conducted as described by Martin *et al*. 2006b.

* Corresponding author: e-mail: hakan@harran.edu.tr

Table 1 — The localities, collector and chromosome numbers of *Trigonella* specimens studied karyologically.

Taxon	2*n*	Ploidy level	Localities	Collector and no
T. aurantiaca	16	4*x* = 32	Burdur	H.Akan 5753 & M.Ekici
T. arenicola	16	4*x* = 32	Antalya	H.Akan 3311 & M.Ekici
T. fischeriana	14	4*x* = 28	Kayseri	H.Akan 3654, Z.Aytaç & M.Ekici
T. tenuis	16	6*x* = 48	Kars	H.Akan 3742, Z.Aytaç & M.Ekici
T. cancellata	16	4*x* = 32	Ağrı	H.Akan 3757, Z.Aytaç & M.Ekici
T. astroites	16		Kayseri	H.Akan 3771 & M.Ekici
T. halophila	16	4*x* = 32	Mersin	H.Akan 3279 & M.Ekici
T. crassipes	16	4*x* = 32	Antalya	H.Akan 3325 & M.Ekici
T. polycarpa	16	4*x* = 32	Antalya	H.Akan 5658 & M.Ekici
T. rigida	16		Adana	H.Akan 4683 & M.Ekici
T. pamphylica	16		Antalya	H.Akan 5764 & M.Ekici
T. carica	16	4*x* = 32	Muğla	H.Akan 3366 & M.Ekici
T. arcuata	16A+2B	4*x* = 32	Kayseri	H.Akan 3723, Z.Aytaç & M.Ekici
T. monantha subsp. *monantha*	16		Antalya	H.Akan 3656, Z.Aytaç & M.Ekici
	28			
	30	4*x* = 32	Şanlıurfa	MNM 1061
			Kayseri	
				H.Akan 3356, Z.Aytaç & M.Ekici
T. monantha subsp. *noeana*	14	4*x* = 32,	Şanlıurfa	H.Akan 3207 & M.Ekici
		6*x* = 48		
T. orthoceras	16		Kars	H.Akan 3746, Z.Aytaç & M.Ekici
	46	4*x* = 32		
			Kayseri	H.Akan 3658, Z.Aytaç & M.Ekici

RESULTS

The chromosome numbers and morphology of 16 taxa of *Trigonella* from Turkey belonging to section (*Bucerates*) are studied. Out of these 16 taxa, 12 are studied for the first time (except *T. fischeriana* and *T. astroites*). In the section *Bucerates*, the chromosome numbers varied among the taxa. There were polyploid in 13 taxa (Table 1, Fig. 1-19).

Diploid chromosome numbers, chromosome sizes, karyotype formula, satellite presences, basic chromosome numbers and B chromosomes of the sixteen taxa of section *Bucerates* studies are given in Table 2. The asterisk in Table 2 indicates the taxa with a pair of satellites.

Section *Bucerates* Boiss

Trigonella aurantiaca Boiss. - C2 Burdur: Gölhisar-Altınyayla 12. km, 29.06.2005, 1275 m, forest clearings, *H.Akan* 5753 *& M.Ekici.* This species is Irano-Turanian Element (Ir.-Tur.) and IUCN category is LC. Habitat and altitude: Stony slopes, limestone steppe, clearances, gardens, road sides, oak woods, forest clearances, 50-1600 m. Distribution areas: Turkey, Syria, Iraq and Iran. Similarity with *T. fischeriana* is significant but the sutures on the fruits are not wavy but plain. This is the first report on the chromosome number and morphology of this species. Mitotic chromosome number is 2*n*=16 (Fig. 1). The chromosome lengths range between 1.40 - 2.08 µm. Six chromosome pairs are metacentric and two are submetacentric. The total haploid chromosome length is 13.54 µm (Table 2). The idiogram of this taxon is given in Fig. 20.

Trigonella arenicola Hub.-Mor. - C3 Antalya: Lara, 22.05.2002, 5 m, sands, *H.Akan* 3311 *& M.Ekici.* It is endemic to Turkey, East Mediterranean Element (E. Medit. el.) and IUCN category is CR. Habitat and altitude: Sands, 0-10 m. Distribution areas: Turkey, a species localized in the south west Anatolia, among the narrow endemics. The chromosome number of *T. arenicola* is 2*n*=16. Besides there is tetraploidy in this species (Fig. 2). There are five metacentric and three submetacentric chromosomes. Chromosomes range from 0.64 to 1.14 µm. The total haploid chromosome length is 6.83 µm (Table 2). The idiogram of this taxon is given in Fig. 20.

Trigonella fischeriana Ser. - B5 Kayseri: Ali Mountain, East slopes, 08.07.2002, 1300 m, roadside, *H.Akan* 3654, *Z.Aytaç & M.Ekici.* It is Irano-Turanian Element (Ir.-Tur.) and IUCN category is LC. Habitat and altitude: Stony slopes, steppe,

clearances, road sides and oak groves, 500-2000 m. Distribution areas: Turkey, Russia and Trans Caucasia. No significant characteristics accept the undulate areas on the sutures of its fruits. The mitotic metaphase chromosome number and karyotype formula are $2n$=14=7m (Fig. 3). The basic chromosome number is x=7. This species is apparently diploid; however, the accession $4x$=28 may be tetraploid based on x=7. Chromosomes lengths vary from 0.79 to 1.67 µm. The total haploid chromosome length is 7.81 µm (Table 2). The idiogram of this taxon is given in Fig. 20.

Trigonella tenuis Fisch. - A9 Kars: Kağızman-Cumaçay 26. km, 14.07.2002, 1800 m, meadows, *H.Akan* 3742, *Z.Aytaç & M.Ekici.* It is Irano-Turanian Element (Ir.-Tur.) and IUCN category is LC. Habitat and altitude: Stony slopes, steppe, forest clearings, oak groves and road sides, 300-1500 m. Distribution areas: Turkey, Balkans, Crimea, S Russia and Caucasia. The diploid chromosome number is $2n$=16 (Fig. 4). The metaphase karyotype comprises three metacentric and five submetacentric chromosomes. The basic chromosome number is x=8. The level of ploidy, $6x$=48, is similar to the other members. Chromosomes length range from 1.79 to 2.87 µm. The total haploid chromosome length is 17.69 µm (Table 2). The idiogram of this taxon, studied for the first time in the present study, is given in Fig. 20.

Trigonella cancellata Desf. - B10 Aˇgrı: Doˇgubeyazıt-Çaldıran 20. km, 14.07.2002, 1350 m, steppe, *H.Akan* 3757, *Z.Aytaç & M.Ekici.* It is Irano-Turanian Element (Ir.-Tur.) and IUCN category is CR. Habitat and altitude: Stony areas, steppe, and 1250-2250 m. Distribution areas: Turkey, S Russia, Caucasia, N Iran, Transcaspia and Turkistan. The natural dispersion of this taxon is in Turkey only in the eastern Anatolia. The closest taxon is *T. tenuis*. Since the amount of flowers of *T. cancellata'* is more than *T. tenuis* (4-5, rarely 8) and its peduncle is longer (1-3 cm) it can easily be differentiated. This is the first chromosome count and morphology-study of this species. The somatic chromosome number is $2n$=16 (Fig. 5). The basic chromosome number is x=8. Seven chromosome pairs are metacentric and one is submetacentric. The level of ploidy is similar to other members, with $4x$=32. Chromosomes lengths range from 0.83 to 1.30 µm. The total haploid chromosome length is 8.19 µm (Table 2). The idiogram of this taxon is given in Fig. 20.

Trigonella astroites Fisch. & Mey. - B5 Kayseri: Kayseri-Ürgüp, 29. km, 16.08.2002, 1180 m,

Table 2 — Comparison of the chromosomes of the sixteen *Trigonella* taxa examined (AR: arm ratio; CI: centromeric index; THC: total length of haploid complement; M: metacentric; SM: submetacentric; X: chromosome basic number, * a pair of satellites seen in the chromosome pairs are marked with an asterisk).

Taxon	Chromosome numbers ($2n$)	Chromosome sizes (µm)	AR	CI	THC (∝m)	M	SM	X
T. aurantiaca	16	1.40-2.08	1.50	6.79	13.54	6	2	8
T. arenicola	16	0.64-1.14	1.68	4.87	6.83	5	3	8
T. fischeriana	14	0.79-1.67	1.37	6.00	7.81	7	-	7
T. tenuis	16	1.79-2.87	1.67	4.73	17.69	3	5	8
T. cancellata	16	0.83-1.30	1.36	5.40	8.19	7	1	8
T. astroites	16	0.74-1.24	1.28	5.50	7.40	8	-	8
T. halophila	16	0.73-1.27	1.25	5.60	8.52	8	-	8
*T. crassipes**	16	1.31-1.83	1.30	5.50	12.25	7	1	8
T. polycarpa	16	1.53-2.44	1.62	4.84	15.30	6	2	8
T. rigida	16	0.93-1.59	1.23	5.61	9.23	8	-	8
T.pamphylica	16	1.56-2.71	1.27	5.51	16.28	8	-	8
T. carica	16	0.82-1.26	1.40	5.30	8.08	7	1	8
T. arcuata	16+2B	0.62-1.12	1.40	5.24	6.39	6	2	8
T. monantha subsp. *monantha*	16	0.61-1.14	1.69	4.81	6.32	4	4	8
	28	1.32-3.26	1.35	3.14	25.19	13	1	-
	30	0.56-0.96	1.20	3.04	11.71	15	-	-
T. monantha subsp. *noeana*	14	1.57-2.65	1.71	5.38	14.72	4	3	7
T.orthoceras	16	0.59-1.08	1.31	5.50	6.16	7	1	8
	46	-	-	-	-	-	-	-

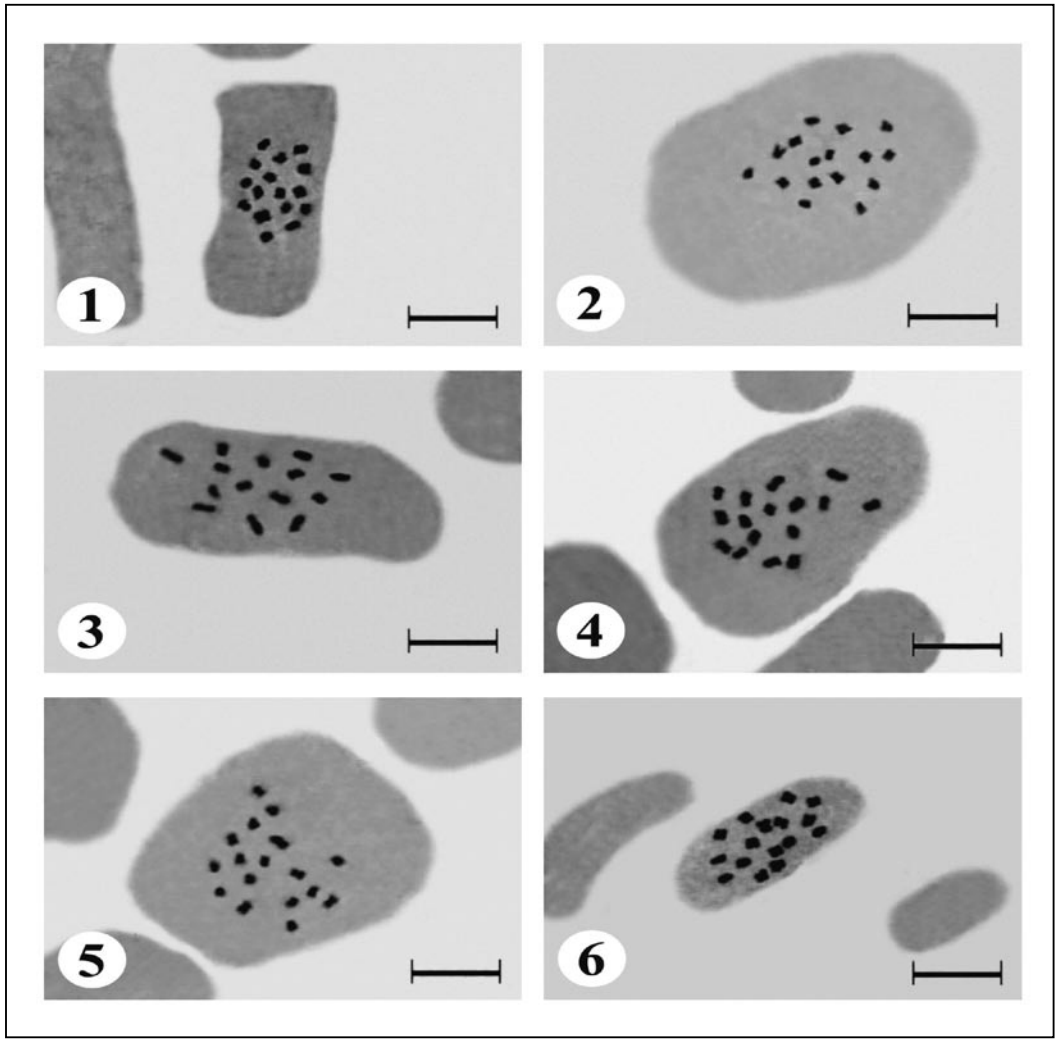


Fig. 1-6 — (1). *Trigonella aurantiaca* (2n=16), (2). *T. arenicola* (2n=16), (3). *T. fischeriana* (2n=14), (4). *T. tenuis* (2n=16), (5). *T. cancellata* (2n=16), (6). *T. astroites* (2n=16), Scale Bar: 10 µm.

roadside, *H.Akan* 3771 *& M.Ekici.* It is Irano-Turanian Element (Ir.-Tur.) and IUCN category is LC. Habitat and altitude: Slopes, steppes, forest clearings, 0-1750 m. Distribution areas: Turkey, Syria desert, Anti-Lebanon, Palestrina, Trans Caucasia, N Iraq and N Iran. It is among the ones with the highest population of *Trigonella* species. The somatic chromosome number and morphology is 2*n*=16=8m (Fig. 6). The basic chromosome number is *x*=8. Chromosomes lengths range from 0.74 to 1.24 µm. The total haploid chromosome length is 7.40 µm (Table 2). The idiogram of this taxon is given in Fig. 20.

Trigonella halophila Boiss. - C5 Mersin: Mersin-Egemen, 21.05.2002, 50 m, sandy hills, *H.Akan* 3279 & *M.Ekici.* It is endemic to Turkey, distributed only in the south of Mersin province. It is East Mediterranean Element (E. Medit. el.) and IUCN category is CR. Habitat and altitude: Seaside sandy areas, 0-50 m. Distribution areas: Turkey. It is among the endemic species disperses narrowly of southern Anatolia. Its morphological closeness to *T. astroites* is significant. The habitat of *T. halophila* is the salty-sandy and thus different form *T. astroites*. This is the first chromosome number and morphology for this species are determined as 2*n*=16=8m (Fig. 7). The basic chromosome number is *x*=8. In addition, tetraploid cells have been observed. Chromosomes lengths vary from 0.73 to 1.27 µm. The total haploid chromosome length is 8.52 µm (Table 2). The idiogram of this taxon is given in Fig. 20.

Trigonella crassipes Boiss. - C3 Antalya: Antalya-Hafizpa¸sa, 23.05.2002, 750 m, maqius, *H.Akan* 3325 *& M.Ekici*. It is Irano-Turanian Element (Ir.-Tur.) and IUCN category is LC. Habitat and altitude: Maquis, pine forest clearings, empty plains, 600-1700 m. Distribution areas: Turkey, Anti-Lebanon, N Iraq and W Iran. It is among the species with the widest spread population in Turkey. The chromosome number and morphology of this species, studied for the first time, is $2n$=16=7m+1sm (Fig. 8). The basic chromosome number is x=8 and there are two pairs of satellite mitotic metaphases. There are also some tetraploid cells. Chromosome sizes vary from 1.31 to 1.83 µm. The total haploid chromosome length is 12.25 µm (Table 2). The idiogram of this taxon is given in Fig. 20.

Trigonella polycarpa Boiss. & Heldr. - C3 Antalya: Antalya-Lara, 07.05.2005, 5 m, sands, *H.Akan* 5658 *& M.Ekici*. It is endemic to Turkey, East Mediterranean Element (E. Medit. el.) and IUCN category is CR. Habitat and altitude: Shore, sandy areas, pebbled areas, pine forest clearings, 0-50 m. Distribution areas: Turkey. Its one of the endemic taxon of this species spread narrowly. It is generally located at southern Anatolia. It is one of the well known species. Though significant for its resemblance with *T.arenicola*, it can easily be separated due to higher number of flowers and longer peduncle.

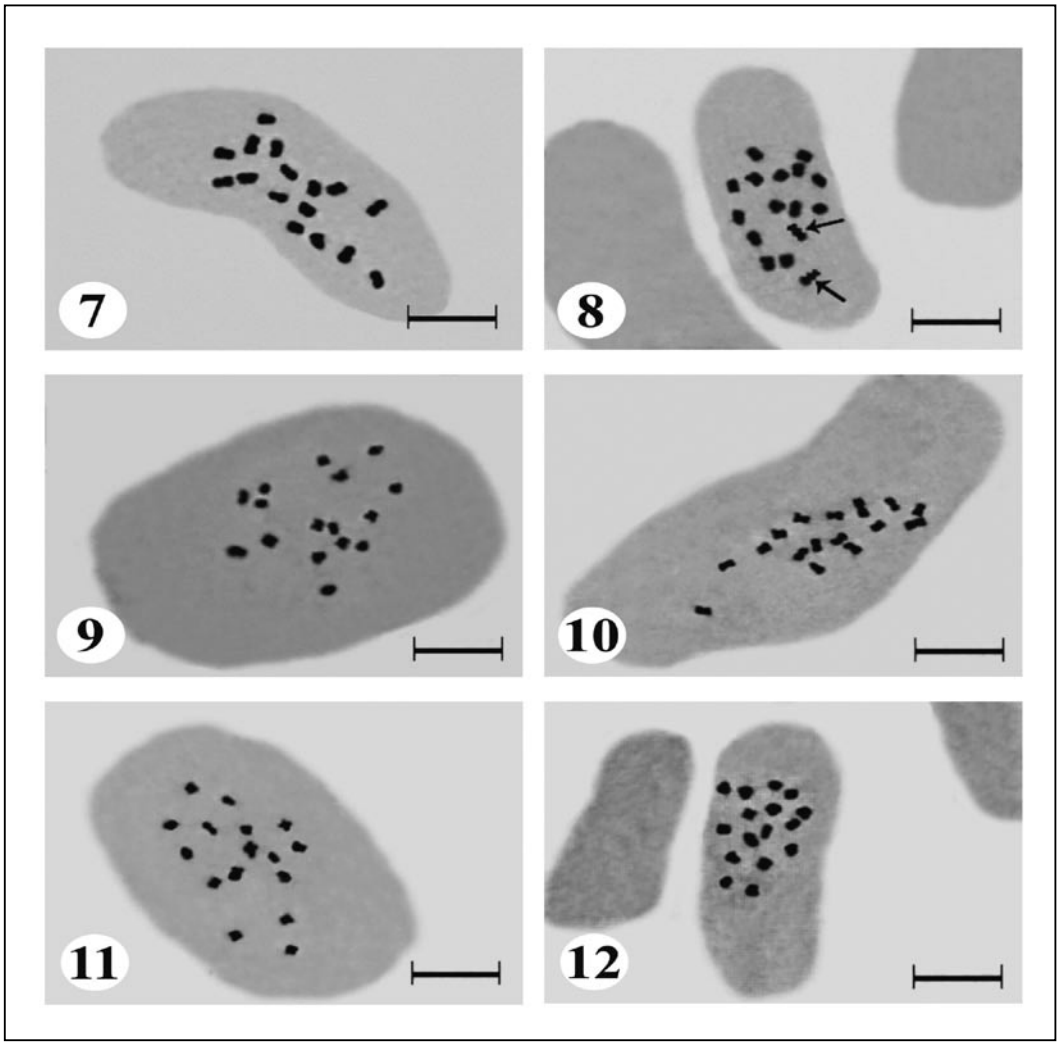


Fig. 7-12 — (7). *T. halophila* (2n=16), (8). *T. crassipes* (2n=16), (9). *T. polycarpa* (2n=16), (10). *T. rigida* (2n=16), (11). *T. pamphylica* (2n=16), (12). *T. carica* (2n=16), Scale Bar: 10 µm.

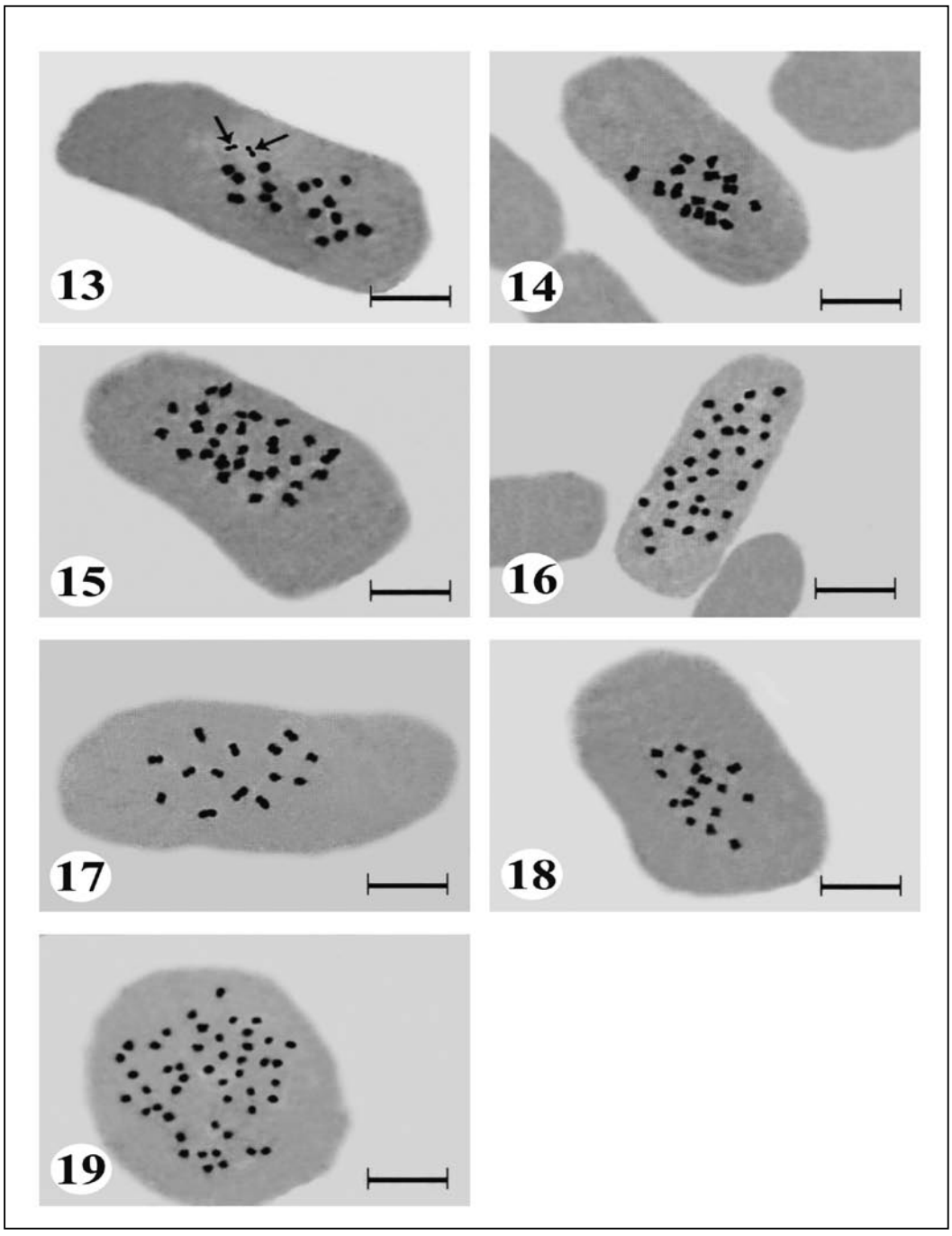


Fig. 13-19 — (13). *T. arcuata* (2*n*=16), (14-16). *T. monantha* subsp. *monantha* (2*n*=16, 28, 30), (17). *T. monantha* subsp. *noeana* (2*n*=14), (18-19). *T. orthoceras* (2*n*=16, 46), Scale Bar: 10 µm.

The chromosome number and morphology of this Turkish species, studied for the first time, is 2*n*=16 =6m+2sm (Fig. 9). The basic chromosome number is *x*=8 and there are tetraploidy in the somatic chromosomes of this taxon. Chromosomes lengths vary from 1.53 to 2.44 µm. The total haploid chromosome length is 15.30 µm (Table 2). The idiogram of this taxon is given in Fig. 20.

Trigonella rigida Boiss. & Bal.- C6 Adana: Pozantı-Çiftehan 8. km, 08.06.2003, 852 m, stony slopes, *H.Akan* 4683 *& M.Ekici.* It endemic to Turkey, East Mediterranean Element (E. Medit. el.) and

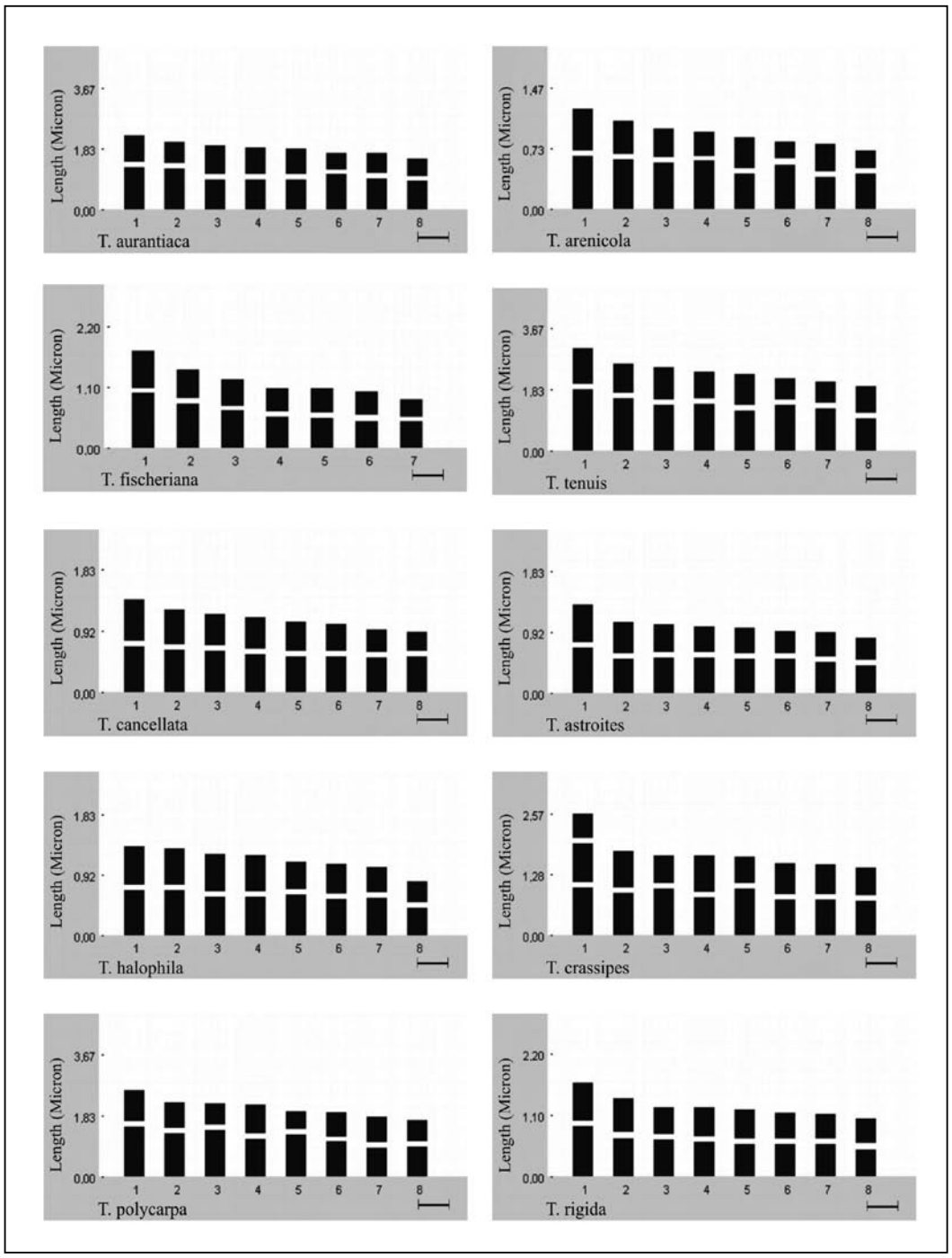


Fig. 20 — Haploid idiograms in taxa belonging to section *Bucerates.*

IUCN category is LC. Habitat and altitude: Calcareous stone hedges, sandy river beds, 120-900 m. Distribution areas: Turkey. This taxon, close to *T. crassipes,* can be easily differentiated for its shorter neck. This is the first report on the chromosome number and morphology of this species. The diploid chromosome number is $2n$=16 =8m (Fig.10). The basic chromosome number is x=8. Chromosomes lengths are from 0.93 to 1.59 µm. The total haploid chromosome length is 9.23 µm (Table 2). The idiogram of this taxon is given in Fig. 20.

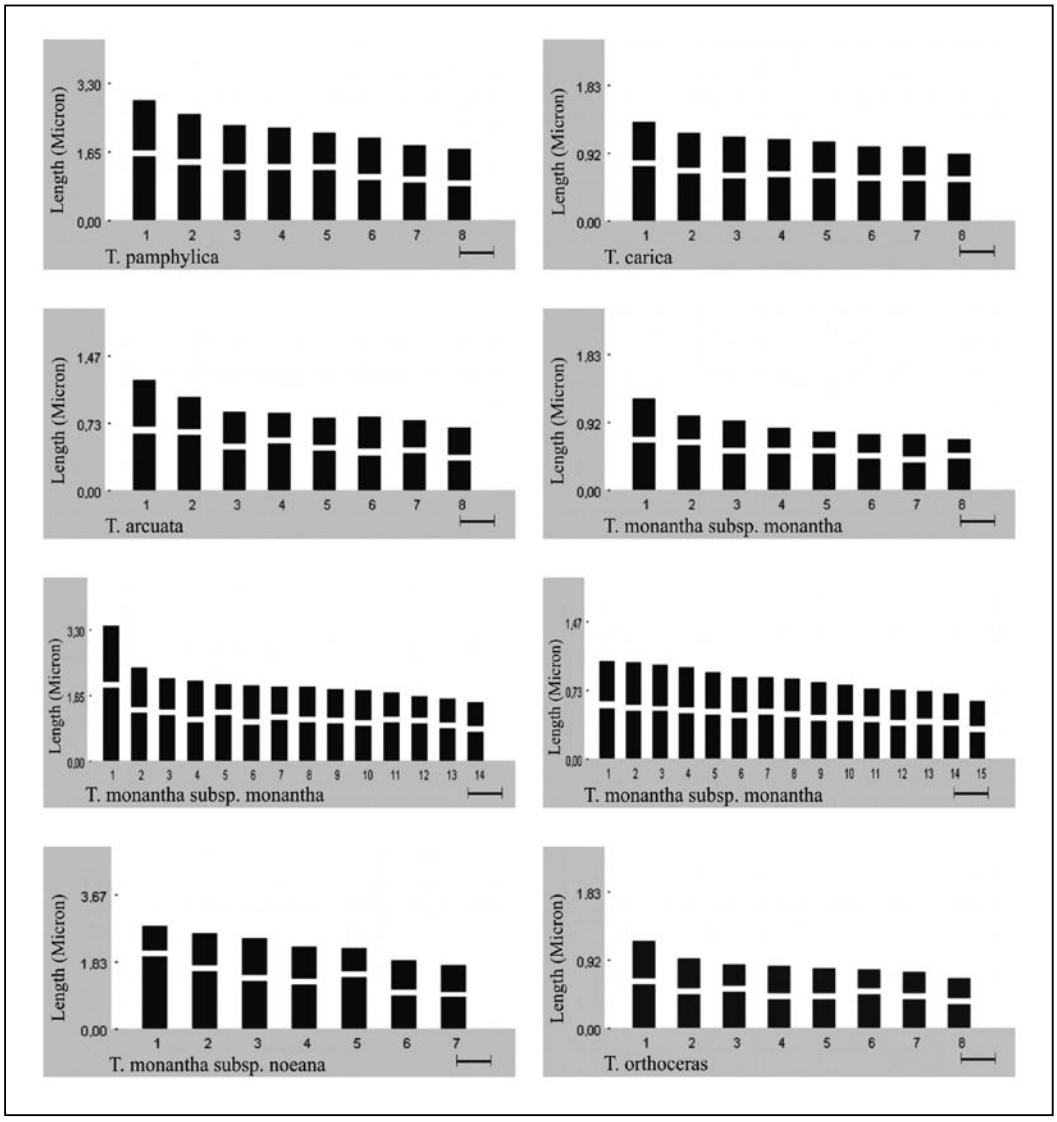


Fig. 21 — Haploid idiograms in taxa belonging to section *Bucerates.*

Trigonella pamphylica Hub.-Mor. & Sirj. - C4 Antalya: Akseki-Seydişehir 10. km, 30.06.2005, 1200 m, *Pinus brutia* clearings, *H.Akan* 5764 & *M.Ekici*. The species is East Mediterranean Element (E. Medit. el.) and IUCN category is VU. Habitat and altitude: Maquis, fir tree forest clearings, 800-1500 m. Distribution areas: Turkey. It is an endemic species only spread in Antalya. The present study determined for the first time the chromosome number and morphology as $2n$=16=8m of this species (Fig.11). The basic chromosome number is x=8. Chromosome lengths vary from 1.56 to 2.71 µm. The total haploid chromosome length is 16.28 µm (Table 2). The idiogram of this taxon is given in Fig. 21.

Trigonella carica Hub.-Mor. - C2 Muğla: Marmaris, ˙Ini¸sdibi district, 24.05.2002, 200 m, maqius, *H.Akan* 3366 & *M.Ekici.* It endemic of Turkey, East Mediterranean Element (E. Medit. el.) and IUCN category is NT. Habitat and altitude: Calcareous stone slopes, maquis, 0-1250 m. Distribution areas: Turkey. It is located mostly in the regions of Mu˘gla and Antalya. This is the first report on the chromosome number and morphology of this species. The somatic chromosome number and karyotype formula is $2n$=16=7m+1sm (Fig. 12). The basic

chromosome number is x=8 and the ploidy level is (4x). Chromosomes sizes vary from 0.82 to 1.26 µm. The total haploid chromosome length is 8.08 µm (Table 2). The idiogram of this taxon is given in Fig. 21.

Trigonella arcuata C.A. Meyer - B6 Kayseri: Kayseri-Hisarcık road, 08.07.2002, 1250 m, roadside, *H.Akan* 3723, *Z.Aytaç & M.Ekici.* It is Irano-Turanian Element (Ir.-Tur.) and IUCN category is NT. Habitat and altitude: Steppe, river sides, 900-1950 m. Distribution areas: Turkey, S Russia, Caucasia, Iran and Middle Asia. It is a species only spread in eastern Anatolia and has a good population in its location. This is the first report on the chromosome number and morphology of this species. The mitotic chromosome number is 2n=16 (Figure 13). The basic chromosome number is x=8. There are 2B chromosomes in some cells. The presence of B chromosome in the genus is unusual because there are rare evidences in the literature. The chromosome lengths range from 0.62 to 1.12 µm. Six chromosome pairs are metacentric and two are submetacentric. The total haploid chromosome length is 6.39 µm (Table 2). The idiogram of this taxon is given in Fig. 21.

Trigonella monantha C.A. Meyer subsp. *monantha* Verz. - C3 Antalya: Antalya-Kalkan, 24.05.2002, 20 m, maqius, *H.Akan* 3356, *Z.Aytaç & M.Ekici,* C7 Şanlıurfa: Şanlıurfa-Bozova, exit of Tektaş village, 13.05.2006, 720 m, fieldside, *MNM* 1061, B5 Kayseri: Ali Mountain, NW foots, 08.07.2002, 1350 m, in the opening of *Quercus*, *H.Akan* 3656, *Z.Aytaç & M.Ekici*. It is Irano-Turanian Element (Ir.-Tur.) and IUCN category is LC. Habitat and altitude: Steppe, slopes, agricultural areas, 300-1850 m. Distribution areas: Turkey, N Iraq and Syria desert, Lebanon, Palestine, Iran and Trans Caucasia. In this study, three different localities have been studied. The count of somatic chromosome numbers for this subspecies have been determined as 2n=16, 28 and 30 (Fig. 14-16). The accessions that have been gathered from Antalya province have a diploid chromosome number of 2n=16 and the karyotype formula is 4m+4sm. The chromosome lengths vary from 0.61 to 1.14 µm and the total haploid chromosome length is 6.32 µm (Table 2). However, the accessions that have been collected from Şanlıurfa province have 2n=28 somatic chromosome number and the karyotype formula is 13m+1sm. Chromosome lengths are varying from 1.32 to 3.26 µm, and the total haploid chromosome length is 25.19 µm (Table 2). On the other hand, the accessions from Ali mountain, province of Kayseri, have mitotic metaphase chromosome number of 2n=30 and all pairs are metacentric. Chromosome lengths are varying between 0.56 and 0.96 µm and the total haploid chromosome length is 11.71 µm (Table 2). Among all chromosome pairs from these three different localities, only this one, (Antalya province) has tetraploidy (4x=32) (Table 2). The idiogram of subspecies are given in Fig. 21.

Trigonella monantha C.A. Meyer subsp. *noeana* (Boiss.) Hub.-Mor. - C7 ¸Sanlıurfa: Birecik-Nizip 4. km, meadows, *H.Akan* 3207 *& M.Ekici.* It is Irano-Turanian Element (Ir.-Tur.) and IUCN category is LC. Habitat and altitude: Vineyards, agricultural land, 400- 1300 m. Distribution areas: Turkey, Syria desert, Palestine, N Iraq, Trans Caucasia, Iran, Afghanistan and Turkistan. It has been studied for the first time in the present study and the chromosome numbers are 2n=14=4m+3sm (Fig. 17). The basic chromosome number is x=7. There are 4x and 6x cytotypes in almost all polyploidy subspecies. The presence of polyploidy in the same populations or within one (mixopolyploidy) indicates the autopolyploid origin of the tetraploid cytotypes and suggests recurrent origins. Chromosomes lengths are between 1.57 to 2.65 µm. The total haploid chromosome length is 14.72 µm (Table 2). The idiogram of this taxon is given in Fig. 21.

Trigonella orthoceras Kar. & Kir. - A9 Kars: Ka˘gızman-Cumaçay 26. km, 14.07.2002, 1800 m, meadows, *H.Akan* 3746, *Z.Aytaç & M.Ekici,* B5 Kayseri: Hisarcık-Erciyes road, 08.07.2002, 1550 m, *H.Akan* 3658, *Z.Aytaç & M.Ekici.* It is Irano-Turanian Element (Ir.-Tur.) and IUCN category is LC. Habitat and altitude: Slopes, steppe, meadows and 350-2000 m. Distribution areas: Turkey, N Iraq, S Russia, Caucasia and Middle Asia. It is mainly spread in middle and eastern Anatolia. It differs from *T. monantha* for the shorter fruit necks. This is the first report on the chromosome number and morphology of this species. The chromosome number of two accessions are defined as 2n=16 and 46 (Fig. 18-19). The distribution locality of this species is far away from each other and the different chromosome numbers are cytological very interesting. The accessions that have been collected from Kars province have a somatic chromosome numbers of 2n=16, and their karyotype formula is 7m+1sm. Chromosomes lengths vary from 0.59 to 1.08 µm. The total haploid chromosome length is 6.16 µm (Table 2). However, the accessions collected from Kayseri province have a somatic chromosome number of 2n=46. The metaphase chromosomes are very small. Therefore their centromer points could not determined, and thus the karyotype study couldn't be conducted (Table 2). The idiogram of this taxon is given in Fig. 21.

DISCUSSION

The karyomorphological study on the section of *Bucerates* shows that chromosome numbers of these taxa are 2*n*=14, 16, 28, 30 and 46. In the relevant literature, the, chromosome numbers are given as 2*n*=16, 46 and 48 (TUTIN and HEYWOOD 1964; LADIZINSKY and VOSA 1986; MARTIN *et al.* 2006a; 2006b; YILMAZ, Unpl. data 2006).

In this section, there are two different basic chromosome numbers (*x*=7 and 8). The chromosome numbers and karyotypes are determined for all taxa, except *T. fischeriana* and *T. astroites*, for the first time in the present study.

In this caryological study, the members of *Bucerates* section have been collected and examined from different parts of Turkey. Among the taxa studied, 14 are collected from one locality. *T. monantha* subsp. *monantha*, on the other hand, has been gathered from three and *T. orthoceras* from two different localities.

T. monantha subsp. *monantha* has the smallest centromeric index (3.04). This taxon has been collected from different localities and it was determined that it has three different chromosome numbers and morphology. This subspecies has the biggest total length of haploid chromosome (25.19 µm). It has the shortest arm ratio (1.20) among the section members. The diploid chromosome numbers have been detected as 2*n*=16, 28 and 30.

One of the accessions, the one from Antalya province has 2*n*=16 somatic chromosome number; the total haploid chromosome length is 6.32 µm, the shortest chromosome length is 0.61, and the tallest chromosome length is 1.14 µm. The karyotype formula is 4m+4sm. However, the other locality, the one from Şanlıurfa province, has a somatic chromosome number of 2*n*=28. Its total haploid chromosome length is 25.19 µm, the shortest chromosome length is 1.32 µm, and the tallest chromosome length is 3.26 µm. The karyotype formula for this locality is 13m+1sm. The last accession, from Kayseri province, has a diploid chromosome number of 2*n*=30. The total haploid chromosome length of this accession is 11.71 µm, the shortest chromosome length is 0.56 µm, and the tallest chromosome length is 0.96 µm. The karyotype formula of this locality is 15m.

The somatic chromosome number of *Trigonella monantha* subsp. *noeana* is 2*n*=14 and its chromosome morphology is 4m+3sm. This fact confirms that *T. monantha* subsp. *monantha* is a tetraploid as the accessions gathered from Bozova, (Şanlıurfa). Among the section members, *T. monantha* subsp. *noeana* has the tallest arm ratio (1.71).

As previously mentioned, *Trigonella orthoceras* has been collected from two different localities; Kars and Kayseri provinces. The accessions that have been collected from Kars province have somatic chromosome numbers of 2*n*=16, and karyotype formula is 7m+1sm. Chromosomes lengths range from 0.59 to 1.08 µm. The total haploid chromosome length is 6.16 µm. In the specimens of this locality the shortest chromosome length is 0.59 µm, and the tallest chromosome length is 1.08 µm. However, the accessions collected from Kayseri province has a somatic chromosome number of 2*n*=46. The metaphase chromosomes are very small making the determination of centromer points impossible. Therefore the karyotype analysis couldn't be conducted for this accession.

YILMAZ, Unpl. data, 2006) reported the chromosome number and morphology of *Trigonella fischeriana* as 2*n*=14. His findings are similar to the findings in our study. His findings regarding *Trigonella astroites*, 2*n*=16, supports the findings of the present study as well.

The chromosome numbers of section *Bucerates* taxa are determined to be the same as previously defined (LADIZINSKY and VOSA 1986). The ploidy level for this genus is 4*x*.

The results of the present study confirm earlier studies on *Trigonella polycarpa* that have determined its chromosome number as 2*n*=16 to be the most common chromosome number of this genus (TUTIN and HEYWOOD 1964).

In this study, two different basic chromosome numbers (*x*=7 and *x*=8) are counted for the species and subspecies of *Bucerates* section. Among these, only two taxa (*T. fischeriana* and *T. monantha* subsp. *noeana*) have *x*=7 as their basic chromosome number.

The basic chromosome number of *T. monantha* subsp. *monantha* and *T. orthoceras* couldn't be determined. The different diploid chromosome numbers have been observed on the different accessions of different localities. These differences hindered the determination of the basic chromosome numbers of *T. monantha* subsp. *monantha* and *T. orthoceras*.

T. arcuata is the only species among the members of section that has 2B chromosomes. This finding is mentioned for the first time in section *Bucerates* and even in genus *Trigonella*.

T. crassipes is the unique species in section for having satellite metaphase chromosomes. The results of the present study confirm earlier studies on genus *Trigonella*. Although *T. strangulata* Boiss.

and *T. cariensis* Boiss. have two pairs of satellite chromosome, a pair of satellite chromosome in *T. velutina* Boiss. (MARTIN *et al*. 2006a).

The karyotype formula of *T. fischeriana*, *T. astroites*, *T. halophila*, *T. rigida*, *T. pamphylica* and *T. monantha* subsp. *monantha* consist only of metacentric chromosome pairs.

The metaphase chromosome cells of some taxa reveal mixoploidy. In the metaphase chromosome preparations, cells with diploid chromosomes and cells with polyploidy chromosomes are present on the same root tips. Two different ploidy levels are observed on the members of section. These are 4*x* (tetraploid) and 6*x* (hexaploid). No polyploidy has been detected for *T. astroites*, *T. rigida* and *T. pamphylica*.

The presence of tetraploidy and hexaploidy at the same time is unique to *T. monantha* subsp. *noeana*. Besides, hexaploidy was present in the metaphase chromosome cells of *T. tenuis*.

The chromosome morphology of the members of this section is consists of metacentric and submetacentric chromosome pairs. Among the taxa studied, the chromosome morphology of *T. orthoceras* could not be conducted.

The factors endangering living creatures such as destruction of natural habitats, field clearances, tourism, dams and irrigation system construction affects the taxon of *Trigonella* as well. Therefore, our biological treasures but especially endemic plant species is endangered. Thus it is an obligation to protect them as *Ex-situ* or *In-situ.*
T. rigida is among the widely spread endemics. The other endemics are *T. arenicola*, *T. halophila*, *T. polycarpa*, *T. pamphylica* and *T. carica*, spread narrowly. The *Trigonella* species are generally localized in the Mediterranean and Western Anatolia but is also partially seen in Western Europe, and in Eastern Anatolia.

The findings of the present and previous studies reveal that the chromosome numbers of different taxa of section *Bucerates* differ. The chromosome numbers and karyotype formula of accessions collected from different localities may be different. These cytogenetical diversions may be a result of infrageneric and infraspecific variations.

Acknowledgements — We would like to thank to The Scientific & Technological Research Council of Turkey (TUBITAK, Project no. TBAG–2099 (101T142) and Scientific Investigation Project Coordinate of Selçuk University (Project no: 05401046) for financial support. We would like also to express our gratitude to Dr. HARUN ŞIMŞEK for proofreading and editing the manuscript.

REFERENCES

AKAN H., EKICI M. and AYTAÇ Z., 2005 — *The endemic species of Trigonella and their conservation in Turkey*, XVII. International Botanical Congress, Vienna, Abstracts, p. 611.

AKAN H., EKICI M., AYTAÇ Z. and PINAR M., 2006 — *Turkey Trigonella L. (Leguminosae)'larının Revizyonu*, TÜBİTAK projesi sonuç raporu, TBAG-2099, Ankara. Unpublished data.

AL-HABORI M., AL-AGHBARI A.M. and AL-MAMARY M., 1998 — *Effects of fenugreek seeds and its extracts on plasma lipid profile: A study on rabbits.* Phytother Res. 12: 572-575.

BIDAK L. and AMIN A.W., 1996 — *Inter-and intraspecific chromosomal variations in four species of Trigonella L.*, J. Union Arab Biol. (Cairo), vol. 3: 203-215.

BROOKES B. and SMALL E., 1988 — *Enhanced floral analysis by low temperature scanning electron microscopy*. Scanning Microsc., 2: 247-256.

DARLINGTON C.D. and WYLIE A.P., 1955 — *Chromosome Atlas of Flowering Plants*. London: Allen & Unwin Press.

DAVIS P.H. (ed.), 1970 — *Flora of Turkey and the East Aegean Islands* 3: 452-482. Edinburgh: Edinburgh Univ. Press.

IUCN 2001 — *IUCN Red List Categories*: *Version 3.1.* Prepared by the IUCN Species Survival Commission. IUCN, Gland, Switzerland and Cambridge, UK.

KABILAN S., KAYALVIZHI R. and BALASUBRAMANIAN S. and RAMALINGAN C., 2002 — *Mass spectral analysis of solvent extracts of Fenugreek seeds*. Asian J. Chem., 14: 844-848.

LADIZINSKY G. and VOSA C.G., 1986 — *Localization and activity of rRNA genes on fenugreek (Trigonella foenum-graecum L.) chromosomes by fluorescent in situ hybridization and silver staining*, Plant Systematics and Evolution, 1-5.

MABBERLY D.J., 1997 — *The plant-book: A Portable Dictionary of the Higher Plants*, CambridgeUniversity Pres, Cambridge, UK.

MARTIN E., AKAN H., EKICI M. and AYTAÇ Z., 2006a — *Turkey'de Yetişen Trigonella L. (Fabaceae) cinsine ait taksonların Karyotip Analizi*, 18. Ulusal Biyoloji Kongresi, Bildiri kitabı, Aydın. p. 25.

MARTIN E., DINÇ M., DURAN A. and ÖZTÜRK M., 2006b — *Karyotype of Lotus strictus Fisher & C.A.Mey. (Leguminosae), Centaurea amanicola Hub.-Mor. (Compositae) and Teucrium lamiifolium d'Urv. subsp. lamiifolium (Labiatae) on taxa*. American-Eurasian Journal of Scientific Research, 1: 12-17.

MURAKAMI T., KISHI A., MATSUDA H. and YOSHIKAWA M., 2000 — *Medicinal foodstuffs. 17. Fenugreek seed.(3): Structures of new furostanol-type steroid saponins, trigoneosides 10a, 10b, 11b, 12a, 12 band 13a from the seeds of Egyptian Trigonella foenum-graceum L.*. Chem Pharm Bull., 48: 994-1000.

PANDITA V.K., NAGARAJAN S. and SHARMA D., 1999 — *Reducing hard seededness in fenugreek byscarification technique*. Seed SCI Technol., 27: 627-637.

SMALL E., BASSETT J.I. and CROMPTON W., 1981 — *Pollen variation in tribe Trigonella (Leguminosae) with special refernce to Medicago*. Pollen et Spores, 12: 295-319.

SMALL E., BROOKES B. and LASSEN P., 1990 — *Circumscription of the genus* Medicago *(Leguminosae) by seed characters*. Can. J. Bot., 68: 613-629.

TUTIN T.G. and HEYWOOD V.H., 1964 — *Flora Europaea*, Vol. I & II. Cambridge University Press, Cambridge.

YILMAZ A., 2006 — *Trigonella L. (Leguminosae) cinsine ait bazı taksonlarda karyotipik bir çalışma*, Yüksek Lisans Tezi, Niğde Üniversitesi, Fen Bilimleri Enstitüsü, Niğde. Unpublished data.

Received June 20th 2007; accepted January 23th 2008