

Full Length Research Paper

# New chromosome numbers in the genus *Trigonella* L. (*Fabaceae*) from Turkey

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Somatic chromosome numbers of 45 *Trigonella* L. (*Fabaceae*), collected from different localities in Turkey was examined. Chromosome numbers were determined as  $2n = 14, 16, 30$  and  $46$ . B chromosome was also observed in somatic cells of some taxa (*Trigonella arcuata* C.A. Meyer and *Trigonella procumbens* (Besser) Reichb.). In addition, one or two satellites were observed in some taxa (*Trigonella lunata* Boiss., *Trigonella velutina* Boiss., *Trigonella strangulata* Boiss., *Trigonella crassipes* Boiss. and *Trigonella cariensis* Boiss.).

**Key words:** Chromosome number, *Leguminosae*, *Trigonella*.

## INTRODUCTION

*Trigonella* L. (*Fabaceae*) includes about 135 species worldwide, and most of the species are distributed in the dry regions around Mediterranean, West Asia, Europe, North and South Africa, North America, and with only two species being present in South Australia (Mabberly, 1997). The genus *Trigonella* has 13 sections and 50 taxa in Turkey (Huber-Morath, 1970). *Trigonella* taxa are localized in different phytogeographical regions in Turkey with 21 endemic species showing 42% endemism rate (Huber-Morath, 1970; Akan et al., 2005; Akan et al., Unpublished data, 2006). All the members of the genus in Turkey are annual.

The somatic chromosome numbers of some taxa in the genus *Trigonella* have also being reported (Darlington and Wylie, 1955; Ghosh, 1980; Astanova, 1981; Agarwal and Gupta, 1983; Ladizinsky and Vosa, 1986; Danin and Small, 1989; Kumari and Bir, 1990; Bidak and Amin, 1996; Pavlova, 1996; Martin et al., 2008; Yilmaz et al., 2009). The aim of this study is to verify or establish the chromosome numbers of taxa *Trigonella* in Turkey. In this contribution, we reported the somatic chromosome numbers of 45 taxa of *Trigonella* belonging to 13

sections. Also, chromosome numbers are determined for the first time in 17 taxa of *Trigonella* which grows naturally.

## MATERIALS AND METHODS

### Plant material

Seedlings were collected between 2002 and 2005. Voucher specimens have been deposited in the Biology Department of Harran and Gazi Universities, Turkey. Section, chromosome number, province and voucher number, chromosome numbers reported and references are given in Table 1.

### Chromosome analysis

The surface of seeds was abraded with emery paper to accelerate germination. Seeds were humidified in the laboratory and germinated in a very short time in Petri dishes at room temperature. Root tips were pretreated with  $\alpha$ -monobromonaphthalene at 4°C for 16 h and fixed with Carnoy for 24 h at 4°C. Before staining, the material was hydrolyzed with 1 N HCl for 13 min at room temperature. The chromosomes were stained with 2% acetic orcein and mounted in 45% acetic acid. Permanent slides were made by using the standard liquid nitrogen method.

The somatic chromosome number of each taxon was counted by the use of permanent preparations containing chromosomes in the

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**Table 1.** Section, chromosome number, province and voucher number, chromosome numbers reported and references of *Trigonella* taxa (a pair of satellites seen in the chromosome pairs are marked with asterisk).

Section	Taxa	Chromosome Number (2n)	Province and voucher number	Chromosome numbers reported (2n)	References
<i>Samaroideae</i>	<i>T. cretica</i>	16	Burdur, Akan 3480 and Ekici	16	Yılmaz et al. (2009)
<i>Pectinatae</i>	<i>T. plicata</i>	14	Konya, Akan 3789, Aytaç and Ekici		Present study
<i>Lunatae</i>	<i>T. brachycarpa</i>	16	Konya, Akan 3786, Aytaç and Ekici		Present study
"	<i>T. rostrata</i>	14	Konya, Akan 3805, Aytaç and Ekici		Present study
"	* <i>T. lunata</i>	16	Adana, Akan 4687 and Ekici		Present study
<i>Falcatulae</i>	<i>T. corniculata</i>	16	İzmir, Akan 4616 and Ekici Muğla, Akan 3391 and Ekici	16	Tutin and Heywood (1964)
"	<i>T. spinosa</i>	16	Muğla, Akan 5655 and Ekici	16	Ghosh (1980); Bidak and Amin (1996)
<i>Cylindricae</i>	<i>T. spruneriana</i>	16	Konya, Akan 4753 and Ekici		Present study
"	<i>T. sibthorpii</i>	16	Antalya, Akan 3307 Aytaç and Ekici Mersin, Akan 3299 Aytaç and Ekici	16	Danin and Small (1989)
"	<i>T. kotschyii</i>	16	İçel, Akan 4769 and Ekici		Present study
"	<i>T. mesopotamica</i>	16	Şanlıurfa, Akan 4577 and Ekici		Present study
"	<i>T. cylindraceae</i>	16	Antalya, Akan 2843 and Ekici		Present study
"	<i>T. cilicica</i>	16	Adana, Akan 5739 and Ekici		Present study
"	<i>T. filipes</i>	16	Şanlıurfa, Akan 3200 and Ekici		Present study
"	* <i>T. velutina</i>	16	Karaman, Akan 3790 Aytaç and Ekici	16	Yılmaz et al. (2009)
"	* <i>T. strangulata</i>	16	Mersin, Akan 3289 and Ekici Antalya, Akan 5758 and Ekici		Present study
"	<i>T. smynea</i>	16	Burdur, Akan 5756 and Ekici		Present study
<i>Bucerates</i>	<i>T. aurantiaca</i>	16	Burdur, Akan 5753 and Ekici	16	Martin et al. (2008)
"	<i>T. arenicola</i>	16	Antalya, Akan 3311 and Ekici	16	Martin et al. (2008)
"	<i>T. fischeriana</i>	14	Kayseri, Akan 3654, Aytaç and Ekici	14	Yılmaz et al. (2009); Martin et al. (2008)
"	<i>T. tenuis</i>	16	Kars, Akan 3742, Aytaç and Ekici Burdur, Akan 3504 and Ekici	16	Martin et al. (2008)
"	<i>T. cancellata</i>	16	Ağrı, Akan 3757, Aytaç and Ekici	16	Martin et al. (2008)
"	<i>T. astroites</i>	16	Kayseri, Akan 3771 and Ekici	16	Yılmaz et al. (2009)
"	<i>T. halophila</i>	16	Mersin, Akan 3279 and Ekici	16	Martin et al. (2008)
"	* <i>T. crassipes</i>	16	Antalya, Akan 3325 and Ekici	16	Martin et al. (2008)
"	<i>T. polycarpa</i>	16	Antalya, Akan 5658 and Ekici	16	Martin et al. (2008)

metaphase stage of mitosis. Photographs were taken at 10 × 100 magnification under a light microscope and transferred to a

computer screen after detecting no shrinkage in root tip somatic cells with a good distribution and clearly visible morphologies in

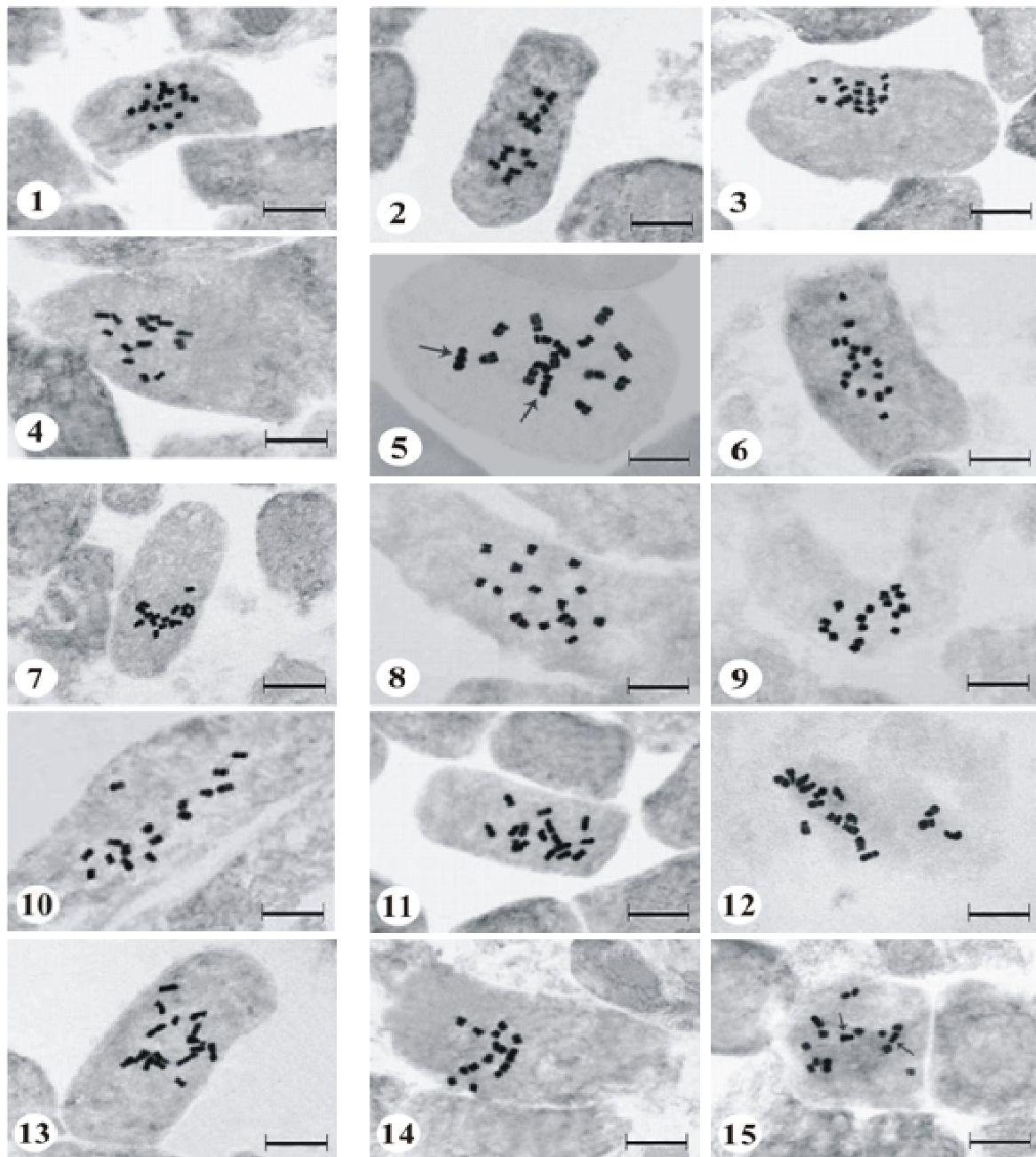
Table 1. Contd.

Section	Taxa	Chromosome number (2n)	Province and voucher number	Chromosome numbers reported (2n)	References
"	<i>T. rigida</i>	16	Adana, Akan 4737 and Ekici	16	Martin et al. (2008)
"	<i>T. pamphylica</i>	16	Antalya, Akan 5764 and Ekici	16	Martin et al. (2008)
"	<i>T. carica</i>	16	Muğla, Akan 3366 and Ekici	16	Martin et al. (2008)
"	<i>T. arcuata</i>	16 + 2B	Kayseri, Akan 3723, Aytaç and Ekici	16+2B	Martin et al. (2008)
"	<i>T. monantha</i> subsp. <i>monantha</i>	16, 30	Kayseri, Akan 3656, Aytaç and Ekici Şanlıurfa, MNM 1061 Antalya, Akan 3356, Aytaç and Ekici	16, 28 and 30	Martin et al. (2008)
"	<i>T. monantha</i> subsp. <i>noeana</i>	14	Şanlıurfa, Akan 3207 and Ekici	14	Martin et al. (2008)
"	<i>T. orthoceras</i>	16, 46	Kayseri, Akan 3658, Aytaç and Ekici Kars, Akan 3746, Aytaç and Ekici	16, 46	Martin et al. (2008)
<i>Reflexae</i>	<i>T. monspeliaca</i>	16	Muğla, Akan 3358 and Ekici Antalya, Akan 3327 and Ekici	16	Darlington and Wylie (1955)
<i>Isthmocarpae</i>	<i>T. isthmocarpa</i>	16	Aksaray, Akan 4695 and Ekici		Present study
"	<i>T. rhytidocarpa</i>	16	Niğde, Akan 3778 and Ekici		Present study
<i>Uncinatae</i>	<i>T. spicata</i>	16	Antalya, Akan 3319 and Ekici, Karavelioğulları		Present study
"	<i>T. cephalotes</i>	16	Aydın, Akan 3398 and Ekici		Present study
<i>Capitatae</i>	<i>T. procumbens</i>	16 + 2B	Konya, Akan 4760 and Ekici	18	Yılmaz et al. (2009)
"	<i>T. capitata</i>	16	Denizli, Akan 4767 and Ekici		Present study
<i>Biebersteinianae</i>	<i>T. coerulescens</i>	16	Konya, Akan 3587 Aytaç and Ekici Kayseri, Akan 3659 and Ekici	16	Yılmaz et al. (2009)
<i>Foenum-graecum</i>	<i>T. gladiata</i>	16	Karaman, Akan 5743 and Ekici	16	Darlington and Wylie (1955); Ladizinsky and Vosa (1986); Bidak and Amin (1996)
"	* <i>T. cariensis</i>	16	İzmir, Akan 4620 and Ekici Antalya, Akan 3332 and Ekici	16	Ladizinsky and Vosa (1986)
"	<i>T. foenum-graecum</i>	16	Adana, Akan 3274	16	Ladizinsky and Vosa (1986); Tutin and Heywood (1964)
"	<i>T. macrorrhyncha</i>	16	İçel, Akan 4354 and Ekici	16	Ladizinsky and Vosa (1986)

preparations on the same plane. The somatic chromosome numbers were counted with measurements taken on enlarged micrographs of ten well spread metaphase plates. The karyological characteristics (number of somatic chromosomes, number of B chromosomes and existence of satellites) were determined from the photographs (Figures 1 - 3).

## RESULTS AND DISCUSSION

The somatic chromosome numbers were determined for the first time in 17 taxa of *Trigonella* which grows naturally. Cytological results obtained from our study are

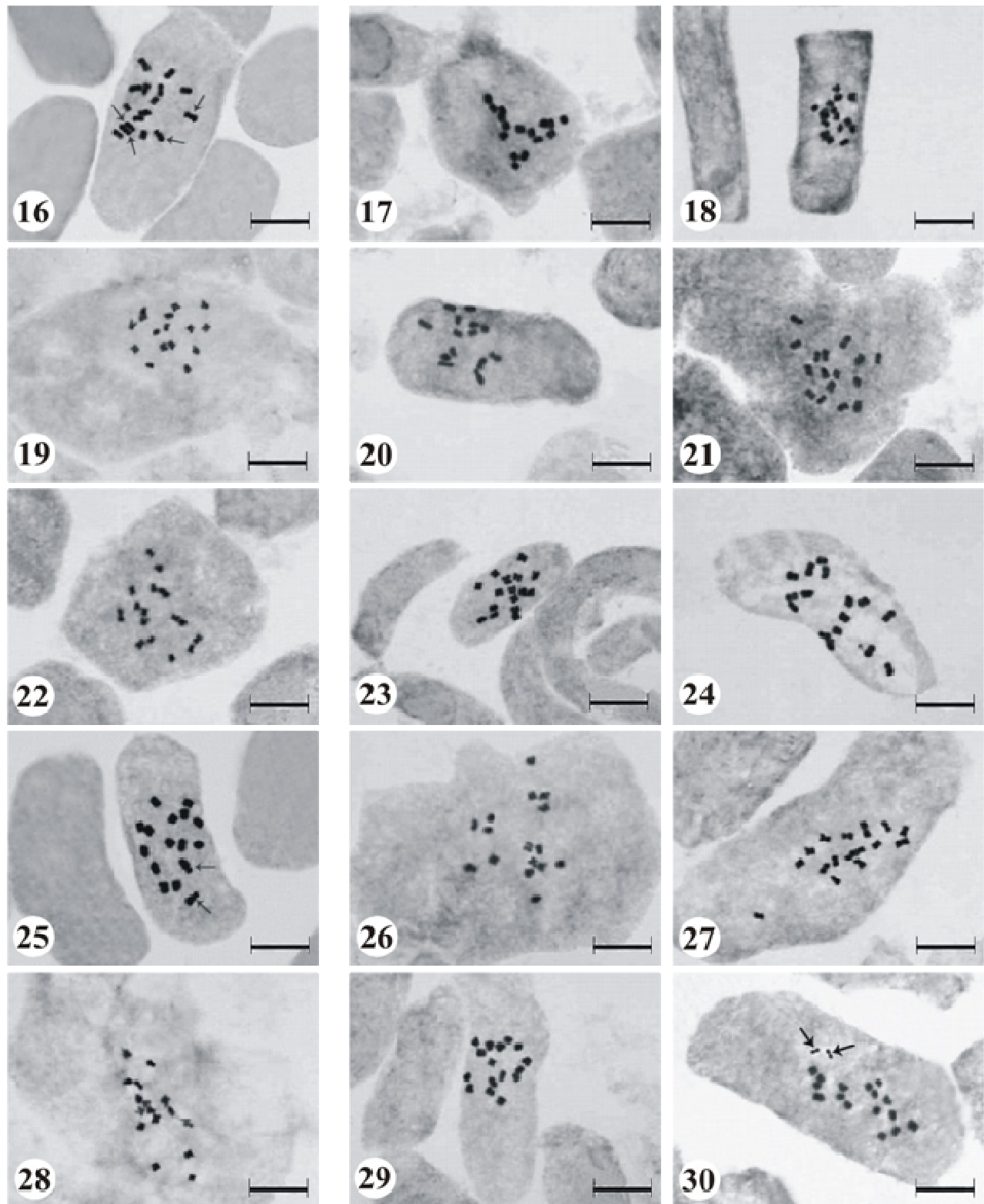


**Figure 1.** 1, *Trigonella cretica*; 2, *Trigonella plicata*; 3, *Trigonella brachycarpa*; 4, *Trigonella rostrata*; 5, *Trigonella lunata*, arrow shows the satellites; 6, *Trigonella corniculata*; 7, *Trigonella spinosa*; 8, *Trigonella spruneriana*; 9, *Trigonella sibthorpii*; 10, *Trigonella kotschyii*; 11, *Trigonella mesopotamica*; 12, *Trigonella cylindracea*; 13, *Trigonella cilicica*; 14, *Trigonella filipes*; 15, *Trigonella velutina*, arrow shows the satellites. Scale bar: 10  $\mu$ m.

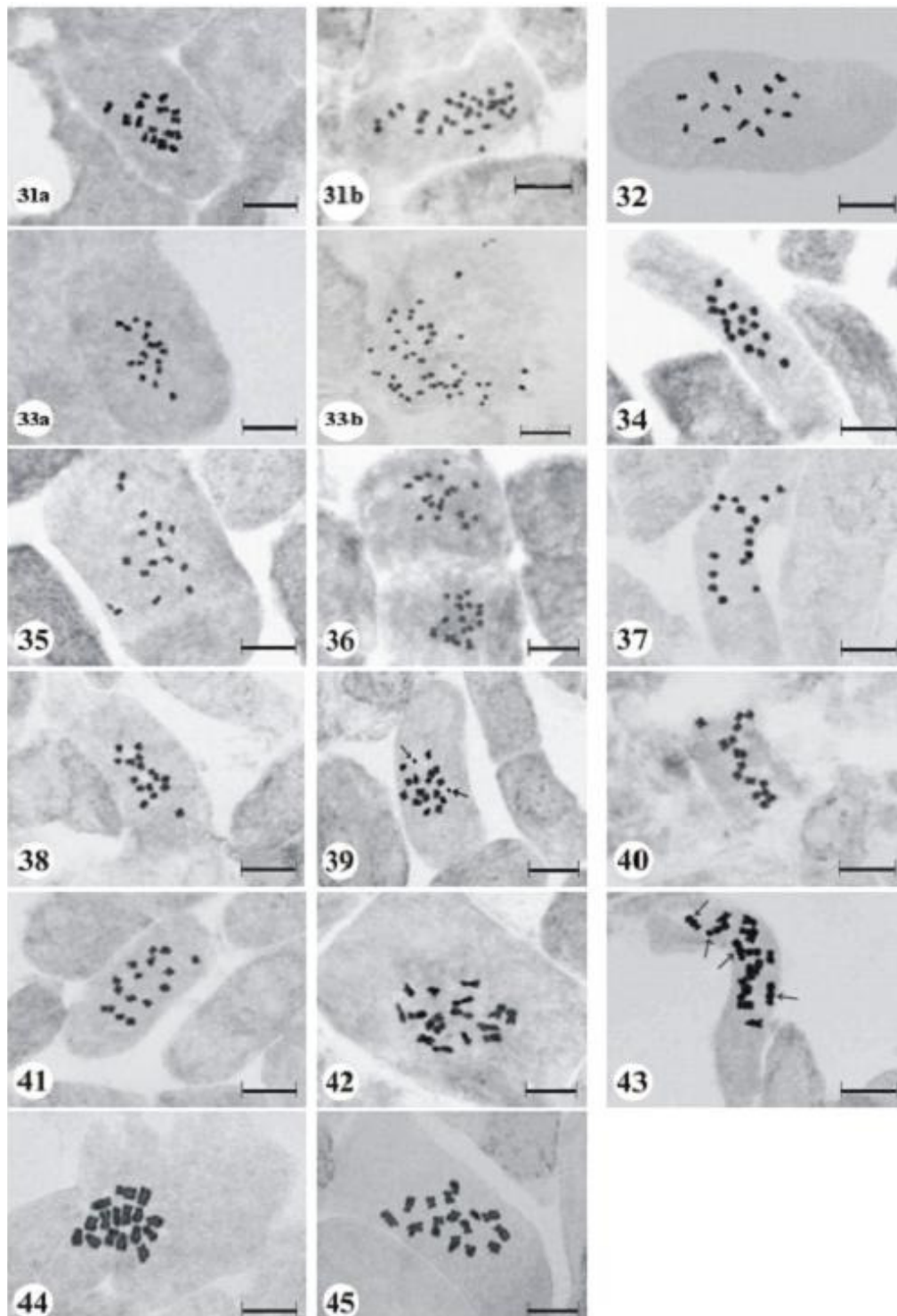
arranged based on the order in the Flora of Turkey.

In this karyological study of *Trigonella* taxa, somatic chromosome numbers were observed as  $2n = 14$  (*Trigonella plicata* (Boiss. and Bal.) Boiss., *Trigonella rostrata* (Boiss. and Bal.) Boiss., *Trigonella fischeriana* Ser. and *Trigonella monantha* C.A. Meyer

subsp. *noeana* (Boiss.) Hub.-Mor.),  $2n = 16$  (for 41 taxa),  $2n = 16$  and 30 (*T. monantha* C.A. Meyer subsp. *monantha* Verz.) and  $2n = 16$  and 46 (*Trigonella orthoceras* Kar. and Kir.). B chromosomes were observed in *Trigonella arcuata* C.A. Meyer and *Trigonella procumbens* (Besser) Reichp., and satellite chromosome pairs are



**Figure 2.** 16, *Trigonella strangulata*, arrow shows the satellites; 17, *Trigonella smyrnea*; 18, *Trigonella aurantiaca*; 19, *Trigonella arenicola*; 20, *Trigonella fischeriana*; 21, *Trigonella tenuis*; 22, *Trigonella cancellata*; 23, *Trigonella astroides*; 24, *Trigonella halophila*; 25, *Trigonella crassipes*, arrow shows the satellites; 26, *Trigonella polycarpa*; 27, *Trigonella rigida*; 28, *Trigonella pamphylica*; 29, *Trigonella carica*; 30, *Trigonella arcuata*, arrow shows the B chromosomes.



**Figure 3.** 31a, *Trigonella monantha* subsp. *monantha* Akan 3356, Aytaç and Ekici; 31b, *Trigonella monantha* subsp. *monantha* Akan 3656, Aytaç and Ekici; 32, *Trigonella monantha* subsp. *noeana* 33a, *Trigonella orthoceras* Akan 3746, Aytaç and Ekici; 33b, *Trigonella orthoceras* Akan 3658, Aytaç and Ekici; 34, *Trigonella monspeliaca*; 35, *Trigonella isthmocarpa*; 36, *Trigonella rhytidocarpa*; 37, *Trigonella spicata*; 38, *Trigonella cephalotes*; 39, *Trigonella procumbens*, arrow shows the B chromosomes; 40, *Trigonella capitata*; 41, *Trigonella coerulescens*; 42, *Trigonella gladiata*; 43, *Trigonella cariensis*, arrow shows the satellites, 44, *Trigonella foenum-graecum*; 45, *Trigonella macrorrhyncha*.

found in *Trigonella lunata* Boiss., *Trigonella crassipes* Boiss., *Trigonella strangulata* Boiss., *Trigonella cariensis* Boiss. and *Trigonella velutina* Boiss.

The section *Samaroideae* Boiss. is represented in Turkey by *Trigonella cretica* (L.) Boiss. The diploid chromosome number for this species is  $2n = 16$  in good agreement with literature (Agarwal and Gupta, 1983; Yilmaz et al., 2009). The section *Pectinatae* Boiss. is represented in Turkey by *T. plicata* (Boiss. and Bal.) Boiss. The diploid chromosome number for *T. plicata* is  $2n = 14$ . The section *Lunatae* Boiss. is represented in Turkey by *Trigonella brachycarpa* (Fisch.) Moris, *T. rostrata* (Boiss. and Bal.) Boiss., *T. lunata* Boiss. and *Trigonella sirjaevii*. By evaluation of the general characteristics of the section, it was determined that two species, *T. brachycarpa* and *T. rostrata* gathered from the same locality have different diploid chromosome numbers. The diploid chromosome number for *T. brachycarpa* is  $2n = 16$  and for *T. rostrata*, it is  $2n = 14$ , respectively. One pair of satellite chromosomes was observed for *T. lunata*, but none for the other members of the section.

The section *Falcatulae* Boiss. is represented in Turkey by *Trigonella corniculata* L., *Trigonella spinosa* L. *T. corniculata* is collected from two different localities (İzmir Province and Muğla Province). These two species have the same diploid chromosome number  $2n = 16$ . The same chromosome numbers in both species confirms the results of earlier karyological studies. Bidak and Amin (1996) reported that *Trigonella gladiata* has  $2n = 16$  and 18, *Trigonella ornithopodiodes* has  $2n = 16$ , *T. spinosa* has  $2n = 16$  and *Trigonella stellata* has  $2n = 18$ . Ghosh (1980) reported that the somatic chromosome number for *T. spinosa* is  $2n = 16$ .

The *Cylindricae* Boiss. section comprises of 14 species worldwide, and 10 of these are found in Turkey: *Trigonella spruneriana* Boiss., *Trigonella sibthorpii* Boiss., *Trigonella kotschyii* Fenzl., *Trigonella mesopotamica* Hub.-Mor., *Trigonella cylindraceae* Desv., *Trigonella cilicica* Hub.-Mor., *Trigonella filipes* Boiss., *Trigonella velutina* Boiss., *T. strangulata* Boiss. and *Trigonella smyrnea* Boiss. Members of this section have been collected from different parts of Turkey, and the somatic chromosome number has been determined as  $2n = 16$ . In addition, it is determined that *Trigonella velutina* has one satellite metaphase chromosome, while *T. strangulata* has two satellite metaphase chromosomes. According to the literature, the chromosome numbers of only two taxa (*T. sibthorpii* and *T. velutina*), have been studied (Danin and Small, 1989; Yilmaz et al., 2009).

The *Bucerates* Boiss. section is represented in Turkey by 16 taxa, namely: *Trigonella aurantiaca* Boiss., *Trigonella arenicola* Hub.-Mor., *Trigonella fischeriana* Ser., *Trigonella tenuis* Fisch., *Trigonella cancellata* Desf., *Trigonella astroites* Fisch. and Mey., *Trigonella halophila* Boiss., *Trigonella crassipes* Boiss., *Trigonella polycarpa* Boiss. and Heldr., *Trigonella rigida* Boiss. and Bal., *Trigonella*

*pamphylica* Hub.-Mor. and Sirj., *Trigonella carica* Hub.-Mor., *T. arcuata* C.A. Meyer, *Trigonella monantha* C.A. Meyer subsp. *monantha* Verz., *Trigonella monantha* C.A. Meyer subsp. *noeana* (Boiss.) Hub.-Mor. and *Trigonella orthoceras* Kar. and Kir. The chromosome number is  $2n = 16$  for 14 of these taxa,  $2n = 14$  for *T. fischeriana* and *T. monantha* subsp. *Noeana*,  $2n = 16$  and 30 for *T. monantha* subsp. *monantha* and  $2n = 16$  and 46 for *T. orthoceras*. The presence of B chromosomes is observed in *T. arcuata*. There are two chromosomes with a satellite in *T. crassipes*, *T. fischeriana* and *T. astroites*, counts in mitotic cells are in agreement with the chromosome numbers determined here for the same species (Yilmaz et al., 2009; Martin et al., 2008). For *T. astroites*, the chromosome number of  $2n = 16$  determined in this species agrees with literature by Yilmaz et al., (2009).

The *reflexae* (Sirj.) Vass. section is represented in Turkey by *Trigonella monspeliaca* L., which was collected from two different localities. The diploid chromosome number is  $2n = 16$  for *Trigonella monspeliaca* for both specimens. According to literature, cytological investigations showed that the members of the *Trigonella* have diploid chromosome numbers from  $2n = 16$  to  $2n = 32$ . For example, *T. gladiata* has  $2n = 16$ , *T. monspeliaca* has  $2n = 16$ , and *Trigonella polyceratia* has  $2n = 28$ , 30 and 32. The somatic chromosome numbers reported here agree with those reported by literature (Darlington and Wylie, 1955; Ladizinsky and Vosa, 1986; Bidak and Amin, 1996). The *Isthmocarpae* Boiss. section is represented in Turkey by *Trigonella isthmocarpa* Boiss. and Bal. and *Trigonella rhytidocarpa* Boiss. and Bal. The diploid chromosome number is observed as  $2n = 16$  for these taxa. The *Uncinatae* Boiss. section is represented in Turkey by *Trigonella spicata* Sibth. and Sm. and *Trigonella cephalotes* Boiss. and Bal. The somatic chromosome number is observed as  $2n = 16$  in these species. The *Capitatae* Boiss. section is represented in Turkey by *T. procumbens* (Besser) Reichp., *Trigonella capitata* Boiss. and *Trigonella pseudocapitata*. The diploid chromosome number of the two species is  $2n = 16$ , and *T. procumbens* has B chromosomes. The chromosome number of *T. procumbens* has been determined as  $2n = 18$  (Yilmaz et al., 2009) in the same locality, but the presence of B chromosomes was not reported.

The *Biebersteinianae* (Sirj.) section is represented in Turkey by *Trigonella coerulescens* (Bieb.) Hal. This species is collected from two different localities. The diploid chromosome number is  $2n = 16$  for *T. coerulescens* from two different localities, in agreement with the chromosome number of  $2n = 16$  for this species determined by Yilmaz et al., (2009). The *Foenum-graecum* Ser. section is represented in Turkey by *T. gladiata* Stev. Fischer, *Trigonella cariensis* Boiss., *Trigonella foenum-graecum* L., *Trigonella macrorryncha* Boiss. and *Trigonella cassia*. Four species of the section have been studied and the somatic chromosome number is  $2n = 16$ . The chromosome

number is determined as  $2n = 16$  for *T. gladiata* in this study, but two different somatic chromosome numbers have been reported as  $2n = 16$  and  $2n = 18$  for this species in literature (Bidak and Amin, 1996). According to Darlington and Wylie (1955), members of the genus *Trigonella* may have a diploid chromosomes change from  $2n = 16$  to 32. For example, *T. gladiata* has  $2n = 16$ , *Trigonella monspeliaca* has  $2n = 16$  and *Trigonella polyseratia* has  $2n = 28, 30$  and 32 and our findings are in agreement with them. The specimens from Antalya Province have two pairs of satellite chromosomes, which is unique among the members of this section. Like the other members of this section, *T. foenum-graecum* has diploid chromosome number  $2n = 16$  and the same results have been determined elsewhere in Europe Flora (Tutin and Heywood, 1964). *T. macrorrhyncha* has the diploid chromosome number  $2n = 16$  like all other members of the section. In an earlier study of six member of this section (*T. gladiata*, *T. cariensis*, *T. foenum-graecum*, *T. berythea*, *T. macrorrhyncha* and *T. cassia*), the mitotic chromosome number is reported as  $2n = 16$  and our results are in agreement with them (Ladizinsky and Vosa, 1986).

The genera *Trigonella*, *Medicago*, *Trifolium* and *Melilotus* belong to the subtribe *Trigonellinae*, tribe *Trifolieae* in the *Fabaceae* family. Several studies on the taxonomical relationship among these genera have been conducted (Small et al., 1987). Generic circumscription has long been a problematic question in the tribe *Trifolieae* subtribe *Trigonellinae* (which contains the genera *Trifolium*, *Melilotus*, *Trigonella* and *Medicago*). In particular, many studies have been undertaken to ascertain the proper relationships between the genera *Medicago* and *Trigonella* (Tutin and Heywood, 1964; Bena, 2001). However, no strict delimitation could be proposed.

The genus *Trigonella* according to Hutchinson (1964) is one of the six genera of the tribe *Trifolieae*, subtribe *Trigonellinae*. The genus is divided into three subgenera, according to the form and shape of calyx and pod by Tutin and Heywood (1964), as follows:

- a: Subgenus *Trigonella*: Calyx usually campanulate and pod not inflated.
- b: Subgenus *Trifolium*: Calyx campanulate and pod inflated.
- c: Subgenus *Foenum-graecum*: Calyx tubular and pod not inflated.

Several investigators have attempted to employ the taxonomy of the genus *Trigonella*; Sirjaev (1935) has given in Latin an elaborate and systematic account of its taxonomy. Vasil'chenko (1953) has published a synopsis in Russian discussing the position of the genus within the family *Leguminosae* and gave keys, synonyms and descriptions of the morphological characters of the different series, their economic importance and geographical distribution. Hutchinson (1964) and Tutin and

Heywood (1964) have also given detailed descriptions of its taxonomic characters. According to these authors, the genus *Trigonella* includes mostly annual or perennial species.

With the help of new observations on the population during this study, it is determined that some endemic species of *Trigonella* are widespread such as *T. plicata*, *T. kotschyii*, *T. rigida* and *T. macrorrhyncha*, while the other endemics are only restricted to a few localities such as *T. sirjaevii*, *T. rostrata*, *T. lycica*, *T. cilicica*, *T. smyrnea*, *T. arenicola*, *T. halophila*, *T. polycarpa*, *T. pamphylica*, *T. isthmocarpa*, *T. carica*, *T. rhytidocarpa*, *T. cephalotes*, *T. cassia*, *T. raphanina* and *Trigonella pseudocapitata*.

In the present study, somatic chromosome numbers of *Trigonella* taxa from the family of *Fabaceae* were determined. We believe this study will play a positive role in enlightening this taxonomically complex genus with cytological features.

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## REFERENCES

- Agarwal K, Gupta PK (1983). Cytological studies in the genus *Trigonella* L. *Cytologia*, 48: 771-779.
- Akan H, Ekici M, Aytaç Z (2005). The endemic species of *Trigonella* and their conservation in Turkey. XVII. International Botanical Congress, Vienna: (17-23 July), Abstracts. p. 611.
- Akan H, Ekici M, Aytaç Z, Pınar M (2006). Turkey *Trigonella* L. (*Leguminosae*)' larının Revizyonu. TÜBİTAK projesi sonuç raporu, TBAG-2099. Ankara. Unpublished data.
- Astanova SB (1981). Chromosome numbers of *Leguminosae* of Flora in Tajikistan. *Dokl. Akad. Nauk Tadziksk. SSR*. 24: 61-63.
- Bena BG (2001). Molecular phylogeny supports the morphologically based taxonomic transfer of the medicagoid *Trigonella* species to the genus *Medicago* L. *Plant. Syst. Evol.* 229: 217-236.
- Bidak L, Amin AW (1996). Inter- and intraspecific chromosomal variations in four species of *Trigonella* L. *J. Union Arab. Biol.* 3: 203-215.
- Danin A, Small E (1989). Contributions to the Flora of Israel and Sinai. V. *Trigonella sibthorpii* Boiss., a new record from Israel. *Israel J. Bot.* 38: 121-124.
- Darlington CD, Wylie AP (1955). *Chromosome Atlas of Flowering Plants*. Allen & Unwin Press, London.
- Ghosh AK (1980). Chromosome number of *Trigonella spinosa*. *Curr. Sci.* 49: 154-155.
- Huber-Morath A (1970). In Davis PH (eds.), *Flora of Turkey and the East Aegean Islands*. Edinburgh Univ. Press, Edinburgh. 3: 452-482.
- Hutchinson J (1964). *The Genera of Flowering Plants*, I. Clarendon Press, Oxford.
- Kumari S, Bir SS (1990). Karyomorphological evolution in *Papilionaceae*. *J. Cytol. Genet.* 25: 173-219.
- Ladizinsky G, Vosa CG (1986). Localization and activity of rRNA genes on fenugreek (*Trigonella foenum-graecum* L.) chromosomes by



- fluorescent in situ hybridization and silver staining. *Plant Syst. Evol.* 153: 1-5.
- Mabberly DJ (1997). *The plant-book: A Portable Dictionary of the Higher Plants*. Cambridge University Press, Cambridge, UK.
- Martin E, Akan H, Ekici M, Aytac Z (2008). Karyomorphological studies on section *Bucerates* Boiss. of *Trigonella* L. (*Leguminosae*) from Turkey. *Caryologia*. 61: 225-236.
- Pavlova D (1996). Mediterranean chromosome number reports. *Flora Mediterranea*, 6: 323-328.
- Sirjaev G (1935). Die Entwicklungsgeschichte der Gattung *Trigonella* (Suppl. Ad Generis *Trigonella* revisio critica) Bull. Assoc. Russe. Rech. Sci. Prague. 2: 135-162.
- Small E, Lassen P, Brookes BS (1987). An expanded circumscription of *Medicago* (*Leguminosae, Trifolieae*) based on explosive flower tripping. *Willdenowia*, 16: 415-437.
- Tutin TG, Heywood VH (1964). *Trigonella* L. *Flora Europaea*, Cambridge University Press, Cambridge. Vol. 1-2.
- Vasil'chenko IT (1953). Bericht über die Arten der Gattung, *Trigonella* Trudy Bot. Inst. Akad. Nauk. Flora of Russian. I: p. 10.
- Yılmaz A, Martin E, Ünal F, Akan H (2009). Karyological study on six *Trigonella* L. species (*Leguminosae*) in Turkey. *Caryologia*. 62: 89-94.

## APPENDIX

*Trigonella cretica* C2 Burdur: Gölhisar-Dirmil 4.km, 30.v. 2002, 900-950 m, conserved area, *Akan* 3480 and *Ekici*; *T. plicata* C4 Konya: Hadim-Konya 10.km, 17. vii. 2002, 1350 m, roadside, *Akan* 3789, *Aytaç* and *Ekici*; *T. brachycarpa* C4 Konya: Hadim-Konya 10. km, 17.vii. 2002, 1400 m, roadside, *Akan* 3786, *Aytaç* and *Ekici*; *T. rostrata* C4 Konya: East of Hadim-Karaman, 17. vii. 2002, 1250 m, roadside, *Akan* 3805, *Aytaç* and *Ekici*; *T. lunata* C6 Adana: Pozantı-Çiftehhan 8.km, 08. vi. 2003, 852 m, stony slopes, *Akan* 4687 and *Ekici*; *T. corniculata* B1 İzmir: Bayraklı, 26. v. 2002, 20-50 m, meadows, *Akan* 4616 and *Ekici*; B1/C2 Muğla: Bodrum castle, 25. v. 2002, 10 m, meadows, *Akan* 3391 and *Ekici*; *T. spinosa* C2 Muğla: Marmaris-Datça 50. km, 06. v. 2005, 5-10 m, maquis, *Akan* 5655 and *Ekici*; *T. spruneriana* C4 Konya: Konya-Akşehir, near Şaharen Village 22. v. 2003, 1165 m, roadside, *Akan* 4753 and *Ekici*; *T. sibthorpii* C3 Antalya: Serik, Kumköy, 22. v. 2002, 5m, sands, *Akan* 3307 *Aytaç* and *Ekici*; C5 Mersin: Mersin-Viranşehir, 21. v. 2002, 10 m, sands, *Akan* 3299 *Aytaç* and *Ekici*; *T. kotschyii* C4 İçel: İçel-Pozantı, between Ulukışla-Çiftehhan, 21. v. 2003, stony fots, *Akan* 4769 and *Ekici*; *T. mesopotamica* C7 Şanlıurfa: Şanlıurfa-Suruç, Payamlı, 20. v. 2003, 600-750 m, steppe, *Akan* 4577 and *Ekici*; *T. cylindraceae* C3 Antalya: Antalya-Akseki 10. km, 19. iv. 2002, 450 m, roadside, *Akan* 2843 and *Ekici*; *T. cilicica* C6 Adana: Şekerpınar-Ulukışla, 1. km, 28. vi. 2005, steppe, fots of mountains, *Akan* 5739 and *Ekici*; *T. filipes* C7 Şanlıurfa: Şanlıurfa-Suruç 20. km, 18. v. 2002, 550-600 m, roadside, *Akan* 3200 and *Ekici*; *T. velutina* C4 Karaman: Hadim-Konya, 17. vii. 2002, 1350 m, roadside, *Akan* 3790 *Aytaç* and *Ekici*; *T. strangulata* C5 Mersin: Tarsus-Egemen, 21. v. 2002, 870 m, stony places, *Akan* 3289 and *Ekici*; C3 Antalya: Akseki-Manavgat, 7-8 km., 30. vi. 2005, 935 m, stony fots, *Akan* 5758 and *Ekici*; *T. smyrnea* C2 Burdur: Gölhisar-Altınyayla 12. km, 29. vi. 2005, 1275 m, forest, *Akan* 5756 and *Ekici*; *T. aurantiaca* C2 Burdur: Gölhisar-Altınyayla 12. km, 29. vi. 2005, 1275 m, screen of forest, *Akan* 5753 and *Ekici*; *T. arenicola* C3 Antalya: Lara, 22. v. 2002, 5 m, sandy, *Akan* 3311 and *Ekici*; *T. fischeriana* B5 Kayseri: Ali Dağı, East fots, 08. vii. 2002, 1300 m, roadside, *Akan* 3654, *Aytaç* and *Ekici*; *T. tenuis* A9 Kars: Kağızman-Cumaçay 26. km, 14. vii. 2002, 1800 m, meadows, *Akan* 3742, *Aytaç* and *Ekici*; C2 Burdur: Gölhisar-Dirmil 10. km, 30. v. 2002, 1700 m, steppe, *Akan* 3504 and *Ekici*; *T. cancellata* B10 Ağrı: Doğubeyazıt-Çaldıran 20. km, 14. vii. 2002, 1350 m, steppe, *Akan* 3757, *Aytaç* and *Ekici*; *T. astroites* B5 Kayseri: Kayseri-Ürgüp, 29. km, 16. viii. 2002, 1180 m, roadside, *Akan* 3771 and *Ekici*; *T. halophila* C5 Mersin: Mersin-Egemen, 21. vi. 2002, 50 m, sands hills, *Akan* 3279 and *Ekici*; *T. crassipes* C3 Antalya: Hafızpaşa, 23. v. 2002, 750 m, maquis, *Akan* 3325 and *Ekici*; *ibid.* 1000 m, calcerous fots, *Akan* 3528 and *Ekici*; *T. polycarpa* C3

Antalya: Antalya-Lara, 07. v. 2005, 5 m, sandy, *Akan* 5658 and *Ekici*; *T. rigida* C6 Adana: Pozantı-Gülek pass, 21. vi. 2003, 900 m, fields, *Akan* 4737 and *Ekici*; Pozantı-Çiftehhan 8. km, 08. vi. 2003, 852 m, stony fots, *Akan* 4683 and *Ekici*; *T. pamphylica* C4 Antalya: Akseki-Seydişehir 10.km, 30. vi. 2005, 1200 m, open *Pinus brutia* forest, *Akan* 5764 and *Ekici*; *T. carica* C2 Muğla: Marmaris, İnişdibi district, 24. v. 2002, 200 m, maquis, *Akan* 3366 and *Ekici*; *T. arcuata* B6 Kayseri: road of Kayseri-Hisarcık, 08. vii. 2002, 1250 m, roadside, *Akan* 3723, *Aytaç* and *Ekici*; *T. monantha* subsp. *monantha* B5 Kayseri: Ali Dağı, NW fots, 08. vii. 2002, 1350 m, in opening of *Quercus* scrub, *Akan* 3656, *Aytaç* and *Ekici*; C7 Şanlıurfa: Urfa-Bozova, exit of Tektaş village, 13. v. 2006, 720 m, fieldside, *MNM* 1061; C3 Antalya: Antalya-Kalkan, 24. v. 2002, 20 m, maquis, *Akan* 3356, *Aytaç* and *Ekici*; *T. monantha* subsp. *noeana* C7 Şanlıurfa: Birecik-Nizip 4.km, meadows, *Akan* 3207 and *Ekici*; *T. orthoceras* B5 Kayseri: Hisarcık-Erciyes road, 08. vii. 2002, 1550 m, *Akan* 3658, *Aytaç* and *Ekici*; A9 Kars: Kağızman-Cumaçay 26. km, 14. vii. 2002, 1800 m, meadows, *Akan* 3746, *Aytaç* and *Ekici*; *T. monspeliaca* C2 Muğla: Dalaman, Ortaca district, 24. v. 2002, 20 m, stony places, *Akan* 3358 and *Ekici*; C3 Antalya: Antalya-Hafızpaşa, 23. v. 2002, 750 m, maquis, *Akan* 3327 and *Ekici*; *T. isthmocarpa* B5 Aksaray: 28 km E of Aksaray, Hasan Dağı fots 08. vi. 2003, 1145 m, *Akan* 4695 and *Ekici*; *T. rhytidocarpa* C5 Niğde: Ulukışla-Pozantı, 5.km, 16. vii. 2002, 1300 m, roadside, *Akan* 3778 and *Ekici*; *T. spicata* C2 Antalya-Bucak 20. km, Pınarbaşı district, 23. vi. 2002, 220-250 m, clearing of *Quercus coccifera*, *Akan* 3319 and *Ekici*, *Karavelioğulları*; *T. cephalotes* C1 Aydın: The National park of the Dilek Peninsula, Aydınlık small bay, 26. ii. 2002, 70 m, *Akan* 3398 and *Ekici*; *T. procumbens* B3 Konya: Akşehir-Gelendost 1-2. km, 22. vi. 2003, 1110 m, roadside of vineyards, *Akan* 4760 and *Ekici*; *T. capitata* C2 Denizli: Pamukkale, 22. vi. 2003, 1550 m, opening of damaged forest, *Akan* 4767 and *Ekici*; *T. coerulescens* C4 Konya: Ereğli-Karapınar 20-25 km, 01.vii. 2002 1000 m, steppe, *Akan* 3587 *Aytaç* and *Ekici*; B5 Kayseri: Kayseri, Hisarcık, Erciyes mountain road, 08. vii. 2002, 1550 m, *Akan* 3659 and *Ekici*; *T. gladiata* C4 Karaman: Pınarbaşı-Kızılkaya 2. km, 28. vii. 2005, 1200 m, opening of *Quercus*, *Akan* 5743 and *Ekici*; *T. cariensis* B1 İzmir: Ayrancılar-İzmir 6. km, 25. v. 2003, 100 m, fots of maquis, *Akan* 4620 and *Ekici*; C3 Antalya: Antalya-Hafızpaşa-Bucak 5. km, 23. v. 2002, 775m, *Akan* 3332 and *Ekici*; *T. foenum-graecum* C5 Adana: Ceyhan-Adana 13. km., 20. v. 2002, 120 m, fields, *Akan* 3274; *T. macrorrhyncha* C4 İçel: Tarsus-Çamliyayla road, 30. km, 18. v. 2003, 850 m, steppe, *Akan* 4354 and *Ekici*.