

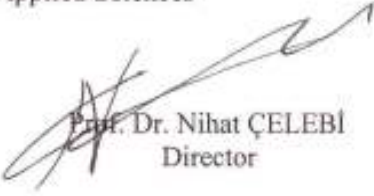
REVISION OF THE GENUS *TULIPA* L. (LILIACEAE) IN TURKEY

by
İSMAİL EKER

THESIS SUBMITTED TO
THE GRADUATE SCHOOL OF NATURAL AND APPLIED SCIENCES
OF
THE ABANT İZZET BAYSAL UNIVERSITY
IN PARTIAL FULFILLMENT OF THE REQUIREMENTS FOR THE DEGREE
OF DOCTOR OF PHILOSOPHY
IN
THE DEPARTMENT OF BIOLOGY

FEBRUARY 2010

Approval of the Graduate School of Natural and Applied Sciences



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I certify that this thesis satisfies all the requirements as a thesis for the degree of Doctor of Philosophy.



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This is to certify that we have read this thesis and that in our opinion it is fully adequate, in scope and quality, as a thesis for the degree of Doctor of Philosophy.



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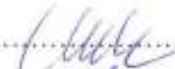
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ABSTRACT

REVISION OF THE GENUS *TULIPA* L. (LILIACEAE) IN TURKEY

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Ph.D. Department of Biology

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February 2010, 294 pages

In this study, the genus *Tulipa* L. in Turkey is revised by using morphological, palynological and cytotaxonomical data. Approximately 1000 fresh and 2000 herbarium specimens belonging to the genus have been examined. In the morphological studies, two systems have been applied for evaluation of the taxa and compared: traditional taxonomy and numerical taxonomy.

After detailed analysis of the taxa, the genus *Tulipa* in Turkey is represented by 17 species, 1 subspecies and 1 variety (19 taxa). The genus is divided into two subgenera: *Eriostemon* and *Tulipa* which were previously used as sections by Marais in “*Flora of Turkey*”. The subgenus *Eriostemon* is divided into five sections adding two new sections: *Sylvestres*, *Orphanideae* sect. nov., *Humiles* sect. nov., *Saxatiles*, *Biflores*. The other subgenus *Tulipa* is divided into two sections: *Tulipa* and *Clusianae*. In section *Sylvestres*, *T. sylvestris* is separated into two subspecies:

subsp. *sylvestris* and subsp. *australis*. In section *Orphanideae*, *T. karamanica* is reduced to synonym of *T. cinnabarina*. In section *Humiles*, *T. pulchella* is increased to species status which was formerly assigned as a synonym of *T. humilis*. Within section *Biflores*, a new species, *T. koyuncui* is described. In section *Tulipa*, *T. armena* var. *lycica* is reduced to synonym of *T. armena*. However, *T. armena* is divided into two varieties: var. *armena* and var. *galatica*. Also, *T. gumusanica* is reduced to synonym of *T. armena* var. *galatica*. A new determination key, detailed descriptions, synonyms and typifications of taxa, features of distribution, habitat, locality and conservation status of all taxa are given.

Keywords: *Tulipa*, Tulip, Turkey Liliaceae, Revision, Taxonomy, Systematics, Classical taxonomy, Numerical taxonomy.

ÖZET

TULIPA L. (LILIACEAE) CINSİNİN TÜRKİYE REVİZYONU

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Şubat 2010. 294 sayfa

Bu çalışmada, Türkiye'deki *Tulipa* L. cinsi morfolojik, palinolojik ve sitotaksonomik veriler kullanılarak yeniden revize edilmiştir. Cinse ait yaklaşık 1000 kendi topladığımız taze örnek ile 2000 herbaryum örneği incelenmiştir. Morfolojik çalışmalarda, klasik ve numerik taksonomi metodları kullanılmış ve karşılaştırılmıştır.

Taksonların detaylı analizi, Türkiye'deki *Tulipa* cinsinin 17 tür, 1 alttür ve 1 varyeteden (19 takson) oluştuğunu ortaya koymaktadır. Daha önce *Flora of Turkey*'de Marais tarafından seksiyon statüsünde kabul edilen iki seksiyon iki altcinsle yükseltilmiştir: *Eriostemon* ve *Tulipa*. Altciins *Eriostemon*'e 2 yeni seksiyon eklenerek 5 seksiyona ayrılmıştır: *Sylvestres*, *Orphanideae* sect. nov., *Humiles* sect. nov., *Saxatiles*, *Biflores*. Diğer altciins *Tulipa* 2 seksiyona ayrılmıştır: *Tulipa* ve *Clusianae*. *Sylvestres* seksiyonundaki *T. sylvestris* iki alttüre ayrılmıştır:

subsp. *sylvestris* ve subsp. *australis*. *Orphanideae* seksiyonundaki *T. karamanica*, *T. cinnabarina*'nın sinonimi durumuna indirgenmiştir. *Humiles* seksiyonunda ise *T. humilis*'in sinonimi kabul edilen *T. pulchella* tekrar tür düzeyine çıkarılmıştır. *Biflores* seksiyonunda yeni bir tür, *T. koyuncui* tanımlanmıştır. *Tulipa* seksiyonundaki *T. armena* var. *lycica*, *T. armena*'nın sinonimi durumuna indirgenmiştir. Bununla birlikte, *T. armena* 2 varyeteye ayrılmıştır: var. *armena* ve var. *galatica*. Keza, *T. gumusanica*, *T. armena* var. *galatica*'nın sinonimi durumuna indirgenmiştir. Taksonlara ait yeni bir tür belirleme anahtarı ve taksonların detaylı betimleri, sinonimleri ve tipifikasyonları, yayılış alanları, habitat ve lokalite özellikleri ile tehlike kategorileri verilmiştir.

Anahtar Kelimeler: *Tulipa*, Lale, Türkiye, Liliaceae, Revizyon, Taksonomi, Sistematiik, Geleneksel taksonomi, Numerik taksonomi.

To My Mother

ACKNOWLEDGEMENTS

I express sincere appreciation to my supervisors, Prof. Dr. M. Tekin BABAÇ and Prof. Dr. Mehmet KOYUNCU for their guidance and insight throughout the research. I would like to thank my committee members, Prof. Dr. Mecit VURAL and Prof. Dr. Şinasi YILDIRIMLI for their suggestions and comments. I offer my gratefull thanks to Ass. Prof. Dr. Serap IŞIK and Prof. Dr. Emel OYBAK DÖNMEZ for their contributions on the palynological part of this thesis. Many thanks to Ass. Prof. Dr. Emel USLU for checking the English grammar and Prof. Dr. Ali A. DÖNMEZ for checking the nomeclatural rules used in this thesis. I would like to thank Abant İzzet Baysal University for financial support (project no: BAP–2007.0301.265), I am also grateful for the former and present heads of department of biology, Prof. Dr. M. Tekin BABAÇ and Prof. Dr. Ömer BOZDOĞAN who allowed me to use facilities in the department during my study. I offer sincere thanks to my mother Fatma AK, my brother Ekrem EKER, my sisters Azize and Zeliha EKER, and Sevim KOYUNCU for their unshakable faith in me.

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ABBREVIATIONS

B	Botanischer Garten und Botanisches Museum Berlin/Germany
Eker	İsmail EKER
ellip	ellipsoid
ellip-sp	ellipsoid-spheroidal
G	Conservatoire et Jardin bot. de la Ville de Genève/Switzerland
GB	University of Gothenburg/Sweden
Hb. Linn.	Linnean Society of London/U.K. England
LA	Long axis
LM	Light microscopy
NT	Numerical taxonomy
OTUs	Operational taxonomic units
PCA	Principle component analysis
SA	Short axis
SEM	Scanning electron microscopy
s.l.	sea level
SL	Similarity level
TBV	Tulip breaking (mosaic) virus

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Ph.D. Department of Biology

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ÖZET

TULIPA L. (LILIACEAE) CINSİNİN TÜRKİYE REVİZYONU

Eker, İsmail

Doktora. Biyoloji Bölümü

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Şubat 2010. 294 sayfa

Bu çalışmada, Türkiye'deki *Tulipa* L. cinsi morfolojik, palinolojik ve sitotaksonomik veriler kullanılarak yeniden revize edilmiştir. Cinse ait yaklaşık 1000 kendi topladığımız taze örnek ile 2000 herbaryum örneği incelenmiştir. Morfolojik çalışmalarda, klasik ve numerik taksonomi metodları kullanılmış ve karşılaştırılmıştır.

Taksonların detaylı analizi, Türkiye'deki *Tulipa* cinsinin 17 tür, 1 alttür ve 1 varyeteden (19 takson) oluştuğunu ortaya koymaktadır. Daha önce *Flora of Turkey*'de Marais tarafından seksiyon statüsünde kabul edilen iki seksiyon iki altcins yükseltilmiştir: *Eriostemon* ve *Tulipa*. Altains *Eriostemon*'e 2 yeni seksiyon eklenerek 5 seksiyona ayrılmıştır: *Sylvestres*, *Orphanideae* sect. nov., *Humiles* sect. nov., *Saxatiles*, *Biflores*. Diğer altains *Tulipa* 2 seksiyona ayrılmıştır: *Tulipa* ve *Clusianae*. *Sylvestres* seksiyonundaki *T. sylvestris* iki alttüre ayrılmıştır:

subsp. *sylvestris* ve subsp. *australis*. *Orphanideae* seksiyonundaki *T. karamanica*, *T. cinnabarina*'nın sinonimi durumuna indirgenmiştir. *Humiles* seksiyonunda ise *T. humilis*'in sinonimi kabul edilen *T. pulchella* tekrar tür düzeyine çıkarılmıştır. *Biflores* seksiyonunda yeni bir tür, *T. koyuncui* tanımlanmıştır. *Tulipa* seksiyonundaki *T. armena* var. *lycica*, *T. armena*'nın sinonimi durumuna indirgenmiştir. Bununla birlikte, *T. armena* 2 varyeteye ayrılmıştır: var. *armena* ve var. *galatica*. Keza, *T. gumusanica*, *T. armena* var. *galatica*'nın sinonimi durumuna indirgenmiştir. Taksonlara ait yeni bir tür belirleme anahtarı ve taksonların detaylı betimleri, sinonimleri ve tipifikasyonları, yayılış alanları, habitat ve lokalite özellikleri ile tehlike kategorileri verilmiştir.

Anahtar Kelimeler: *Tulipa*, Lale, Türkiye, Liliaceae, Revizyon, Taksonomi, Sistematiik, Geleneksel taksonomi, Numerik taksonomi.

To My Mother

ACKNOWLEDGEMENTS

I express sincere appreciation to my supervisors, Prof. Dr. M. Tekin BABAÇ and Prof. Dr. Mehmet KOYUNCU for their guidance and insight throughout the research. I would like to thank my committee members, Prof. Dr. Mecit VURAL and Prof. Dr. Şinasi YILDIRIMLI for their suggestions and comments. I offer my gratefull thanks to Ass. Prof. Dr. Serap IŞIK and Prof. Dr. Emel OYBAK DÖNMEZ for their contributions on the palynological part of this thesis. Many thanks to Ass. Prof. Dr. Emel USLU for checking the English grammar and Prof. Dr. Ali A. DÖNMEZ for checking the nomeclatural rules used in this thesis. I would like to thank Abant İzzet Baysal University for financial support (project no: BAP–2007.0301.265), I am also grateful for the former and present heads of department of biology, Prof. Dr. M. Tekin BABAÇ and Prof. Dr. Ömer BOZDOĞAN who allowed me to use facilities in the department during my study. I offer sincere thanks to my mother Fatma AK, my brother Ekrem EKER, my sisters Azize and Zeliha EKER, and Sevim KOYUNCU for their unshakable faith in me.

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ABBREVIATIONS

B	Botanischer Garten und Botanisches Museum Berlin/Germany
Eker	İsmail EKER
ellip	ellipsoid
ellip-sp	ellipsoid-spheroidal
G	Conservatoire et Jardin bot. de la Ville de Genève/Switzerland
GB	University of Gothenburg/Sweden
Hb. Linn.	Linnean Society of London/U.K. England
LA	Long axis
LM	Light microscopy
NT	Numerical taxonomy
OTUs	Operational taxonomic units
PCA	Principle component analysis
SA	Short axis
SEM	Scanning electron microscopy
s.l.	sea level
SL	Similarity level
TBV	Tulip breaking (mosaic) virus

CHAPTER 1. INTRODUCTION

The genus *Tulipa* L. is one of the members of the family Liliaceae. The Liliaceae was formerly treated as a large family (Liliaceae *sensu lato*). According to Cronquist (1981), the Liliaceae consisted of about 280 genera and nearly 4000 species. But more recently studies have broken it up into numerous segregate families such as Smilacaceae, Ruscaceae, Asparagaceae, Convallariaceae, Asphodelaceae, Anthericaceae, Alliaceae, Hyacinthaceae, Nartheciaceae, Hemerocallidaceae, Liliaceae, Colchicaceae etc.

Takhtajan (1997) included three tribes and 10 genera in the Liliaceae *sensu stricto*: Lloydieae includes *Gagea* Salisb., and *Lloydia* Salisb. ex Reichenb. Liliaceae Ritgen contains *Cardiocrinum* (Endl.) Lindl., *Lilium* L., *Notholirion* Wall. ex Boiss., *Nomocharis* Franch., *Fritillaria* L., and *Rhinopetalum* Fisch. ex D. Don. Tulipeae Koch comprises *Tulipa* L. and *Erythronium* L.

The Liliaceae comprising 11 genera and about 550 species according to last studies, distributed in mostly steppes and mountain meadows of temperate and subtropical regions of the northern hemisphere, especially western Asia, Himalayas, and eastern Asia (Tamura, 1998). The Liliaceae can be subdivided into two subfamilies: Medeoloideae (Benth.) M.N. Tamura and Lilioideae Engl. Medeoloideae comprises *Medeola* L. and *Clintonia* Rafin. Lilioideae can be further divided into two tribes: Tulipeae Koch and Liliaceae Ritgen. The Tulipeae include *Gagea* Salisb. (c. 90), *Lloydia* Salisb. ex Reichenb. (c. 20), *Tulipa* L. (c. 150), and

Erythronium L. (24). The Liliaceae include *Fritillaria* L. (c. 130), *Nomocharis* Franch. (7), *Notholirion* Wall. ex Boiss. (5), *Cardiocrinum* Endl. (3), and *Lilium* L. (c. 110). (Tamura, 1998; Hayashi and Kawano, 2000; Patterson and Givnish, 2002; Simpson, 2006). However, the relationships among the major groups of the Liliaceae are still being discussed.

Tulipa seems to be closely related to *Erythronium*, which has 24 species in temperate regions of the Northern Hemisphere, abundant in western North America (15). In Turkey, there is only one record of *Erythronium dens-canis* L. from İstanbul Belgrad forest in 1857. But, after it was first collected by Louis Charrel, there is no recent records, possibly extinct in Turkey (Edmondson, 1984; Tamura, 1998).

The other genera, *Gagea* and *Lloydia* placed within the same tribe with *Tulipa*, are very similar. *Gagea* has about 90 species in temperate Eurasia while *Lloydia* has about 20 species in temperate regions of the Northern Hemisphere, abundant in Eurasia (Tamura, 1998).

1.1. The genus *Tulipa* L.

The mainland of the genus *Tulipa* L. is the Tien Shan and Pamir Alai mountain ranges in the Central Asia. The genus extends naturally from central Asia, western China, and the western Himalaya to the west, spreads Caucasus, Turkey, Iran and the Middle East. In the North, the range reaches southern Siberia, and to the south, progress is halted by the hot, dry deserts of the Arabian Peninsula and south-eastern Pakistan, and the Sahara of Africa. Moreover, although the genus also spreads from the Iberian Peninsula of south-western Europe and North Africa, to along the northern and southern coasts of the Mediterranean, these regions are not natural distribution areas of the species. It is thought that these species were formerly carried

by merchants and travelers from Anatolia and the Central Asia and then, these species escaped from cultivation to the wild and naturalized (Figure 1) (Hoog, 1973; Pavord, 1999; Dobbs, 2003; Juodkaite et al., 2005; Wilford, 2006; Tuyl & Creij, 2006).

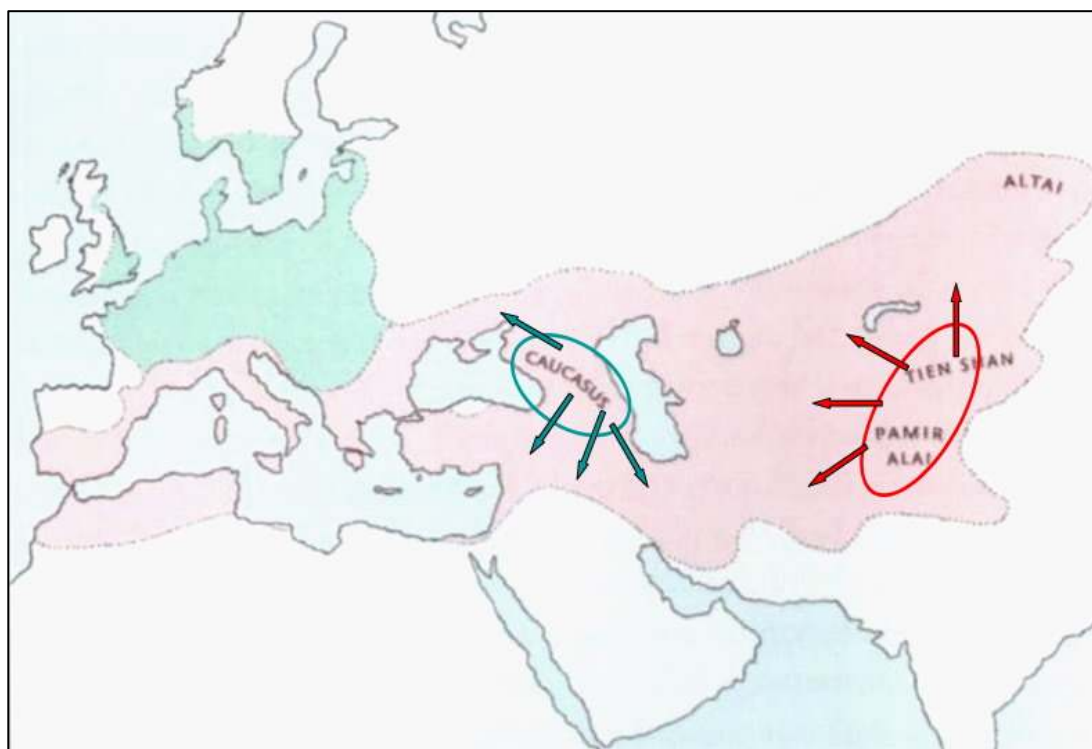


Figure 1. The origin of the genus *Tulipa* in the world: The area shown in red, the natural distribution spreads from south-western Europe and North Africa to north-western China and the western Himalaya. The area shown in green in northern Europe includes naturalized plants, primarily *T. sylvestris* (Wilford, 2006).

The definite number of tulip taxa in the world has not been known exactly, but according to different researchers the genus *Tulipa* is represented by between 40-150 species. In the world checklist of selected plant families (Govaerts, 2009), for *Tulipa*, 469 were named and 113 were accepted there. Most of species are distributed in the Central Asia and Caucasus (65 species), Iran and adjoining regions (36 species), and

Turkey (17 species) (Table 1) (Bonnet & Barratte, 1896; Borg, 1927; Post & Dinsmore, 1933; Vvedenskii, 1935; Korovin, 1941; Stojanov & Stefanov, 1948;

Table 1. Distribution and number of species belonging to the genus *Tulipa* L. in the world.

Turkey	17 species (18 taxa)
Flora of the USSR (including Russia, Central Asia and Caucasus)	65 species
Kazakhstan	32 species
Tajikistan	25 species
Uzbekistan	21 species
Russia	6 species
Armenia	7 species
Flora Iranica (including Iran, Afghanistan, West-Pakistan, North-Iraq, Azerbaijan, Turkmenistan)	36 species (38 taxa)
Iraq	3 species (4 taxa)
Syria, Palastine and Sinai	10 species (13 taxa)
Palaestine	3 species (4 taxa)
Israel	5 species
Jordan	3 species
Saudi Arabia	1 species
Pakistan	6 species
Afghanistan	8 species
India	2 species (6 taxa)
Balkans	7 species
Greece	6 species
Bulgaria	4 species (7 taxa)
Croatia	2 species
Romania	6 species (7 taxa)
Serbia	5 species
Helvetia	2 species (3 taxa)
Malta	2 species
Flora Europea	11 species (12 taxa)
Italy	9 species
France	13 species
Iberian Peninsula	6 species
Cyprus	2 species
Crete	4 species
Chios	4 species
Corsica	2 species
Morocco	1 species (2 taxa)
Egypt	2 species
Algeria	1 species
Libya	1 species
Tunis	1 species
North Africa	4 species (9 taxa)
China	14 species
Hungary	1 species
Mongolia	1 species

Maire et al., 1958; Pavlov, 1958; Kitamura, 1960; Ovchinnikov, 1963; Heß et al., 1967; Hoog, 1973; Soó, 1973; Josifović, 1975; Zangheri, 1976; Jafri & El-Gadi, 1978; Guinochet & Vilmorin, 1978; Grey-Wilson & Matthews, 1980; Grubov, 1982; Beniston & Beniston, 1984; Stork, 1984; Marais, 1984; Wendelbo, 1985; Meikle, 1985; Feinbrun, 1986; Polunin, 1987; Huxley & Taylor, 1989; Rechinger, 1990; Sfikas, 1992; Turland et al., 1993; Matin & Iranshahr, 1998; Dawud, 1998; Pavord, 1999; Persson, 2000; Özhatay & Koçak, 2000; Xinqi & Mordak, 2000; Nikolić, 2000; Ciocârlan, 2000; Takhtajan, 2001; Snogerup et al., 2001; Fedorov, 2001; Chaudhary, 2001; Terzioğlu & Coşkunçelebi, 2002; Valdés et al., 2002; Zhao, 2003; Boulos, 2005; Wilford, 2006; Sing & Sanjappa, 2006; Ghahreman et al., 2007; Ali & Qaiser, 2007; Jeanmonod & Gamisans, 2007; Lauber & Wagner, 2007; Zonneveld, 2009; Anonymous 1, 2009a; Anonymus 2, 2009b).

1.2. Classification History of the Genus *Tulipa* L.

First scientific records about the genus *Tulipa* was appeared in Linnaeus' *Species Plantarum* (1753). He published three species including *Tulipa gesneriana*, *T. sylvestris*, and *T. breyniana*. But, *T. breyniana* is now placed in *Baeometra* (Colchicaceae). However, another species *Tulipa uniflora* was appeared as *Ornithogalum uniflorum* in the same publication (Linnaeus 1753; Wilford, 2006).

After years, three new species were published by different researchers: *Tulipa biflora* was described (1776) by Peter Simon von Pallas in *Reise*. *T. suaveolens*, from cultivated plant, was described (1794) by Roth in *Annals of Botany*. *T. australis* was described (1799) by Link in *Schrader J.f.d. Bot* (Hall, 1940).

Augustin Pyramus de Candolle described three new species: *T. chusiana* in 1802, *T. celsiana* in 1803, and *T. agenensis* in 1804 in the first four volumes of

Redoute's Liliacees. He also published four tulips in the third edition of *Flore Française* (1805) including *T. sylvestris*, *T. suaveolens*, *T. gesneriana*, and *T. oculus-solis* (syn. *T. agenensis*). (de Candolle, 1805; Wilford, 2006).

Eugenio de Reboul first divided thirteen tulip species, known from southern Europe, into two groups in the second volume of *Giornale Botanico Italiano* (1847) (Table 2). Reboul's classification is very important because the hairiness of the bulb tunic is first used as a characteristic for subdividing the genus. This characteristic is still used today. (Reboul, 1847).

Table 2. Reboul's classification on the genus *Tulipa*.

<i>Tulipanum</i> Reboul: species with a woolly layer of hairs on the inside of the bulb tunic	<i>Dulipanum</i> Reboul: species do not have a woolly layer inside the tunic
<i>T. strangwaysiana</i>	<i>T. sylvestris</i> <i>T. bonarotiana</i>
<i>T. praecox</i>	<i>T. gesneriana</i> <i>T. neglecta</i>
<i>T. oculus-solis</i>	<i>T. serotina</i> <i>T. variopicta</i>
<i>T. maleolens</i>	<i>T. strangulata</i> <i>T. suaveolens</i>
<i>T. clusiana</i>	

Carolus Koch (1849) described two new species and placed another species in *Linnaea*. He also used the hairiness of the bulb tunic to divide the genus (Table 3).

Table 3. Koch's classification on the genus *Tulipa*.

<i>Lanigera</i> C. Koch: species with hairy tunics	<i>Leiobulbos</i> C. Koch: species with glabrous tunics
<i>T. Julia</i> C. Koch	<i>T. biebersteiniana</i> R. et S. <i>T. thirkeana</i> C. Koch

Eduard Regel first divided the genus (1873) into two groups based on the presence or absence of hairs on the base of filaments. This character is still used in modern classifications to split the genus in two, and recent studies of tulip DNA and pollen have supported this view. He divided the twenty-six species into two primary sections, which he did not name, in the second volume of *Acta Horti Petropolitani*. Regel used various characteristics to identify species, such as hairiness of the flower stem, shape of the tepals and leaves, and hairiness of the bulb tunic (Regel, 1873; Wilford, 2006) (Table 4).

Regel described more tulip species in *Gartenflora* and *Acta Horti Petropolitani*, including *T. eichleri* and *T. korolkowi* in 1874, *T. turkestanica* in 1875, *T. kaufmanniana*, *T. albertii* and *T. kolpakowskiana* in 1877, *T. kesselringi* in 1878, *T. iliensis* in 1879, *T. ostrowskiana*, *T. linifolia* and *T. lanata* in 1884, *T. batalini* and *T. maximowiczi* in 1889 (Regel, 1874a, 1874b, 1875, 1877a, 1877b, 1878, 1879, 1884a, 1884b, 1889; Hall, 1940; Wilford, 2006).

Table 4. Regel's classification on the genus *Tulipa*.

Base of inner sepals and stamens pubescent	Base of inner sepals and stamens glabrous		
<i>T. sylvestris</i> L.	<i>T. oculus-solis</i> St. Amand	<i>T. baeotica</i> Boiss. et Heldr.	<i>T. sibthorpiana</i> Sm.
<i>T. biflora</i> L.	<i>T. didieri</i> Jordan	<i>T. gesneriana</i> L.	<i>T. suaveolens</i> Roth.
<i>T. celsiana</i> Redouté.	<i>T. borszczowi</i> Regel	<i>T. schrenki</i> Regel	<i>T. strangulata</i> Reboul
<i>T. saxatilis</i> Sieber.	<i>T. julia</i> C. Koch	<i>T. lehmanniana</i> Merckl.	<i>T. altaica</i> Pall.
	<i>T. boissieri</i> Regel	<i>T. soogdiana</i> Bunge	<i>T. turcica</i> Roth
	<i>T. greigi</i> Regel	<i>T. armena</i> Boiss.	<i>T. undulatifolia</i> Boiss.
	<i>T. eunanthiae</i> Orph.	<i>T. clusiana</i> Vent.	
	<i>T. aleppensis</i> Boiss.	<i>T. montana</i> Lindl.	

John Gilbert Baker published a monograph on tribe Tulipeae in the *Journal of the Linnean Society* in 1874. He included the genus *Orithyia*, established by David

Don in 1836, within *Tulipa*, treating it as subgenus *Orithyia* (D. Don) Baker. He placed all the other species in subgenus *Eutulipa* Baker and divided them into five sections: *Eriobulbi* Baker, *Gesnerianae* Baker, *Scabriscapae* Baker, *Saxatiles* Baker, and *Silvestres* Baker (Table 5). Nine years later, Baker revised his classification in *The Gardeners' Chronicle* in 1883. He changed the name of subgenus *Eutulipa* as subgenus *Tulipa* and again divided it into five sections: *Eriobulbae* Baker, *Clusianae* Baker, *Gesnerianae* Baker, *Saxatiles* Baker, and *Sylvestres* Baker. Also, he changed the arrangement of species and separated section *Gesnerianae* into four sub-sections (Baker, 1874, 1883a, 1883b; Wilford, 2006) (Table 6).

A couple of his sectional names, *Clusianae* and *Saxatiles*, are still in use, but his classification has been largely discredited, as it places too much emphasis on unreliable characteristics, such as flower colour (Wilford, 2006). Baker also described several new species in *The Gardeners' Chronicle* between 1883-1894 including *Tulipa aucheriana*, *T. ciliatula*, *T. sintenisii*, *T. concinna* and *T. sprengeri* (Baker, 1883c, 1890, 1891, 1893, 1894).

Table 5. Baker's monograph on the genus *Tulipa* in the *Journal of the Linnean Society* in 1874.

Subgenus <i>Eutulipa</i> Baker: Style obsolete.	
Section <i>Eriobulbi</i> Baker: Inner tunics densely lanate. Peduncle glabrous, smooth. Filament base glabrous.	
<i>T. oculus-solis</i> St. Amans (syn: <i>T. oculus-solis</i> var. <i>typica</i> Regel, <i>T. agenensis</i> , <i>T. acutiflora</i> Poir.)	
var. <i>lortetii</i> Baker (syn: <i>T. lortetii</i> Jord.)	
var. <i>lycica</i> Baker	
var. <i>aleppica</i> Baker (syn: <i>T. aleppica</i> Boiss. & Hausskn.)	
<i>T. sogdiana</i> Bunge	
<i>T. chrysantha</i> Boiss. (syn: <i>T. lehmanniana</i> Merckl., <i>T. undulata</i> Jacquem.)	
<i>T. montana</i> Lindl. (syn: <i>T. armeniaca</i> Parkinson)	
var. <i>julia</i> K. Koch	
<i>T. maleolens</i> Reboul (syn: <i>T. oculus-solis</i> var. <i>maleolens</i> Regel)	
var. <i>variegata</i> Sweet	
<i>T. praecox</i> Ten. (syn: <i>T. gesneriana</i> , <i>T. oculus-solis</i> , <i>T. bombycina</i> flore rubro Parkinson, <i>T. oculus-solis</i> var. <i>praecox</i> Regel)	
<i>T. clusiana</i> Vent. (syn: <i>T. praecox</i> Car., <i>T. rubro-alba</i> Brotero, <i>T. persica</i> praecox Clus., <i>T. persica</i> Parkinson)	
<i>T. stellata</i> Hook. (syn: <i>T. clusiana</i> var. <i>stellata</i> Regel)	
<i>T. borszczowi</i> Regel	

Table 5. (continued).

Section <i>Gesnerianae</i> Baker: Inner tunics glabrous or slightly adpressed pilose. Peduncle glabrous, smooth. Filament base glabrous. <i>T. acuminata</i> Vahl. (syn: <i>T. stenopetala</i> Mord., <i>T. cornuta</i> DC., <i>T. turcica</i> Kunth) <i>T. retroflexa</i> Hort. <i>T. bithynica</i> Griseb. <i>T. didieri</i> Jord. (syn: <i>T. gesneriana</i> Bellardi non L.) var. <i>mauriana</i> Jord. var. <i>planifolia</i> Jord. var. <i>billietiana</i> Jord. <i>T. campsopetala</i> Delaunay (syn: <i>T. gesneriana</i> L. var. ? <i>campsopetala</i> Kunth) <i>T. serotina</i> Reboul <i>T. boissieri</i> Regel (syn: <i>T. pulchella</i> Boiss.) <i>T. gesneriana</i> L. <i>T. fulgens</i> Hort. <i>T. platystigma</i> Jord. (syn: <i>T. didieri</i> Gren.)
Section <i>Scabriscapae</i> Baker: Inner tunics glabrous or slightly adpressed pilose. Peduncle slightly pubescent. Filament base glabrous. <i>T. undulatifolia</i> Boiss. <i>T. elegans</i> Hort. <i>T. boeotica</i> Boiss & Heldr. (syn: <i>T. strangulata</i> et <i>oculus-solis</i> Heldr.) <i>T. strangulata</i> Reboul (syn: <i>T. scabriscapa</i> var. <i>strangulata</i> Fox-Strangw.) <i>T. suaveolens</i> Roth (syn: <i>T. dubia</i> pumilio Clus., <i>T. praecox</i> Parkinson) <i>T. altaica</i> Pall. <i>T. eunanthiae</i> Orph. <i>T. pubescens</i> Willd. (syn: <i>T. suaveolens</i> β. <i>pubescens</i> Kunth, <i>T. suaveolens</i> β. <i>latifolia</i>) <i>T. maculata</i> Hort. <i>T. greigi</i> Regel
Section <i>Saxatiles</i> Baker: Perianth purplish at both surfaces. Filament base bearded. <i>T. saxatilis</i> Sieb. <i>T. pulchella</i> Fenzl (syn: <i>T. sylvestris</i> var. <i>pulchella</i> Regel, <i>T. alpina</i> J. Gay)
Section <i>Silvestres</i> Baker: Perianth yellow or light-yellow within, never purplish. Bulb tunic apice pilose. Filament base bearded. <i>T. violaceae</i> Boiss. et Buhse <i>T. sylvestris</i> L. <i>T. fragrans</i> Munby <i>T. biebersteiniana</i> Schult f. (syn: <i>T. sylvestris</i> Pall. non L., <i>T. sylvestris</i> β. minor, <i>T. sylvestris</i> β. <i>biebersteiniana</i> Regel, <i>T. pumila</i> Tausch., <i>T. celsiana</i> Henning) var. <i>aurantiaca</i> Baker <i>T. patens</i> Agardh (syn: <i>T. tricolor</i> Led., <i>T. sylvestris</i> var. <i>tricolor</i> Led.) <i>T. biflora</i> L. (syn: <i>Orihyia biflora</i> Kunth, <i>T. sylvestris</i> var. <i>biflora</i> Led.) <i>T. humilis</i> Herb. (syn: <i>T. buhseana</i> Boiss., <i>T. biflora</i> var. <i>buhseana</i> Regel) <i>T. microgyna</i> Baker <i>T. australis</i> Link (syn: <i>T. celsiana</i> DC., <i>T. transtagana</i> Brot., <i>T. breyniana</i>, <i>T. sylvestris</i> Gouan et Desf., <i>T. narbonensis</i> et <i>lusitanica</i> Parkinson) <i>T. crispatula</i> Boiss. et Buhse <i>T. gallica</i> Lois. (syn: <i>T. acrocarpa</i> Jord.) <i>T. orphanidea</i> Boiss. (syn: <i>T. orphanidesii</i> hort. Angl., <i>T. mineryae</i> et <i>atheniensis</i> Orph., <i>T. sylvestris</i> var. <i>orphanidea</i> Regel) <i>T. cretica</i> Boiss. & Heldr. (syn: <i>T. sylvestris</i> var. <i>cretica</i> Regel) <i>T. lownei</i> Baker var. <i>haynei</i> Baker
Subgenus <i>Orithyia</i> (D. Don) Baker: Style and ovary at equal long. <i>T. uniflora</i> Besser (syn: <i>Ornithogalum uniflorum</i> L., <i>Gagea uniflora</i> G. Don, <i>Orithyia uniflora</i> D. Don) <i>T. heterophylla</i> Baker (syn: <i>Orithyia heterophylla</i> Regel) <i>T. edulis</i> Baker (syn: <i>Orithyia edulis</i> Miq., <i>Orithyia oxypetala</i> A. Gray)
Doubtful species <i>T. oxypetala</i> Steven

Table 6. Baker's revised classification on the genus *Tulipa* in the *Gardeners' Chronicle* in 1883.

Subgenus <i>Tulipa</i>: Ovary with a sessile stigma
Section <i>Eriobulbae</i> Baker: Filaments without a turf of hairs at the base. Outer bulb-coats densely coated inside with soft intertangled cottony hairs. Lower leaf usually oblong-lanceolate, and perianth bright red. <i>T. oculus-solis</i> St. Amans (syn: <i>T. agenensis</i> DC., <i>T. acutiflora</i> Poir.) <i>T. praecox</i> Ten. <i>T. montana</i> Lindl. <i>T. maleolens</i> Reboul <i>T. sogdiana</i> Bunge
Section <i>Clusianae</i> Baker: Filaments without a turf of hairs at the base. Outer bulb-coats densely hairy inside. Leaves narrow and grass-like. Flowers between funnel-shaped and campanulate, mainly white. <i>T. clusiana</i> Vent. (syn: <i>T. praecox</i> Cavanilles, <i>T. rubro-alba</i> Brotero) <i>T. stellata</i> Hook.
Section <i>Gesnerianae</i> Baker: Filaments without a turf of hairs at the base. Bulb-coats glabrous, or with only a few adpressed hairs inside. Perianth campanulate, usually bright red. Lower leaf broad, with two or three exceptions. This is the largest section and it may be divided into sub-sections. Sub-section I: Perianth segments all uniform and acuminate. Peduncles glabrous or pubescent. <i>T. acuminata</i> Vahl. (syn: <i>T. cornuta</i> DC., <i>T. turcica</i> Kunth, <i>T. stenopetala</i> Mord.) <i>T. retroflexa</i> Hort. <i>T. elegans</i> Hort. Sub-section II: Perianth segments all or three outer oblong acute. Peduncle glabrous. <i>T. didieri</i> Jord. <i>T. undulatifolia</i> Boiss. <i>T. elwesii</i> Baker <i>T. cruciata</i> Baker (<i>T. bithynica</i> Baker) <i>T. kolpakowskiana</i> Regel <i>T. kesselringii</i> Regel <i>T. brachystemon</i> Regel <i>T. triphylla</i> Regel <i>T. aristata</i> Regel <i>T. oxypetala</i> Steven Sub-section III: Perianth segments all six broadly rounded at the apex, with a small cusp in the centre. Peduncle glabrous. <i>T. gesneriana</i> L. <i>T. macrospeila</i> Baker <i>T. platystigma</i> Jord. <i>T. korolkowi</i> Regel <i>T. borschowi</i> Regel <i>T. boissieri</i> Regel <i>T. tetraphylla</i> Regel <i>T. behmiana</i> Regel Sub-section IV: All the six segments of perianth, narrowed to an acute point. Peduncle permanently pubescent. <i>T. suaveolens</i> Roth <i>T. strangulata</i> Reboul <i>T. boetica</i> Boiss. et Heldr. <i>T. kaufmanniana</i> Regel <i>T. altaica</i> Pall.
Section <i>Saxatiles</i> Baker: Filament furnished with a turf of hairs at the base. Perianth red or lilac. Example, <i>T. saxatilis</i>.
Section <i>Sylvestres</i> Baker: Filaments with a turf of hairs at the base. Perianth bright yellow or pale yellow, sometimes flushed with red on the outside. Example, <i>T. sylvestris</i>.
Subgenus <i>Orithyia</i> (D. Don) Baker: Ovary narrowed into a distinct style. Stigma small, Dwarf plants with linear leaves. Example, <i>T. uniflora</i>.

Edmond Boissier made many trips to the Alps, the eastern Mediterranean, Anatolia, and the Near East and published *Diagnoses Plantarum Orientalium Novarum* between 1844-1859, shortly before Baker's monograph about tulips. In this collected works, he included some new species: *T. undulatifolia* Boiss., *T. cretica* Boiss. et Heldr., *T. montana* Lindl. var. *chrysantha* Boiss. et Hohen, *T. buhseana* Boiss., *T. armena* Boiss., *T. boeotica* Boiss. et Heldr. (Boissier 1844, 1853, 1859). Then, Boissier published the volume five of *Flora Orientalis*, including a region that extends from the eastern Mediterranean to Central Asia, in 1882. In *Flora Orientalis* Boissier named Regel's two sections of the genus *Tulipa* as *Leiostemones* Boiss. and *Eriostemones* Boiss. The name of the Boissier's second section is still in use. The first has been renamed as section *Tulipa* according to the international rules of botanical nomenclature (Boissier, 1882; Wilford, 2006) (Table 7).

The popularity of tulip species increased rapidly in the late nineteenth and early twentieth centuries. New species were discovered by collectors such as Albert Regel and introduced to cultivation by bulb firms. Dutch firm of C. G. van Tubergen, established in 1869, one of these firms. Van Tubergen grown these tulips in Holland and sold across Europe. This firm employed to bring bulbs with some European collectors such as Paul Sintenis and John Hoog, which were travelled to Asia to collect plants. Although many new species were described during this period, there was no attempt to classify these new introductions until Aleksei Ivanovich Vvedensky's the publication of volume four of *Flora of the USSR* in 1935 and Alfred Daniel Hall's *The Genus Tulipa*, published by the Royal Horticultural Society (RHS) in 1940 (Wilford, 2006).

Aleksei Ivanovich Vvedensky wrote (1935) the genus *Tulipa* in *Flora of the USSR*. Vvedensky followed Boissier's naming for two main sections *Leiostemones*

Boiss. and *Eriostemon* Boiss., but he also added four sections: *Tulipanum* Rebol, *Spiranthera* Vved., *Lophophyllon* Vved., *Orithyia* (D. Don) Vved. However, he described many new species.

Vvedensky's study had a great understanding of the genus and his conclusions should not be dismissed lightly. Although he did not subdivide the sections, he segregated the species with respect to their relationship to each other (Vvedensky, 1935; Wilford, 2006) (Table 8).

Table 7. Boissier's classification on the genus *Tulipa* in the *Flora Orientalis* in 1882.

Section <i>Leiostemon</i> Boiss.: species with glabrous filaments
* Inner tunics densely lanate. <i>T. oculis-solis</i> St. Amand β <i>aleppica</i> Baker (syn: <i>T. aleppensis</i> Boiss. et Hausskn.) <i>T. praecox</i> Ten. <i>T. montana</i> Lindl. β <i>julia</i> Baker (syn: <i>T. julia</i> C. Koch) <i>T. chrysantha</i> Boiss. <i>T. sogdiana</i> Bge. <i>T. clusiana</i> Vent.
** Inner tunics glabrous or moderately and adpressed hirsute at apice. + Peduncle glabrous <i>T. gesneriana</i> L. β <i>minor</i> (syn: <i>T. armena</i> Boiss., <i>T. schrenkii</i> Regel) ++ Peduncle pubescent <i>T. eichleri</i> Regel <i>T. suaveolens</i> Roth <i>T. baeotica</i> Boiss. et Heldr. β <i>euanthiae</i> (syn: <i>T. euanthia</i> Orph.) <i>T. undulatifolia</i> Boiss. <i>T. greigi</i> Regel
Section <i>Eriostemon</i> Boiss.: with hairy filaments
Grandiflorae - Flower large <i>T. saxatilis</i> Sieb. <i>T. sylvestris</i> L. <i>T. orphanidea</i> Boiss. <i>T. hageri</i> Heldr.
Parviflorae - Flower smaller <i>T. pulchella</i> Fenzl <i>T. lownei</i> Baker <i>T. bithynica</i> Griseb. <i>T. violacea</i> Boiss. et Buhse <i>T. biebersteiniana</i> R. et Sch. <i>T. humilis</i> Herb. β <i>crispatula</i> (syn: <i>T. crispatula</i> Boiss. et Buhse) <i>T. cretica</i> Boiss. et Heldr. <i>T. biflora</i> L. β <i>major</i>

Table 8. Vvedensky's classification on the genus *Tulipa* in the *Flora of USSR* in 1935.

Section <i>Tulipanum</i> Rebol: Bulb tunics profusely arachnoid-shaggy over the whole inner surface; flowers large, bright-colored; filament glabrous; ovary with a sessile stigma. <i>T. tubergeniana</i> Hoog. <i>T. kuschkenensis</i> B. Fedtsch. <i>T. hoogiana</i> B. Fedtsch. (syn: <i>T. amabilis</i> B. Fedtsch., <i>T. ingens</i> B. Fedtsch. non Hoog) <i>T. julia</i> C. Koch. (syn: <i>T. montana</i> var. <i>julia</i> Baker)	
Section <i>Leiostemones</i> Boiss.: Bulb tunics nearly glabrous on the inside, or hairy at summit or all over, or profusely woolly, or merely at summit profusely arachnoid-shaggy; filaments naked; ovary with sessile stigma or with a style, this always shorter than ovary. <i>T. florenskyi</i> Woron. (syn: <i>T. montana</i> var. <i>julia</i> Baker) <i>T. lanata</i> Regel <i>T. ingens</i> Hoog <i>T. fosteriana</i> Irv. <i>T. carinata</i> Vved. <i>T. praestans</i> Hoog (syn: <i>T. suaveolens</i> Regel) <i>T. subpraestans</i> Vved. <i>T. alberti</i> Regel <i>T. greigii</i> Regel (syn: <i>T. altaica</i> var. <i>karatavica</i> Regel) <i>T. mogoltavica</i> M. Pop. et Vved. <i>T. micheliana</i> Hoog (syn: <i>T. greigii</i> Boiss.) <i>T. eichleri</i> Regel <i>T. schimidtii</i> Fom. <i>T. maximowiczii</i> Regel (syn: ? <i>T. batalini</i> Regel) <i>T. linifolia</i> Regel <i>T. wilsoniana</i> Hoog <i>T. lehmanniana</i> Merckl. <i>T. behmiana</i> Regel <i>T. borszczowii</i> Regel (syn: <i>T. aurata</i> Litv.) <i>T. korolkovii</i> Regel <i>T. nitida</i> Hoog <i>T. rosea</i> Vved. <i>T. schrenkii</i> Regel (syn: ? <i>T. oxypetala</i> Stev., <i>T. gesneriana</i> Ldb. non L., <i>T. gesneriana</i> var. <i>acutiflora</i> Pacz., <i>T. monticola</i> Wulff, <i>T. suaveolens</i> auct.) <i>T. ostrovskiana</i> Regel <i>T. kolpakovskiana</i> Regel (syn: <i>T. triphylla</i> auct.) <i>T. zenaidae</i> Vved. <i>T. bracystemon</i> Regel <i>T. platystemon</i> Vved. <i>T. altaica</i> Pall. ex Spreng. <i>T. dubia</i> Vved. <i>T. iliensis</i> Regel (syn: <i>T. hoeltzeri</i> Dykes) <i>T. ferganica</i> Vved. <i>T. anisophylla</i> Vved. (syn: <i>T. kolpakovskiana</i> var. <i>humilis</i> Regel) <i>T. korshinskyi</i> Vved. <i>T. tianschanica</i> Regel <i>T. tetraphylla</i> in A.H.P. III (<i>T. kesselringii</i> Regel) <i>T. hissarica</i> M. Pop. et Vved. <i>T. krauseana</i> Regel	
Section <i>Spiranthera</i> Vved.: Anthers opening gradually and slowly from apex to base, becoming contorted; filaments naked; ovary with subsessile stigma; bulb tunics more or less hairy on the inside. <i>T. kaufmanniana</i> Regel	
Section <i>Lophophyllon</i> Vved.: Leaf solitary, with twisted longitudinal crests; bulb tunics hairy on the inside; filaments hairy; ovary short-styled. <i>T. regelii</i> Krasn.	
Section <i>Eriostemones</i> Boiss.: Bulb tunics glabrous or hairy or arachnoid-lanate on the inside; flowers in most species small, inconspicuous; filaments pubescent, in one species (<i>T. sogdiana</i>) naked; ovary with subsessile stigma or with a more or less developed style, but this never longer than ovary. <i>T. violaceae</i> Boiss. et Buhse <i>T. caucasica</i> Lipsky (syn: <i>T. lipskyi</i> Grossh.) <i>T. silvestris</i> L. <i>T. biebersteiniana</i> Schult. (syn: <i>T. silvestris</i> var. <i>minor</i> Ldb., <i>T. silvestris</i> var. <i>niphontiana</i> Czern., <i>T. silvestris</i> var. <i>biebersteiniana</i> Regel, <i>T. bessarabica</i> Zapal., <i>T. australis</i> var. <i>taurica</i> Miscz., <i>T. silvestris</i> M. B.) <i>T. patens</i> Agardh. ex Schult. (syn: <i>T. tricolor</i> Ldb., <i>T. silvestris</i> var. <i>tricolor</i> Ldb.) <i>T. sogdiana</i> Bge (syn: <i>T. androssovii</i> Litw.) <i>T. buhseana</i> Boiss. <i>T. turkestanica</i> Rgl. (syn: <i>T. silvestris</i> var. <i>turkestanica</i> Regel) <i>T. turcomanica</i> B. Fedtsch. <i>T. bifloriformis</i> Vved. (syn: <i>T. biflora</i> auct.) <i>T. biflora</i> Pall. (<i>T. silvestris</i> var. <i>biflora</i> Ldb.) <i>T. polychroma</i> Stapf. (syn: <i>T. biflora</i> var. <i>grandiflora</i> Grossh.) <i>T. koktebelica</i> Junge <i>T. callieri</i> Halacsy et Lev. <i>T. orithyioides</i> Vved. <i>T. dasystemonoides</i> Vved. <i>T. dasystemon</i> Regel (syn: <i>Orithyia dasystemon</i> Regel) <i>T. tarda</i> Stapf.	

Table 8. (continued).

Section <i>Orithyia</i> (D. Don) Vved.: Bulb tunics naked on the inside or appressed-hairy at summit; filaments naked; style as long as ovary. <i>T. heteropetala</i> Ldb. (syn: <i>Ornithogalum oxypetalum</i> Ldb., <i>Orithyia oxypetala</i> Kunth, <i>O. uniflora</i> var. <i>oxypetala</i> Regel) <i>T. uniflora</i> (L.) Bess. ex Baker (syn: <i>Ornithogalum uniflorum</i> L., <i>Orithyia uniflora</i> Don, <i>O. nutans</i> Trautv., <i>O. uniflora</i> var. <i>typica</i> Regel, <i>T. nutans</i> B. Fedtsch.) <i>T. heterophylla</i> (Regel) Baker (syn: <i>Orithyia heterophylla</i> Regel)

Alfred Daniel Hall wrote two publication about tulips called *The Book of the Tulip* in 1929 and *The Genus Tulipa* in 1940. He used Boissier's sections as two divisions named *Eriostemon*es and *Leios*temones in *The Genus Tulipa*. He divided *Eriostemon*es into three sections: *Australes* A. D. Hall, *Saxatiles* Baker, and *Biflores* A. D. Hall. The *Leios*temones was divided into five: *Clusianae* Baker, *Gesnerianae* Baker, the *Oculus-solis* Group (equivalent to Vvedensky's section *Tulipanum*), *Eichleres* A. D. Hall, and *Kolpakowskianae* A. D. Hall. A third section, *Orithyia* (D. Don) Vved., comprised two species then removed by Masaji Honda into a new genus, *Amana* Honda. Hall had not studied the species placed in section *Orithyia*. He also included some uncertain species under the *Eriostemon*es and the *neo Tulipae* under the section *Gesnerianae* Baker. Hall separated species in respect of their morphological characters and chromosome numbers. e.g., he separated the diploid *Tulipa biflora* from the tetraploid *T. turkestanica*, although in other respects they are similar Hall's division of the *Eriostemon*es into three sections is still used today. However, his work was largely based on cultivated material, often of unknown origin and from commercial sources. Nevertheless, there have no any monograph on the whole of the genus *Tulipa* since Hall's publication has been published. Hall emphasized the need to study living tulips rather than herbarium specimens, where essential characteristics can be hidden or lost (Hall, 1929, 1940; Wilford, 2006) (Table 9, 10).

Table 9. Hall's classification for the *Eriostemon*es in *The Genus Tulipa* (1940).

<i>Eriostemon</i>es Boiss.: Hairy boss at base of filaments Section I. <i>Australes</i> A. D. Hall <i>T. australis sensu lato</i> Subsidiary species <i>T. australis</i> Link <i>T. celsiana</i> DC. (syn: <i>T. breyniana</i> Ker-Gawler, <i>T. persica</i> of gardens, <i>T. australis</i> var. <i>arvorum</i> Stapf) <i>T. grisebachiana</i> Pantocsek <i>T. patens</i> Agardh ex Schultes (syn: <i>T. tricolor</i> Ledebour) <i>T. primulina</i> Baker <i>T. urumiensis</i> Stapf <i>T. silvestris</i> L. <i>T. hageri sensu lato</i> Subsidiary species <i>T. hageri</i> Heldr. <i>T. orphanidea</i> Boiss. ex Heldr. (syn: <i>T. atheniensis</i>, <i>T. celsiana</i> Heldr., <i>T. orphanides</i>, <i>T. orphanidesii</i>, <i>T. sylvestris</i> var. <i>orphanidea</i> (Heldr.) Regel <i>T. whittallii</i> (syn: <i>T. orphanidea</i> Elwes, <i>T. orphanidea</i> var. <i>whittallii</i> Dykes)
Section II. <i>Saxatiles</i> Baker <i>T. humilis sensu lato</i> Subsidiary species <i>T. humilis</i> Herbert <i>T. pulchella</i> Fenzl (syn: <i>T. alpina</i> Gay.) <i>T. violaceae</i> Boiss. et Buhse var. <i>pallida</i> <i>T. aucheriana</i> Baker <i>T. lownei</i> Baker <i>T. saxatilis sensu lato</i> Subsidiary species <i>T. cretica</i> Boiss et Heldr. <i>T. bakeri</i> A. D. Hall <i>T. saxatilis</i> Sieb. ex Sprengel (syn: <i>T. beccariana</i> Bicchii, <i>T. chrysobasis</i> Coust. et Gandoger)
Section III. <i>Biflores</i> A. D. Hall <i>T. biflora</i> Pall. <i>T. turkestanica</i> Regel <i>T. polychroma</i> Stapf <i>T. tarda</i> Stapf (syn: <i>T. dasystemon</i> hort. non Regel)
Uncertain species: Belonging to this group a number of species have been described from the Crimea, the Caucasus, and further east to Turkistan and Persia, but which by the diagnoses given cannot be clearly differentiated from the species described above: <i>T. androssowi</i> Litwinow <i>T. bessarabica</i> Zapolowicz <i>T. bifloriformis</i> Vvedensky <i>T. buhseana</i> Boiss. <i>T. callieri</i> Halacsy et Levier <i>T. dasystemonoides</i> Vvedensky <i>T. koktebelica</i> Junge <i>T. orithyioides</i> Vvedensky <i>T. sogdiana</i> Bunge <i>T. turcomanica</i> B. Fedtschenko.

Table 10. Hall's classification for the *Leiostemones* in *The Genus Tulipa* (1940).

<i>Leiostemones</i> Boiss.: No hairs on filaments	
Subsection I. <i>Clusianae</i> Baker <i>T. aitchisonii sensu lato</i> Subsidiary species <i>T. aitchisonii</i> A. D. Hall subsp. <i>cashmeriana</i> A. D. Hall <i>T. stellata</i> Hooker <i>T. stellata chrysantha</i> (T. chrysantha of gardens, not <i>T. chrysantha</i> Boiss.) <i>T. chitralensis</i> <i>T. clusiana</i> DC.	
<i>T. montana sensu lato</i> Subsidiary species <i>T. linifolia</i> Regel <i>T. maximowiczii</i> Regel <i>T. batalini</i> Regel <i>T. montana</i> Lindl. (syn: <i>T. wilsoniana</i> Hoog., <i>T. chrysantha</i> Boiss.)	
Subsection II. <i>Gesnerianae</i> Baker <i>T. gesneriana sensu lato</i> <i>T. gesneriana</i> L. <i>T. suaveolens</i> Roth (syn: <i>T. schrenki</i> Regel) <i>T. armena</i> Boiss. <i>T. galatica</i> Freyn <i>T. hungarica</i> Borbas <i>T. rhodopea</i> Velenovsky (syn: <i>T. orientalis</i> var. <i>rhodopea</i> Velenovsky) <i>T. boeotica</i> Boiss. et Heldr.	
<i>The Neo-Tulipae:</i> The history of these tulips, which began to be recognised and described as species in the first half of the nineteenth century, notable by Reboul, is most fully dealt with by Levier, and nothing significant has since been added to the discussion. The following list is based on Levier's work, but <i>T. lorteti</i>, <i>T. maleolens</i> and <i>T. martelliana</i> do not belong to the Gesnerian group, since they possess a woolly coat round the bulb: <i>T. aximensis</i> Perrier et Sonceon, <i>T. baldaccii</i> Mattei, <i>T. bilietiana</i> Jord., <i>T. bonarotiana</i> Reboul, <i>T. connivens</i> Levier, <i>T. didieri</i> Jord., <i>T. etrusca</i> Levier, <i>T. fransoniana</i> Parlatores, <i>T. hungarica</i> Borbas, <i>T. lorteti</i> Jord., <i>T. lurida</i> Levier, <i>T. maleolens</i> Reboul, <i>T. marjolettii</i> Perrier et Sonceon, <i>T. martelliana</i> Levier, <i>T. mauritiana</i> Jord. (syn: <i>T. mauriana</i> Jord. Et Fourr., <i>T. neglecta</i> (Reboul) Reboul, <i>T. orientalis</i> Levier (syn: <i>T. hungarica</i> Borbas), <i>T. passeriana</i> Levier, <i>T. planifolia</i> Jord., <i>T. platystigma</i> Jord., <i>T. pubescens</i> Willdenow, <i>T. scabrisca</i> Fox-Strangways (syn: <i>T. scabriscape</i> var. <i>buonarrotiana</i>, <i>T. buonarrotiana</i> Reboul var. <i>mixta</i>, <i>T. variopicta</i> Reboul var. <i>primulina</i>, <i>T. neglecta</i> Reboul var. <i>strangulata</i>, <i>T. strangulata</i> Reboul), <i>T. segusiana</i> Perrier et Sonceon, <i>T. serotina</i> Reboul, <i>T. sommieri</i> Levier, <i>T. spathulata</i> Bertoloni, <i>T. strangulata</i> Reboul, <i>T. variopicta</i> Reboul.	
Subsection III. The <i>Oculus-solis</i> Group <i>T. oculus-solis sensu lato</i> Subsidiary species <i>T. oculus-solis</i> St. Amans <i>T. systola</i> Stapf <i>T. julia</i> C. Koch <i>T. sharonensis</i> Dinsmore <i>T. stapfii</i> Turrill <i>T. cypria</i> Stapf <i>T. undulatifolia</i> Boiss. <i>T. praecox</i> Ten. <i>T. aleppensis</i> Boiss. ex Regel <i>T. veneris</i> A. D. Hall	
Other species <i>T. kuschakensis</i> B. Fedtschenko <i>T. lanata</i> Regel <i>T. hoogiana</i> B. Fedtschenko <i>T. sovietica</i> A. D. Hall <i>T. amabilis</i> B. Fedtschenko	

Table 10. (continued).

Subsection IV. <i>Eichleres</i> A. D. Hall <i>T. eichleri</i> Regel <i>T. ingens</i> Hoog <i>T. tubergeniana</i> Hoog <i>T. fosteriana</i> Hoog ex W. Irving <i>T. micheliana</i> Hoog <i>T. greigi</i> Regel <i>T. kaufmanniana</i> Regel <i>T. praestans</i> Hoog
Subsection V. <i>Kolpakowskianae</i> A. D. Hall <i>T. kolpakowskiana</i> Regel <i>T. iliensis</i> Regel (syn: <i>T. hoelzeri</i> Dykes, <i>T. triphylla</i> var. <i>hoelzeri</i> Regel, <i>T. kolpakowskiana</i> var. <i>hoelzeri</i> hort.) <i>T. altaica</i> Pall. ex Sprengel <i>T. kesselringi</i> Regel <i>T. corynestemon</i> A. D. Hall <i>T. ostrakowskiana</i> Regel (syn: <i>T. korolkowi concolor</i> hort., <i>T. kolpakowskiana cocciana</i> hort.) <i>T. korolkowi</i> Regel <i>T. lehmanniana</i> Mercklin
Solitary species: There are two very distinct species which cannot be associated with any of the sections previously described, which again have no affinities with one another but appear to stand alone. <i>T. schmidtii</i> Fomin <i>T. sprengeri</i> Baker
<i>Orithyia</i> (D. Don) Vved.: This section is very distinct than the other tulips and includes a defined style, small flowers and 2 (3-4) linear bracts. <i>Amana edulis</i> (Miquel) Honda (syn: <i>T. edulis</i> (Miquel) Baker, <i>Orithyia edulis</i> Miquel) <i>Amana graminifolia</i> (Baker) A. D. Hall (syn. <i>T. graminifolia</i> Baker)

Zinaida Botschantzeva wrote a book about tulips called *Tyul'pany (Tulips)* in 1962, translated into English by H. Q. Varekamp in 1982. This book includes the central Asian tulips in great detail and follows the classification used by Vvedensky (1935) in *Flora of the USSR* (Table 11) (Botschantzeva, 1982).

Table 11. Botschantzeva's classification on the Genus *Tulipa* (1982).

Section <i>Tulipanum</i> Rebol: Bulb tunics profusely arachnoid-shaggy over the whole inner surface. Flowers large, brightly coloured; filaments glabrous; ovary with a sessile stigma. <i>T. tubergeniana</i> Hoog. <i>T. julia</i> K. Koch. <i>T. kuschkenensis</i> B. Fedtsch. <i>T. subquinelifolia</i> Vved. <i>T. hoogiana</i> B. Fedtsch.	
Section <i>Leiostemon</i> Boiss.: Bulb tunics nearly glabrous on the inside, or hairy at apex or all over, or with a thick woollen coating, or merely at the apex profusely arachnoid-shaggy; filaments glabrous; ovary with sessile stigma or with a rather long style but always shorter than the ovary. <i>T. sosnowskyi</i> Akhv. et Mirz. <i>T. wilsoniana</i> Hoog <i>T. florenskyi</i> Woron <i>T. lehmanniana</i> Merckl. <i>T. kaghyzmanica</i> Fom. <i>T. behmiana</i> Regel <i>T. lanata</i> Regel <i>T. borszczowii</i> Regel <i>T. ingens</i> Hoog <i>T. korolkowii</i> Regel <i>T. fosteriana</i> Hoog ex W. Irving <i>T. nitida</i> Hoog <i>T. carinata</i> Vved. <i>T. rosea</i> Vved. <i>T. affinis</i> Z. Botsch. <i>T. schrenkii</i> Regel <i>T. praestans</i> Hoog. <i>T. ostrowskiana</i> Regel <i>T. subpraestans</i> Vved. <i>T. kolpakowskiana</i> Regel <i>T. butkovii</i> Z. Botsch. <i>T. zenaidae</i> Vved. <i>T. albertii</i> Regel <i>T. brachstemon</i> Regel <i>T. greigii</i> Regel <i>T. platystemon</i> Vved. <i>T. mogoltavica</i> M. Pop. et. Vved. <i>T. altaica</i> Pall. ex Spreng. <i>T. vvedenskyi</i> Z. Botsch. <i>T. iliensis</i> Regel <i>T. micheliana</i> Hoog <i>T. ferganica</i> Vved. <i>T. eichleri</i> Regel <i>T. anisophylla</i> Vved. <i>T. karabachensis</i> A. Grossh. <i>T. korshinskyi</i> Vved. <i>T. mucronata</i> Fom. <i>T. tianschanica</i> Regel <i>T. schmidtii</i> Fom. <i>T. tetraphylla</i> Regel <i>T. maximowiczii</i> Regel <i>T. hissarica</i> M. Pop. et. Vved. <i>T. linifolia</i> Regel <i>T. krauseana</i> Regel	
Section <i>Spiranthera</i> Vved.: Anthers opening gradually and slowly from apex to base, coiling; filaments glabrous; ovary with subsessile stigma; bulb tunics more or less hairy on the inside. <i>T. kaufmanniana</i> Regel <i>T. anadroma</i> Z. Botsch. <i>T. dubia</i> Vved. <i>T. tschimganica</i> Z. Botsch.	
Section <i>Lophophyllon</i> Vved.: Leaf solitary, with twisted longitudinal crests on the upper side; bulb tunics hairy on the inside; filaments hairy; ovary short-styled. <i>T. regelii</i> Krassn.	
Section <i>Eriostemon</i> Boiss.: Bulb tunics on the inside glabrous or hairy or arachnoid-woolly; flowers in most species small, inconspicuous; filaments pubescent, in one species (<i>T. sogdiana</i>) glabrous; ovary with subsessile stigma or with a more or less developed style, but this never longer than ovary. <i>T. violaceae</i> Boiss. et Buhse <i>T. turkestanica</i> Regel <i>T. caucasica</i> Lipsky <i>T. turcomanica</i> B. Fedtsch. <i>T. lipskyi</i> A. Grossh. <i>T. bifloriformis</i> Vved. <i>T. sylvestris</i> L. <i>T. orthopoda</i> Vved. <i>T. biebersteiniana</i> Schult. <i>T. biflora</i> Pall. <i>T. ophiophylla</i> Klok. et Zoz. <i>T. polychroma</i> Stapf <i>T. scythica</i> Klok. et Zoz. <i>T. koktebelica</i> Junge <i>T. patens</i> Agardh. ex Schult. <i>T. callieri</i> Halacsy et Lev. <i>T. sogdiana</i> Bunge <i>T. orithyioides</i> Vved. <i>T. buhseana</i> Boiss. <i>T. dasystemonoides</i> Vved. <i>T. binutans</i> Vved. <i>T. dasystemon</i> (Regel) Regel <i>T. taliievii</i> Vved. <i>T. neustruevae</i> Pobed. <i>T. alaica</i> Vved. <i>T. tarda</i> Stapf	
Section <i>Orithyia</i> (D. Don) Vved.: Bulb tunics naked on the inside or appressed-hairy at summit; filaments naked; style as long as ovary. <i>T. heteropetala</i> Ledeb. <i>T. heterophylla</i> (Regel) Baker <i>T. uniflora</i> (L.) Bess. ex Baker	

The most considerable publications on tulips were enrolled in the late years of twentieth century. These publications were floras that covered areas within the range of the genus *Tulipa* such as *Flora Europaea*, *Flora of Turkey*, *Flora of Iraq*, *Flora Palaestina*, and *Flora Iranica* (Grey-Wilson & Matthews, 1980; Marais, 1984; Wendelbo, 1985; Feinbrun, 1986; Rechinger, 1990).

The genus *Tulipa* was formerly divided in two sections: *Tulipa* (syn: *Leiostemones* Boiss.) and *Eriostemones* Boiss. until the publications of two papers by van Raamsdonk and de Vries in the journal *Plant Systematics and Evolution*. Van Raamsdonk and de Vries raised (1992, 1995) these sections to subgenera and divided the subgenus *Tulipa* into five sections: *Tulipa*, *Tulipanum* Reboul, *Eichleres* (A.D. Hall) Raamsd., *Kolpakowskianae* (A.D. Hall) Raamsd., *Clusianae* Baker. Section *Eichleres* was further divided into eight series: *Lanatae* Raamsd., *Eichleres* A.D. Hall p.p., *Vinistriatae* Raamsd., *Undulatae* Raamsd., *Luteo-apiculatae* Raamsd., *Multiflorae* Raamsd., *Spiranthera* (Vved.) Raamsd., *Glabrae* Raamsd. The other subgenus *Eriostemones* (Boiss.) Raamsd. were accepted as three sections following Daniel Hall's treatment: *Australes* sensu A.D. Hall, *Saxatiles* Baker, *Biflores* sensu A.D. Hall (Table 12).

In the years of 1999 and 2006, two considerable books were published about tulip taxonomy: respectively, “*The Tulip*” by Pavord and “*Tulips-Species and Hybrids for the Gardener*” by Wilford. Both books give information about taxonomy, geography and cultivation of species in the world and also include historical and chronical properties of them. Wilford added (2006) two sections following Vvedensky's treatment, which were not determined by van Raamsdonk and de Vries: section *Orithyia* (D. Don) Vved. for the subgenus *Tulipa* and section *Lophophyllon* Vvedensky for the subgenus *Eriostemones* (Table 12).

Table 12. Classification on the genus *Tulipa* at level of subgenera and sections according to the studies of Vvedensky (1935), Hall (1940), Raamsdonk & Vries (1992, 1995), and Wilford (2006).

Subgenus *Tulipa*

- filaments glabrous and about the same length
- outer tepals longer and/or wider than inner ones
- bowl shaped flowers with a rounded base
- lowest leaf lanceolate or oblong-lanceolate, undulate

Section *Tulipa*

- have papery tunics, usually lined with only a few straight hairs
- flowers generally red with a black basal blotch margined with yellow

Section *Tulipanum* Reboul

- with a dense layer of woolly, often rippled hairs lining the bulb tunics

Section *Eichleres* (A.D. Hall) Raamsd.

- bulb tunics usually lined with a few straight hairs, or form a thick layer, or glabrous
- leaves often broad, and the tepals bright and glossy on their inner surface

Section *Kolpakowskianae* (A.D. Hall) Raamsd.

- narrow, glaucous leaves, often with undulate margins
- yellow, orange, or red flowers
- in yellow-flowered forms the backs of the outer tepals usually stained with red or reddish purple
- bulb tunics lined with hairs at the tip and often at the base

Section *Orithyia* (D. Don) Vved.

- have a distinctive elongated style
- with two leaves and with yellow flowers stained dingy violet or green on the outside. The bulb tunics are hairy at the tip or glabrous

Section *Clusianae* Baker

- bulbs distinctive, being fairly small and having a prominent tuft of hairs protruding from the top
- leaves long and narrow and usually spaced apart on the stem, the upper ones often attached to the stem well above ground level
- flowers red, yellow, or white with red backs to the outer tepals

Subgenus *Eriostemon* (Boiss.) Raamsd.

- filaments swollen and hairy base, unequal, inner ones longer
- outer tepals narrower and/or shorter than inner ones
- funnel-shaped flowers with a constricted base

Section *Australes* sensu A.D. Hall

- flowers range from creamy white and pale yellow to bright, golden yellow and brownish red

Section *Saxatiles* Baker

- flowers in shades of violet, pink, pinkish red, brick-red, with a yellow or blue-black blotch

Section *Biflores* sensu A.D. Hall

- produce many flowers from one bulb, up to twelve
- flowers small and yellow, or white with a yellow blotch of varying size

Section *Lophophyllon* Vved.

- has unusual leaves, that is, raised, undulating ridges along their length, a feature not found in any other species of tulip

Recently, some floras including tulip species have been written such as *Flora of India*, *Flora of Pakistan*, *Flora Helvetica* and *Flora Corsica* (Sing & Sanjappa, 2006; Ali & Qaiser, 2007; Lauber & Wagner, 2007; Jeanmonod & Gamisans, 2007). Also, some new species have been described (Terzioğlu & Coşkunçelebi, 2002; Zhao, 2003; Ghahreman et al., 2007).

Latest study about tulip taxonomy has been published by Zonneveld (2009) in the journal *Plant Systematics and Evolution*. Mainly nuclear genom sizes of taxa has been measured by flow cytometry with propidium iodide and evaluated here in combination with available morphological, geographical, and molecular data. In this study, all tulips are attributed to four subgenera, *Clusianae* (Baker) Zonn., *Tulipa*, *Eriostemon* Raamsd., and *Orithya* (D. Don) Baker and divided further into 12 sections. Seven of the eight series of section *Eichleres* (A.D. Hall) Raamsd. are now placed in four sections: *Lanatae* (Raamsd.) Zonn., *Multiflorae* (Raamsd.) Zonn. (including series *Glabrae*), *Vinistriatae* (Raamsd.) Zonn. (including series *Undulatae*), and *Spiranthera* Vved. ex Zonn. & Veldk. The subgenus *Tulipa* is divided into seven sections: *Kolpakowskianae* Raamsd. ex Zonn. & Veldk., *Multiflorae* (Raamsd.) Zonn., *Lanatae* (Raamsd.) Zonn., *Vinistriatae* (Raamsd.) Zonn., *Spiranthera* Vved. ex Zonn. & Veldk., *Tulipanum* Reboul, and *Tulipa*. The subgenus *Eriostemon* (Boiss.) Raamsd. is divided into three sections: *Sylvestres* (Baker) Baker (syn.: *Australes*), *Biflores* A.D. Hall ex Zonn. & Veldk., and *Saxatiles* (Baker) Baker. *T. regelii* with unique ridges on the leaf was placed in a separate section *Lophopyllon* by Vvedensky (1935). Here, it is accepted under the section *Biflores* based on DNA content and flower morphology. Also, section *Orithya* is placed under the subgenus *Orithya* (D. Don) Baker (Table 13).

Table 13. Zonnevald's classification on the genus *Tulipa* at level of subgenera and sections (2009).

Subgenus <i>Clusianae</i> (Baker) Zonn.: Subgenus <i>Clusianae</i> is distinguished from the remaining tulips by its low amount of DNA-32 pg instead of 36-69 pg for the other tulips. Moreover, meiosis takes place at the start of spring in March in contrast to other species of <i>Tulipa</i> where it occurs in the period September-November. Section <i>Clusianae</i> Baker
Subgenus <i>Tulipa</i>: They are characterized by glabrous filaments and about the same length each other. Outer tepals are longer and/or wider than inner ones. Bowl shaped flowers with a rounded base. Lowest leaf is lanceolate or oblong-lanceolate, undulate. Section <i>Kolpakowskianae</i> Raamsd. ex Zonn. & Veldk.: They have a DNA 2C value of 36-45 pg. Species of this section can be divided into two groups: first group is multiflowered, with yellow flowers and hairy scapes. second group is single-flowered with red or yellow flowers and have glabrous scape. Section <i>Multiflorae</i> (Raamsd.) Zonn.: They have a DNA 2C value of 45-51 pg. The species are multiflowered, and with tough bulb skin, and without a basal tepal spot. Section <i>Lanatae</i> (Raamsd.) Zonn.: They have a DNA 2C value of 48-55 pg. Section <i>Vinistriatae</i> (Raamsd.) Zonn.: They have a DNA 2C value of 48-54 pg. Section <i>Spiranthera</i> Vved. ex Zonn. & Veldk.: They have a DNA 2C value of 50-55 pg. Tulips of this section were originally named for anthers that open up from apex to bottom, becoming contorted afterwards. They usually have flowers with yellow or white background, in contrast to section <i>Vinistriatae</i>, whose flowers are all mainly red. Section <i>Tulipanum</i> Reboul: They have a DNA 2C value of 51-62 pg. They are characterized by a dense layer of woolly, often rippled hairs lining the bulb tunics. Section <i>Tulipa</i>: They have a DNA 2C value of 61-69 pg. They are characterized by large bulbs with a papery tunic with a few adpressed hairs near the base and apex, by green buds, often a yellow-edged black base to the red tepals, and deep purple pollen.
Subgenus <i>Eriostemon</i> Raamsd.: They are characterized by filaments with bundle of hairs at the basis or with at least a swollen basis. The flowers are funnel shaped with a slight constriction just above the base. They have mainly lanceolate leaves and three short and three long anthers. Most are multiflowered caused by a branching of the apical bud. Section <i>Sylvestres</i> (Baker) Baker: They have a DNA 2C value of 55-66 pg. They have flowers range from creamy white and pale yellow to bright, golden yellow and brownish red. Section <i>Biflores</i> A.D. Hall ex Zonn. & Veldk.: They have a DNA 2C value of 48-60 pg. They have whitish-yellow flowers, mainly differing in the number and consequently size of the flowers on a stalk. Section <i>Saxatiles</i> (Baker) Baker: They have a DNA 2C value of 60-65 pg. They have flowers in shades of violet, pink, pinkish red, or brick-red, with a yellow or blue-black blotch.
Subgenus <i>Orithyia</i> (D. Don) Baker: The species of subgenus <i>Orithyia</i> are characterized by a style nearly as long as the ovary and bulb tunics that are usually naked on the inside. They have a DNA 2C value of only 38-39 pg. They have small, yellow flowers. and are found at the eastern/northern border of the tulip area. Section <i>Orithyia</i> (D. Don) Vved.

1.3. Chromosome Numbers and Polyploidy of the Genus *Tulipa* L.

The chromosomes of tulips have been studied since the early twentieth century. Guignard, who first determined the chromosome complement in tulips, found the three species to be diploids with 24 chromosomes in 1900. In 1925, de Mol found a basic number of 12, examining varieties of the garden tulips. Also, he discovered one triploid, 'Pink Beauty', with 36 chromosomes. In 1927 and 1929, Newton published two papers including his discovery of triploids, tetraploids and one pentaploids. Moreover, Kroon & Jongerius first discovered one hexaploid origin of *T. polychrome* in 1986. (Guignard, 1900; de Mol, 1925; Newton, 1927; Newton & Darlington, 1929; Hall, 1940; Wilford, 2006).

Many tulips have a chromosome number of 24 ($2n=24$) and the nuclei of tulip pollen grains have 12 chromosomes ($n=12$). But, also many tulips have more than the basic number of $2n=24$ such as triploid ($2n=36$), tetraploid ($2n=48$), pentaploid ($2n=60$), or very exceptionally hexaploid ($2n=72$). These polyploid plants are usually larger and more robust, and they often have reduced fertility so do not produce much viable seed. Thus, the plants compensate by being more stoloniferous, allowing them to spread vegetatively, but all the individuals will be exactly the same genetically. A polyploidy tulip arises from a diploid tulip so it could be called a secondary stage in the evolution of a species. The reduction of fertility suggests that polyploidy is an evolutionary dead-end. It is from the fertile diploid plants that new species will eventually evolve. Sexual reproduction involves the genes of two plants coming together to create a new individual. This is where variation among plants is initiated. The significance of polyploidy in taxonomy of tulip species varies from author to author. Hall separated species in respect of their morphological characters and

chromosome numbers. e.g., he divided the diploid *Tulipa biflora* from the tetraploid *T. turkestanica*, although in other respects they are similar (Hall, 1940; Wilford, 2006).

1.4. Palynological Characteristics of the Genus *Tulipa* L.

A comparative study on the pollen morphology of the whole Liliaceae family has been presented by Kosenko. In his study, the palynomorphological results are in agreement with the division of the genus *Tulipa* in two main groups of species, that correspond to the subgenera *Eriostemon* and *Tulipa*. The species of the subgenus *Eriostemon* are characterized by monosulcate pollen grains with microreticulate-striate exine surface. Most of the species of the subgenus *Tulipa* possess distal-lateral-threesulcate pollen grains with microreticulate-striate exine surface (Kosenko, 1991, 1992). There is no any comprehensive palynomorphological study relating to the genus *Tulipa* except of Kosenko's publications. Apertures are very variable in *Tulipa*, including monosulcate with or without an operculum, pontoperculate or possibly disulcate, triaperturate with one aperture with an operculum, triaperturate without opercula have granular aperture membranes (Nair & Sharma, 1965; Rădulescu, 1973; Schulze, 1980; Kosenko, 1999; Rudall et al., 2000; Furness & Rudall, 1999, 2003; Harley, 2004).

1.5. Historical and Economical Importance of the Genus *Tulipa* L.

The English word "tulip" came from the Turkish words "turban, tülband", incorrectly. In fact, it should be "Lâle". The only word in Turkish for a tulip is "Lâle"; "tülband" is the Turkish form of the Persian "dulband", referring to the cloth used as their traditional or religious headdress. The mistake was made by Ogier Ghiselin de Busbecq (1522-1592), the Austrian Emperor's Ambassador to Sleiman the

Magnificent, in 1554 during his journey to İstanbul. Busbecq's interpreter must have used the word "tülband" either to compare the shape of the tulip to a "turban" or, more likely, because it was common practice at the time to decorate the "turban" by slipping a tulip between its folds. Busbecq earned his place in history as allegedly being the first westerner to encounter the tulip and as the man who introduced it into Europe. Also, tulip was translated into Latin as *Tulipa* (Hessayon, 1995; King, 2005).

Busbecq sent bulbs to his botanist friend, professor Carolus Clusius working in Prague and Vienna. Clusius was well-known for his scientific studies of medicinal plants; he directed the Imperial Medicinal Herb Garden of Prague. In the 1590, he became the director of Hortus Botanicus of the University of Leiden (Netherlands), the oldest botanical garden of Europe. Before he left Vienna, he brought with him the tulip bulbs sent to him by Busbecq. Clusius planted the tulips in Leiden's Hortus valuing the plants from a scientific point of view in 1593. When gardeners saw the blooms, the bulbs were in instant demand. Clusius refused to give any away and, it's said, demanded a high price for them. A portion of the tulip collection was stolen and in a short time tulips were widely distributed throughout the Low Countries. Simultaneously the commercial production of tulips in Europe began (Dobbs, 2003; King, 2005).

Tulips became popular with the royalty and the wealthy, in particular forms with flowers streaked and splashed with contrasting colours. Botanist and merchants swapped bulbs, artists drew them, and wealthy sought them as novelties and status symbols. Already they were losing the modest look of the species and were taking on a more showy appearance. Their transformation can be charted in paintings of the time. A thriving trade developed around the city of Haarlem in Holland. At the same time, Amsterdam was thriving as a port and trading center, and a logical extension of

this growth was to create an exchange there in order to handle different currencies. The Dutch East India Company was established in 1602 and demand for the most exquisite forms of tulip grew. Prices of tulips rocketed in France between 1610 and 1620. Between 1634 and the end of 1637 “Tulipmania” broke out in Holland. The market in the most famous bulbs ran out of control as people from all levels of Dutch society became involved speculating in tulip bulbs. Possessions of all sorts were sold to buy bulbs: a rare type could cost the price of a farm, house or coach and horses. In reality, there were not enough bulbs to go round and so Tulipmania became a paper speculation. Promissory notes were sold from one investor to another and then it happened. In 1647 the Dutch Government decreed that all Tulip Notes had to be honoured with bulbs and so the market crashed. Tulipmania, that caused the economic crisis in Holland, was over no longer. Tulips were also grown in France and what was then Flanders, where many interesting varieties were bred, but these growers were not as commercially minded as the Dutch. But, prices of tulips rocketed in France between 1610 and 1620. Meanwhile in England, in Victorian times, tulips were also often grown in pots. The streaked and flecked tulips infected with virus are no longer sold commercially in England, but their descendants live on in private collections (Hessayon, 1995; Dobbs, 2003; King, 2005).

The Tulip was first cultivated by the Turks as early as 1000 AD. Starting from twelfth century, the tulip entered into decorative art in stylized form during Seljuk Empire. In the fourteenth and fifteenth centuries, that is, during the first period of Ottoman Empire, the people maintained fond for the tulip. Mehmed II, the Conqueror of İstanbul, had a special interest in literature and art, also laid great importance on gardening and tulip growing in İstanbul. Shortly after conquering İstanbul, Mehmed II initiated the construction of his magnificent Topkapı Palace,

was an extensive garden with magnificent views across the Bosphorus where plants, especially tulips, were planted. Süleyman the Magnificent, the great-grandson of Mehmed II, came to the throne in 1520. During his reign, the Ottoman Empire was at its most powerful and extensive. It was at this time that the Turks began to breed tulips rather than just gather them from the wild. The passion for tulips nurtured by Süleyman and later his son Selim II declined around the end of the sixteenth century with the accession of Mehmed III in 1595. It was not until 1647, when Mehmed IV became sultan, that the tulip regained royal favour. He restored the imperial gardens and decreed that all new species of flower should be registered and classified, and he established a council of florists to judge all new tulip cultivars. In seventeenth century wall tile decorations, the tulip was appeared as the most predominant flower. The tulip was also held an important place in the works of the poets and it was truly deserved. In addition to these it appeared in frescoes, fabrics and book illuminations and by 1630 apparently there were eight flower shops and 300 professional florists (Ünver, 1969; King, 2005).

By the time of Tulip Era (Lale Devri) of 1718-1730, the cult of the tulip became as extravagant in the Ottoman Empire during the reign of Ahmed III (1702-1720) as it did in Holland during the ‘Tulipmania’ of 1634-1637. Sultan Ahmed III was importing vast numbers of bulbs from Holland for his gardens and for tulip festivals. Fabulous prices were paid for tulips. Descriptions of these festivals make them sound almost decadent, and the sultan’s subjects were aghast at the cost. However, when Ahmed died in 1730, the impetus for tulip worship appeared to die with him (Bryan & Griffiths, 1995; Dobbs, 2003).

Holland has long been regarded as the world’s leading bulb nation, but the original source of main types of tulips was the Ottoman Empire and not Holland.

Before Tulipmania began, there were hundreds of flower shops selling bulbs in İstanbul (Hessayon, 1995).

Today, Holland is the world's largest producer of bulbs and millions of tulips cultivated with different production methods in Holland are exported every year to our country and the world. Thus, this small country obtains high income to sell this expensive ornamental plant. The other major producers of bulbs are Great Britain, United States and Japan (Hessayon, 1995).

1.6. The General Morphology of the Genus *Tulipa* L.

1.6.1. The Bulb

The bulb is specialized organ that is not only for vegetative reproduction but also the foodstore of the plant. A mature bulb includes four to six thick, fleshy scales (metamorphic leaves) packed with the reserve materials that support the future growth of the plant. The outside of the bulb is clothed by another specialized scales, the tunics, originating dead scales of previous years. The tunics protect the bulb from inappropriate environmental conditions and their morphological features are very important to distinguish tulip species. The disc-shaped lowest part of the bulb is called the basal plate and from the edge of it, roots arise. On the centre of the basal plate of an adult bulb, a small apical bud develops into the flowering shoot and the leaves. Other such buds or at least one bud may be found on the basal plate in the axils of fleshy scales which will grow into offsets, additional bulbs of various sizes for the next season, some of which may attain flowering size. In this way, the tulip increases itself vegetatively and all the offsets will produce new plants identical to the mother plant. Many species are stoloniferous, and the buds on the basal plate that form the offsets grow outwards, forming a hollow tube with a new bulb at the end. This

stoloniferous habit may be very marked, especially in triploid and pentaploid species such as *T. saxatilis* and *T. clusiana* which can rarely reproduce from seed. Not only does the tulip increase in this way, but it spreads as well, creating an expanding colony (Hall, 1940; Botschantzeva, 1982; Wilford, 2006).

1.6.2. The Stem and Leaves

The stem of the tulip appears in three main forms: the basal plate, the stem as a component part of the stolon and the stem of the flowering shoot with the peduncle. In a seedling, during its first year, the stem takes only two forms: basal plate, as a shortened and broadened modification of the stem and portion of the stem giving growth and development of the stolon. The third form, the stem of the flowering shoot, appears only after the tulip enters the adult phase. It consists of three parts: the stem between the lowest leaf and the basal plate of the bulb, a centre part of the stem between the lowest leaf and the upper leaf which is bearing the assimilatory leaves, and an upper part, the peduncle which is crowned by a flower (Botschantzeva, 1982).

The stem of many *Eriostemon* species branches above the upper leaf and the individual pedicels of the semi-umbellate inflorescence are crowned by flowers of the same dimensions as those of uniflorous plants. The flowering shoot may also develop branches from the axils of all stem leaves (Botschantzeva, 1982).

The stem is the first organ of the flowering shoot to be initiated in the bulb in the form of meristematic dome. In many species, it grows laterally from September till March like the basal plate of the bulb. The internodes of the stem begin to grow only after the initiation of all organs, including the carpels of the flower, has been completed (Botschantzeva, 1982).

Tulips have five types of leaves: in the first year, a plant gives only one “cotyledon leaf”. Then, up to the flowering phase, there appears every spring one “petiolar sheathing leaf” above the ground. When the plant enters the adult phase that forms two to four “sessile stem leaves”. But, there may be fewer or more leaves such as *T. regelii* has one leaf and *T. schmidtii* has 12 leaves. The sessile stem leaves are quite fleshy, glaucous to green coloured, membranous margined and often held alternately on the stem. They decrease in size up the stem and clasp it rather than having a distinct petiole. The other types of leaves, modified basal leaves, form “the tunics” and “the fleshy scales” of bulb (Hall, 1940; Botschantzeva, 1982; Wilford, 2006).

1.6.3. The Flower

The flower is mostly erect, large, actinomorphic, and carried by a strong peduncle. Its parts are arranged in alternate whorls. This pentacyclic, trimerous flower are composed two whorls of free tepals, two whorls of stamens and one whorl of carpel. There are no nectaries. The stamens and ovary are shorter than the tepals and held within the flower (Botschantzeva, 1982; Wilford, 2006).

Outer tepals differ from the inner tepal in structure, shape, and colouring. Traditionally, the presence or absence of pubescence at the base of the stamens has formed the basis of the subgenera. Species of subgenus *Eriostemon* have pubescent filaments whereas those of subgenus *Tulipa* are glabrous. The ovary is superior and consists of three connate carpels (trilocular). In each carpel, two rows of ovules are inserted on the plasentae, formed by the incurved edges of the carpels. The gynoecium includes an ovary, a short or unclear style and a sessile stigma (Botschantzeva, 1982).

1.6.4. The Fruit

The ovary develops into a trilocular, globular or ellipsoid capsule with three compartments. In each locule, two horizontal layers of seeds are attached to the incurved edges of the carpels. Seeds are numerous and flat. Their shapes are triangular with two rounded edges to orbicular (Hall, 1940; Botschantzeva, 1982; Wilford, 2006).

1.7. The History of Classification of the Genus *Tulipa* L. in Turkey

The most valuable study relating to the genus *Tulipa* in Turkey was performed by Marais who published 15 taxa (14 species and 1 variety) in the *Flora of Turkey and East Aegean Islands* (1984) (Table 14).

Table 14. Marais' classification on the genus *Tulipa* in *Flora of Turkey and East Aegean Islands*.

Section <i>Eriostemon</i> Boiss. Lowest leaf long $\pm$ parallel-sided. Young flower or bud infundibular or $\pm$ globose above the narrow, constricted base. Perianth segments with hairy claws, outer narrower and/or shorter. Filaments unequal, inner longer, all swollen and hairy at base. Ovary with a small, narrow stigma. <i>T. biflora</i> Pallas <i>T. humilis</i> Herbert <i>T. saxatilis</i> Sieber ex Sprengel <i>T. sylvestris</i> L. <i>T. orphanidea</i> Boiss. ex Heldr.	
Section <i>Tulipa</i>: Lowest leaf lanceolate or oblong-lanceolate, not parallel-sided. Young flowers campanulate to globular or stellate, rounded at base. Outer perianth segments longer than wider than inner. Filaments without swollen, hairy base. Stigma generally wide. <i>T. armena</i> Boiss. var. <i>armena</i> <i>T. armena</i> Boiss. var. <i>lycica</i> (Baker) Marais <i>T. sintenesii</i> Baker <i>T. aleppensis</i> Boiss. ex Regel <i>T. undulatifolia</i> Boiss. <i>T. julia</i> C. Koch <i>T. agenensis</i> DC. <i>T. praecox</i> Ten. <i>T. sprengeri</i> Baker <i>T. clusiana</i> DC.	

It has not been tried any revision study of the genus *Tulipa* after Marais' study. However, three new species from Turkey have been published: *T. cinnabarina* K. Perss. from Karaman by Persson (2000), *T. karamanica* Özhatay & Koçak from Konya by Özhatay & Koçak (2000), and lastly *T. gumusanica* Terzioğlu from Gümüşhane by Terzioğlu & Coşkunçelebi (2002). Thus, the total number of tulip species increased with addition of new species to 18 (17 species and 1 variety).

Apart from mentioned studies above, there are some morphological, cytotaxonomical and anatomical studies. These studies chronologically: Baytop, 1975, 1998; Ekim et al., 1991; Erik, 1995; Başak & Özhatay, 1997; Kandemir & Özkan, 2000; Koyuncu, 2000; Maunder et al., 2001; Özhatay, 2002; Ocak et al., 2004; Satıl & Akan, 2006; Coşkunçelebi et al., 2008.

1.8. Fixed Taxonomical Problems of the Genus *Tulipa* L.

1. The essential problem in tulip taxonomy in the world is that, previous studies have been mainly performed with many herbarium specimens and commercial stocks. This situation can cause some confusions in colour, shape, size. However, gradual variations within populations and between taxa cause confusing of them with each other. Dry materials complicate to see these variations.
2. Taxonomic problems of the genus *Tulipa* was emphasized by W. Marais who is author of this genus in the “*Flora of Turkey and East Aegean Islands*”. He especially emphasized that, *T. praecox* with *T. agenensis* and *T. aleppensis* with *T. sintenisii* may well be clonal selections of the same species.
3. Some character states using for identification of the species in the *Flora of Turkey* and other world floras can not classify some taxa exactly owing to they are not discriminative characters. Also, there is no sufficient character correlation at least in

some species. Therefore, users of the key are faced with some difficulties to identify specimens. These confusing taxa:

- *T. armena* var. *armena*, *T. armena* var. *lycica*, *T. gumusanica* and *T. julia* show high morphological variations. They are classified according to tunic pubescence and flower colour. But, these characters do not separate the taxa, sufficiently.
- *T. praecox*, *T. agenensis*, *T. aleppensis* and *T. sintenisii* are very similar morphologically and grow in similar habitats. They are almost classified according to their geographical distribution. Also, they are morphologically very similar with above group all together and they have still been classified related to geographical distribution and habitat differences.
- *T. humilis*, *T. cinnabarina* and *T. karamanica* grow in similar habitats and they are very similar morphologically and have high variation range.
- Populations of *T. sylvestris* and *T. orphanidea* show high variations.

It should be determined whether these species are the same or different, definitely. If they are different taxa, either new discriminative characters will be determined or available characters will be supported with new auxiliary characters. In this case, it will be ensured correlation of old and new characters. If they are the same taxa, these controversial species will be rearranged as a synonym of each other. Also, some uncertain species previously gathered by different investigators may be stated as a new species if it is necessary.

4. Fruit and seed characters of this genus were not almost used for species description and in classifying species in the *Flora of Turkey* and most of the world floras. Likely, most of fruiting specimens were not collected during writing of the *Flora of Turkey* or their taxonomical values were defectived in classification of species. In this study, it has been aimed to collect both flowering and fruiting

specimens and to use fruit characteristics in classification process and identification key preparations at the end of the revision.

5. *T. sprengeri* was first described in 1894 by Baker. Type specimen of this species is a cultivated one, originating from A5/6 Amasya/Turkey. The plant, which formerly collected from its original locality, have not been collected again since that time. This species was indicated in the EW (Extinct species in the wild) category in 1995 by Erik. Probably, either it has been extinct because of environmental effects or it has been never re-collected. In this study, it has been aimed to designate existence or nonexistence of this species.

6. After first collecting, also there are some species which have not been re-collected in our country such as *T. praecox*, *T. clusiana* and *T. saxatilis*. Although the origin of *T. praecox* may be pointed out as south-west or the Central Asia by Turkish and European floras, but the real origin of it has not been known yet. Besides, it is determined that this species was naturalized to south Europe. There are two doubtful records of the species from Amasya and İzmir in Flora of Turkey. But, collecting time and the other necessary information were not given. Also, type specimen of this plant has not been defined in both Floras. If this species is fixed in nature, type specimens will be determined for it. *T. saxatilis* has been only known from Crete, Rhodes and Muğla (Turkey) in the world. Also, this species has been not collected from Turkey secondly as above species. The record of *T. clusiana* from Turkey is doubtful, that is, the natural distribution of this species is only known from Iran and Pakistan.

The existence of these species in Turkey will be researched, and if they will be fixed, their geographic distribution and population conditions will be examined.

7. *T. cinnabarina* collected from Karaman by Persson (2000) and *T. karamanica* collected from Konya by Özhatay & Koçak (2000) were published in different publications as two separate new species for Turkey. But, they are more likely the same species because of both locations are the same place and there are no morphological differences between them. Persson's study was published before Özhatay & Koçak's study, therefore *T. karamanica* has to be the synonym of *T. cinnabarina* according to priority rule.

8. According to phytogeographic regions, six taxa are Irano-Turanian elements while four taxa are Mediterranean elements. However, phytogeographic regions of eight taxa have not been designated. Phytogeographic regions of these taxa will be tried to determine with this study.

9. New distribution areas of the taxa will be indicated. Endemics and rare species will be particularly examined.

1.9. Purpose

In this thesis, it is aimed to revise the genus *Tulipa* L. in Turkey for its taxonomical problems. The morphological, geographical, palynological and cytotaxonomical analyses of the taxa will be studied, the degree of relationship between species and their taxonomic positions will be determined. Descriptions of the taxa will be revised, and systematics problems will be resolved by using the forementioned techniques. Some of the taxa might be moved to a synonym status while some of them would be described as new species. Also, there are a species in EW threatened category and three species which have not been re-collected from Turkey after the first gathering. In addition to these, endemic and rare taxa will be collected during the research, and their threatened categories will be exhibited.

CHAPTER 2. MATERIALS AND METHODS

2.1. Materials

This thesis presents a taxonomic revision of the genus *Tulipa* L. (Liliaceae) in Turkey and is based mainly on fresh plant material collected from Turkey by the author. Field trips were performed between March and June in the years of 2006 and 2009. Approximately 1000 fresh specimens belonging to the genus from 100 localities have been collected for the study. The voucher specimens of all individuals are deposited in the herbarium of Abant İzzet Baysal University (AIBU). In addition to the fresh specimens, the study based on approximately 2000 herbarium materials from the following herbaria, abbreviated as in Thiers (2009):

AEF	Ankara University, Faculty of Pharmacy, Department of Pharmaceutical Botany, Ankara, Turkey
AIBU	Abant İzzet Baysal University, Faculty of Science & Literature, Department of Biology, Bolu, Turkey
ANK	Ankara University, Department of Biology, Ankara, Turkey
BM	The Natural History Museum, Department of Botany, London, U. K. England
E	Royal Botanic Garden, Edinburgh, U.K. Scotland
EGE	Ege University, Botanic Garden and Herbarium Research and Application Center, İzmir, Turkey

FUH	Fırat University, Faculty of Science & Literature, Department of Biology, Elazığ, Turkey
GAZI	Gazi University, Faculty of Science & Literature, Department of Biology, Ankara, Turkey
HUB	Hacettepe University, Faculty of Science, Department of Botany, Ankara, Turkey
ISTE	İstanbul University, Faculty of Pharmacy, Department of Pharmaceutical Botany, İstanbul, Turkey
ISTF	İstanbul University, Faculty of Science, Department of Botany, İstanbul, Turkey
K	Royal Botanic Gardens, Kew, U. K. England
KATO	Karadeniz Technical University, Faculty of Forestry, Department of Forest Botany, Trabzon, Turkey
KNYA	Selçuk University, Faculty of Science & Literature, Department of Biology, Konya, Turkey
VANF	Yüzüncü Yıl University, Faculty of Science & Literature, Department of Biology, Van, Turkey

2.2. Methods

2.2.1. Morphological Analyses

The description of taxa is based on measurements and examinations made on fresh and dried plants. All of the quantitative characters and most of the qualitative characters excluding the features of colour and position of plant parts are measured/examined on dried plants. The features of colour and position of plant parts

were observed during the field study and supported with photographs in the habitat of species. Measurements/observations of microscopic structures were taken with a ruler under the stereo-microscope while measurements/observations of macroscopic structures were taken with a ruler.

In the morphological studies, two systems were applied for evaluation of the taxa: traditional taxonomy and numerical taxonomy:

For the traditional taxonomic analyses, at least 10 specimens from each of 60 populations, and between 3 and 8 specimens from other populations (approximately 40) were sampled randomly. Additionally, some fresh fruiting specimens and herbarium specimens were used for some measurements and observations in the field. In the descriptions of the taxa, 47 quantitative, 61 qualitative and 5 supplement characters related to habitat features and phenology were used. Totally, more than $[(47 + 61) \times 10 \times 60] + [60 \times 5] = 64800 + 300 = 65100$ characters were measured/observed. Qualitative characters used in the plant descriptions are listed below. Quantitative characters are represented in the figures 2, 3 and 4.

Qualitative Characters

No	Abbreviation of character	Explanation of character
1	SP	Stem pubescence
2	SC	Stem colour
3	ES	Existence of a stolon
4	BT	Bulb type
5	TT	Tunic type
6	TC	Tunic colour
7	TTH	Type of tunic hairs
8	OHM	Hair distribution and occurrence of hairs at middle part of bulb tunic
9	LBP	Leaf blade pubescence
10	LCO	Leaf colour
11	LAR	Leaf arrangement
12	LLT	Lowest leaf type
13	LLU	Lowest leaf undulation

14	LLMCO	Lowest leaf margin colour
15	LLMC	Lowest leaf margin ciliate
16	LLTI	Lowest leaf tip
17	SLLT	Second lowest leaf type
18	SLLU	Second lowest leaf undulation
19	SLLMCO	Second lowest leaf margin colour
20	SLLMC	Second lowest leaf margin ciliate
21	SLLTI	Second lowest leaf tip
22	FS	Flower shape
23	EB	Existence of a blotch
24	BC	Blotch colour
25	EBE	Existence of a blotch edge
26	BEC	Blotch edge colour
27	COTIS	Colour of outer tepal at inner surface
28	COTOS	Colour of outer tepal at outer surface
29	SOT	Shape of outer tepal
30	TOT	Tip of outer tepal
31	BSOT	Blotch shape of outer tepal
32	OTTP	Outer tepal tip pubescence
33	OTMP	Outer tepal margin pubescence
34	OTMIP	Outer tepal midrib pubescence
35	CITIS	Colour of inner tepal at inner surface
36	CITOS	Colour of inner tepal at outer surface
37	SIT	Shape of inner tepal
38	TIT	Tip of inner tepal
39	ITTP	Inner tepal tip pubescence
40	ITMPB	Inner tepal margin pubescence
41	ITMIP	Inner tepal midrib pubescence
42	BSIT	Blotch shape of inner tepal
43	FC	Filament colour
44	FIS	Filament shape
45	PFB	Pubescence of filament base
46	AS	Anther shape
47	AC	Anther colour
48	EAA	Existence of an apicula on anther
49	PC	Pollen colour
50	OS	Ovary shape
51	OC	Ovary colour
52	PO	Pubescence of ovary
53	STC	Stigma colour
54	PS	Pubescence of stigma
55	CS	Capsule shape
56	PCA	Pubescence of capsule
57	SEC	Seed colour
58	SS	Seed shape
59	SST	Seed structure
60	SSU	Seed surface
61	SEW	Seed wing

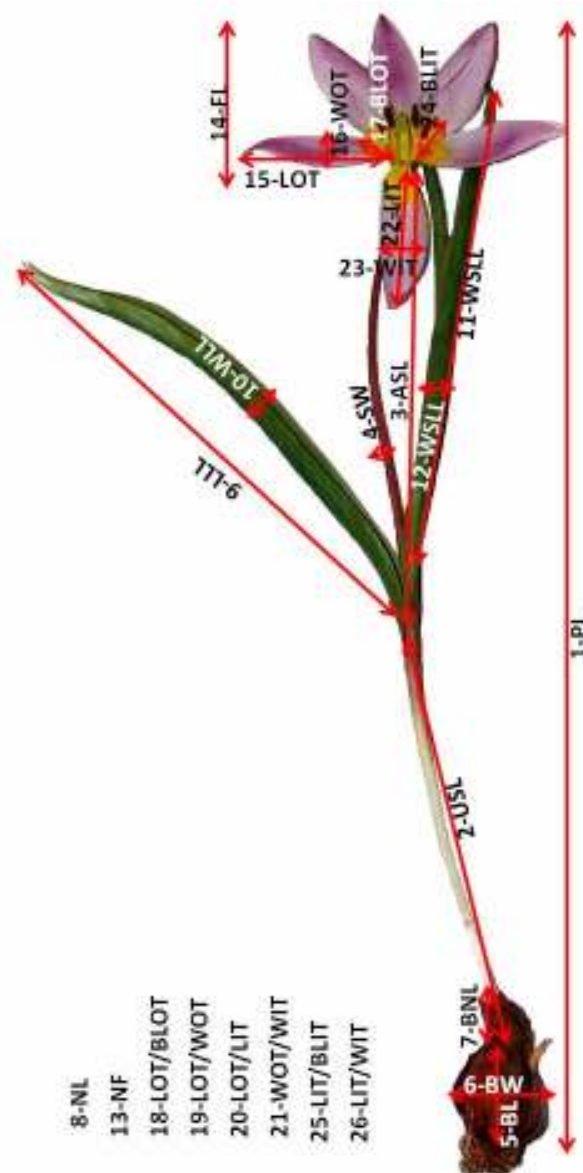


Figure 2. Measurement locations of the quantitative characters (1-PL: Plant length, 2-USL: Underground stem length, 3-ASL: Aerial stem length, 4-SW: Stem width, 5-BW: Bulb width, 6-BL: Bulb length, 7-BNL: Bulb neck length, 8-NL: Number of leaves, 9-LLL: Length of lowest leaf, 10-WLL: Width of lowest leaf, 11-LSLL: Length of second lowest leaf, 12-WSLL: Width of second lowest leaf, 13-NF: Number of flower, 14-FL: Flower length, 15-LOT: Length of outer tepal, 16-WOT: Width of outer tepal, 17-BLOT: Blotch length of outer tepal, 18-LOT/BLOT: Length of outer tepal/ Blotch length of outer tepal, 19-LOT/WOT: Length of outer tepal/ Width of outer tepal, 20-LOT/LIT: Length of outer tepal/ Length of inner tepal, 21-WOT/WIT: Width of outer tepal/ Width of inner tepal, 22-LIT: Length of inner tepal, 23-WIT: Width of inner tepal, 24-BLIT: Blotch length of inner tepal, 25-LIT/BLIT: Length of inner tepal/ Blotch length of inner tepal, 26-LIT/WIT: Length of inner tepal/ Width of inner tepal).

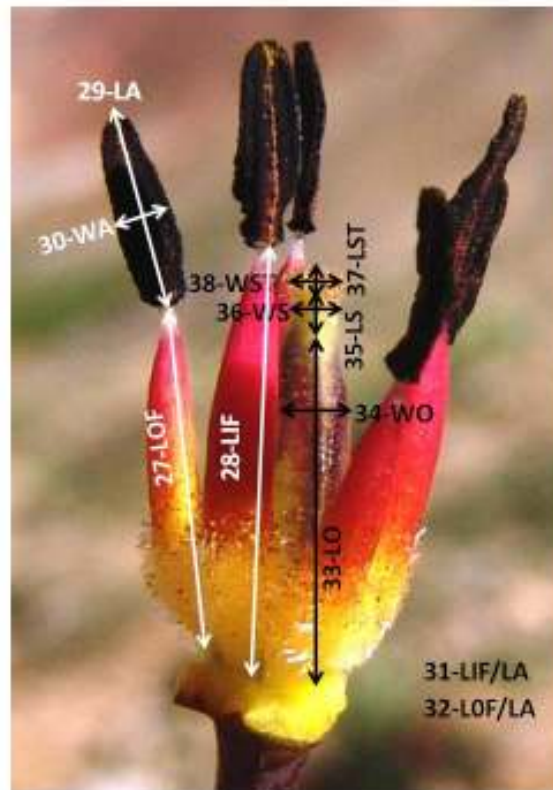


Figure 3. Measurement locations of quantitative characters for the generative organs (27-LOF: Length of outer filament, 28-LIF: Length of inner filament, 29-LA: Length of anther, 30-WA: Width of anther, 31- LIF/LA: Length of inner filament/ Length of anther, 32-LOF/LA: Length of outer filament/ Length of anther, 33-LO: Length of ovary, 34-WO: Width of ovary, 35-LS: Length of style, 36-WS: Width of style, 37-LST: Length of stigma, 38-WST: Width of stigma).

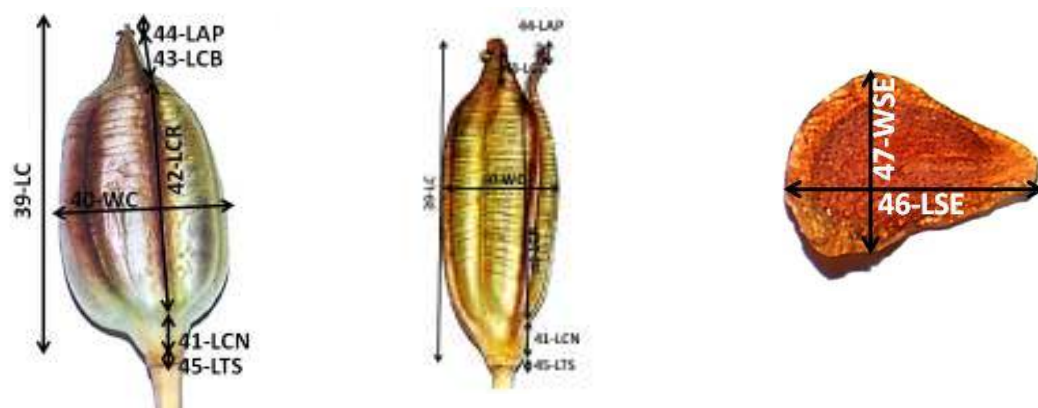


Figure 4. Measurement locations of quantitative characters for fruit and seed (39- LC: Length of capsule, 40-WC: Width of capsule, 41-LCN: Length of capsule neck, 42-LCR: Length of capsule rib, 43-LCB: Length of capsule beak, 44-LAP: Length of capsule apicula, 45-LTS: Length of tepal scar, 46-LSE: Length of seed, 47-WSE: Width of seed).

General characteristics and generic descriptions of *Tulipa* are followed by names, characteristics of subgenara, and sections with their authors. A dichotomus identification key for the Turkish species is followed by the treatment of the species.

Taxonomic nomenclatures of the taxa are given in the following order:

- Sequential number, valid species name, author(s), the publication: The publication of Brummitt and Powell (1992) is followed for the author citations.
- Citation of illustration(s)
- Homotypic and heterotypic synonym(s), author(s), full reference to the original publication(s)
- Type citation
- Description: The description of taxa is based on measurements/ observations made on fresh and dried specimens. In consideration of the original description, the variation ranges of characters were indicated covering the total variation exhibited by a taxon. Extreme values have been placed in paranthesis before/after or at the both sides of ranges of taxa.
- Phenology
- Distribution
- Habitat
- Phytogeographic region
- Conservation status
- Selected Specimens Examined: Citation of a specimen is constituted of locality, habitat, altitude, GPS (Global Position System) coordinate,

date of collection, collector number, herbarium acronyms, are given if any of those are available.

- Other selected collections
- Maps: Distribution of a taxon in the world and Turkey.
- Illustrations

For the numerical taxonomic analyses, taxonomic characters were measured or observed from each of ten fresh specimens collected randomly from each population. Totally, 600 specimens from 60 populations (OTUs) were evaluated for numerical analyses (Table 15). All qualitative and quantitative characters are coded according to Sneath & Sokal (1973), and Abbott et al. (1985). Qualitative characters with simple two-states were coded in binary forms, e.g., by scoring “0” for lowest leaf undulation “absent” and “1” for lowest leaf undulation “present”. Multi-state characters were coded as in ordered series of discrete states, e.g., by scoring “0” for tunic type is “papyraceus”, “1” for tunic type is “coriaceus”, and “2” for tunic type is “crustaceus” (Table 16).

Quantitative characters were measured by a ruler in millimetres or by a tape measure in centimeters (Table 17). The mean values of each character are calculated. The raw measurements of each character were obtained for each of ten individuals from a single population. Then, mean values of the raw measurements were calculated for every characters from each population. Afterwards, according to the modified Whisker’s graph (Massart et al., 2005), the mean values of each characters with their standard errors were plotted on one group graph by using Graphpad program (Figure 5). When means and standard error lines of each quantitative characters belonging to different populations have overlapped with each other, they were grouped and coded as the same state of the character in ascending order

(modified from Almeida and Bisby, 1984). After all quantitative characters were coded in this technique, a taxonomic matrix was generated (Appendix 1).

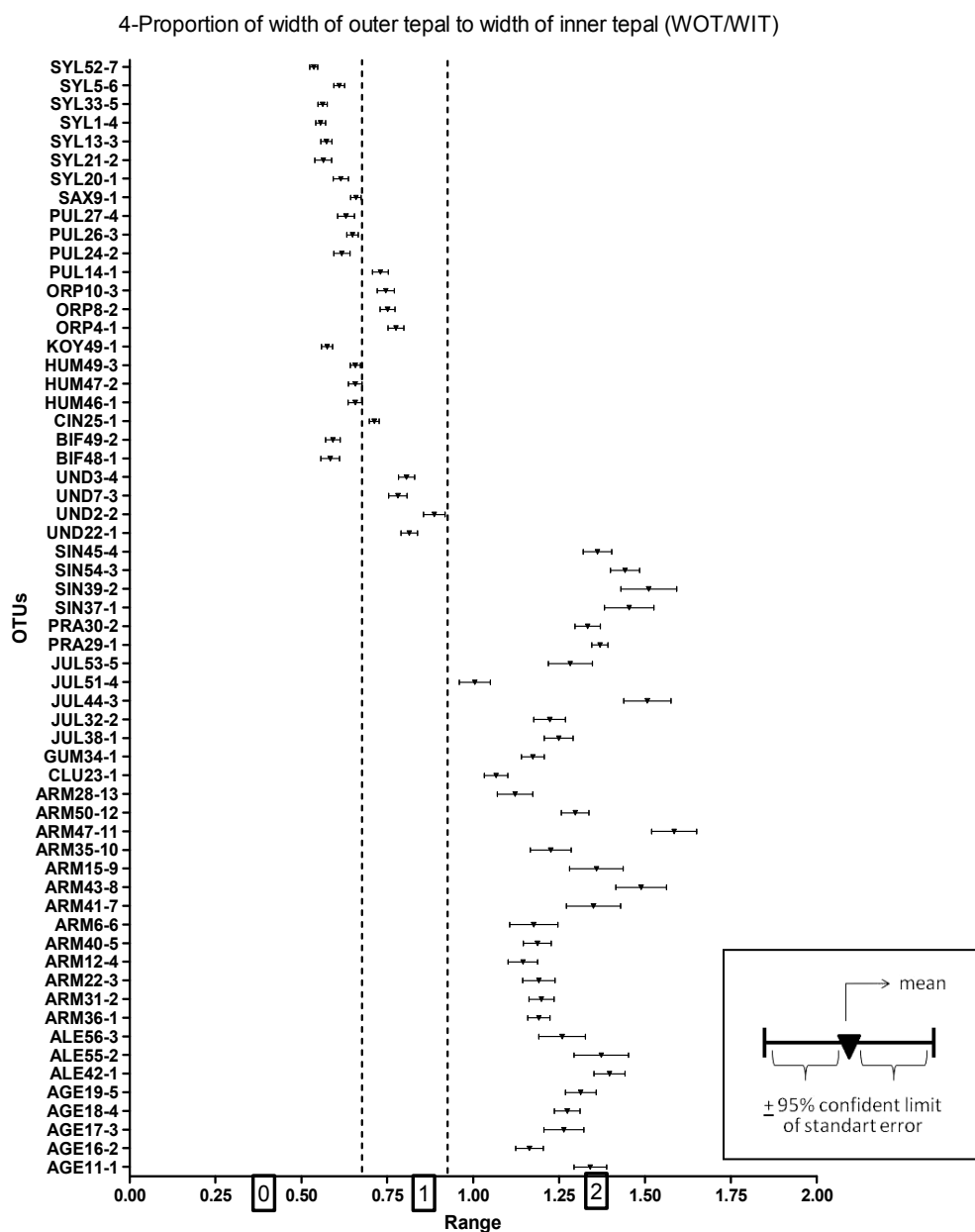


Figure 5. Grouping and coding the character states of a quantitative character on a modified Whisker's graph. The character states of this character were coded as follows: the mean values are less than 0.65 was scored by 0, the mean values are between 0.65 and 0.9 was scored by 1, and finally the mean values are more than 0.9 was scored by 2 (<0.65 : 0, $0.65 - 0.9$: 1, and $0.9 <$: 2).

A data matrix has been created by thirteen quantitative characters showing good separation and twenty-five qualitative characters versus 60 OTUs were subjected to the NT analyses. MINITAB (Meyer & Krueger, 2004) statistical package program was used for cluster and principal component analysis (PCA).

In cluster analysis, for measuring the distance between OTUs in n-dimensional space, Average Linkage between groups was used because of strengthening the tree diagrams geometrically. In analysis of clusters and establishing of dendrogram, Mannhattan's City block method was used because of high variations between OTUs.

Table 15. Operational taxonomic units (OTUs) used in numerical analyses (* Number of OTU/**First Abbreviation of OTU (the first number represents its locality, the second number represents its population number in the same precoded OTUs/** Second Abbreviation of OTUs).

1*	AGE11-1**	AG1***	Adana-Kozan	31	SIN37-1	SI1	Ağrı-Patnos
2*	AGE16-2**	AG2***	Hatay-Arsılyazı	32	SIN39-2	SI2	Ağrı-Tutak
3*	AGE17-3**	AG3***	Hatay-Üçgedik	33	SIN54-3	SI3	Gaziantep-Sof
4*	AGE18-4**	AG4***	Hatay-Şenköy	34	SIN45-4	SI4	Muş-Tigem
5*	AGE19-5**	AG5***	Mersin-Gilindere	35	UND22-1	UN1	Ankara-Tuzgölü
6*	ALE42-1**	AL1***	Elazığ-Harput	36	UND2-2	UN2	Çanakkale-Dümrek
7*	ALE55-2**	AL2***	Şanlıurfa-Halfeti	37	UND7-3	UN3	İzmir-Urla
8*	ALE56-3**	AL3***	Şanlıurfa-Karacadağ	38	UND3-4	UN4	Tekirdağ-Şarköy
9*	ARM36-1**	AR1***	Ağrı-Kılıçdağları	39	BIF48-1	BI1	Van-Çatak
10*	ARM31-2**	AR2***	Amasya-Ferhat	40	BIF49-2	BI2	Van-Güzeldere
11*	ARM22-3**	AR3***	Ankara-Tuzgölü	41	CIN25-1	CI1	Karaman-Sarıveliler
12*	ARM12-4**	AR4***	Antalya-Çimi	42	HUM46-1	HU1	Van-Artos
13*	ARM40-5**	AR5***	Bitlis-Süte	43	HUM47-2	HU2	Van-Bahçesaray
14*	ARM6-6**	AR6***	Denizli-Honaz	44	HUM49-3	HU3	Van-Güzeldere
15*	ARM41-7**	AR7***	Elazığ-Gözeli	45	KOY49-1	KO1	Van-Güzeldere
16*	ARM43-8**	AR8***	Erzurum-Köşk	46	ORP4-1	OR1	Aydın-Köşk
17*	ARM15-9**	AR9***	Hatay-Amanoslar	47	ORP8-2	OR2	Manisa-Spil
18*	ARM35-10**	AR10***	Tokat-Başçiftlik	48	ORP10-3	OR3	Muğla-Gülağzı
19*	ARM47-11**	AR11***	Van-Bahçesaray	49	PUL14-1	PU1	Antalya-Gevne
20*	ARM50-12**	AR12***	Van-Hakkari road	50	PUL24-2	PU2	Karaman
21*	ARM28-13**	AR13***	Yozgat-Şefaati	51	PUL26-3	PU3	Konya-Gevne
22*	CLU23-1**	CL1***	Ankara Üniv	52	PUL27-4	PU4	Niğde-Medetsiz
23*	GUM34-1**	GU1***	Gümüşhane-Zigana	53	SAX9-1	SA1	Muğla-Bozburun
24*	JUL38-1**	JU1***	Ağrı-Tahir	54	SYL20-1	SY1	Ankara-Akyarma
25*	JUL32-2**	JU2***	Bayburt-Kop	55	SYL21-2	SY2	Ankara-Beypazarı
26*	JUL44-3**	JU3***	Hakkari-Çukurca	56	SYL13-3	SY3	Antalya-Elmalı
27*	JUL51-4**	JU4***	Van-Keşiş	57	SYL1-4	SY4	Balıkesir-Kazdağı
28*	JUL53-5**	JU5***	Van-Muradiye	58	SYL33-5	SY5	Bolu-Aladağlar
29*	PRA29-1**	PR1***	Amasya-Alptekin G.	59	SYL5-6	SY6	Denizli-Babadağ
30*	PRA30-2**	PR2***	Amasya-Derbent	60	SYL52-7	SY7	Van-Merkez

Cluster analysis techniques can group the OTUs according to their similarities or dissimilarities quite well according to the distances measured among the OTUs. But real places of the OTUs in n dimensional space, their connection levels, and the group structures can not be shown easily by cluster analysis. Because of these reasons, the PCA is performed to overcome these restrictions of cluster analysis. During the PCA, two-dimensional case factor scatter-plots were generated by using most appropriate components which are the components 1, 2, and 3. The two-dimensional plotted graphs of OTUs were created according to the components 1 vs. 2, 1 vs. 3, and 2 vs. 3 which gave the most meaningful groups of OTUs. Also, the three-dimensional plotted graphs of OTUs were created according to the components 1, 2 and 3. The PCA analyses were generated by using the MINITAB (Meyer & Krueger, 2004) and SPSS (Levesque, 2007) statistical package programs.

Table 16. Qualitative characters and character states used in numerical analyses.

	List of characters	Abb.	Character states (Coding)
1	Stem pubescence	SP	glabrous (0)/glabrous or pubescent (1)/pubescent (2)
2	Existence of a stolon	ES	absent (0)/absent or inconspicuously present (1)/conspicuously present (2)
3	Tunic type	TT	papyraceus (papery) (0)/coriaceous (leathery) (1)/crustaceus (crust-like) (2)
4	Tunic colour	TC	brown or reddish-brown (0)/dark brown or blackish-brown(1)
5	Type of tunic hairs	TTH	pilose (0)/lanate (1)
6	Occurrence of hairs at middle part of bulb tunic	OHM	absent (0)/absent or present (1)/present (2)
7	Lowest leaf type	LLT	lanceolate (0)/linear-lanceolate (1)
8	Lowest leaf undulation	LLU	absent (0)/present (1)
9	Second lowest leaf type	SLLT	lanceolate (0)/linear-lanceolate (1)
10	Second lowest leaf undulation	SLLU	absent (0)/present (1)
11	Flower shape	FS	infundibular (0)/campanulate (1)
12	Blotch colour	BC	absent (0)/yellow (1)/eggplant (2)/reddish-purple (3)/blurred purplish-black (4)/bicoloured (bluish-violet and yellow) or yellow (5)
13	Colour of outer tepal at inner surface	COTIS	bright white (0)/shiny yellow (1)/shiny mauve (2)/shiny pinkish-purple to magenta (3)/shiny red (4)

Table 16. (continued).

	List of characters	Abbreviations	Character states (Coding)
14	Colour of outer tepal at outer surface	COTOS	pale white tinged greyish-violet (0)/pale white with a reddish-pink band from the flower base to tip (1)/pale yellow often tinged with greyish-violet (1)/pale yellow often tinged reddish-brown, reddish-pink, red or green (2)/pale mauve (3)/pale pinkish-purple to magenta (4)/pale red (5)
15	Shape of outer tepal	SOT	narrowly elliptic (0)/elliptic (1)/elliptic-ovate to ovate(2)/elliptic-ovate to elliptic-obovate (3)
16	Tip of outer tepal	TOT	acute to obtuse (0)/acute to acuminate (1)
17	Outer tepal tip pubescence	OTTP	absent to very slightly(obscurely) pubescent (0)/distinctly pubescent (1)
18	Colour of inner tepal at inner surface	CITIS	bright white (0)/shiny yellow (1)/shiny mauve (2)/shiny pinkish-purple to magenta (3)/shiny red (4)
19	Colour of inner tepal at outer surface	CITOS	pale white (0)/pale yellow (1)/pale yellow often tinged reddish-brown, reddish-pink or green only at base (2)/pale mauve (3)/pale pinkish-purple to magenta (4)/pale-red (5)
20	Shape of inner tepal	SIT	obovate to spatulate (0)/elliptic-ovate narrowed at base (1)
21	Tip of inner tepal	TIT	obtuse (0)/obtuse or acute (1)/acute (2)
22	Inner tepal margin pubescence at base	ITMPB	glabrous (0)/pubescent (1)
23	Filament colour	FC	yellow to orange (0)/purple (1)/brownish-black to purplish-black (2)/bicoloured (red and yellow or white and yellow or purple and yellow) or yellow (3)/yellow or black (4)
24	Pubescence of filament base	PFB	glabrous (0)/pubescent (1)
25	Anther colour	AC	yellow to orange (0)/purple to purplish-black (1)/yellow or purple (2)

Table 17. Quantitative characters used in numerical analyses (character states are given in app. 1).

	List of characters	Abbreviations
1	Length of outer tepal/ Blotch length of outer tepal	LOT/BLOT
2	Length of outer tepal/ Width of outer tepal	LOT/WOT
3	Length of outer tepal/ Length of inner tepal	LOT/LIT
4	Width of outer tepal/ Width of inner tepal	WOT/WIT
5	Length of inner tepal/ Blotch length of inner tepal	LIT/BLIT
6	Length of inner filament/ Length of anther	LIF/LA
7	Length of outer filament/ Length of anther	LOF/LA
8	Width of lowest leaf	WLL
9	Width of second lowest leaf	WSLL
9	Length of outer tepal	LOT
10	Width of outer tepal	WOT
11	Length of anther	LA
12	Width of anther	WA

2.2.2. Palynological Analyses

The pollen material was collected from the field studies. Altogether, the specimens from 59 populations by light microscopy and 6 population by scanning electron microscopy (SEM) have been examined.

For light microscopy (LM) observations, the pollen was prepared following the method of Wodehouse (1935). In this method, pollen grains were put on a microscope slide and 2-3 drops of 96% alcohol were added to clean resinous and fatty bodies. The microscope slide was heated at 30-40 °C to remove the alcohol. 1-2 mm³ of solution of glycerin-gelatine with safranin was/were dropped on pollen grains and heated for a while. Pollen grains were distributed, homogeneously on slide. The microscope slides were kept for 1 month at room temperature to fix the slides and regularly to distribute the pollen grains. Then, pollen grains were investigated on a light microscope and identified (10X100). The following features were described:

1. pollen type
2. pollen size (long axis and short axis)
3. pollen shape
4. exine sculpturing
5. thickness of exine
6. thickness of intine (exintine, endintine, exintine near aperture)
7. sulcus length
8. sulcus width (in monosulcate pollen)
9. feature of sulcus membran
10. feature of exine towards aperture (s)
11. operculum length (in monosulcate pollen)

12. operculum width (in monosulcate pollen)

Pollen measurements were made with Nikon SE light microscope. Pollen size values are means of 30 pollen grains. For the other parameters, 10 measurements were made. The photomicrographs of pollen grains were taken with a camera (Olympus DP71) connected to a light microscope (Olympus BX51) at 10X100 magnification.

Scanning electron microscopy (SEM) was also used to investigate exine sculpture in detail. In SEM study, the pollen was first treated with 70% alcohol, then taped onto a stub with double-stick tape, coated with gold and viewed with JEOL JSM 6490 LV scanning electron microscope.

Pollen terminology follows mainly that of Punt et al. (1994).

2.2.3. Cytotaxonomical Analyses

Collected bulbs belonging to taxa from the field studies were transferred into the pots at Abant İzzet Baysal University and counted chromosome numbers of taxa following aceto-orcein method. Altogether, the approximately 200 specimens from 50 populations by light microscopy have been examined (Elçi, 1982).

In this analysis, growing root tips (1-1.5 cm long) were taken from the plant specimens. Root tips were put in saturated solution of 1-bromonaphthalene in early hours of morning and kept in refrigerator for 24 hours. The aim of this treatment is to prevent the forming of spindle microtubules and to stop the chromosomes in metaphase during mitosis. Then, root tips were put in Carnoy fixative (1:3 Glacial acetic acid-absolute ethanol) and kept in refrigerator for 24 hours. Root tips were taken out from the fixative and hydrolysed in 1 N HCL at 60 °C for 20 min. Samples were placed to stain in aceto-orcein at the room temperature for 2 hour. The

hydrolysed and stained meristematic zone was maserated and arranged in a drop of 45 % acetic acid on a slide. Finally, it was squashed between the slide and the coverslip to separate the cells. The dividing cells were quickly observed under a light microscope with a low magnification objective (10X). The chromosomes of specimens were observed under a higher magnification objective (100X) using immersion oil and counted chromosome numbers of taxa. The photomicrographs of chromosomes were taken with a camera (Olympus DP71) connected to a light microscope (Olympus BX51) at 10X100 magnification.

CHAPTER 3. RESULTS

3.1. General Characteristics of the Genus *Tulipa* L.

The following classification of the genus *Tulipa* is newly designated according to the results of this study and present data. Infrageneric categories adopted to present classification systems of Baker, 1874, 1883a, Vvedensky, 1935, Hall, 1940; Marais, 1984; van Raamsdonk & Vries, 1992, 1995; Wilford, 2006; Zonnevald, 2009 with new additions and specific/infraspecific descriptions are generated related to the new findings obtained from this study.

Kingdom: Plantae

Subkingdom: Tracheobionta

Division: Magnoliophyta Cronquist, Takht & Zimmerm. ex Reveal

Class: Liliopsida Batsch

Subclass: Liliidae J. H. Schaffn.

Order: Liliales Perleb

Family: Liliaceae Juss.

Genus: *Tulipa* L.

Bulbous perennials. Bulb tunics variously lined with hairs or glabrous. Leaves 2-8, cauline. Flowers 1-2(-4). Perianth segments 6, free, petaloid, the two series $\pm$ dissimilar. Nectaries absent. Anthers dehiscing laterally; filaments widened or

swollen at base. Style obscure or very short. Fruit sort or long, subspherical to ellipsoid, sometimes shortly stipitate and/or beaked. Seeds numerous, flat, $\pm$ triangular (Marais, 1984).

3.2. Identification Key to Subgenera and Sections of the Genus *Tulipa* L. in Turkey

1. Filaments hairy and swollen at base (except *T. sprengeri*); Young flower infundibular or $\pm$ globose above the narrow, constricted base. Outer perianth segments narrower and/or shorter than inner ones Subgenus *Eriostemon*
2. Tunics with a ring of short hairs around basal plate and adpressed, bristly hairy at neck, middle part glabrous
3. Flowers yellow or mandarin red to orange
 4. Flowers yellow Section *Sylvestres* (Baker) Baker
 4. Flowers range from mandarin red to orange
..... Section *Orphanideae* Eker & Babaç, *sect. nov.*
3. Flowers in shades of mauve, pink, purple, magenta or pinkish-white
 5. Lowest leaf glaucous, less than 1.5 cm in width
..... Section *Humiles* Eker & Babaç, *sect. nov.*
 5. Lowest leaf shiny green, more than 2.5 cm in width
..... Section *Saxatiles* (Baker) Baker
2. Tunic densely, lanate hairy Section *Biflores* sensu A. D. Hall
1. Filaments glabrous and not swollen at base; Young flowers campanulate to globular or stellate, rounded at base. Outer perianth segments longer and wider than inner ones (except *T. undulatifolia*) Subgenus *Tulipa*
6. They have papery, brown or reddish-brown tunics, usually lined with only a few

straight hairs or with a dense layer of woolly, often rippled hairs lining the bulb tunics. Leaves linear-lanceolate and undulate Section *Tulipa*

6. They have coriaceous, blackish-brown or dark brown tunics. Bulbs distinctively small and having a prominent tuft of hairs protruding from the top. Leaves long, narrow and linear..... Section *Clusianae* Baker

Subgenus *Eriostemon* (Boiss.) Raamsd.

These species are characterized by their hairy and swollen filaments at base (except *T. sprengeri*), which are unequal. The outer three filaments are shorter than the inner three filaments. Inner perianth segments with hairy claws. Young flower or bud infundibular or $\pm$ globose above the narrow, constricted base. In the sun the flowers open wide to form a star. Flower colour is yellow, white, pink, mauve or mandarin red to orange-red. Multi-flowered plants are common in this subgenus. Outer perianth segments narrower and/or shorter than inner ones. Lowest leaf long $\pm$ parallel-sided. Ovary with a small, narrow stigma (Marais, 1984; van Raamsdonk & de Vries 1992; Wilford, 2006).

Exceptions to this include *T. sprengeri* and *T. sogdiana*, which have glabrous filaments, but in all other respects they belong to this subgenus and in some cases may only be abnormal forms of species with otherwise hairy filaments (Wilford, 2006).

- Section *Sylvestres* (Baker) Baker

Flowers range from pale yellow to bright, golden yellow. Tunics with a ring of short hairs around basal plate and adpressed, bristly hairy at neck, middle part glabrous.

- Section *Orphanideae* Eker & Babaç, *sect. nov.*

Type: *Tulipa orphanidea* Boiss. ex Heldr.

Flowers range from mandarin red to orange, brownish-red. This section includes some specimens (*T. orphanidae*) or taxon (*T. sprengeri*) with glabrous filament base.

- Section *Saxatiles* (Baker) Baker

Flowers pinkish-purple with a yellow blotch. Lowest leaf shiny green, more than 2.5 cm in width.

- Section *Humiles* Eker & Babaç, *sect. nov.*

Type: *Tulipa humilis* Herb.

Flowers in shades of mauve, pink, purple, magenta or pinkish-white with a yellow or bicolored blotch. Lowest leaf glaucous, less than 1.5 cm in width.

- Section *Biflores* sensu A. D. Hall

Produce many flowers from one bulb, up to twelve. Flowers small, yellow or white with a yellow blotch of varying size. Tunic densely, lanate hairy.

Subgenus *Tulipa*

These species are characterized by their glabrous filaments without swollen, which are all about the same length. Young flowers campanulate to globular or stellate, rounded at base, and the colour is predominantly red or rarely yellow. Yellow forms of normally red species lack the red pigments and are equivalent to albinos. Outer perianth segments longer and wider than inner ones (except *T. undulatifolia*). Lowest leaf lanceolate or oblong-lanceolate, not parallel-sided (undulate). Stigma generally wide (Marais, 1984; van Raamsdonk & de Vries 1995; Wilford, 2006).

- Section *Tulipa*

They have papery, brown or reddish-brown tunics, usually lined with only a few straight hairs or with a dense layer of woolly, often rippled hairs lining the bulb tunics. Flowers generally red with an eggplant basal blotch with or without yellow.

- Section *Chusianae* Baker

They have coriaceous, blackish-brown or dark brown tunics. Bulbs distinctively small and having a prominent tuft of hairs protruding from the top. Leaves long, narrow and usually spaced apart on the stem, the upper ones often attached to the stem well above ground level. Flowers red, yellow, or white with red backs to the outer tepals.

3.3. Identification Key to the Genus *Tulipa* L. in Turkey

1. Filaments hairy and swollen at base (except *T. sprengeri*); Young flower infundibular or $\pm$ globose above the narrow, constricted base. Outer perianth segments narrower and/or shorter than inner ones (Subgenus *Eriostemon*)

2. Tunics lined with long felted hairs; leaves always 2

3. Flowers white with a yellow blotch inside *T. biflora*

3. Flowers pure yellow *T. koyuncui*

2. Tunics with a ring of hairs around basal plate and with short straight hairs at neck; leaves 2-7

4. Flowers yellow without a blotch *T. sylvestris*

4. Flowers not yellow

5. Flowers mandarin red to orange red

6. Anther bright yellow at fresh; tunics papery, chestnut-brown ..*T. sprengeri*

6. Anther purple or bluish-black at fresh; tunics coriaceous or crustaceous,

dark brown or blackish-brown

7. Blotch distinctly present, bulurred purplish-black; filament brownish-black *T. orphanidea*

7. Blotch often absent, rarely very slightly present, if it is present yellow or bicoloured; filament yellow, orange, red or bicoloured ... *T. cinnabarina*

5. Flowers in various shades of pink, mauve or purple

8. Lowest leaf 3-4.2 cm, shiny green; inner periant segments 42-60 x 16-28 mm *T. saxatilis*

8. Lowest leaf 0.3-1.4 cm, glaucous; inner periant segments 17-40 x 6-16 mm

9. Tunic pale brown; flowers mauve with a distinct yellow blotch *T. humilis*

9. Tunic blackish-brown; Flowers pinkish-purple to magenta with often an obscure, bicoloured blotch (bluish-violet & yellow; purplish-pink & yellow; white & yellow) or purple or yellow *T. pulchella*

1. Filaments glabrous and not swollen at base; Young flowers campanulate to globular or stellate, rounded at base. Outer perianth segments longer and wider than inner ones (except *T. undulatifolia*) (Subgenus *Tulipa*)

10. Flowers white with a purple blotch, outer perianth segments white with a reddish-pink band from base to tip outside *T. clusiana*

10. Flowers often red with eggplant coloured blotch, rarely yellow with or without a dark blotch

11. Bulb tunics densely felted or matted, woolly hairs (lanate)

12. Dwarf plants of natural habitats, not stoloniferous *T. julia*

12. Larger plants, often weeds of cultivation, rarely maquis or meadow elements; markedly or limited stoloniferous

13. Aerial stem length (15-)30-60 cm; not forming mature capsule and seed
 *T. praecox*
13. Aerial stem length 4-28 cm; forming mature capsule and seed
14. Blotch 1/4-1/2 length of segments; anther purplish-black; tunics
 matted lanate..... *T. agenensis*
14. Blotch (1/12)1/8-1/4 length of segments; anther purple; tunics
 densely lined with arachnoid lanate or straight-untangled hairs
 *T. aleppensis*
11. Bulb tunics in middle part glabrous to densely pilose hairy
15. Plants of natural habitats, not stoloniferous *T. armena*
15. Weeds of cultivation, markedly or limited stoloniferous
16. Aerial stem and upper leaves usually puberulous to pubescent; inner
 periant segments wider or equal to outer periant segments; stigma
 often wider than ovary *T. undulatifolia*
16. Aerial stem and upper leaves glabrous; outer periant segments wider
 and longer than inner periant segments
17. Tunics densely lined with arachnoid lanate or straight-untangled hairs
 *T. aleppensis*
17. Tunics with hairs around basal plate and neck, middle part sparsely
 hairy to glabrous *T. sintenisii*

3.4. Morphological, Pollinological and Cytotaxonomical Features of Taxa

Section *Sylvestres* (Baker) Baker

1. *Tulipa sylvestris* L. in Species Plantarum: 305 (1753)!

≡ *Liriopogon sylvestre* (L.) Raf., Fl. Tellur. 2: 35 (1837).

Plant 18.5-49 cm. Stem glabrous, stem width 1-3(4) mm, underground stem length 2.5-17 cm, aerial stem length (8.5-)12-26(-32) cm. Stoloniferous or not. Bulb ovoid to globose-ovoid, 1.3-2.5 × 1.2-2.2 cm. Bulb neck 0.3-6.5(-10) cm. Tunics coriaceous, yellowish-brown to reddish-brown, tunics with a ring of short hairs around basal plate and adpressed, pilose, bristly and longer hairy at neck, middle part glabrous. Leaves 2-4, erecto-patent, semierect, erect, semifalcate, falcate or emerging erect, but bending over the ground, linear-lanceolate, canaliculate, glaucous or green, alternate, obtuse to acute, leaf margin membranous, glabrous or ciliate and entire; Lowest leaf 10-27 × (0.3-)0.5-1.8(-2.4) cm; second lowest leaf 7.5-23 × 0.3-1.3 cm. Flowers 1(-2), infundibular to stellate or globular, yellow without central blotch inside; outer tepals shiny yellow inside and often tinged green, pink, red or reddish-pink on a pale yellow ground outside, narrowly elliptic to elliptic, acute to acuminate, glabrous or very slightly pubescent only at tip, 21-50 × 5-15 mm; inner tepals shiny yellow inside and pale yellow or often slightly tinged green, reddish-brown or reddish-pink on a pale yellow ground outside, elliptic-ovate with narrowed base, acute to acuminate, distinctly pubescent at base and slightly pubescent at tip, 22-53 × 9-26 mm. Filaments yellow to orange-yellow, lanceolate to linear-lanceolate and pubescent at base; outer filaments 5-13 mm, inner ones 7-16

mm. Anthers $2.5-8 \times 1-3$ mm, oblong, yellow at fresh, apiculate or not. Pollen light yellow. Ovary subfusiform to fusiform, green at fresh, glabrous, $6-16 \times 1.5-5$ mm. Style very short or obscure, $0.5-2.5 \times (0.6-0.8-2)$ mm. Stigma pubescent, light yellow or green at fresh, $0.5-1(-1.5) \times 1-2.5$ mm. Capsule $1.9-3.2 \times 1.2-1.8$ cm, ellipsoid-obovoid to obovoid, glabrous; neck 1-3 mm, rib 12-25 mm, beak 2-5, apicula 1-2 mm; tepal scar 0.5-1 mm. Seeds numerous, flattened with rugose surface, triangular with two rounded angles to orbicular, light brown, $3.5-6.5 \times 2.5-5.5$ mm, winged.

1. Lowest leaf 1.1-2.4 cm; flower globular; anther width 2-3 mm; markedly stoloniferous subsp. *sylvestris*
1. Lowest leaf 0.3-1(-1.3) cm; flower infundibular, anther width 1-2 mm; inconspicuously stoloniferous subsp. *australis*

Phenology: Flowering in May, and fruiting in June.

Distribution: Turkey (West Anatolia and exceptionally in Van province), widely naturalized in Europe and N. Africa to Siberia and the Middle East: Greece, Bulgaria, Albania, Croatia, Serbia, Romania, Italy, Sardinia, Sicily, Spain, Portugal, France, Britain, Germany, Austria, Switzerland, Poland, Hungary, the Czech Republic, Slovakia, Netherlands, Belgium, Luxembourg, Denmark, Sweden, Norway, European Russia, Latvia, Estonia, Armenia, Crimea, Algeria, Morocco, Tunisia (Figure 6-7).

Habitat: *T. sylvestris* naturally distributes in west Anatolia, but also it was reported two record from Van province in east Anatolia. This record is a cultivar form of *T.*

sylvestris in gardens. Wild populations (subsp. *australis*) grow in stony plains or screes with red, reddish-brown or brown soils of higher forest clearing at an elevation of 1000-2000 m. Cultivated populations (subsp. *sylvestris*) grow in orchards or gardens with gray soils at elevation of 1700-3000 m.

Phytogeographic region: Naturalized and widespread, unknown phytogeographic origin.

Conservation status: (IUCN, 2001). Populations of *T. sylvestris* in West Anatolia (subsp. *australis*) have extensive populations and there is no risk presently although excessive grazing of wild distribution areas in the regions. Thus, the subspecies may be classified as ‘Least Concern’ (LC). The other populations in Van province (subsp. *sylvestris*) have restricted ranges in cultivated areas, gardens and orchards. Their natural habitats might be threatened due to the urbanization. Thus, the subspecies may be classified as ‘Vulnerable’ (VU).

subsp. *sylvestris*

= *Tulipa turcica* Roth, Catal. Bot. 1: 45 (1797); *Tulipa gallica* Delaun. ex Loisel., Herb. Amateur Fleurs 3: t. 160 (1829); *Tulipa sylvestris* var. *gallica* (Delaun. ex Loisel.) Kunze, Flora 29: 699 (1846); *Tulipa grisebachiana* Pant., Oesterr. Bot. Z. 23: 265 (1873); *Tulipa florentina* Baker, J. Linn. Soc., Bot. 14: 290 (1874)! *Tulipa marshalliana* Andr. ex Baker, J. Linn. Soc., Bot. 14: 290 (1874)! *Tulipa grisebachii* Borbás, Oesterr. Bot. Z. 33: 202 (1883); *Tulipa australis* var. *gallica* (Delaun. ex Loisel.) Levier, Tulip. Eur.: 103 (1884)! *Tulipa balcanica* Velen., Abh. Böhm. Ges. Wiss. 37: 65 (1892 publ. 1893); *Lilium bononiense* E.H.L.Krause in J.Sturm,

Deutschl. Fl., ed. 2, 1: 91 (1906); *Tulipa abatinoi* Borzi & Mattei, Boll. Reale Orto Bot. Palermo 11: 241 (1912).

Iconibus: (Figure 11).

Type: Described from Montpellier, the Apennines and London (Hb. Linn. 425/1, photo!).

Selected Specimens Examined: B9 Van: City center, Cumhuriyet street, Çalık avenue, Yörükevleri, no 58, cultivated in the orchard, 1729 m, 38° 29.671' N 043° 23.178' E, 01.05.2007, Eker 1842 in AIBU! ibid., 07.06.2008, Eker 2198 (fruiting time) in AIBU! Gevaş, south east corner of Lake Van, Artos Dağı, limestone, 2500-3000 m, June/July 1968, Rix 734 in E!

subsp. *australis* (Link) Pamp. in Boll. Soc. Bot. Ital. 1914: 114 (1914).

≡ *Tulipa australis* Link, J. Bot. (Schrader) 2: 317 (1799), Basionym/Replaced Synonym.

= *Tulipa pumila* Moench, Methodus: 301 (1794); *Tulipa breyniana* Ker Gawl., Bot. Mag. 19: t. 717 (1804), nom. illeg.; *Tulipa transtagana* Brot., Fl. Lusit. 1: 519 (1804); *Tulipa maculata* Roth, Nov. Pl. Sp.: 196 (1821); *Tulipa sylvestris* var. *montana* Kunze, Flora 29: 637 (1846); *Tulipa thirkeana* K.Koch, Linnaea 22: 226 (1849)! *Tulipa australis* var. *campestris* Willk. in M.Willkomm & J.M.C.Lange, Prodr. Fl. Hispan. 1: 219 (1862); *Tulipa australis* var. *montana* (Kunze) Willk. in M.Willkomm & J.M.C.Lange, Prodr. Fl. Hispan. 1: 219 (1862); *Tulipa australis* var. *parviflora* Willk. in M.Willkomm & J.M.C.Lange, Prodr. Fl. Hispan. 1: 219 (1862);

Tulipa fragrans Munby, Bull. Soc. Bot. France 13: 256 (1866); *Tulipa alpestris* Jord. & Fourr., Brev. Pl. Nov. 2: 120 (1868); *Tulipa celsiana* var. *maculata* Regel, Trudy Imp. S.-Peterburgsk. Bot. Sada 2: 445 (1873); *Tulipa acrocarpa* Jord. ex Baker, J. Linn. Soc., Bot. 14: 293 (1874)! *Tulipa biebersteiniana* var. *aurantiaca* Baker, J. Linn. Soc., Bot. 14: 291 (1874)! *Tulipa maculata* Baker, J. Linn. Soc., Bot. 14: 289 (1874), nom. illeg.! *Tulipa caucasica* Orph. ex Nyman, Consp. Fl. Eur.: 723 (1882), pro syn.; *Tulipa celsiana* var. *alpestris* (Jord. & Fourr.) Nyman, Consp. Fl. Eur.: 723 (1882); *Tulipa celsiana* var. *transtagana* (Brot.) Nyman, Consp. Fl. Eur.: 723 (1882); *Tulipa australis* var. *fragrans* (Munby) Levier, Tulip. Eur.: 103 (1884)! *Tulipa australis* var. *transtagana* Levier, Tulip. Eur.: 104 (1884)! *Tulipa celsiana* var. *fragrans* (Munby) Batt. & Trab. in J.A.Battandier & al., Fl. Algérie, Monocot.: 167 (1884)! *Tulipa australis* subsp. *gallica* (Delaun. ex Loisel.) K.Richt., Pl. Eur. 1: 216 (1890); *Tulipa australis* subsp. *montana* (Kunze) K.Richt., Pl. Eur. 1: 216 (1890); *Tulipa australis* subsp. *transtagana* (Brot.) K.Richt., Pl. Eur. 1: 216 (1890); *Tulipa fragrans* var. *montana* (Kunze) T.Durand & Schinz, Consp. Fl. Afric. 5: 408 (1894); *Tulipa abatinoi* var. *aurea* Borzí & Mattei, Boll. Reale Orto Bot. Palermo 11: 242 (1913); *Tulipa sylvestris* f. *aurea* (Borzí & Mattei) Pamp., Boll. Soc. Bot. Ital. 1914: 116 (1914); *Tulipa sylvestris* f. *fragrans* (Munby) Pamp., Boll. Soc. Bot. Ital. 1914: 116 (1914); *Tulipa sylvestris* var. *mediterranea* Pamp., Boll. Soc. Bot. Ital. 1914: 115 (1914); *Tulipa sylvestris* f. *montana* (Kunze) Pamp., Boll. Soc. Bot. Ital. 1914: 116 (1914); *Tulipa sylvestris* f. *scappuccii* Pamp., Boll. Soc. Bot. Ital. 1914: 116 (1914); *Tulipa tchitounyi* Azn., Magyar Bot. Lapok 16: 34 (1917 publ. 1918)! *Tulipa paschalis* Sennen, Ann. Soc. Linn. Lyon, n.s., 70: 63 (1923 publ. 1924); *Tulipa sylvestris* var. *mauritii* Valdés, Lagasalia 18: 326 (1996); *Tulipa sylvestris* var. *alpestris* (Jord. & Fourr.) O.Bolòs & Vigo, Fl. Països Catalans 4: 80 (2001).

Iconibus: (Figure 8-10).

Type: Type not indicated.

Selected Specimens Examined: A3 Bolu: Aladağlar, Ardıç, Harmancık serisi, 1450-1550 m, 14.05.1963, Sevim S20 in E! Ankara: Beypazarı, Karlık mountain, around Taşocağı pass, stony plains in high forest clearing, 1624 m, 40° 20.271' N 031° 56.366' E, 13.05.2008, Eker 2172 in AIBU! Bolu: between Bolu-Kıbrıscık, 29 km to Kıbrıscık, Gökhaliller, 1475 m, stony plains in high forest clearing, 40° 31.420' N 031° 42.737' E, 13.05.2008, Eker 2168 in AIBU! ibid., 10.06.2008, Eker 2214 (fruiting time) in AIBU! Aladağlar, Sarıalan mevkii, 22.05.2000, N. İkinci 1844 in AIBU! A4 Bolu: between Kızılcahamam-Gerede, Akyarma pass, stony plains in high forest clearing, 1568 m, 40° 37.189' N 032° 28.143' E, 12.05.2008, Eker 2166 in AIBU! Çankırı: Kızılcahamam-Çerkeş road, steppe, 1300 m, 01.05.1996, B. Erdoğan (Z. Aytaç 7337) in AEF & GAZİ! B1 Balıkesir: Edremit, Kazdağları, Sarıkız hill, stony plains and alpine meadow, 1715 m, 39° 41.475' N 026° 52.486' E, 30.05.2009, Eker 2426 in AIBU! Sarıköy, Kazdağı, scree at summit, 1727 m, 19.05.1962, Dudley (D. 34810) in E! Edremit, Kazdağı, east slopes, 560 m, 13.05.1964, Kayacık & Eliçin 2090 in E! B2 Kütahya: Murat mountain, Oktay pasturage, near Harman, 1450 m, 17.5.1978, A. Baytop (ISTE 39387) in K! Sarıçiçek pasturage, in forest, 1900 m, 27.4.1986, Ö. Seçmen 3252 in EGE! B3 Eskişehir, Sündiken mountain, Başören vilage, 1000 m, 21.05.1971, Ekim 679 in E & ANK! Isparta: Şarkikaraağaç, Kızıldağ Milli Parkı, north-east slopes, serpentine, 1300 m, 04.05.1998, H. Şağdan 2143 in HUB! ibid., *Cedrus libani* forest, stony slopes, 1250-1300 m, 22.04.1994, B. Mutlu in HUB! C2 Denizli: Babadağ, 2 km above Çakıroluk Çeşmesi, *Pinus nigra* forest,

1507 m, 37° 42.276' N 029° 03.447' E, 28.05.2009, Eker 2423 in AIBU! ibid., 10.05.1996, Ö. Seçmen et al. (S. Oluk 1196) in EGE! Antalya: Elmalı to Çiğlikara, Aym ovası, c. 1650 m, 28.04.1968, Meyer et al. (EGE 6919) in K! Muğla: Sandras mountain, near Kartal lake, rocky field, 1900-1950 m, 23.05.2002, Ö. Varol 4014 in AEF! C3 Antalya: Elmalı, to Çiğlikara, near Abidin Kuyuları, *Cedrus libani* forest, calcerous rocky field, 1650-1900 m, 04.05.1975, A. Güner 1250 in HUB! Çiğlikara, Ayn plain, 1650 m, 28.04.1968, Meyer et al. in EGE! Elmalı Sedir Araştırma Ormanı, W. of Kızlar Sivrisi, north slopes, scree with *Euphorbia* sp. and meadow fragments, 1895 m, 36° 35.784' N 030° 04.042' E, 27.05.2009, Eker 2412 in AIBU!

Other Selected Collections: A3 Ankara: Beypazarı, Karaşar, 1000 m, Akman 859; B2 Uşak: Murat mountain, above Gürlek, A. Baytop (ISTE 39426); C3 Isparta: Davraz mountain, 2000 m, A. & T. Baytop (ISTE 4295); Antalya: W. foot of Beydağları, above Avlan lake, between Sarnıç Alanı and Çam Kuyuları, Bozakman & Fitz 215.

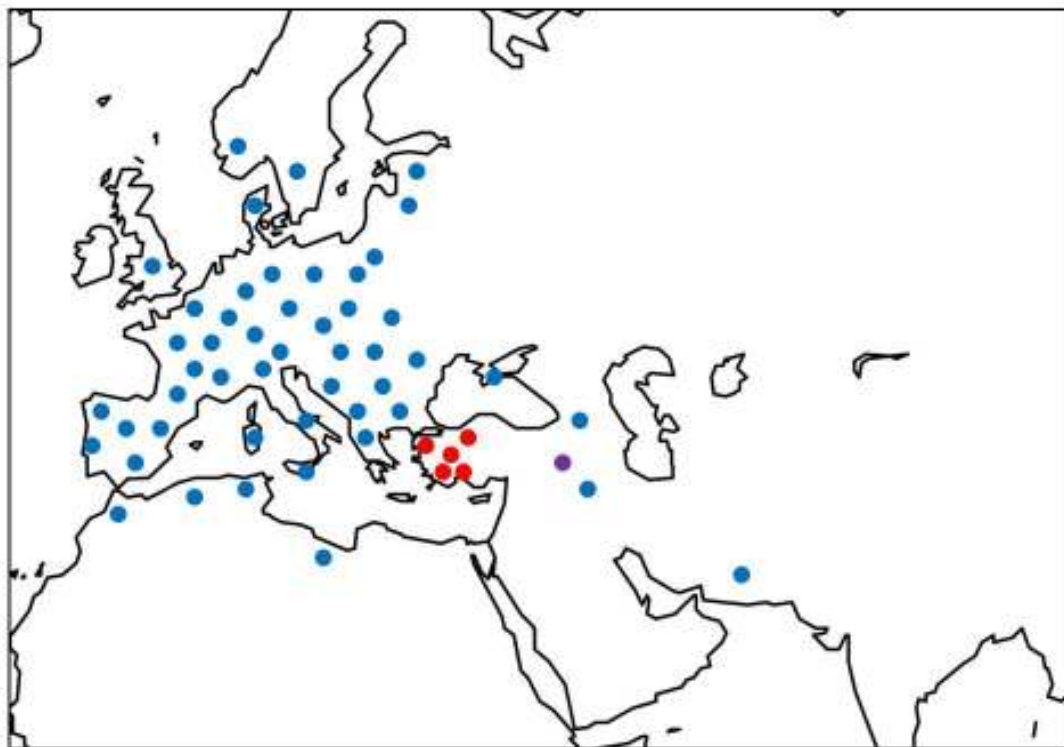


Figure 6. Distribution of *T. sylvestris* in the world (red dots represent natural range of the species while blue dots represent naturalised areas, also purple dot represents cultivated area in Turkey).

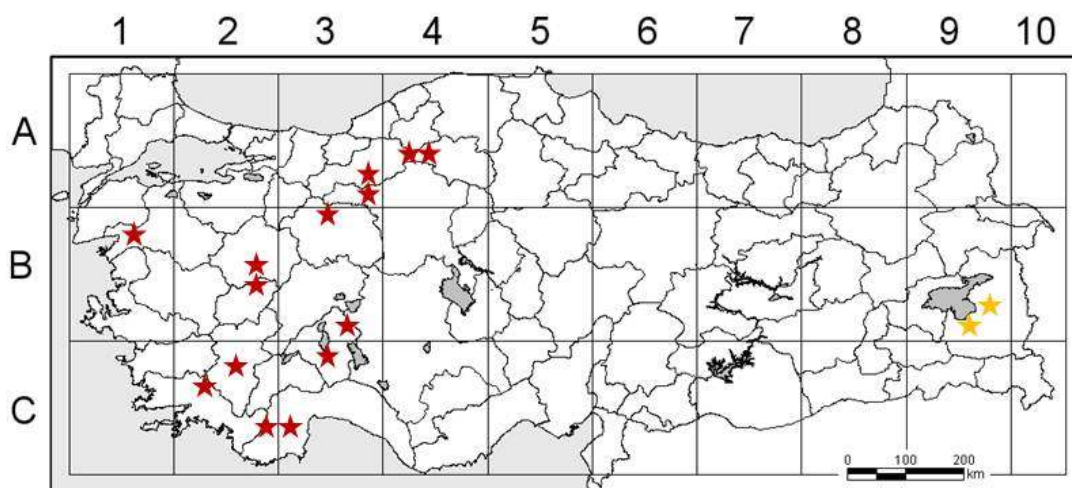


Figure 7. Distribution of *T. sylvestris* in Turkey (red stars represent natural range of subsp. *australis* while yellow stars represent subsp. *sylvestris* in cultivated areas).



Figure 8. Habit of *T. sylvestris* subsp. *australis*.



Figure 9. Habit of *T. sylvestris* subsp. *australis* in the wild.

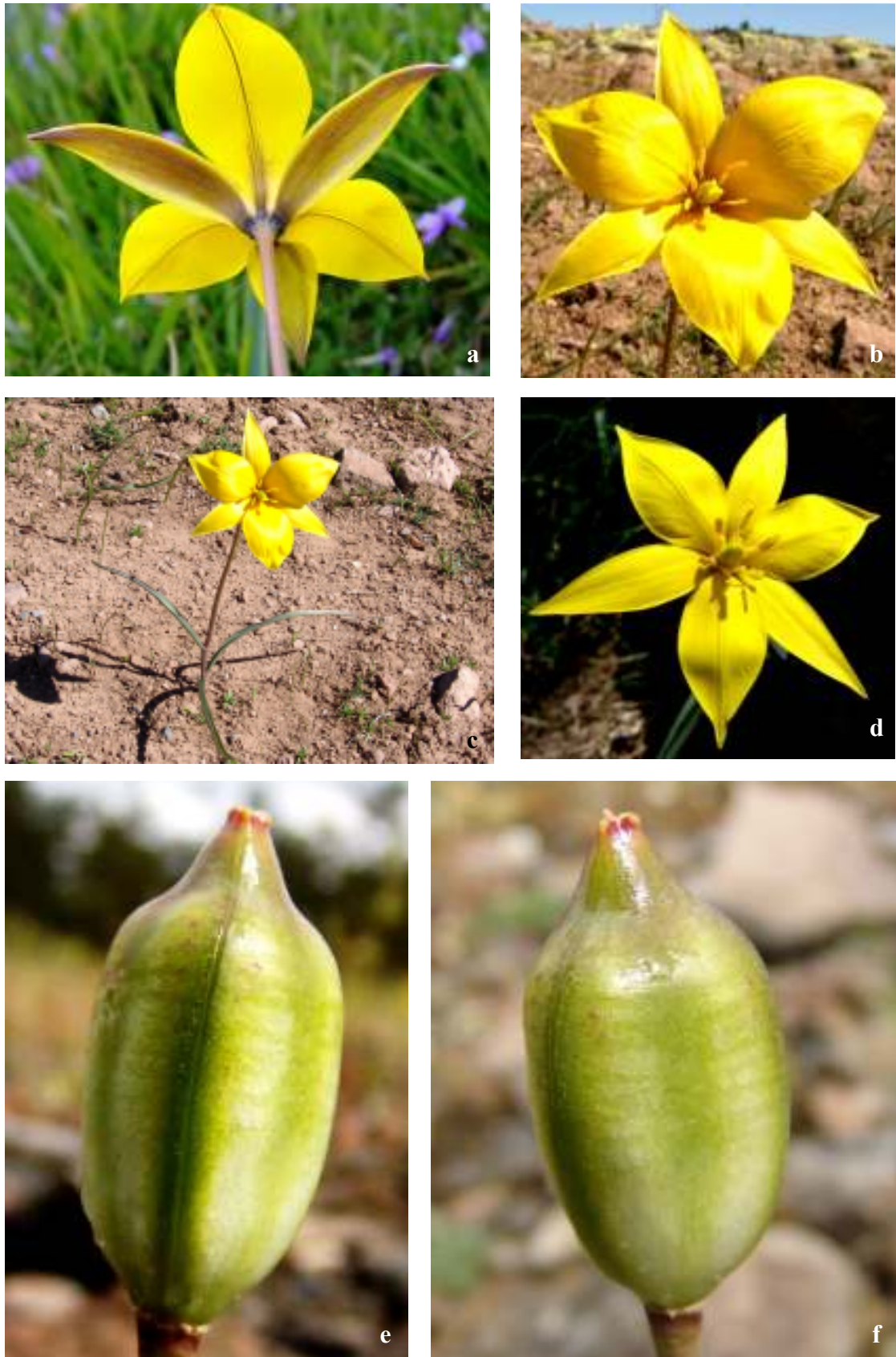


Figure 10. *T. sylvestris* subsp. *australis* - a: The flower from the exterior, b-d: The flower from the interior, e-f: Fruit.



Figure 11. *T. sylvestris* subsp. *sylvestris* - a, e: Habit of *T. sylvestris* subsp. *sylvestris* in orchards and gardens (cultivated plants from Van province), b: The flower from the exterior, c-d: The flower from the interior f: Fruit.

Pollen morphology: Pollen grains monosulcate, heteropolar, ellipsoid or ellipsoid-spheroidal in polar view. Long axis 42.5-61.25 μm and short axis 35-53.75 μm . Exine 1-1.9 μm thick. Exine surface (exine pattern) perforate-rugulate (SEM; Eker 2427). Intine bi-layered, outer intine (exintine) 0.6-1.8 μm and inner intine (endintine) 0.5-0.75 μm in thickness. Outer intine thicker in aperture (sulcus) region, up to 3.5 μm . Sulcus extends full length of grain; wide, almost equal to the short axis of grain or 27-41 μm ; the exine plate extends irregularly towards the aperture; a one-banded operculum, band 16-48 μm in length or longer than long axis of grain, 5-26 μm wide (Figure 12-13).

Specimens examined for subsp. *sylvestris*: B9 Van: Eker 1842.

Specimens examined for subsp. *australis*: A4 Ankara: Eker 2166, B1 Balıkesir: Eker 2427, C2 Denizli: Eker 2423, C3 Antalya: Eker 2050.

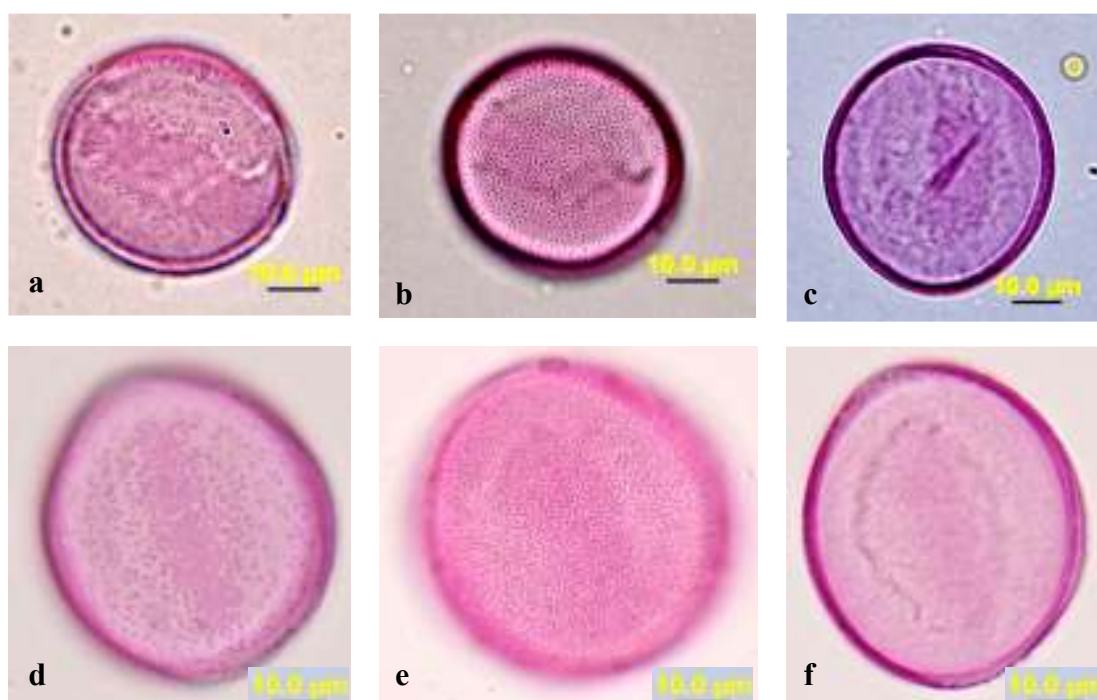


Figure 12. LM images of *T. sylvestris* - Monosulcate pollen- a. one-banded operculum of subsp. *australis* (Eker 2427), distal face b. perforate exine (exine pattern) of subsp. *australis* (Eker 2427), proximal face c. pollen wall in optical section of subsp. *australis* (Eker 2427); exine (black arrow), outer and inner intine (white arrow), d. one-banded operculum of subsp. *sylvestris* (Eker 1842), distal face e. perforate exine (exine pattern) of subsp. *sylvestris* (Eker 1842), proximal face f. pollen wall in optical section of subsp. *sylvestris* (Eker 1842); exine (black arrow), outer and inner intine (white arrow).

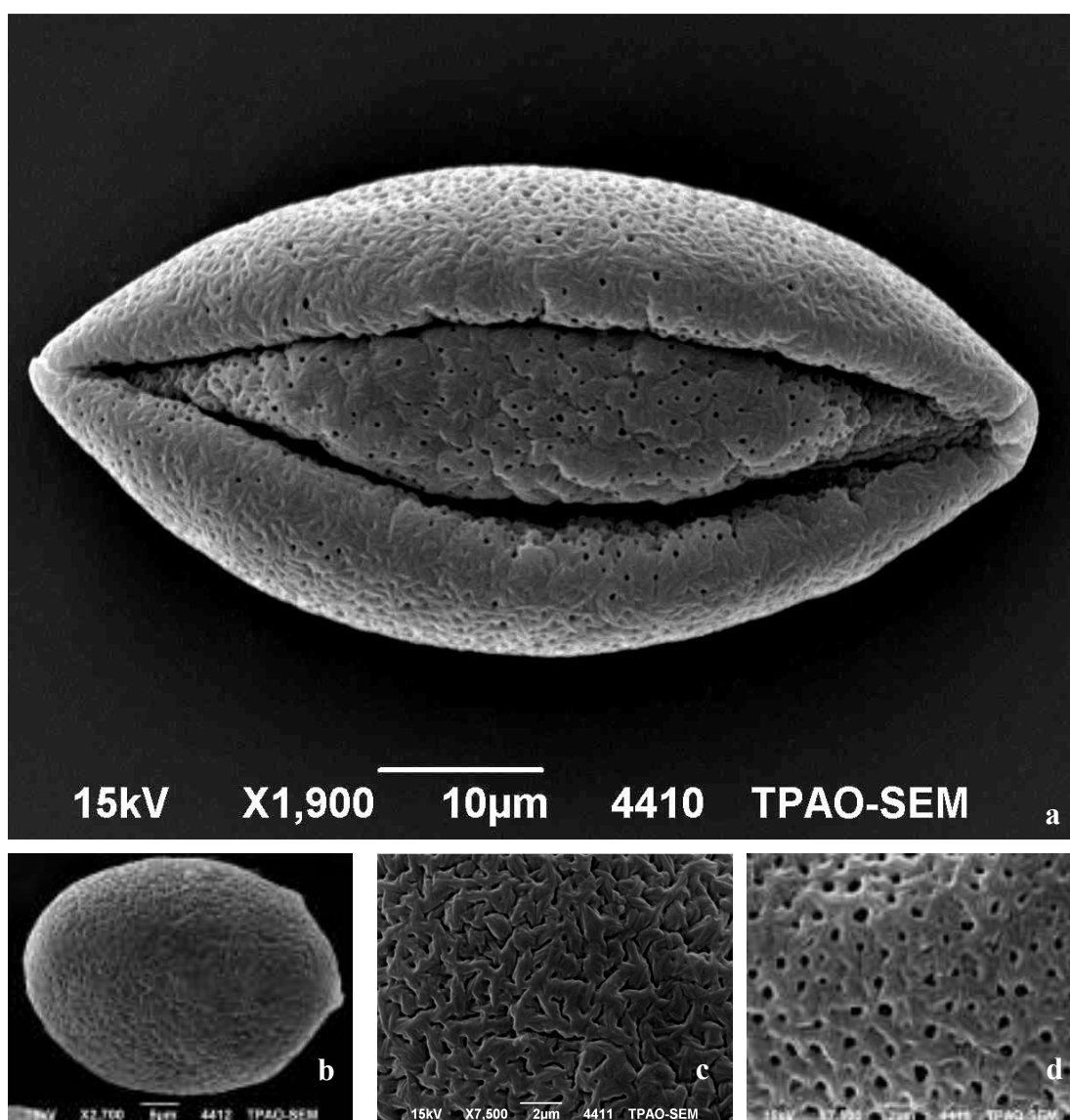


Figure 13. SEM images of *T. sylvestris* subsp. *australis* (Eker 2427) - Monosulcate pollen - a. one-banded operculum, distal face, b. proximal face of pollen grain c-d. perforate- rugulate exine (exine pattern), proximal face.

Chromosome number: $2n=24, 48$.

Specimens examined for subsp. *sylvestris*: B9 Van: Eker 1594 ($2n=48$, Figure 14).

Specimens examined for subsp. *australis*: A3 Bolu: Eker 2168 ($2n=24$, Figure 14), Ankara: Eker 2172 ($2n=24$), A4 Ankara: Eker 2166 ($2n=24$), B1 Balıkesir: Eker 2427 ($2n=24$), C2 Denizli: Eker 2423 ($2n=24$), C3 Antalya: Eker 2050 ($2n=24$).

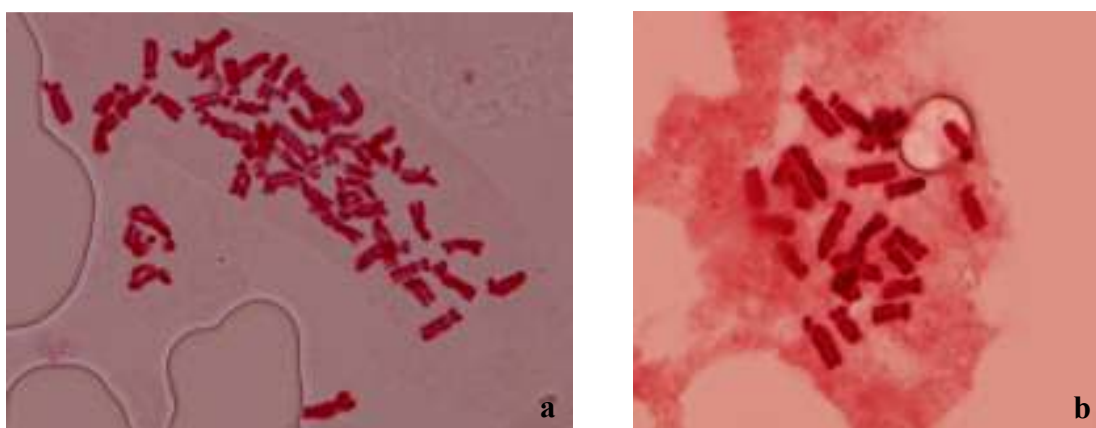


Figure 14. Somatic chromosome number of *T. sylvestris* - a. Tetraploid specimens (subsp. *sylvestris*, Eker 1594), b. Diploid specimens (subsp. *australis*, Eker 2168).

Section *Orphanideae* Eker & Babaç, *sect. nov.*

2. *Tulipa orphanidea* Boiss. ex Heldr. in Gartenflora 11: 309-310, t. 373 (1862)!

≡ *Tulipa sylvestris* var. *orphanidea* (Boiss. ex Heldr.) Regel, Trudy Imp. S.-Peterburgsk. Bot. Sada 2: 443 (1873).

= *Tulipa turcica* Griseb., Spic. Fl. Rumel. 2: 382 (1846), nom. illeg; *Tulipa atheniensis* Orph., Bull. Congr. Bot. Petersb. 1869: 116 (1870); *Tulipa crocata* Orph., Bull. Congr. Bot. Petersb. 1869: 116 (1870); *Tulipa bithynica* Griseb. ex

Baker, J. Linn. Soc., Bot. 14: 282 (1874)! *Tulipa minervae* Orph. ex Baker, J. Linn. Soc., Bot. 14: 294 (1874); *Tulipa theophrasti* Candargy, Bull. Soc. Bot. France 44: 143 (1897); *Tulipa thracica* Davidov, Sborn. B'lghar. Akad. Nauk 12: 118 (1915)! *Tulipa doerfleri* Gand., Fl. Cret. 102: 1814 (1916); *Tulipa whittallii* A.D.Hall, Book Tulip: 70 (1926)! *Tulipa orphanidea* var. *whittallii* (A.D.Hall) Dykes, Notes on Tulip Species: 34 (1930)! *Tulipa hellespontica* Árpád, Magyar Bot. Lapok 32: 145-146 (1933)! *Tulipa hayatii* O.Schwarz, Repert. Spec. Nov. Regni Veg. 36: 69 (1934)! *Tulipa goulimyi* Sealy & Turrill, Kew Bull. 10: 59-61 (1955)! *Tulipa splendens* Delip., Feddes Repert. 87: 3 (1976).

Iconibus: Botanical Magazine 102: t. 6242 (1876), as *T. hageri*! Botanical Magazine 103: t. 6310 (1877)! (Figure 17-18).

Type: [Greece] am Berge Malevo (bei Hagios Petros und Xerokampi) im östlichen Laconien, Orphanides 843.

Plant 24-50 cm. Stem glabrous or pubescent, stem width (1-)1.5-3.5 mm, underground stem length 6.5-19.5 cm, aerial stem length 7.5-27 cm. Stoloniferous or not. Bulb globose-ovoid to globose, (1.6-)1.9-3 × 1.5-2.6 cm. Bulb neck 1-3(-5.5) cm. Tunics crustaceous, dark brown, tunics with a ring of short hairs around basal plate and adpressed, bristly, pilose and longer hairy at neck, middle part glabrous. Leaves 3-6, erect-recurved, falcate or erecto-patent, linear-lanceolate, canaliculate, glaucous, alternate, leaf margin glabrous or slightly ciliate, membranous and entire; Lowest leaf 14-29 × 0.8-1.6(-2) cm, obtuse to subacute; second lowest leaf 15-27 × (0.4-)0.6-1.2(-1.5) cm, subacute to acute. Flowers 1(-2), infundibular to stellate,

shiny mandarin red to orange red with blurred purplish-black blotch inside and paler mandarin red to orange red with greenish-yellow base or buff colored on all of surface outside; outer tepals elliptic to elliptic-ovate, acute to subacute, glabrous and pubescent only at tip, $33-57 \times 7-15$ mm; inner tepals elliptic to elliptic-obovate, obtuse, obtuse-apiculate to acute, pubescent at tip and glabrous or very slightly pubescent at base, $33-58 \times 9-21$ mm. Outer blotch 10-20 mm and inner blotch 10-22 mm in length. Blotch $1/5-2/5$ length of segments. Filaments brownish-black, lanceolate and pubescent at base; outer filaments 7-11 mm, inner ones 9-12 mm. Anthers $5.5-16 \times 2-3$ mm, oblong to linear-oblong, purple at fresh, not apiculate. Pollen purple or yellow at fresh; purple, yellow or mustard yellow at dry (purple colour at fresh is turned tones of yellow at dry). Ovary fusiform, subfusiform or oblong, yellowish-green, purplish-green, reddish-green, violet-green or violet at fresh, glabrous, $8-15(-19) \times 2.5-5.5$ mm. Style very short or obscure, $0.5-1 \times 0.5-2(-2.5)$ mm. Stigma pubescent, yellow, reddish-pink, reddish-yellow or greenish-yellow at fresh, $0.5-1 \times 1-3$ mm. Capsule $1.6-2.8 \times 1-1.8$ cm, ellipsoid, elliptic-obovoid, glabrous; neck $0.5-2(-3)$ mm, rib 12-22 mm, beak 2-5, apicula 0.5-1 mm; tepal scar 0.5-1 mm. Seeds numerous, flattened with rugose surface, triangular with two rounded angles to orbicular, light brown, $4-6 \times 3-4.5$ mm, winged.

Phenology: Flowering in Late April, and fruiting in Late May to Early June.

Distribution: Turkey (W. & S.W. Anatolia and European Turkey), Greece, Bulgaria, Crete, (Figure 15-16).

Habitat: It grows in gravelly places in the forest clearing, fallow fields under olive trees or fields at roadsides with brown or reddish-brown soils at an elevation of s.l.-1700 m.

Phytogeographic region: East Mediterranean element.

Conservation status: NT (IUCN, 2001). *T. orphanidea* distributes only in West Anatolia and European Turkey, especially in the coastal cities. It has restricted populations. These populations might be threatened due to excessive land clearing of wild distribution areas in the region. Thus, the species may be classified as 'Near Threatened' (NT) (IUCN 2001).

Selected Specimens Examined: A1(A) Balıkesir: Bandırma, Tatlısu, seaside, s.l., 28.04.1996, T. Yorgancı 1001 in HUB! A1(E) Tekirdağ: on the way from Naipköy to Işıklar, at the road-cross to Işıklar, in a field, 30.04.1967, A. & T. Baytop (ISTE 10861) in E and K! Edirne: Keşan to Ipsala, near Kurucuköyü, A. & T. Baytop (ISTE 17648) in K! Çanakkale: Helles, Ingoldby 100! A2(A) Bursa: Karacabey, M. Ahmet & S. Oflas (EGE 24637) in EGE! Yalova: near Armutlu, 22.04.1968, A. & T. Baytop 12534 in ISTE! Armutlu, west shore of Armutlu dock, orchards and meadows, 26.04.1964, Demiriz & Tütel (ISTF 5125) in ISTF! İstanbul: Alemdağ, in scrubs, 300 m, 27.04.1978, T. Baytop 39145 in ISTE! Beykoz fidanlığı, 20.04.1971, T. Baytop (ISTE 22202) in ISTE! Beykoz, 04.1946, M. Başarman (ISTF 3404) in ISTF! A2(E) İstanbul: Silivri, Değirmenköy, T. Baytop (ISTE 12487) in K! near Arpalı çeşmesi, sandy stubble field, 18.04.1968, T. Baytop & R. Bul. (ISTF 3414) in ISTF! B1 Balıkesir: Edremit, Kazdağları, around Tozlu Çeşmesi, 5 km to Sarıkız hill, rush-

bed, 1460 m, 39° 42.472' N 026° 53.024' E, 30.05.2009, Eker 2433 in AIBU! Gürgen mountain, Bostandere mevkii, 700 m, roadside, 05.05.1993, A. Erdağ (EGE 6488) in EGE! İzmir: Bergama, Kozak, pasturage of Kıranlı village, Kocakıran mevkii, gravely places in the forest clearing, 788 m, 39° 18.610' N 027° 11.770' E, 30.04.2008, Eker 2084 in AIBU! *ibid.*, near forest depot, 750 m, 24.04.1986, Ö. Seçmen 3195 in EGE! Madra mountain, underside of *Pinus nigra* forest, 1200 m, 22.05.1986, Ö. Seçmen 3307 in EGE! Ödemiş, Bozdağ, 1500 m, 12.5.1971, M. Koyuncu in AEF! Bozdağ-Büyük Çamlar upland, 1450 m, 30.05.1974, E. Leblebici & C. Ödemiş (EGE 13574) in EGE! Bozdağ road, Gölcük, 1200 m, 17.05.1969, K. Fitz (EGE 4311) in EGE! *ibid.*, 1150 m, 10.05.1975, Ö. Seçmen et al. (EGE 24101) in EGE! between Yamanlar camping-Karagöl, 800 m, 04.05.1967, H. Peşmen (EGE 13572) in EGE! Yamanlardağı, from Karşıyaka up to Karagöl, 27.04.1969, K. Fitz (EGE 4110) in EGE! Bornova, Kayadibi village, Çatalpınar mevkii, 700 m, maquis, 27.04.1971, B. Yıldız et al. (EGE 7419) in EGE! Manisa: Spil mountain, Atalanı mevkii, gravely places in the forest clearing, 1253 m, 38° 32.983' N 027° 25.123' E, 30.04.2008, Eker 2078 in AIBU! *ibid.*, 29.05.2009, Eker 2424 in AIBU! *ibid.*, 1450 m, 25.05.1975, Ö. Seçmen et al. (EGE 13571) in EGE! Başpınar village to Atalanı mevkii, 920 m, 11.05.1978, Ö. Seçmen et al. 1293 in EGE! Çanakkale: Bayramiç, between Bayramiç to Etili, roadsides, 05.05.1965, Kayacık & Yalt. (ISTO 3754) in E! Balıkesir: Edremit, vii 1960, Kayacık in E and K! B2 Aydın: Köşk, pasturage of Sarıçam village, fallow fields under olive trees, 1292 m, 38° 01.585' N 028° 06.340' E, 27.04.2008, Eker 2075 in AIBU! Kütahya: Simav, Kıcır to Akdağ, on *Pinus nigra* forest, on forest road, 19.06.1965, 1700 m, Coode & Jones 2671 in E! Manisa, Salihli, Bozdağı, 23.05.1993, N. Tanker et al. in AEF! B3 Afyon: Kumalar mountain, Taşoluk-Şuhut road, above Koçyatağı upland, 1400 m, 19.05.2000, E. Akçiçek 2567

in GAZİ! C1 Muğla: Bodrum, Bodrum Pazarı, near Kuzkaya village, under olive trees, 16.03.2001, Muazzez from Kuzkaya in GAZİ! C2 Muğla: 8 km from Muğla to Ula, Gülağzı village, fields at roadsides, 638 m, 37° 08.198' N 028° 22.303' E, 25.04.2008, Eker 2062 & 2063 in AIBU! ibid., 03.06.2008, Eker 2183 in AIBU! ibid., 29.04.1982, T. Ekim & M. Koyuncu 5050! Muğla-Marmaris road, Ula road junction, in fields, 600 m, 16.04.1992, M. Koyuncu 9003 in AEF! Karabağlar mevkii, in orchards, 550 m, 02.05.1982, M. Koyuncu 5179 & T. Ekim in AEF! Aydın: Bozdoğan, Papazlı village, 750 m, 04.05.1982, M. Koyuncu-5187 & T. Ekim in AEF! Denizli: Babadağ, Karcı Ali mountain, picnic site, east hills, end of forest road, 1400 m, *Pinus nigra* forest, 12.05.1996, S. Oluk 1301 in EGE! C3 Isparta: 28 km from Burdur to Kindili, in fallow corn fields covering several screes, 09.05.1976, Marais 1504 in E! Antalya, Kumluca, Adrasan village, slopes of Musadağı, Kızılmevkii, serpentine slopes, *Pinus brutia* forest, 0-150 m, 23.03.1979, H. Peşmen 4251 & A. Güner in ANK & HUB! C4 Antalya: Gazipaşa, Cimbiti upland, 1650 m, 18.05.1983, H. Sümbül 1798 in ANK! Çayırakası upland, 1750 m, 20.05.1983, H. Sümbül 1875 in HUB! 1 km from Söğütler to Çiğdem mountain, calcerous slopes, opening of *Pinus nigra* & *Juniperus excelsa* forest, 1323 m, 36° 34.471' N 032° 22.944' E, 14.04.2006, Ali A. Dönmez et al. 12775 in HUB! Sugözü village, Belbaşı mevkii, end of the forest, 1500 m, 16.05.1983, H. Sümbül 1710 in HUB! ibid., Akçal hill, 1900-2000 m, 17.05.1983, H. Sümbül 1747 in HUB!

Other Selected Collections: B1 İzmir: Bornova, T. Baytop (ISTE 21462)! ibid., 800-900 m, O. Schwarz 241 (syntype of *T. hayatii*); C1 Aydın: Söke mountain, A. & T. Baytop (ISTE 19172); C2 Denizli: Honaz mountain (Cadmus), 1842, Boiss. (syntype of *T. bithynica*); Muğla: Muğla to Fethiye, A. Baytop.

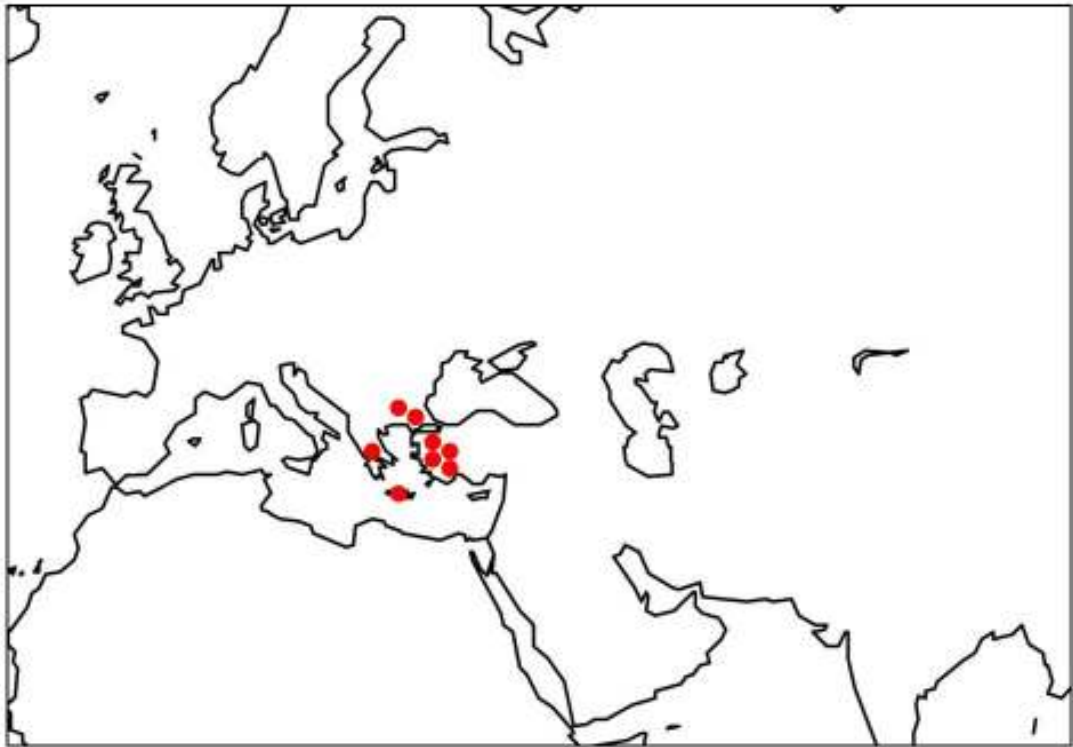


Figure 15. Distribution of *T. orphanidea* in the world.

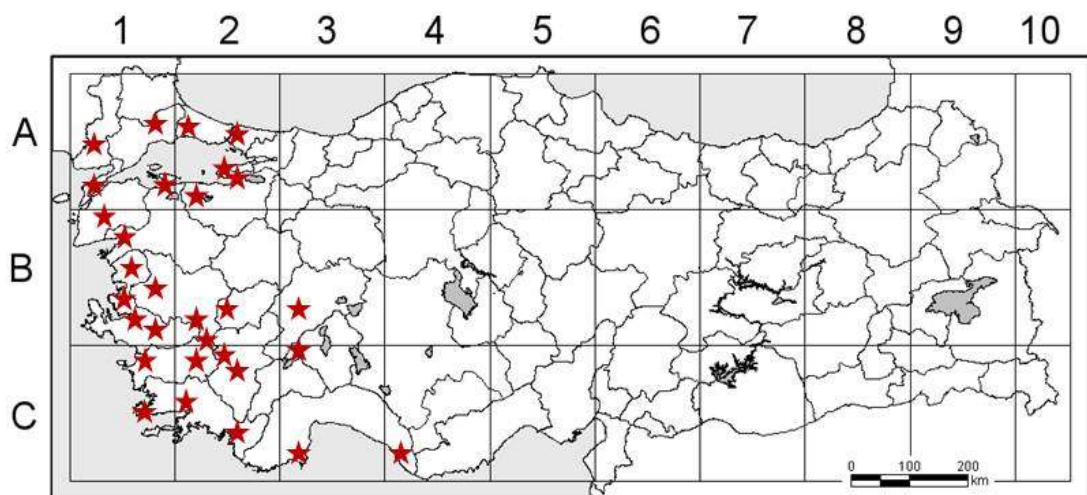


Figure 16. Distribution of *T. orphanidea* in Turkey.



Figure 17. Habit of *T. orphanidea*.



Figure 18. *T. orphanidea* - a-b: The flower from the exterior, c-e: The flower from the interior, f: Fruit.

Pollen morphology: Pollen grains monosulcate, heteropolar, ellipsoid in polar view. Long axis 38.75-60 μm and short axis 32.5-51.25 μm . Exine 1-2 μm thick. Exine surface (exine pattern) perforate (LM). Intine bi-layered, outer intine (exintine) 0.6-2.5 μm and inner intine (endintine) 0.5-0.75 μm in thickness. Outer intine thicker in aperture (sulcus) region, up to 5 μm . Sulcus extends full length of grain; wide, almost equal to the short axis of grain or 20-38 μm ; the exine plate extends irregularly towards the aperture; a one-banded operculum, band 34-56 μm in length or longer than long axis of grain, 11-35 μm wide (Figure 19).

Specimens examined: B1 Manisa: Eker 2078, Balıkesir: Eker 2433, C2 Muğla: Eker 2062.

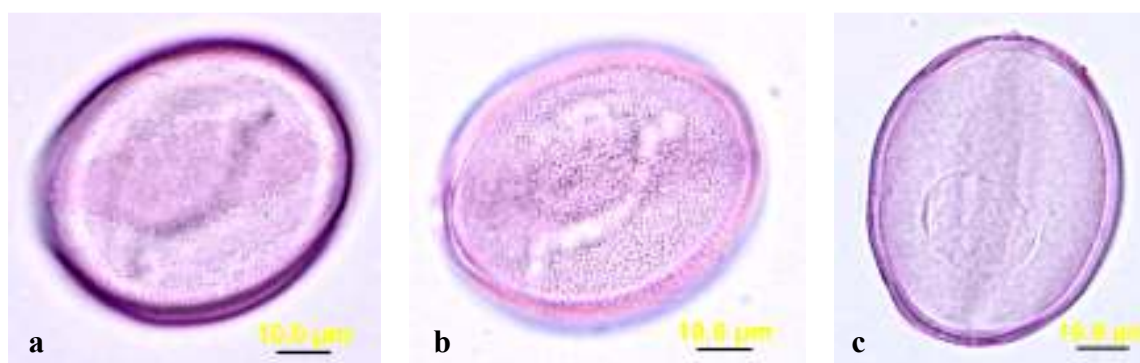


Figure 19. LM images of *T. orphanidea* (Eker 2433)- Monosulcate pollen- a. one-banded operculum, distal face b. perforate exine (exine pattern), proximal face c. pollen wall in optical section; exine (black arrow), outer and inner intine (white arrow).

Chromosome number: $2n=24, 36$.

Specimens examined: B1 İzmir: Eker 2084 ($2n=24$), Manisa: Eker 2078 & 2424 ($2n=24$, Figure 16), B2 Aydın: Eker 2182 ($2n=36$), C2 Muğla: Eker 2183 ($2n=36$, Figure 20).

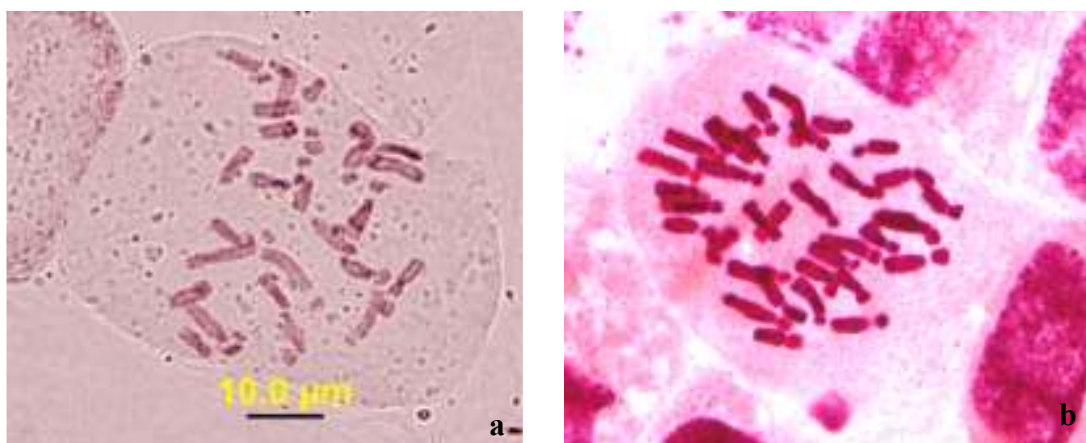


Figure 20. Somatic chromosome number of *T. orphanidea* - a. Diploid specimens (Eker 2424), Triploid specimens (Eker 2183).

3. *Tulipa sprengeri* Baker in Gardeners' Chronicle 3(15): 716 (1894)!

Iconibus: Hall, The Genus *Tulipa* t. 39 (1940)! (Figure 23).

= *Tulipa brachyanthera* Freyn, Bull. Herb. Boissier 4: 187 (1896).

Iconibus: Botanical Magazine 102: t. 6242 (1876), as *T. hageri*! Botanical Magazine 103: t. 6310 (1877)! (Figure 23-24).

Type: A cultivated specimen originating from [Turkey A5/A6 Amasya], (holotype K!)

Height 40 cm. Bulb 2-3 cm diam., ovoid. Tunics papery, chestnut-brown, glabrous or subglabrous. Leaves 5-6, bright shiny green, strap-shaped, glabrous. Lowest leaf to 25 × 2.5 cm. Stem glabrous, to 30-40 cm. Flower solitary, infundibular with constricted base, orange-red to shiny scarlet, without blotch. Outer perianth segments oblong-elliptic, buff or yellowish on the back, to 6.5 × 2 cm. Inner perianth segments obovat, to 7 × 3 cm. Filaments bright red, unequal, 8-18 mm, glabrous, swollen at base; anthers bright yellow, 8-11 mm. Pollens yellow. Capsule ± ellipsoid, pointed at both ends (Marais, 1984; Bryan & Griffiths, 1995; Pavord, 1999; Wilford, 2006).

Phenology: Flowering in Late May to Early June.

Distribution: Turkey (North Anatolia), persists in cultivation in Europe (Figure 21-22). It is endemic to Turkey.

Phytogeographic region: Cultivated, unknown phytogeographic origin.

Conservation status: EW (IUCN, 2001). *T. sprengeri* was first collected from Amasya in Turkey in 1894. Then, it was last recorded by J. J. Manissadjian in 1986. But, it has never again been found in the wild since that time. Also, during our field studies, it has not been found. Thus, the species may be classified as ‘Extinct in the wild’ (EW) (IUCN 2001).

Selected Specimens Examined: A5 Amasya: Amasya, Maniss. 1151 (type of *T. brachyanthera*) in K! Amasya, Asia minor, from Damman and Company, Baker (type of *T. sprengeri*) in K! (Figure 24).

Notes: *T. sprengeri* was first found in 1892 by Muhlendorff, who was a German gardener lived in Amasya in that years. He sent bulbs to a nurseryman, Carl Sprenger of Damman and Company of Naples, Italy, in 1894 by. Sprenger sent the bulbs to J. Gilbert Baker, and then Baker described the species that year in the Gardeners' Chronicle. Baker named the new species after Carl Sprenger (Figure 24). Also, the species was introduced into cultivation in 1894 (Pavord, 1999).

After two years, J. J. Manissaadjian who was a schoolmaster in American college of Merzifon (Figure 25), collected the last record of the plant (Figure 24). A single bulb was found in a shipment to the Dutch bulb firm of Van Tubergen from their collector in Turkey, Manissaadjian before World War I (Hall, 1940). It has been traced to the region about Amasya, but has never again been found in the wild. Manissaadjian's specimens were published as *Tulipa brachyanthera* in Bull. Herb. Boissier in 1896 by Freyn (this is now a synonym of *T. sprengeri*).

During our field studies, it has not been found. Thus, the species may be classified as 'Extinct in the wild' (EW).

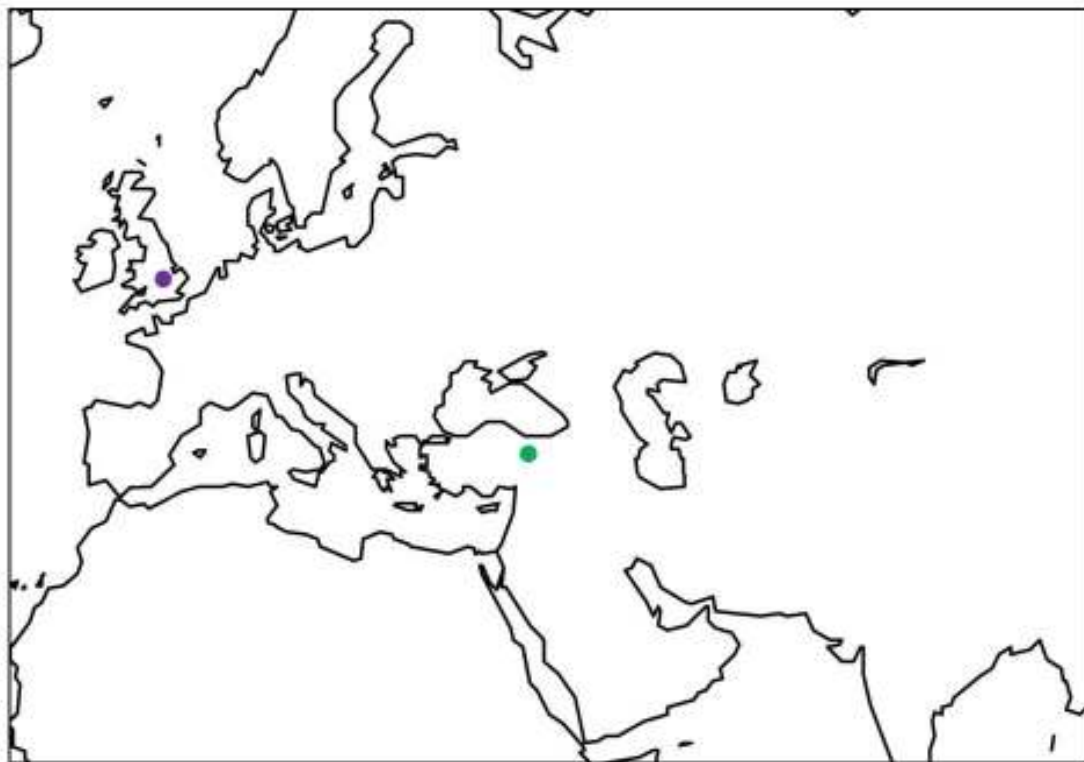


Figure 21. Distribution of *T. sprengeri* in the world (green dots represent natural range of the species, but it is now extinct in the wild while purple dot represents cultivated area in England).

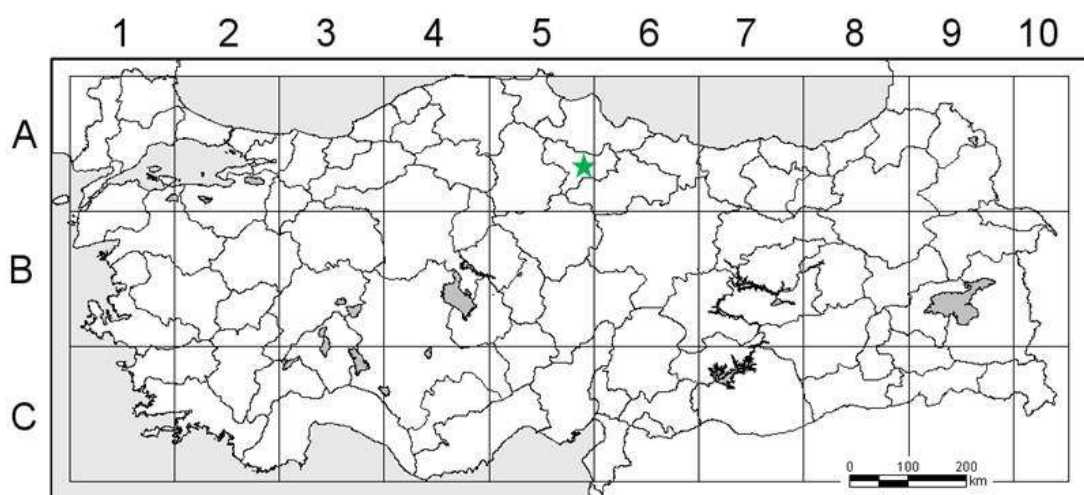


Figure 22. Distribution of *T. sprengeri* in Turkey (green star represents natural range of the species, but it is now extinct in the wild).



Figure 23. *T. sprengeri* - a: The flower from the exterior, b: The flower from the interior (these two photos of *T. sprengeri* were taken from Anonymous 3 (2009c).



Figure 24. Herbarium specimens of *T. sprengeri* - a, c-f: Type specimen of *T. sprengeri*, b: The last record of *T. sprengeri* from Amasya collected by Manissadjian.



Figure 25. The ruins of American College of Merzifon from Amasya.

4. *Tulipa cinnabarina* K. Perss. in The New Plantsman 7: 200-208 (2000)!

= *Tulipa karamanica* N. Özhatay & B. Koçak *syn. nova*, in Fl. of Turkey and East Aegean Islands, 11(suppl. II): 246 (2000)!

Iconibus: Persson, The New Plantsman 7: 202-203 (2000)! (Figure 28-30).

Type: Turkey, Konya: between Ermenek and Hadım, calcareous slopes, 1750-1800 m, 03.04.1990, Kammerlander, Pasche, Persson & Zetterlund 90-37 (holotype GB).

Plant 14-35 cm. Stem glabrous, stem width 1-2 mm, underground stem length 3-12.5 cm, aerial stem length 6-16 cm. Markedly stoloniferous. Bulb ovoid, 1.4-2.2 × 1.2-2 cm. Bulb neck 0.8-3.5 cm. Tunics coriaceous, dark brown, innermost tunics with a ring of short hairs around basal plate and, adpressed, pilose, bristly and longer hairs at neck, middle part glabrous. Leaves 2-3, erect to erecto-patent, lanceolate, canaliculate, glaucous, alternate, leaf margin membranous, glabrous or ciliate, and entire; Lowest leaf 7.5-23 × 0.5-1.3 cm, obtuse; second lowest leaf 7.5-20 × 0.3-1.2 cm, acute to subacute. Flower solitary, infundibular, shiny mandarin red to orange red with or without greenish-yellow or bicoloured (yellow & purple) blotch inside and paler mandarin red to orange red outside; outer tepals elliptic, narrowed at base, suacute to acute, glabrous and pubescent only at tip, 28-44 × 7-13 mm; inner tepals elliptic-obovate, narrowed at base, obtuse or obtuse-apiculate, pubescent at tip and distinctly pubescent at base, 30-44 × 10-18 mm. Outer and inner blotchs 6-10 mm in length. Blotch 1/4-1/6 length of segments. Filaments orange, yellow or rarely red, lanceolate and pubescent at base; outer filaments 7-10 mm, inner ones 8-11 mm. Anthers 5.5-8 × 1.5-2.5 mm, oblong, purple or bluish-black at fresh, apiculate or not.

Pollen yellow. Ovary oblong, fusiform or subfusiform, pale green, yellowish-green, purplish-green or yellow at fresh, glabrous, $6.5-13 \times 2-4$ mm. Style very short or obscure, $0.8-1.5 \times 0.5-1.5$ mm. Stigma pubescent, pinkish-white, whitish-yellow or yellow at fresh, $0.4-1 \times 1-2$ mm. Capsule $2.8-4 \times 1.6-2.2$ cm, obovoid, glabrous; neck 1.5-5 mm, rib 22-30 mm, beak 2.5-4, apicula 1-1.5 mm; tepal scar 0.5-1 mm. Seeds numerous, flattened with rugose surface, triangular with two rounded angles to orbicular, light brown, $5-6 \times 3.5-4.5$ mm, winged.

Phenology: Flowering in Late April, and fruiting in Early June.

Distribution: *T. cinnabarina* is known only from South Anatolia. It is endemic to Turkey (Figure 26-27).

Habitat: It grows in calcerous stony alpinic slopes (steppe) with red soils of higher mountains at an elevation of 1700-1800 m.

Phytogeographic region: Mediterranean element.

Conservation status: CR (IUCN, 2001). *T. cinnabarina* was found at only one locality. It has a very limited distribution: it is represented by less than 200 individuals in the whole population that covers less than 500 m^2 . The area is being continuously destroyed by goat flocks. Thus, the habitat of *T. cinnabarina* is under threat and its destruction would lead to a dramatic decrease of the abundance or even complete extinction of this species. Taking into account all these points, the species

should be classified as “Critically Endangered” (CR) (criterion B1 a; IUCN 2001) and both it and the site should be protected.

Selected Specimens Examined: C4 Karaman: Sarıveliler, 13 km from Sarıveliler to Taşkent, calcareous slopes with red soils, 1746 m, 36° 46.098' N 032° 37.664' E, 24.04.2008, Eker 2030 in AIBU! *ibid.* 04.06.2008, Eker 2186 (fruiting time)! *ibid.* 28.04.2009, Eker 2312 in AIBU!

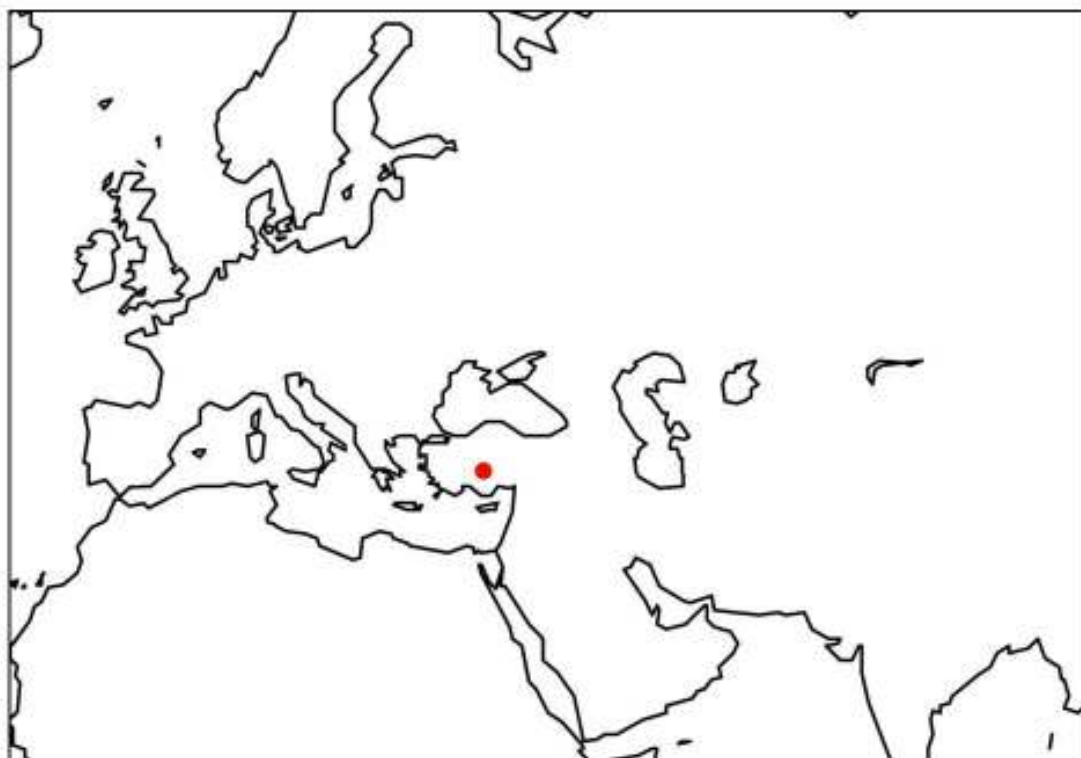


Figure 26. Distribution of *T. cinnabarina* in the world.



Figure 27. Distribution of *T. cinnabarina* in Turkey.



Figure 28. Habit of *T. cinnabarina*.



Figure 29. *T. cinnabarina* - a-c: The flower from the interior, d-e: Figure 3. The flower from the interior, f-g: Fruit.



Figure 30. The flower of *T. cinnabarina* from the interior.

Pollen morphology: Pollen grains monosulcate, heteropolar, ellipsoid in polar view. Long axis 42.5-53.75 μm and short axis 35-46.25 μm . Exine 1-1.5 μm thick. Exine surface (exine pattern) perforate (LM). Intine bi-layered, outer intine (exintine) 1-2 μm and inner intine (endintine) 0.5-0.75 μm in thickness. Outer intine thicker in aperture (sulcus) region, up to 3.5 μm . Sulcus extends full length of grain; wide, almost equal to the short axis of grain or 21-41 μm ; the exine plate extends irregularly towards the aperture; a one-banded operculum, band 38-52 μm in length, 8-27 μm wide (Figure 31).

Specimens examined: C4 Karaman: Eker 2030 & 2312.

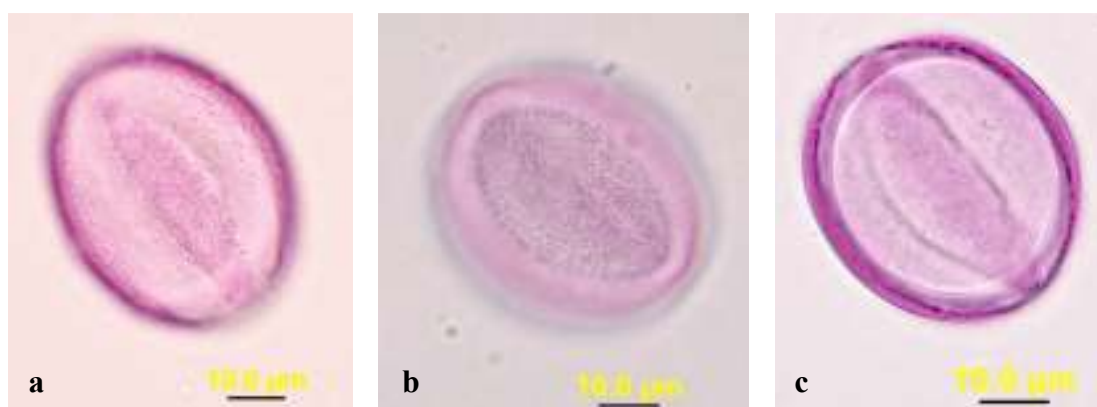


Figure 31. LM images of *T. cinnabarina* (Eker 2312) - Monosulcate pollen - a. one-banded operculum, distal face b. perforate exine (exine pattern), proximal face c. pollen wall in optical section; exine (black arrow), outer and inner intine (white arrow).

Chromosome number: $2n=24$

Specimens examined: C4 Karaman: Eker 2030 ($2n=24$, Figure 32).

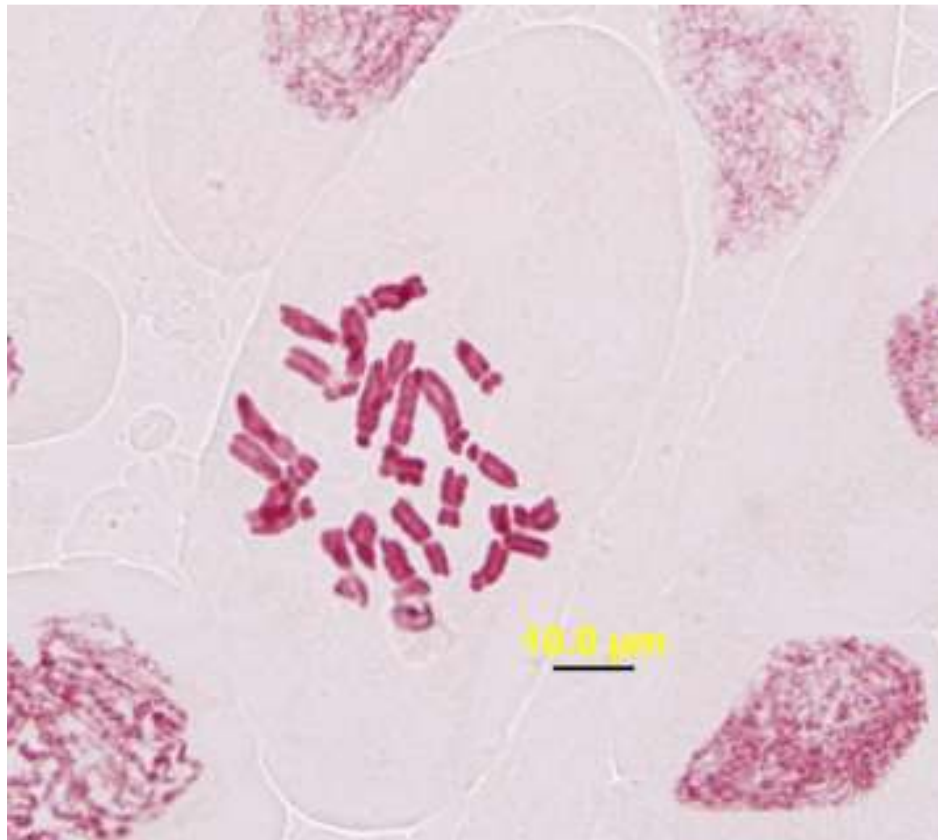


Figure 32. Somatic chromosome number of *T. cinnabarina* (Eker 2030).

Section *Saxatiles* (Baker) Baker

5. *Tulipa saxatilis* Sieber ex Spreng. in Systema Vegetabilium 2: 63 (1825)!

= *Tulipa beccariana* Bicchi, Descr. Nuov. Sp. Tulip.: 2 (1860); *Tulipa chrysobasis* Coustur. & Gand., Bull. Soc. Duffour 1914: 38 (1914); *Tulipa bakeri* A.D.Hall, J. Bot. 76: 316 (1938).

Iconibus: Hall, The Genus *Tulipa* t. 10 (1940)! (Figure 35-36).

Type: Described from Crete, Sieber (type K!).

Plant 40-60 cm. Stem glabrous, stem width 2-3 mm, underground stem length 13-21 cm, aerial stem length 20-32 cm. Markedly stoloniferous. Bulb ovoid, $1.8-3 \times 1.8-3$ cm. Bulb neck 0.8-4 cm. Tunics coriaceous, blackish-brown, innermost tunics with a ring of short hairs around basal plate and, adpressed, pilose, bristly and longer hairs at neck, middle part glabrous (pilose). Leaves 3-4, falcate, broadly lorate-lanceolate, flat or slightly canaliculate, emerging erect, but bending over the ground, shiny-green, alternate, obtuse to subacute, leaf margin membranous, glabrous and entire; Lowest leaf $20-28 \times 3-4.2$ cm.; second lowest leaf $17.5-26 \times 1.6-2.8$ cm. Flowers 1-3, infundibular, shiny pinkish purple to pink with yellow blotch, with or without white blotch edge inside and paler outside; outer tepals elliptic to elliptic-ovate, acute, glabrous and pubescent only at tip, $35-52 \times 11-18$ mm; inner tepals broadly elliptic to broadly elliptic-ovate, acute, pubescent at tip and distinctly pubescent at base, $42-60 \times 16-28$ mm. Outer blotch 10-20 mm and inner blotch 15-24 mm in length. Blotch $1/2-1/4$ length of segments. Filaments orange to yellow, lanceolate and pubescent at base; outer filaments 7.5-10.5 mm, inner ones 10.5-13 mm. Anthers $6-7 \times 2-2.5$ mm, oblong, purple to chocolate brown at fresh, apiculate. Pollen light yellow or golden yellow. Ovary fusiform, green at fresh, glabrous or slightly pubescent only at lower part, $11-18 \times (3-4.5-6.5)$ mm. Style very short or obscure, $2-3 \times 1-2$ mm. Stigma pubescent, pinkish-white or yellow at fresh, $1-1.5 \times 2.5-4$ mm. Not forming mature capsule and seed.

Phenology: Flowering in Early March.

Distribution: Turkey, Crete, Rhodes (Figure 33-34).

Habitat: It grows in rocky places with reddish-brown soils seaside at an elevation of 50-100 m.

Phytogeographic region: East Mediterranean element.

Conservation status: VU (IUCN, 2001). *T. saxatilis* was found at only one locality. It has a very limited distribution. It is represented by less than 200 individuals in the whole population that covers less than 500 m². The area is being continuously destroyed by goat flocks. Thus, the habitat of *T. saxatilis* might be threatened and its destruction would lead to a dramatic decrease of the abundance or even complete extinction of this species at least in Turkey. Thus, the species may be classified as ‘Vulnerable’ (VU).

Selected Specimens Examined: C2 Muğla: Bozburun, Keraye mevkii, rocky places, 70 m, 36° 36.102' N 028° 02.004' E, 16.03.2009, Eker 2220 in AIBU!

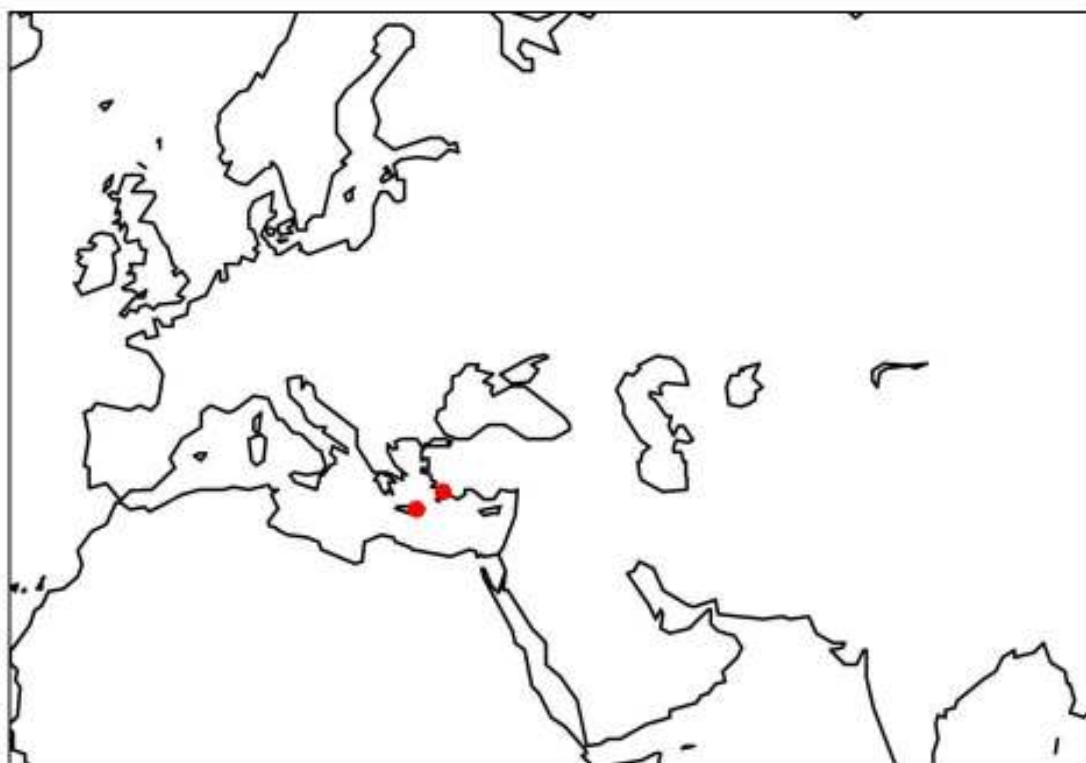


Figure 33. Distribution of *T. saxatilis* in the world.

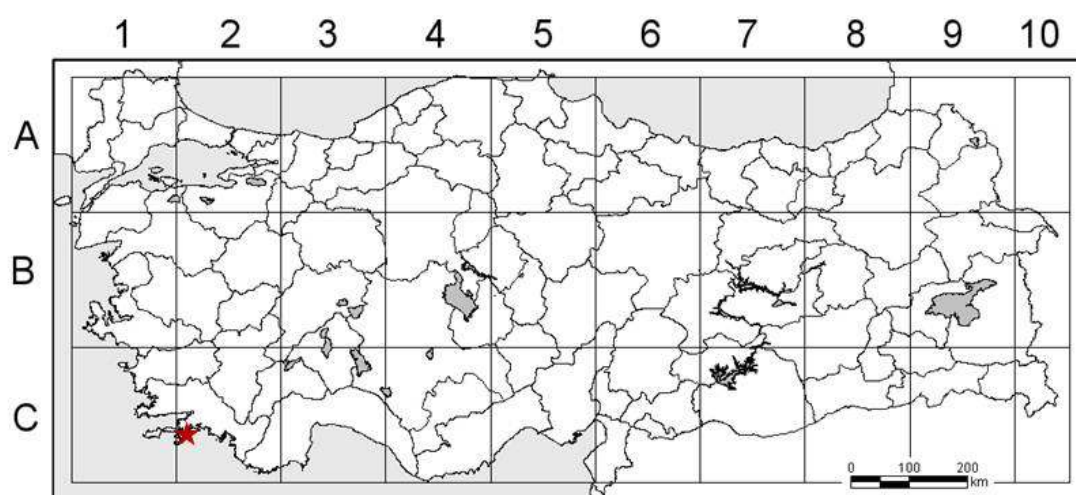


Figure 34. Distribution of *T. saxatilis* in Turkey.



Figure 35. Habit of *T. saxatilis*.



Figure 36. *T. saxatilis* - a: The flower from the exterior, b: The flower from the interior.

Pollen morphology: Pollen grains monosulcate, heteropolar, ellipsoid or ellipsoid-spheroidal in polar view. Long axis 50-62.5 μm and short axis 41.25-48.75 μm . Exine 1-1.9 μm thick. Exine surface (exine pattern) perforate (LM). Intine bi-layered, outer intine (exintine) 0.9-1.5 μm and inner intine (endintine) 0.5-0.75 μm in thickness. Outer intine thicker in aperture (sulcus) region, up to 4 μm . Sulcus extends full length of grain; wide 33-43 μm ; the exine plate extends irregularly towards the aperture; exine surface granular or a one-banded operculum (in various length), band 11-56 μm in length, 7-13 μm wide (Figure 37).

Specimens examined: C2 Muğla: Eker 2220.

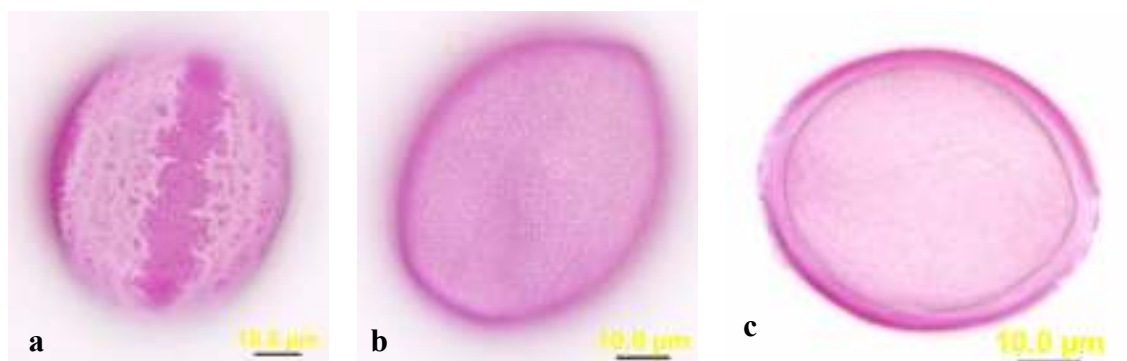


Figure 37. LM images of *T. saxatilis* (Eker 2220) - Monosulcate pollen - a. one-banded operculum, distal face b. perforate exine (exine pattern), proximal face c. pollen wall in optical section; exine (black arrow), outer and inner intine (white arrow).

Chromosome number: $2n=24$.

Specimens examined: C2 Muğla: Eker 2064 ($2n=24$, Figure 38).

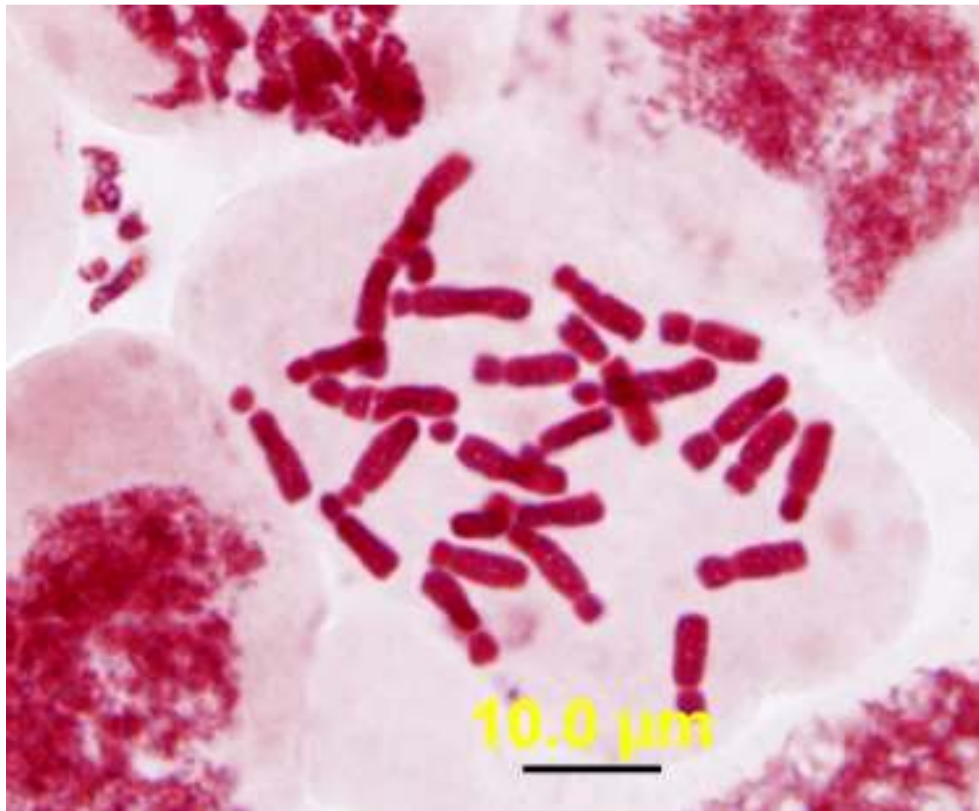


Figure 38. Somatic chromosome number of *T. saxatilis* (Eker 2064).

Section *Humiles* Eker & Babaç, *sect. nov.*

6. *Tulipa humilis* Herb. in Edwards's Botanical Register 30(Misc.): 30-31 (1844)!

= *Tulipa violacea* Boiss. & Buhse, Aufz. Transk. Pers. 211 (1860)! *Tulipa aucheriana* Baker, Gard. Chron., n.s., 20: 168 (1883); *Tulipa caucasica* Lipsky, Vestn. Tiflissk. Bot. Sada 6(1): 85 (1905); *Tulipa lipskyi* Grossh., Fl. Kavkaza 1: 223

(1928), nom. superfl.; *Tulipa humilis* subsp. *matinae* Zojajifar & Sheidai, Iranian J. Bot. 9: 66 (2001).

Iconibus: Curtis' Botanical Magazine 177: t. 571 (1970)! (Figure 41-43).

Type: A cultivated specimen originating from N. Iran, Mount Elburz, Kotschy.

Plant 12.5-27 cm. Stem glabrous, stem width 1-2.5 mm, underground stem length 2.5-11 cm, aerial stem length 5-11.5 cm. Not stoloniferous. Bulb ovoid to globose-ovoid, $1.5-2.6 \times 1.3-2.3$ cm. Bulb neck 0.7-3 cm. Tunics crustaceous, pale brown, tunics with a ring of short hairs around basal plate and adpressed, pilose, bristly and longer hairy at neck, middle part glabrous. Leaves 3-6, falcate, semifalcate, erecto-patent, erect, linear-lanceolate, canaliculate, glaucous, alternate, leaf margin ciliate or glabrous, membranous and entire; Lowest leaf $7-16.5 \times 0.6-1.4$ cm, subacute to obtuse; second lowest leaf $7-15.5 \times 0.3-0.9$ cm, subacute to acute. Flower solitary, infundibular, shiny mauve or rarely purple to pinkish-white with yellow blotch inside and paler with yellow base outside; outer tepals narrowly elliptic, acute, glabrous, pubescent at tip and sometimes slightly pubescent at base, $23-39 \times 6-11$ mm; inner tepals obovate with narrowed base, obtuse-apiculate or obtuse, distinctly pubescent at base and slightly pubescent at tip, $23-40 \times 9-16$ mm. Outer blotch 5-10 mm and inner blotch 6-10 mm in length. Blotch $1/5-1/3$ length of segments. Filaments yellow to orange or dark, lanceolate and pubescent at base; outer filaments 4.5-9 mm, inner ones 6.5-11 mm. Anthers $3-7 \times 1.5-2$ mm, oblong, yellow or orange at fresh, apiculate or not. Pollen light yellow. Ovary fusiform, green or yellowish-green at fresh, glabrous, $6-12.5 \times 2-4.5$ mm. Style very short or

obscure, $0.5-2 \times 0.5-2$ mm. Stigma pubescent, yellow, greenish-yellow or green at fresh, $0.5-1 \times 0.8-2.5$ mm. Capsule $2.5-3.9 \times 1.5-2$ cm, elliptic-ovoid, oblong-ovoid, obovoid or ellipsoid, glabrous; neck 1-5 mm, rib 20-30 mm, beak 3-5, apicula 0.5-1 mm; tepal scar 0.5-1 mm. Seeds numerous, flattened with rugose surface, triangular with two rounded angles to orbicular, light brown, $5-8 \times 3.5-6$ mm, winged.

Phenology: Flowering in May to Early June, and fruiting in June to Early July.

Distribution: Turkey (S.E. Anatolia), Azerbaijan, Iran (Figure 39-40).

Habitat: It grows in stony slopes and screes with red or reddish-brown soils of higher mountains at an elevation of 2200-3000 m.

Phytogeographic region: Irano-Turanian element.

Conservation status: LC (IUCN, 2001). *T. humilis* distributes only in East Anatolia (B9, C9, C10) and has extensive populations. There is no risk presently for these populations although excessive grazing of wild distribution areas in the region. Thus, the species may be classified as 'Least Concern' (LC) (IUCN 2001).

Selected Specimens Examined: B9 Van, between Van-Başkale, Güzeldere pass, stony slopes on high mountain steppe, 2728 m, $38^{\circ} 11.670' N$ $043^{\circ} 54.539' E$, 19.05.2006, Eker 1563 in AIBU! *ibid.* 05.05.2008, Eker 2111 in AIBU! *ibid.*, 05.06.2009, Eker 2474 (fruiting time) in AIBU! *ibid.*, 15.06.2002, Ali A. Dönmez 11099 in HUB! *ibid.*, 2750 m, 12.06.1984, A. & T. Baytop (ISTE 54292) in ISTE!

around Güzeldere Bakımevi, alpinic steppe, 2600 m, A. Güner 1559, 04.05.1977 in HUB! south slopes of Güzeldere pass, 2800 m, 12.05.1978, J. Trelawny & M. Phail 2014 in HUB! Choh pass, limestone and shaley screes, 3000 m, May 1972, E. M. Rix 1965 in ISTF! Gevaş, Artos (Çadır) mountain, between Gevaş-İçimli village, scree, 2638 m, 38° 13.437' N 043° 05.436' E, 06.06.2009, Eker 2479 in AIBU! ibid., 2577 m, 38° 13.073' N 043° 05.523' E, 06.06.2009, Eker 2481 (fruiting time) in AIBU! ibid., 2987 m, 16.07.1954, Davis & O. Polunin 22779 in ANK! ibid., west slopes, 2300 m, 06.06.1993, Y. Altan 5078 in GAZI! ibid., north slopes, 2800 m, 13.5.2001, S. İşler in VANF! Bahçesaray, Vari Krapit (Karabel) pass, above Y. Narlıca vllage, stony slopes, 2627 m, 38° 08.397' N 042° 56.525' E, 06.06.2009, Eker 2475 in AIBU! Bahçesaray road, Abdülbeyir upland, near stream, snowy and gravelly slopes, 2700 m, 21.06.1986, Ö. Seçmen 3682 & S. Oflas in EGE! Bitlis: Adilcevaz: Süphandağı, Çanakyayla village, Süte meadow, stony places with *Astragalus* sp. and *Acantholimon* sp., 2234 m, 04.06.1993, Y. Altan 4803 in GAZI! B10 Van: Özalp, Yukarı Tulgalı village, boundary upland, rocky places, 2300 m, 23.05.1998, F. Özgökçe 6151 in VANF! C9 Hakkari: S. slope of Reşko hill, ridge above Ziri village, snowy, rocky slopes, 2230-2380 m, 16.05.1946, Trelawny & McPhail 2512 in E! C10 Hakkari: Sat mountain, between Varegöz and Sat lake, rocky slopes, 26.06.1966, 2900-3000 m, D. 45595 in E! Yüksekova, south of Reşko hill (Cilo), between Marte-Ziri villages, 2330 m, 16.05.1978, J. Trelawny & M. Phail 2512 in HUB! above Marte village, İmdat mountain, 2380 m, 15.5.1978, J. Trelawny & M. Phail 2502 in HUB!

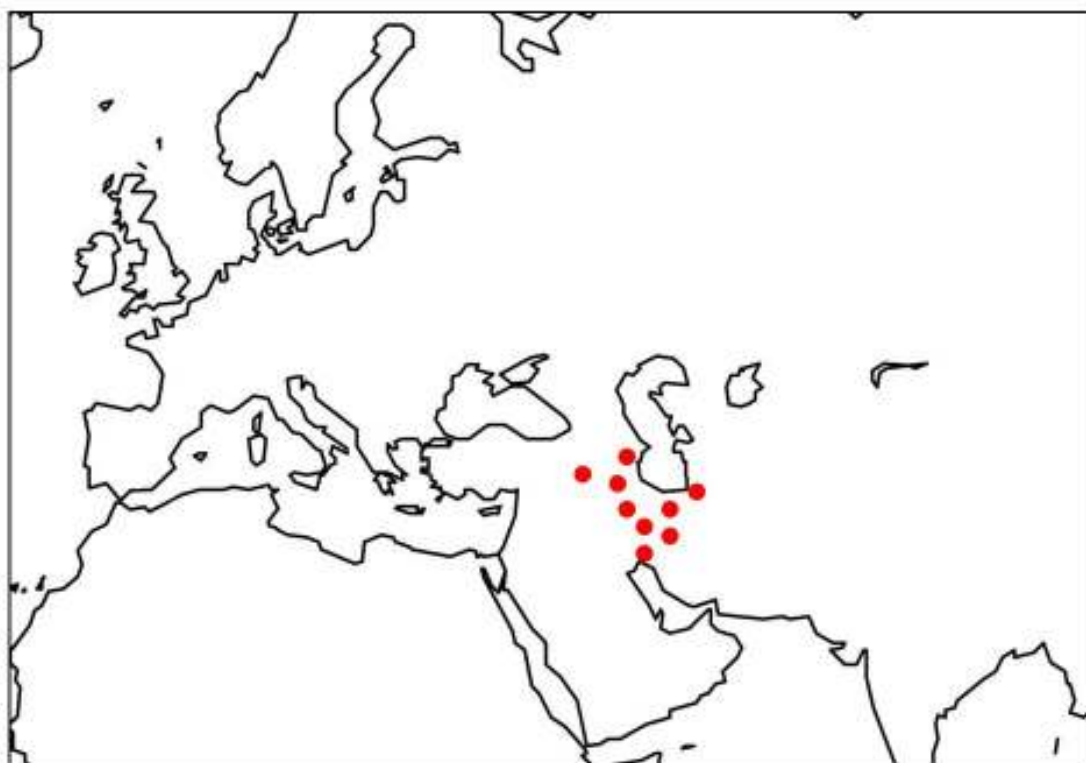


Figure 39. Distribution of *T. humilis* in the world.

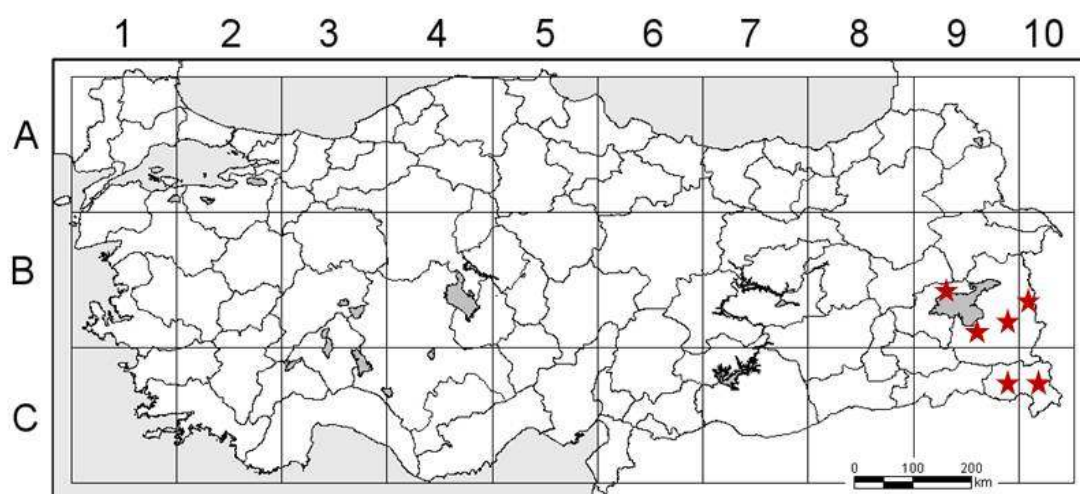


Figure 40. Distribution of *T. humilis* in Turkey.



Figure 41. Habit of *T. humilis*.



Figure 42. The flowers of *T. humilis* from the exterior.

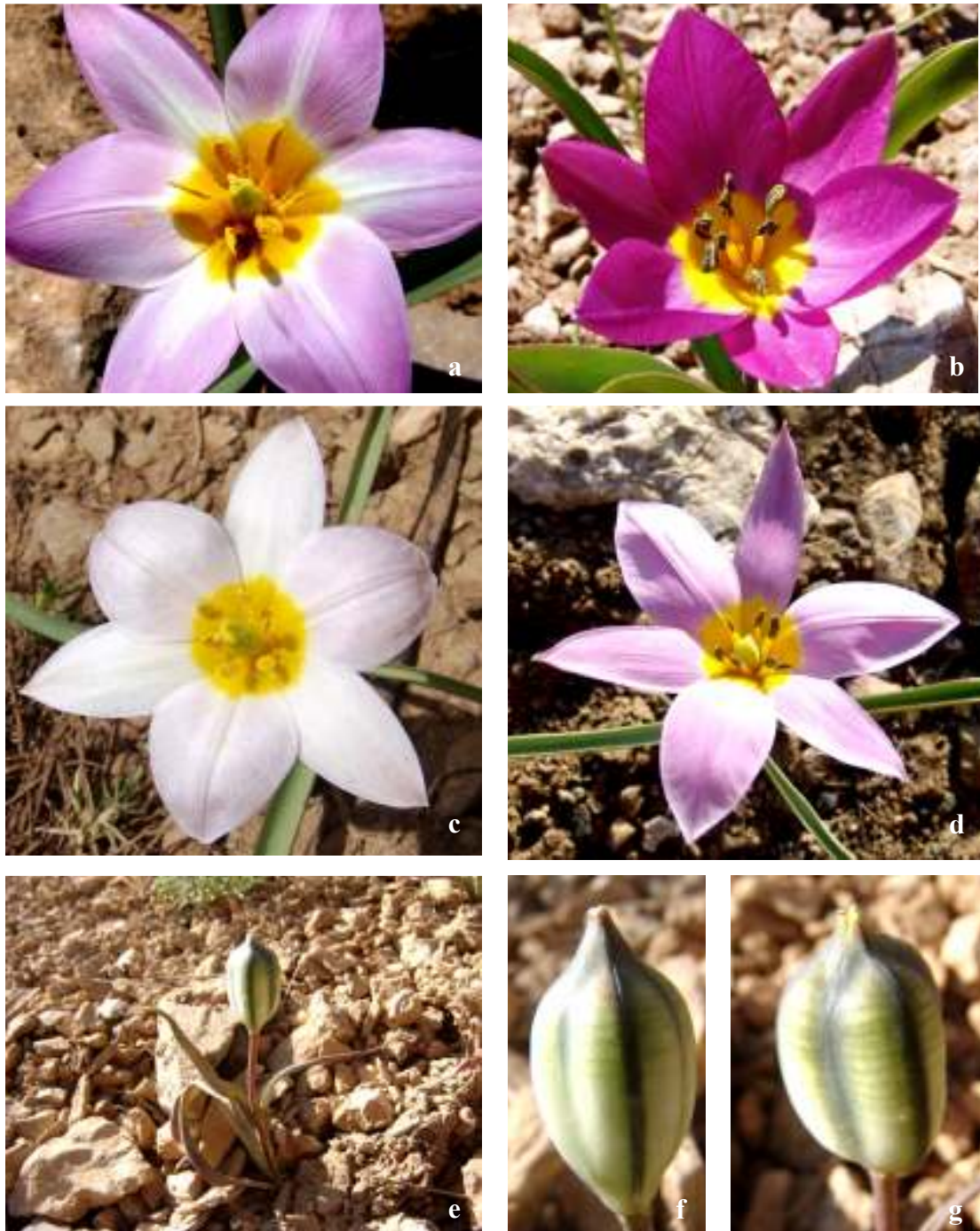


Figure 43. *T. humilis* - a-d: The flower from the interior, e-g: Fruit.

Pollen morphology: Pollen grains monosulcate, heteropolar, ellipsoid or ellipsoid-spheroidal in polar view. Long axis 37.5-57.5 μm and short axis 35-51.25 μm . Exine 1-1.8 μm thick. Exine surface (exine pattern) perforate-striate (SEM; Eker 2479). Intine bi-layered, outer intine (exintine) 0.5-2 μm and inner intine (endintine) 0.5-0.75 μm in thickness. Outer intine thicker in aperture (sulcus) region, up to 5 μm . Sulcus extends full length of grain; wide, almost equal to the short axis of grain or 24-42 μm ; the exine plate extends irregularly towards the aperture; exine surface granular or a one-banded operculum (in various length), band 20-52 μm in length, 3-25 μm wide (Figure 44-45).

Specimens examined: B9 Van: Eker 2111, 2474 & 2479.

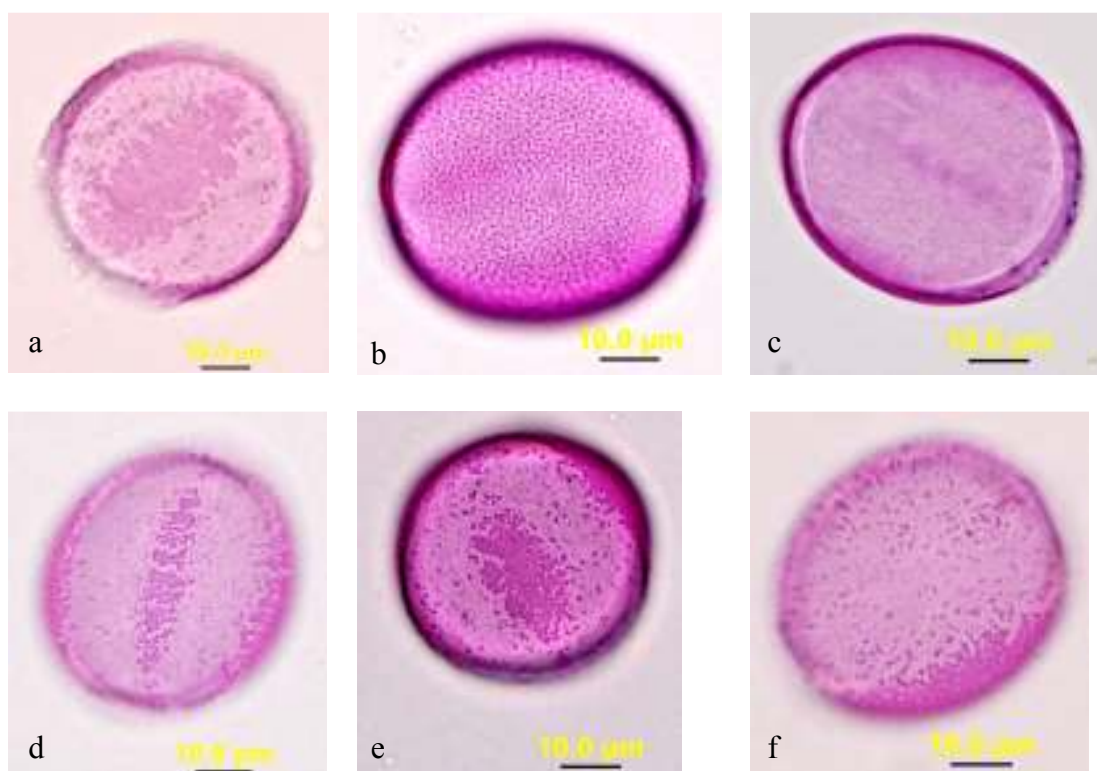


Figure 44. LM images of *T. humilis* - Monosulcate pollen - a. one-banded operculum, distal face (Eker 2474) b. perforate exine (exine pattern), proximal face (Eker 2479) c. pollen wall in optical section;

exine (black arrow), outer and inner intine (white arrow) (Eker 2479) d. one-banded narrow operculum, distal face (Eker 2479) e. one-banded short operculum, distal face (Eker 2479) f. without operculum, distal face (Eker 2479).

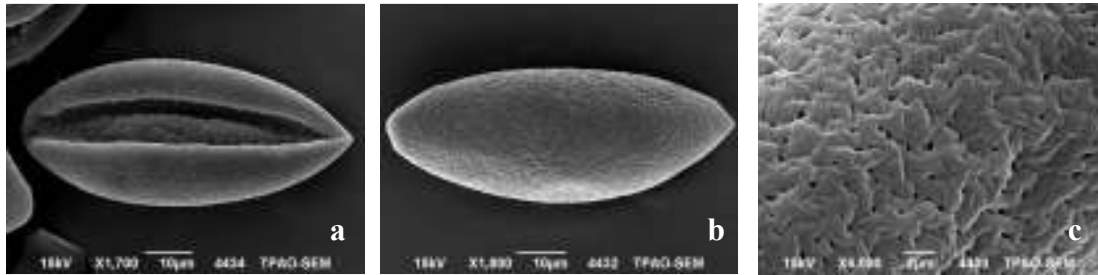


Figure 45. SEM images of *T. humilis* (Eker 2479) - Monosulcate pollen - a. one-banded operculum, distal face, b. proximal face of pollen grain c. perforate- striate exine (exine pattern), proximal face.

Chromosome number: $2n=24$.

Specimens examined: B9 Van: Eker 1563 ($2n=24$, Figure 46).

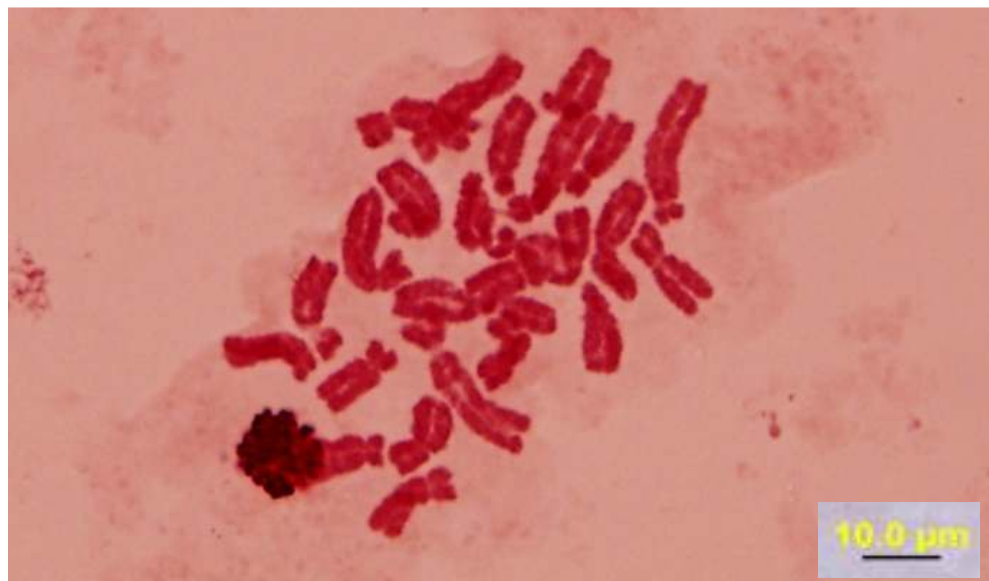


Figure 46. Somatic chromosome number of *T. humilis* (Eker 1563).

7. *Tulipa pulchella* (Regel) Baker in Journal of Linnean Society, Bot. 14: 289 (1874)!

≡ *Tulipa sylvestris* var. *pulchella* Regel, Acta Horti Petrop. (Trudy Imp. S.-Peterburgsk. Bot. Sada) 2: 443 (1873)!

= *Tulipa alpina* J.Gay ex Baker, J. Linn. Soc., Bot. 14: 289 (1874), nom. inval!
Tulipa kurdica Wendelbo, Bot. Not. 127: 276 (1974).

Iconibus: Curtis' Botanical Magazine 103: t. 6304 (1877)! (Figure 49-52).

Type: Turkey, Toros Mountain, alpine regions (Asia minor, regio Alpina montium Tauri), Kotschy, 506 (1836), (type K!, as *T. humilis* (= *T. pulchella*)).

Plant 8.5-30(-34) cm. Stem glabrous, stem width 0.5-1.5 mm, underground stem length 3-14 cm, aerial stem length 2-16 cm. Not stoloniferous. Bulb ovoid to globose-ovoid, 1-2.2 × 0.9-2 cm. Bulb neck 0.7-5 cm. Tunics crustaceous, blackish-brown or dark brown, with a ring of short hairs around basal plate and adpressed, bristly, pilose and longer hairy at neck, middle part glabrous. Leaves 2-4, falcate, erecto-patent, semierect, erect or ascending, linear-lanceolate to linear, canaliculate, glaucous, alternate, leaf margin ciliate or glabrous, membranous and entire; Lowest leaf 4.5-21(-31) × 0.3-1.2 cm, obtuse; second lowest leaf 4-20(-26) × 0.3-1 cm, obtuse to acute. Flower solitary, infundibular, shiny pinkish-purple, whitish-pink to magenta with bicoloured (bluish-violet and yellow; purplish-pink and yellow; white and yellow), purple or yellow blotch inside and paler outside; outer tepals narrowly elliptic, obtuse, subacute or acute, glabrous, pubescent at tip, 17-35 × 4-10 mm; inner tepals obovate to elliptic-obovate with narrowed base, obtuse or obtuse-apiculate,

distinctly pubescent at base and slightly pubescent at tip, $17-35 \times 6-15$ mm. Outer blotch 4-10 mm and inner blotch 5-10 mm in length. Blotch $1/5-1/3$ length of segments. Filaments bicolored (white and yellow; red and yellow, yellow and orange purple and yellow) or yellow, linear-lanceolate or linear-oblong, pubescent at base; outer filaments 5-10 mm, inner ones 6.5-12 mm. Anthers $2-7 \times 1-1.5(-2)$ mm, oblong, linear-oblong, oblong-ovoid, blackish-purple at fresh, apiculate or not. Pollen sulphure yellow, olive yellow, salmon yellow or golden yellow. Ovary fusiform, pinkish-green, yellow, reddish-green, pinkish-purple, purple or greenish-brown at fresh, glabrous or pubescent, $6-12 \times (1.5-)2-4.5$ mm. Style very short or obscure, $0.5-1 \times 0.5-1.5(-2)$ mm. Stigma pubescent, yellow, whitish-yellow, reddish-pink, reddish-green, pinkish-green, pink or white at fresh, $0.5-1 \times 0.5-2(-2.5)$ mm. Capsule $1.3-2.5 \times 1-1.7$ cm, elliptic-globose, globoid, elliptic-ovoid, ellipsoid, elliptic-obovoid, glabrous; neck 0.5-3 mm, rib 10-20 mm, beak 1-3, apicula 0.5-3 mm; tepal scar 0.5-1 mm. Seeds numerous, flattened with rugose surface, triangular with two rounded angles to orbicular, light brown, $3-6 \times 2.5-5$ mm, winged.

Phenology: Flowering in Mid April to Late May, and fruiting Late May to Late June.

Distribution: Turkey (S. Anatolia), N. Iraq, Iran (Figure 47-48).

Habitat: It grows in stony and rocky slopes with red or reddish-brown soils of higher mountain steppes at an elevation of 1000-2500 m.

Phytogeographic region: Widespread and unknown phytogeographic origin.

Conservation status: LC (IUCN, 2001). *T. pulchella* distributes only in the West and Central Toros mountains (C4, C5) and has extensive populations. There is no risk presently for these populations although excessive grazing of wild distribution areas in the region. Thus, the species may be classified as 'Least Concern' (LC) (IUCN 2001).

Selected Specimens Examined: B5 Aksaray: Kızılkaya village, Lalelik mevkii, 1200 m, 08.04.1994, F. Ertuğ 13 in GAZI! C3 Konya: between Konya-Beyşehir, around Altınapa dam, 1100 m, 13.04.1996, M. Koyuncu 11336, T. Ekim in AEF! C4 Antalya: Alanya-Taşkent highway, 2 km from Alanya-Konya road junction to Taşkent, stony slopes, 1271 m, 36° 42.626' N 032° 26.852' E, 28.04.2009, Eker 2304 in AIBU! Karaman: 15 km from Taşkent to Sarıveliler, stony slopes with red soils, 1800 m, 36° 50.894' N 032° 33.343' E, 24.04.2008, Eker 2042 in AIBU! ibid. 04.06.2008, Eker 2188 (fruiting time)! ibid., 02.05.1993, M. Koyuncu 9778 et al. in AEF! between Ayrancı-Ereğli, 19 km from Ereğli to Ayrancı, Melen hill, stony slopes, 1093 m, 37° 27.244' N 033° 51.386' E, 24.04.2008, Eker 2046 in AIBU! Ermenek, Yellibel, 15.06.1970, A. Pamukoğlu & Quezel in HUB! Konya: Alanya-Taşkent highway, below Çukuryurt pass, rocky and stony slopes on high mountain steppe, 1861 m, 36° 50.771' N 032° 30.284' E, 28.04.2009, Eker 2308 in AIBU! ibid., 26.05.2009, Eker 2403 (fruiting time) in AIBU! ibid., 24.04.1999, H. Duman 6900 in GAZI! Bozkır, Küçük Geyik mountain, 2200 m, 14.06.1967, R. Çetik et al. 44 in KNYA! between Kanlıgöl-Kızılot, 1800 m, 11.06.1968, R. Çetik et al. 295 in KNYA! Üçpınar, near Aslantaş, 1700 m, 15.05.1968, R. Çetik et al. 6850 in KNYA! between Konya-Karaman, Ağaçoba village, Muradın hill, south slopes, 2100 m, 08.04.1984, M. Serin 791 in KNYA! C5 Konya: Ereğli, Aydos mountain, Meydan

upland, Berendi, alpinic steppe, 2500 m, 19.05.1977, S. Erik 1999 in E & HUB! towards to the summit of Aydos mountain, Tahtalı, rocky places, 2500 m, 26.05.1978, S. Erik 2805 in HUB! Niğde: Bolkar mountains, from Madenköy to Medetsiz, W. of the summit, slopes with gravel and meadow fragments, 2360, 37° 25.327' N 034° 33.779' E, 25.05.2009, Eker 2383 in AIBU! ibid., 14.06.2009, Eker 2532 in AIBU! just N of a lake, 2450 m, slopes with gravel and meadow fragments, limestone, 27.7.1984, 37°24' N 34°40', G. Görk et al. 24076 in EGE! Adana: ± 15 km S.W. of Pozantı, Elmalı Dağ, 20.05.1959, S.E. slopes, just below the melting snow, with boulders, Nighoff 1300 in ANK!

Other Selected Collections: C4 Konya: 19 km frn Ereğli to Ayrancı, 1150 m, A. Baytop (ISTE 34613); C5 Adana Bürücek, Azir pass, Balls 1311; İçel: N. of Gülek Boğazı, 04.07.1855, Bal.

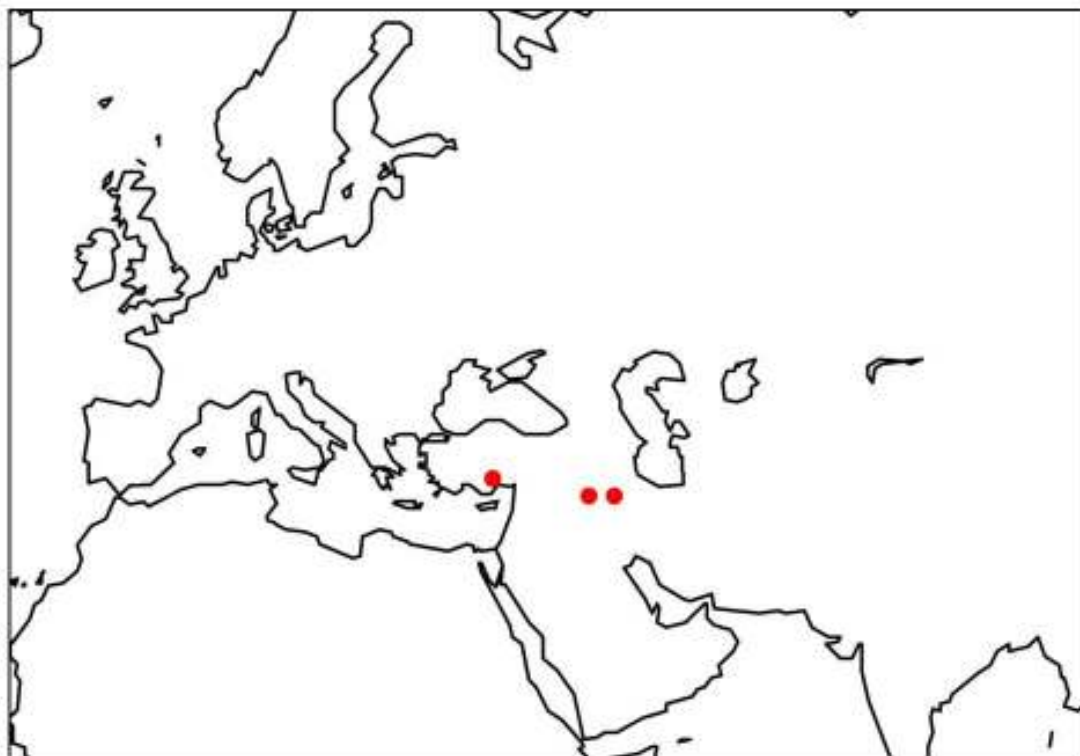


Figure 47. Distribution of *T. pulchella* in the world.

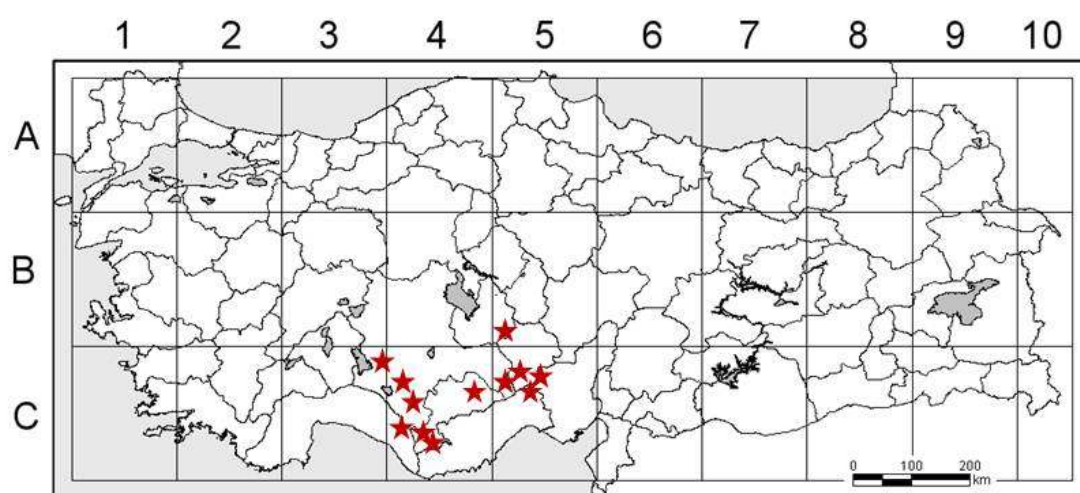


Figure 48. Distribution of *T. pulchella* in Turkey.



Figure 49. Habit of *T. pulchella*.



Figure 50 Leaf and flower variations in *T. pulchella*.



Figure 51. *T. pulchella* - a-d: The flower from the exterior, e-f: Fruits.



Figure 52. The flowers of *T. pulchella* from the interior.

Pollen morphology: Pollen grains monosulcate, heteropolar, ellipsoid or ellipsoid-spheroidal in polar view. Long axis 38.75-67.5 μm and short axis 32.5-50 μm . Exine 1-2 μm thick. Exine surface (exine pattern) perforate-striate (SEM; Eker 2304). Intine bi-layered, outer intine (exintine) 0.7-2 μm and inner intine (endintine) 0.5-0.75 μm in thickness. Outer intine thicker in aperture (sulcus) region, up to 4 μm . Sulcus extends full length of grain, wide, almost equal to the short axis of grain or 25-42; the exine plate extends irregularly towards the aperture; a one-banded operculum, band 30-67 μm in length or longer than long axis of grain, 9-34 μm wide (Figure 53-54).

Specimens examined: C4 Antalya: Eker 2304, Karaman: Eker 2315, Konya: Eker 2297, C5 Niğde: Eker 2383.

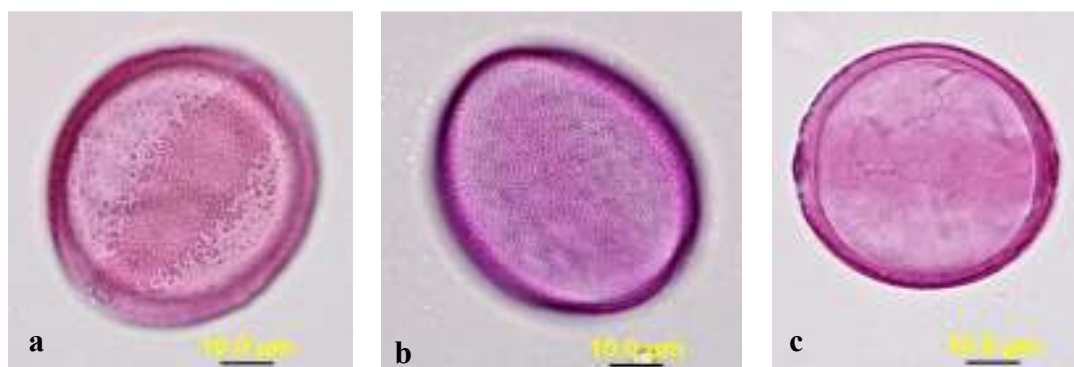


Figure 53. LM images of *T. pulchella* (Eker 2383) - Monosulcate pollen - a. one-banded operculum, distal face b. perforate exine (exine pattern), proximal face c. pollen wall in optical section; exine (black arrow), outer and inner intine (white arrow).

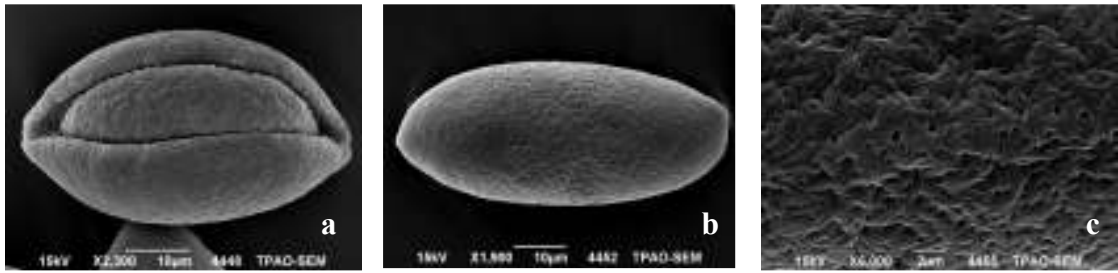


Figure 54. SEM images of *T. pulchella* (Eker 2304) - Monosulcate pollen - a. one-banded operculum, distal face, b. proximal face of pollen grain c. perforate- striate exine (exine pattern), proximal face.

Chromosome number: $2n=24$.

Specimens examined: C4 Karaman: Eker 2042 ($2n=24$, Figure 55).

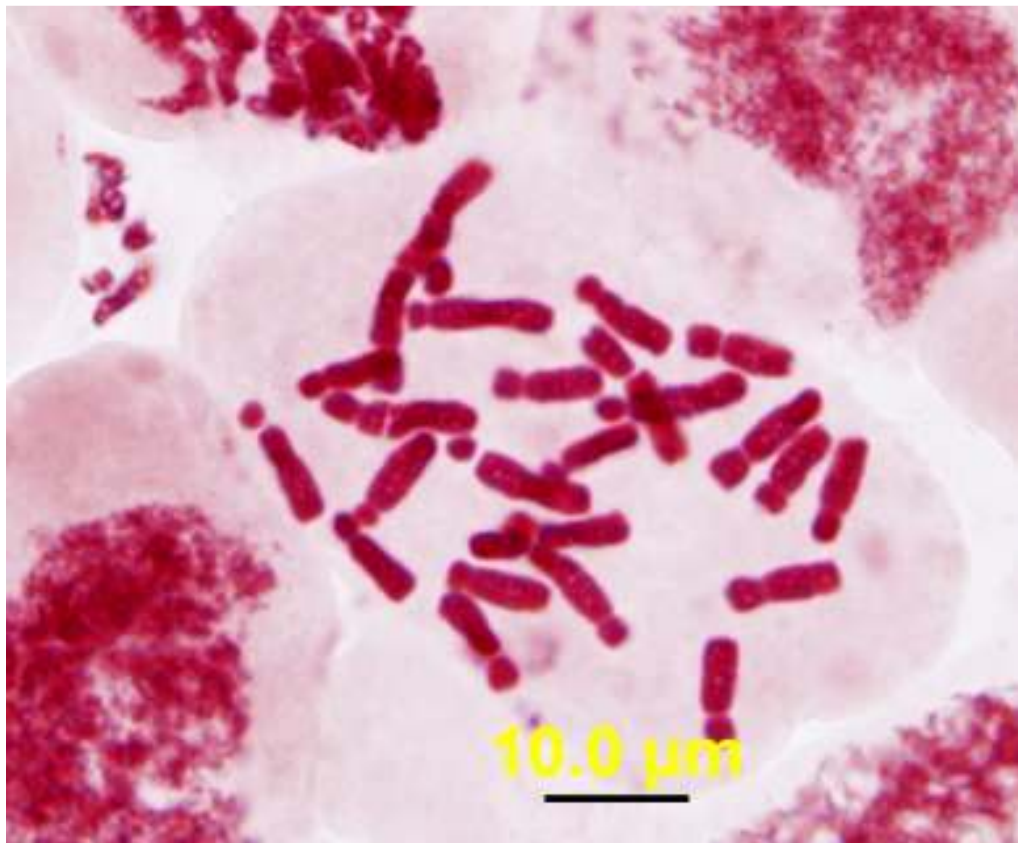


Figure 55. Somatic chromosome number of *T. pulchella* (Eker 2042).

Section *Biflores* sensu A. D. Hall

8. *Tulipa biflora* Pall. in Reise des Russichen Reichs 3: 727 (1776)!

≡ *Liriopogon biflorum* (Pall.) Raf., Fl. Tellur. 2: 35 (1837); *Orithyia biflora* (Pall.) Kunth, Enum. Pl. 4: 227 (1843); *Tulipa sylvestris* var. *biflora* (Pall.) Ledeb., Fl. Ross. 4: 136 (1853).

= *Podonix albiflora* Raf., Fl. Tellur. 4: 28 (1838); *Tulipa buhseana* Boiss., Diagn. Pl. Orient., II, 4: 98 (1859); *Tulipa crispatula* Boiss. & Buhse, Nouv. Mém. Soc. Imp. Naturalistes Moscou 12: 211 (1860); *Tulipa biflora* var. *buhseana* Regel, Trudy Imp. S.-Peterburgsk. Bot. Sada 2: 444 (1873); *Tulipa biflora* var. *major* Boiss., Fl. Orient. 5: 200 (1882)! *Tulipa humilis* var. *crispatula* (Boiss. & Buhse) Boiss., Fl. Orient. 5: 200 (1882)! *Tulipa callieri* Halácsy & Levier, Jahreskat. Wiener Bot. Tauschanst. 1897: 69 (1897); *Tulipa bessarabica* Zapal., Consp. Fl. Gallic. Crit. 1: 167 (1906); *Tulipa koktebelica* Junge, Trudy Bot. Muz. Imp. Akad. Nauk 16: 112 (1916); *Tulipa talijevii* Klovov & Zoz, Trudy Inst. Bot. Kharkivs'k. Derzhavn. Univ. 1: 66 (1936); *Tulipa halophila* Bornm. & Gauba, Repert. Spec. Nov. Regni Veg. 47: 77 (1939); *Tulipa binutans* Vved., Bot. Mater. Gerb. Inst. Bot. Zool. Akad. Nauk Uzbeksk. S.S.R. 13: 33 (1952).

Iconibus: Wendelbo, Tulips & Irises of Iran 39: t. 37 (1977) (Figure 58-59).

Type: Described from S. Russia, Pallas (3 syntypes BM!).

Plant 10-23 cm. Stem glabrous, stem width 0.5-1(-1.5) mm, underground stem length 3.5-13 cm, aerial stem length 2.5-6 cm. Not stoloniferous. Bulb ovoid, 1.5-2.2

× 1.2-1.8 cm. Bulb neck 1-3.5 cm. Tunics papery, pale brown, innermost tunics densely lined with arachnoid-lanate, slender, silky hairs. Leaves 2, falcate, linear-lanceolate, canaliculate, glaucous, alternate to subopposite, subacute to acute, leaf margin ciliate or glabrous, membranous and entire; Lowest leaf 6-12 × 0.6-1.2 cm; second lowest leaf 4-9.5 × 0.2-0.9 cm. Flowers 1-4, infundibular, white with yellow blotch inside; outer tepals bright white inside and tinged greyish-violet on a pale white ground outside, narrowly elliptic, acute, glabrous or very slightly pubescent only at tip, 20-29 × 5-8 mm; inner tepals bright white inside and pale white outside, elliptic-ovate with narrowed base, obtuse-apiculate to subacute, distinctly pubescent at base and glabrous or very slightly pubescent at tip, 20-30 × 8-13 mm. Outer blotch 6-10 mm and inner blotch 6-11 mm in length. Blotch 1/4-1/2 length of segments. Filaments yellow to orange, linear-lanceolate and pubescent at base; outer filaments 5-9 mm, inner ones 7-10 mm. Anthers 2.5-4 × 1-1.5 mm, oblong to oblong-ovoid, orange-yellow to yellow with often purple tip at fresh, apiculate or not. Pollen yellow. Ovary fusiform, yellowish-green or green at fresh, glabrous, 6.5-12 × 1.5-4 mm. Style very short or obscure, 0.5-1 × 0.5-1 mm. Stigma pubescent, yellow or whitish-yellow at fresh, 0.3-1 × 0.8-1.5 mm. Capsule 1.3-3 × 1-1.5 cm, ellipsoid, ellipsoid-globose, elliptic-obovoid, elliptic-ovoid or ellipsoid-oblong, glabrous; neck 1-3 mm, rib 10-24 mm, beak 1.5-3, apicula 0.5-1.5 mm; tepal scar 0.5-1 mm. Seeds numerous, flattened with rugose surface, triangular with two rounded angles to orbicular, light brown, 4-6 × 3-4 mm, winged.

Phenology: Flowering in Late April-Early May, and fruiting in May.

Distribution: Turkey (East Anatolia), N. Iraq, Syria, Iran, Armenia, Uzbekistan, Turkmenistan, W. Kazakhstan, S.W. Turkestan, Pakistan, Afghanistan, S.W. Russia. Also, there are some isolated records from Krym, Macedonia, Saudi Arabia and Egypt (Figure 56-57).

Habitat: It grows in screes and stony slopes with brown soils of higher mountains at an elevation of 2000-3000 m.

Phytogeographic region: Irano-Turanian element.

Conservation status: VU (IUCN, 2001). *T. biflora* distributes only in East Anatolia and has restricted populations. These populations might be threatened due to the excessive grazing of wild distribution areas in the region. Thus, the species may be classified as 'Vulnerable' (VU) (IUCN 2001).

Selected Specimens Examined: B9 Van, between Van-Çatak, 33 km to Çatak, screes, 2078 m, 38° 13.761' N 043° 13.943' E, 02.05.2007, Eker 1849 in AIBU! *ibid.* 05.05.2008, Eker 2098! between Güzelsu (Hoşap)-Başkale, Güzeldere pass, stony slopes, 2706 m, 38° 11.741' N 043° 54.522' E, 05.05.2008, Eker 2110 in AIBU! *ibid.* 06.06.2009, Eker 2482! *ibid.*, 2800 m, 03.06.1985, T. Baytop (ISTE 55318) in ISTE! Bitlis: Adilcevaz: Süphandağı, Süte meadow, stony places, 2000 m, 04.06.1993, Y. Altan 4802 in GAZI!

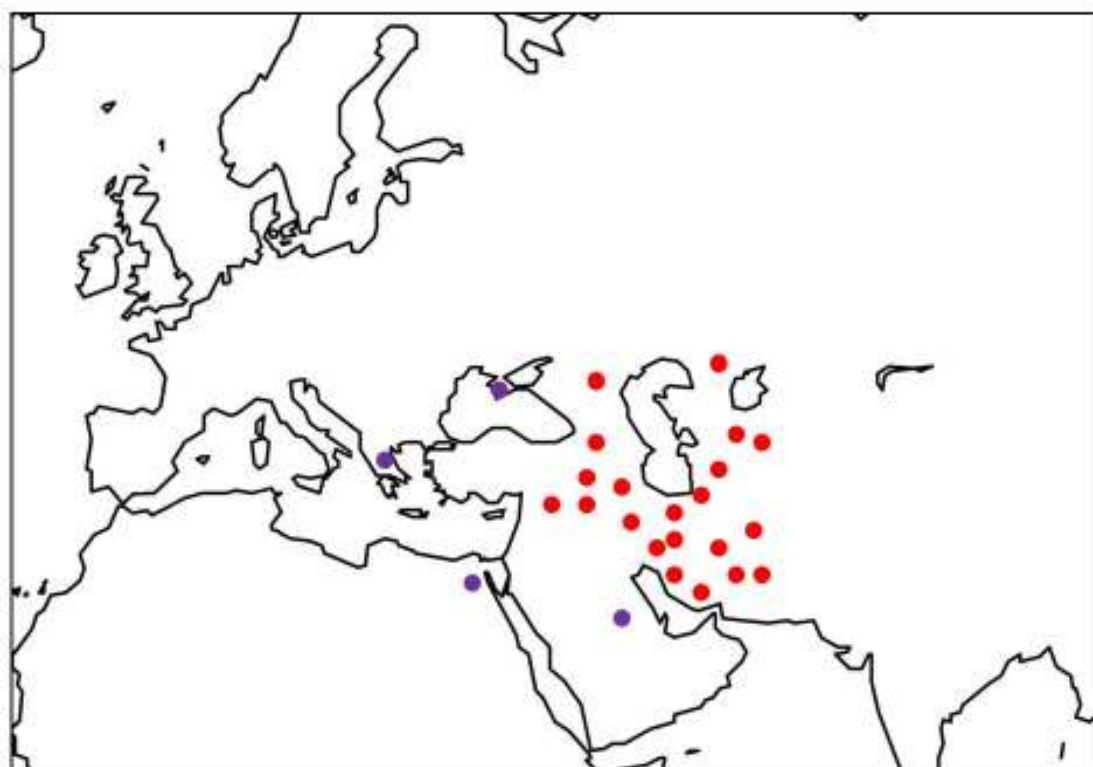


Figure 56. Distribution of *T. biflora* in the world (red dots represent natural range of the species while purple dots represent isolated areas).

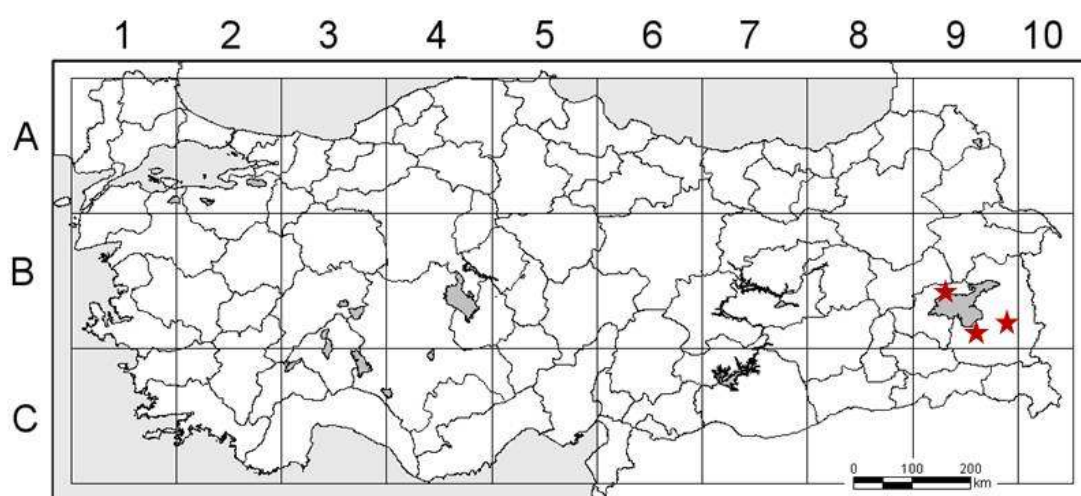


Figure 57. Distribution of *T. biflora* in Turkey.



Figure 58. Habit of *T. biflora*.



Figure 59. *T. biflora* - a-b: The flower from the exterior, c-e: The flower/flowers from the interior, f: Fruit with three headed.

Pollen morphology: Pollen grains monosulcate, heteropolar, ellipsoid or ellipsoid-spheroidal in polar view. Long axis 37.5-56.25 μm and short axis 32.5-50 μm . Exine 1-1.5 μm thick. Exine surface (exine pattern) perforate (LM). Intine bi-layered, outer intine (exintine) 0.6-1.5 μm and inner intine (endintine) 0.5-0.75 μm in thickness. Outer intine thicker in aperture (sulcus) region, up to 3 μm . Sulcus extends full length of grain, wide, almost equal to the short axis of grain or 24-43 μm ; the exine plate extends irregularly towards the aperture; a one-banded operculum, band 28-46 μm in length, 6-20 μm wide (Figure 60).

Specimens examined: B9 Van: Eker 1567 & 1849.

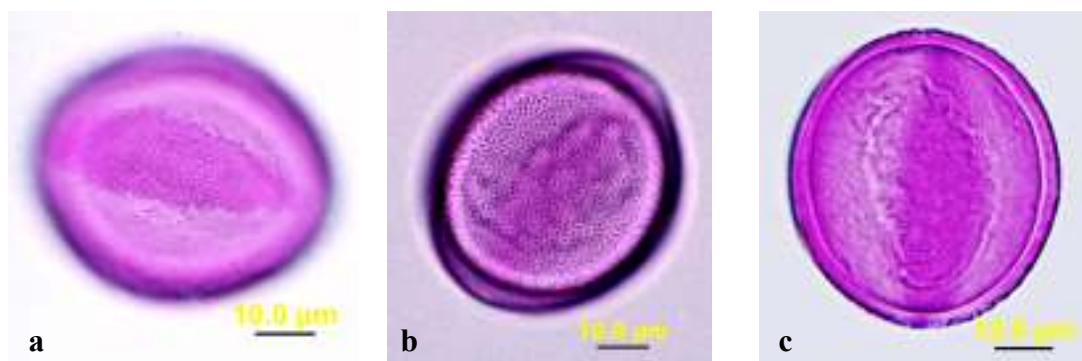


Figure 60. LM images of *T. biflora* (Eker 1849) - Monosulcate pollen - a. one-banded operculum, distal face b. perforate exine (exine pattern), proximal face c. pollen wall in optical section; exine (black arrow), outer and inner intine (white arrow).

Chromosome number: $2n=24$.

Specimens examined: B9 Van: Eker 2098 ($2n=24$, Figure 61).



Figure 61. Somatic chromosome number of *T. biflora* (Eker 2098).

9. *Tulipa koyuncui* Eker & Babaç *sp. nov.* in Nordic J. Bot. (in press, 2010).

Iconibus: (Figure 64-67).

Type: Turkey, B9 Van, between Van-Başkale, Güzeldere pass, rocky and stony slopes, 2738 m, 19.05.2006, Eker 1565 (holotype AIBU, isotype AEF).

Plant 10-20(-26) cm. Stem glabrous, stem width 0.5-1(-1.5) mm, underground stem length (3-)6-11(-15) cm, aerial stem length 3-5.5 cm. Not stoloniferous. Bulb ovoid to globose-ovoid, $1.6-2.3 \times 1.5-1.8$ cm. Bulb neck 2-3.5 cm. Tunics papery, brown, innermost tunics densely lined with arachnoid-lanate, slender, silky hairs. Leaves 2, falcate, linear-lanceolate, canaliculate, glaucous, alternate to subopposite, acute, leaf margin membranous and entire; Lowest leaf $6-13 \times 0.7-1.2$ cm, leaf margin glabrous; second lowest leaf $4.5-8 \times 0.3-0.8$ cm, leaf margin often glabrous or very rarely ciliate. Flowers 1-2, infundibular, yellow without central blotch inside; outer tepals bright yellow inside and tinged greyish-violet or reddish-brown on a pale yellow ground outside, narrowly elliptic, acute, glabrous or very slightly pubescent only at tip, $19-23 \times 4-6$ mm; inner tepals bright yellow inside and outside, elliptic-ovate with narrowed base, obtuse-apiculate to subacute, distinctly pubescent at base and glabrous or very slightly pubescent at tip, $18-23 \times 8-10$ mm. Filaments yellow, linear-lanceolate and pubescent at base; outer filaments 4-5 mm, inner ones 5.5-7 mm. Anthers $2.5-4 \times 1-1.5$ mm, oblong-ovoid, yellow at fresh, apiculate or not. Pollen yellow. Ovary subfusiform to fusiform, yellowish-green or green at fresh, glabrous, $5-10 \times 2-3.5$ mm. Style very short or obscure, $0.8-1 \times 0.5-1$ mm. Stigma pubescent, yellow or whitish-yellow at fresh, $0.4-0.6 \times 0.8-2$ mm. Capsule $1.6-2.5 \times 0.9-1.3$ cm, ellipsoid, ellipsoid-globose or ellipsoid-oblong, glabrous; neck 1-3 mm, rib 12-20 mm, beak 2-3.5, apicula 1-2 mm; tepal scar 0.8-1 mm. Seeds numerous, flattened with rugose surface, triangular with two rounded angles to orbicular, light brown, $3-5.5 \times 2-3.5$ mm, winged.

Phenology: Flowering in Late April to Early May, and fruiting in Early June.

Distribution: *T. koyuncui* is known only from East Anatolia. It is endemic to Turkey (Figure 62-63).

Habitat: It grows in rocky and stony slopes with red soils of higher mountains at an elevation of 1950-3000 m with *Iris pseudocaucaucasica* Grossh., *Bellevallia rixii* Wendelbo, *Fritillaria crassifolia* Boiss. & Huet subsp. *kurdica* (Boiss. & Noë) Rix, *Puschkinia scilloides* Adams and *Tulipa humilis* Herb.

Phytogeographic region: Irano-Turanian element.

Conservation status: EN (IUCN, 2001). *T. koyuncui* was found at three closest localities (B9 Van), with an area of occupancy estimated to be less than 500 km². It has a very limited distribution and is not so common in its natural habitats. Thus, the species may be classified as 'Endangered' (EN) (criterion B2) (IUCN 2001).

Selected Specimens Examined: B9 Van, between Van-Başkale, Güzeldere pass, rocky and stony slopes, 2738 m, 38° 11.763' N 043° 54.539' E, 19.05.2006, Eker 1565 in AIBU! 10 km to Hoşap, north slopes of Zerne Dam, 2094 m, 38° 21.067' N 043° 41.057' E, 08.06.2009, Eker 2487 (fruiting time) in AIBU! between Hoşap-Başkale, 20 km to Başkale, steppe, snowy places, 2200 m, 23.05.1993, Y. Altan 4947 in GAZI as *T. sylvestris*! Gürpınar, north slopes of Zerne Dam, 1950 m, 23.04.2007, İ. Demir 44 in VANF as *T. sylvestris*! Bölmeçalı road junction, steppe, 2200 m, 06.04.2001, M. Ünal 4796 in VANF as *T. sylvestris*! southwest of Yedisalkım village, stony slopes, 2400 m, 07.04.2001, M. Ünal 4707 in VANF as *T. sylvestris*! B10 Van: Özalp, southeast hills of Bakışık village, 2412 m, 38° 43.299' N

044° 14.705' E, 07.06.2009, Eker 2485 (fruiting time) in AIBU! plateau of Yukarı Balçıklı village, steppe, 2300 m, 23.05.1998, F. Özgökçe 5959 in VANF as *T. sylvestris*!

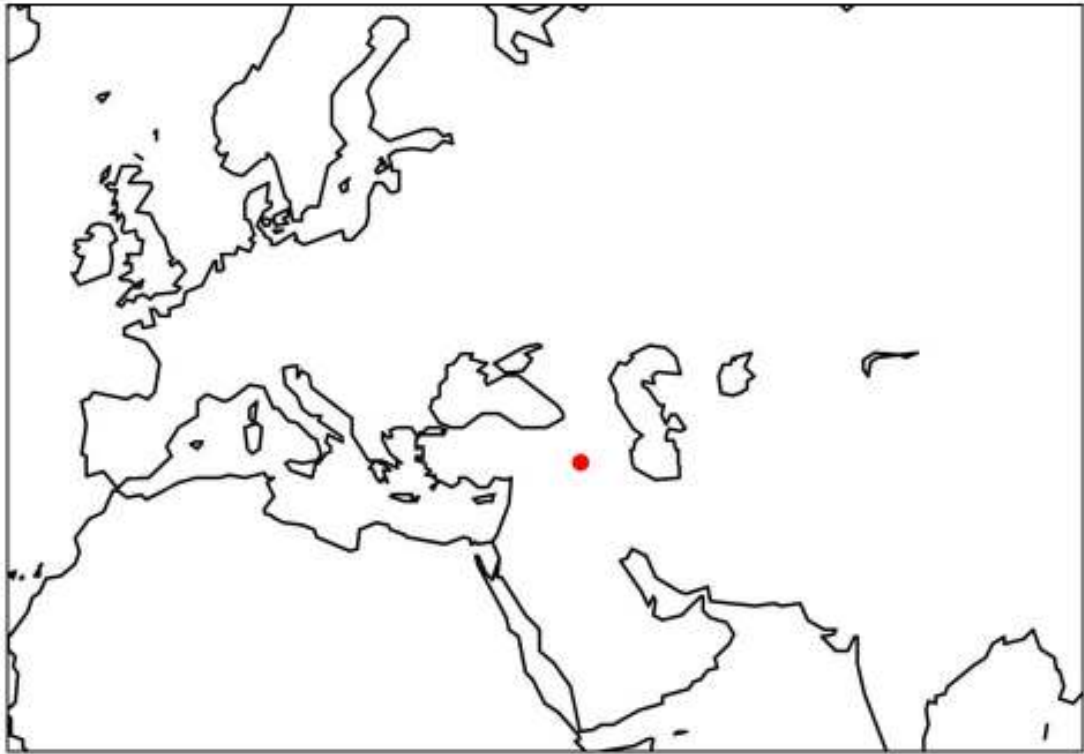


Figure 62. Distribution of *T. koyuncui* in the world.

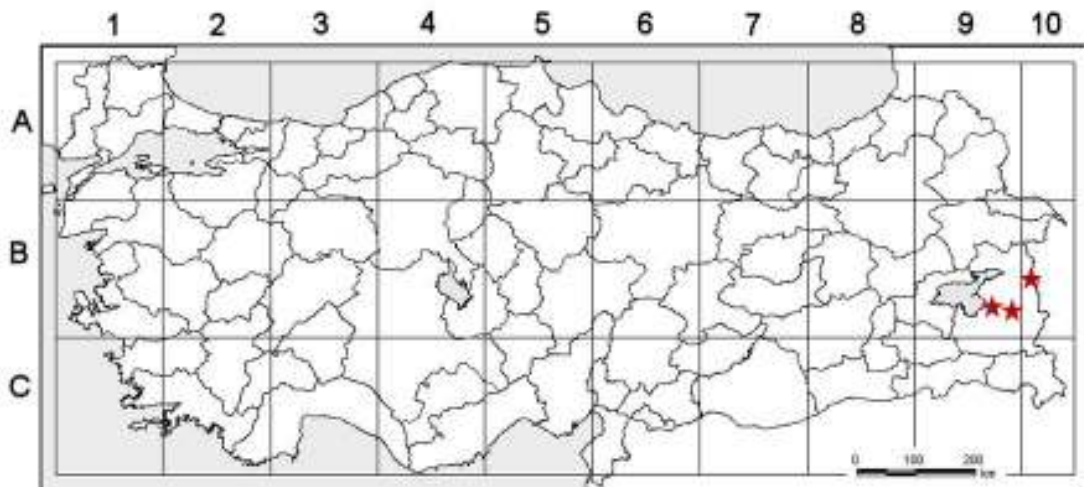


Figure 63. Distribution of *T. koyuncui* in Turkey.

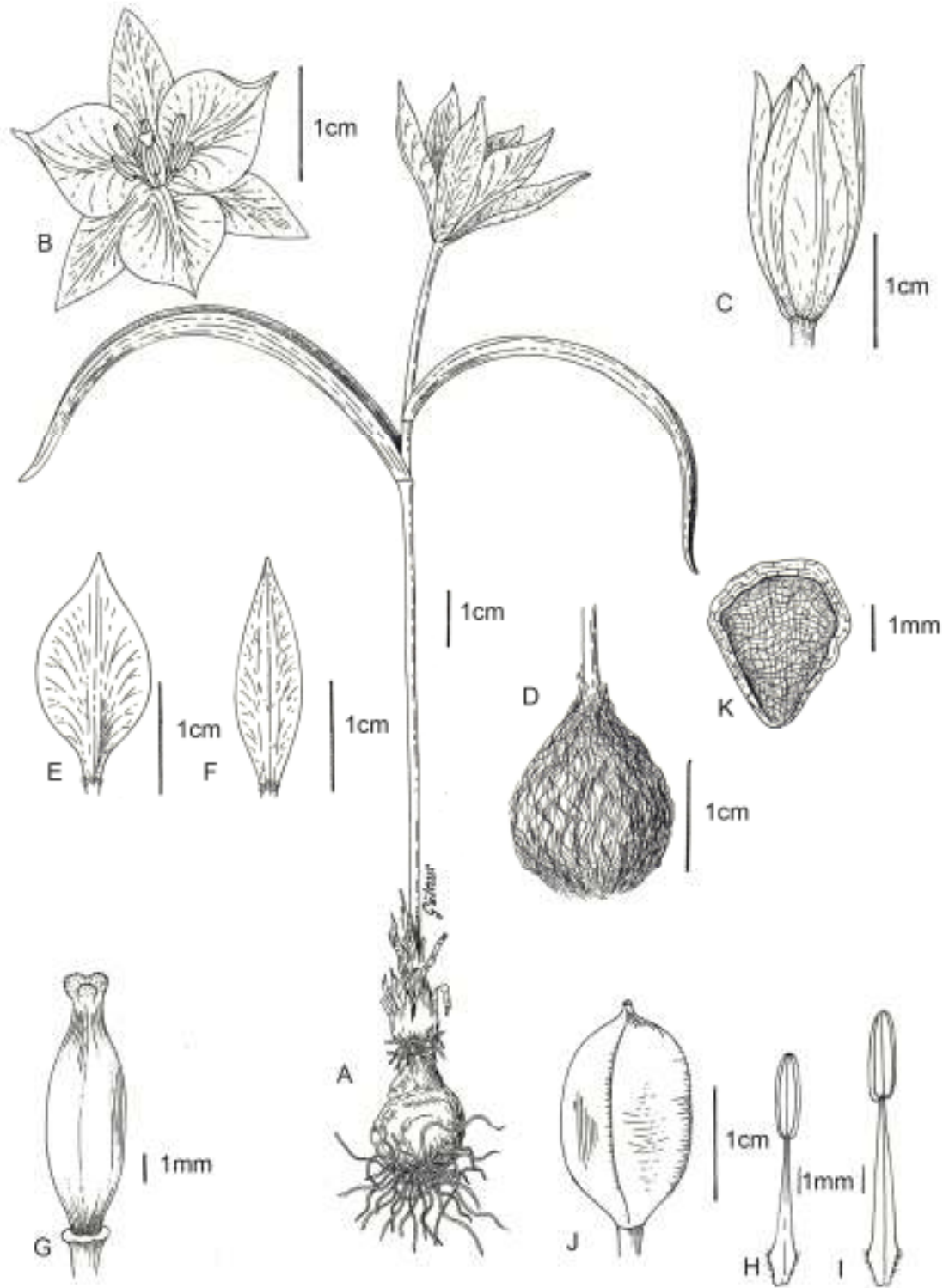


Figure 64. *Tulipa koyuncui* Eker & Babaç sp. nov. — A: Habit. (holotype) — B: Flower from the overhead — C: Flower from the outside — D: Tunic hairiness inside — E: Inner perianth segment — F: Outer perianth segment — G: Gynoecium — H: Outer stamen — I: Inner stamen — J: Fruit — K: Seed.



Figure 65. General view of *T. koyuncui* from the interior.



Figure 66. General view of *T. koyuncui* from the exterior.



Figure 67. *T. koyuncui* - a-c: General view of flowers in their habitat, c-d: General morphology of the plant, e: Fruit.

Pollen morphology: Pollen grains monosulcate, heteropolar, ellipsoid in polar view. Long axis 47.5-55 μm and short axis 38.75-46.25 μm . Exine 0.9-1.5 μm thick. Exine surface (exine pattern) perforate (LM). Intine bi-layered, outer intine (exintine) 0.6-0.9 μm and inner intine (endintine) 0.5-0.75 μm in thickness. Outer intine thicker in aperture (sulcus) region, up to 3 μm . Sulcus extends full length of grain, wide; almost equal to the short axis of grain; the exine plate extends irregularly towards the aperture; a one-banded operculum, band 38-48 μm in length, 17-24 μm wide (Figure 68).

Specimens examined: B9 Van: Eker 2108.



Figure 68. LM images of *T. koyuncui* (Eker 2108)- Monosulcate pollen- a. one-banded operculum, distal face b. perforate exine (exine pattern), proximal face c. pollen wall in optical section; exine (black arrow), outer and inner intine (white arrow).

Chromosome number: $2n=24$.

Specimens examined: B9 Van: Eker-2108 ($2n=24$, Figure 69).

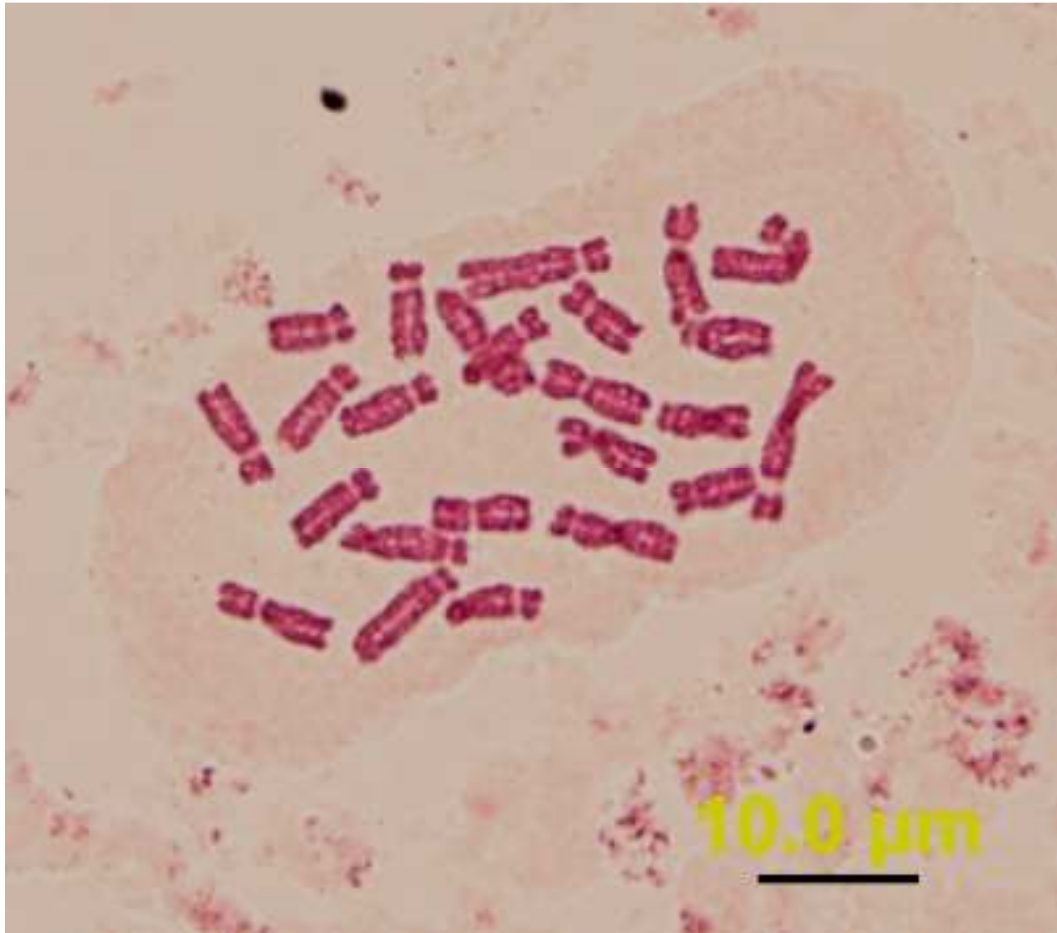


Figure 69. Somatic chromosome number of *T. koyuncui* (Eker 2108).

Notes: Initially, these specimens might be thought either as dwarf forms of *T. sylvestris* L. or a variant of *T. biflora* Pall. *T. sylvestris* distributes in west Anatolia, but also it was reported some doubtful records around Van province in east Anatolia (Marais, 1984; unpubl. data). These records were investigated and it was concluded that some of these records were cultivar forms of *T. sylvestris* in gardens or

naturalized plants escaped from cultivation. A few records collected from natural habitats, which were reported as *T. sylvestris*, were described in this study. Some remarkable morphological differences such as tunic type, type of tunic hairs, hair distribution of tunic, number of leaves, measurements of all plant parts were also detected between them. At the same time, the specimens were compared with *T. biflora*. In our field studies, to observe variations within and between populations of *T. biflora*, further specimens were examined. Although colour of tepals of *T. biflora* may have limited colour differences, in fact, white flowers and yellow central blotch are characteristics for *T. biflora*. Our specimens were rather different by having discrete yellow flowers without central blotch and shorter outer and inner filaments. The same plants from their same localities were collected during 2007-2008 and extensive materials belonging to the genus were examined by Eker to solve taxonomical positions of the species. The collected specimens were identified by using diagnostic keys in the 'Flora of Turkey and the East Aegean Islands' (Marais, 1984) and the floras of neighbouring regions such as Iran (Rechinger 1990), Iraq (Wendelbo 1985), Syria, Palastine (Post & Dinsmore 1933), Central Asia, Caucasus (Vvedenskii 1935), and Europe (Grey-Wilson & Matthews, 1980). They were consequently compared with the similar specimens at international and national herbaria; AIBU, AEF, ANK, BM, ISTE, ISTF, GAZI, E, EGE, FUH, HUB, K, KNYA, and VANF. Our detailed studies showed that the specimens were closely related to *T. biflora* and *T. sylvestris*, but very important morphological differences were apparent between them. Besides, bulbs of three species were collected from the different localities and they were cultivated to observe invariability of differences and similarities in a neutral environment in Bolu province. Consequently, our specimens were distinctly different from the other *Tulipa* species

and it was concluded that they represent a new species to science.

T. koyuncui resembles *T. biflora* and *T. sylvestris*. This new species clearly differs from them by having smaller outer and inner filaments (4-5 and 5.5-7). It also differs from *T. biflora* by having 1-2 yellow flowers without central blotch (neither 1-4, nor white flowers with yellow blotch) while it differs from *T. sylvestris* by having papery tunics and densely covered with lanate hairs throughout tunics, two falcate leaves and smaller flowers.

The name of the new species is given in honour of the Turkish plant taxonomist Prof. Dr Mehmet Koyuncu, who is expert of geophytes in Turkey.

Section *Tulipa*

10. *Tulipa armena* Boiss. in Diagnoses Plantarum Orientalium 3(4): 99 (1859)!

= *Tulipa heterochroa* Freyn in Bull. Herb. Boissier 4: 184 (1896)!

Plant 17.5-56(-82) cm. Stem glabrous, stem width 1-3(-5) mm, underground stem length 4.5-30 cm, aerial stem length 3-27(-37) cm. Not stoloniferous. Bulb ovoid to globose-ovoid, 1.6-3.5(-5) × 1.5-3(-4) cm. Bulb neck 1-6 cm. Tunics papery, brown to reddish-brown. Basal plate and neck densely hairy, middle part densely to sparsely hairy (pilose). Leaves (2-)3-6, alternate, glaucous, undulate, ciliate or glabrous, and membranous on margins. Lowest leaf lanceolate, canaliculate, falcate, semi-falcate, erecto-patent, semierect or erect, obtuse to acute, 5.5-27 × 1-5.5 cm. Second lowest leaf falcate, semifalcate, erecto-patent, semierect or erect, subacute to acute, 5-26 × 0.4-3.8 cm. Flower solitary, campanulate. Generally, flowers shiny red with short eggplant blotch inside with or without yellow

blotch edge, paler red with or without greenish-yellow base outside. Some flowers shiny yellow with or without black blotch inside, paler yellow outside. Also, there are some mix flowers (partly red and partly yellow, figure 75-77). Outer perianth segments elliptic-ovate, ovate to elliptic, rarely elliptic-obovate, acute, subacute to acuminate, $24-65(-99) \times 9-34$ mm, glabrous, puberulous only at tip. Inner perianth segments obovate, spatulate to rarely ovate or caudate, obtuse to rarely acute to acuminate, apiculate or notched, glabrous and often pubescent at tip, $20-58(-68) \times 8-32$ mm. Outer blotch $4-16(-22)$ mm and inner blotch $4-16$ mm in length. Blotch $(1/14-1/10-1/3)$ length of segments. Filaments $4-14$ mm, glabrous, lanceolate to linear-lanceolate, purplish-black or yellow. Anthers $4-18 \times 1.5-3.5$ mm, oblong to oblong-ovoid, linear-oblong, purple or yellow at fresh, apiculate or not. Pollens purple or yellow at fresh, yellow, sulphur yellow, olive yellow or mustard yellow at dry (purple colour at fresh is turned tones of yellow at dry). Ovary $65-20(-25) \times 1.5-5(-6)$ mm, oblong, subfusiform, fusiform, glabrous, green, yellow, yellowish-green or reddish-yellow at fresh. Style very short or obscure, $0.5-2.5(-3) \times 0.8-4$ mm. Stigma green, yellow, yellowish-green, reddish-green, reddish-yellow or whitish-yellow at fresh, pubescent, $0.5-2.5 \times 1.5(-6)$ mm. Capsule $(1.75-2.3-5.8) \times 1.3-2.5$ cm, ellipsoid, elliptic-ovoid, ovoid, oblong-ovoid or globoid, glabrous; neck $1-5$ mm, rib $12-46$ mm, beak $2-8(-12)$, apicula $(0.5-1-2)$ mm; tepal scar $1-2$ mm. Seeds numerous, flattened with rugose surface, triangular with two rounded angles to orbicular, light brown, $(4.5)5-9 \times 4-8$ mm, winged.

1. Flowers red with short eggplant blotch inside var. *armena*

1. Flowers yellow without blotch inside var. *galatica*

Phenology: Flowering in Mid-April to Early June, fruiting in Late May to Late June.

Distribution: Turkey, N.W. Iran, Transcaucasica (Figure 70-71).

Habitat: The populations of *T. armena* are mainly found on screes and stony slopes, also in high mountain steppe (alpine), grassland, opening of forest with reddish-brown, red, brown, grayish-brown and gray soils at an elevation of 850-2750 m.

Phytogeographic region: Irano-Turanian element.

Conservation status: LC (IUCN, 2001). The populations of *T. armena* are widespread in Turkey except of Marmara region and coast cities of Karadeniz and Ege regions. These populations have wide distribution ranges and there is no risk presently. Thus, the species may be classified as ‘Least Concern’ (LC) (IUCN 2001).

var. *armena*.

≡ *Tulipa oculus-solis* St. Amans var. *lycica* Baker in J. Linn. Soc. (Bot.) 14: 278 (1874), Basionym/Replaced Synonym!

= *T. foliosa* Stapf in Denkschr. Kaiserl. Akad. Wiss. Wien. Math.-Naturwiss. Kl. 50: 80 (1885); *T. ciliatula* Baker in Gard. Chron. III, 7: 640 (1890)! *T. concinna* Baker in Gard. Chron. III, 13: 538 (1893)! *T. mucronata* Fomin in Monit. Jard. Bot. Tiflis 9: 13 (1908)! ***T. armena* var. *lycica* (Baker) Marais syn. nova**, in Kew Bull. 35: 258 (1980)!

Iconibus: Hall, The Genus *Tulipa* t. 20 (1940)! (Figure 72-73, 76-78).

Type: [Turkey A8] In montibus inter Erzurum et İspir, prope İspir, 1200-1500 m, june 1853, Huet du Pavillon as *T. montana* (holotype G, isotype K!).

Selected Specimens Examined: A4 Ankara, Kızılcahamam, above Soğuksu, 28.04.2001, 1500 m, M. Vural 8483 in GAZI! ibid., 1040 m, gravelly slope, 25.04.1994, Ali A. Dönmez 4087 in GAZI & HUB! A5 Amasya: Ferhat mountain, north rocky slopes, 954 m, 40° 38.305' N 035° 49.467' E, 11.05.2009, Eker 2165 in AIBU! ibid., 02.06.2009, Eker 2447 (fruiting time) in AIBU! Karaman mountain, Maniss. 173b (type of *T. heterochroa*) in K! ibid., 800 m, 10.05.1974, T. Baytop (ISTE 28122) in ISTE! A6 Tokat: Başçiftlik, East slopes of Başçiftlik, stony slopes and screes, 1312 m, 40° 31.936' N 037° 10.796' E, 02.06.2009, Eker 2451 in AIBU! Çamlıbel pass between Yıldızeli-Tokat, shally scree, 1650 m, 23.05.1976, Marais 1594 in K! A7 Gümüşhane: Torul, Zigana Mountain, around Köstere village, screes in opening of forest, 1898 m, 40° 39.682' N 039° 22.204' E, 03.06.2009, Eker 2454 in AIBU! above Karaca cave, screes with red soils, 1560 m, 40° 32.587' N 039° 24.046' E, 03.06.2009, Eker 2459 in AIBU! Köse mountain, on screes, 1700 m, 19.05.1933, Balls 281 in E! A8 Bayburt: Osluk bridge, open limestone slopes, 1700 m, 21.06.1967, Tobey 2157 (fruiting time) in E! Soğanlı mountains, 2200 m, 01.06.1975, Y. Akman 9835 in ANK! Erzurum: around Köşk village, high mountain grassland, 2509 m, 40° 02.591' N 041° 28.815' E, 10.06.2009, Eker 2501 in AIBU! Erzurum to Oltu, 34 km N.E. of Erzurum, 2 km beyond Yeşildere, scree and bank above stream, 2100 m, 20.05.1976, Marais 1570 in K! A9 Kars: Digor, around Sinco stream, 1820 m, 23.06.1973, A. Yürül in EGE! B2 Uşak: Murat mountain, above Gürlek, rocky slopes, 1650 m, 19.05.1978, A. Baytop (ISTE 39425) in K & ISTE! B3 Konya: Sultan mountains, Kızıl hill, 11 km S.W. of Akşehir, 2000 m, Watson et

al. 2589 in K! Isparta: Şebinkaraağaç, Kızıldağ Milli Parkı, north slope of Kalankaya, 1400 m, 11.05.1995, B. Mutlu 1355 in HUB! Eskişehir: Alpu, Bozan Ağaçlandırma Sahası, steppe, 945 m, 39° 48.198' N 031° 07.906' E, 10.05.2006, Ali A. Dönmez 12973 in HUB! B4 Ankara: between Ankara-Şereflikoçhisar, 10 km to Şereflikoçhisara, hills around Tuz lake, stony slopes, 985 m, 39° 02.490' N 033° 26.915' E, 01.05.2009, Eker 2334 in AIBU! ibid., 01.06.2009, Eker 2443 in AIBU! B5 Kayseri: Bakırdağ, S.E. of Kayseri, 1600 m, Mathew & Tomlinson 4113 in E! Yozgat: Şefaati, between Şefaati-Yerköy, Karanlıkdere, Şekerci mountain, scree, 922 m, 39° 32.583' N 034° 43.261' E, 29.04.2009, Eker 2324a! ibid., 01.06.2009, Eker 2445 (fruiting time) in AIBU! B6 Adana: Tufanbeyli, between Tufanbeyli-Yeşilkent arası, 1-2 km from Kaangeçidi to Yeşilkent, steppes near fields, 1622 m, 38° 15.137' N 036° 20.749' E, 22.05.2009, Eker 2379 in AIBU! Kayseri: Binboğa mountains, S.W. slopes of Sarız, rocky limestone slopes, 2300 m, 22.06.1968, Rix et al. 679 in E! Pınarbaşı, Kaynar, above Karaahmedin ağılı, Hınzır mountain, 1750 m, 18.05.1980, N. Çelik 1073 in AEF, ANK & HUB! above Tersakan village, Hınzır mountain, Üçkuyular, 1800 m, 28.05.1981, N. Çelik 1711 in AEF! Malatya: south slopes of Kubbe mountain, 1950 m, 19.05.1981, Y. Altan 1281 in FUH! Hekimhan, Zurbahan mountain, high mountain steppe, 1951 m, 38° 52.297' N 037° 56.640' E, 12.06.2009, Eker 2506 in AIBU! Sivas: between Sivas-Tatlıca, gypsaceous chalk hills, 1600 m, 29.04.1966, Tobey 1656 in E! Taşlıdere, Hocabey village, deeply grounded land, 1400 m, 18.5.1983, B. Yıldız 3493 in EGE! Kahramanmaraş: 5 km west of Göksun, Kuluştas mevkii, 1400 m, 22.04.1978, B. Yıldız 1644! B7 Elazığ: from Elazığ-Malatya highway to Gözeli-Sivrice highway, 3 km to Gözeli village, screes and stony slopes, 1384 m, 38° 26.857' N 039° 04.903' E, 25.04.2009, Eker 2287 in AIBU! ibid., 20.05.2009, Eker 2369 (fruiting time) in AIBU! Erzincan:

Pöske mountain, north slopes of Ahmediye village, stony slopes, 2313 m, 39° 53.970' N 039° 21.830' E, 11.06.2009, Eker 2504 in AIBU! Kemaliye, above Sırakonaklar, wet rocky slopes, 1400 m, 17.05.1992, M. Koyuncu 9060 & O. Soner in AEF! Malatya: Pütürge, uzun çayır mevkii, 2500 m, 03.06.1981, Y. Altan 1562 in FUH! B7-8 Elazığ: around Guleman mineral deposit, 30.04.1983, T. Ekim in GAZI! B8 Erzurum: Palandöken pass, W. of Erzurum, dry stony hillside, 2300 m, 24.05.1965, Mathew & Tomlinson 4327 in K! B8/9 Bitlis: Altın Kabur, April 1973, T. Baytop (ISTE 24201) in K! B9 Ağrı: between Tutak-Eleşkirt, 1 km to Tutak, Kılıçdağları, Kılıçgediği, 39° 40.092' N 042° 47.842' E, 08.05.2008, Eker 2140 in AIBU! ibid., 08.06.2008, Eker 2204 (fruiting time) in AIBU! Bitlis: Adilcevaz, Çanakyayla village, Süte pasture, rocky and stony places on high mountain grassland, 2381 m, 38° 51.469' N 042° 40.848' E, 07.05.2008, Eker 2130 in AIBU! Pelli mountain, on road from Tatvan to Van, by rocks on the south shoulder, 2000 m. May 1972, Rix & Peşmen 1875 in K! Erzurum: Çakmak mountain, from S.W. spur above Karayazı, 2500-2900 m, 22.6.1966, Watson et al. 1668 in K! Erzurum: Hınıs, Bingöl mountain, alpinic steppe, 2500 m, 15.6.1981, M. Koyuncu 4515 et al. in AEF! Van: 8 km from Çatak-Bahçesaray road junction to Bahçesaray, above Yukarı Narlıca village, stony and rocky slopes with red soils, 2295 m, 38° 08.500' N 043° 01.025' E, 05.05.2009, Eker 2099! C1/2 Muğla: Marmaris to Datça, Horton 1093 in K! C2 Antalya: Elmalı to Çiğlikara, Ayın meadow, c. 1650 m, 28.04.1968, Meyer et al. (EGE 6922) in K & EGE! Denizli: Honaz mountain, alpine steppe, 2073 m, 37° 41.389' N 029° 16.078' E, 28.05.2009, Eker 2421 in AIBU! Muğla: Fethiye, between Eşen-Babadağ, 26 km from Eşen to Babadağ, below Dokuzgöl, stony places on roadsides, 1077 m, 36° 27.893' N 029° 09.953' E, 19.04.2009, Eker 2255 in AIBU! C3 Antalya: Akseki, Çimi pasture, stony places on high mountain grassland, 1772 m, 37° 00.744' N 031°

55.599' E, 26.05.2009, Eker 2404 in AIBU! Geyran upland, south slopes of Kocaoluk, stony places, 13.05.1995, 1500 m, A. Duran in GAZI! Kemer, Tahtalı mountain, around Kızılalan, *C. libani* forest, 1000 m, 04.05.1979, Peşmen & Güner 4666 in E & ANK! Manavgat, Kızıldağ village, Güzle upland, openings of forest, 1200 m, 08.05.1982, M. Koyuncu 5240 & T. Altan in AEF! Gündoğmuş, upland of Narağacı village, 1400-1700 m, 24.05.1983, M. Koyuncu 6026 & S. Erik in AEF! Konya, between Beyşehir-Akseki, Küpe mountain, 1600 m, 19.5.1984, M. Koyuncu 6865 et al., in AEF! C4 İçel: Mut, Magras mountain, 1300 m, limestone slopes, 11.05.1965, Coode & Jones 830 in K! between Mut-Ermenek, above Çamlıca village, rocky slope, 700 m, 23.4.1982, M. Koyuncu 4950 & M. Coşkun in AEF! Karaman, between Ermenek-Karaman, from Yelibel mountain to İhsaniye village, 1800 m, 24.05.1992, M. Koyuncu 9097 et al. in AEF! Konya: Seydişehir, ridges of Çeltekk hill, stony and rocky places, 1800 m, 18.05.1982, H. Ocakverdi 1374 in KNYA! Antalya: Gazipaşa, Esenpınar village, between Erikli-Kaşpazarı, 1600-2200 m, 20.05.1984, H. Sümbül 2891! Alanya, Çiğdem upland, calcereous, 1885 m, 36° 28.281' N 032° 24.152' E, 20.05.2006, Ali A. Dönmez 13106 et al. in HUB! C5 Adana: Pozantı, above Dağdibi village, around Mazmılı, screes, 2068 m, 37° 38.943' N 035° 02.434' E, 23.05.2009, Eker 2382 in AIBU İçel: Arslanköy, Aksoy mevkii, 18.5.1975, Meriçli & Bilmenoğlu (ISTE 31588) in K! C6 Hatay: Amanoslar, below Sümbürlükarlıktepe, stony places, 1446 m, 36° 18.273' N 036° 02.551' E, 20.04.2008, Eker 2002 in AIBU! ibid. 05.06.2008, Eker 2191 (fruiting time) in AIBU! Belen, Karlıktepe above Soğukoluk, igneous scree, 1200 m, 24.04.1957, D. 27060 in K & ANK! Kahramanmaraş: Ahır mountain, Yedikuyular mevkii, around Çağman hill, 03.05.1991, gravelly slopes, 1600-2000 m, Z. Aytaç 3532 & H. Duman in GAZI & HUB! Süleymanlı, Berit mountain, Sarıgöl mevkii, 2000-2400 m, south

calcerous slopes, 11.06.1978, B. Yıldız 2049 in HUB! Engizek mountain, around Sırasöğüt upland, 1800 m, 31.05.1988, H. Duman 3953 (fruiting time) in GAZI! C9 Hakkari: between Hakkari-Uludere, Süvari Halil pass, east metamorphic slopes, steppe, 2200 m, 30.04.1978, A. Güner 1670 in HUB! C10 Hakkari: between Başkale-Hakkari, 52 km to Hakkari, screes, 1770 m, 37° 44.911' N 044° 04.768' E, 02.05.2007, Eker 1858 in AIBU! ibid. 08.06.2009, Eker 2490 (fruiting time) in AIBU! Mor mountain, stony ridges, screes, crevices, 2600 m, 30.06.1967, Watson et al. 3001 in K! Süryan hill, above Süryan, 24 km N.E. of Yüksekova, 2750 m, 09.06.1966, Albury et al. 1551 in K! near Şemdinli, 29.3.1978, T. Baytop (ISTE 38994) in K! 20 km north of Yüksekova, on Iran road, 2170 m, 18.5.1978, J. Trelawny & M. Phail 2043 in HUB!

Other Selected Collections: C3 Isparta: Dedegöl mountains, 1600 m, Sorger 66-46-64. C4 Karaman: E. of Ermenek, Yellibel mountain, 2300-2350 m, Hub.-Mor. 11674.

var. *galatica* (Freyn) Eker *comb. & stat. nov.*

≡ *T. galatica* Freyn in Bull. Herb. Boiss. 4: 186 (1896)! *T. lutea* Freyn in Bull. Herb. Boissier 4: 185 (1896)! *T. armena* f. *galatica* (Freyn) Raamsd. in Pl. Syst. Evol. 195: 41 (1995)!

= *T. gumusanica* Terzioğlu *syn. nova*, in Ann. Bot. Fenn. 39: 149-151 (2002)!

Iconibus: Hall, The Genus *Tulipa* t. 21 as *T. galatica* (1940)! (Figure 74, 76-78).

Type: [Turkey A8] In montibus inter Erzurum et İspir, prope Setchanek et Gökdağ, 1800-2100 m, june 1853, Huet du Pavillon as *T. montana* var. *flava* (isotype K!).

Selected Specimens Examined: A7 Gümüşhane: Torul, Zigana Mountain, around Köstere village, screes in opening of forest, 1898 m, 40° 39.682' N 039° 22.204' E, 03.06.2009, Eker 2453 in AIBU! *ibid.*, 1930 m, 40° 39.691' N 039° 22.197' E, 27.06.2008, Eker 2216 (fruiting time) in AIBU! A8/9 Erzurum: near Oltu, c. 1400 m, 19.5.1982, T. Baytop (ISTE 48829) in K! B5 Aksaray: Kızılkaya village, Lalelik mevki, 1200 m, 26.04.1995, F. Ertuğ 354 in GAZI! Yozgat: Şefaati, between Şefaati-Yerköy, Karanlıkdere, Şekerci mountain, scree, 922 m, 39° 32.583' N 034° 43.261' E, 29.04.2009, Eker 2324b in AIBU! *ibid.*, 01.06.2009, Eker 2444 (fruiting time) in AIBU! B6 Kayseri: Pınarbaşı, above Tersakan village, Hınzır mountain, Üçkuyular, 1900 m, 18.05.1980, N. Çelik 1129 in AEF! B10 Ağrı: between Doğubeyazıt-Gürbulak, hills above Telçeker village, 16.05.1983, M. Kırıcı (ISTE 50455) in ISTE!

Other Selected Collections: A5 Amasya: Galatia, in planitie Suluova versus Merzifon, 28.04.1894, with *T. lutea* Freyn, Manissadjian (exs. 1110b).

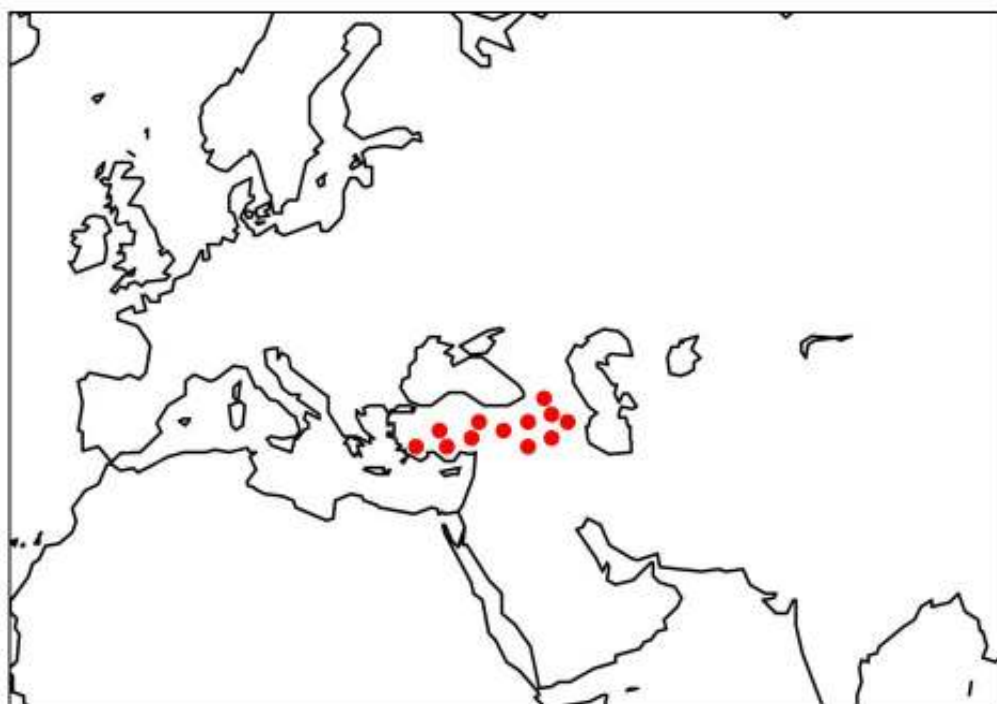


Figure 70. Distribution of *T. armena* in the world.

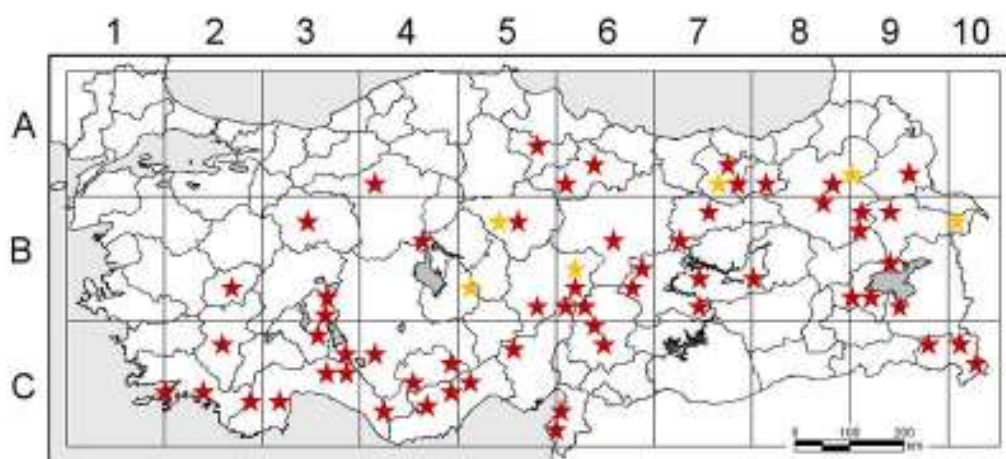


Figure 71. Distribution of *T. armena* in Turkey (red stars represent *var. armena* while yellow stars represent *var. galatica*).



Figure 72. General view of a *T. armena* population in Zigana mountain, both varieties alltogether.



Figure 73. Habit of *T. armena* var. *armena*.



Figure 74. Habit of *T. armena* var. *galatica*.



Figure 75. Habit of *T. armena* with mix flower.



Figure 76. The flowers of *T. armena* from the exterior; a-c: *T. armena* var. *armena*, d: *T. armena* var. *galatica*, e-h: The mix flowers, i: The flower infected TBV.

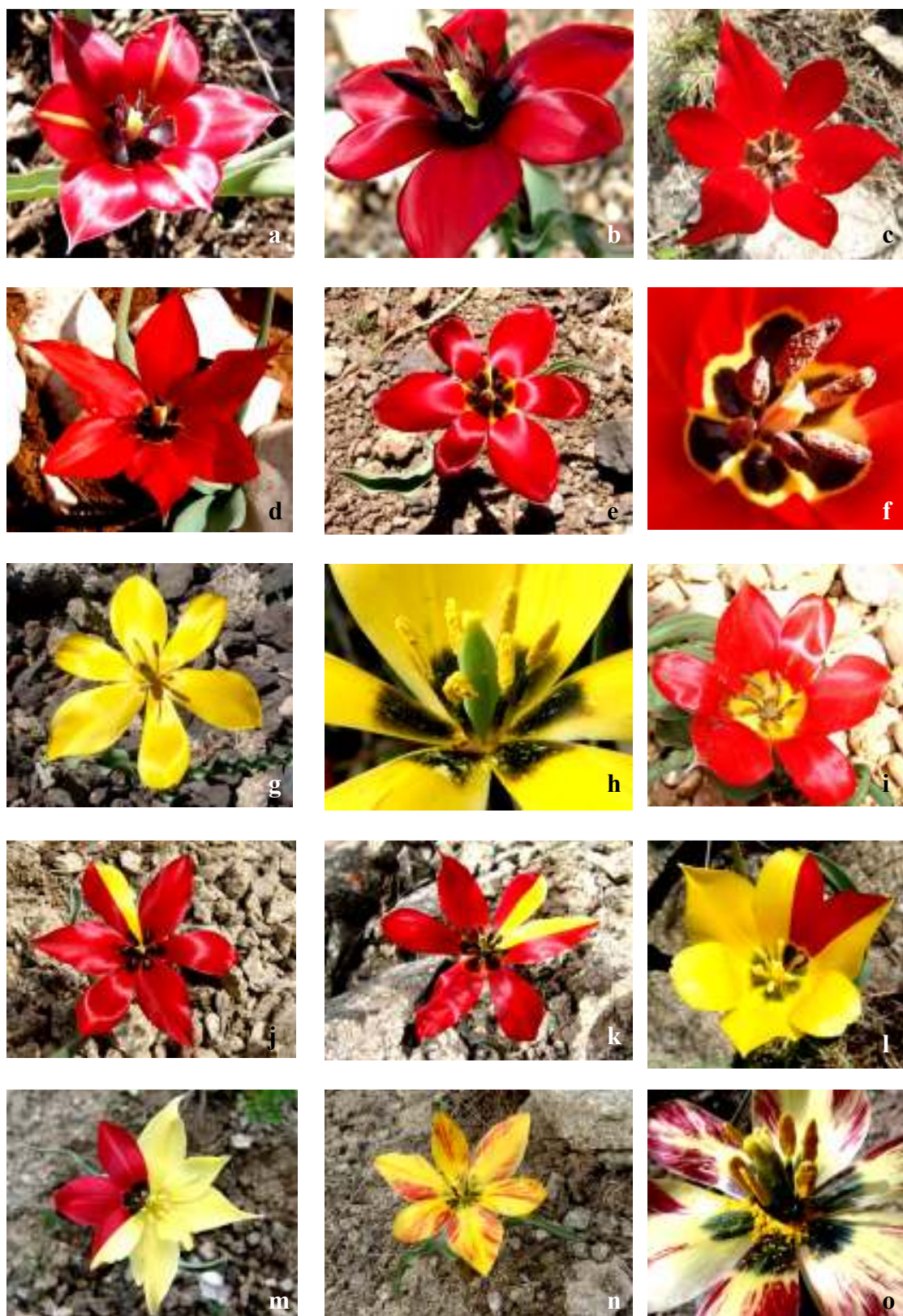


Figure 77. The flowers of *T. armena* from the interior; a-f: *T. armena* var. *armena*, g: *T. armena* var. *galatica*, i-m: The mix flowers, n-o: The flower infected TBV.

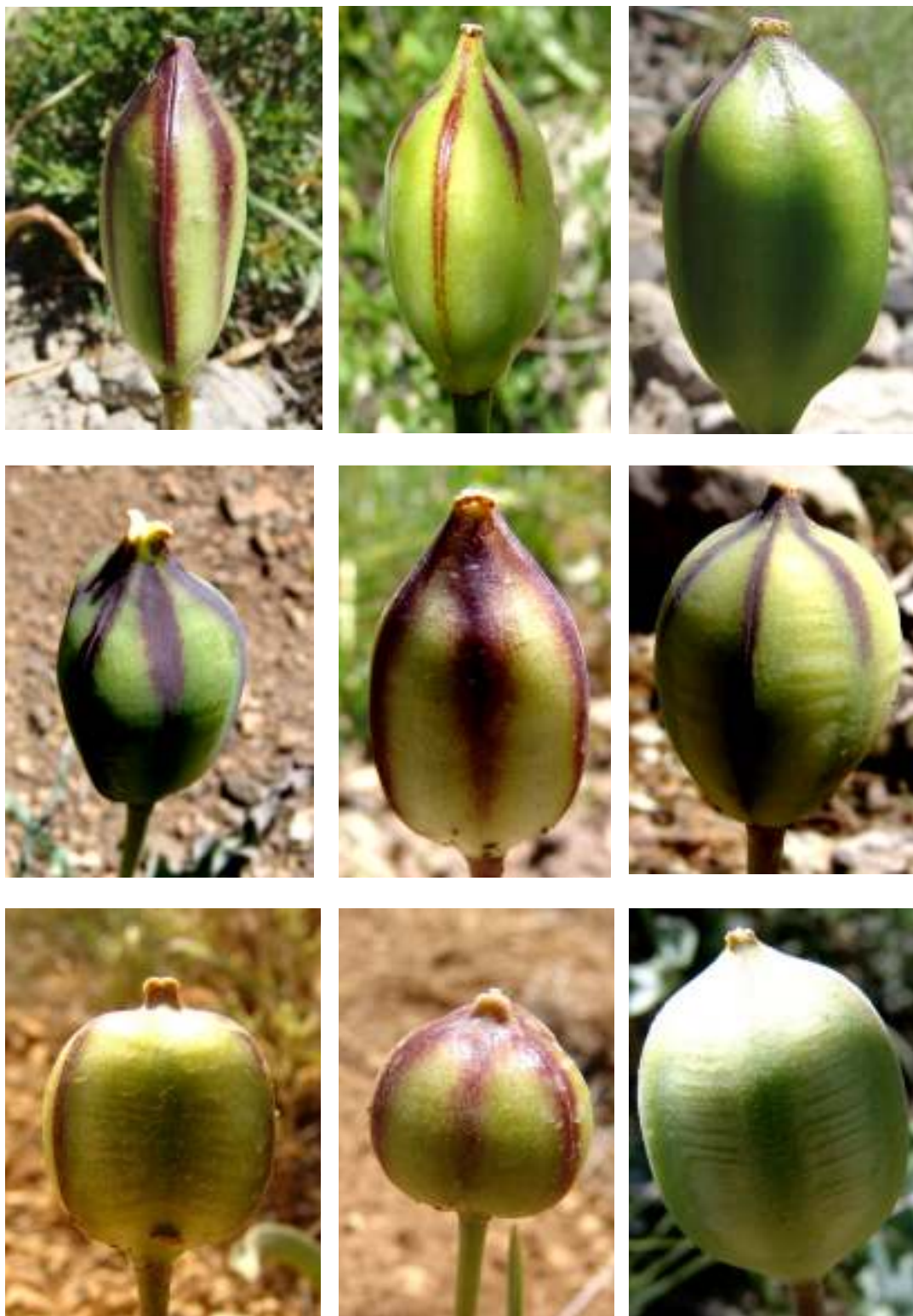


Figure 78. The fruits of *T. armena*.

Pollen morphology: Pollen grains predominantly trisulcate, recorded also tetrasulcate (Eker 2324c, Eker 2421), pentasulcate (Eker 2324c, Eker 2421), inaperturate (Eker 2453) and diaperturate (with por like apertures, Eker 2453), ellipsoid or ellipsoid-spheroidal in polar view. Long axis 42.5-73.75 μm and short axis 35-67.5 μm . Exine 1-2.5 μm thick. Exine surface (exine pattern) perforate-rugulate (SEM; Eker 2324). Intine bi-layered: outer intine 0.5-2 μm and inner intine 0.5-0.75 μm in thickness. Outer intine thicker in aperture (sulci) region, up to 5 μm . The exine plate extends irregularly towards the aperture. Surface of sulcus membrane granular (Figure 79-80).

Specimens examined for var. *armena*: A5 Amasya: Eker 2165, A6 Tokat: Eker 2451, A7 Gümüşhane: Eker 2454, B4 Ankara: Eker 2334, B5 Yozgat: Eker 2324a, B7 Elazığ: Eker 2288, B9 Bitlis: Eker 2130, Van: Eker 2099, C2 Denizli: Eker 2421 & 2422; Muğla: Eker 2255, C3 Antalya: Eker 2404; C6 Hatay: Eker 2002.

Specimens examined for var. *galatica*: A7 Gümüşhane: Eker 2453, B5 Yozgat: Eker 2324b.

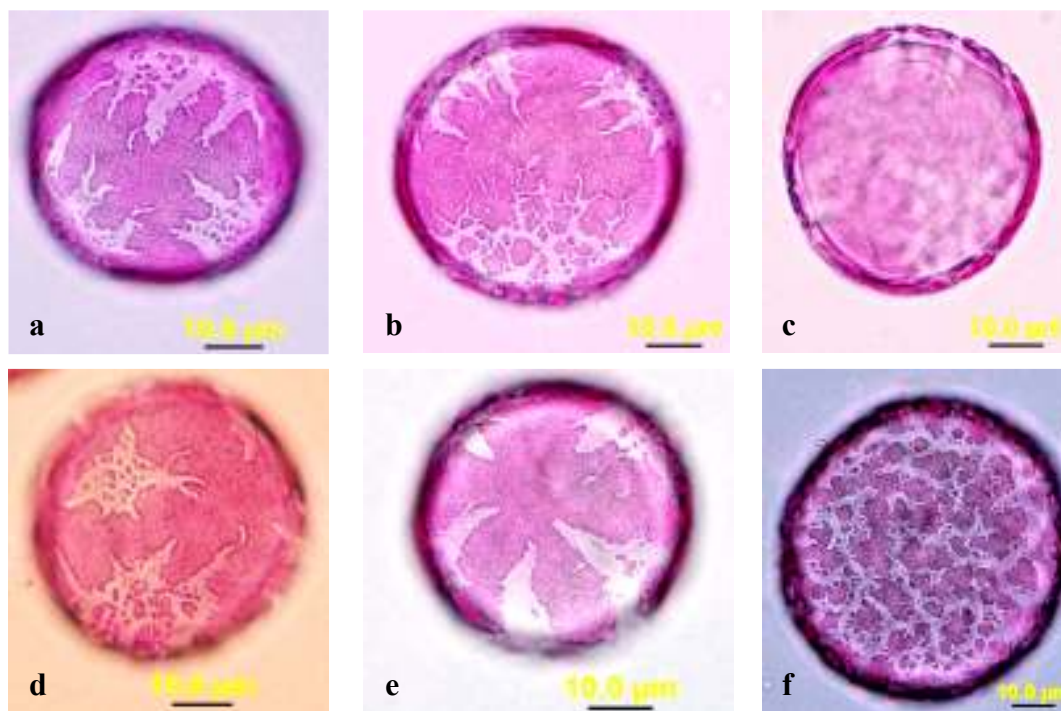


Figure 79. LM images of *T. armena* - a. Trisulcate pollen grain in equatorial view of var. *armena* (Eker 2324a), b. Perforate exine (exine pattern) in polar view of var. *armena* (Eker 2324a), c. Pollen wall in optical section: exine (black arrow), outer and inner intine (white arrow) of var. *armena* (Eker 2324a), d. Tetrasulcate pollen grain in equatorial view of mix flower (Eker 2324c), e. Pentasulcate pollen grain in equatorial view of mix flower (Eker 2324c), f. Inaperturate pollen in equatorial view of var. *galatica* (Eker 2453).

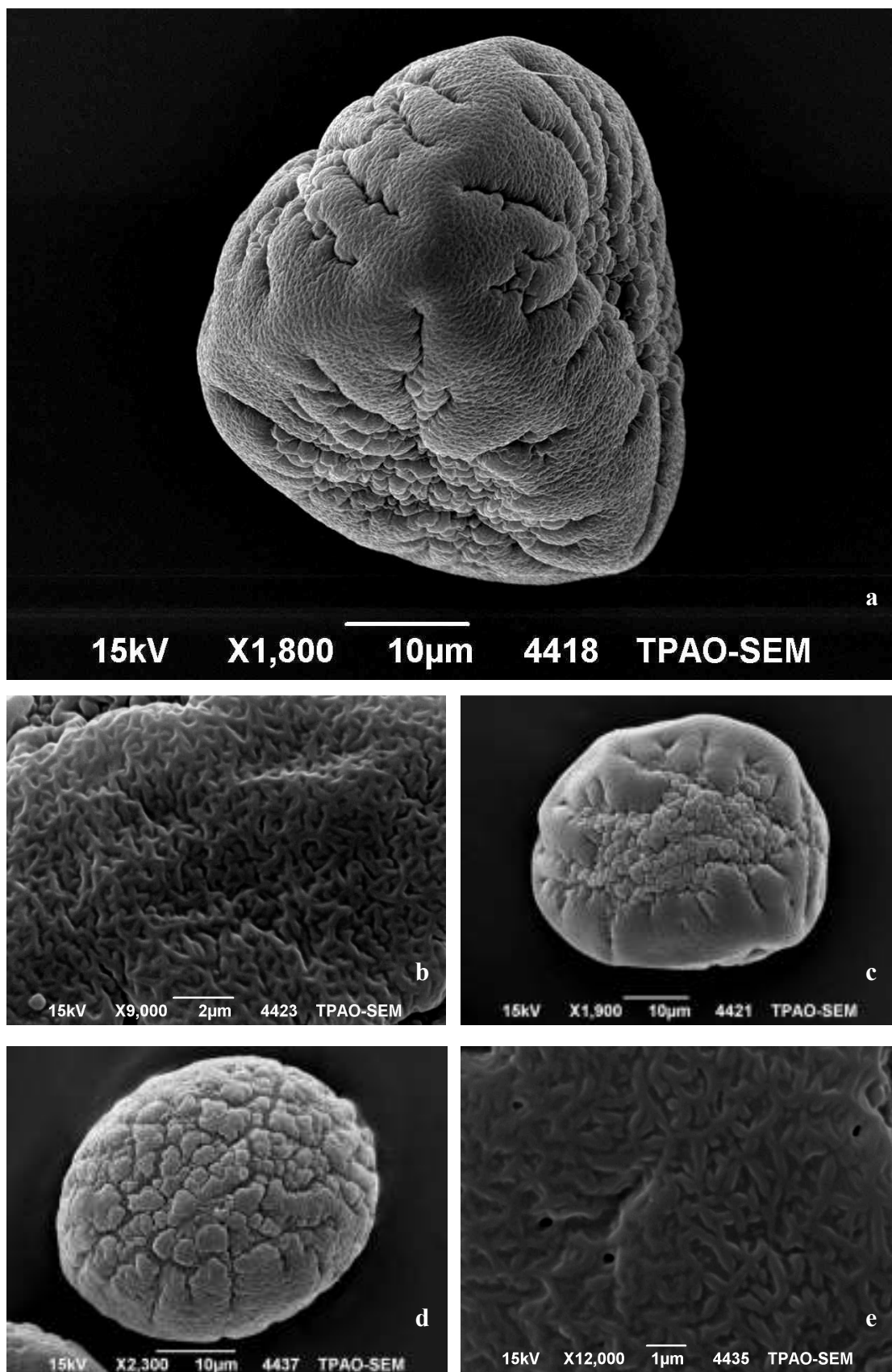


Figure 80. SEM images of *T. armena* - a. Trisulcate pollen grain in equatorial view in var. *armena* (Eker 2324), b. Perforate-rugulate exine (exine pattern) in polar view in var. *armena* (Eker 2324), c.

granular sulcus membrane in var. *armena* (Eker 2324), d. Inaperturate pollen grain in var. *galatica* (Eker 2453), e. Perforate-rugulate exine (exine pattern) in polar view in var. *galatica*.

Chromosome number: $2n=24$.

Specimens examined for var. *armena*: A7 Gümüşhane: Eker 2459 ($2n=24$), B9 Van: Eker 2099 ($2n=24$), C6 Hatay: Eker 2002 ($2n=24$, Figure 81).

Specimens examined for var. *galatica*: A7 Gümüşhane: Eker 2216 ($2n=24$, Figure 81), B5 Yozgat: Eker 2444 ($2n=24$).

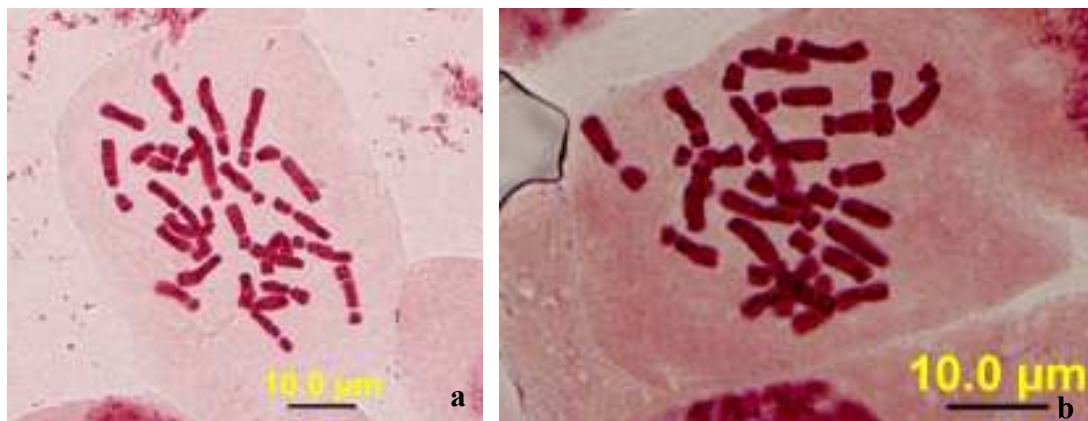


Figure 81. Somatic chromosome number of *T. armena*; a: var. *armena* (Eker 2002), b: var. *galatica* (Eker 2216).

11. *Tulipa sintenisi* Baker in Gardeners' Chronicle 3(9): 330 (1891)!

Iconibus: Botanical Magazine 117: t. 7193 (1891)! (Figure 84-85).

Type: A specimen (not preserved) cultivated at Kew from material collected at [B7 Elazığ/Turkey] Schuschnass (Şuşnaz) near Erzeroum, Sintenis (type K!, illustration).

Plant 24-64 cm. Stem glabrous, stem width 1.5-4 mm, underground stem length (6-)11-34 cm, aerial stem length 8.5-34 cm. Markedly stoloniferous. Bulb ovoid, 2-4 × 1.5-3 cm. Bulb neck 0.5-5 cm. Tunics papery to subcoriaceous, brown. Basal plate and neck densely hairy, middle part sparsely hairy (pilose) or glabrous. Leaves 4, alternate, glaucous, undulate and membranous on margins. Lowest leaf lanceolate, canaliculate, falcate, semi-falcate, erecto-patent, semierect or erect, obtuse to subacute, ciliate on margins, (9.5-)12-26 × 1.9-5.7 cm. Second lowest leaf erect to semierect, erecto-patent or semifalcate, acute to subacute, ciliate on margins especially at tip, 10-30 × 1-4 cm. Flower solitary, campanulate, shiny red with short eggplant blotch inside with or without yellow blotch edge, paler red with or without greenish-yellow base outside; outer tepals elliptic-ovate to lanceolate, acute to acuminate, (34-)42-85 × 15-38 mm, glabrous, puberulous only at tip; inner tepals obovate to elliptic-obovate, obtuse, apiculate or notched, glabrous and pubescent or not at tip, (25-)32-58 × (7-)11-29 mm. Outer blotch 7-27 mm and inner blotch 7-22 mm in length. Blotch 1/8-2/5 length of segments. Filaments 5-9 mm, glabrous, lanceolate to linear-lanceolate, purplish-black. Anthers 10-21 × (2-)2.5-3(-4) mm, oblong, linear-oblong or oblong-ovoid, purple at fresh, apiculate or not. Pollens purple or yellow at fresh, yellow, sulphur yellow, olive yellow or mustard yellow at dry (purple colour at fresh is turned tones of yellow at dry). Ovary 9-22 × 3-6.5 mm, oblong, subfusiform, fusiform, glabrous, reddish-green, greenish-yellow, green or yellow at fresh. Style very short or obscure, 1-2 × (1-)1.5-4 mm. Stigma reddish-yellow, greenish-yellow, reddish-green or yellow at fresh, pubescent, 1-2.5 × (2-)2.5-5.5 mm. Capsule 2.7-5.4 × 1.6-2.6 cm, oblong-ovoid, elliptic-ovoid, ellipsoid or ovoid, glabrous; neck 1-5 mm, rib 21-45 mm, beak 3-7, apicula 1-2 mm; tepal scar 1-

2 mm. Seeds numerous, flattened with rugose surface, triangular with two rounded angles to orbicular, light brown, $5-9 \times 4-7.5$ mm, winged.

Phenology: Flowering in Mid-April to Early May, fruiting in Late May to Mid June.

Distribution: *Tulipa sintenisii* is known only from South and East Anatolia. It is endemic to Turkey (Figure 82-83).

Habitat: The populations of *T. sintenisii* spread in cultivated areas (fields and orchards), with reddish-brown or grayish-brown soils at an elevation of 950-1700 m.

Phytogeographic region: Irano-Turanian element.

Conservation status: VU (IUCN, 2001). The populations of *T. sintenisii* are scattered and situated in two regions: the primary distribution center includes around Ağrı, Muş and Erzurum. The second distribution center includes around Kahramanmaraş and Gaziantep. Also, there are some doubtful records from Kayseri, Siirt and Hakkari. The specimens from Hakkari, which were recorded as *Tulipa sintenisii* by Marais in Flora of Turkey, are certainly belong to *Tulipa julia*. The specimens from Kayseri have no bulb and so difficult to decide what species without bulb. The populations might be threatened due to the cultivation and excessive grazing. Thus, the species may be classified as ‘Vulnerable’ (VU) (IUCN 2001).

Selected Specimens Examined: B8 Erzurum: Aşkale to Tercan, 1830 m, Furse & Synge 41 in K! Muş: Alparslan Tarım İşletmesi Müdürlüğü, fields, 1270 m, 38°

47.684' N 041° 30.872' E, 03.05.2007, Eker 1864 in AIBU! ibid., 05.06.2009, Eker 2464 (fruiting time) in AIBU! B9 Ağrı: 1 km from Tutak to Eleşkirt, fields, 1665 m, 39° 33.298' N 042° 46.219' E, 08.05.2008, Eker 2139 in AIBU! ibid., 08.06.2008, Eker 2202 (fruiting time) in AIBU! 21 km from Patnos to Tutak, fields, 1675 m, 39° 24.091' N 042° 45.594' E, 08.05.2008, Eker 2137 in AIBU! ibid., 08.06.2008, Eker 2199 (fruiting time) in AIBU! ibid. 22.05.1966, D. 43473 in E! C6 Gaziantep: Sof mountain, 3 km above Işıklı village, fallow fields, 1193 m, 37° 08.530' N 037° 10.937' E, 19.04.2008, Eker 1998 in AIBU! ibid., 05.06.2008, Eker 2193 (fruiting time) in AIBU! Üçgöze village, orchards, 952 m, 37° 12.691' N 037° 12.113' E, 19.04.2008, Eker 1994 in AIBU! Kurt mountain, Gaziantep to Fevzipaşa, limestone hills, 1370 m, 24.04.1935, Balls 2171 in K! Kahramanmaraş: Koyunoluk mountain, between Maraş and Göksun, in vineyards, 1100 m, 04.05.1957, D. 27416 in E, K and BM!

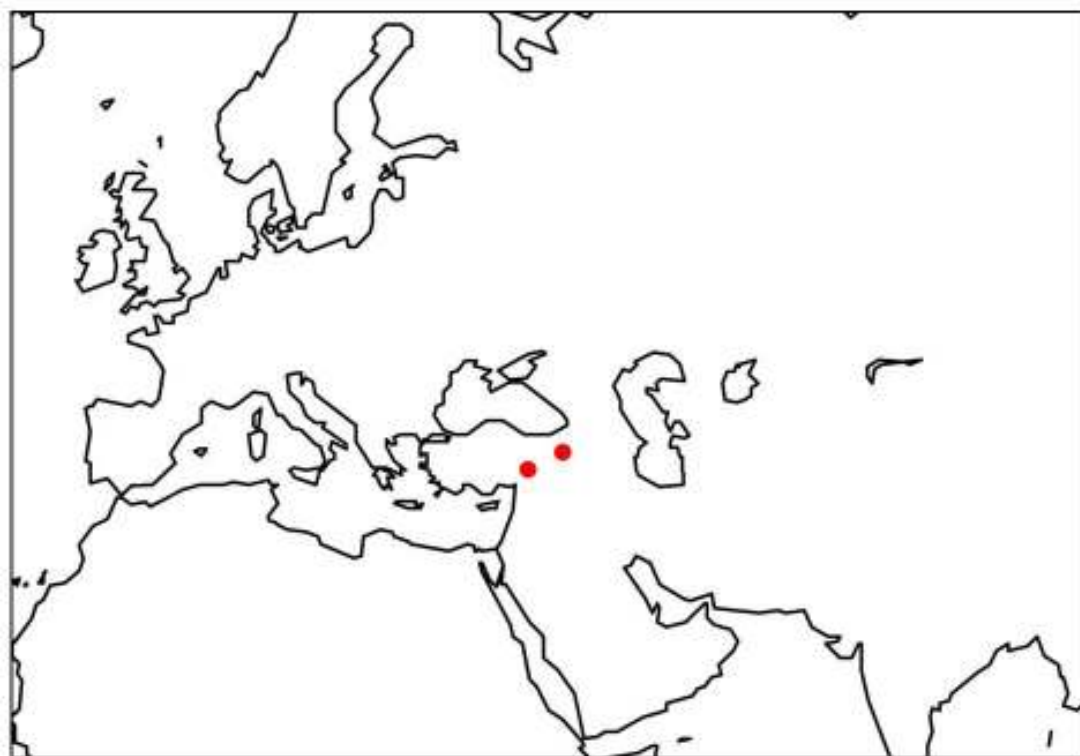


Figure 82. Distribution of *T. sintensisii* in the world.

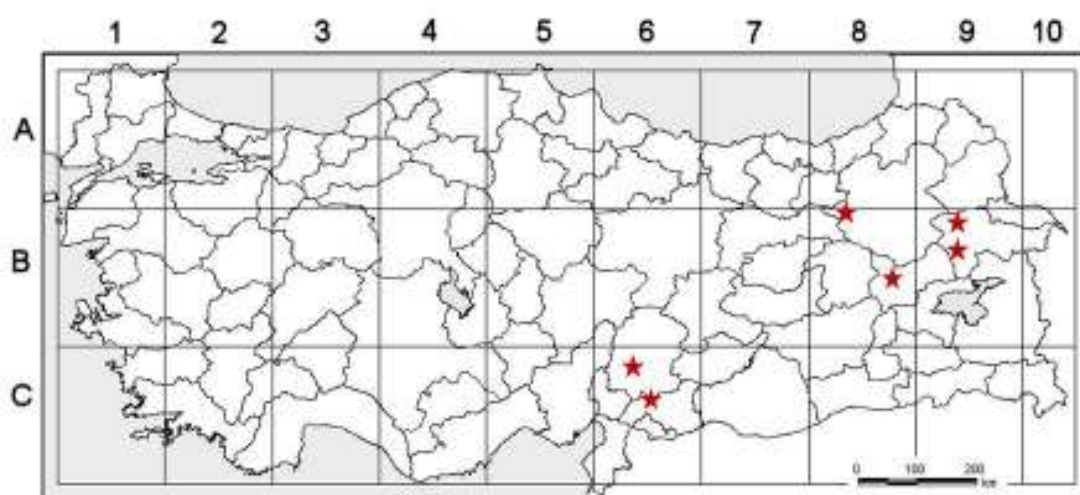


Figure 83. Distribution of *T. sintensisii* in Turkey.



Figure 84. Habit of *T. sintenisii*.



Figure 85. *T. sintenisii* - a, c-h: The flower of from the interior, b: Fruit.

Pollen morphology: Pollen grains trisulcate, ellipsoid or ellipsoid-spheroidal in polar view. Long axis 40-52.5 μm and short axis 35-46.25 μm . Exine 1.5-2.5 μm thick. Exine surface (exine pattern) perforate (LM). Intine bi-layered: outer intine 0.7-2 μm and inner intine 0.5-0.75 μm in thickness. Outer intine thicker in aperture (sulci) region, up to 5 μm . The exine plate extends irregularly towards the aperture. Surface of sulcus membrane granular (Figure 86).

Specimens examined: B8 Muş: Eker 1864, B9 Ağrı: Eker 2139, C6 Gaziantep: Eker 1761.



Figure 86. LM images of *T. sintensis* (Eker 1864) - a. Trisulcate pollen grain in equatorial view, b. Perforate exine (exine pattern) in polar view, c. Pollen wall in optical section: exine (black arrow), outer and inner intine (white arrow).

Chromosome number: $2n=24$.

Specimens examined: B8 Muş: Eker 1546 & 1864 ($2n=24$, Figure 87), B9 Ağrı: Eker 2139 ($2n=24$), C6 Gaziantep: Eker 1761 ($2n=24$).

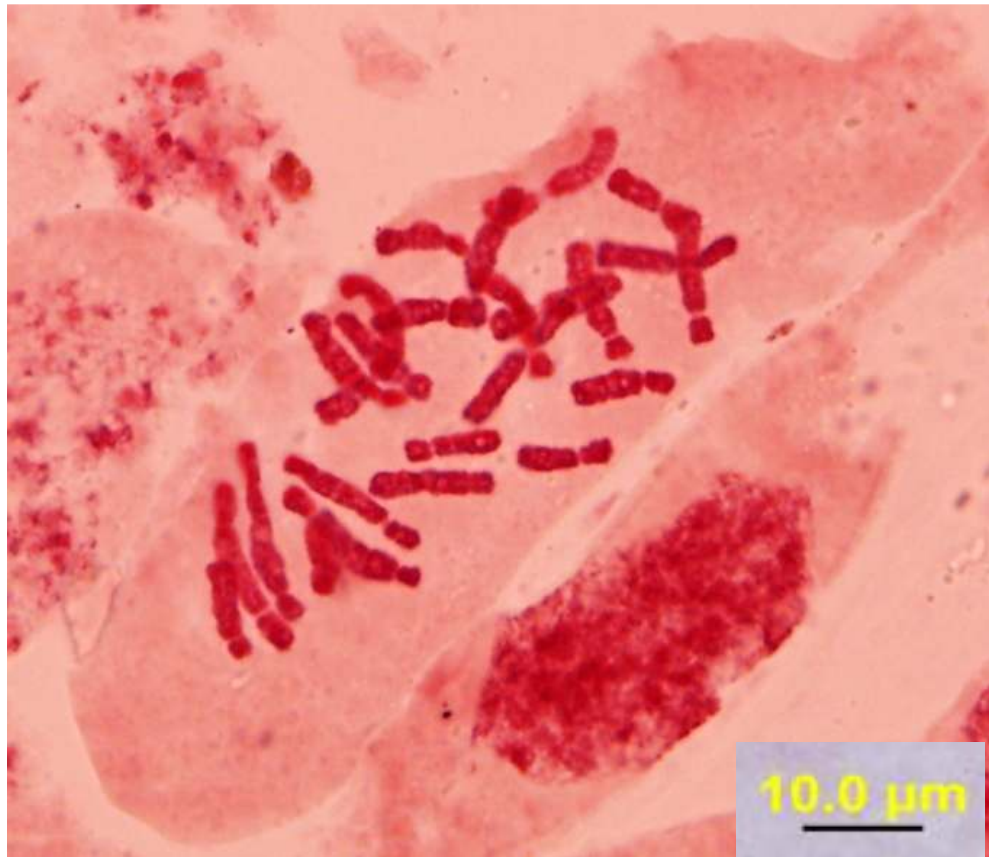


Figure 87. Somatic chromosome number of *T. sintenisii* (Eker 1546).

12. *Tulipa julia* C. Koch in Linnaea 22: 225 (1849)!

≡ *Tulipa montana* var. *julia* (K.Koch) Baker, J. Linn. Soc., Bot. 14: 279 (1874)!

= *Tulipa kaghyzmanica* Fomin, Vestn. Tiflissk. Bot. Sada 9: 13 (1908)!

Iconibus: Sheasby, Bulbous Plants of Turkey and Iran fig. 361 (2007)! (Figure 90-91).

Type: Turkey A9 Kars: plain of Arpa river, 1525-1830 m, C. Koch, (type B).

Plant 15-38(-50) cm. Stem glabrous, stem width 0.8-3 mm, underground stem length 1-18 cm, aerial stem length 4-18(-26) cm. Not stoloniferous. Bulb ovoid to

globose-ovoid, $2-3.5 \times 1.5-3.5$ cm. Bulb neck $0.5-3.5$ cm. Tunics papery but sometimes some of outer tunics became suberized, brown, densely lined with long, soft, tangled, slender, woolly hairs (arachnoid-lanate) or straight-untangled (straight-lanate). Leaves 3-5, alternate, glaucous, undulate, ciliate or not and membranous on margins. Lowest leaf lanceolate, canaliculate, falcate, erecto-patent to erect, obtuse to subacute, $6.5-24 \times 0.7-4.2$ cm. Second lowest leaf erect, erecto-patent to falcate, acute to subacute, $6-23 \times 0.4-2.5$ cm. Flower solitary, campanulate, shiny red with short eggplant blotch inside with or without yellow blotch edge, paler red with greenish-yellow base outside; outer tepals elliptic-ovate or elliptic-obovate, acute to acuminate or obtuse-apiculate, $26-57 \times 10-26$ mm, glabrous, puberulous only at tip; inner tepals obovate to obovate-spathulate, obtuse, apiculate or notched, glabrous and often pubescent at tip or not, $22-48 \times 8-22$ mm. Outer blotch 5-16 mm and inner blotch 5-11 mm in length. Blotch $1/7-1/3$ length of segments. Filaments 5-11 mm, glabrous, lanceolate or linear-lanceolate, purplish-black. Anthers $5.5-13 \times 1.5-3$ mm, oblong or oblong-ovoid, purple at fresh, apiculate or not. Pollens purple or yellow at fresh; yellow, sulphur yellow or olive yellow at dry (purple colour at fresh is turned tones of yellow at dry). Ovary $6-19 \times 2-5$ mm, oblong to fusiform, glabrous, yellow, yellowish-green or reddish-yellow at fresh. Style very short or obscure, $(0.5-1.2 \times (0.8-1.25(-3))$ mm. Stigma yellow or reddish-yellow at fresh, pubescent, $(0.6-0.8-2 \times 1.5-4(-5))$ mm. Capsule $2.4-5.5 \times 1.3-2.1$ cm, elliptic-ovoid, elliptic-oblong, ovoid or oblong-ovoid, glabrous; neck $(0.5-1.5)$ mm, rib 18-41 mm, beak 2-8, apicula 1-2 mm; tepal scar 0.5-2 mm. Seeds numerous, flattened with rugose surface, triangular with two rounded angles to orbicular, light brown, $4.5-7.5 \times 3-6.5$ mm, winged.

Phenology: Flowering in Early May to Early June, fruiting in Early June to Early July.

Distribution: Turkey (East Anatolia), Transcaucasica, N.W. Iran (Figure 88-89).

Habitat: The populations of *T. julia* spread in rocky and stony slopes, scree or high mountain meadow with reddish-brown or red soils at an elevation of 1200-2800 m.

Phytogeographic region: Irano-Turanian element.

Conservation status: LC (IUCN, 2001). The populations of *T. julia* are widespread in East Anatolia. These populations have wide distribution ranges and there is no risk presently. Thus, the species may be classified as ‘Least Concern’ (LC) (IUCN 2001).

Selected Specimens Examined: A8 Bayburt: 24 km from Bayburt to Aşkale, slopes of Kop mountain, rocky slopes near Kop stream, 1811 m, 40° 05.271' N 040° 25.400' E, 08.05.2008, Eker 2141 in AIBU! ibid., 08.06.2008, Eker 2205 (fruiting time) in AIBU! Erzurum: 60 km from Erzurum to İspir, around Çamlık village, dry hills, 2000 m, 28.5.1971, T. Baytop (ISTE 19907) in K! Aşkale, Kopdağı, stony slopes, 2100 m, M. Koyuncu et al. 4435 in AEF! A9 Kars: Kağızman, above Peşli village, 1800 m, 02.06.1971, T. Baytop (ISTE 19977) in K! around Karakurt, 1650 m, 21.05.1976, T. Baytop (ISTE 34905) in ISTE! 8-10 km from Sarıkamış to Karakurt, *Pinus sylvestris* forest, 2000 m, 16.05.1979 (HUB 35107) in HUB! B7 Erzincan, 11 km from Erzincan to Çayırılı, Kolçekmez mountain, stony slopes and scree, 1785 m, 39° 47.908' N 039° 30.521' E, 11.06.2009, Eker 2505 (fruiting time) in AIBU! B9

Ağrı: between Eleşkirt-Horasan, Tahir village, Tahir mountain, around transmitter station, high mountain meadow, 2556 m, 39° 51.557' N 042° 29.911' E, 10.06.2009, Eker 2497 in AIBU! Tahir mountain pass, grassy slopes, 2400 m, 12.05.1970, Rix 1644 in E! Tahir mountain, near Aktaş village, 2000 m, 21.05.1976, T. Baytop et al. (34907) in ISTE! between Tahir pass and Eleşkirt, Kavurucu mountain, above Dikenlidere village, 2200 m, T. Baytop (ISTE 19996) in ISTE! Van: Gürpınar, Erek mountain, 8 km above Gölardı village, west of Lake Keşiş (Turna), screes with red soils, 2589 m, 38° 28.022' N 043° 34.809' E, 06.05.2008, Eker 2114 in AIBU! ibid., 05.05.2009, Eker 2465 (fruiting time) in AIBU! above Kevenni village, metamorphic fields, steppe, 2250 m, 29.05.1978, A. Güner 1708 in HUB! 35 km from Van to Muradiye, around Kireç Ocağı, rocky places, 2000 m, 20.05.2006, Eker 1593 in AIBU! Muradiye, 3 km to Görecek village, rocky places, 1800 M, 05.05.2002, O. Karabacak 2902 in VANF! around Adaklı village, steppe, 2400 m, 19.05.1998, M. Ünal 2464 in VANF! B10 Van: Özalp, Yukarı Balçıklı village, around Ziyaret hill, stony places, 2300 m, 04.05.2008, Eker 2096 in AIBU! above Şahbağı mountain and Kalecik village, steppe, 1900-2300 m, 21.05.1993, Y. Altan 4909 in GAZI! C9 Hakkari: 9 km from Hakkari to Çukurca, slopes of Sümbül mountain, scree, 1240 m, 37° 29.927' N 043° 43.319' E, 02.05.2007, Eker 1862 in AIBU! ibid., 20.05.2006, Eker 1590 (fruiting time) in AIBU! C9/10 Hakkari: Zap gorge, opposite turning to Hakkari, loose slopes, May 1972, Rix 1925 in K!

Other Selected Collections: B7 Erzincan: Chama, between Kulit Çay and Avşin, Sint. 1890: 2187.

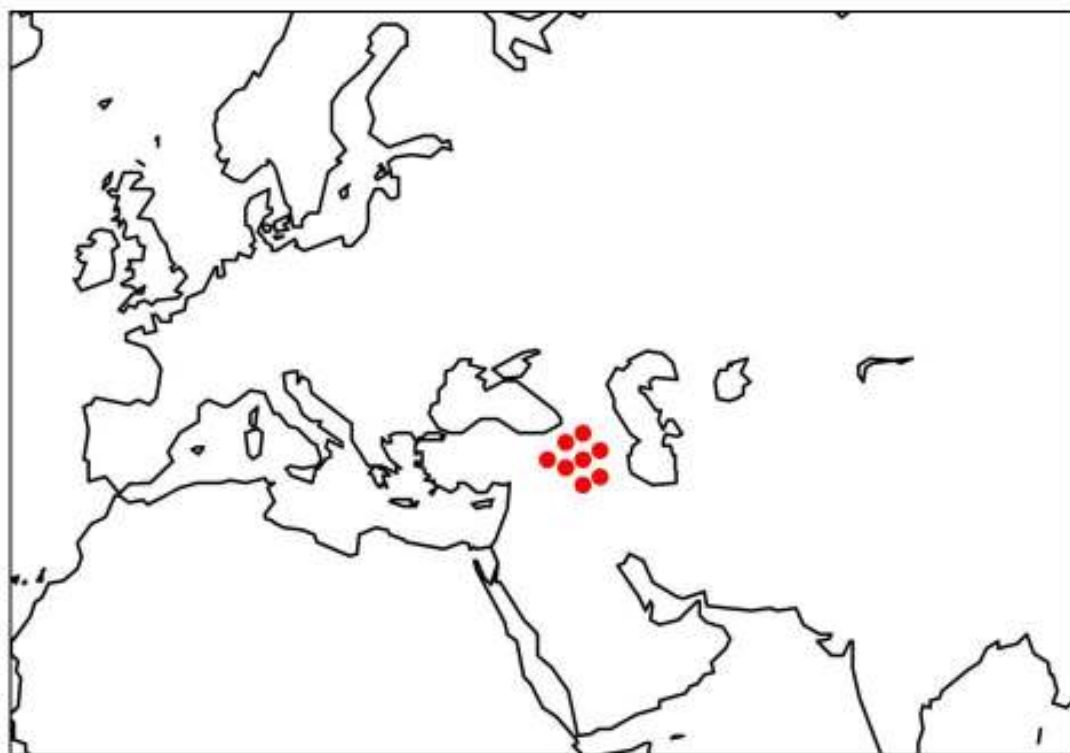


Figure 88. Distribution of *T. julia* in the world.

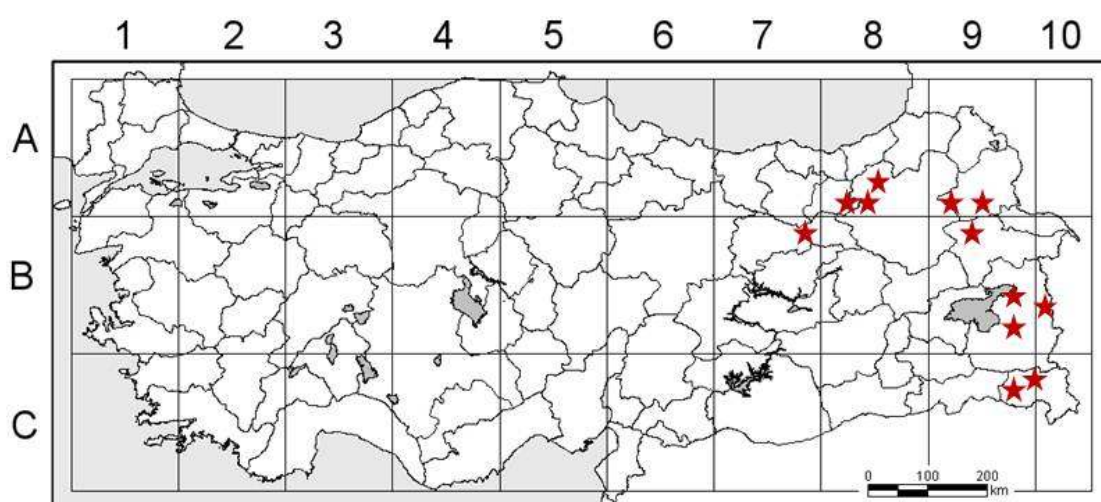


Figure 89. Distribution of *T. julia* in Turkey.



Figure 90. Habit of *T. julia*.

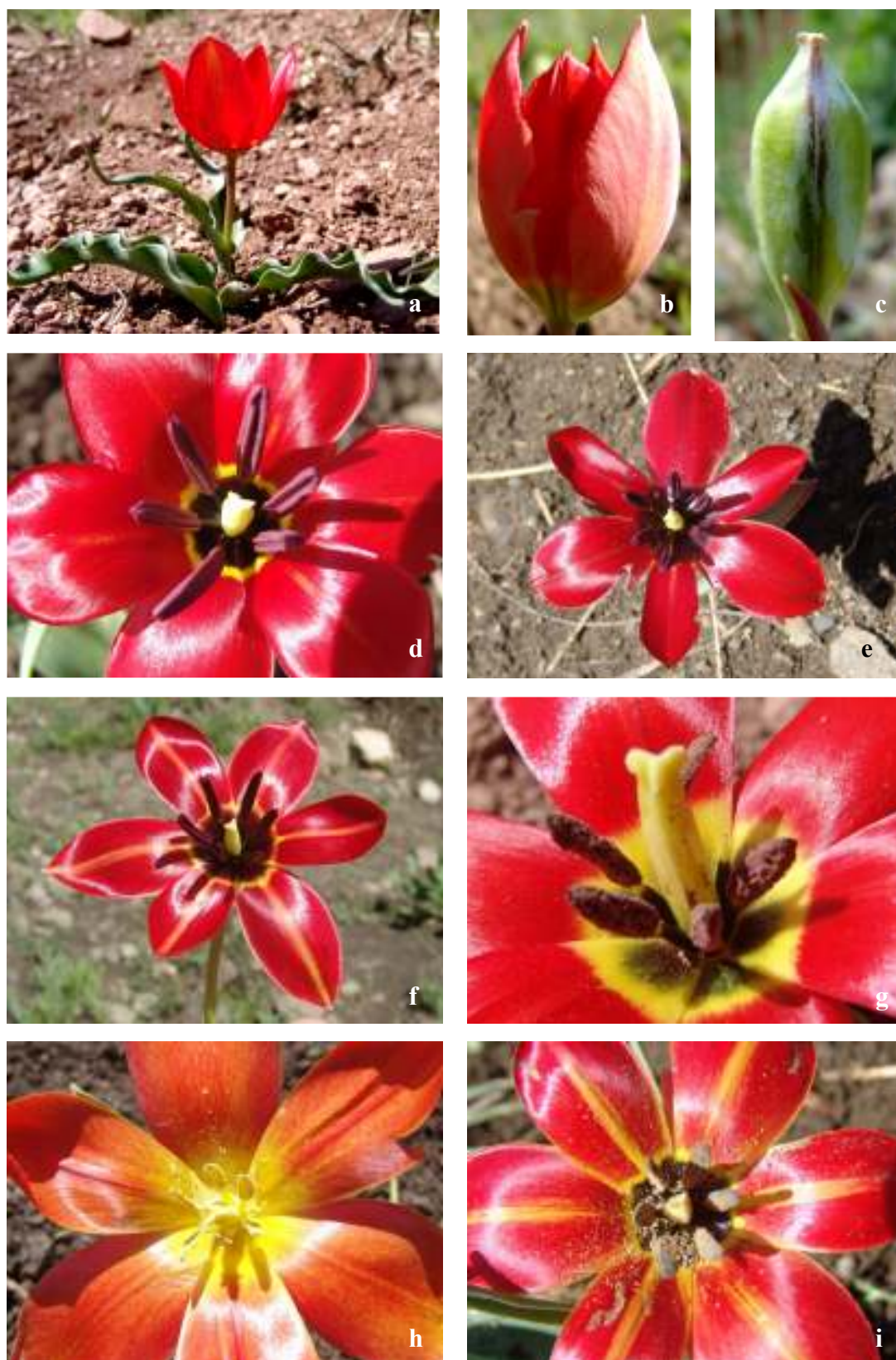


Figure 91. *T. julia* - a-b: The flower from the exterior, c: Fruit, d-i: The flower from the interior, j-l: Fruit.

Pollen morphology: Pollen grains trisulcate, ellipsoid or ellipsoid-spheroidal in polar view. Long axis 43.75-63.75 μm and short axis 37.5-61.25 μm . Exine 1.5-2.5 μm thick. Exine surface (exine pattern) perforate (LM). Intine bi-layered: outer intine 0.8-2 μm and inner intine 0.5-0.75 μm in thickness. Outer intine thicker in aperture (sulci) region, up to 9 μm . The exine plate extends irregularly towards the aperture. Surface of sulcus membrane granular (Figure 92).

Specimens examined: A8 Bayburt: Eker 2141, B9 Ağrı: Eker 2497, Van: Eker 2114, B10 Van: Eker 2096.



Figure 92. LM images of *T. julia* (Eker 2497) - a. Trisulcate pollen grain in equatorial view, b. Perforate exine (exine pattern) in polar view, c. Pollen wall in optical section: exine (black arrow), outer and inner intine (white arrow).

Chromosome number: $2n=24$.

Specimens examined: A8 Bayburt: Eker 2141 & 2205 ($2n=24$), B7 Erzincan: Eker 2505 ($2n=24$), B9 Ağrı: Eker 2497 ($2n=24$), Van: Eker 1593 ($2n=24$), Eker 2114 ($2n=24$, Figure 93).

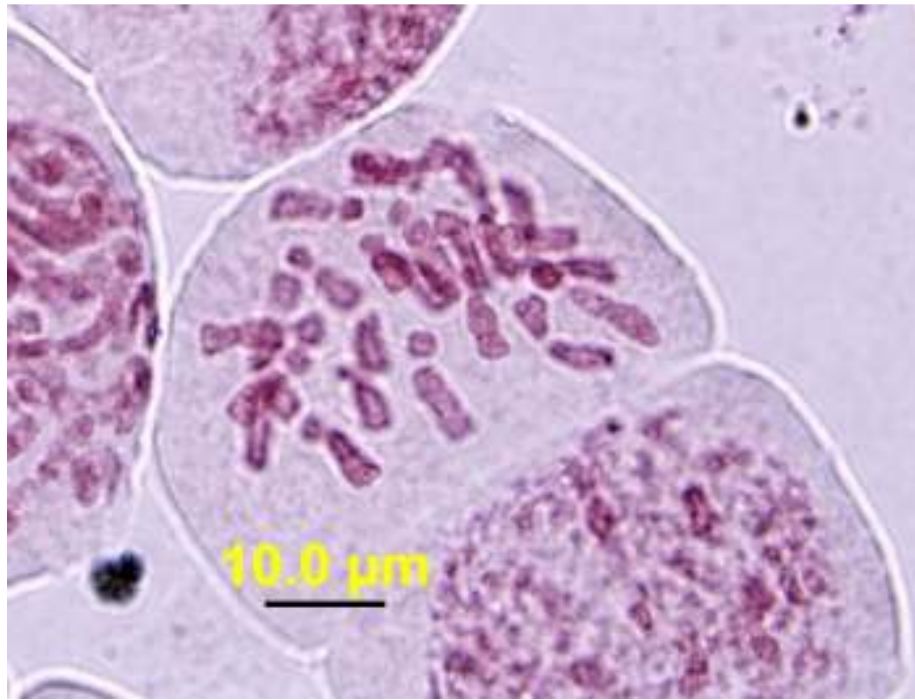


Figure 93. Somatic chromosome number of *T. julia* (Eker 2114).

13. *Tulipa aleppensis* Boiss. ex Regel in Acta Horti Petropolitani (Trudy Imp. S.-Peterburgsk. Bot. Sada) 2: 450 (1853)!

= *T. oculis-solis* St. Amans var. *aleppica* Baker in J. Linn. Soc. (Bot.) 14: 278 (1874)!

Iconibus: (Figure 96-97).

Type: In Syria, prope urbem Aleppo, Haussknecht (isotype K! -also holotype of *T. oculis-solis* var. *aleppica*).

Plant (15-)19-50(-55) cm. Stem glabrous, stem width 1-3 mm, underground stem length 5.5-30 cm, aerial stem length 4-17 cm. Stoloniferous or not. Bulb ovoid, 2.2-3.6 × 1.8-3(-3.5) cm. Bulb neck (1-)2-6(-8) cm. Tunics papery, brown, densely

lined with long, soft, tangled, woolly hairs (arachnoid-lanate) or straight-untangled. Leaves (3-)4, alternate, glaucous, undulate and membranous on margins. Lowest leaf lanceolate, canaliculate, falcate to semifalcate, obtuse to subacute, ciliate or not on margin, $8.5-20 \times 1.1-5.1$ cm. Second lowest leaf semifalcate to erect, acute to acuminate, ciliate on margin, $7-17.5 \times (0.7-)0.9-3$ cm. Flower solitary, campanulate, shiny red or rarely shiny orange-red with short eggplant blotch inside with or without yellow blotch edge, paler red or rarely paler orange-red with or without greenish-yellow base outside; outer tepals broadly elliptic-ovate to elliptic-ovate, acute to acuminate, $29-69 \times 12-43$ mm, glabrous, puberulous only at tip; inner tepals obovate, obtuse, apiculate or notched, glabrous and often pubescent at tip, $21-51(65) \times 9-36$ mm. Outer blotch 4-12 mm and inner blotch 3-11 mm in length. Blotch $(1/12-1/8-1/4)$ length of segments. Filaments 4-9.5 mm, glabrous, lanceolate, purplish-black. Anthers $5-13(-22) \times (1.5-)2-3$ mm, oblong to linear-oblong, purple at fresh, apiculate or not. Pollens purple or yellow at fresh, yellow, sulphur yellow or olive yellow at dry (purple colour at fresh is turned tones of yellow at dry). Ovary $6.5-18 \times 2-5$ mm, oblong to fusiform, glabrous, yellow, green, yellowish-green, reddish-green or reddish-yellow at fresh. Style very short or obscure, $0.5-2 \times 0.8-3$ mm. Stigma red, reddish-yellow or yellow at fresh, pubescent, $0.8-2 \times 1-5$ mm. Capsule $2.2-7.7 \times 1.5-3.2$ cm, elliptic-ovoid, elliptic, ovoid, oblong or elliptic-globose, glabrous; neck 1-4 mm, rib 18-60 mm, beak $(1-)2.5-10(-14)$, apicula 1-2 mm; tepal scar 1-2 mm. Seeds numerous, flattened with rugose surface, triangular with two rounded angles to orbicular, light brown, $5.5-10 \times 4-7$ mm, winged.

Phenology: Flowering in Mid-April to Late April, fruiting in Mid May to Early June.

Distribution: Turkey (South Anatolia: Mesopotamia) and Syrian Desert (Figure 94-95).

Habitat: The populations of *Tulipa aleppensis* spread in cultivated areas (fields), pasturages or roadside calcerous barrens with reddish-brown or reddish-gray soils at an elevation of 400-1750 m.

Phytogeographic region: Irano-Turanian element.

Conservation status: VU (IUCN, 2001). The populations of *T. aleppensis* in C7 Şanlıurfa-Birecik and Halfeti have almost been disappeared. The other populations in C7 Karacadağ, C7 Adıyaman-Kahta and B7 Elazığ-Harput has restricted ranges. Also, these populations might be threatened due to the cultivation and excessive grazing. Thus, the species may be classified as ‘Vulnerable’ (VU) (IUCN 2001).

Selected Specimens Examined: B7 Elazığ: Harput, around Göllübağ, meadow, 1548 m, 38° 43.785' N, 039° 17.763' E, 25.04.09, Eker 2287 in AIBU! ibid., 20.05.2009, Eker 2368 (fruiting time) in AIBU! Göllübağ rocks, Şüşnaz, 1450 m, (FUH 1003) in FUH! C7 Şanlıurfa: Siverek, Karacadağ, Karabahçe village, near graveyard, in fields, 1276 m, 37° 47.997' N 039° 45.896' E, 12.04.2007, Eker 1797 in AIBU! ibid., 1250 m, 08.04.1979, H. Malyer (ISTE 43252) in ISTE! Mamo mezarısı, 41 km from Diyarbakır to Siverek, rocky meadow, 1200 m, 17.04.1990, T. Baytop (ISTE 61430) in ISTE! 1 km from Karabahçe to ridgeway, in fields, 1320 m, 37° 46.875' N 039° 45.915' E, 12.04.2007, Eker 1805 in AIBU! Soydan village, around Karıncalı, in fields, 1114 m, 37° 46.243' N 039° 39.864' E, 06.06.2008, Eker

2195 (fruiting time) in AIBU! Birecik, 4 km from Birecik-Halfeti road junction to Halfeti, calcerous barrens at roadsides, 446 m, 37° 03.943' N, 038° 00.953' E, 14.04.2007, Eker 1814 in AIBU! *ibid.*, 19.05.2009, Eker 2361 (fruiting time) in AIBU! Adıyaman: Kahta, Nemrut Dağı, rocky and stony places, 1728 m, 37° 57.735' N, 038° 45.049' E, 21.05.2009, Eker 1814 (fruiting time) in AIBU! rocks near Eski Kahta, May 1972, Rix 1859 in Kew and NHM!

Other Selected Collections:

B7 Elazığ: Harput, Şuşnaz, Sint. 1889: 325; C6 Şanlıurfa: Birecik, Çiflik, Sint. 1888: 357; C7 Şanlıurfa: Rum Kala'a (Halfeti), Sint. 1888: 415.

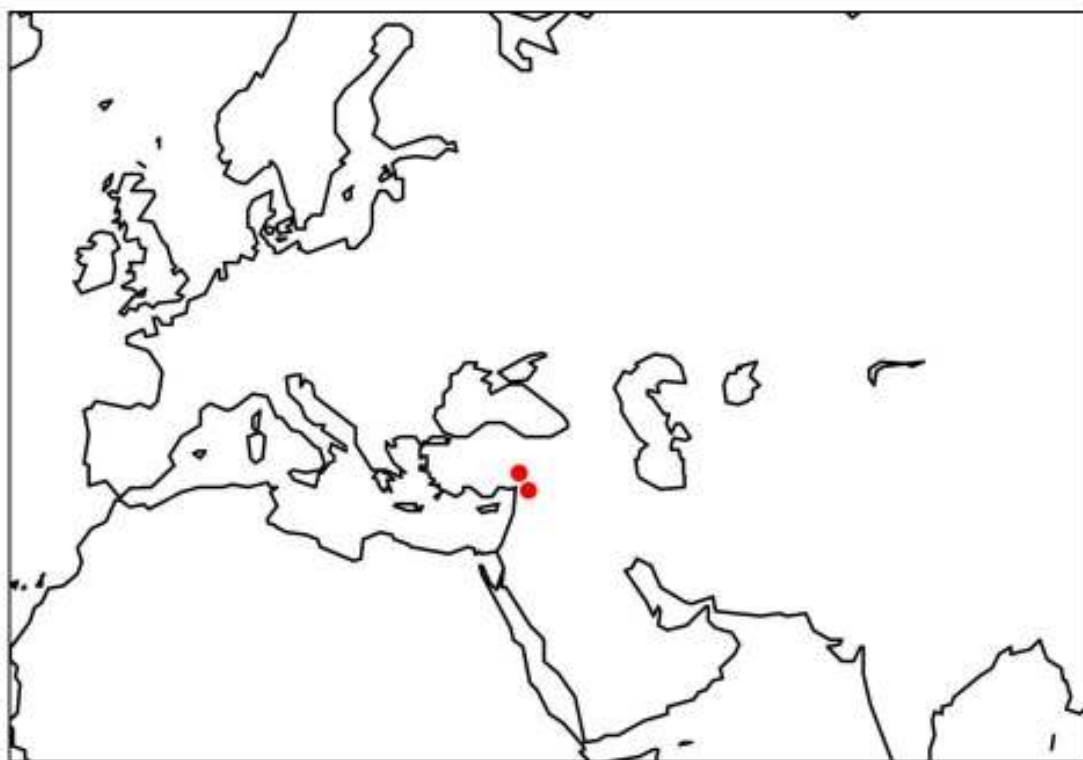


Figure 94. Distribution of *T. aleppensis* in the world.

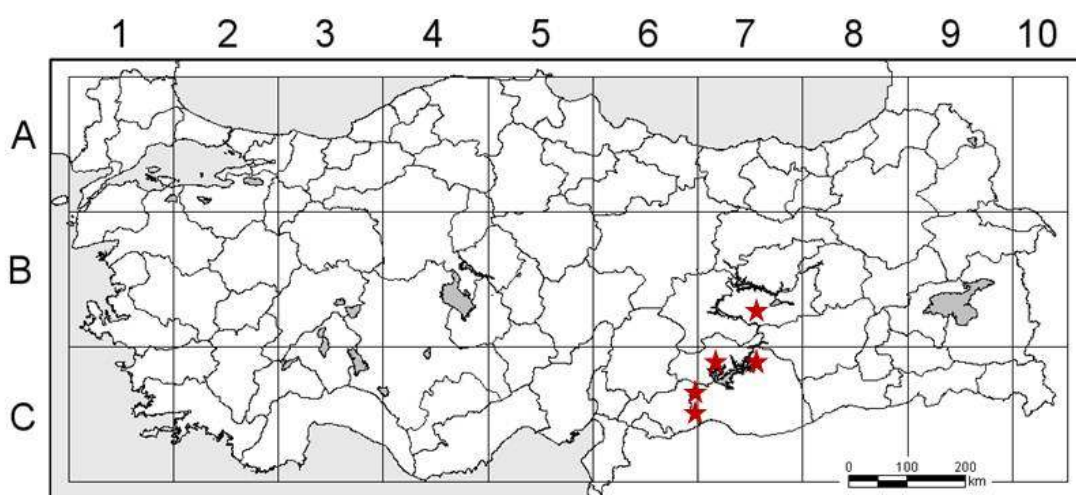


Figure 95. Distribution of *T. aleppensis* in Turkey.



Figure 96. Habit of *T. aleppensis*.



Figure 97. *T. aleppensis* - a-c: The flower from the exterior, d-g: The flowers of *T. aleppensis* from the interior, h-i: Fruit.

Pollen morphology: Pollen grains predominantly trisulcate, recorded also inaperturate (Eker 1985) and diaperturate (with por like apertures) (Eker 1985), ellipsoid or ellipsoid-spheroidal in polar view. Long axis 42.5-82.5 μm and short axis 37.5-55 μm . Exine 1-2.5 μm thick. Exine surface (exine pattern) perforate (LM). Intine bi-layered: outer intine 0.8-1.5 μm and inner intine 0.5-0.75 μm in thickness. Outer intine thicker in aperture (sulci) region, up to 4 μm . The exine plate extends irregularly towards the aperture. Surface of sulcus membrane granular (Figure 98-99).

Specimens examined: B7 Elazığ: Eker 2287, C7 Şanlıurfa: Eker 1814, Eker 1985.

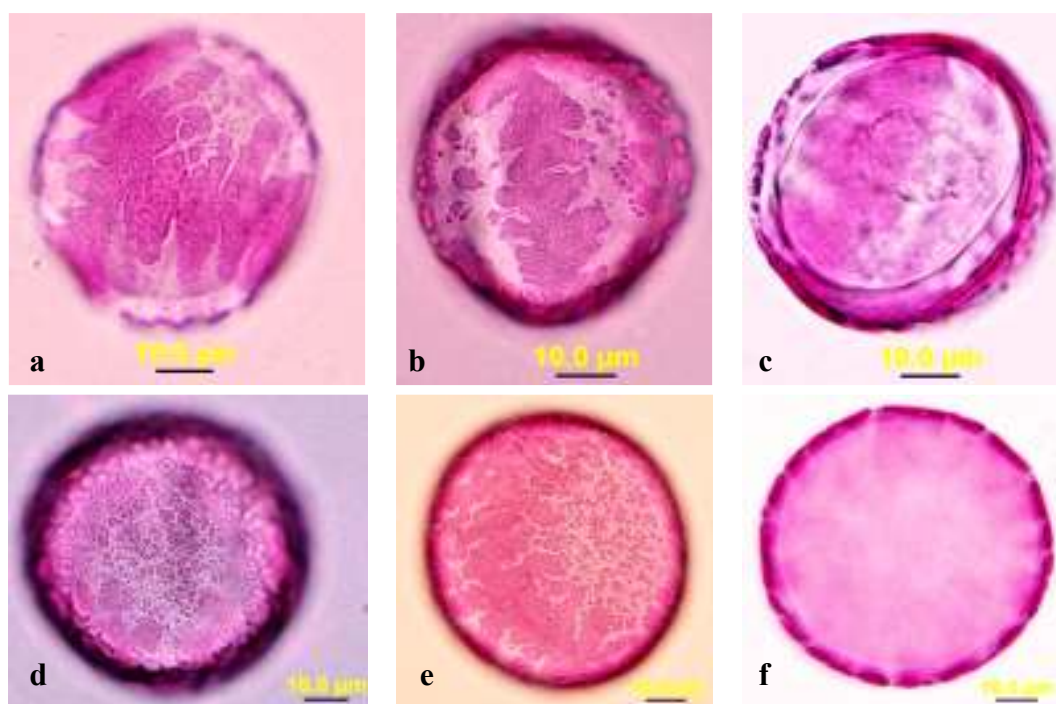


Figure 98. LM images of *T. aleppensis* - a. Trisulcate pollen grain in equatorial view (Eker 1814), b. Perforate exine (exine pattern) in polar view (Eker 1814), c. Pollen wall in optical section: exine (black arrow), outer and inner intine (white arrow) (Eker 1814), d. Biulcate pollen grain in equatorial view (Eker 1985), e. Perforate exine (exine pattern) in polar view (Eker 1985), f. Pollen wall in optical section: exine (black arrow), outer and inner intine (white arrow) (Eker 1985).

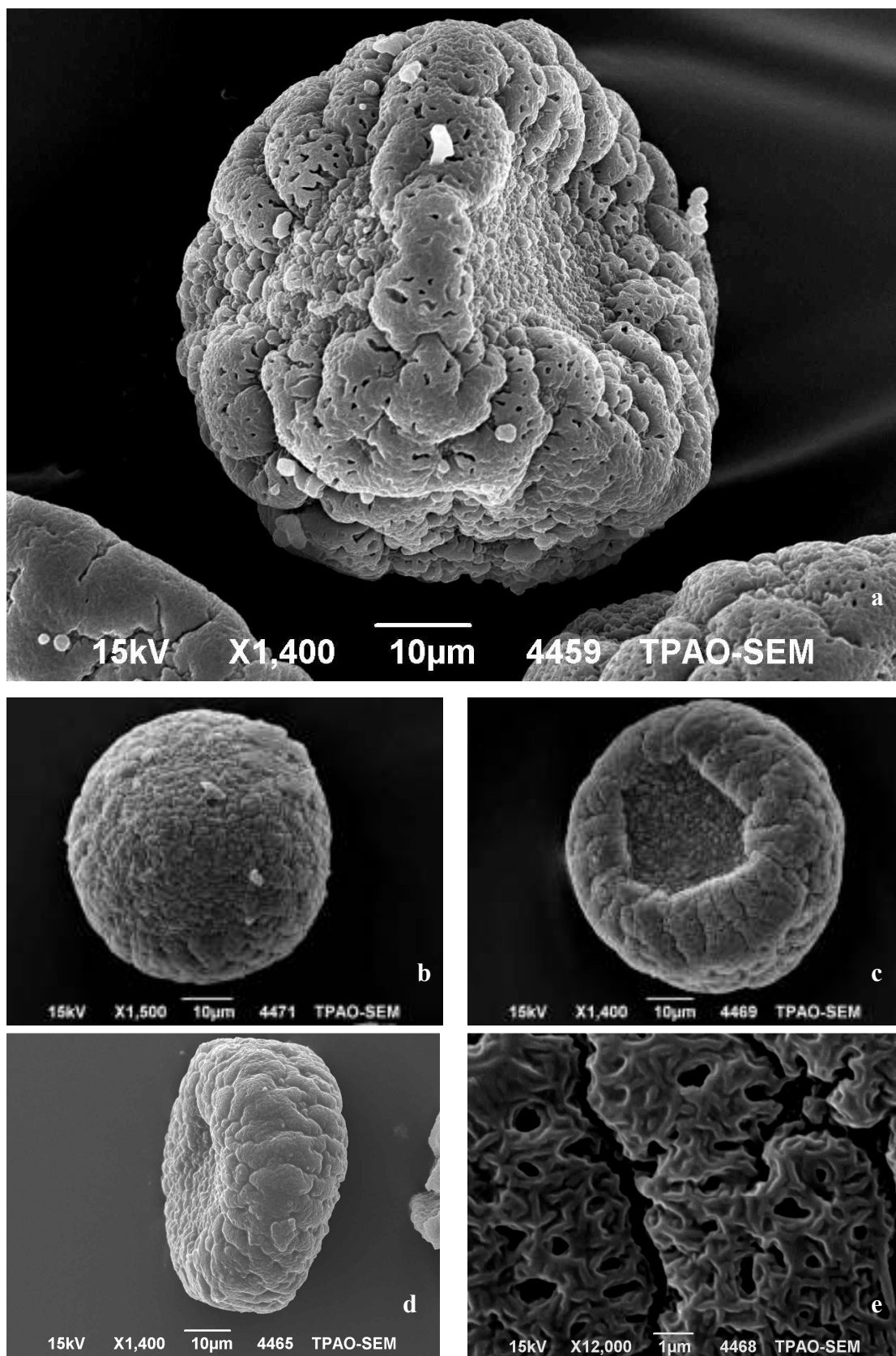


Figure 99. SEM images of *T. aleppensis* (Eker 1985) - a. Trisulcate pollen grain in equatorial view, b. Inaperturate pollen grain c-d. Diaperturate pollen grain (with por like apertures) e. Perforate-rugulate exine (exine pattern).

Chromosome number: $2n = 24, 36$.

Specimens examined: B7 Elazığ: Eker 2287 ($2n = 24$), C7 Şanlıurfa: Eker 1805 ($2n = 24, 36$, Figure 100) & Eker 1814 ($2n = 24$).

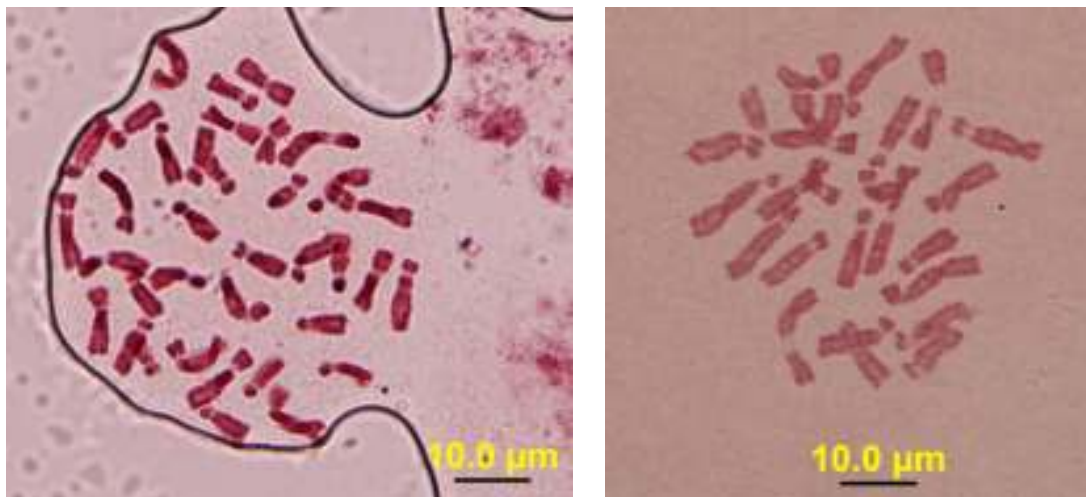


Figure 100. Somatic chromosome number of *T. aleppensis* (Diploid and triploid specimens, Eker 1805).

14. *Tulipa agenensis* DC. in Redouté, Les Liliacées 1: 60, add. (1804).

= *T. oculis-solis* St. Amans in Recueil Soc. Agric. & Sci. Agen. 1: 75 (1804), nomen;

T. oculis-solis DC. in J.B.A.M.de Lamarck & A.P.de Candolle, Fl. Fr., ed. 3, 3: 200

(1805)! *T. sharonensis* Dinsm. in G.E.Post, Fl. Syria, ed. 2, 2: 621 (1933)! *T.*

agenensis subsp. *sharonensis* (Dinsm.) Feinbrun, Fl. Palaestina 4: 41 (1986)!

Iconibus: Redouté, Les Liliacées 4: t. 219, (1808), as *T. oculis-solis*! (Figures 103-104).

Type: Described from Agen in SW France.

Plant 20-75(-90) cm. Stem glabrous, stem width 1.5-4.5 mm, underground stem length (5-)8-36(-44) cm, aerial stem length 7-28 cm. Stoloniferous or not. Bulb ovoid, $2-3.5 \times 1.8-2.7$ cm. Bulb neck (0.5-)1-4.5(-6) cm. Tunics papery, brown, densely lined with long, soft, tangled, woolly hairs (matted-lanate). Leaves 4, alternate, glaucous or glaucous-green, undulate, ciliate and membranous on margins. Lowest leaf lanceolate, canaliculate, falcate to erecto-patent, obtuse to acute, $12.5-34 \times 1.1-3.5$ cm. Second lowest leaf erect to erecto-patent, acute, $11.5-32.5 \times 0.6-2.5$ cm. Flower solitary, campanulate, shiny red with short eggplant blotch inside often with yellow blotch edge, paler red with greenish-yellow base outside; outer tepals elliptic-ovate, acute to acuminate, (30-)37-65(-71) $\times$ 13-26(-30) mm, glabrous, puberulous only at tip; inner tepals obovate, obtuse, apiculate or notched, glabrous and often pubescent at tip, (26-)32-61 $\times$ 9-23 mm. Outer blotch 11-30 mm and inner blotch 9-24 mm in length. Blotch 1/4-1/2 length of segments. Filaments 5-13 mm, glabrous, lanceolate, purplish-black. Anthers 5.5-15.5 $\times$ 2-4 mm, oblong, purplish-black at fresh, apiculate or not. Pollens purple or yellow at fresh; yellow, sulphur yellow or olive yellow at dry (purple colour at fresh is turned tones of yellow at dry). Ovary 6-20 $\times$ 2-6 mm, oblong to fusiform, glabrous, yellowish-green with pinkish lined at fresh. Style very short or obscure, (0.5-)1-3.5(-4) $\times$ (0.8-)1-3 mm. Stigma yellow, greenish-yellow, reddish-yellow or green at fresh, pubescent, 0.8-2(-2.5) $\times$ 1.5-5(-5.5) mm. Capsule 2.2-4.4 $\times$ 1-2 cm, ovoid, elliptic-ovoid, oblong-ovoid or elliptic-globose, glabrous; neck (0.5-)1-5 mm, rib 16-32 mm, beak 3-10, apicula 0.5-1 mm; tepal scar 1-2 mm. Seeds numerous, flattened with rugose surface, triangular with two rounded angles to orbicular, light brown, 4-7 $\times$ 3-6 mm, winged.

Phenology: Flowering in April, fruiting in May.

Distribution: Turkey (South and West Anatolia), Syria, N.W. Iran, Palestine, Israel and East Aegean Islands (Cyprus, Khios, Kampos, Kampochora). Naturalised in S. France and Italy (Figure 101-102).

Habitat: The populations of *T. agenensis* spread in cultivated areas (fields) or maquis with reddish-brown soils at an elevation of 300-1700 m.

Phytogeographic region: East Mediterranean element

Conservation status: VU (IUCN, 2001). The populations of *T. agenensis* spreads around C4 İçel, C5 Adana and C6 Hatay, Maraş in south Anatolia and B1 İzmir, B2 Afyon, C2 Denizli, Aydın in west Anatolia. These populations have restricted ranges and might be threatened due to the cultivation and excessive grazing. Thus, the species may be classified as ‘Vulnerable’ (VU) (IUCN 2001).

Selected Specimens Examined: B1 İzmir: Çeşme, field side, bulbs collected from Çeşme bloomed at 26.03.1971 in İstanbul/Maltepe, T. Baytop (ISTE 19033) in ISTE! B2 Afyon: Dazkırı, west of Sarıkavak village, steppe, 1100 m, 07.05.1984, Z. Aytaç 1109 in GAZI! C2 Denizli: Çardak, Maymun mountain, Zinar hill, steppe, 1500-1640 m, 10.05.1984, Z. Aytaç 1235 in GAZI! Beşparmak mountain, Çatalburun, steppe, 10.05.1984, Z. Aytaç 1238 in GAZI! Aydın: Nazilli, Yamalak-Taşpınar village road, *P. brutia* forest, 600 m, 24.04.1998, S. Oluk 2750 in EGE! C4 İçel: Aydıncık-Gülnar arası, Gilindere, around Eskiörük village, in fields, 658 m,

36° 14.122' N 033° 22.586' E, 20.04.2009, Eker 2263 in AIBU! Gülnar, Ahirini, between Gülnar & Gilindire, fallow fields on S. Metamorphic slopes, Davis 25970 & O. Polunin in ANK, E and K! C5 Adana: Kozan, 27 km from Kozan to Feke, around Horzum bridge, maquis, openings of forest, 626 m, 37° 38.788' N 035° 51.321' E, 21.04.2009, Eker 2270 in AIBU! 28 km from Kozan to Feke, Çulluşağı village, pasturage, stony slopes, 718 m, 37° 40.285' N 035° 52.286' E, 21.04.2009, Eker 2270 in AIBU! Kozan-Feke (Antitaurus), 550 m, edge of igneous corn fields 18 miles (29 km) from Kozan, 11.4.1957, Davis 26587 & Hedge in ANK, E, K and BM! İçel: Lomas (Lamas Çayı), 04.1985, Siehe 1895: 140 in E, K and BM! Limonluk, 14.04.1984, T. Baytop (ISTE 52851) in ISTE! C6 Hatay: Antakya, Şenköy, 4-5 km from Şenköy to Yayladağı, in fields, 924 m, 36° 01.343' N 036° 07.394' E, 21.04.2009, Eker 2000 & 2001 in AIBU! *ibid.*, 1000 m, 07.04.1989, T. Baytop (ISTE 60155) in ISTE! Şenköy to Yayladağı, 1000 m, 28.04.1957, D. 27193 in E, K and BM! Kışlak, around Arslanyazı village, in fields under olive trees, 491m, 35° 56.738' N 036° 10.372' E, 26.04.2009, Eker 2292 in AIBU! Antakya-Adana highway, Üçgedik village, northwest slopes, maquis, 376 m, 36° 19.049' N 036° 09.840' E, 05.04.2009, Eker 2247b in AIBU! Kahramanmaraş: Koyunoluk mountain, between Maraş-Göksun, 1100 m, In Vineyards, 04.05.1957, Davis 27416 & Hedge in ANK!

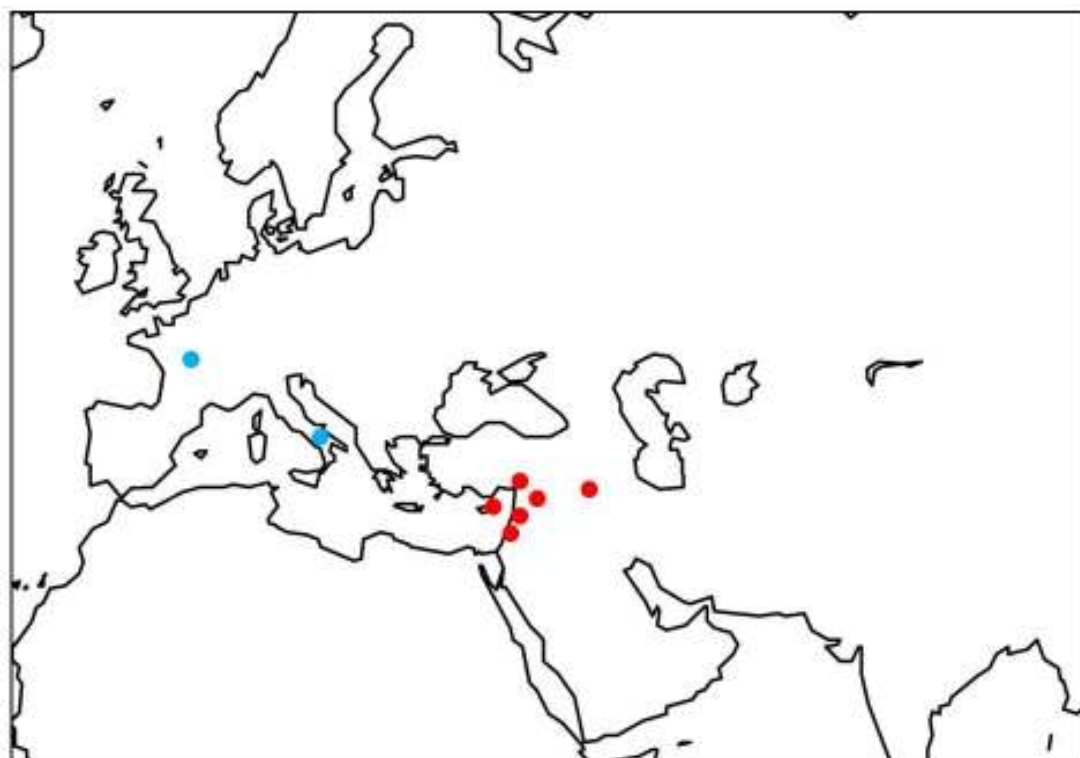


Figure 101. Distribution of *T. agenensis* in the world (red dots represent natural range of the species while blue dots represent naturalised areas in Europe).

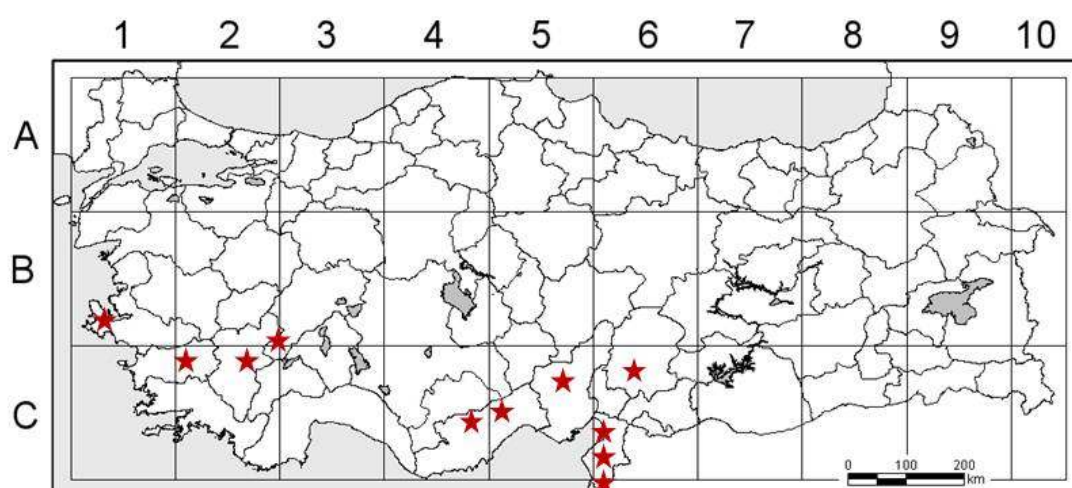


Figure 102. Distribution of *T. agenensis* in Turkey.



Figure 103. Habit of *T. agenensis*.



Figure 104. *T. agenensis* - a-c: The flower from the exterior, d-i: The flower from the interior, j-l: Fruit.

Pollen morphology: Pollen grains trisulcate, ellipsoid or ellipsoid-spheroidal in polar view. Long axis 42.5-85 μm and short axis 35-80 μm . Exine 1.5-2.5 μm thick. Exine surface (exine pattern) perforate (LM). Intine bi-layered: outer intine 0.5-1.8 μm and inner intine 0.5-0.75 μm in thickness. Outer intine thicker in aperture (sulci) region, up to 3 μm . The exine plate extends irregularly towards the aperture. Surface of sulcus membrane granular (Figure 105).

Specimens examined: C5 Adana: Eker 2270, İçel: Eker 2423, C6 Hatay: Eker 2001, Eker 2292.

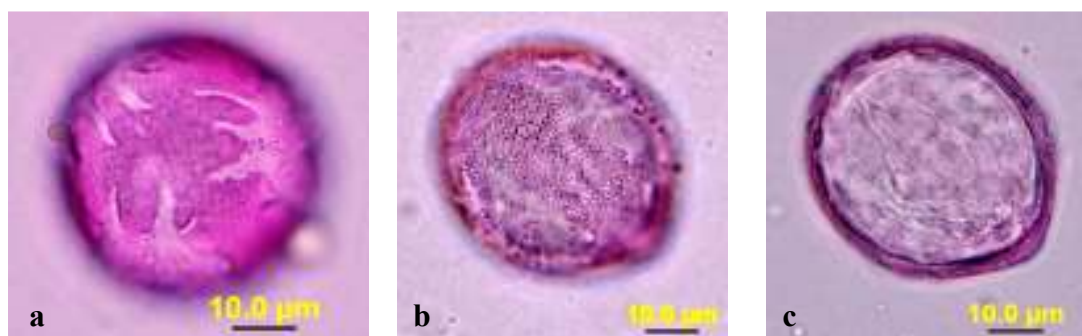


Figure 105. LM images of *T. agenensis* - a. Trisulcate pollen grain in equatorial view (Eker 2263), b. Perforate exine (exine pattern) in polar view (Eker 2270), c. Pollen wall in optical section: exine (black arrow), outer and inner intine (white arrow) (Eker 2270).

Chromosome number: $2n=24$.

Specimens examined: C6 Hatay: Eker 2000, 2292 & 2357 ($2n=24$, Figure 106).



Figure 106. Somatic chromosome number of *T. agenensis* (Eker 2000).

15. *Tulipa praecox* Ten. in Flora Napolitana 1: 170-172 (1811)!

≡ *Tulipa oculus-solis* var. *praecox* Regel, Trudy Imp. S.-Peterburgsk. Bot. Sada 2: 447 (1873).

= *Tulipa praecox* var. *foxiana* (Reboul) Levier, Tulip. Eur.: 53 (1884); *Tulipa praecox* var. *hexagonata* (Borbás) Levier, Tulip. Eur.: 54 (1884); *Tulipa praecox* subsp. *foxiana* (Reboul) K.Richt., Pl. Eur. 1: 214 (1890); *Tulipa praecox* subsp. *loretii* (Jord.) K.Richt., Pl. Eur. 1: 214 (1890); *Tulipa praecox* subsp. *raddii* (Reboul) K.Richt., Pl. Eur. 1: 214 (1890).

Iconibus: The Botanical Register 3: t. 204 (1817), as *T. oculis-solis*! (Figure 109-110).

Type: Type not indicated. But, a neotype will be designated among collected specimens.

Plant (25-)45-95 cm. Stem glabrous, stem width 5-6 mm, underground stem length (2-)12-28 cm, aerial stem length (15-)30-60 cm. Markedly stoloniferous. Bulb ovoid, 3-4 × 2.5-3.5 cm. Bulb neck 0.5-6 cm. Tunics papery, brown, densely lined with long, soft, tangled, woolly hairs (matted-lanate). Leaves 4, alternate, glaucous, undulate or ±entire, ciliate and membranous on margins. Lowest leaf broadly lanceolate-lorate, slightly canaliculate, erecto-patent or emerging erect but bending to the ground, obtuse, (17.5-)27-49 × 3.1-8 cm. Second lowest leaf lanceolate to broadly lanceolate, slightly canaliculate, erect to erecto-patent, subacute to acute, (19-)25-45 × (1.6-)2-5.5 cm. Flower solitary, campanulate, shiny red with short eggplant blotch inside with yellow blotch edge, paler red with greenish-yellow base outside; outer tepals broadly elliptic-ovate to elliptic-ovate, acute to acuminate, 49-80 × 19-39 mm, glabrous, pubescent only at tip; inner tepals obovate to elliptic-obovate, obtuse, apiculate or notched, glabrous and pubescent only at tip, 40-58 × 15-32 mm. Outer blotch 16-25(-32) mm and inner blotch 14-20 mm in length. Blotch 2/7-2/5 length of segments. Filaments 7-10 mm, glabrous, lanceolate, brownish-black. Anthers 10-17 × 2.5-4 mm, oblong to oblong-ovoid, purple at fresh, apiculate or not. Pollens yellow, sulphur yellow or olive yellow at fresh. Ovary (10-)15-25 × 3.5-6 mm, oblong, glabrous, yellowish with pinkish lined at fresh. Style very short or

obscure, $1.5-3.5 \times 1.5-4$ mm. Stigma yellow, greenish-yellow, reddish-yellow or green at fresh, pubescent, $1.5-2.5 \times 2.5-5$ mm. Not forming mature capsule and seed.

Phenology: Flowering in Late March.

Distribution: Turkey (around Amasya), Locally naturalized in S. Europe (France, Greece, Italy, Portugal) (Figure 107-108).

Habitat: The populations of *T. praecox* is found in orchards and gardens with grayish-brown soils at an elevation of 350-500 m.

Phytogeographic region: Naturalized and widespread, unknown phytogeographic origin.

Conservation status: NT (IUCN, 2001). During the field studies, three closest populations belonging to *T. praecox* were determined in A5 Amasya. One of them was in the garden of a house in city center. Unfortunately, this population was disappeared owing to building construction. The other two populations have restricted ranges in orchards and their natural habitats might be threatened due to the cultivation, urbanization and excessive grazing. Thus, the species may be classified as 'Vulnerable' (VU).

Selected Specimens Examined: A5 Amasya: Amasya-Çorum highway, Derbent Bağları (Helvacı street), orchards, 468 m, $40^{\circ} 36.748' \text{ N } 35^{\circ} 49.602' \text{ E}$, 02.04.2009, Eker 2240 & 2245 in AIBU! ibid., 500m, 31.03.1978, T. Baytop 38976 in ISTE!

around Alptekin Gazi, gardens and orchards, 403 m, 40° 37.483' N 035° 48.901' E, 02.04.2009, Eker 2244 in AIBU! *ibid.*, 30.04.2009, Eker 2230 in AIBU! city center, Hacılar Meydanı street, Yavuz Acar road, Çardak avenue, no 20, garden of a house, 391 m, 40° 38.953' N 035° 48.946' E, 02.04.2009, Eker 2239 in AIBU!

Other Selected Collections: A5 Amasya: 'Gartenland' (near Amasya?). Maniss. 29.

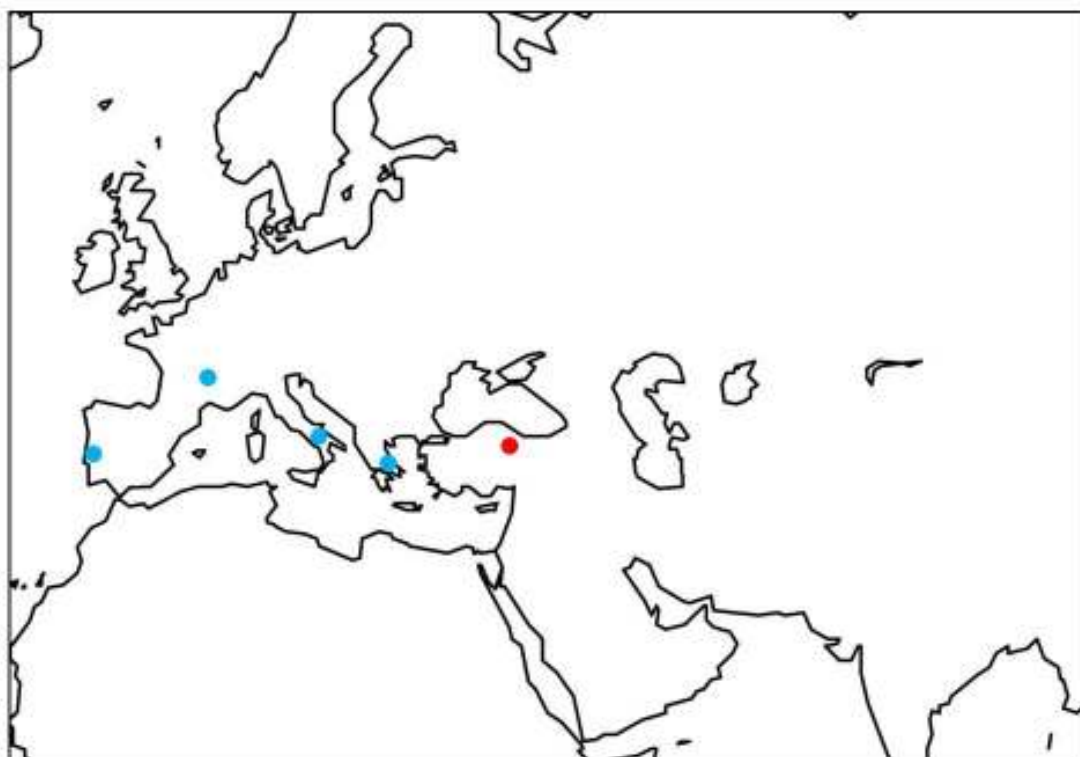


Figure 107. Distribution of *T. praecox* in the world (red dots represent natural range of the species while blue dots represent naturalised areas in Europe).

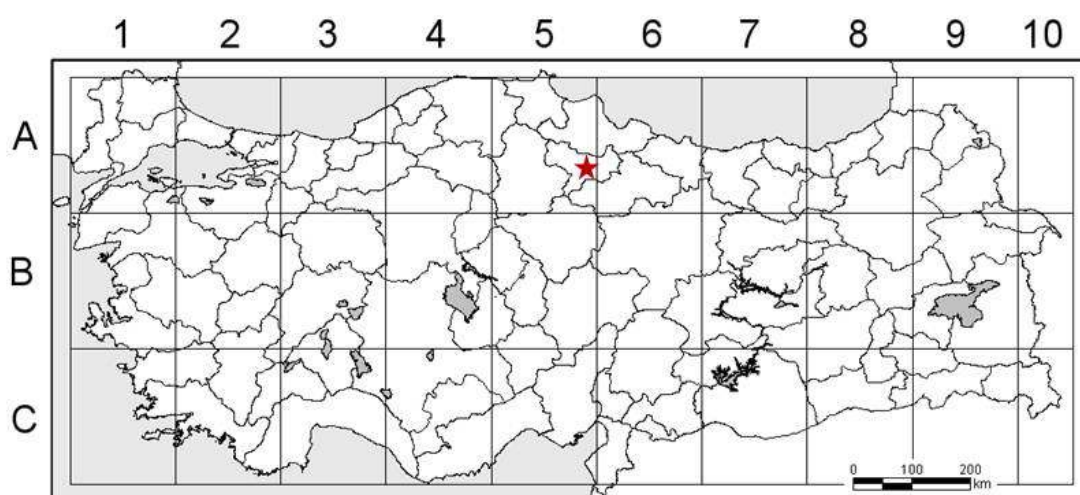


Figure 108. Distribution of *T. praecox* in Turkey.



Figure 109. Habit of *T. praecox*.



Figure 110. *T. praecox* - b, d: The flower from the exterior, a, e, f: The flower from the interior, c: Stamens and carpel.

Pollen morphology: Pollen grains trisulcate, ellipsoid-spheroidal in polar view. Long axis 47.5-65 μm and short axis 40-63.75 μm . Exine 2-2.5 μm thick. Exine surface (exine pattern) perforate (LM). Intine bi-layered: outer intine 1-1.5 μm and inner intine 0.5-0.75 μm in thickness. Outer intine thicker in aperture (sulci) region, up to 3 μm . The exine plate extends irregularly towards the aperture. Surface of sulcus membrane granular (Figure 111).

Specimens examined: A5 Amasya: Eker 2243 & 2244.



Figure 111. LM images of *T. praecox* - a. Trisulcate pollen grain in equatorial view (Eker 2244), b. Perforate exine (exine pattern) in polar view (Eker 2243), c. Pollen wall in optical section: exine (black arrow), outer and inner intine (white arrow) (Eker 2244).

Chromosome number: $2n=36$.

Specimens examined: A5 Amasya: Eker 2147 ($2n=36$, Figure 112).



Figure 112. Somatic chromosome number of *T. praecox* (Eker 2147).

16. *Tulipa undulatifolia* Boiss. in Diagnoses Plantarum Novarum Orientalium 1(5): 57 (1844)!

= *Tulipa boeotica* Boiss. & Heldr. in P.E.Boissier, Diagn. Pl. Orient., II, 4: 99 (1859)! *Tulipa euanthiae* Orph. in P.E.Boissier, Diagn. Pl. Orient., II, 4: 100 (1859)!

Tulipa strangulata Heldr. ex Baker, J. Linn. Soc., Bot. 14: 286 (1874), nom. inval!

Tulipa boeotica Boiss. & Heldr. subsp. *euanthiae* (Orph.) K.Richt., Pl. Eur. 1: 215 (1890).

Iconibus: (Figure 115-117).

Type: [Turkey B1 İzmir] in herbosis pinguibus ad pedem rupium in summo monte Tartali (Tahtalı Da.) supra Smyrnam, v 1842, Boissier (holotype G).

Plant 15-80 cm. Stem puberulous to pubescent, rarely glabrous, stem width 1-4 mm, underground stem length 5.5-43 cm, aerial stem length 2.5-34 cm. Stoloniferous or not. Bulb ovoid to globose-ovoid, $1.5-5 \times 1.2-3.5$ cm. Bulb neck 1-7.5 cm. Tunics papery to subcoriaceous, pale brown to reddish-brown. with a ring of hairs around basal plate and adpressed, pilose, bristly hairy at neck, middle part glabrous or slightly hairy (pilose). Leaves (2-)3-4(-5), alternate, glaucous, undulate and membranous on margins. Lowest leaf lanceolate, canaliculate, falcate, semi-falcate, semierect or erect, obtuse to subacute, ciliate or not on margins, $7-31 \times (0.75-)1.2-7.2$ cm. Second lowest leaf erect to semierect, falcate or semifalcate, acute, ciliate on margins, usually finely puberulous at tip, $(5.5-)8-29 \times (0.3-)0.5-5.6$ cm. Flower ssolitary, campanulate, shiny red with short eggplant blotch inside with or without yellow blotch edge, paler red with or without greenish-yellow base outside; outer tepals elliptic-ovate to ovate-lanceolate, acuminate to acute, $26-85(-105) \times 8-29(-38)$ mm, glabrous, puberulous only at tip; inner tepals obovate to elliptic-obovate, obtuse and abruptly apiculate, glabrous and pubescent only at tip, $25-83(-101) \times 9-38(-46)$ mm. Outer tepals often wider or rarely equal to inner tepals. Outer blotch 4-18(-25) mm and inner blotch 4-21(-25) mm in length. Blotch $1/7-2/3$ length of segments. Filaments 4-12 mm, glabrous, lanceolate to linear-lanceolate, purplish-black to black. Anthers $5-21 \times (1-)1.5-4(-5)$ mm, oblong or oblong-ovoid, purple or purplish-black at fresh, apiculate or not. Pollens purple or yellow at fresh, yellow, sulphur yellow,

olive yellow or mustard yellow at dry (purple colour at fresh is turned tones of yellow at dry). Ovary 5-30 × (1.5-)2-5 mm, oblong, subfusiform, fusiform, glabrous, yellow, pinkish-yellow, greenish-yellow or green at fresh. Style very short or obscure, (0.5-)1 × 1-3(-3.5) mm. Stigma yellow, greenish-yellow, reddish-green or green at fresh, pubescent, 1-6.5 × 1.5-13 mm. Stigma often wider than ovary. Capsule 3-6.5 × 1.5-3 cm, elliptic-ovoid, glabrous; neck 2-5 mm, rib 22-48 mm, beak 5-9, apicula 2-3.5 mm; tepal scar 1-2 mm. Seeds numerous, flattened with rugose surface, triangular with two rounded angles to orbicular, light brown, 5-7.5 × 4-6 mm, winged.

Phenology: Flowering in Mid-April to Early May, fruiting in Mid May to Early June.

Distribution: Turkey (West and Central Anatolia, European Turkey), S. Balkan peninsula (Greece, formerly Yugoslavia), Lesvos (Figure 113-114).

Habitat: The populations of *T. undulatifolia* spread in cultivated areas (fields) or barrens on opening of *Pinus nigra* forest, with red, reddish-brown or grayish-brown soils at an elevation of 40-950 m.

Phytogeographic region: Widespread and unknown phytogeographic origin.

Conservation status: VU (IUCN, 2001). The populations of *T. undulatifolia* are found in two regions: the primary distribution center includes around A1 Tekirdağ, B1 Çanakkale and İzmir. The second distribution center includes around B4 lake

Tuz. The populations might be threatened due to the cultivation and excessive grazing. Thus, the species may be classified as ‘Vulnerable’ (VU) (IUCN 2001).

Selected Specimens Examined: A1(E) Tekirdağ: 4 km from Şarköy to Mürefte, around Eriklice village, Zeytinlidere mevkii, fallow fields, 47 m, 40° 37.974' N 027° 09.379' E, 01.05.2008, Eker 2086 in AIBU! ibid., 02.06.2008, Eker 2180 (fruiting time) in AIBU! B1 Çanakkale: İntepe (Erenöy), Dümrek village, Çemberlininbahçe mevkii, barrens on opening of *Pinus nigra* forest, 287 m, 39° 57.623' N 026° 22.762' E, 01.05.2008, Eker 2085 in AIBU! Menderes mountain, Dümrek stream, Sint. 1883: 335 in K! İzmir: Urla, Aşağı Nohutalan village, Dolina mevkii, fields, 201 m, 38° 17.779' N 026° 31.540' E, 18.04.2009, Eker 2248 in AIBU! ibid., 30.03.1972, E. Leblebici (EGE 9918) in EGE! ibid., 18.04.1974, Kesercioğlu (EGE 11964) in EGE! Lake Çeşme, Nohutalan village, A. Baytop (ISTE 19047) in K! B4 Ankara: 34 km from Koçhisar to Ankara, fallow fields, 918 m, 39° 09.007' N 033° 17.546' E, 01.05.2008, Eker 2336 in AIBU! 4 km N. of lake Tuz, 950 m, Coode & Jones 124 in E! Ankara-Adana highway, fields between Lake Tuz and highway, V.1971, N. Tanker 3527 in AEF! ibid., 950 m, 01.05.1966, H. Bağda in ANK! Konya, around Lake Tuz, N. Tanker 10176 in AEF!

Other Selected Collections: A1(E) Tekirdağ: 5 km from Şarköy to Mürefte, Marais 1500.

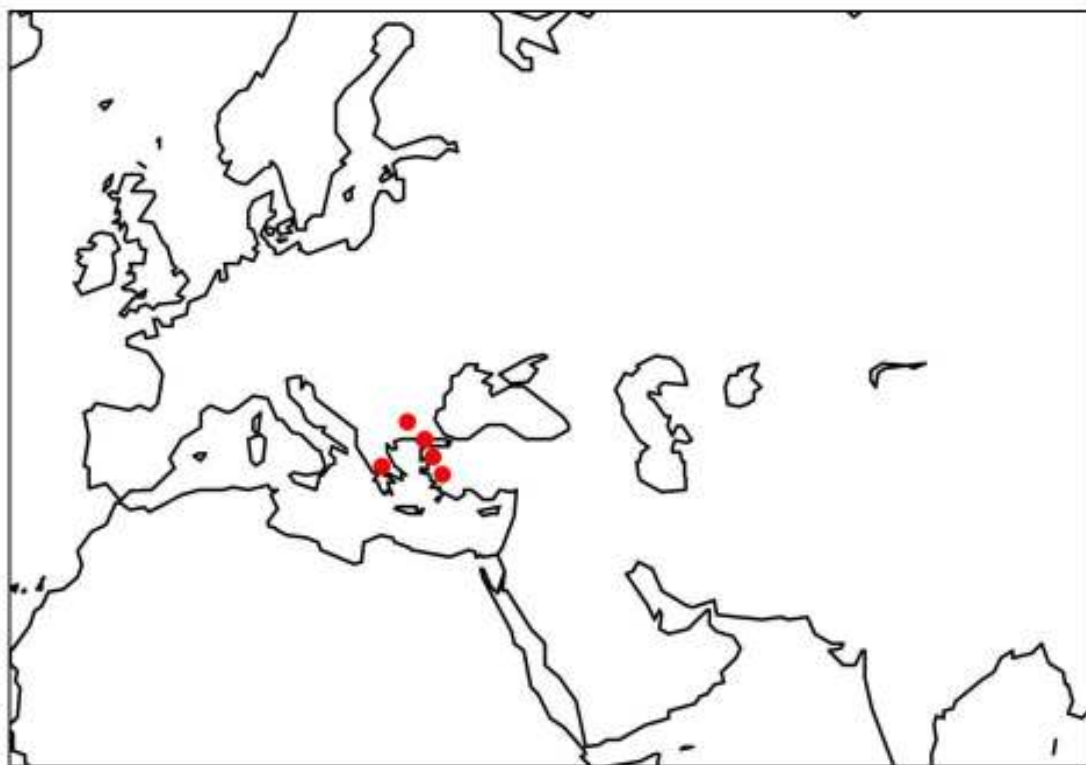


Figure 113. Distribution of *T. undulatifolia* in the world.

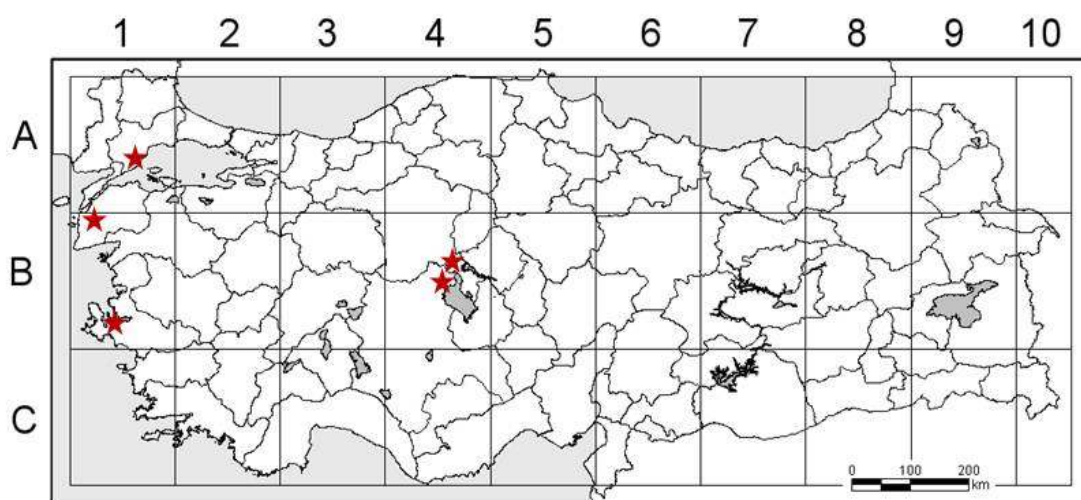


Figure 114. Distribution of *T. undulatifolia* in Turkey.



Figure 115. Habit of *T. undulatifolia*.



Figure 116. *T. undulatifolia* - a-c: The flower from the exterior, d-e: Fruits, f-i: The flower from the interior.



Figure 117. Habit of *T. undulatifolia*.

Pollen morphology: Pollen grains predominantly trisulcate, recorded also tetrasulcate (Eker 2085), ellipsoid-spheroidal in polar view. Long axis 47.5-62.5 μm and short axis 43.75--57.5 μm . Exine 1.7-2.5 μm thick. Exine surface (exine pattern) perforate (LM). Intine bi-layered: outer intine 0.9-2 μm and inner intine 0.5-0.75 μm in thickness. Outer intine thicker in aperture (sulci) region, up to 8 μm . The exine plate extends irregularly towards the aperture. Surface of sulcus membrane granular (Figure 118).

Specimens examined: A1 Tekirdağ: Eker 2086, B1 Çanakkale: Eker 2085, İzmir: Eker 2077 & 2248, B4 Ankara: Eker 2336.

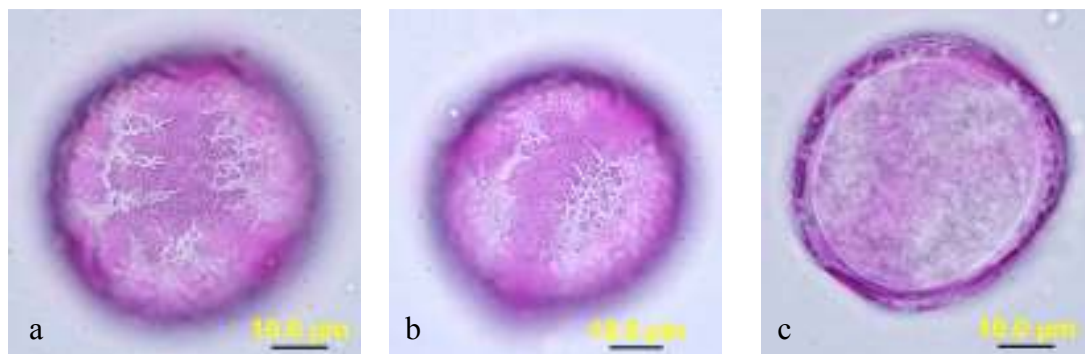


Figure 118. LM images of *T. undulatifolia* (Eker 2336) - a. Trisulcate pollen grain in equatorial view, b. Perforate exine (exine pattern) in polar view, c. Pollen wall in optical section: exine (black arrow), outer and inner intine (white arrow).

Chromosome number: $2n=24$.

Specimens examined: A1 Tekirdağ: Eker 2086 ($2n=24$), B1 Çanakkale: Eker 2085 ($2n=24$, Figure 119), İzmir: Eker 2077 ($2n=24$).



Figure 119. Somatic chromosome number of *T. undulatifolia* (Eker 2085).

Section *Clusianae* Baker

17. *Tulipa clusiana* DC. in Redouté, Les Liliacées 1: t. 37 (1805)!

= *Tulipa rubroalba* Brot., Fl. Lusit. 1: 520 (1804); *Tulipa stellata* Hook., Bot. Mag. 54: t. 2762 (1827); *Tulipa hispanica* Willd. ex Schult. & Schult.f. in J.J.Roemer & J.A.Schultes, Syst. Veg. 7: 380 (1829); *Liriactis albiflora* Raf., Fl. Tellur. 2: 97

(1837); *Tulipa chrysantha* Boiss. in C.G.T.Kotschy, Exsicc. (Pl. Pers. Bor.) 1846: 78 (1846); *Tulipa clusiana* var. *stellata* (Hook.) Regel, Trudy Imp. S.-Peterburgsk. Bot. Sada 2: 54 (1873); *Tulipa montana* var. *chrysantha* (Boiss.) Regel, Trudy Imp. S.-Peterburgsk. Bot. Sada 2: 454 (1873); *Tulipa undulata* Jacquem. ex Baker, J. Linn. Soc., Bot. 14: 279 (1874); *Tulipa clusiana* var. *rubroalba* (Brot.) Nyman, Consp. Fl. Eur.: 724 (1882); *Tulipa leichtlinii* Regel, Trudy Imp. S.-Peterburgsk. Bot. Sada 10: 366 (1887); *Tulipa fernandezii* Blatt., J. Bombay Nat. Hist. Soc. 27: 420 (1934); *Tulipa porphyreochrysantha* Blatt., J. Bombay Nat. Hist. Soc. 37: 421 (1934); *Tulipa aitchisonii* A.D.Hall, J. Bot. 76: 313 (1938); *Tulipa hafisii* Bornm. & Gauba, Repert. Spec. Nov. Regni Veg. 47: 77 (1939); *Tulipa chitralensis* A.D.Hall, Gen. Tulipa: 85 (1940); *Tulipa stellata* var. *chrysantha* A.D.Hall, Gen. Tulipa: 85 (1940); *Tulipa clusiana* var. *chrysantha* (A.D.Hall) Sealy, Bot. Mag. 165: t. 13 (1948); *Tulipa aitchisonii* var. *clusianoides* Wendelbo, Biol. Skr. 10(3): 162 (1958); *Tulipa clusiana* f. *clusianoides* (Wendelbo) S.Dasgupta & Deb, Candollea 40: 169 (1985); *Tulipa clusiana* f. *fernandezii* (Blatt.) S.Dasgupta & Deb, Candollea 40: 169 (1985); *Tulipa clusiana* f. *porphyreochrysantha* (Blatt.) S.Dasgupta & Deb, Candollea 40: 168 (1985); *Tulipa clusiana* f. *stellata* (Hook.) S.Dasgupta & Deb, Candollea 40: 165 (1985); *Tulipa clusiana* f. *cashmeriana* (A.D.Hall) Raamsd., Pl. Syst. Evol. 195: 37 (1995); *Tulipa clusiana* f. *diniaie* Raamsd., Pl. Syst. Evol. 195: 36 (1995); *Tulipa linifolia* f. *chrysantha* (Boiss.) Raamsd., Pl. Syst. Evol. 195: 38 (1995).

Iconibus: Curtis' Botanical Magazine 34: t. 1390 (1811)! Wendelbo, Tulips & Irises of Iran t. 31 (1977)! (Figure 122-124).

Type: The illustration of ‘*Tulipa persica praecox*’ in Clusius, *Curae posteriores* p. 9 (1611).

Plant 30-50 cm. Stem glabrous, stem width 2-3 mm, underground stem length 6-15(-19) cm, aerial stem length 18-30 cm. Markedly stoloniferous. Bulb globose-ovoid, $1.7-2.5 \times 1.5-2$ cm. Bulb neck 0.3-0.9 cm. Tunics coriaceous, dark brown, short, soft, and crinkly hairy around basal plate; bristly, longer, and protruding hairy at neck; middle part glabrous or slightly hairy (pilose). Leaves 3-5, alternate, glaucous, smooth, elongated-narrowed, linear, canaliculate, erect to erecto-patent, canaliculate, subacuminate to acuminate, glabrous and membranous on margins. Lowest leaf $20-28 \times 0.7-1.3$ cm. Second lowest leaf $17.5-26 \times 0.5-0.8$ cm. Flower solitary, campanulate, bright white with purple blotch without blotch edge inside, paler white with a reddish-pink band from the base to tip outside; outer tepals elliptic, acute, $32-52 \times 9-15$ mm, glabrous, puberulous only at tip; inner tepals obovate, obtuse, glabrous and puberulous only at tip, $27-42 \times 9-12$ mm. Outer blotch 7-12 mm and inner blotch 7-11 mm in length. Blotch $1/5-1/3$ length of segments. Filaments 6-9 mm, glabrous, linear-lanceolate, purple. Anthers $6-9 \times 1.5-2$ mm, narrowly oblong, deep purple at fresh, apiculate. Pollens purple at fresh, yellow at dry (purple colour at fresh is turned yellow colour at dry). Ovary $7-10 \times 2-3.5$ mm, oblong to subfusiform, glabrous, green or yellowish-green at fresh. Style very short or obscure, $0.5-1 \times 1-2.5$ mm. Stigma pinkish-white or pinkish-yellow at fresh, pubescent, $1-1.5 \times 1.5-3$ mm. Not forming mature capsule and seed.

Phenology: Flowering in Late April.

Distribution: Iran, N. Pakistan, Afghanistan. Naturalized in Turkey, Grece, Italy, France, Spain and Portugal (Figure 120-121).

Habitat: The populations of *T. clusiana* is found in cultivated areas (gardens) with reddish-brown soils at an elevation of 850-900 m.

Phytogeographic region: Irano-Turanian element

Conservation status: VU (IUCN, 2001). *T. clusiana* was found at only one locality. It has a very limited distribution: it is represented by less than 50 individuals in the whole population that covers less than 50 m². The area is being continuously destroyed by people. Thus, the habitat of *T. clusiana* is under threat and its destruction would lead to a dramatic decrease of the abundance or even complete extinction of this species at least in Turkey. Taking into account all these points, the species should be classified as “Vulnarable” (VU).

Selected Specimens Examined: B4 Ankara: Ankara University, garden of Faculty of Science, gardens, 860 m, 39° 14.56.161' N 032° 49.975' E, 30.04.2007, Eker 1841 in AIBU!

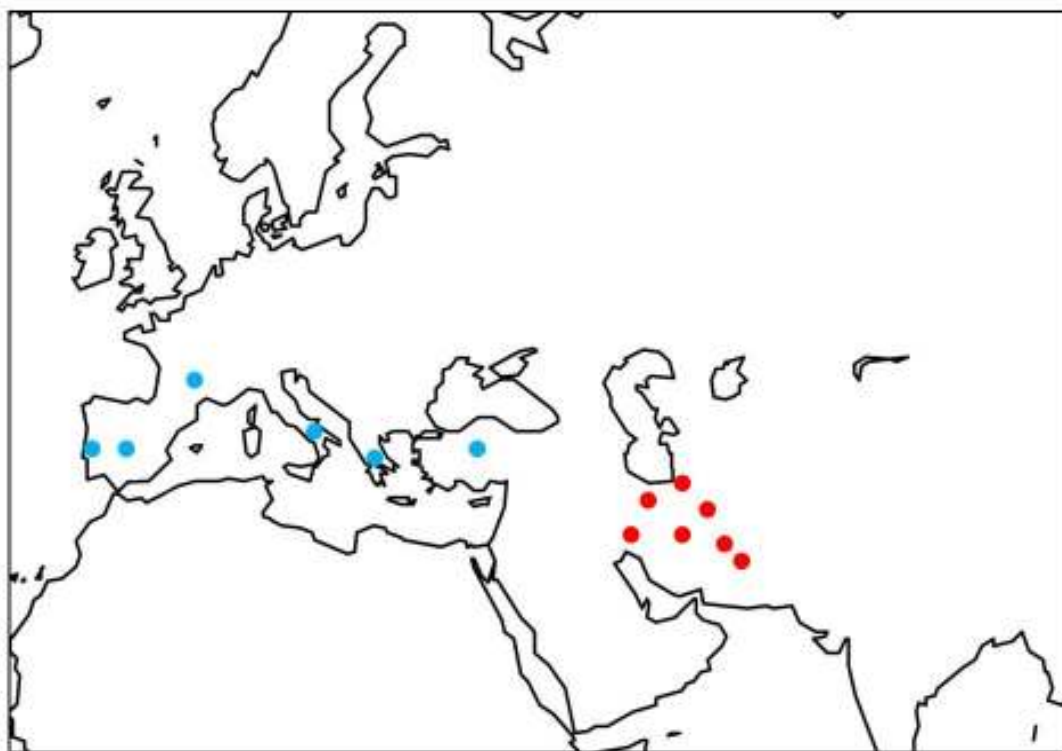


Figure 120. Distribution of *T. clusiana* in the world (red dots represent natural range of the species while blue dots represent naturalised areas in Europe).

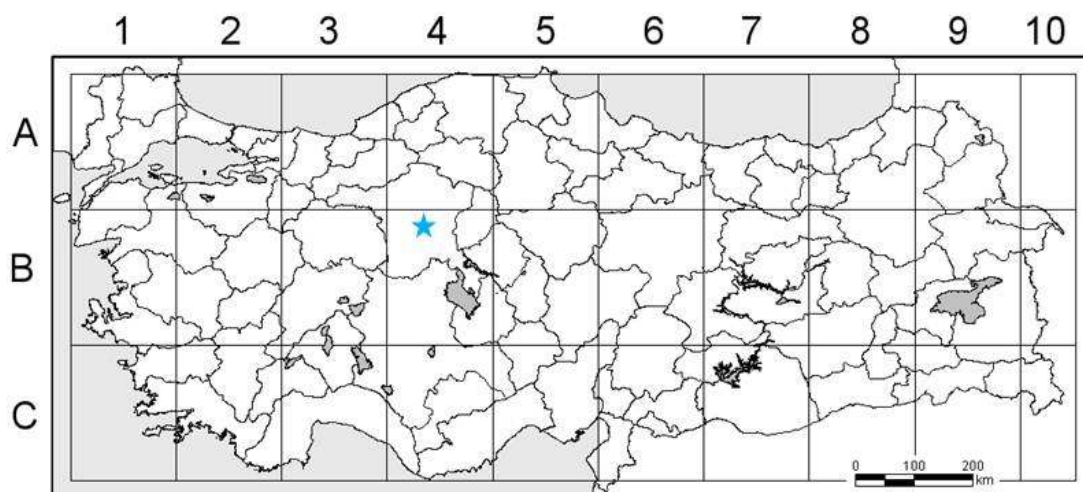


Figure 121. Distribution of *T. clusiana* in Turkey (blue star represents naturalised area in Turkey).



Figure 122. Habit of *T. clusiana*.



Figure 123. The flower of *T. clusiana* from the exterior.



Figure 124. The flower of *T. clusiana* from the interior.

Pollen morphology: Pollen grains trisulcate, ellipsoid-spheroidal in polar view. Long axis 47.5-62.5 μm and short axis 38.75-57.5 μm . Exine 1.5-2.5 μm thick. Exine surface (exine pattern) perforate (LM). Intine bi-layered: outer intine 0.6-1.5 μm and inner intine 0.5-0.75 μm in thickness. Outer intine thicker in aperture (sulci) region, up to 3 μm . The exine plate extends irregularly towards the aperture. Surface of sulcus membrane granular (Figure 125).

Specimens examined: B4 Ankara: Eker 1841.



Figure 125. LM images of *T. clusiana* (Eker 1841) - a. Trisulcate pollen grain in equatorial view, b. Perforate exine (exine pattern) in polar view, c. Pollen wall in optical section: exine (black arrow), outer and inner intine (white arrow).

Chromosome number: $2n=60$.

Specimens examined: B4 Ankara: Eker 1841 ($2n=60$, Figure 126).



Figure 126. Somatic chromosome number of *T. clusiana* (pentaploid, Eker 1841).

Notes: There is a doubtful record of *T. clusiana* in West Anatolia. Although all of comprehensive studies in the region between 2008-2009, these populations could not find. The one collection in *Flora of Turkey and East Aegean Islands* is recorded as İzmir/near Kurutepe. The current name of Kurutepe is Laletepe. But, any track of this species could not found neither in previous collection region nor West Anatolia.

3.5. Results of Numerical Analyses

In the numerical evaluation of taxa, principle component and cluster analyses are used to analyse the variation of 38 morphological characters measured for 60 OTUs. The character states are listed in Table 18.

In PCA analyses, both components 1 and 2 gave a good result which contained 89.392% of the variations (Table 19). Therefore, only these two components are graphed as a result of PCA (Figure 127) and interpreted.

In PCA graph, the populations of both subgenera *Eriostemon* and *Tulipa* were separated as two big groups (Figure 127). But *T. clusiana* was far from both groups as being between these groups. On the other hand, this taxon was closer to subgenus *Tulipa* group (Figure 128) in the three-dimensional graph type of same data using SPSS program. The populations of subgenus *Eriostemon* group were fairly located. In this group, populations of sections *Sylvestres* and *Biflores* mixed to each other. For this reason, only the populations of these two sections were run for PCA analysis separately from the other taxa using MINITAB program (Figure 129). In this situation, both sections were clearly separated from each other. Moreover, *T. koyuncui* took place quite far from these two taxa in the graph (Figure 129). *T. sylvestris*, and *T. biflora* were also clearly separated each other. The populations of *T. orphanidea* were located on quite different part from those of its traditional group, section *Sylvestres*. It was located between *T. cinnabarina* and *T. pulchella* in the section *Saxatiles*. *T. humilis*, *T. saxatilis*, *T. orphanidea*, *T. cinnabarina* and *T. pulchella* were absolutely not mixed each other. However, *T. saxatilis* was located far from the other taxa in the same section according to PCA results.

Many populations of subgenus *Tulipa* formed a complex group in PCA (Figure 127) and *T. agenensis* and *T. praecox* were not located inside the complex group.

Therefore, populations of this group were separately analysed from the other taxa observing their distinctions in PCA (Figure 130). In this graph, separation of *T. undulatifolia* and *T. sintenisii* from the complex were seen clearly. Nevertheless, *T. gumusanica* did not show a distinction from the *T. armena* populations. *T. julia* has distributed at vicinity of *T. armena* populations. On the other hand, two populations of *T. alepensis* took place nearer to complex group, but they were separated from its third population which was on the side of *T. sintenisii* populations.

The results of cluster analysis can be determined as follows (Figure 131): All the clusters were generated between 33.51-100.00% similarity levels. At 98.41% similarity level (SL), AG1 & AG3, and AG2 & AG4 were generated as the first clusters that they are completely the same with each others. But AG5 population showed some differences which was joined to the AG populations at 96.03% SL. Therefore, all AG populations were placed in the same cluster. AR1 & AR11, AR3 & AR5 & AR6 generated two different clusters at 98.41% SL. Other AR populations showed different clusters at different SLs. AR9 & AR10 joined to each other at 100.00 SL. AR2 linked to AR9-AR10 cluster at 98.41% SL. On the other hand, AR12 & JU5 and AR13 & GU1 formed two different clusters at 95.24% SL. AR8 linked to AR13-GU1 cluster at 98.41% SL. JU5-AR12 group also linked to AR2-AR9-AR10 cluster at 96.56% SL. Populations AR7 & AL1 also joined to each other at 98.41% SL. As JU3 & JU4 were generated a single cluster at 100.00 SL, AL2 linked to this group at 98.41% SL.

The group of AR7-AL1-AL2-JU3-JU4 combined to group of AR1-AR11-AR3-AR5-AR6 at 96.56% SL. At the same time the groups of JU5-AR12-AR2-AR9-AR10 and AR8-AR13-GU1 were also combined to each other. The homogenous cluster of AR group (AR1-AR11-AR3-AR5-AR6) and heterogenous group of AR7-

AL1-AL2-JU3-JU4 linked to each other at 96.56% SL, and the heterogenous groups of JU5-AR12-AR2-AR9-AR10 and AR8-AR13-GU1 also linked to each other at 95.24% SL. Finally, these two groups, AR1-AR11-AR3-AR5-AR6-AR7-AL1-AL2-JU3-JU4 and JU5-AR12-AR2-AR9-AR10-AR8-AR13-GU1 combined with each other at 94.44% SL which can be called as AR complex group (AR-AL-JU-GU heterogenous group). After populations of JU1 & JU2 joined to each other at 100.00% SL, they linked to AR complex group at 92.77% SL. Additionally, the AR4 population which remained alone was also merged to this big AR complex group at 91.90% SL. This big AR complex group and AG homogenous group (AG1-AG3-AG2-AG4-AG5) generated a big subgroup (SG-I) at 89.81% SL (Figure 131).

Another subgroup (SG-II) contained the heterogenous clusters as well. In this subgroup, as SG-II, PR1 & PR2 were combining to each other at 98.41% SL, firstly SI1 population linked to this group at 94.48% SL, secondly AL3 merged to PR1-PR2-SI1 group at 92.06% SL. The SI2 & SI4 generated a single group at 98.41% SL and later at 92.86% SL, SI3 joined to this group and they generated a small homogenous group. Finally the groups of AL3-PR1-PR2-SI1 and SI2-SI4-SI3 linked to each other at 89.71% SL (Figure 131).

SG-II merged to the first subgroup (SG-I) at 86.25% SL. On the other hand, UN1 & UN3 joined to each other and generated another nucleus cluster at 100.00% SL. At the same time UN2 & UN4 also joined at 90.48% SL. Then these two groups linked to each other at 85.71% SL and generated the third subgroup (SG-III). This SG-III linked to the clusters of SG-I and SG-II at 81.65% SL. Finally, another subgroup (SG-IV) containing only a single population of CL1 joined to the clusters of subgroups (SG-I, SG-II, and SG-III) at 48.26% SL. Consequently, the first main

group (MG1) that was the representative of Subgenus *Tulipa* was generated (Figure 131).

The second main group (MG2) contained a very few problems and produced more or less homogenous subgroups. First of all, there were two nuclei clusters at 100.00% SL which were HU2 & HU3, and SY1 & SY5. Then HU1 joined to this first cluster at 98.41% SL. Secondly, the PU2 and PU4 linked to each other at 98.41% SL and then PU3 joined to this group and PU1 linked to the group of PU2-PU4-PU3 at 97.62% SL and 96.30% SL respectively. Populations of OR1 & OR3 linked to each other at 92.06% SL and OR2 joined to this group at 88.10 SL. Later, the unique population of CI1 linked to this OR1-OR3-OR2 group at 76.19 SL. Then the two groups, HU1-HU2-HU3-PU1-PU2-PU4-PU3 and CI1-OR1-OR3-OR2 combined with each other at 68.42% SL. Finally an unique population of SA1 also linked to this homogenous group at 62.48 SL and the fifth subgroup (SG-V) was generated (Figure 131).

SY1 & SY5 generated a nucleus cluster at 100.00% SL. Later both SY4 & SY6 joined each other and SY3 merged into the first nucleus group (SY1-SY5) at 98.41% SLs. Then these two clusters, which are SY1-SY5-SY3 and SY4-SY6 combined to each other at 96.51% SL. Then, SY2 linked to this group and SY7 also joined this group, SY1-SY5-SY3-SY4-SY6-SY2 at 94.92% SL and 88.36% SL respectively. As a result, these populations were generated a big homogenous cluster. On the other hand, BI1 & BI2 joined to each other at 98.41% SL, and then unique population of KO1, which is a new species, also joined to BI1-B2 group at low similarity level, such as 81.75% SL. Finally, these two homogenous groups, BI1-BI2-KO1 and SY1-SY5-SY3-SY4-SY6-SY2-SY7 linked to one another at 70.82% SL. Consequently they formed the last subgroup, SG-VI (Figure 131).

As a final result of the cluster analysis, SG-V and SG-VI linked to one another and then generated the second main group, MG2 at 52.20% SL. Consequently, this main group comprised the members of Subgenus *Eriostemon* (Figure 131).

Table 18. Selected characters and character states used in principal component and cluster analyses.

Ch OTUs	CHARACTERS AND CHARACTER STATES																																						
	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32	33	34	35	36	37	38	
	S P	E S	T T	T C	TT H	OH M	LL T	LL U	SLL T	SLL U	FS	B C	COTI S	COTO S	SO T	TO T	OTT P	CITI S	CITO S	SI T	TI T	ITMP B	FC	PF B	A C	LOT/ BLO T	LOT / WO T	LOT / LIT	WOT / WIT	LIT/ BLI T	LIF / LA	LOF / LA	WL L	WSL L	LO T	WO T	LA	W A	
AG1	0	1	0	0	1	2	0	1	0	1	0	2	4	5	2	1	1	4	5	0	0	0	2	0	1	1	0	2	2	1	0	0	1	1	1	1	1	2	1
AG2	0	1	0	0	1	2	0	1	0	1	0	2	4	5	2	1	1	4	5	0	0	0	2	0	1	1	0	2	2	1	0	0	1	1	1	1	2	2	1
AG3	0	1	0	0	1	2	0	1	0	1	0	2	4	5	2	1	1	4	5	0	0	0	2	0	1	1	0	2	2	1	0	0	1	1	1	1	1	2	1
AG4	0	1	0	0	1	2	0	1	0	1	0	2	4	5	2	1	1	4	5	0	0	0	2	0	1	1	0	2	2	1	0	0	1	1	1	1	2	2	1
AG5	0	1	0	0	1	2	0	1	0	1	0	2	4	5	2	1	1	4	5	0	0	0	2	0	1	1	0	2	2	1	0	0	1	1	1	2	2	3	1
AL1	0	1	0	0	1	2	0	1	0	1	0	2	4	5	2	1	1	4	5	0	0	0	2	0	1	3	0	2	2	2	0	0	1	1	1	1	2	2	1
AL2	0	1	0	0	1	2	0	1	0	1	0	2	4	5	2	1	1	4	5	0	0	0	2	0	1	3	0	2	2	2	0	0	1	1	1	1	1	2	1
AL3	0	2	0	0	1	2	0	1	0	1	0	2	4	5	2	1	1	4	5	0	0	0	2	0	1	3	0	2	2	2	0	0	2	2	1	3	3	1	
AR1	0	0	0	0	0	1	0	1	0	1	0	2	4	5	2	1	1	4	5	0	0	0	2	0	1	3	0	2	2	2	0	0	1	1	1	1	2	1	
AR2	0	0	0	0	0	2	0	1	0	1	0	2	4	5	2	0	1	4	5	0	0	0	2	0	1	2	0	2	2	2	0	0	1	1	1	1	1	2	1
AR3	0	0	0	0	0	2	0	1	0	1	0	2	4	5	2	1	1	4	5	0	0	0	2	0	1	3	0	2	2	2	0	0	1	1	1	1	1	2	1
AR4	0	0	0	0	0	2	0	1	0	1	0	2	4	5	2	1	1	4	5	0	0	0	2	0	1	3	0	2	2	2	0	0	2	2	1	1	3	1	
AR5	0	0	0	0	0	2	0	1	0	1	0	2	4	5	2	1	1	4	5	0	0	0	2	0	1	3	0	2	2	2	0	0	1	1	1	1	2	1	
AR6	0	0	0	0	0	2	0	1	0	1	0	2	4	5	2	1	1	4	5	0	0	0	2	0	1	3	0	2	2	2	0	0	1	1	1	1	2	1	
AR7	0	0	0	0	0	2	0	1	0	1	0	2	4	5	2	0	1	4	5	0	0	0	2	0	1	3	0	2	2	2	0	0	1	1	1	1	2	2	1
AR8	0	0	0	0	0	1	0	1	0	1	0	2	4	5	2	0	1	4	5	0	0	0	2	0	1	3	0	2	2	2	0	0	1	1	1	1	2	2	1
AR9	0	0	0	0	0	1	0	1	0	1	0	2	4	5	2	0	1	4	5	0	0	0	2	0	1	2	0	2	2	2	0	0	1	1	1	1	1	2	1
AR10	0	0	0	0	0	1	0	1	0	1	0	2	4	5	2	0	1	4	5	0	0	0	2	0	1	2	0	2	2	2	0	0	1	1	1	1	1	2	1
AR11	0	0	0	0	0	1	0	1	0	1	0	2	4	5	2	1	1	4	5	0	0	0	2	0	1	3	0	2	2	2	0	0	1	1	1	1	1	2	1
AR12	0	0	0	0	0	2	0	1	0	1	0	2	4	5	2	0	1	4	5	0	0	0	2	0	1	2	0	2	2	2	0	0	1	1	1	1	2	2	1
AR13	0	0	0	0	0	1	0	1	0	1	0	2	4	5	2	1	1	4	5	0	0	0	2	0	2	3	0	2	2	2	0	0	1	1	1	1	2	2	1
CL1	0	2	1	1	0	1	0	1	0	1	0	3	0	1	1	1	1	0	0	0	0	0	1	0	1	2	1	2	2	2	0	0	0	0	0	1	0	2	0
GU1	0	0	0	0	0	1	0	1	0	1	0	2	4	5	2	0	1	4	5	0	0	0	2	0	2	3	0	2	2	2	0	0	1	1	1	1	2	2	1
JU1	0	0	0	0	1	2	0	1	0	1	0	2	4	5	3	0	1	4	5	0	0	0	2	0	1	3	0	2	2	2	0	0	1	0	1	1	1	2	1
JU2	0	0	0	0	1	2	0	1	0	1	0	2	4	5	3	0	1	4	5	0	0	0	2	0	1	3	0	2	2	2	0	0	1	0	1	1	1	2	1
JU3	0	0	0	0	1	2	0	1	0	1	0	2	4	5	2	1	1	4	5	0	0	0	2	0	1	3	0	2	2	2	0	0	1	1	1	1	2	2	1
JU4	0	0	0	0	1	2	0	1	0	1	0	2	4	5	2	1	1	4	5	0	0	0	2	0	1	3	0	2	2	2	0	0	1	1	1	1	1	2	1
JU5	0	0	0	0	1	2	0	1	0	1	0	2	4	5	2	1	1	4	5	0	0	0	2	0	1	3	0	2	2	2	0	0	1	1	1	1	1	2	1
PR1	0	2	0	0	1	2	0	1	0	1	0	2	4	5	2	1	1	4	5	0	0	0	2	0	1	1	0	2	2	1	0	0	2	2	2	3	3	1	
PR2	0	2	0	0	1	2	0	1	0	1	0	2	4	5	2	1	1	4	5	0	0	0	2	0	1	1	0	2	2	1	0	0	2	2	2	2	3	1	
SI1	0	2	0	0	0	1	0	1	0	1	0	2	4	5	2	1	1	4	5	0	0	0	2	0	1	2	0	2	2	1	0	0	2	2	2	2	3	1	
SI2	0	2	0	0	0	1	0	1	0	1	0	2	4	5	2	1	1	4	5	0	0	0	2	0	1	3	0	2	2	2	0	0	1	1	1	1	2	3	1
SI3	0	2	0	0	0	1	0	1	0	1	0	2	4	5	2	1	1	4	5	0	0	0	2	0	1	3	1	2	2	2	0	0	2	2	2	1	3	1	
SI4	0	2	0	0	0	1	0	1	0	1	0	2	4	5	2	1	1	4	5	0	0	0	2	0	1	3	0	2	2	2	0	0	1	1	2	2	3	1	
UN1	2	1	0	0	0	0	0	1	0	1	0	2	4	5	2	1	1	4	5	0	0	0	2	0	1	3	0	1	1	2	0	0	2	2	3	2	3	1	
UN2	2	1	0	0	0	1	0	1	0	1	0	2	4	5	2	1	1	4	5	0	0	0	2	0	1	3	0	1	1	2	0	0	0	0	0	1	1	2	0
UN3	2	1	0	0	0	0	0	1	0	1	0	2	4	5	2	1	1	4	5	0	0	0	2	0	1	3	0	1	1	2	0	0	2	2	3	2	3	1	
UN4	1	1	0	0	0	0	0	1	0	1	0	2	4	5	2	1	1	4	5	0	0	0	2	0	1	2	0	1	1	2	0	0	1	1	1	1	2	1	
BI1	0	0	0	0	1	2	1	0	1	0	1	1	0	0	0	1	0	0	0	1	1	1	0	1	0	1	1	1	0	1	2	3	0	0	0	0	0	0	0
BI2	0	0	0	0	1	2	1	0	1	0	1	1	0	0	0	1	0	0	0	1	1	1	0	1	0	1	1	1	0	1	2	3	0	0	0	0	0	0	0
CI1	0	2	1	0	0	0	1	0	1	0	1	1	4	5	1	0	1	4	5	0	0	1	0	1	1	3	1	1	1	2									

OR3	0	1	2	1	0	0	1	0	1	0	1	4	4	5	1	1	1	4	5	0	1	0	2	1	1	1	1	1	1	1	1	1	0	0	1	0	2	1
PU1	0	0	2	1	0	0	1	0	1	0	1	5	3	4	0	0	1	3	4	0	0	1	3	1	1	2	1	1	1	2	1	2	0	0	1	0	1	0
PU2	0	0	2	1	0	0	1	0	1	0	1	5	3	4	0	0	1	3	4	0	0	1	3	1	1	2	1	1	0	2	1	1	0	0	0	0	1	0
PU3	0	0	2	1	0	0	1	0	1	0	1	5	3	4	0	0	1	3	4	0	0	1	3	1	1	2	1	1	0	2	1	1	0	0	1	0	1	0
PU4	0	0	2	1	0	0	1	0	1	0	1	5	3	4	0	0	1	3	4	0	0	1	3	1	1	2	1	1	0	2	1	2	0	0	0	0	1	0
SA1	0	2	1	1	0	0	1	0	1	0	1	1	3	4	1	1	1	3	4	1	2	1	0	1	0	1	1	0	0	1	1	1	2	1	1	1	2	1
SY1	0	1	1	0	0	0	1	0	1	0	1	0	1	2	1	1	0	1	2	1	2	1	0	1	0	0	1	1	0	0	1	1	0	0	1	0	1	0
SY2	0	1	1	0	0	0	1	0	1	0	1	0	1	2	1	1	0	1	2	1	2	1	0	1	0	0	1	1	0	0	1	1	0	0	1	0	2	1
SY3	0	1	1	0	0	0	1	0	1	0	1	0	1	2	0	1	0	1	2	1	2	1	0	1	0	0	1	1	0	0	1	1	0	0	1	0	1	0
SY4	0	1	1	0	0	0	1	0	1	0	1	0	1	2	0	1	0	1	2	1	2	1	0	1	0	0	1	1	0	0	1	2	0	0	1	0	1	0
SY5	0	1	1	0	0	0	1	0	1	0	1	0	1	2	1	1	0	1	2	1	2	1	0	1	0	0	1	1	0	0	1	1	0	0	1	0	1	0
SY6	0	1	1	0	0	0	1	0	1	0	1	0	1	2	0	1	0	1	2	1	2	1	0	1	0	0	1	1	0	0	1	2	0	0	0	0	1	0
SY7	0	2	1	0	0	0	1	0	1	0	1	0	1	2	1	1	0	1	2	1	2	1	0	1	0	0	1	1	0	0	2	3	1	1	1	0	1	1

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Table 19. Total variance explained in PCA.

Component	Total	% of Variance	Cumulative %
1	80,087	82,083	82,083
2	7,13	7,308	89,392
3	3,25	3,331	92,723
4	1,867	1,913	94,636
5	1,302	1,335	95,971
6	0,778	0,797	96,768

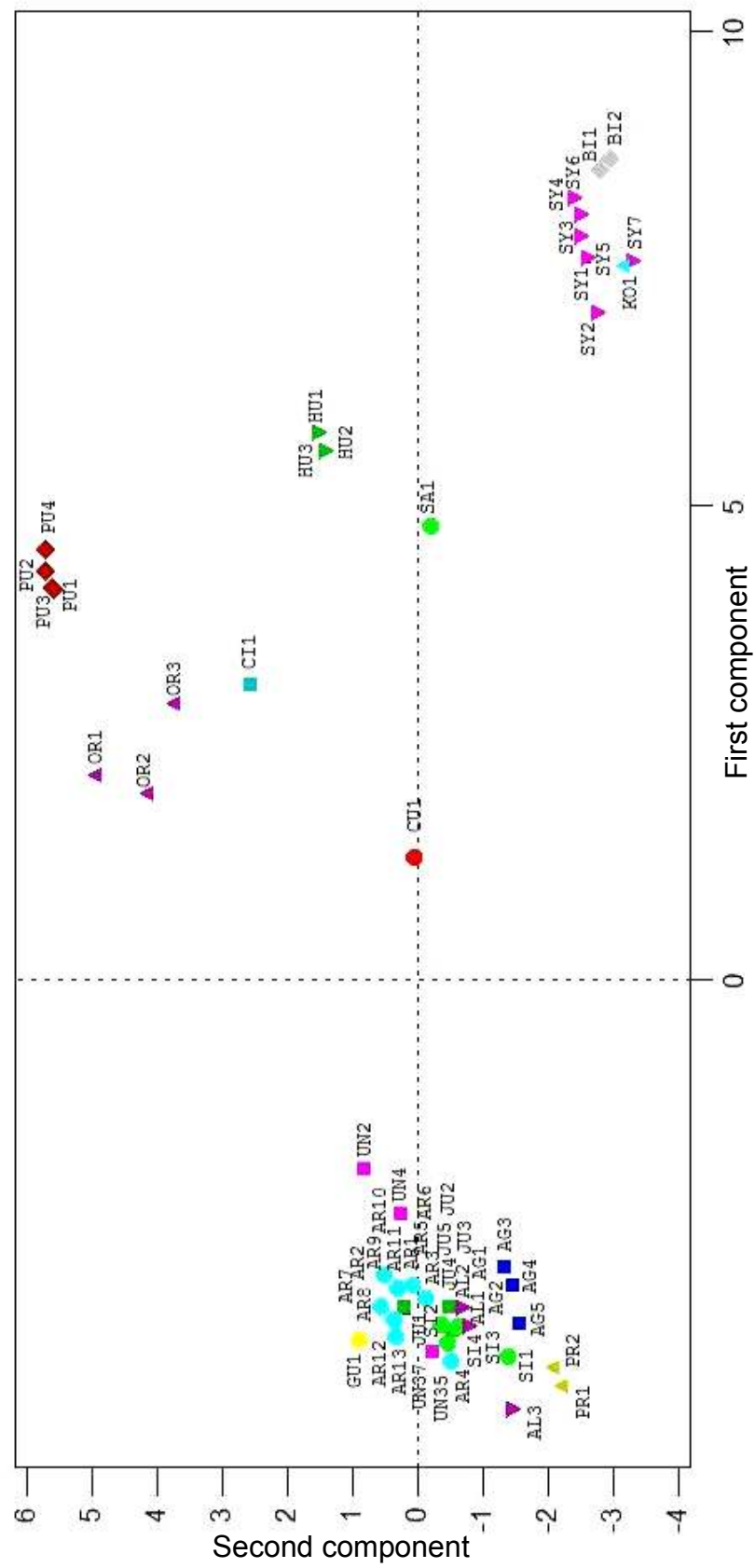


Figure 127. The results of principle component analysis of all taxa.

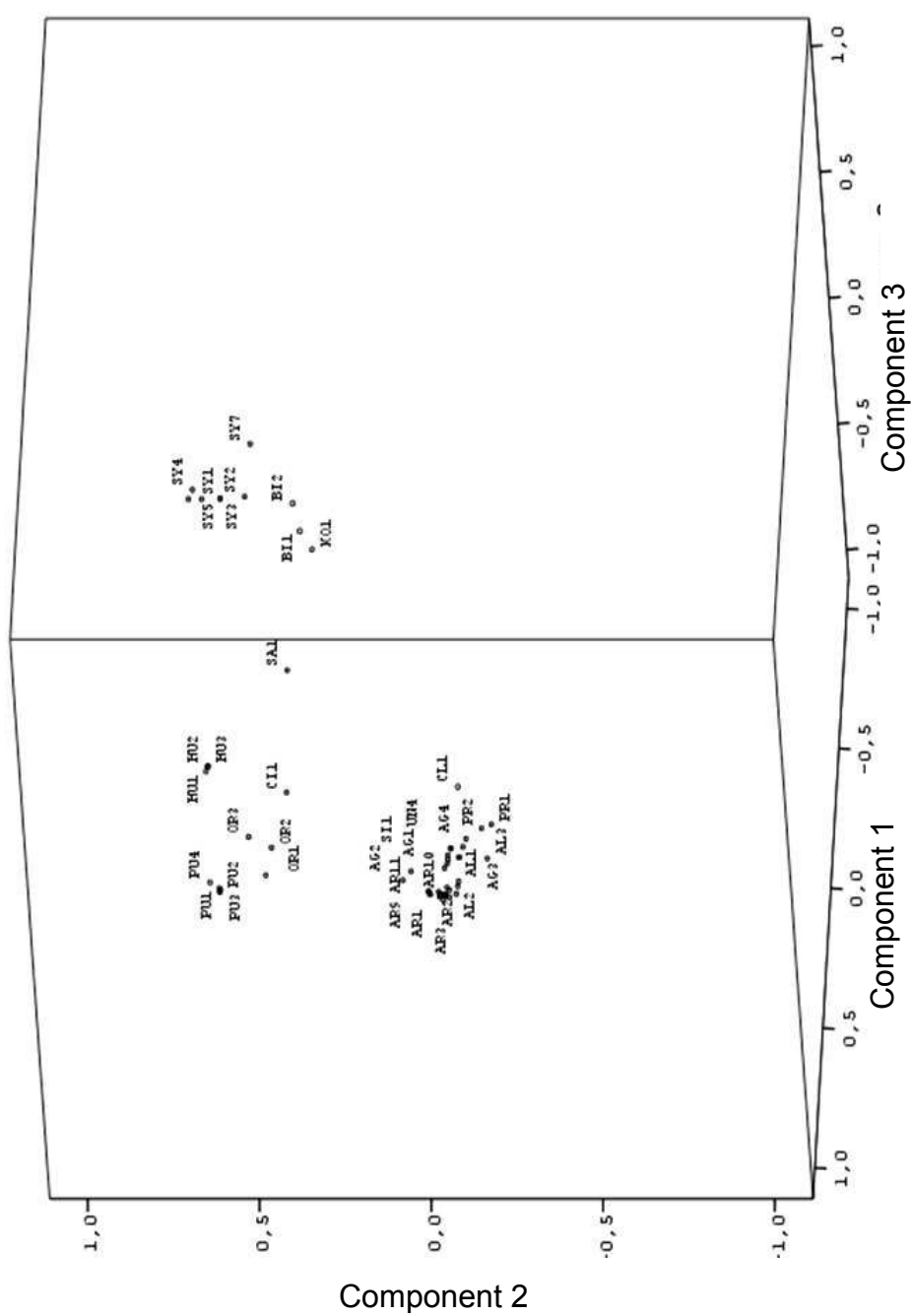


Figure 128. The 3D results of principle component analysis of taxa.

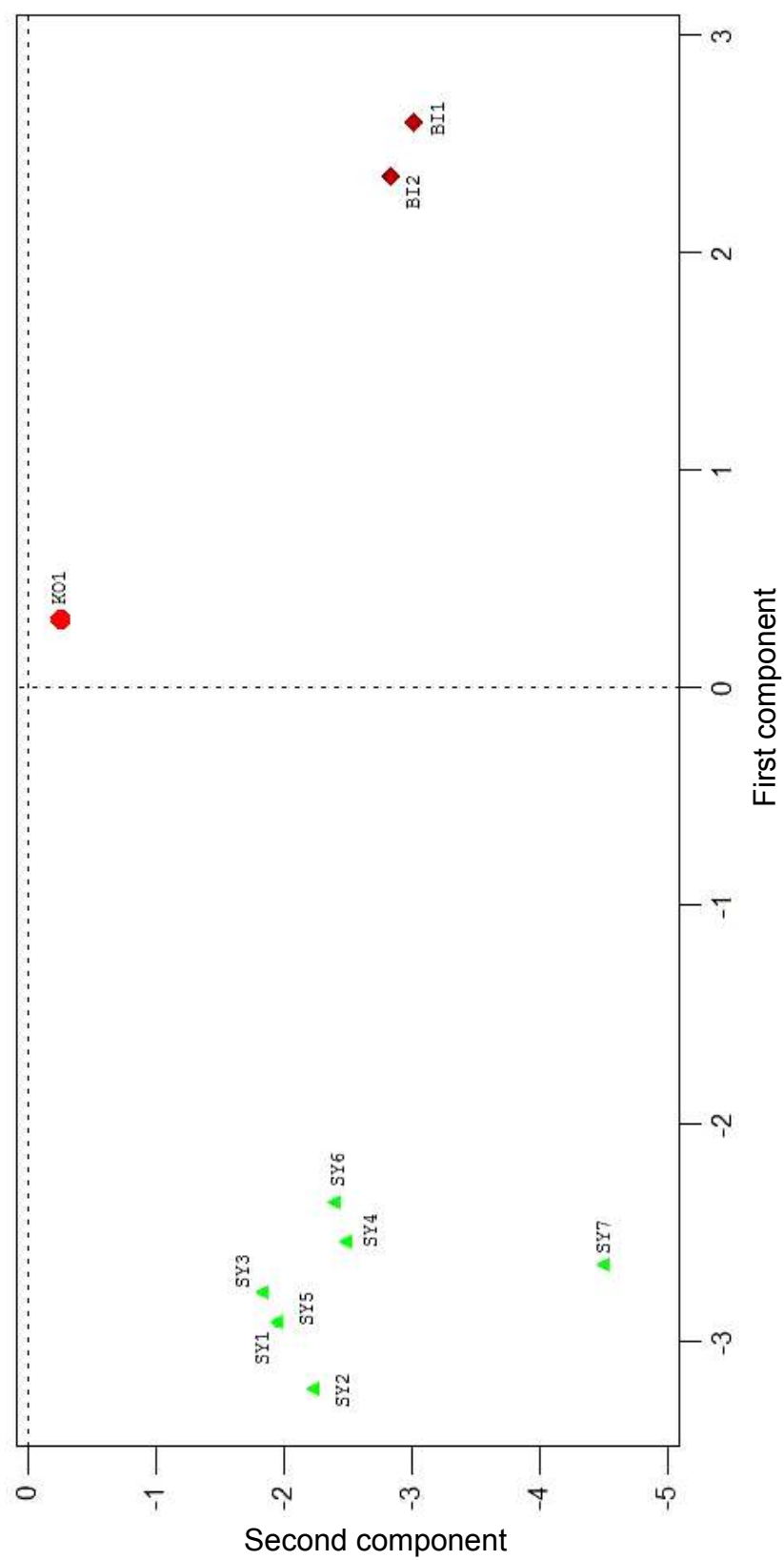


Figure 129. The results of principle component analysis of sections *Sylvestres* and *Biflores*.

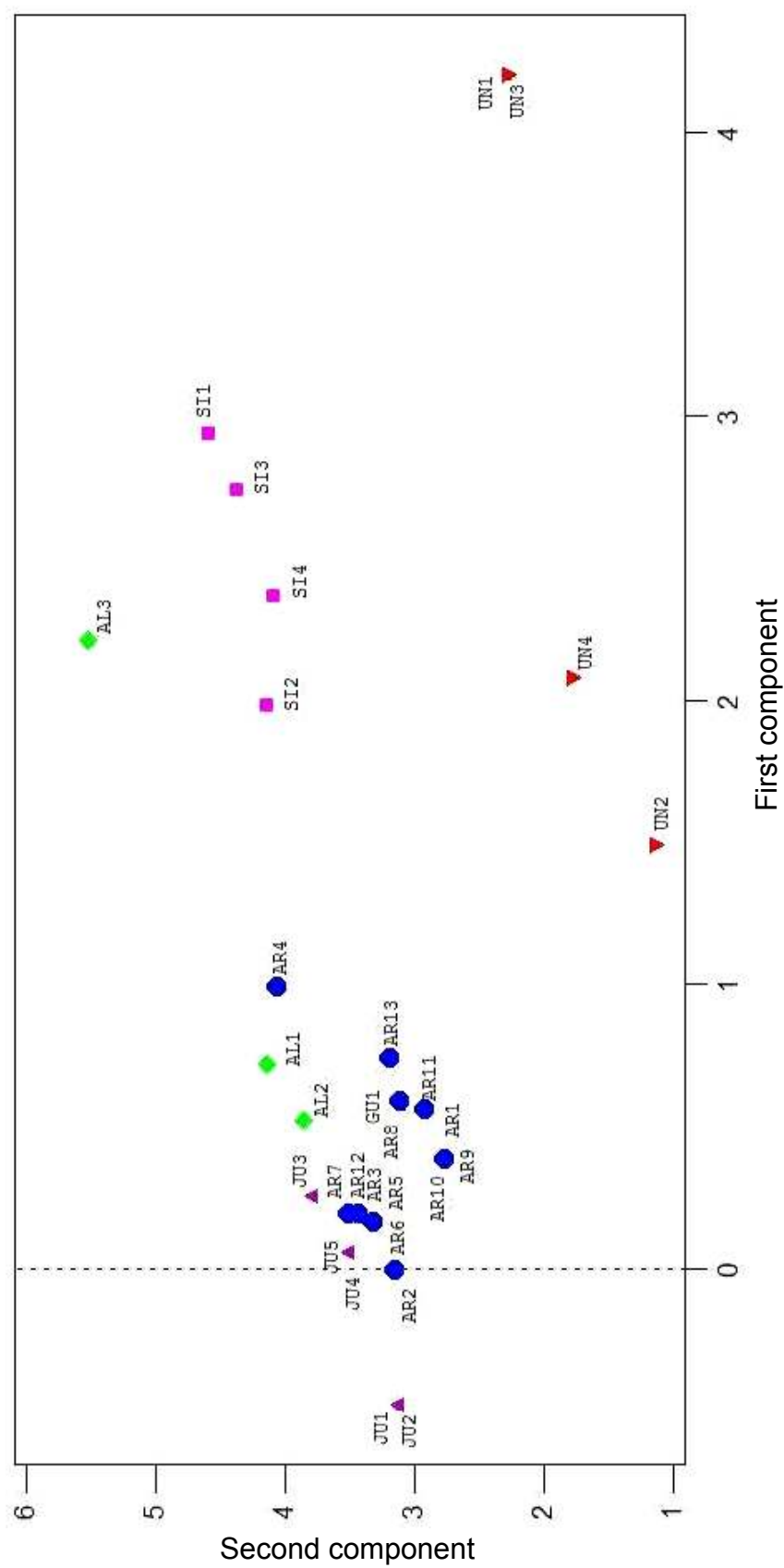


Figure 130. The results of principle component analysis of the complex group in subgenus *Tulipa*.

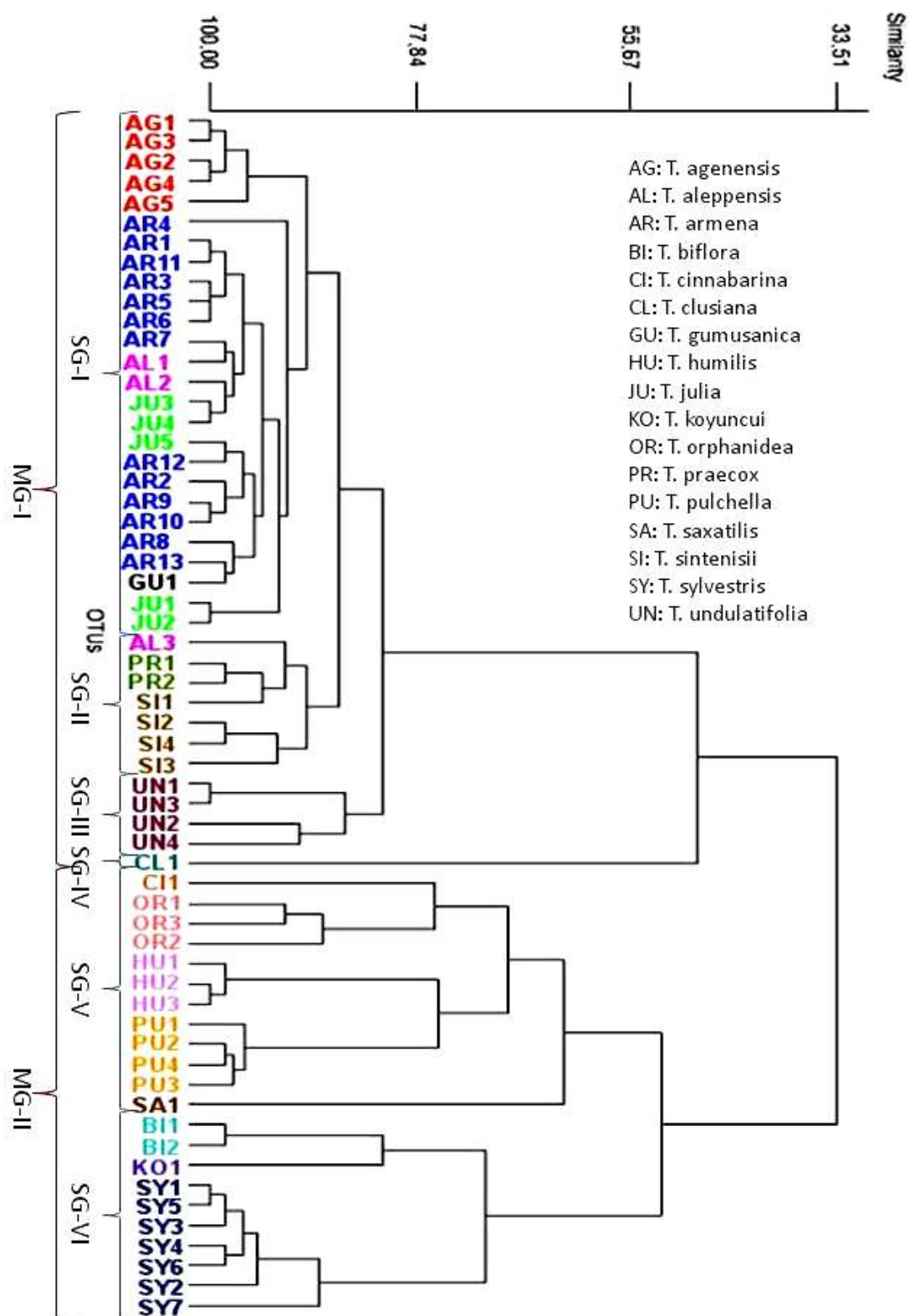


Figure 131. Dendrogram of average linkage (between groups) hierarchical cluster analysis of 60 populations (OTUs) using Manhattan block distance.

CHAPTER 4. DISCUSSION

Tulips are one of the taxonomically complex genera in the world. In “*The Tulip*”, Pavord (1999) put it another way: “*Tulips laugh at taxonomy*” while Vvedensky (1935) wrote “*Study of the genus Tulipa is beset with exceptionally great obstacles*” in “*Flora of USSR*”. If so, why is the classification of tulips so difficult? For one reason, many of them grow in inhospitable places, in remote hills and valleys, where winters are harsh and summers long and dry. There they may only flower for a short period before retreating underground. If you visit at the wrong time you will miss them. Local botanists will have a through knowledge of their own country’s flora, but to get overall impression of a species or group of closely related species, you need a broad view, not easy when one species may be found over a wide area, covering several countries (Wilford, 2006).

The Floras do not mostly agree about the delimitations of the taxa belonging to the different taxonomic levels. The accounts in *Flora Europaea* and *Flora of Turkey* take a broad view of the species. For example, they treat *Tulipa orphanidea* as a variable tulip covering a range of forms previously described as individual species, such as *T. hageri*, *T. bithynica*, and *T. whittallii*. *Flora Iranica* shows a different view, often recognizing a range of similar species, varying only slightly from each other. For example, it recognizes *T. aitchisonii*, *T. oreophila*, *T. stellata*, *T. grey-wilsonii*, and *T. clusiana*, which could all be regarded as variants of one species, *T. clusiana* (Wilford, 2006).

The essential problem in tulip taxonomy in the world is previous studies have been mainly performed on many herbarium specimens and commercial stocks. Hall, is the author of “*The Genus Tulipa*”, emphasized the need to study living tulips rather than herbarium specimens, where essential characteristics can be hidden or lost (Hall, 1940). However, gradual variations within and between populations cause confusing of them with each other. Dry materials complicate to see these variations.

Wilford wrote in his book that “...., commercial stocks did not show the full range of variation of many species and often only one clone was, and still is, in cultivation. Furthermore, tulips can change in cultivation, producing larger flowers or sometimes more leaves than would normally be found in the wild” (Wilford, 2006).

Taxonomical problems of the genus *Tulipa* are not only for Turkish species but also for all of species in the world. Using dry herbarium specimens and commercial stocks in previous studies were common and this situation can cause some confusions in colour, shape, size of different plant parts, and range of variations.

Many measured and observed characters in the genus *Tulipa* show considerable overlap in the ranges per species. Therefore, codifying quantitative characters into discrete ordinal character states is a big problem for numerical analyses. So those, 1/3 of measured morphological character only were able to codified in this study.

To avoid some of the problems mentioned above and to solve taxonomical problems of taxa, natural and fresh materials were mainly used. Also, geographical distributions and population conditions of species were examined in detail meticulously to understand the spectrum of exact variations and limitation of the variations.

Traditionally, the genus *Tulipa* was divided into two sections: *Tulipa* (syn.: *Leiostemones*) and *Eriostemones*. Van Raamsdonk and de Vries (1992, 1995) raised

up these sections to subgenera. They obtained 35 morphological characters in section *Eriostemon* and 34 in section *Tulipa*. They included flowering time; height of plants; hairiness of stems, leaves, tepals and bulb tunic; dimension of the stems, tepals, and stamens; colour of anthers; and the occurrences of a blotch in the flower. They also considered geography and polyploidy for devising their classification. Not every known species was studied but most of those in general cultivation were included (Raamsdonk & Vries, 1992, 1995; Wilford, 2006) as well.

The recent study on tulip taxonomy has been based on mainly nuclear genome sizes and evaluated in combination with available morphological, geographical, and molecular data by Zonneveld (2009). In this study, all tulips have been classified into four subgenera: *Clusianae*, *Tulipa*, *Eriostemon*, and *Orithya* and divided further into 12 sections.

In this revision, the Turkish genus *Tulipa* is divided into two subgenera such as *Eriostemon* (Boiss.) Raamsd. and *Tulipa* according to the detailed morphological, palynological and cytotaxonomical studies. These two taxa were previously used as sections by Marais (1984) in “Flora of Turkey”. In this study, the classification system of van Raamsdonk and de Vries (1992, 1995) were adopted here and it was also strongly supported by our traditional and numerical taxonomic analyses and palynomorphological results. Zonneveld (2009) placed *T. clusiana* in a separate subgenus, *Clusianae*. He distinguished this taxon from the remaining tulips according to its low amount of DNA-32 pg instead of 36-69 pg for the other tulips. Moreover, meiosis takes place at the beginning of spring in March, contrasting to other species of *Tulipa* where it occurs in the period of September-November. The results of PCA and cluster analyses indicated two big groups around 33.51% similarity level, subgenera *Eriostemon* and *Tulipa*, and also *T. clusiana* was linked

to subgenus *Tulipa* as a single population. This result supported the classification of Zonnevald (2009). Therefore, in this revision it was also accepted a monotypic section *Clusianae* Baker with a single species of *T. clusiana*, in sensu Zonnevald.

Morphologically, the occurrence of hairs at filament base are basic to separate the subgenera. Subgenus *Eriostemon*es with hairy filament base is different than subgenus *Tulipa* which has glabrous filament base. The other differences between both subgenera are listed in table 20.

Table 20. Differences between subgenera *Eriostemon*es and *Tulipa*.

Subgenus <i>Eriostemon</i> es	Subgenus <i>Tulipa</i>
Hairy and swollen filaments (except <i>T. sprengeri</i>)	Glabrous filaments without swollen
The outer three filaments are shorter than the inner three	All filaments about the same length
Outer perianth segments narrower and/or shorter than inner ones	Outer perianth segments longer and wider than inner ones (except <i>T. undulatifolia</i>)
Lowest leaf long $\pm$ parallel-sided	Lowest leaf lanceolate or oblong-lanceolate, not parallel-sided
Young flower or bud infundibular or $\pm$ globose above the narrow, constricted base. In the sun the flowers open wide to form a star	Young flowers campanulate to globular or stellate, rounded at base
Multi-flowered plants are common in this subgenus.	Flower solitary
Stigma small and narrow	Stigma generally wide

Palynologically, pollen grains in the subgenus *Eriostemon*es are homogenously monosulcate while those in the subgenus *Tulipa* are predominantly trisulcate. In addition to trisulcate pollen, other aperture types have been recorded in some taxa of the latter; tetrasulcate (*T. armena*, *T. undulatifolia*), pentasulcate (*T. armena*), inaperturate (*T. armena* var. *galatica* = *T. gumusanica*, *T. aleppensis*) and two-aperturate (with pores like apertures, *T. aleppensis*). The subgenus *Eriostemon*es

characterised by monosulcate pollen can be distinguished from the subgenus *Tulipa* with respect to aperture type. This palynomorphological results are in agreement of the subgenera. All of palynomorphological measurements and observations of this research are listed in Appendix 2. Moreover, similar results are seen in Kosenko's palynomorphological studies about the family Liliaceae, especially in Caucasus and Central Asia species. Kosenko's studies support two separate subgenera for tulips as in our palynomorphological results (Kosenko, 1991, 1992, 1999).

The taxa in subgenus *Eriostemones* were clearly separated in principal component and cluster analyses. The results suggested that three of them were the sections already described by several taxonomists (Baker, 1874, 1883; Hall, 1940): *Sylvestres* (Baker) Baker, *Saxatiles* (Baker) Baker, and *Biflores* sensu A. D. Hall. However, two of them were new sections which were described in this revision: *Orphanideae* Eker & Babaç and *Humiles* Eker & Babaç. Taxonomic evidences obtained from the PCA and cluster analysis have also supported the traditional taxonomic studies. The reasons of placing these two taxa into their own sections and differences between the traditional sections were given in Table 21.

Table 21. Differences between sections of subgenus *Eriostemones*.

Section <i>Sylvestres</i> (Baker) Baker Flowers range from pale yellow to bright, golden yellow. Tunics with a ring of short hairs around basal plate and adpressed, bristly hairy at neck, middle part glabrous.
Section <i>Orphanideae</i> Eker & Babaç <i>sect. nov.</i> Flowers range from mandarin red to orange, brownish-red. This section includes some specimens (<i>T. orphanidae</i>) or taxon (<i>T. sprengeri</i> , in some cases may only be abnormal forms of species with otherwise hairy filaments) with glabrous filament base.
Section <i>Saxatiles</i> (Baker) Baker Flowers pinkish-purple with a yellow blotch. Lowest leaf shiny green, more than 2.5 cm in width.
Section <i>Humiles</i> Eker & Babaç <i>sect. nov.</i> Flowers in shades of mauve, pink, purple, magenta or pinkish-white with a yellow or bicolored blotch. Lowest leaf glaucous, less than 1.5 cm in width.
Section <i>Biflores</i> sensu A. D. Hall Produce many flowers from one bulb, up to twelve. Flowers small and yellow, or white with a yellow blotch of varying size. Tunic densely, lanate hairy.

T. sylvestris can be found in diploid, triploid or tetraploid forms. Diploid forms are named subsp. *australis* and triploid and tetraploid forms are named subsp. *sylvestris* (Grey-Wilson & Matthews, 1980; Wilford, 2006). The results of traditional, numerical taxonomic analyses and chromosome studies carried out in this research have supported these cytotaxonomic studies mentioned above. Chromosome number of the natural populations of *T. sylvestris* in West Anatolia (subsp. *australis*) is $2n=24$ while the other populations in Van province (subsp. *sylvestris*) have $2n=48$. On the other hand, triploid forms were also reported from Turkey by Özhatay (2002) and from Norway by Zonnevald (2009).

In Turkey, tetraploid forms have been observed in cultivated areas, gardens and orchards. Thus, there are habitat and geographical differences for both subspecies at least in Turkey in addition to the evidences of chromosome numbers. In morphological respect, subsp. *sylvestris* is different than subsp. *australis* having more broad lowest leaves and anthers, globular flowers, markedly stoloniferous structures. In PCA, subsp. *sylvestris* (SY7) was placed far from the other populations of subsp. *australis* (SY1-SY5-SY3-SY4-SY6-SY2), and in cluster analysis SY7 also joined this group, at 88.36% SL (Figure 131). The others linked each other between 94.92% - 100.00% SLs. According to the results of these analyses, the taxa distributed in East Anatolia were described as subsp. *australis*. Therefore, the other taxon was taxonomically decreased to subspecific level as subsp. *sylvestris*. Their dissimilarities were given in Table 22.

The tetraploid forms of this species have become naturalized in northern Europe, reaching as far as Britain and Scandinavia (Wilford, 2006). Nevertheless, the origin of *T. sylvestris* is unknown. It is very difficult to decide the origin of this species. Most probably it may be indigenous for the regions including inner parts of

west Anatolia, and from north (Bolu-Çankırı) downwards to south (Antalya). Because, this species does not exceed the Anatolian Diagonal (Ekim & Güner, 1986) eastwards, and naturally spreads in the west of the diagonal, there is a disconnection to main gene center of tulips in Central Asia. Presumably, the plant may be transferred to Europe from inner parts of West Anatolia by travelers and then it have naturalized there.

Table 22. Differences between subsp. *australis* and subsp. *sylvestris*.

subsp. <i>australis</i>	subsp. <i>sylvestris</i>
it spreads in west Anatolia	it spreads in Van province
it grows in stony plains or screes with red, reddish-brown or brown soils of higher forest clearing at an elevation of 1000-2000 m.	it grows in orchards or gardens with gray soils at elevation of 1700-3000 m.
lowest leaf width often less than 1 cm	lowest leaf width has more than 1 cm
flower infundibular	flower globular
anther width 1-2 mm	anther width 2-3 mm
inconspicuously stoloniferous	markedly stoloniferous
Diploid	Tetraploid

Marais (1984) in “*Flora of Turkey*” reduced *T. pulchella* as a synonym of *T. humilis* and evaluated it in *T. humilis* concept. Van Raamsdonk and de Vries (1992) accepted this species as a form of *T. humilis*. Zonnevald (2009) considered them as separate species according to DNA 2c value with 61.7 pg for *T. pulchella* and 65.0 pg for *T. humilis*. The results of the traditional and numerical analyses revealed that *T. pulchella* was a distinct species. Although both species show a large variation in flower colours, owing to cautiously observations in fields, the mauve colour for *T. humilis* and pinkish-purple to magenta colours for *T. pulchella* may be observed as dominant flower colours. *T. pulchella* is also different than *T. humilis* having blackish-brown bulb tunics and bicoloured blotch. Additionally, there is a geographical isolation between these two taxa at least in Turkey. Because of such

taxonomic evidences, specific status of *T. pulchella* was re-accepted again in the study. Differences between these species are given in Table 23.

Table 23. Differences between *T. humilis* and *T. pulchella*.

<i>T. humilis</i>	<i>T. pulchella</i>
It spreads in South East Anatolia (around Van, Hakkari)	It spreads in the central and west Taurus (around Antalya, Konya, Karaman, Adana, Niğde)
Tunic pale brown	Tunic blackish-brown
Leaves 3-6	Leaves 2-4
Flowers mauve	Flowers pinkish-purple to magenta
Blotch yellow	Blotch often bicoloured (bluish-violet&yellow; purplish-pink&yellow; white&yellow) or purple or yellow
Robust	Weak
Anther width 2-4.5 mm	Anther width 1-1.5(-2) mm
Anther often yellow to orange, rarely dark	Anther blackish-purple
Capsule 2.5-3.9 x 1.5-2cm	Capsule 1.3-2.5 x 1-1.7 cm

Van Raamsdonk and de Vries (1992) placed *T. orphanidae* and *T. sprengeri* under the section *Australes* sensu A. D. Hall, then Zonnevald (2009) changed the name of this section as *Sylvestres* but accepted mentioning both species in the same section. Wilford (2006) mentioned in his book that section *Australes* can be split into two groups: in the first group the flowers are in shades of yellow or creamy, in the second group the flowers are in shades of red, brownish red, and orange. But, he does not design another section for the second group. Our PCA and cluster analyses support the view of Wilford. In PCA analyses, *T. orphanidae* and *T. cinnabarina* are found close to each other and far from their traditional place in section *Sylvestres* (syn: *Australes*). In cluster analyses, they also far from the section *Sylvestres* at 52.20% SL and close the other new section *Humiles* at 68.42%. Thus, both species with *T. sprengeri* form a new section, *Orphanideae*. In this new section, *T. karamanica* is reduced to a synonym of *T. cinnabarina* according to priority rule due to they are the same species from collected the same place by different researchers.

Morphological differences of sections are given in Table 21 and the differences of close species *T. cinnabarina*, *T. pulchella* and *T. orphanidea* are given in Table 24.

Table 24. Differences between *T. cinnabarina*, *T. orphanidea* and *T. pulchella*.

<i>T. cinnabarina</i>	<i>T. pulchella</i>	<i>T. orphanidea</i>
<u>bulb coriaceous</u>	<u>crustaceous</u>	<u>crustaceous</u>
<u>markedly stoloniferous</u>	<u>often not stoloniferous</u>	<u>rarely stoloniferous</u>
<u>Leaves 2-3</u>	<u>Leaves 2-4</u>	<u>Leaves 3-6</u>
<u>Flower orange-red to mandarin-red</u>	<u>Flower pinkish-purple to magenta or whitish-pink</u>	<u>Flower orange-red to mandarin-red</u>
<u>blotch often absent, rarely very slightly present, if it is present yellow or bicoloured</u>	<u>blotch distinctly present, often bicoloured</u>	<u>blotch distinctly present, bulurred purplish-black</u>
<u>Capsule 2.8-4 x 1.6-2.2 cm, capsule rib 22-30 mm</u>	<u>Capsule 1.3-2.5 x 1-1.7 cm, capsule rib 10-20 mm</u>	<u>1.6-2.8 x 1-1.8 cm, capsule rib 12-22 mm</u>
<u>If it is present blotch length 6-10 mm</u>	<u>Blotch 4-10 mm</u>	<u>Blotch 10-22 mm</u>
<u>Filament yellow, orange or red or bicoloured</u>	<u>Filament often bicoloured yellow, orange, red, purple, white</u>	<u>Filament brownish-black</u>

T. sprengeri was first described in 1894 by Baker. Also, Manissadjian collected the plant after two years (Marais, 1984). Unfortunately, this taxon has not been collected again since that time. In “*Red Data Book of Turkish Plants*” (Ekim et al., 2000), *T. sprengeri* was listed under the NE (not evaluated) category. Previously, this species was listed under the EW (Extinct species in the wild) category by Erik (1995). Although comprehensive field studies were performed to rediscover this species, unfortunately it has not been found. The reasons for undiscovered of this species may be either it has become extinct because of environmental effects or it has never been collected again. Thus, the species may be classified under the EW category (IUCN 2001). Taxonomic position of this taxon was evaluated and interpreted under the light of present studies and making comparisons with our results.

In PCA, *T. saxatilis* was far from the other species and also in cluster analyses it was linked to sections *Orphanideae* and *Humiles* at 62.48% SL. *T. humilis* and *T. pulchella*, which were formerly placed in this section, were removed to their new section *Humiles*. Section *Saxatiles* was also different than section *Humiles* having unique broad shiny green leaves (Table 21). Thus, section *Saxatiles* included only one species, *T. saxatilis*, in Turkey.

One population collected from East Anatolia showed some morphological similarities to *T. biflora* and *T. sylvestris* and also showed differences to some extent from *T. biflora* and *T. sylvestris*. This population was closer to *T. biflora* with tunic hairiness, and also closer to *T. sylvestris* with yellow flower. In the field studies, quite large number of specimens were examined to observe variations within and between populations of *T. biflora*. Although colour of tepals of *T. biflora* may have limited colour variations, in fact, white flowers colour and yellow central blotch were characteristics for *T. biflora*. The specimens collected from the field were rather different by having discrete yellow flowers without central blotch and shorter outer and inner filaments. Differentiations of the specimens from those of *T. sylvestris* can be obtained easily as seen in Table 25. In PCA, this population was also observed far from the populations of *T. sylvestris* and *T. biflora*. In cluster analysis, populations of *T. biflora* joined to each other at 98.41% SL, and then this unique population joined to *T. biflora* group at low level, such as 81.75% SL. Consequently, a new species, *T. koyuncui* Eker & Babaç was described from East Anatolia (Eker and Babaç, in press) and was compared with the closely related species of *T. biflora* and *T. sylvestris*. The comparisons of these three taxa are given in Table 25. Detailed information about the new species was given in the chapter of results. Both of *T. biflora* and *T. koyuncui* were placed in to the section *Biflores*.

Table 25. Differences between *T. koyuncui*, *T. biflora* and *T. sylvestris*.

<i>T. koyuncui</i>	<i>T. biflora</i>	<i>T. sylvestris</i>
Tunics papery	papery	leathery
Tunic hairs densely covered with lanate hairs throughout tunic	densely covered with lanate hairs throughout tunic	basal plate and neck with pilose hairs, middle part glabrous
Leaves 2	2	2-4
Flowers 1-2	1-4	1(-2)
Flower colour <u>yellow without central blotch inside</u>	<u>white with yellow central blotch inside</u>	yellow without central blotch inside
Outer tepal size 19-23 x 4-6 mm	20-29 x 5-8 mm	21-50 x 5-15 mm
<u>Colour of outer tepal at outer surface greenish-violet or reddish-brown</u>	<u>greyish-violet</u>	entirely or partly tinged with reddish-brown or greenish-violet or greenish-yellow
Inner tepal size 18-23 x 8-10 mm	20-30 x 8-13 mm	22-53 x 9-26 mm
<u>Length of outer filaments 4-5 mm</u>	<u>5-9 mm</u>	5-13 mm
<u>Length of inner filaments 5.5-7 mm</u>	<u>7-10 mm</u>	7-16 mm

Raamsdonk and de Vries (1992, 1995) divided the subgenus *Tulipa* into five sections: *Tulipa*, *Tulipanum*, *Eichleres*, *Kolpakowskianae*, *Clusianae* Baker. Also, section *Eichleres* was further divided into eight series: *Lanatae*, *Eichleres*, *Vinistriatae*, *Undulatae*, *Luteo-apiculatae*, *Multiflorae*, *Spiranthera*, *Glabrae*. Then, Wilford added (2006) another section following Vvedensky's treatment (1935), which was not determined by van Raamsdonk and de Vries: section *Orithyia* for the subgenus *Tulipa*. Zonnevald (2009) attributed to four subgenera: *Clusianae* (Baker) Zonn., *Tulipa*, *Eriostemon* Raamsd., and *Orithyia* (D. Don) Baker and divided subgenera further into 12 sections. Seven of the eight series of section *Eichleres* in Raamsdonk's treatment (1995) were placed in four sections: *Lanatae*, *Multiflorae* (including series *Glabrae*), *Vinistriatae* (including series *Undulatae*), and *Spiranthera*. Also, the subgenus *Tulipa* is divided into seven sections by Zonnevald (2009): *Kolpakowskianae*, *Multiflorae*, *Lanatae*, *Vinistriatae*, *Spiranthera*, *Tulipanum*, and *Tulipa*.

In this revision, the most populations of subgenus *Tulipa* formed a complex group in PCA and only *T. agenensis* and *T. praecox* were not located inside this

complex group. Therefore, populations of this group were separately analysed from the other taxa observing their distinctions in PCA. In the second attempt, *T. undulatifolia* and *T. sintenisii* were clearly separated from the complex. *T. armena*, *T. gumusanica*, *T. julia* and *T. aleppensis* still formed a complex. In cluster analyses, this complex linked each other at between 91.90-100.00% SLs. Moreover, except *T. clusiana*, the other populations were very close to each other, such as between 81.65-100.00% SLs. Whereas, the closest sections in subgenus *Eriostemon* are at 70.82% SL. Due to this high similarity level in subgenus *Tulipa*, the species formerly showed under three sections collected together under the section *Tulipa*. *T. clusiana* was linked to subgenus *Tulipa* as a single population at 48.26% SL. Also, both sections were separated by different leaf types, tunic colours and types. Consequently these results suggested two separate sections: *Tulipa* and *Clusianae* Baker. Differences between these sections are given in Table 26.

Table 26. Differences between sections of subgenus *Tulipa*.

Section <i>Tulipa</i> They have papery, brown or reddish-brown tunics, usually lined with only a few straight hairs or with a dense layer of woolly, often rippled hairs lining the bulb tunics. Flowers generally red with an eggplant basal blotch with or without yellow.
Section <i>Clusianae</i> Baker They have coriaceous, blackish-brown or dark brown tunics. Bulbs distinctively small and having a prominent tuft of hairs protruding from the top. Leaves long, narrow and usually spaced apart on the stem, the upper ones often attached to the stem well above ground level. Flowers red, yellow, or white with red backs to the outer tepals.

Marais (1984) emphasized that *T. agenensis* with *T. praecox* will be cloned selections of the same species. They were very similar species according to previous studies. In the cluster analysis, all populations of *T. agenensis* were placed in the same cluster and linked the closest cluster that was the complex group of *T. armena*-*T. aleppensis*-*T. julia*-*T. gumusanica* at 89.81 SL (Figure 131). But, the *T. aleppensis*

group was somewhat far from the other complex cluster where populations of *T. praecox* were placed. Morphologically, *T. praecox* is different than *T. agenensis* having more robust structures. Furthermore, chromosome number of *T. praecox* was $2n=36$ (triploid) whereas $2n=24$ in *T. agenensis*. In Addition, *T. agenensis* was morphologically similar to *T. aleppensis*. Morphological differences of these species are given in Tables 27 and 28.

Table 27. Differences between *T. agenensis* and *T. praecox*.

<i>T. agenensis</i>	<i>T. praecox</i>
Lengths of aerial stem and underground stem variable; aerial stem 7-28 cm	Aerial stem longer than underground stem; aerial stem (15-)30-60 cm
Stem width 1.5-4.5 mm	Stem width 5-6 mm
Inconspicuously stoloniferous	Markedly stoloniferous
Anther purplish-black	Anther purple
Diploid	Triploid (not forming mature capsule and seed)
Lowest leaf width 1.2-3.5 cm, lanceolate, canaliculate	Lowest leaf width 3.1-8 cm, broadly lanceolate-lorate, slightly canaliculate
Blotch 1/4-1/2 length of segments	Blotch 2/7-2/5 length of segments
Filament purplish-black	Filament brownish-black

Table 28. Differences between *T. agenensis* and *T. aleppensis*.

<i>T. agenensis</i>	<i>T. aleppensis</i>
Blotch 1/4-1/2 length of segments	Blotch (1/12)1/8-1/4 length of segments
Diploid	Diploid or triploid
Tunic matted-lanate	Tunic matted-lanate to straight-untangled hairy
Anther purplish-black	Anther purple
Outer tepals more pointed (acuminate)	Less pointed
Leaves more erect to erectopatent	Leaves more falcate, more undulalate

Although the origin of *T. praecox* may be pointed out as South-west or the Central Asia by Turkish (1984) and European (1980) Floras, but the real origin of this taxon has not been known yet. Moreover, it was determined that this species was naturalized at the south Europe. There were two doubtful records of the species from

Amasya and İzmir in Flora of Turkey. But, collecting time and the other necessary information were not given. Also, type specimen of *T. praecox* has not been defined in both Floras and publications. In this revision, during typification studies in RBG-Kew, it was seen a specimen which was a potential to be a type specimen (Figure 132). But, it was noted on the sheet of herbarium specimen only as “Tenore” who described first this species to science. But, there were no any additional information about it. In this case, it was very difficult to decide whether Tenore’s specimen or not. If it can be decided that this specimen was of Tenore, this specimen would be selected as a lectotype. However, status of this specimen was doubtful and it would be likely designated as a neotype among collected specimens.

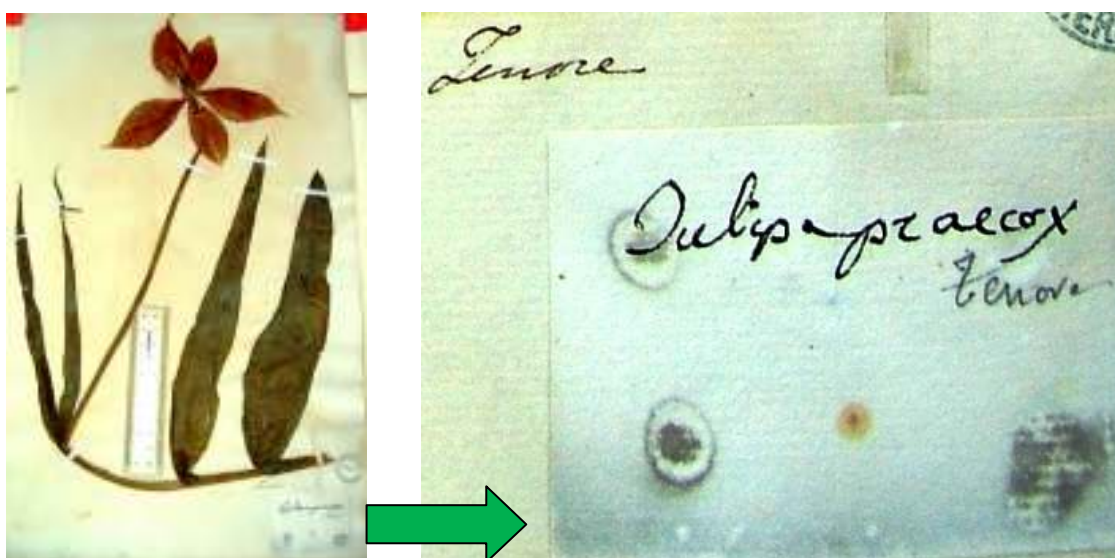


Figure 132. The specimen in Kew which has a potential to be a type specimen.

In PCA, *T. undulatifolia* and *T. sintenisii* were clearly separated from the complex group. In cluster analyses, populations of *T. undulatifolia* were separated from the other populations in subgenus *Tulipa* at 81.65% SL. Populations of *T. sintenisii* formed a cluster with populations of *T. praecox*. But, one population of *T. aleppensis* caused a peculiarity together with populations of *T. praecox* and *T.*

sintensis within clusters. As a contrast of clustering event, *T. sintensisii* and *T. praecox* were morphologically quite different from each other and than *T. aleppensis*. These differences are given in Table 29.

Table 29. Differences between *T. aleppensis*, *T. sintensisii* and *T. praecox*.

<i>T. aleppensis</i>	<i>T. sintensisii</i>	<i>T. praecox</i>
Tunic hairs often arachnoid-lanate or straight-untangled, middle part densely hairy	Tunic hairs pilose, middle part slightly hairy or glabrous	Tunic hairs matted-lanate, middle part densely hairy
Stem width 1-3 mm	Stem width 1.5-4 mm	Stem width 5-6 mm
Aerial stem 4-17 cm	Aerial stem 8.5-34 cm	Aerial stem longer than underground stem; aerial stem (15-)30-60 cm
Stoloniferous or not	Markedly stoloniferous	Markedly stoloniferous
Fields, meadow and calcerous barrens	Fields	Orchards and gardens
Lowest leaf lanceolate, distinctly canaliculate	Lowest leaf lanceolate, distinctly canaliculate	Lowest leaf broadly lanceolate-lorate, slightly canaliculate
Diploid or triploid	Diploid	Triploid

In subgenus *Tulipa*, cluster results were similar to PCA. The most complex group in the genus *Tulipa*, mentioned above, contained the populations of *T. armena* var. *armena*, *T. armena* var. *lycica*, *T. julia*, *T. gumusanica* and *T. aleppensis*. This group showed high variations between and within populations. Traditionally, the main differences of these taxa have been based on tunic hairiness, habitat and geographical distribution. Marais (1984) in “*Flora of Turkey*” accepted two varieties of *T. armena* according to hair structure and distribution on inner tunics of bulb. *T. armena* var. *armena* has shorter, and more bristle hairs, that may be sparsely around the middle of the bulb. *T. armena* var. *lycica* has densely lined with long, and soft hairs. But, in practice this distinction is out of use. Because, there are intermediate specimens in the same population and also there are some specimens having two features of varieties of their different tunic layers. Therefore, this property was accepted here as a variation that was not enough to separate these two varieties.

Additionally, it was observed that there were not any considerable differences among the results of numerical analyses, cytotaxonomic and palynologic studies. Because of these reasons *T. armena* var. *lycica* was reduced to a synonym of *T. armena*. On the other hand, *T. gumusanica* did not show a distinction from the *T. armena* populations. It was accepted to represent the yellow forms of *T. armena* where one difference was yellow flower colour. During the field studies, some populations with yellow and red flowers have been examined intensively. Based on these observations, *T. armena* was divided into two varieties: var. *armena* and var. *galatica*. Moreover, *T. gumusanica* was reduced a synonym of *T. armena* var. *galatica*. If the main flower colour of a tulip is red, to see yellow form of it should not surprised for taxonomists. This situation is common for tulips with red flowers.

In cluster analyses, populations of *T. julia* has distributed at the vicinity of *T. armena* populations. On the other hand, two populations of *T. aleppensis* took place nearer to complex group, especially to *T. julia* at 96.56% SL. Almost there were no differences morphologically between *T. julia* and *T. aleppensis*. *T. aleppensis* can be thought as the native forms of *T. julia*, also some populations of *T. aleppensis* grows on calcareous barrens (Birecik population) and meadow (Harput population) in the fields. Some forms or populations of both species have the same morphological characters with *T. armena*. Similarity levels of *T. julia* to *T. armena* in different clusters were between 92.77-98.41. In this case, *T. armena* can be thought a variety or a variable form of *T. julia*. Consequently, owing to more detailed studies in future, the taxonomic delimitation of this complex should be designated. For the time being, these taxa were kept as separate species in this study. But, more satisfactory results are probably going to be exhibited by means of new observations and examinations

performed in near future. Some differences and similarities of these three taxa are given in Table 30.

Table 30. Some differences and similarities between *T. aleppensis*, *T. julia* and *T. armena*.

<i>T. aleppensis</i>	<i>T. julia</i>	<i>T. armena</i>
Tunic hairs often arachnoid-lanate or straight-untangled, middle part densely hairy	Tunic hairs often arachnoid-lanate or straight-untangled, middle part densely hairy	Tunic hairs pilose, middle part slightly hairy to densely hairy
Leaves (3-)4	3-5	(2-)3-6
Stoloniferous or not	Not stoloniferos	Not stoloniferos
Fields, meadow and calcerous barrens	Rocky and stony slopes or places, scree or high mountain meadow	Rocky and stony slopes or places

CHAPTER 5. CONCLUSIONS

The genus *Tulipa* in Turkey was revised to solve its taxonomical problems observed in the Flora of Turkey and in some other works. After detailed morphological, palynological and cytotaxonomical analyses of the taxa, the genus *Tulipa* in Turkey was represented by 17 species, 1 subspecies and 1 variety (totally 19 taxa). A new identification key for the species and detailed descriptions of taxa were given as a result of this revision. Moreover, synonyms and typification as far as possible, features of distribution, habitat types, localities and conservation status of all taxa were given.

The genus *Tulipa* was separated into two subgenera according to the pubescence of filament base, flower and lowest leaf shape. It was adopted here classification systems of van Raamsdonk and de Vries (1992, 1995) which were also strongly supported by the results of this revision. However, Marais grouped Turkish tulips into two sections, which were raised up into subgenera in the present study. The subgenus *Eriostemones* was divided into five sections following Baker (1874, 1883) and Hall's (1940) treatments, also added two new sections to them: *Sylvestres*, *Orphanideae* *sect. nov.*, *Humiles* *sect. nov.*, *Saxatiles*, *Biflores*. The other subgenus *Tulipa* was divided into two sections: *Tulipa* and *Clusianae*.

Marais placed *T. sprengeri* in section *Tulipa*. But it was accepted here in subgenus *Eriostemones*. Although it has glabrous filaments, in all other respects it belongs to subgenus *Eriostemones* and in some cases may only be abnormal forms of species with otherwise hairy filaments (Wilford, 2006).

Section *Sylvestres* included only one species in Turkey, *T. sylvestris* which was separated into two subspecies: subsp. *sylvestris* and subsp. *australis*. *T. orphanidea*, *T. sprengeri* and *T. cinnabarina* which were formerly evaluated in this section, were placed here into a new section *Orphanideae*. In this new section, *T. karamanica* was reduced to synonym of *T. cinnabarina*.

Section *Saxatiles* included only one species, *T. saxatilis*, in Turkey. *T. humilis* and *T. pulchella*, which were formerly evaluated in this section, are placed into a new section *Humiles*. Marais in “*Flora of Turkey*” reduced *T. pulchella* as a synonym of *T. humilis* and evaluated it in *T. humilis* concept. But, results of these analyses performed in the revision indicated that *T. pulchella* is a separate species.

Section *Biflores* included *T. biflora* and *T. koyuncui* sp. nov. where the latter was described as a new species.

Section *Tulipa* included *T. armena*, *T. sintenisii*, *T. julia*, *T. aleppensis*, *T. undulatifolia*, *T. agenensis* and *T. praecox* which were previously accepted under the three sections, *Tulipa*, *Tulipanum*, and *Eichleres*. In this section, Marais in “*Flora of Turkey*” accepted two varieties of *T. armena* according to the hair structures and distribution on inner tunics of bulbs. They were var. *armena* and var. *lycica*. But, according to the results of analyses made in this study, var. *lycica* was reduced to a synonym of *T. armena*. However, *T. armena* was also divided into two varieties: var. *armena* and var. *galatica* comb. & stat. nov. Additionally, *T. gumusanica* was reduced to synonym of *T. armena* var. *galatica*.

Section *Chusianae* included only *T. chusiana* in Turkey.

After the first collections of materials, there were some re-collected species in our country such as *T. praecox*, *T. chusiana* and *T. saxatilis*. Existences of them were doubtful. Thereby, these species were re-collected again and verified in this study.

Population conditions of the species and their geographical distributions and habitat differences were detailed. Among the tulips in Turkey, *T. armena* contained the widest distributional area while *T. saxatilis*, *T. cinnabarina*, *T. sylvestris* subsp. *sylvestris* and *T. clusiana* were collected from only one but different localities. *T. praecox*, *T. aleppensis*, *T. biflora* and *T. koyuncui* restricted to very narrow distributional areas. Additionally, *T. clusiana* was not a native plant to Turkey. Generally, it is used as an ornamental plant in gardens. It is native in the regions of Iran, Afghanistan to N. Pakistan.

T. sprengeri was first described in 1894 by Baker. In addition, Manissaadjian collected the plant after two years. But, it has not been collected again since that time. Although all of the comprehensive research to fix this species, unfortunately it has not been in success. Probably, either it has been became extinct because of environmental effects or it has never re-collected again. Thus, the species might be classified as EW (IUCN 2001).

Bulbs of Tulips collected during this study were ensured as *ex-situ* conservation in Abant İzzet Baysal University and Nezahat Gökyiğit Botanical Garden as two “Tulip Collections”. In this connection, it was aimed to prevent extinction of species, especially endemic and rare plants (Figure 133).



Figure 133. *Ex-situ* conservation at private garden in Abant İzzet Baysal University.

According to new results, taxonomy of Turkish tulips is summarized in table 31. Four species of all them (*Tulipa sprengeri*, *T. cinnabarina*, *T. sintenisii* and *T. koyuncui* sp. nov.) are endemic for Turkey and nine taxa are first known as type specimen from Turkey.

Table 31. New taxonomy of Turkish tulips (*: endemic taxon; #: taxon first known from Turkey as type specimen)

Subgenus <i>Eriostemon</i> (Boiss.) Raamsd. - Section <i>Sylvestres</i> (Baker) Baker 1. <i>Tulipa sylvestris</i> L. subsp. <i>sylvestris</i> subsp. <i>australis</i> (Link) Pamp. - Section <i>Orphanidea</i> Eker & Babaç, sect. nov. 2. <i>Tulipa orphanidea</i> Boiss. ex Heldr. *# 3. <i>Tulipa sprengeri</i> Baker *# 4. <i>Tulipa cinnabarina</i> K. Perss. - Section <i>Saxatiles</i> (Baker) Baker 5. <i>Tulipa saxatilis</i> Sieber ex Spreng. - Section <i>Humiles</i> Eker & Babaç, sect. nov. 6. <i>Tulipa humilis</i> Herb. # 7. <i>Tulipa pulchella</i> (Regel) Baker - Section <i>Biflores</i> sensu A. D. Hall 8. <i>Tulipa biflora</i> Pall. *# 9. <i>Tulipa koyuncui</i> Eker & Babaç sp. nov.
Subgenus <i>Tulipa</i> - Section <i>Tulipa</i> # 10. <i>Tulipa armena</i> Boiss. var. <i>armena</i> # var. <i>galatica</i> (Freyn) Eker comb. & stat. nov. *# 11. <i>Tulipa sintenisi</i> Baker # 12. <i>Tulipa julia</i> C. Koch 13. <i>Tulipa aleppensis</i> Boiss. ex Regel 14. <i>Tulipa agenensis</i> DC. 15. <i>Tulipa praecox</i> Ten. # 16. <i>Tulipa undulatifolia</i> Boiss. - Section <i>Clusianae</i> Baker 17. <i>Tulipa clusiana</i> DC.

According to IUCN categories, *T. sprengeri* may be classified as EW (Extinct in the wild). *T. cinnabarina* is placed in CR (Critically endangered) category while *T. koyuncui* is placed in EN (Endangered) category. Nine taxa were placed in VU (Vulnerable) category, 6 taxa is placed in LC (Least concern) category, and 1 species is placed in NT (Near threatened) category (Table 32).

Table 32. Threatened categories of tulips in Turkey.

Names of Taxa	Threatened categories	
	Ekim et al., 2000	Present study, 2010
<i>T. sylvestris</i> subsp. <i>sylvestris</i>	Not indicated	<u>VU</u>
<i>T. sylvestris</i> subsp. <i>australis</i>	Not indicated	<u>LC</u>
<i>T. orphanidea</i>	Not indicated	<u>NT</u>
<i>T. sprengeri</i>	NE	<u>EW</u>
<i>T. cinnabarina</i>	Not indicated	<u>CR</u>
<i>T. saxatilis</i>	VU	VU
<i>T. humilis</i>	Not indicated	<u>LC</u>
<i>T. pulchella</i>	Not indicated	<u>LC</u>
<i>T. biflora</i>	VU	VU
<i>T. koyuncui</i>	Not indicated	<u>EN</u>
<i>T. armena</i> var. <i>armena</i>	LR (lc)	<u>LC</u>
<i>T. armena</i> var. <i>galatica</i>	Not indicated	<u>LC</u>
<i>T. sintenisii</i>	LR (lc)	<u>VU</u>
<i>T. julia</i>	Not indicated	<u>LC</u>
<i>T. aleppensis</i>	VU	VU
<i>T. agenensis</i>	Not indicated	<u>VU</u>
<i>T. praecox</i>	NE	<u>VU</u>
<i>T. undulatifolia</i>	Not indicated	<u>VU</u>
<i>T. clusiana</i>	Not indicated	<u>VU</u>

According to floristic regions of the taxa, Irano-Turanian elements were the first among the taxa by 47.37% ratio. It was also followed by the taxa of Mediterranean elements by 21.05% ratio. Some of the taxa (31.58%) were naturalized and/or cultivated, widespread and of unknown phytogeographic origin (Table 33).

Table 33. Phytogeographic regions of tulips in Turkey.

Names of Taxa	Phytogeographic regions	
	Marais, 1984; Persson, 2000	Present study, 2010
<i>T. sylvestris</i> subsp. <i>sylvestris</i>	Not indicated	Naturalized and widespread, unknown phytogeographic origin
<i>T. sylvestris</i> subsp. <i>australis</i>	Not indicated	Naturalized and widespread, unknown phytogeographic origin
<i>T. orphanidea</i>	East Mediterranean	East Mediterranean
<i>T. sprengeri</i>	Not indicated	Cultivated, unknown phytogeographic origin
<i>T. cinnabarina</i>	Mediterranean	<u>East Mediterranean</u>
<i>T. saxatilis</i>	East Mediterranean	East Mediterranean
<i>T. humilis</i>	Not indicated	<u>Irano-Turanian</u>
<i>T. pulchella</i>	Not indicated	Widespread and unknown phytogeographic origin
<i>T. biflora</i>	Irano-Turanian	Irano-Turanian
<i>T. koyuncui</i>	Not indicated	<u>Irano-Turanian</u>
<i>T. armena</i> var. <i>armena</i>	Irano-Turanian	Irano-Turanian
<i>T. armena</i> var. <i>galatica</i>	Irano-Turanian	Irano-Turanian
<i>T. sintenisii</i>	Irano-Turanian	Irano-Turanian
<i>T. julia</i>	Irano-Turanian	Irano-Turanian
<i>T. aleppensis</i>	Irano-Turanian	Irano-Turanian
<i>T. agenensis</i>	Not indicated	<u>East Mediterranean</u>
<i>T. praecox</i>	Not indicated	Naturalized and widespread, unknown phytogeographic origin
<i>T. undulatifolia</i>	Not indicated	Widespread and unknown phytogeographic origin
<i>T. clusiana</i>	Not indicated	<u>Irano-Turanian</u>

It was expected that the study of revision of the genus *Tulipa* will provide an important base for establishing of a new illustrated Flora of Turkey, which has been planned to complete until 2023 by Turkish botanists. The increasing of revision will reduce taxonomic problems in Turkish Flora, also from the point of solving systematic problems it will provide a great contribution to the world taxonomy.

Turkey has a great potential to manage naturally distributed ornamental plants such as tulips. The obtained data from the results of this study may be used to see inventory of tulips in Turkey and may provide the base of an alternative agriculture products because of their commercial values.

Announcements of the results of study in national and international media will be stimulated interest in tulip culture and will increase to interest of commercial sectors such as tourism, ecotourism and also private botanical excursions.

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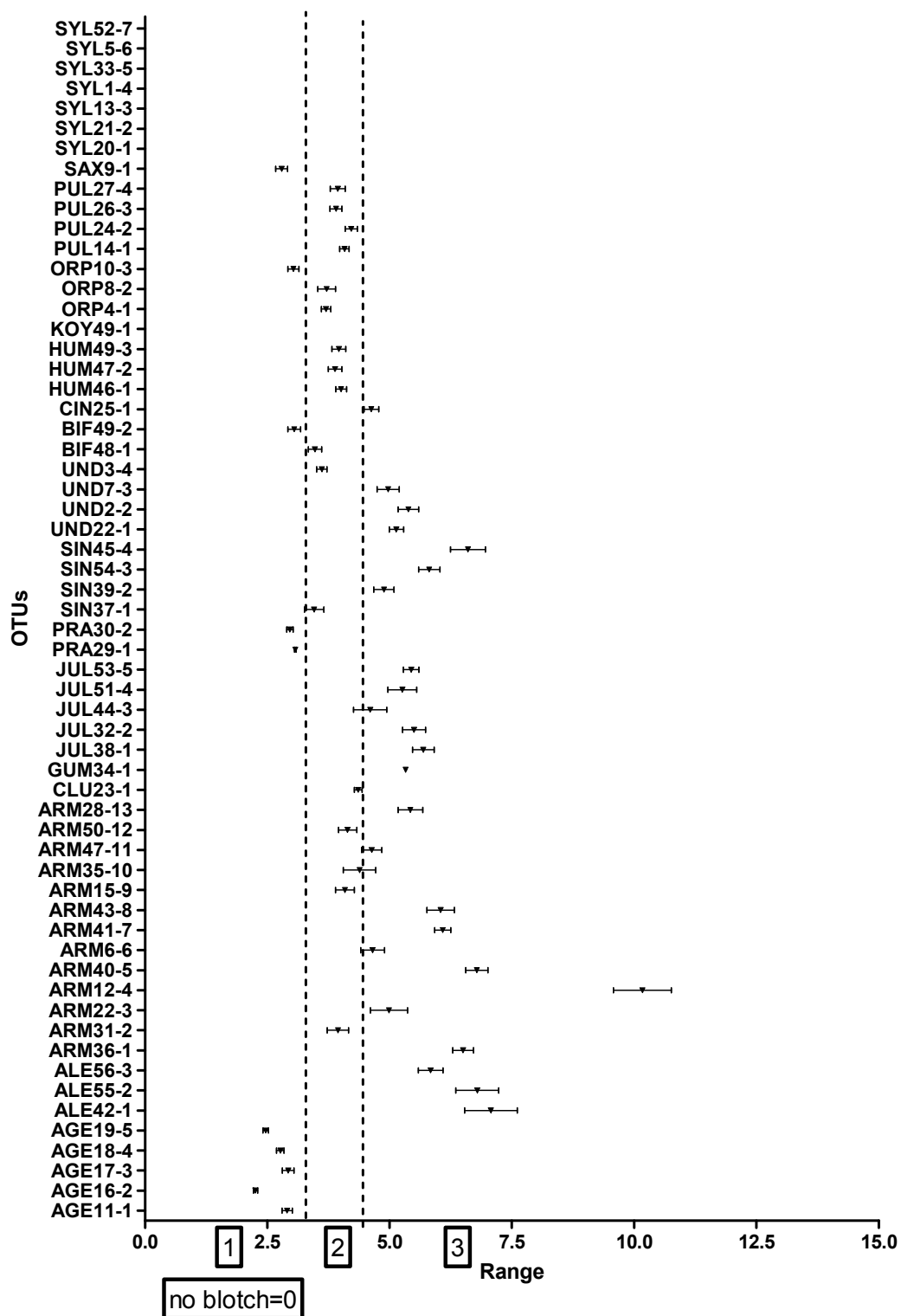
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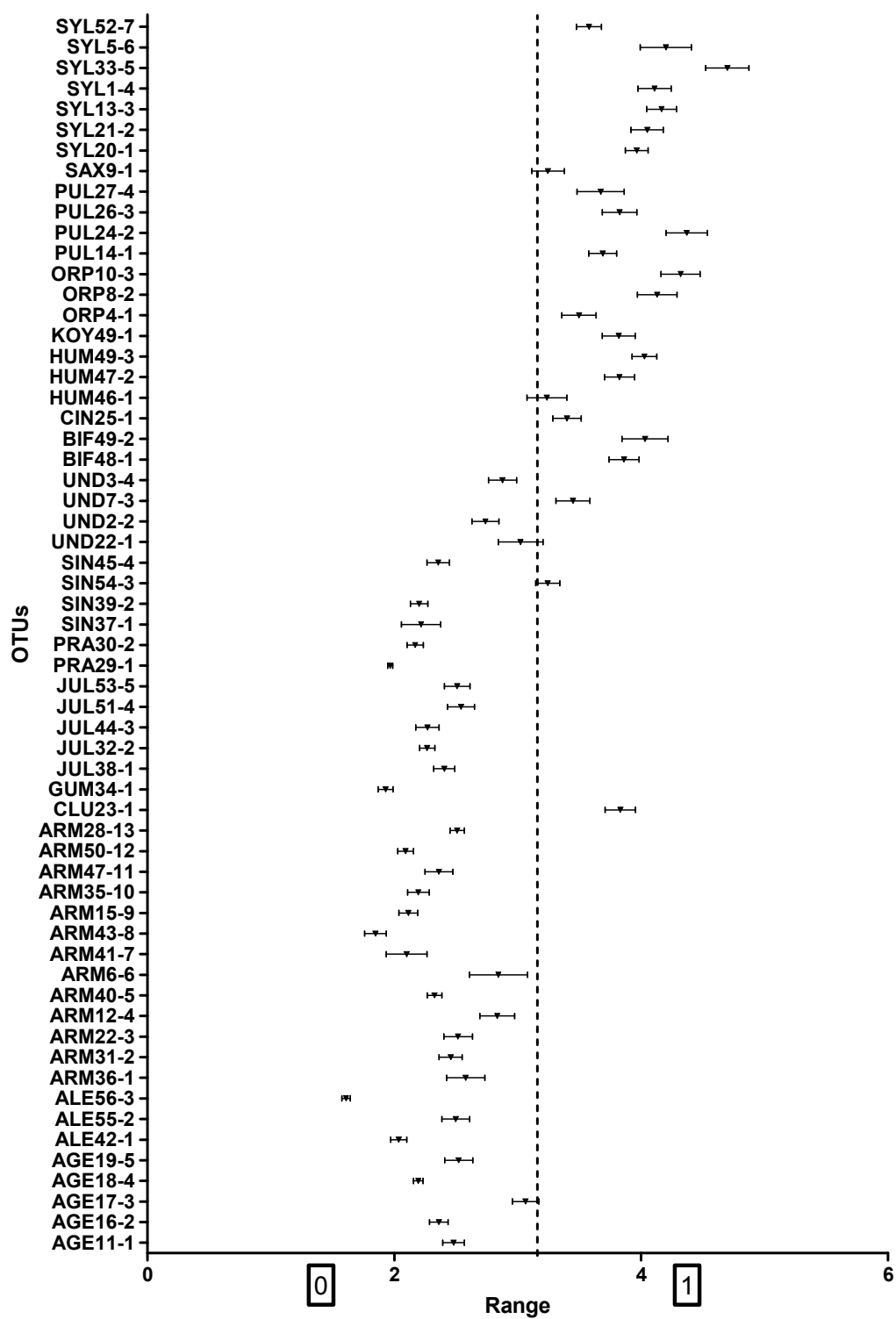
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APPENDIX 1. List of Codified Quantitative Characters in Graphpad Program
(Means with Standart Error Plots).

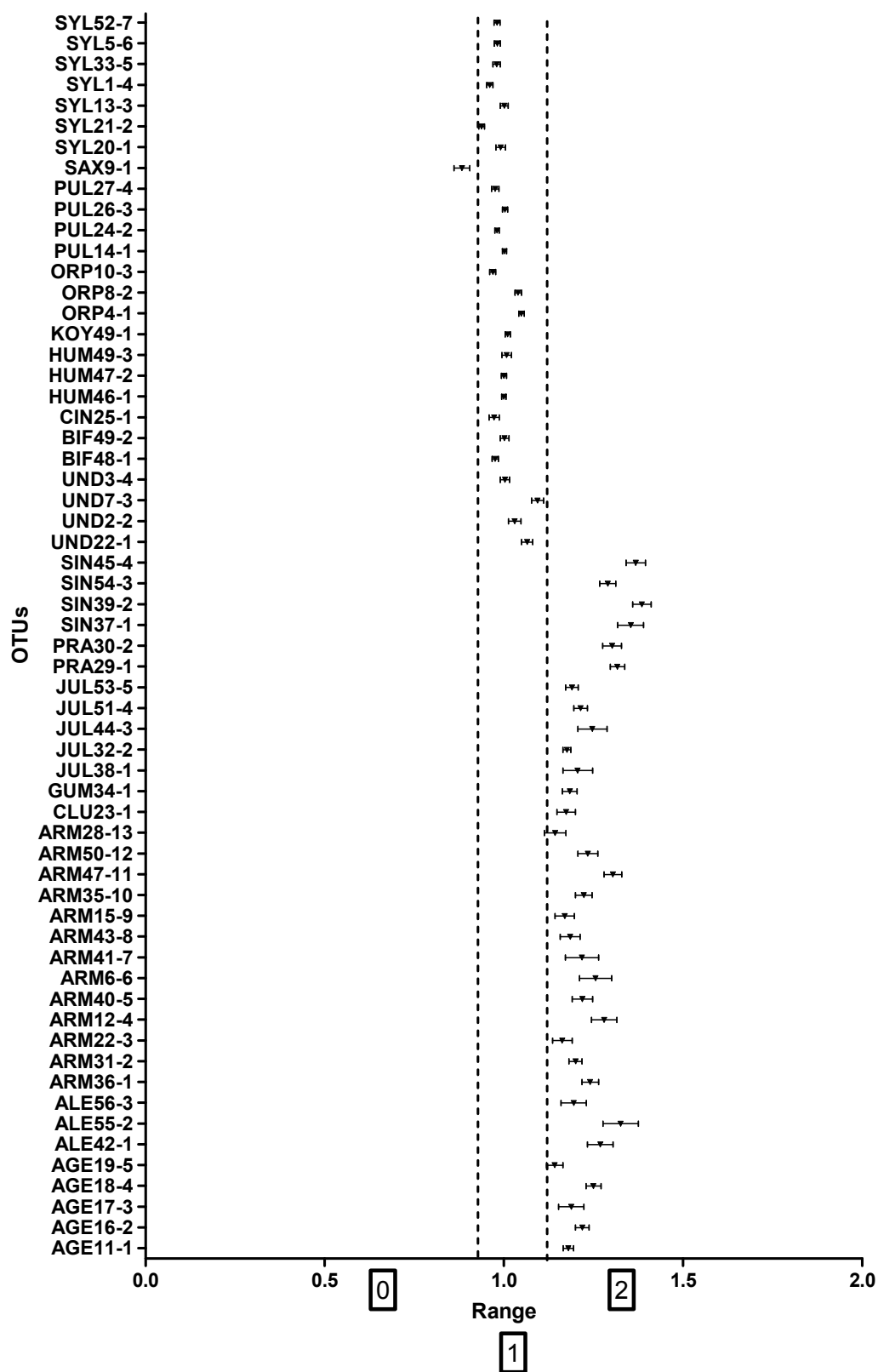
1-Proportion of length of outer tepal to blotch length at center (LOT/BLOT)



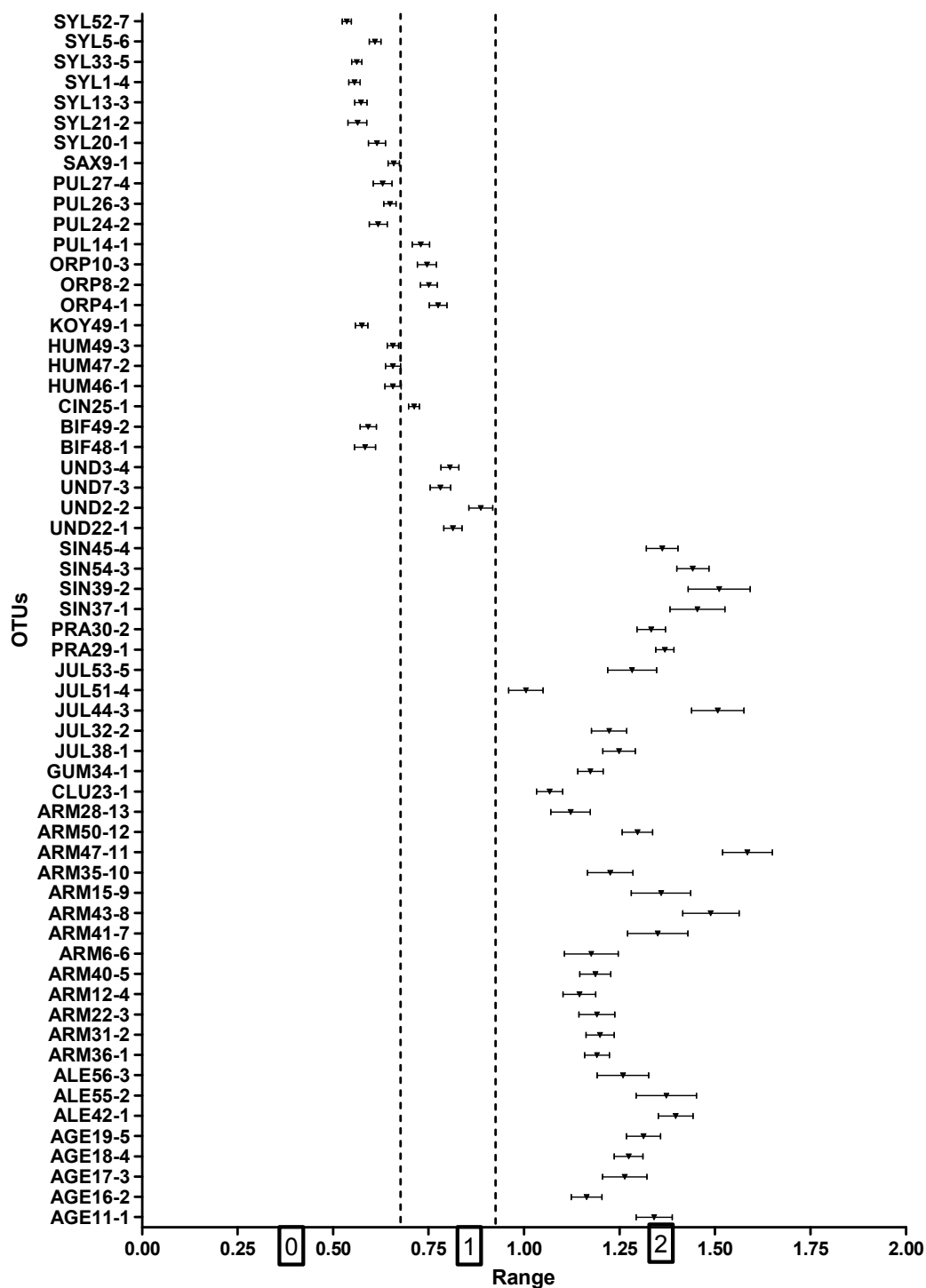
2- Proportion of length of outer tepal to its width (LOT/WOT)



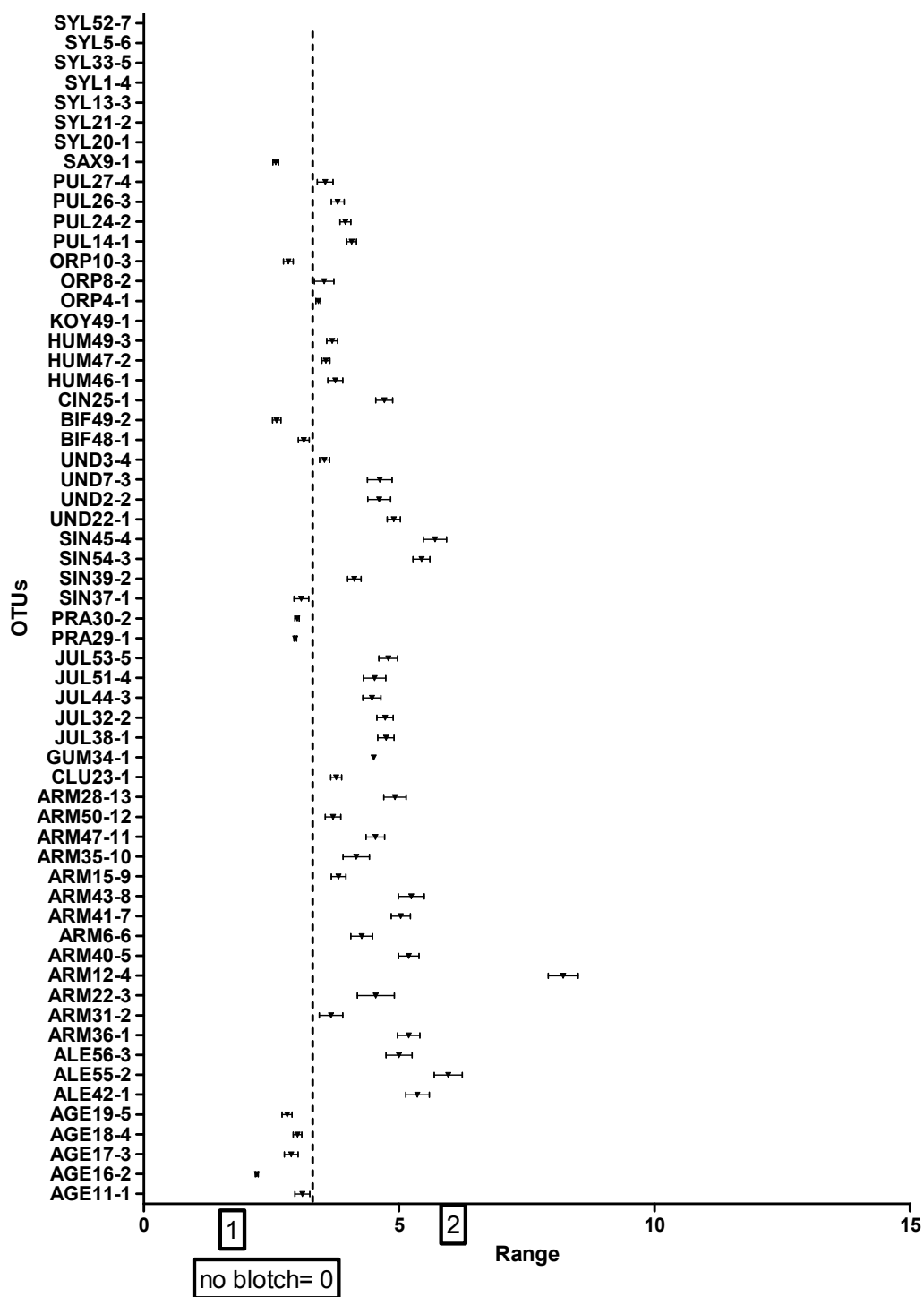
3-Proportion of length of outer tepal to length of inner tepal (LOT/LIT)



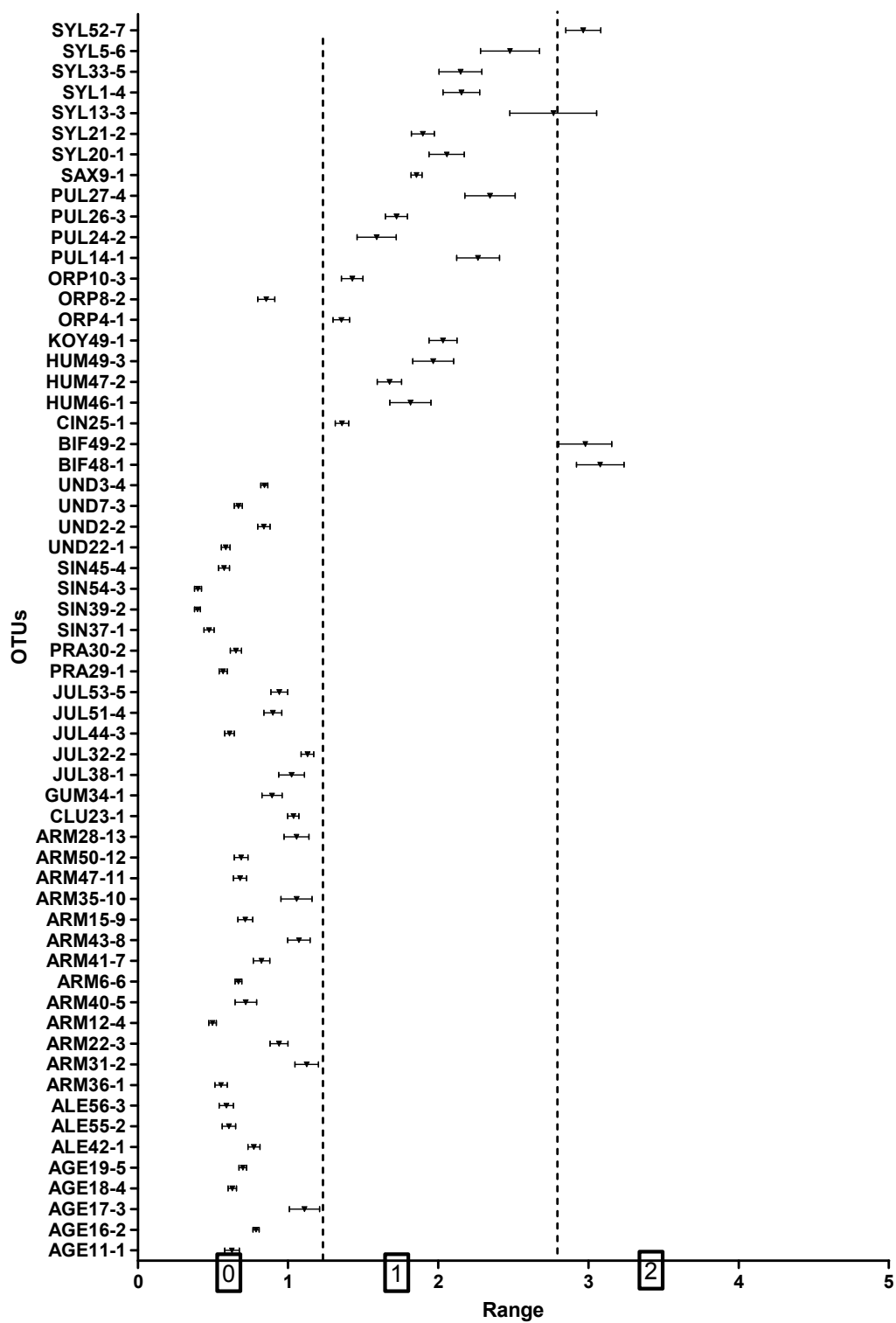
4-Proportion of width of outer tepal to width of inner tepal (WOT/WIT)



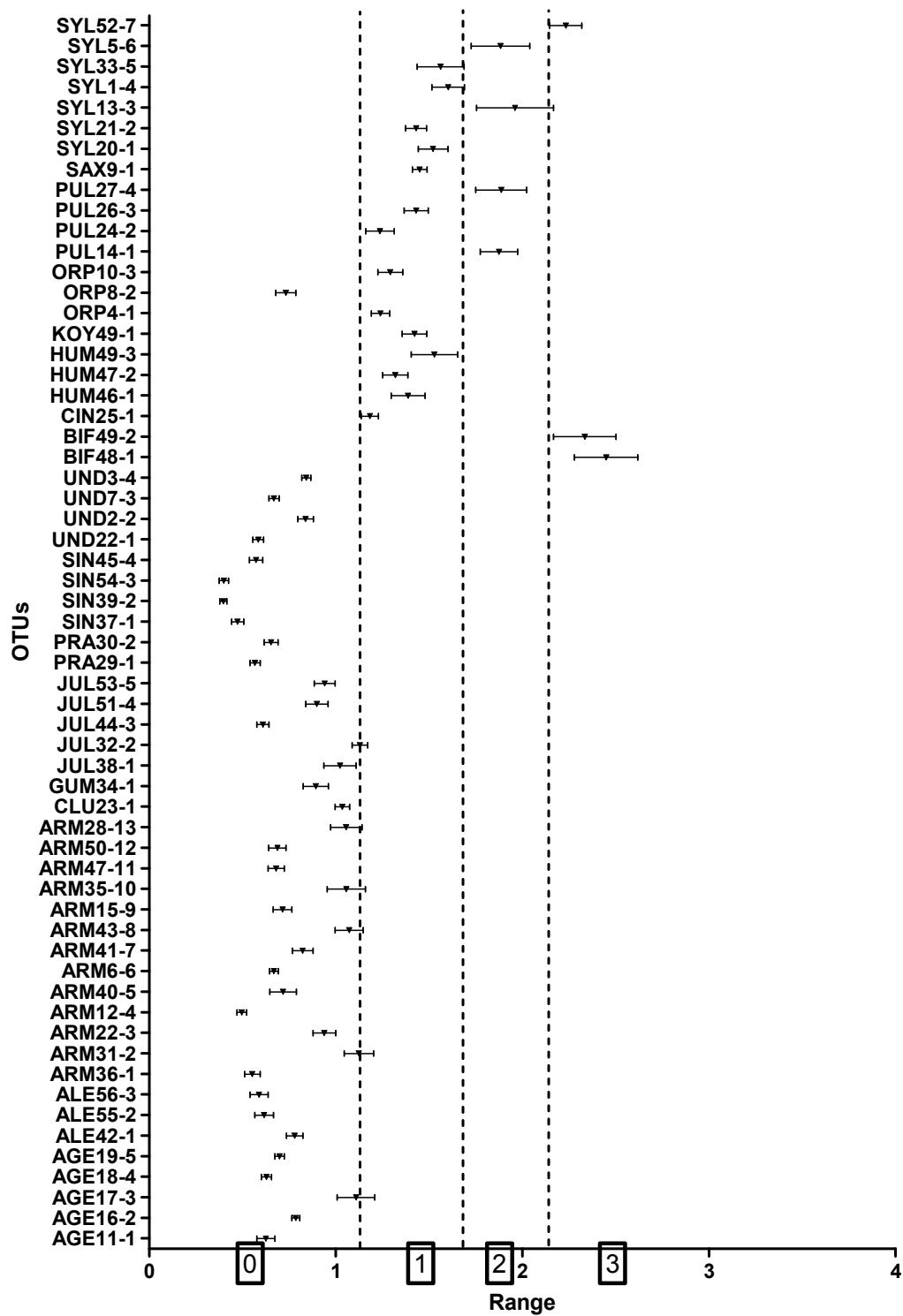
5-Proportion of length of inner tepal to blotch length at center (LIT/BLIT)



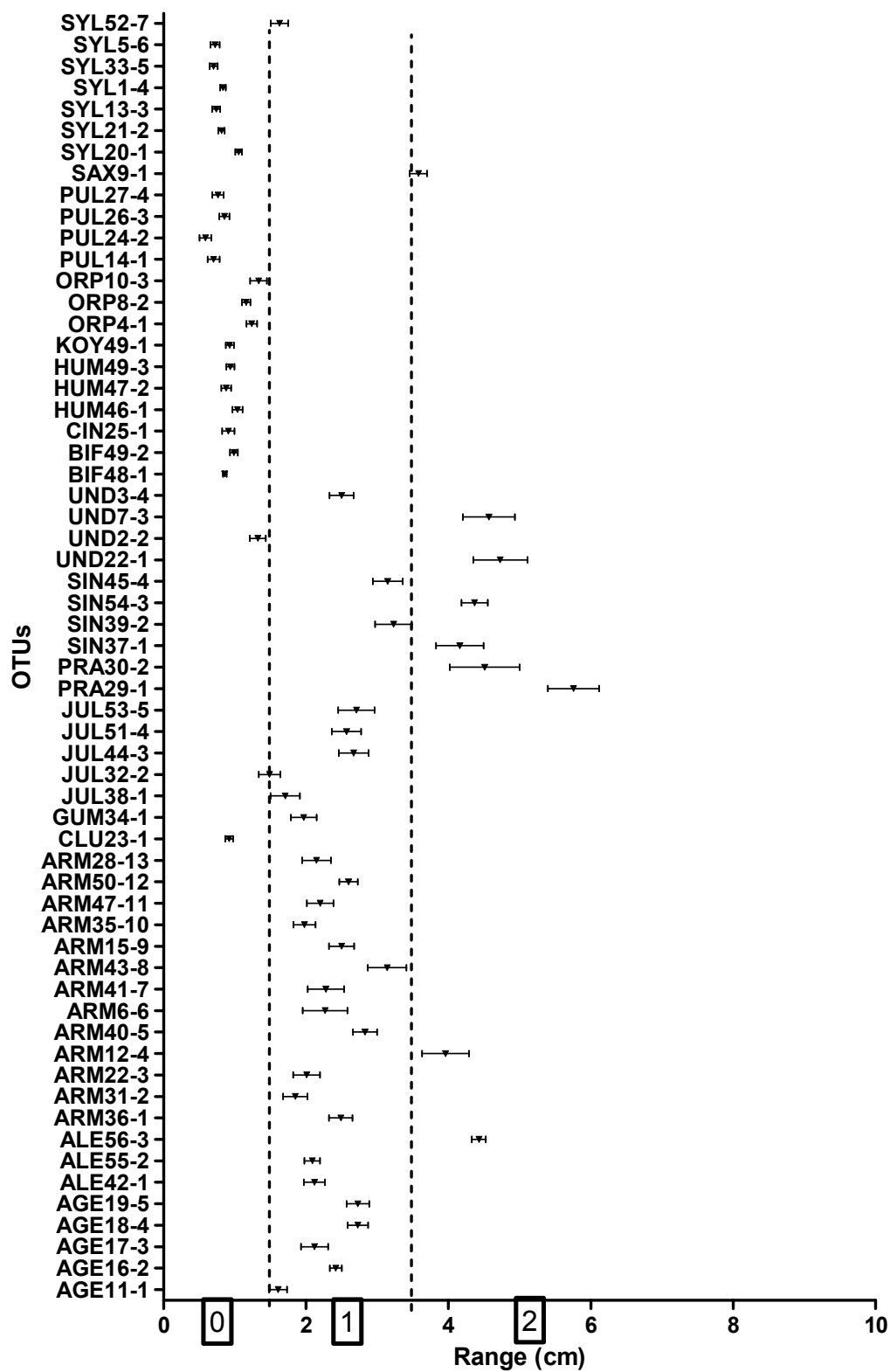
6-Proportion of length of inner filament to anther length (LIF/LA)



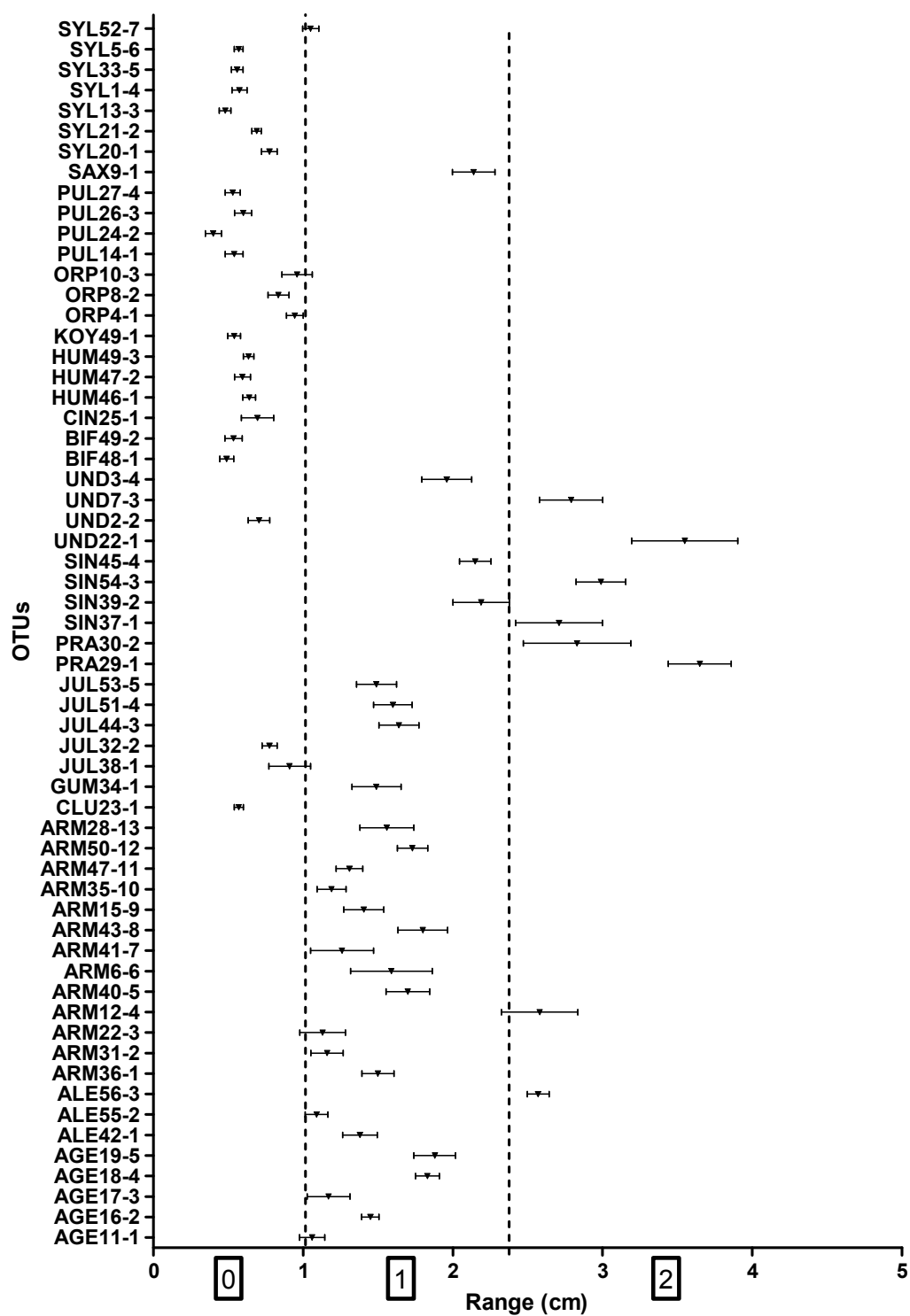
7-Proportion of length of outer filament to anther length(LOF/LA)

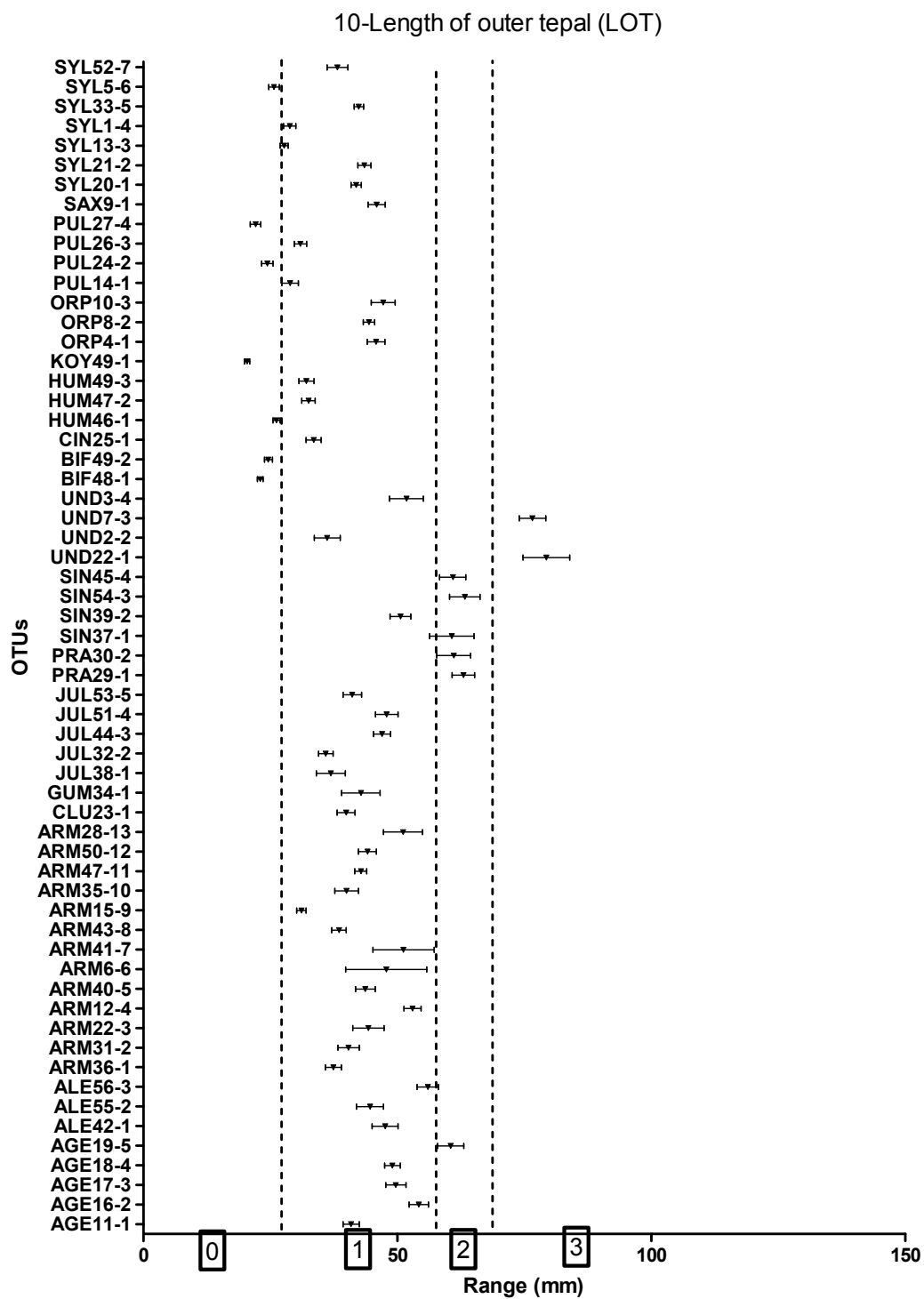


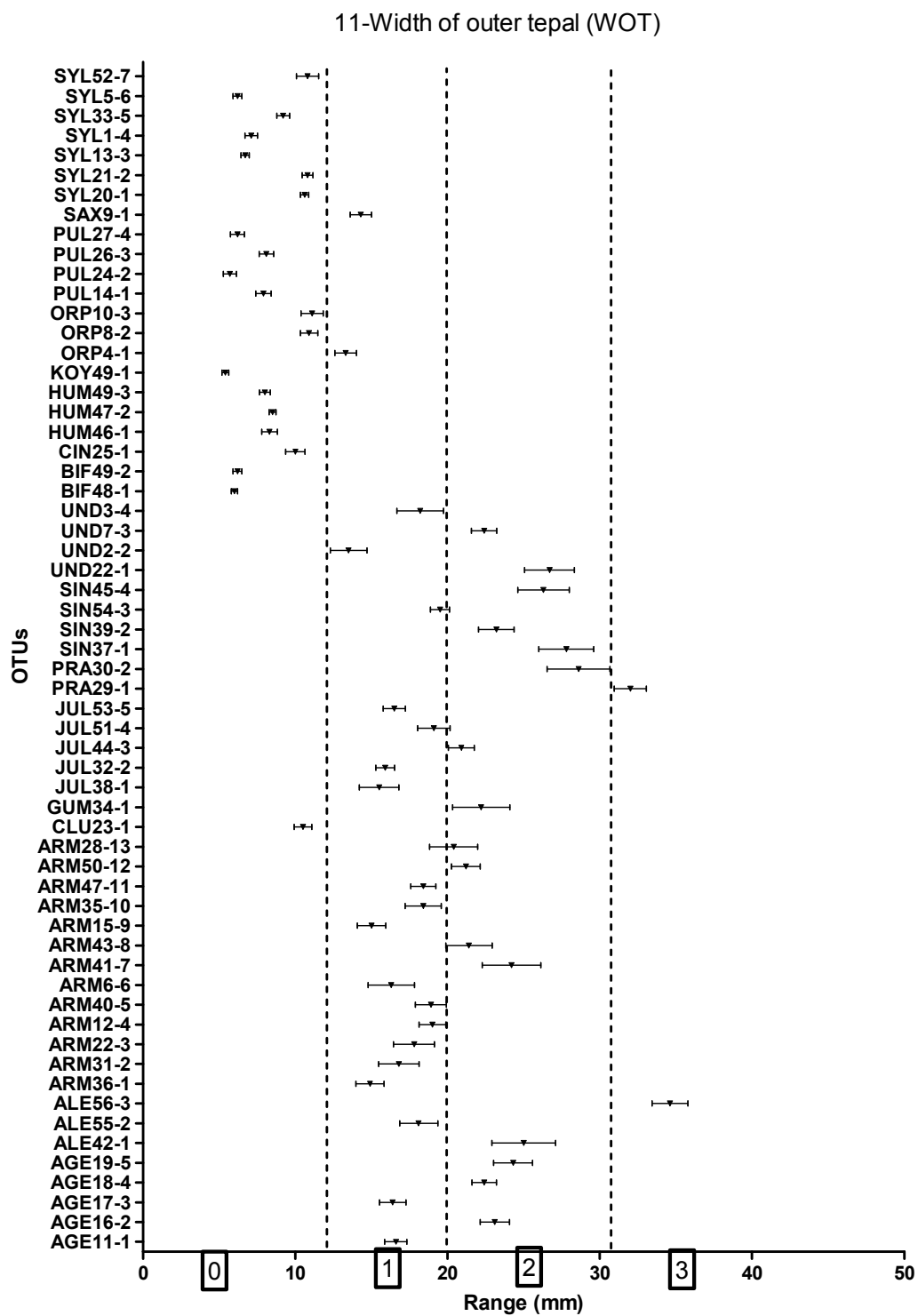
8- Width of lowest leaf (WLL)

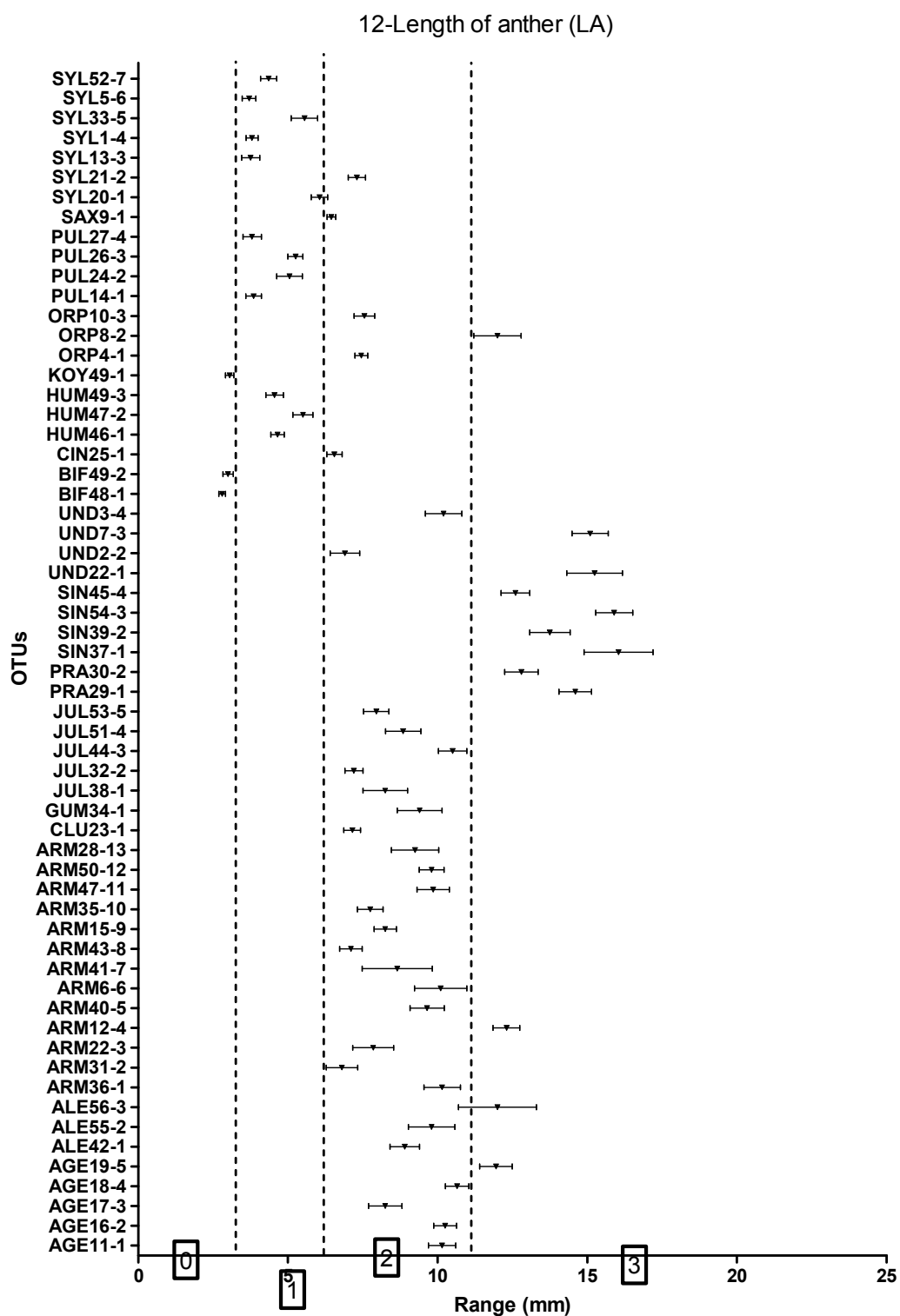


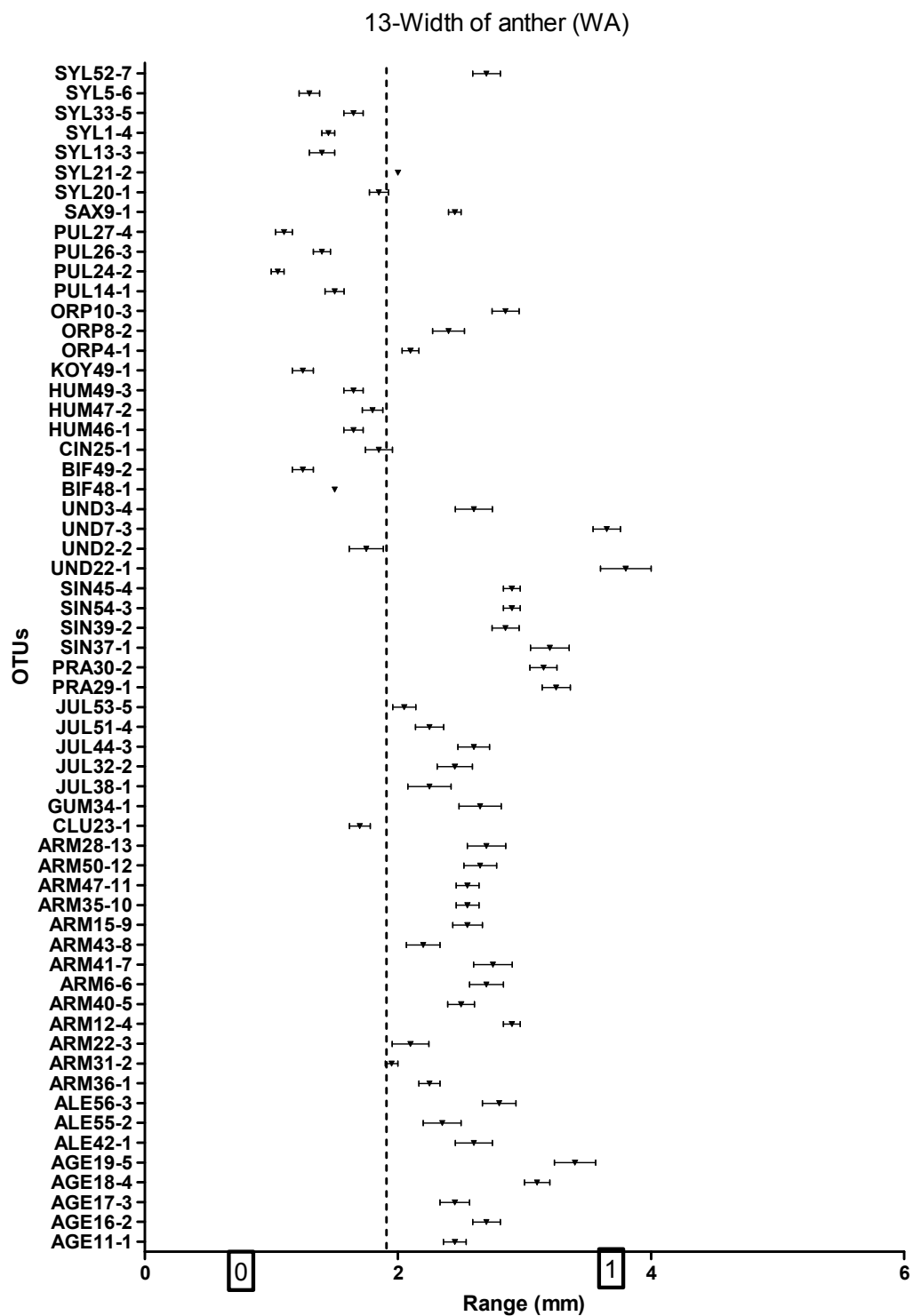
9-Width of second lowest leaf (WSLL)











Taxa	Specimen	Pollen Type	Long axis			Short axis			Pollen shape
			Mµm	St	Vµm	Mµm	St	Vµm	
1. Subgenus <i>Eriostemon</i>									
1.1. Section <i>Australes</i>									
<i>T. sylvestris</i> subsp. <i>australis</i>	A4 Ankara: Eker 2166	monosulcate	49	±0.92	45-52.5	39.93	±1.04	35-46.25	ellip
	B1 Balıkesir: Eker 2427	monosulcate	47.68	±1.18	42.5-55	42.13	±1.20	37.5-50	ellip-sp
	C2 Denizli: Eker 2423	monosulcate	47.5	±1.06	47.5-60	43.05	±1.02	38.75-48.75	ellip
	C3 Antalya: Eker 2050	monosulcate	49.68	±0.69	47.5-52.5	40.38	±0.96	37.5-47.5	ellip
<i>T. sylvestris</i> subsp. <i>sylvestris</i>	B9 Van: Eker 1842	monosulcate	54.88	±1.23	50-61.25	45.83	±0.93	42.5-53.75	ellip
<i>T. orphanidae</i>	B1 Balıkesir: Eker 2433	monosulcate	53.83	±1.18	47.5-60	43.58	±1.34	36.25-50	ellip
	B1 Manisa: Eker 2078	monosulcate	43.68	±0.90	38.75-47.5	36.45	±0.62	32.5-38.75	ellip
	C2 Muğla: Eker 2062	monosulcate	54.5	±1.08	48.75-60	44.88	±0.95	40-51.25	ellip
<i>T. cinnabarina</i>	C4 Karaman: Eker 2030	monosulcate	49.18	±0.98	43.75-53.75	40.63	±0.82	37.5-46.25	ellip
	C4 Karaman: Eker 2312	monosulcate	48.5	±0.99	42.5-52.5	38.63	±0.62	35-41.25	ellip
1.2. Section <i>Saxatiles</i>									
<i>T. saxatilis</i>	C2 Muğla: Eker 2220	monosulcate	55.88	±1.48	50-62.5	44.58	±0.82	41.25-48.75	ellip
<i>T. humilis</i>	B9 Van: Eker 2111	monosulcate	49.05	±1.47	37.5-53.75	41.68	±1.18	35-46.25	ellip
	B9 Van: Eker 2474	monosulcate	51.83	±1.01	47.5-57.5	45.58	±1.30	40-51.25	ellip-sp
	B9 Van: Eker 2479	monosulcate	50.88	±0.95	47.5-55	43.58	±0.57	41.25-46.25	ellip
<i>T. pulchella</i>	C4 Antalya: Eker 2304	monosulcate	45.5	±0.58	42.5-48.75	38.58	±0.45	36.25-41.25	ellip
	C4 Karaman: Eker 2315	monosulcate	46.88	±1.01	42.5-53.75	40.75	±1.01	37.5-40.25	ellip-sp
	C4 Konya: Eker 2297	monosulcate	42.25	±0.54	38.75-43.75	35.38	±0.51	32.5-37.5	ellip
	C5 Niğde: Eker 2383	monosulcate	51.3	±1.94	41.25-67.5	46.05	±1.34	36.25-50	ellip-sp
1.3. Section <i>Biflores</i>									
<i>T. biflora</i>	B9 Van: Eker 1567	monosulcate	45.38	±2.04	37.5-55	37.38	±1.01	32.5-42.5	ellip
	B9 Van: Eker 1849	monosulcate	49.58	±0.93	46.25-56.25	43.5	±1.05	40-50	ellip-sp
<i>T. koyuncui</i>	B9 Van: Eker 2108	monosulcate	51.33	±0.81	47.5-55	41.63	±0.86	38.75-46.25	ellip

Taxa	Specimen	Pollen type	Long axis			Short axis			Pollen shape
			Mµm	St	Vµm	Mµm	St	Vµm	
2. Subgenus <i>Tulipa</i>									
2.1. Section <i>Tulipa</i>									
<i>T. armena</i> var. <i>armena</i>	A5 Amasya: Eker 2165	trisulcate	50.58	±1.30	45-60	45.58	±1.28	40-52.5	ellip-sp
	A6 Tokat: Eker 2451	trisulcate	48.83	±1.10	43.75-53.75	43.33	±1.06	37.5-48.75	ellip-sp
	A7 Gümüşhane: Eker 2454	trisulcate	54.05	±1.46	47.5-61.25	48.70	±1.96	41.25-57.5	ellip-sp
	B4 Ankara: Eker 2334	trisulkat	47.08	±0.86	42.5-52.5	40.68	±0.79	35-45	ellip
	B5 Yozgat: Eker 2324a	trisulcate	49	±0.63	46.25-52.5	42.75	±0.65	40-47.5	ellip-sp
	B7 Elazığ: Eker 2288	trisulcate	47.33	±0.44	45-50	42.88	±0.56	40-46.25	ellip-sp
	B9 Bitlis: Eker 2130	trisulcate	48.68	±0.99	42.5-52.5	43.93	±1.18	38.75-50	ellip-sp
	B9 Van: Eker 2099	trisulcate	47.43	±1.05	42.5-55	40.75	±1.13	37.5-47.5	ellip
	C2 Denizli: Eker 2421	tri-, tetra-, pentasulcate	49.63	±1.17	45-60	45.58	±1.11	37.5-55	ellip-sp
	C2 Denizli: Eker 2422	trisulcate	59.68	±2.77	48.75-73.75	50.13	±2.61	40-67.5	ellip
	C2 Muğla: Eker 2255	trisulcate	47.8	±0.86	43.75-50	41.30	±0.61	38.75-43.75	ellip-sp
	C3 Antalya: Eker 2404	trisulcate	52.08	±0.78	47.5-56.25	46.13	±0.85	42.5-50	ellip-sp
	C6 Hatay: Eker 2002	trisulcate	49.25	±1.02	45-57.5	45.33	±1.37	42.5-57.5	ellip-sp
<i>T. armena</i> var. <i>galatica</i>	A7 Gümüşhane: Eker 2453	trisulcate, inaperturate, diaperturate	56.55	±2.15	45-70	51.38	±2.22	40-62.5	ellip-sp
	B5 Yozgat: Eker 2324b	trisulcate	45.45	±0.75	42.5-50	39.70	±0.73	36.25-43.75	ellip-sp
<i>T. armena</i> (mix flower)	B5 Yozgat: Eker 2324c	tri-, tetra-, pentasulcate	51.50	±0.86	47.5-56.25	42.5	±0.87	42.5-50	ellip-sp
<i>T. sintenisii</i>	B8 Muş: Eker 1864	trisulcate	44.95	±0.80	41.25-50	37.38	±0.56	35-40	ellip
	B9 Ağrı: Eker 2139	trisulcate	44.7	±1.21	40-52.5	38.88	±1.07	35-46.25	ellip-sp
	C6 Gaziantep: Eker 1998	trisulcate	45.38	±0.79	42.5-48.75	38.55	±0.63	35-42.5	ellip
2.2. Section <i>Tulipanum</i>									
<i>T. aleppensis</i>	B7 Elazığ: Eker 2287	trisulcate	45.45	±0.69	42.5-50	41.68	±0.44	40-43.75	ellip-sp
	C7 Şanlıurfa: Eker 1814	trisulcate	49.95	±1.18	43.75-60	44.33	±1.28	37.5-55	ellip-sp
	C7 Şanlıurfa: Eker 1985	trisulcate, inaperturate, diaperturate	66.88	±2.42	57.5-82.5	61.65	±2.41	52.5-73.75	ellip-sp

Taxa	Specimen	Pollen type	Long axis			Short axis			Pollen shape
			M μ m	St	V μ m	M μ m	St	V μ m	
<i>T. julia</i>	A8 Bayburt: Eker 2141	trisulcate	52.08	± 0.95	47.5-57.5	45.68	± 0.83	42.5-50	ellip-sp
	B9 Ağrı: Eker 2497	trisulcate	57.88	± 1.04	53.75-63.75	55.58	± 1.17	50-61.25	ellip-sp
	B9 Van: Eker 2114	trisulcate	53.58	± 1.07	47.5-60	48	± 0.92	42.5-52.5	ellip-sp
	B10 Van: Eker 2096	trisulcate	48.70	± 0.99	43.75-52.5	40.70	± 0.85	37.5-45	ellip
<i>T. agenensis</i>	C5 Adana: Eker 2270	trisulcate	50.58	± 0.69	47.5-53.75	41.93	± 0.67	38.75-45	ellip
	C5 İçel: Eker 2263	trisulcate	46.95	± 1.12	45-50	41.93	± 0.41	40-43.75	ellip-sp
	C6 Hatay: Eker 2001	trisulcate	46.75	± 1.28	42.5-53.75	39.38	± 1.24	35-47.5	ellip
	C6 Hatay: Eker 2247b	trisulcate	50.68	± 1.35	46.25-60	44.38	± 1.64	38.75-55	ellip-sp
	C6 Hatay: Eker 2292	trisulcate	62.13	± 3.81	45-85	57.68	± 4.39	37.5-80	ellip-sp
<i>T. praecox</i>	A5 Amasya: Eker 2243	trisulcate	55.33	± 1.75	47.5-65	50.33	± 2.18	40-63.75	ellip-sp
	A5 Amasya: Eker 2244	trisulcate	53.25	± 1.53	47.5-62.5	49.13	± 1.81	42.5-60	ellip-sp
2.3. Section <i>Eichleres</i>									
<i>T. undulatifolia</i>	A1 Tekirdağ: Eker 2086	trisulcate	54.3	± 1.34	47.5-62.5	49.25	± 1.41	43.75-56.25	ellip-sp
	B1 Çanakkale: Eker 2085	tri-, tetrasulcate	53.58	± 0.96	50-60	52.93	± 0.93	48.75-57.5	ellip-sp
	B1 İzmir: Eker 2248	trisulcate	51.55	± 0.70	48.75-55	46.38	± 0.55	45-50	ellip-sp
	B4 Ankara: Eker 2336	trisulcate	54.55	± 1.17	51.25-62.5	48.18	± 0.90	43.75-55	ellip-sp
2.4. Section <i>Clusianae</i>									
<i>T. clusiana</i>	B4 Ankara: Eker 1841	trisulcate	52.2	± 1.52	47.5-62.5	45.68	± 1.46	38.75-57.5	ellip-sp

Taxa	Specimen	Exine pattern	Exine thickness µm	Exintine thickness µm	Endintine thickness µm	Exintine thickness near aperture (sulcus) µm
1. Subgenus <i>Eriostemon</i>						
1.1. Section <i>Australes</i>						
<i>T. sylvestris</i> subsp. <i>australis</i>	A4 Ankara: Eker 2166	perforate*	(1)-1.57-(1.9)	(0.6)-0.83-(1)	0.5-0.75	(1.5)-1.9-(3)
	B1 Balıkesir: Eker 2427	perforate-rugulate**	(1.2)-1.52-(1.8)	(0.8)-1.19-(1.7)	0.5-0.75	(1.5)-2.05-(3)
	C2 Denizli: Eker 2423	perforate*	(1)-1.6-(1.9)	(0.6)-1.29-(1.8)	0.5-0.75	(2)-2.85-(3.5)
	C3 Antalya: Eker 2050	perforate*	(1)-1.36-(1.5)	(0.8)-0.96-(1)	0.5-0.75	(2)-2.60-(3)
<i>T. sylvestris</i> subsp. <i>sylvestris</i>	B9 Van: Eker 1842	perforate*	(1)-1.59-(1.9)	(0.6)-0.88-(1.5)	0.5-0.75	(2)-2.2-(3)
<i>T. orphanidae</i>	B1 Balıkesir: Eker 2433	perforate*	(1)-1.2-(1.5)	(0.6)-1.1-(1.5)	0.5-0.75	(1.5)-2.05-(3)
	B1 Manisa: Eker 2078	perforate*	(1)-1.29-(1.5)	(1)-1.2-(1.8)	0.5-0.75	(2)-2.8-(4)
	C2 Muğla: Eker 2062	perforate*	(1)-1.56-(2)	(1)-1.87-(2.5)	0.5-0.75	(3)-3.4-(5)
<i>T. cinnabarina</i>	C4 Karaman: Eker 2030	perforate*	(1)-1.45-(1.5)	(1.5)-1.55-(2)	0.5-0.75	(2)-2.95-(3.5)
	C4 Karaman: Eker 2312	perforate*	(1)-1.4-(1.5)	(1)-1.2-(2)	0.5-0.75	(2)-2.55-(3)
1.2. Section <i>Saxatiles</i>						
<i>T. saxatilis</i>	C2 Muğla: Eker 2220	perforate*	(1)-1.52-(1.9)	(0.9)-1.13-(1.5)	0.5-0.75	(2)-2.7-(4)
<i>T. humilis</i>	B9 Van: Eker 2111	perforate*	(1)-1.35-(1.5)	(1)-1.51-(2)	0.5-0.75	(3)-4.2-(5)
	B9 Van: Eker 2474	perforate*	(1)-1.33-(1.8)	(0.5)-0.74-(1)	0.5-0.75	(1.5)-1.95-(3)
	B9 Van: Eker 2479	perforate-striate **	(1)-1.32-(1.7)	(0.5)-0.66-(1)	0.5-0.75	(1)-1.85-(2)
<i>T. pulchella</i>	C4 Antalya: Eker 2304	perforate-striate**	(1)-1.33-(1.8)	(0.9)-1.02-(1.5)	0.5-0.75	(2)-2.7-(4)
	C4 Konya: Eker 2297	perforate*	(1)-1.48-(1.8)	(0.7)-1.05-(2)	0.5-0.75	(1.5)-2.15-(3)
	C4 Karaman: Eker 2315	perforate*	(1)-1.35-(1.5)	(1)-1.23-(1.8)	0.5-0.75	(2)-2.7-(3)
	C5 Niğde: Eker 2383	perforate*	(1.5)-1.7-(2)	(0.8)-1.02-(1.5)	0.5-0.75	(2)-2.45-(3.5)
1.3. Section <i>Biflores</i>						
<i>T. biflora</i>	B9 Van: Eker 1567	perforate*	(1)-1.35-(1.5)	(0.6)-0.82-(1)	0.5-0.75	(1.5)-1.85-(2)
	B9 Van: Eker 1849	perforate*	(1)-1.15-(1.5)	(0.8)-1.13-(1.5)	0.5-0.75	(2)-2.1-(3)
<i>T. koyuncui</i>	B9 Van: Eker 2108	perforate*	(0.9)-1.21-(1.5)	(0.6)-0.76-(0.9)	0.5-0.75	(2)-2.5-(3)

Taxa	Specimen	Exine pattern	Exine thickness μm	Exintine thickness μm	Endintine thickness μm	Exintine thickness near aperture (sulcus) μm
2. Subgenus <i>Tulipa</i>						
2.1. Section <i>Tulipa</i>						
<i>T. armena</i> var. <i>armena</i>	A5 Amasya: Eker 2165	perforate*	(1.8)-1.97-(2)	(1)-1.42-(2)	0.5-0.75	(2.5)-3.2-(5)
	A6 Tokat: Eker 2451	perforate*	(1.9)-2.02-(2.5)	(0.8)-0.95-(1)	0.5-0.75	(2)-2.5-(5)
	A7 Gümüşhane: Eker 2454	perforate*	(1.5)-1.83-(2)	(0.8)-1.13-(1.5)	0.5-0.75	(2)-2.65-(4)
	B4 Ankara: Eker 2334	perforate*	(1)-1.42-(1.5)	(0.8)-0.99-(1.2)	0.5-0.75	(2)-2.6-(3)
	B5 Yozgat: Eker 2324a	perforate-rugulate**	(1.5)-1.73-(2)	(0.5)-0.94-(1.5)	0.5-0.75	(2)-2.4-(3)
	B7 Elazığ: Eker 2288	perforate*	(1.5)-1.69-(2)	(0.5)-0.99-(1.5)	0.5-0.75	(1.5)-2.20-(3)
	B9 Bitlis: Eker 2130	perforate*	(1.5)-1.81-(2)	(1)-1.7-(2)	0.5-0.75	(2.5)-2.95-(3.5)
	B9 Van: Eker 2099	perforate*	(1.6)-1.74-(1.9)	(1)-1.42-(1.8)	0.5-0.75	(2.5)-3.65-(5)
	C2 Denizli: Eker 2421	perforate*	(1.5)-1.78-(2)	(0.9)-1.02-(1.5)	0.5-0.75	(2)-2.25-(3)
	C2 Denizli: Eker 2422	perforate*	(1.5)-1.93-(2)	(1)-1.25-(1.5)	0.5-0.75	(2)-2.15-(3)
	C2 Muğla: Eker 2255	perforate*	(1)-1.42-(1.5)	(0.8)-1.05-(1.5)	0.5-0.75	(2)-2.3-(3)
	C3 Antalya: Eker 2404	perforate*	(1.5)-1.86-(2)	(0.7)-0.93-(1)	0.5-0.75	(2)-2.9-(3.5)
	C6 Hatay: Eker 2002	perforate*	(1.8)-2.03-(2.3)	(1)-1.4-(2)	0.5-0.75	(3)-3.8-(5)
<i>T. armena</i> var. <i>galatica</i>	A7 Gümüşhane: Eker 2453	perforate-rugulate**	(1.9)-2.09-(2.5)	(0.9)-1.14-(1.5)	0.5-0.75	(2)-2.45-(3)
	B5 Yozgat: Eker 2324b	perforate*	(1.9)-2.14-(2.5)	(0.5)-0.94-(1.5)	0.5-0.75	(2)-2.65-(3)
<i>T. armena</i> (mix flower)	B5 Yozgat: Eker 2324c	perforate*	(1.9)-1.97-(2)	(0.5)-0.85-(1)	0.5-0.75	(2)-2.1-(2.5)
<i>T. sintenisii</i>	B8 Muş: Eker 1864	perforate*	(1.9)-1.92-2.00	(0.7)-0.88-(1)	0.5-0.75	(2)-2.05-(2.5)
	B9 Ağrı: Eker 2139	perforate*	(1.8)-2.22-(2.5)	(0.9)-0.98-(1)	0.5-0.75	(2)-3-(5)
	C6 Gaziantep: Eker 1998	perforate*	(1.5)-1.79-(2)	(1)-1.41-(2)	0.5-0.75	(3)-3.3-(5)
2.2. Section <i>Tulipanum</i>						
<i>T. aleppensis</i>	B7 Elazığ: Eker 2287	perforate*	(1)-1.58-(2)	(0.8)-0.95-(1)	0.5-0.75	(2)-2.35-(3)
	C7 Şanlıurfa: Eker 1814	perforate*	(2)-2.25-(2.5)	(1)-1.2-(1.5)	0.5-0.75	(2.5)-3.35-(4)
	C7 Şanlıurfa: Eker 1985	perforate-rugulate**	(1.5)-1.84-(2)	(0.9)-1.23-(1.5)	0.5-0.75	(2)-2.5-(3)

Taxa	Specimen	Exine pattern	Exine thickness μm	Exintine thickness μm	Endintine thickness μm	Exintine thickness near aperture (sulcus) μm
<i>T. julia</i>	A8 Bayburt: Eker 2141	perforate*	(1.8)-2.08-(2.5)	(1)-1.62-(2)	0.5-0.75	(3)-5.4-(9)
	B9 Ağrı: Eker 2497	perforate*	(1.8)-1.95-(2)	(1)-1.2-(1.5)	0.5-0.75	(2)-2.35-(3)
	B9 Van: Eker 2114	perforate*	(1.5)-1.78-(2)	(1)-1.64-(2)	0.5-0.75	(3)-4.2-(5)
	B10 Van: Eker 2096	perforate*	(1.9)-2.23-(2.5)	(0.8)-0.94-(1)	0.5-0.75	(2)-2.4-(3)
<i>T. agenensis</i>	C5 Adana: Eker 2270	perforate*	(1.5)-1.88-(2)	1	0.5-0.75	(2)-2.25-(3)
	C5 İçel: Eker 2263	perforate*	(1.9)-2.08-(2.5)	(0.7)-0.92-(1)	0.5-0.75	(2)-2.3-(3)
	C6 Hatay: Eker 2001	perforate*	(1.7)-2.1-(2.5)	(0.5)-1.02-(1.8)	0.5-0.75	(2)-2.65-(2.5)
	C6 Hatay: Eker 2247b	perforate*	(1.5)-1.82-(2)	(0.9)-1.05-(1.5)	0.5-0.75	(2)-2.6-(3)
	C6 Hatay: Eker 2292	perforate*	(1.8)-2.13-(2.5)	(1)-1.30-(1.5)	0.5-0.75	(2)-2.6-(3)
<i>T. praecox</i>	A5 Amasya: Eker 2243	perforate*	(2)-2.15-(2.5)	(1)-1.10-(1.5)	0.5-0.75	(2)-2.15-(2.5)
	A5 Amasya: Eker 2244	perforate*	(2)-2.25-(2.5)	(1)-1.15-(1.5)	0.5-0.75	(2)-2.2-(3)
2.3. Section <i>Eichleres</i>						
<i>T. undulatifolia</i>	A1 Tekirdağ: Eker 2086	perforate*	(1.8)-2-(2.5)	(0.9)-1.03-(1.5)	0.5-0.75	(2)-2.2-(3)
	B1 Çanakkale: Eker 2085	perforate*	(1.7)-1.92-(2)	(1)-1.45-(2)	0.5-0.75	(4)-5.20-(8)
	B1 İzmir: Eker 2248	perforate*	(1.7)-1.94-(2)	(0.9)-1.09-(1.5)	0.5-0.75	(2)-2.15-(3)
	B4 Ankara: Eker 2336	perforate*	(1.9)-1.96-(2)	(1)-1.43-(1.8)	0.5-0.75	(2)-2.4-(3)
2.4. Section <i>Clusianae</i>						
<i>T. clusiana</i>	B4 Ankara: Eker 1841	perforate*	(1.5)-2.05-(2.5)	(0.6)-0.95-(1.5)	0.5-0.75	(2)-2.3-(3)

* LM

** SEM

Taxa	Specimen	Sulcus length µm	Sulcus width µm	Exine towards aperture	Sulcus membrane	operculum length µm	operculum width µm
1. Subgenus <i>Eriostemon</i>							
1.1. Section <i>Australes</i>							
<i>T. sylvestris</i> subsp. <i>australis</i>	A4 Ankara: Eker 2166	>LA	27, ³ SA	extend irregularly	1-banded operculum	40, > LA	(17)-20.7-(26)
	B1 Balıkesir: Eker 2427	>LA	38, ³ SA	extend irregularly	1-banded operculum	(32)-36.1-(42)	(18)-20.7-(25)
	C2 Denizli: Eker 2423	>LA	(30)-32.3-(36)	extend irregularly	1-banded operculum	(38)-43.7-(48)	(10)-14.3-(16)
	C3 Antalya: Eker 2050	>LA	³ SA	extend irregularly	1-banded operculum	(40)-42.75-(45)	(5)-10.3-(15)
<i>T. sylvestris</i> subsp. <i>sylvestris</i>	B9 Van: Eker 1842	>LA	(33)-36.86-(41), ³ SA	extend irregularly	1-banded operculum	(33)-39.3-(44)	(12)-15.2-(19)
<i>T. orphanidae</i>	B1 Balıkesir: Eker 2433	>LA	(20)-26.9-(33)	extend irregularly	1-banded operculum	(41)-49.3-(56)	(13)-17-(22)
	B1 Manisa: Eker 2078	>LA	(23)-24.67-(27), ³ SA	extend irregularly	1-banded operculum	(34)-41.9-(46)	(11)-13.7-(18)
	C2 Muğla: Eker 2062	>LA	(30)-34.4-(38), ³ SA	extend irregularly	1-banded operculum	(45)-49.4-(52)	(20)-27-(35)
<i>T. cinnabarina</i>	C4 Karaman: Eker 2030	>LA	(34)-37.5-(41), ³ SA	extend irregularly	1-banded operculum	(38)-46.1-(52)	(13)-17.8-(27)
	C4 Karaman: Eker 2312	>LA	(21)-26.6-(32)	extend irregularly	1-banded operculum	(40)-42.5-(48)	(8)-10.3-(15)
1.2. Section <i>Saxatiles</i>							
<i>T. saxatilis</i>	C2 Muğla: Eker 2220	>LA	(33)-37.4-(43)	extend irregularly	1-banded operculum	(11)-37.3-(56)	(7)-11.4-(13)
<i>T. humilis</i>	B9 Van: Eker 2111	>LA	(25)-26-(27), ³ SA	extend irregularly	1-banded operculum	(37)-43.6-(52)	(9)-10.8-(14)
	B9 Van: Eker 2474	>LA	42, ³ SA	extend irregularly	1-banded operculum	(40)-45.4-(50)	(12)-17.3-(25)
	B9 Van: Eker 2479	>LA	(24)-28.8-(34)	extend irregularly	1-banded operculum	(20)-38.6-(48)	(3)-6.2-(14)
<i>T. pulchella</i>	C4 Antalya: Eker 2304	>LA	(30)-32-(33), ³ SA	extend irregularly	1-banded operculum	(35)-39.5-(43)	(11)-13.9-(17)
	C4 Karaman: Eker 2315	>LA	(25)-32.5-(40)	extend irregularly	1-banded operculum	(30)-42.4-(48)	(11)-14.9-(20)
	C4 Konya: Eker 2297	>LA	(28)-30-(33), ³ SA	extend irregularly	1-banded operculum	(34)-38.8-(42)	(9)-11.8-(17)
	C5 Niğde: Eker 2383	>LA	(31)-37.13-(42), ³ SA	extend irregularly	1-banded operculum	(49)-56.1-(67)	(16)-22.7-(34)
1.3. Section <i>Biflores</i>							
<i>T. biflora</i>	B9 Van: Eker 1567	>LA	(24)-28.8-(32)	extend irregularly	1-banded operculum	(28)-36.4-(40)	(6)-10.1-(13)
	B9 Van: Eker 1849	>LA	(36)-38-(43), ³ SA	extend irregularly	1-banded operculum	(39)-42.2-(46)	(14)-17-(20)
<i>T. koyuncui</i>	B9 Van: Eker 2108	>LA	≥SA	extend irregularly	1-banded operculum	(38)-42.5-(48)	(17)-19.9-(24)

Taxa	Specimen	Exine towards aperture (s)	Sulcus membrane
2. Subgenus <i>Tulipa</i>			
2.1. Section <i>Tulipa</i>			
<i>T. armena</i> var. <i>armena</i>	A5 Amasya: Eker 2165	extend irregularly	granular
	A6 Tokat: Eker 2451	extend irregularly	granular
	A7 Gümüşhane: Eker 2454	extend irregularly	granular
	B4 Ankara: Eker 2334	extend irregularly	granular
	B5 Yozgat: Eker 2324a	extend irregularly	granular
	B7 Elazığ: Eker 2288	extend irregularly	granular
	B9 Bitlis: Eker 2130	extend irregularly	granular
	B9 Van: Eker 2099	extend irregularly	granular
	C2 Denizli: Eker 2421	extend irregularly	granular
	C2 Denizli: Eker 2422 (giant specimen)	extend irregularly	granular
	C2 Muğla: Eker 2255	extend irregularly	granular
	C3 Antalya: Eker 2404	extend irregularly	granular
	C6 Hatay: Eker 2002	extend irregularly	granular
<i>T. armena</i> var. <i>galatica</i>	A7 Gümüşhane: Eker 2453	extend irregularly	granular
	B5 Yozgat: Eker 2324b	extend irregularly	granular
<i>T. armena</i> (mix flower)	B5 Yozgat: Eker 2324c	extend irregularly	granular
<i>T. sintenisii</i>	B8 Muş: Eker 1864	extend irregularly	granular
	B9 Ağrı: Eker 2139	extend irregularly	granular
	C6 Gaziantep: Eker 1998	extend irregularly	granular
2.2. Section <i>Tulipanum</i>			
<i>T. aleppensis</i>	B7 Elazığ: Eker 2287	extend irregularly	granular
	C7 Şanlıurfa: Eker 1814	extend irregularly	granular
	C7 Şanlıurfa: Eker 1985	extend irregularly	granular

Taxa	Specimen	Exine towards aperture (s)	Sulcus membrane
<i>T. julia</i>	A8 Bayburt: Eker 2141	extend irregularly	granular
	B9 Van: Eker 2114	extend irregularly	granular
	B9 Ağrı: Eker 2497	extend irregularly	granular
	B10 Van: Eker 2096	extend irregularly	granular
<i>T. agenensis</i>	C5 Adana: Eker 2270	extend irregularly	granular
	C5 İçel: Eker 2263	extend irregularly	granular
	C6 Hatay: Eker 2001	extend irregularly	granular
	C6 Hatay: Eker 2247b	extend irregularly	granular
	C6 Hatay: Eker 2292	extend irregularly	granular
<i>T. praecox</i>	A5 Amasya: Eker 2243	extend irregularly	granular
	A5 Amasya: Eker 2244	extend irregularly	granular
2.3. Section <i>Eichleres</i>			
<i>T. undulatifolia</i>	A1 Tekirdağ: Eker 2086	extend irregularly	granular
	B1 Çanakkale: Eker 2085	extend irregularly	granular
	B1 İzmir: Eker 2248	extend irregularly	granular
	B4 Ankara: Eker 2336	extend irregularly	granular
2.4. Section <i>Clusianae</i>			
<i>T. clusiana</i>	B4 Ankara: Eker 1841	extend irregularly	granular

APPENDIX 3. Some Important Points Taken Into Consideration During Researches
on the Genus *Tulipa* L.

In field studies;

1. Bulb tunics of specimens should be taken without fragmented. For this, a large circular pit around the plant must be digged without damaging the plant.
2. Some species are markedly stoloniferous. During collection whether the plant is stoloniferous should be carefully observed.
3. Anther and pollen colour of specimen should be noted at fresh (e.g. purple colour at fresh changes to the tones of yellow at dry).
4. Sizes of fresh and dry anthers are very variable. Therefore, anther sizes should be noted as dry or fresh in descriptions.

During herbarium studies,

5. Flowers of specimens should be dried in opened position among the papers for observations of internal organs.

APPENDIX 4. Curriculum Vitae

Name : İsmail EKER
 Permanent Address : Abant İzzet Baysal University, Faculty of Science
 & Literature, Department of Biology, Gölköy,
 14280 Bolu/TURKEY
 Degree and date to be conferred : Ph.D., 19.02.2010
 Place Date of Birth : Şanlıurfa, 06.11.1976
 Secondary education : Adana Erkek Lisesi, Adana, 1994

<u>Collegiate instituons attended</u>	<u>Dates</u>	<u>Degree</u>	<u>Date of Degree</u>
Harran University	1997-2001	B.S.	25.07.2001
Harran University	2001-2005	M.S.	26.01.2005
Abant İzzet Baysal University	2005-2010	Ph.D.	19.02.2010

Publications :

International Journal Articles

1. Eker İ., Koyuncu M. 2008. *Muscari babachii* sp. nov. (Hyacinthaceae) from south Anatolia. Nordic J Bot 26: 49-52.
2. Eker İ., Koyuncu M., Akan H. 2008. The geophytic flora of Şanlıurfa Province, Turkey. Turk J Bot 32: 367-380.
3. Akan H., Eker İ., Satıl F. 2007. The morphological and anatomical properties of endemic *Crocus leichtlinii* (D. Dewar) Bowles (Iridaceae) in Turkey. Pak J Bot 39(3): 711-718.
4. Akan H., Eker İ. 2005. A new record for Turkey: *Colchicum crocifolium* Boiss., with a contribution to the description of the species. Belg J Bot 138 (1): 93-96.
5. Satıl F., Eker İ., Akan H., 2005. Some contributions to the morphological and

anatomical description of *Anemone coronaria* L. (Ranunculaceae) Occuring in Şanlıurfa, Turkey. Asian J Bot 4 (1): 40-43.

6. Akan H., Eker İ. 2005. Check-list of the Genus *Colchicum* in the Flora of Turkey. Turk J Bot, 29: 327-331.

7. Akan H., Kaya Ö.F., Eker İ., Cevheri C. 2005. The Flora of Kaşmer Dağı (Şanlıurfa, Turkey). Turk J Bot 29: 291-310.

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