

## *Crocus biflorus* MILLER (Liliiflorae, Iridaceae) in Anatolia — Part IV

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**Abstract:** In the course of our research on Turkish crocuses in areas of the Anatolian Diagonal (central eastern Turkey) a new understanding of the genus *Crocus* was obtained. Phenotypic and morphological parameters were used for comparison purposes, as well as geographical distributions of genetic groupings. Eleven new species were found and are described.

**Zusammenfassung:** Im Zuge der Erforschung türkischer Krokusse im Bereich der Anatolischen Diagonale (zentrale Osttürkei) wurden umfangreiche neue Erkenntnisse über die Gattung *Crocus* gewonnen. Phänotypische und morphologische Parameter wurden für umfangreiche Vergleiche herangezogen, genauso wie die geografische Verbreitung genetischer Gruppen. Elf neue Arten wurden gefunden und werden beschrieben.

**Key words:** New crocus species, Anatolian Diagonal, phenotype, geography, morphology, Turkey, *Crocus kartaldagensis*, *Crocus romuleoides*, *Crocus marasensis*, *Crocus pelitensis*, *Crocus schneideri*, *Crocus münzurense*, *Crocus malatyensis*, *Crocus kangalensis*, *Crocus sivasensis*, *Crocus ponticus*, *Crocus berytius*.

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### Introduction

In the most recent classification (MATHEW 1982) *Crocus biflorus* MILLER was described as a variable species concerning karyology ( $2n = 8, 10, 12, 14, 18, 20, 22$ ; BRIGHTON et al. 1973) and morphology. Therefore, MATHEW (1982) divided this species into several subspecies distributed from Italy to the Caucasus and Iran, with the type species referring to the Italian *C. biflorus* populations and the highest taxon diversity in Turkey.

Nearly 20 years ago, we started morphological and geographical investigations of *C. biflorus* populations in Turkey after seeing many strange crocus populations in Lycia, which were not identifiable with the known keys at that time. Therefore, with the aim to clarify the situation and to identify those populations, we measured and analysed 20 morphological parameters of a statistically sufficient number of randomly selected specimens of a population (we accumulated about 100,000 raw data of 76 crocus populations all over Turkey; KERNDORFF & PASCHE 2004b, 2006).

Our investigations (KERNDORFF & PASCHE 1993, 1994, 1997, 2003, 2004a, 2004b, 2006; KERNDORFF et al. 2011, 2012; PASCHE 1993) also resulted in the description of new taxa treated as subspecies following MATHEW's (1982) classification. However, doubts arose concerning their taxonomical rank, because 23 subspecies of one species would be unique in the genus and seemed to be rather improbable to us.

In part three we completed our field studies on *Crocus biflorus* "sensu lato" in south-west Anatolia. We obtained interesting new information on the alliance and distribution of the crocuses in this area and continued our research in the mountains of central-east Anatolia.

### General aspects of the new situation in the genus *Crocus*

From our present state of knowledge it seems necessary to recognise and discuss some fundamental principles in plant tax-

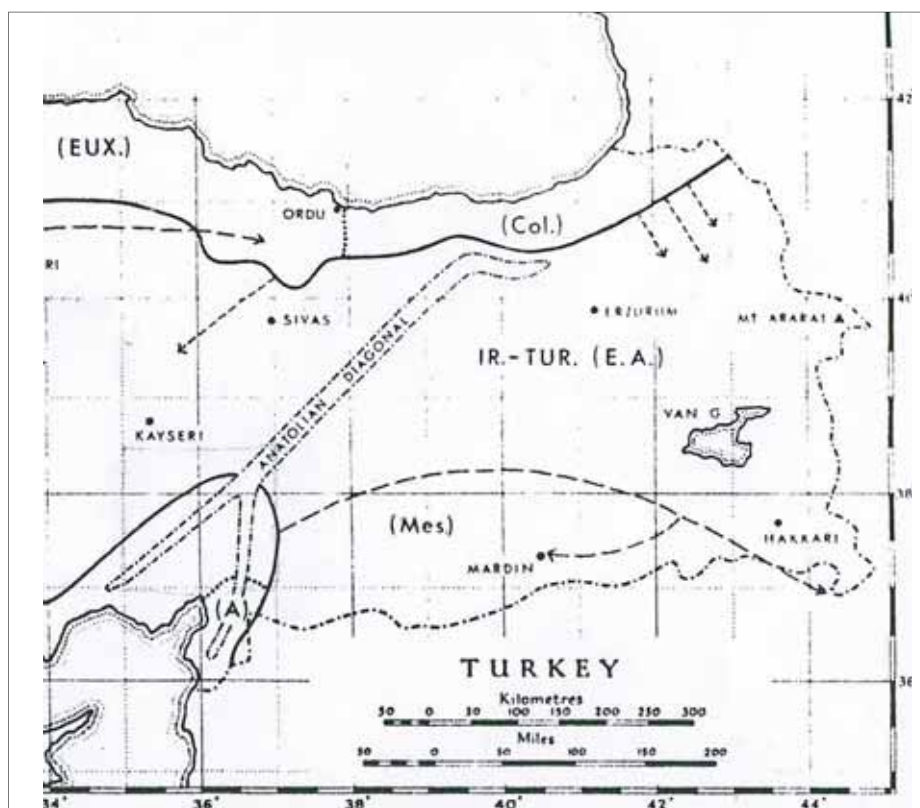


Fig. 1: The Anatolian Diagonal and its phytogeographic districts (extract of Davis, 1971).

onomy and systematic which were followed by us in our recent work to clarify the taxonomical status of the crocuses investigated. First of all, we had the necessity to consider the accepted definitions of the taxonomic units of subspecies and species.

- (i) Subspecies (= infraspecific taxon), are taxa which are slightly morphologically differentiated as well as geographically and/or ecologically isolated but still potentially capable of interbreeding without substantial reduction in fertility (e.g., WETTSTEIN 1898; MEIKLE 1957; FUCHS 1958).
- (ii) The main difference of a species in comparison to a subspecies is its reproductive isolation from other taxa (e.g., MAYR 1992). As consequence, different species of the same genus and at the same locality should only occasionally produce hybrids or only sterile hybrids.

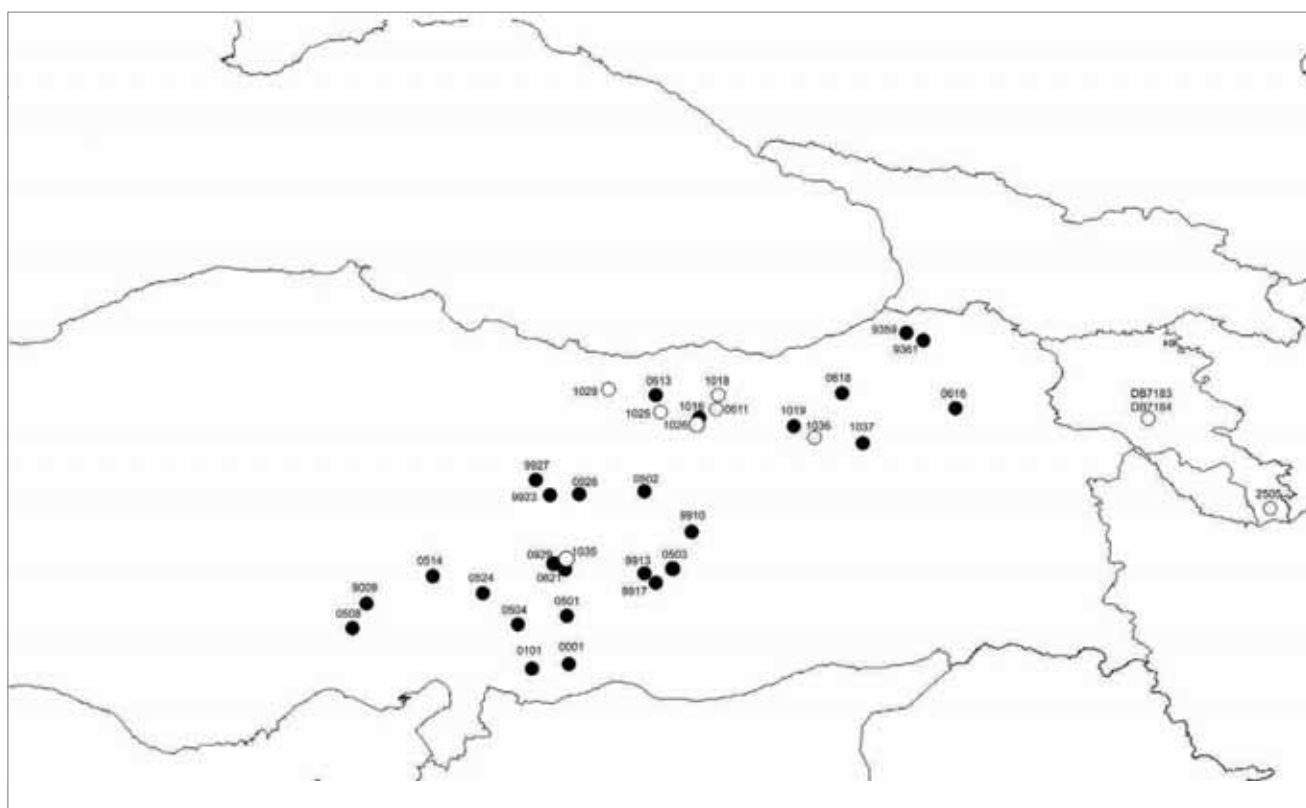
However, the definitions of a “species” are much more complex and still a matter of controversial discussions and there is still much space for individual interpretation. Therefore, in case of systematic uncertainties the term subspecies is often used as a dumping ground for similar taxa of varying rank.

Nevertheless, if one looks at the known existing hybrids in the series *Biflori*, it is surprising that there are only some (none fertile?) between *C. chrysanthus* HERBERT and *C. biflorus* but none between the other taxa and none between the defined *C. biflorus* subspecies, not even when tried to cross artificially. We found mixed populations of “allegedly” *C. biflorus* subspecies flowering at the same time but without any trace of hybrids.

Significant examples for such co-flowering populations without interbreeding were found in the Antitaurus (area 14) with the taxa *C. albocoronatus* KERND. & PASCHE and *C. petitensis* (a new taxon described in this paper), in Pisidia with the taxa aff. *C. isauricus* (SIEHE EX BOWLES) B. MATHEW and *C. crewei* (HOOK. F.) B. MATHEW, in Caria *C. ionopharynx* KERND. & PASCHE and *C. caricus* KERND. & PASCHE, in the Lycian Taurus with the taxa aff. *C. nubigena* (HERB.) B. MATHEW and *C. babadagensis* KERND. & PASCHE.

Furthermore, phylogenetic investigations clearly support a distinction at species level (PETERSEN et al. 2008; HARPKE et al. 2013) as *C. biflorus* subspecies were found in distinct clusters. One cluster is very homogenous and occupies the sister group position to a large clade comprising series *Aleppici*, *Flavi*, *Speciosi*, *Reticulati* and other former *C. biflorus* subspecies (HARPKE et al. 2013). Surprisingly, taxa of this very distinct cluster are inhabitants of the Anatolian Diagonal or are occurring north, east, and south-east of it. They are characterized by having chromosome numbers mainly between 18 and 24 while *C. cf. biflorus* west of the Anatolian Diagonal have chromosome numbers between 6 and 12 (SCHNEIDER et al. 2013). For species of this distinct cluster (“Adami cluster”) we will establish a new series in a new systematic treatment of the genus. The crocuses presented in this article all belong to this cluster (HARPKE et al. 2013, and own unpublished data).

Furthermore, phylogenetic (HARPKE et al. 2013, unpublished) and morphological (KERNDORFF et al. unpublished) investigations suggest that *C. biflorus* from the type region in Italy gener-



Phytogeographical differentiations in and adjacent to the Anatolian Diagonal (DAVIS 1971) can be seen on Fig. 1. According to the actual situation, areas belonging to the Irano-Turanian region are predominant in central Anatolia, divided by the Anatolian Diagonal into a western part (central Anatolia, C.A.) and into an eastern part (east Anatolia, E.A.). The southern and south-eastern part of east Anatolia is Mesopotamia (Mes.), which is warmer and dryer. In the wetter Euxine province (EUX.) of northern Anatolia primarily Euro-Siberian elements

can be found. However, the eastern part of this province is called Colchic sector (Col., east of Ordu) in which Caucasian elements are significantly increased. This wet and sheltered part evidently inhabits descendants of the Boreal Tertiary flora (DAVIS 1971).

In the area of the southern bifurcation of the diagonal mainly constituents of the east Mediterranean province are existent, subdivided into the Taurus district (T.) and the Amanus district (A.). The last one is remarkable for its numerous Euro-Siberian elements, which might have immigrated from the north, probably along the Anatolian Diagonal during the glacial (pluvial) phases of the Pleistocene, starting about 2.5 million years (Ma) ago.

The mountains of the Anatolian Diagonal, especially in the bifurcation, belong to complex geological formations and hence have very different soil types. Different rocks and soils have influence on ecosystems and plant life. Nevertheless, there is no tendency observable that *Crocus* species prefer a special type of edaphic condition because they seem to be evenly distributed on all kinds of soils, as long as these are rich in nutrients. For this reason they mostly can be found on black or brown humus-rich soils.

## Climate

There are several different climatic influences and microclimates along the Anatolian Diagonal. In general, the borders of the recent climatic zones of the investigation area may be defined as follows:

- (i) In the south-western part of the Anatolian Diagonal the Mediterranean belt extends from the southern Bolkar Dağları (Mersin) to approximately Kahramanmaraş in the north including the Amanus range with an eastern edge near Gaziantep. This region is predominated by dry summers and relatively humid and mild winters.
- (ii) North of this area and west of the Diagonal central Anatolian climate (continental climate) exists.
- (iii) East of the Diagonal central-east Anatolian climate is predominant (east continental type, very cold and dry winters) with easing conditions south of the Antitaurus and the Güney Doğu Dağları mountain arc (Mesopotamia climate type in the Euphrates-Tigris area, very hot and dry summers).
- (iv) In the north (Pontic range) the climate is much wetter and milder except for the high mountain areas above 1500 m elevation.

All this and intermediates of climatic regions (regional microclimates) influence the occurrence and distribution of crocuses. In the southern slopes of, e.g., the Antitaurus, crocuses grow at 700–900 m elevation, with lower boundaries for the occurrence towards the middle of the Anatolian Diagonal, where they mostly grow above 900 m, regularly around 1500 m but also up to approximately 2500 m or even higher. In the wetter and milder climate of the northern and north-eastern parts of the mountain ranges crocuses are mainly concentrated in the higher mountains and above ground appearance is confined to the months between April and October. Exceptions are the north-eastern lee-sides of the Pontic range, which are not more than 30 km away from the Black Sea coast, where crocuses grow as low as 500 m above sea level and can flower already from mid of January onwards.

## Field studies

Looking at the dimensions of the mountain belt an exhaustive investigation of all *Crocus* populations is nearly impossible within a lifespan. All the mountains are inhabited by many interesting and sparsely understood crocus populations, which were merged into only four taxa by MATHEW (1982): *C. biflorus* subsp. *adamii* GAY and subsp. *tauri* MAW inside the diagonal, subsp. *artvinensis* PHILIPPOV in north-eastern Turkey, and in Mesopotamia subsp. *pseudonubigena* MATHEW.

To reduce our travelling distances, we divided our investigation area in a southern and a northern part where we made 11 expeditions to selected mountain ranges between 1995 and 2013. Field studies were conducted on 26 different populations on mountain ranges or mountain stocks in Lazistan (five populations), Antitaurus (three populations), Amanus (one population), Cappadocia (four populations), Upper Euphrates (five populations), Mesopotamia (five populations), North Armenia (two populations) and South Armenia (one population) (Fig. 2 & Tab. 1a). Of several other populations in these areas and those to the east and south-east no field studies could be made for different reasons but genetic investigations of leaf-material were possible (Tab. 1b).

The same morphological characters/parameters were considered, as described previously (KERNDORFF & PASCHE 2006). Again, we photographed a large number of flowering specimens to document the variability of colouring and the general appearances/distinctness of flowers of each population. A selection is presented in the five colour plates (Figs. 5–9), which include four examples from the type locality of each investigated population.

## The type of *C. tauri*

One of the first findings was that a typical *C. tauri* form is, contrary to the present knowledge (MATHEW 1982), not at all common in all the areas investigated. In addition, beneath extreme variations of the flowers among individuals within populations, we also found significant phenotypic and morphological differences between populations. Their morphological differentiation is also supported by karyological (SCHNEIDER et al. 2013) and phylogenetic investigations (HARKE et al. 2013, unpublished).

Therefore, to distinguish and describe new taxa found in the *C. tauri* distribution region, a comparison with the type became necessary. The type locality of *C. tauri* is said to be “near the Cilician Gates” at an elevation of 1330 m, collected by Mr. Aucher-Eloy (specimens nos. 2128 and 2654 in Kew and Geneva herbaria). The surroundings of the Cilician Gates at this altitude seem to be highly improbable from the ecological point of view for an “alpine crocus”, that *C. tauri* is meant to be. Unfortunately, after a long thorough search in this area and on mountains on both sides of the Cilician Gate we were not able to find it.

In the original description of the species MAW (1886) made a painting of *C. tauri* drawn from a herbarium sheet which he lent from “Monsieur de Candolle”, which allegedly stems from specimens of the type locality. On this sheet are plants of the Aucher-Eloy collection no. 2654. We investigated digital copies of herbarium specimens of the Geneva herbarium, which were kindly sent to us (Aucher-Eloy’s plants no. 2654 (G00096624) and 2128 (G00096625 & G00150495)). The plants with the collection no.

**Table 1a:** Identity parameters of investigated *Crocus* populations of the Anatolian Diagonal including chromosome numbers

| population identity (HKEP)* | area               | mountain range (or city surroundings) | altitude (or range) (m) | date of field studies | specimens investigated (n) | taxon definition on genetic, morphological and geographic bases | 2n   |
|-----------------------------|--------------------|---------------------------------------|-------------------------|-----------------------|----------------------------|-----------------------------------------------------------------|------|
| 0001                        | 22 Mesopotamia     | Nizip environs                        | 800-900                 | 17.02.2000            | 29                         | <i>pseudonubigena</i>                                           | 18   |
| 0101                        | 22 Mesopotamia     | foot of Kartal Dağı                   | 1000-1100               | 15.03.2005            | 40                         | <i>kartaldagensis</i>                                           | 18   |
| 0501                        | 22 Mesopotamia     | Güz Dağı                              | 900-1200                | 15.03.2005            | 30                         | <i>romuleoides</i>                                              | 18   |
| 0504 <sup>2</sup>           | 15 Amanus          | Karaman-Maraş env.                    | 900-1100                | 18.03.2005            | 30                         | <i>marasensis</i>                                               | 22   |
| 0508                        | 14 Antitaurus      | Karanfil Dağı                         | 1000-1200               | 20.03.2005            | 31                         | <i>pelitensis</i>                                               | 22   |
| 0514                        | 20 Cappadocia      | Tahtalı Dağları                       | 2000-2300               | 03.05.2005            | 31                         | <i>schneideri</i>                                               | 20   |
| 0524                        | 14 Antitaurus      | Berit Dağı                            | 1900-2300               | 02.04.2009            | 26                         | <i>bervytius</i>                                                | 18   |
| 0613**                      | 04 Lazistan        | Giresun Dağları                       | 1500-1600               | 15.03.2006            | 31                         | undefined (adamii-group)                                        | 18   |
| 0616                        | 24 North Armenia   | Güllü Dağları                         | 2000-2100               | 17.03.2006            | 30                         | undefined (adamii-group)                                        | 18   |
| 0618                        | 21 Upper Euphrates | Mescit Dağları                        | 2100-2200               | 19.03.2006            | 34                         | undefined (adamii-group)                                        | 20   |
| 0621                        | 04 Lazistan        | Gül Dağı                              | 1900-2100               | 20.03.2006            | 32                         | <i>ponticus</i>                                                 | 18   |
| 0926                        | 20 Cappadocia      | Yama Dağı                             | 1900-2000               | 28.03.2009            | 31                         | undefined (adamii-group)                                        | 18   |
| 0929                        | 21 Upper Euphrates | Agörmez Dağı                          | 1800-2000               | 23.03.2009            | 37                         | <i>tauri</i> epitype                                            | 18   |
| 1016                        | 04 Lazistan        | Kalkanlı Dağları                      | 2200-2300               | 10.04.2010            | 36                         | <i>aërius</i>                                                   | 22   |
| 1019**                      | 24 North Armenia   | Kop Dağı                              | 2300-2400               | 11.04.2010            | 16                         | undefined (NE-Anatol. gr.)                                      | 18   |
| 1037***                     | 25 South Armenia   | Palandöken Dağları                    | 2300-2400               | 20.04.2010            | 28                         | <i>adamii</i> f. <i>roopiae</i> WOR.                            | 18   |
| 9009                        | 14 Antitaurus      | Central Taurus                        | 900-1200                | 19.03.2005            | 31                         | <i>albocoronatus</i>                                            | 20   |
| 9347                        | 21 Upper Euphrates | Munzur Dağları                        | 900-1200                | 16.03.2005            | 23                         | <i>munzurensis</i>                                              | 20   |
| 9359                        | 04 Lazistan        | Karçal Dağı                           | 500-800                 | 15.02.2007            | 36                         | <i>artvinensis</i>                                              | 20   |
| 9361                        | 04 Lazistan        | Cadır Dağı                            | 1000-1200               | 18.02.2007            | 33                         | <i>fibroannulatus</i>                                           | 24   |
| 9910**                      | 21 Upper Euphrates | Kaplıkaya tepe                        | 1200-1300               | 24.03.1999            | 18                         | aff. <i>munzurensis</i>                                         | 20   |
| 9913                        | 21 Upper Euphrates | Kub Dağı                              | 1500                    | 27.03.1999            | 29                         | undefined (NE-Anatol. gr.)                                      | 18   |
| 9914                        | 22 Mesopotamia     | Maden Dağları                         | 900-1100                | 17.03.2005            | 33                         | <i>malatyensis</i>                                              | n.d. |
| 9917                        | 22 Mesopotamia     | Malatya Dağları                       | 1500-2100               | 27.03.1999            | 29                         | undefined (NE-Anatol. gr.)                                      | 20   |
| 9923                        | 20 Cappadocia      | Kangal environs                       | 1400                    | 28.03.1999            | 31                         | <i>kangalensis</i>                                              | 18   |
| 9927                        | 20 Cappadocia      | Tecer Dağları                         | 1500-1800               | 28.03.1999            | 34                         | <i>sivasensis</i>                                               | 36   |

\* investigators Helmut Kerndorff & Erich Pasche<sup>2</sup> discovered by J. Lebsa & W. Näcke under JLWN 9807

\*\* no photographs are available for these populations

\*\*\* 1037 is genetical (ITS-region) identical to *C. adamii* ArmGet\_1\_2, *C. adamii* Arm Van, *C. adamii* MP9676 (see table 1b)**Table 1b:** Identity of *Crocus* populations with DNA-results only (no field studies existent)

| population identity (collector)             | area                      | mountain range or nearest city                      | altitude (or range) (m) | taxon classified according to genetic groups or morphology |
|---------------------------------------------|---------------------------|-----------------------------------------------------|-------------------------|------------------------------------------------------------|
| HKEP 0611                                   | Turkey 21 Upper Euphrates | Köse Dağı                                           | 1900-2000               | undefined (E&NE-Anatolian group)                           |
| HKEP 1018                                   | Turkey 21 Upper Euphrates | E-Giresun Dağları                                   | 1900-2000               | undefined (E&NE-Anatolian group)                           |
| HKEP 1020                                   | Turkey 21 Upper Euphrates | E-Giresun Dağları                                   | 2100-2200               | undefined                                                  |
| HKEP 1025*                                  | Turkey 21 Upper Euphrates | Sarıççek Dağları                                    | 2000-2100               | undefined (adamii-group)                                   |
| HKEP 1026                                   | Turkey 21 Upper Euphrates | E-Giresun Dağları                                   | 1700-1800               | undefined (adamii-group)                                   |
| HKEP 1029                                   | Turkey 04 Lazistan        | Karagöl Dağı                                        | 1900-2000               | undefined (adamii-group)                                   |
| HKEP 1032                                   | Turkey 21 Upper Euphrates | Köroğlu Dağı                                        | 1700-1800               | undefined (belongs to western taxa)                        |
| HKEP 1034                                   | Turkey 21 Upper Euphrates | Kepez Dağı                                          | 1800-1900               | undefined ( <i>tauri</i> -group, cf. 0929)                 |
| HKEP 1035                                   | Turkey 21 Upper Euphrates | Kepez Dağı                                          | 1700                    | undefined ( <i>tauri</i> -group, cf. 0929)                 |
| HKEP 1036                                   | Turkey 24 North Armenia   | Palandöken Dağları                                  | 1800                    | undefined                                                  |
| ?                                           | Persia                    | Zanjan Abhar                                        | 2150                    | cf. <i>adamii</i>                                          |
| JMM 01-136                                  | Persia, Kurdistan         | E of Sanandaj                                       | 2100                    | cf. <i>adamii</i>                                          |
| MP 9676                                     | Armenia                   | Gegam Mountains (Gekhard)                           | ?                       | cf. <i>adamii</i> (= type of <i>C. geghartii</i> SOSN.)    |
| Zhirair Basmajian                           | Armenia                   | Vanadzor                                            | ?                       | cf. <i>adamii</i>                                          |
| Zhirair Basmajian                           | Armenia                   | Getahovit                                           | ?                       | cf. <i>adamii</i>                                          |
| Zhirair Basmajian                           | Georgia / Russia ?        | Caucasus                                            | ?                       | cf. <i>adamii</i>                                          |
| Dr. R. Fritsch 2505                         | Armenia                   | GPS 39.051694, 46.302109                            | 2800                    | cf. <i>adamii</i>                                          |
| 7183**, B 10 0355320                        | Armenia                   | surroundings of Geghard monastery                   | ?                       | <i>biflorus</i> , (referred by us to adamii-group)         |
| 7184***, B 10 0355321 (DNA Nr/ voucher Nr.) | Armenia                   | surroundings of Artashchavan, near river Khloidzhur | 1800                    | <i>biflorus</i> , (referred by us to adamii-group)         |

\* photographs from this population are shown in Fig. 9

\*\* col. 24.4.1946, then cultivated until 29.3.1968

\*\*\* voucher from 30.3.1960, Botanical Garden Berlin

2654 have seven respectively eight leaves corresponding to the painting of Maw. Bracts and bracteoles of these specimens are still more or less silvery but the upper cataphylls are significantly brown. From parts of the corm tunic still left in one plant, one can suppose a papery one. MATHEW's (1982) description of subsp. *tauri* is fitting to this except for the colour of the cataphylls, which are silvery. Specimens on the two other sheets of *C. tauri* with collection no. 2128, collected in the same area, have either only four leaves (G00150495) or five leaves (G00096625). Specimens of no. 2128 were also deposited in Kew and a digital copy of it was kindly provided by Brian Mathew. On this sheet there is a remark of Maw, that he was seeing this specimen as identical to number 2654. Thus, either the Aucher-Eloy plants of collection 2654 belong to a different species not yet rediscovered or represent individuals of *C. tauri* with exceptionally many leaves. The latter would be in agreement with our field studies (26 populations, approximately 800 individuals), where eight leaves were found only once (in population HKEP 0101 from near Kartal Dağ of which 40 specimens were investigated) and seven leaves found only four times in three populations (HKEP 0514: 2 specimens out of 31, HKEP 9009: 1 out of 31 specimens, HKEP 0613: 1 out of 31 specimens). But all of these plants are phenotypically very different from *C. tauri* of the herbarium specimens. As we were not able to rediscover the type locality, and especially the number of leaves of the type is disputable, we decide to apply the morphological parameters used by MATHEW (1982) for the characterisation of *C. biflorus* subsp. *tauri* to define an epitypus. Specimens of the population HKEP 0929 seem to fit best. The population is located in the central Anatolian Diagonal, near the city of Darende, between Malatya and Kayseri, which was also described as typical area for this species (MATHEW 1982).

All morphological parameters used by Mathew were compared to the epitype:

#### *C. biflorus* subsp. *tauri* according to MATHEW (1982):

|                   |                                                                                                                                        |
|-------------------|----------------------------------------------------------------------------------------------------------------------------------------|
| corm tunic:       | rather membranous, not usually markedly coriaceous                                                                                     |
| leaves, no.:      | 4-9, stiffly erect and shorter than to equalling the flower at anthesis                                                                |
| leaves, diam.:    | 1.5-3.5 mm                                                                                                                             |
| bract, bracteole: | silvery, often rather large and conspicuous, not markedly long-attenuate at the apex                                                   |
| flowers:          | pale to mid lilac with no prominent darker stripes on the exterior but sometimes finely veined or feathered darker; throat pale yellow |

#### Specimens of HKEP 0929 (Epitype of *C. tauri* MAW deposited at Gatersleben, GAT 7147):

|                   |                                                                                                                                                                                                                               |
|-------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| corm tunic:       | Outer and inner corm tunics membranous                                                                                                                                                                                        |
| leaves, no.:      | 2-5, median 4 (see comments in the text), leaves stiffly erect and shorter than to equalling the flower at anthesis                                                                                                           |
| leaves, diameter: | 1.5-2 mm                                                                                                                                                                                                                      |
| bract, bracteole: | silvery, skinny, conspicuous, not significantly prolonged                                                                                                                                                                     |
| flowers:          | pale to mid lilac with no prominent darker stripes on the interior and exterior but sometimes finely veined or feathered darker, especially towards the perianth tube (see colour plate 3), throat pale yellow to dark yellow |

The parameter values are mostly identical. The discrepancy in the leaf-number is already recognisable in former collections of this species (see discussion above). The difference in leaf-width can be referred to the fact that only very few herbarium specimens were available for the measurements of the original description and not a statistical representative number of individuals like in our investigation. Indeed, the herbarium specimens from Geneva of *C. tauri* sent to us have 4-5 leaves and are between 1 and 2 mm in diameter, which is congruent to our observation. A detailed description of the *C. tauri* epitype is given under point 12 of the description of new species.

## Morphological investigations

### General Observation

The results of the considered morphological and phenotypical characters of all investigated populations are summarized in Tabs. 2a-d. It is noteworthy that in all the investigated populations the median of the leaf-number is three or four, thus little variable. In contrary to that the numbers of leaf-ribs underneath varies from one to five, with the tendency to higher numbers in the north. Cataphylls, bracts and bracteoles are all white/silvery except for populations HKEP 9009, HKEP 0621, HKEP 9359, which are aging brown, in population HKEP 0504 they are even persistent, and in population HKEP 1016 only rarely brownish. Median lengths of outer segment sizes vary from 20 to 29 mm, the width from 5 to 10 mm. Results of inner segments are slightly lower (Tab. 2b). The shortest filaments are found within population HKEP 9347 (mean 2.17 mm), the longest with HKEP 9913 (mean 5.17 mm). Very prominent anthers were observed within population HKEP 0504 (mean 12.1 mm), the shortest ones in HKEP 0501 (mean 7.42 mm). Mean-length of style-branches vary from 4.3 mm (HKEP 0504) to 8 mm (HKEP 9923). Style-lengths compared to stamen are always shorter within population HKEP 0504 and mostly longer within population HKEP 9914. All other populations show significant variation for this parameter.

Remarkable under the habitual point of view are populations from the Kartal Dağ (large and colourful, HKEP 0101), Güz Dağı (very small flowers, open like flat stars near the ground similar to *Romulea*, HKEP 0501), and Maden Dağları (large and unusual rosy-lilac ground-colours and prominent frequent turquoise or blue-violet blotches near the perianth tube, HKEP 9914). Most interesting is a population from the surroundings of Karaman-Maraş (HKEP 0504), discovered by J. Lebsa & W. Näcke (personal collection no. JLWN 9807) where all individuals have dark brown persistent cataphylls (Fig. 7f), which is known to be typical only for some taxa of series *Flavi*.

Very interesting are two extremely small populations in the Anti-Taurus and the Munzur Dağları. The first one, described by KERNDORFF (1993) as *C. biflorus* subsp. *albocoronatus*, has rather narrow star-like segments, inside a deep rosy-lilac colour, the outside of the outer segments buff-coloured and violet striped. It has intensive brown cataphylls/bract/bracteole with age, in few specimens the cataphylls are also persistent (HKEP 9009). The second one from the Munzur Dağları, is conspicuously ciliated on mature leaves, which is very unusual in crocus. The anthers of all investigated populations are yellow, except the ones of HKEP 0101 (all black), HKEP 0501 (93% black, 7% yellow), and HKEP 0001 (blackish, greyish, and greenish).

**Table 2a:** Results of field studies for cataphylls, bracts, bracteoles, and true leaves

| population<br>(HKEP) | cataphylls/<br>bracts/bracteoles<br>colour | true leaves    |      |        |                            |                 |                           |
|----------------------|--------------------------------------------|----------------|------|--------|----------------------------|-----------------|---------------------------|
|                      |                                            | number (range) | mean | median | diameter <sup>3</sup> (mm) | ribs underneath | white stripe <sup>1</sup> |
| 0001                 | silvery / white                            | 2-5            | 3,24 | 3      | 1-1,5                      | 1-2             | <1/3 – 1/3                |
| 0101                 | silvery / white                            | 3-8            | 4,49 | 4      | 1-2                        | 2               | ¼ - 1/3                   |
| 0501                 | silvery / white                            | 2-5            | 3,17 | 3      | 1                          | (1)2            | <1/3 – 1/3                |
| 0504                 | silvery/aging brown <sup>4</sup>           | 2-5            | 3,43 | 3      | 1,5                        | (1)2            | <1/3 – 1/3                |
| 0508                 | silvery / white                            | 2-5            | 3,16 | 3      | 1-1,5                      | 2               | 1/3(>1/3)                 |
| 0514                 | silvery / white                            | 3-7            | 4,29 | 4      | 2-2,5                      | (3)4(5)         | ¼ - 1/3                   |
| 0524                 | silvery / white                            | 3-5            | 4,24 | 4      | 1                          | (1)2            | <1/3                      |
| 0613                 | silvery / white                            | 2-7            | 4,03 | 4      | 1,5                        | 2(3)            | <1/3 – 1/3                |
| 0616                 | silvery / white                            | 3-6            | 3,63 | 3      | 1,5-2                      | 2(3)            | <1/3 – 1/3                |
| 0618                 | silvery / white                            | 2-5            | 3,18 | 3      | 1-1,5                      | 2               | ¼ - 1/3                   |
| 0621                 | silvery/aging brown <sup>4</sup>           | 3-6            | 3,73 | 4      | 1,5-2                      | 2(3)            | <1/3 – 1/3                |
| 0926                 | silvery / white                            | 2-4            | 3,32 | 3      | 1-2                        | 2-3             | <1/3                      |
| 0929                 | silvery / white                            | 2-5            | 3,62 | 4      | 1,5-2                      | 2               | <1/3 – 1/3                |
| 1016                 | silvery / rarely brownish                  | 2-5            | 3,17 | 3      | 2-2,5                      | 2               | ¼ - 1/3                   |
| 1019                 | silvery / white                            | 3-7            | 4,25 | 4      | 1,5-2(2,5)                 | (2)3(4)         | ¼ - 1/3                   |
| 1037                 | silvery / white                            | 2-4            | 3,14 | 3      | 1,5-2                      | (2)3            | 1/6-1/4 (1/3)             |
| 9009                 | silvery/aging brown <sup>2</sup>           | 3-7            | 4,10 | 4      | 1-1,5                      | 2               | 1/3->1/3                  |
| 9347                 | silvery ?dried                             | 2-4            | 3,13 | 3      | 1,5                        | 2-3             | 1/3->1/3                  |
| 9359                 | silvery/aging brown                        | 3-6            | 4,31 | 4      | 1-1,5                      | 1-2             | 1/3->1/3                  |
| 9361                 | silvery / white                            | 3-5            | 3,74 | 4      | 1                          | 2               | <1/4                      |
| 9910                 | silvery / white                            | 3-4            | 3,30 | 3      | 1,5-2                      | 3-4             | <1/3 – 1/3                |
| 9913                 | silvery / white                            | 2-6            | 3,47 | 3      | 1-2                        | 2               | 1/3                       |
| 9914                 | silvery / white                            | 3-6            | 3,55 | 3      | 1,5-2                      | 1-2(3)          | 1/3->1/3                  |
| 9917                 | silvery / white                            | 3-5            | 3,66 | 4      | 1-2                        | 2(3)            | 1/3                       |
| 9923                 | silvery / white                            | 3-5            | 3,58 | 4      | 1-2                        | (1)2(3)         | 1/3                       |
| 9927                 | silvery / white                            | 2-5            | 3,68 | 4      | 1-2                        | 2(3-4)          | 1/3                       |

<sup>1</sup> in dimension of leaf-diameter (approximately 1/3 is considered as “normal”)<sup>2</sup> rarely persistent    <sup>3</sup> persistent<sup>4</sup> get brown already in early stadium<sup>5</sup> at broadest part**Table 2b:** Results of field studies for segment sizes

| population<br>(HKEP) | range of segment sizes (mm) |                          |                           |                          |
|----------------------|-----------------------------|--------------------------|---------------------------|--------------------------|
|                      | outer length <sup>1</sup>   | outer width <sup>1</sup> | inner length <sup>1</sup> | inner width <sup>1</sup> |
| 0001                 | 23, 29, 32                  | 05, 06, 08               | 22, 26, 28                | 05, 06, 08               |
| 0101                 | 19, 25, 34                  | 05, 08, 11               | 17, 24, 33                | 05, 08, 10               |
| 0501                 | 16, 20, 24                  | 03, 05, 07               | 14, 18, 22                | 03, 05, 06               |
| 0504                 | 17, 25, 33                  | 04, 05, 07               | 16, 25, 33                | 04, 06, 08               |
| 0508                 | 16, 22, 32                  | 04, 05, 08               | 16, 21, 29                | 05, 07, 09               |
| 0514                 | 19, 23, 29                  | 05, 08, 13               | 18, 23, 28                | 05, 08, 12               |
| 0524                 | 15, 22, 32                  | 07, 10, 15               | 13, 21, 31                | 05, 09, 14               |
| 0613                 | 20, 24, 31                  | 06, 08, 13               | 19, 23, 30                | 05, 08, 11               |
| 0616                 | 20, 24, 30                  | 07, 09, 15               | 19, 23, 29                | 06, 09, 13               |
| 0618                 | 16, 22, 26                  | 05, 08, 10               | 15, 20, 25                | 05, 08, 11               |
| 0621                 | 20, 24, 33                  | 06, 08, 10               | 19, 23, 31                | 04, 08, 11               |
| 0926                 | 09, 23, 28                  | 07, 09, 11               | 18, 22, 27                | 06, 08, 11               |
| 0929                 | 20, 24, 30                  | 07, 09, 12               | 18, 22, 29                | 06, 08, 10               |
| 1016                 | 21, 30, 38                  | 07, 11, 16               | 21, 29, 45                | 06, 11, 17               |
| 1019                 | 19, 25, 35                  | 06, 09, 12               | 19, 26, 36                | 06, 10, 12               |
| 1037                 | 20, 25, 33                  | 06, 09, 13               | 19, 24, 32                | 05, 09, 12               |
| 9009                 | 18, 25, 34                  | 03, 05, 08               | 17, 23, 34                | 04, 06, 08               |
| 9347                 | 15, 21, 28                  | 05, 08, 11               | 15, 20, 26                | 04, 08, 10               |
| 9359                 | 17, 24, 32                  | 05, 07, 09               | 16, 23, 30                | 05, 08, 11               |
| 9361                 | 19, 23, 26                  | 06, 07, 09               | 19, 22, 25                | 06, 07, 10               |
| 9910                 | 23, 29, 36                  | 06, 08, 12               | 20, 26, 34                | 05, 08, 11               |
| 9913                 | 21, 27, 31                  | 05, 08, 12               | 20, 26, 30                | 05, 08, 13               |
| 9914                 | 19, 29, 39                  | 06, 09, 12               | 19, 27, 33                | 06, 09, 11               |
| 9917                 | 20, 25, 32                  | 07, 08, 15               | 20, 25, 31                | 07, 09, 13               |
| 9923                 | 22, 28, 36                  | 07, 10, 12               | 20, 27, 34                | 07, 09, 13               |
| 9927                 | 20, 25, 33                  | 07, 09, 12               | 19, 25, 33                | 07, 09, 13               |

<sup>1</sup> left side = minimum, middle = mean, right side = maximum values

**Table 2c:** Results of field studies for filaments, anthers, and styles

| population | filaments             |                         | anthers               |                         | styles                             |                                       |                                                 |
|------------|-----------------------|-------------------------|-----------------------|-------------------------|------------------------------------|---------------------------------------|-------------------------------------------------|
| (HKEP)     | length (mm)<br>(mean) | length (mm)<br>(median) | length (mm)<br>(mean) | length (mm)<br>(median) | length <sup>1</sup> (mm)<br>(mean) | length acc. to<br>stamen <sup>2</sup> | length acc. to<br>stamen<br>(mean) <sup>3</sup> |
| 0001       | 3,75                  | 4                       | 8,10                  | 8                       | 6,96                               | 02, 02, 25                            | -0,79                                           |
| 0101       | 3,95                  | 4                       | 9,82                  | 10                      | 6,86                               | 03, 00, 20                            | -0,63                                           |
| 0501       | 4,13                  | 4                       | 7,42                  | 7                       | 5,71                               | 01, 02, 24                            | -0,81                                           |
| 0504       | 3,90                  | 4                       | 12,10                 | 12                      | 4,31                               | 00, 00, 30                            | -1,00                                           |
| 0508       | 3,71                  | 4                       | 8,65                  | 9                       | 5,73                               | 09, 09, 13                            | -0,13                                           |
| 0514       | 2,87                  | 3                       | 8,07                  | 8                       | 5,33                               | 13, 06, 11                            | -0,17                                           |
| 0524       | 4,78                  | 5                       | 10,38                 | 9                       | 4,45                               | 13, 32, 10                            | 0,05                                            |
| 0613       | 4,00                  | 4                       | 10,16                 | 10                      | 7,14                               | 09, 12, 10                            | -0,03                                           |
| 0616       | 3,10                  | 3                       | 9,63                  | 10                      | 5,94                               | 15, 13, 02                            | 0,43                                            |
| 0618       | 3,58                  | 4                       | 8,45                  | 8                       | 5,15                               | 22, 08, 03                            | 0,58                                            |
| 0621       | 4,59                  | 5                       | 11,53                 | 11                      | 7,77                               | 13, 15, 04                            | 0,28                                            |
| 0926       | 3,74                  | 4                       | 10,16                 | 10                      | 8,48                               | 22, 09, 00                            | 0,71                                            |
| 0929       | 3,23                  | 3                       | 9,94                  | 10                      | 6,23                               | 08, 19, 08                            | 0,00                                            |
| 1016       | 4,33                  | 4,5                     | 11,47                 | 10,5                    | 6,82                               | 13, 16, 07                            | 0,25                                            |
| 1019       | 4,50                  | 4,5                     | 9,73                  | 10                      | 5,21                               | 10, 07, 05                            | 0,09                                            |
| 1037       | 4,43                  | 4,5                     | 8,14                  | 8                       | 4,94                               | 06, 19, 03                            | 0,57                                            |
| 9009       | 3,81                  | 4                       | 9,03                  | 9                       | 6,70                               | 13, 05, 13                            | -0,26                                           |
| 9347       | 2,70                  | 3                       | 10,27                 | 10                      | 6,27                               | 06, 04, 13                            | -0,39                                           |
| 9359       | 3,00                  | 3                       | 9,58                  | 10                      | 8,19                               | 34, 02, 00                            | 0,94                                            |
| 9361       | 3,21                  | 3                       | 10,67                 | 11                      | 8,92                               | 30, 03, 00                            | 0,71                                            |
| 9910       | 5,07                  | 5                       | 9,56                  | 10                      | 6,06                               | 07, 09, 02                            | 0,39                                            |
| 9913       | 5,17                  | 5                       | 9,69                  | 10                      | 6,39                               | 11, 13, 04                            | 0,34                                            |
| 9914       | 4,36                  | 4                       | 10,71                 | 10                      | 7,14                               | 07, 22, 02                            | 0,65                                            |
| 9917       | 5,13                  | 5                       | 10,10                 | 10                      | 5,69                               | 18, 08, 03                            | 0,17                                            |
| 9923       | 5,00                  | 5                       | 9,58                  | 10                      | 8,00                               | 18, 03, 10                            | -0,23                                           |
| 9927       | 3,75                  | 4                       | 9,79                  | 10                      | 6,19                               | 17, 01, 16                            | -0,44                                           |

<sup>1</sup> length of branches<sup>2</sup> no. equal, longer, shorter (of investigated specimens)<sup>3</sup> mean of styles longer (1), equal (0), and shorter (-1) of stamens

In the northern part of the Anatolian Diagonal, six populations of *Crocus* could be investigated. One of those is the remarkable *C. artvinensis* known since 1917 to occur in the vicinity of the city of Artvin. Its most characteristic flower-aspect is a very broad violet stripe in the centre of the outside of the outer segments, although this feature is more variable than previously thought (Fig. 6i-l). The second one is *C. fibroannulatus*, discovered in 1993 (KERNDORFF & PASCHE 1993) and described as *C. biflorus* subsp. *fibroannulatus*. This one has a strange outer corm-tunic consisting of narrow parallel fibre-like bands and sporadically basal rings. The third one is a very strange population not alike the two others from a high alpine region of the eastern Pontic range (Gül Dağı). In this the segments are comparatively pointed and the basal colour is in general rather light blue to soft lilac with white veins, resembling a mixture between the species “*fibroannulatus*” and “*tauri*”, but the corm tunic is similar to *C. artvinensis*. Most spectacular, however, in this one is a salmon-coloured throat along with filaments and styles of the same colour to be found in several individuals. This colour was seen by us for the first time in the genus.

The diversity of the 26 populations studied all along and within the Diagonal is surprising compared to the, absolutely seen, few localities investigated. It shows a very high degree of variability, which we never expected, but is indeed comparable to the one we found in south-western Anatolia.

### Differentiation of genetic sub-groups in the “Adami cluster”

Due to the completely changed situation in our work it seems useful to us only to compare those populations phenotypically and morphologically, which were genetically clustered together in distinct units or subunits (groups) (Tab. 3 & Fig. 3 “Adami”-cluster; same colours of groups on both). Detailed genetic results concerning this cluster as well as all others of section *Nudiscapus* will be published elsewhere. As already mentioned in part two and three, both, qualitative and quantitative characters (parameters) are used for comparison purposes. These are presented in two parts, at first in a comparison of the flower variation of each population in Fig. 4 and secondly in a comparison of the most important morphological and phenotypic results of Tab. 4. The genetic analyses revealed five major sub-clusters of the large “Adami cluster” (Tab. 3). These sub-clusters (groups) are the “E & NE Anatolian” group, the “adamii” group (west and east), the “munzurense group”, the “pseudonubigena group”, and the “tauri” group. Separate or single positions in the large “Adami-cluster” have *C. schneideri* (HKEP 0514), *C. munzurense* and a related species (HKEP 9347 and HKEP 9910), *C. beryti* (HKEP 0524) and *C. pelitensis* (HKEP 0508), the last four described in this paper. Although support values for some phylogenetic groups are quite low at the present state of investigation they are of course worth a comparison with phenotypic and morphological parameters.

**Table 2d:** Results of field studies for colours of filaments, connectives, anthers, and styles

| population identity (HKEP) | colour of filaments        | colour of connectives      | colour of anthers   | colour of styles      |
|----------------------------|----------------------------|----------------------------|---------------------|-----------------------|
| 0001                       | light yellow to yellow     | colourless                 | black/gray/greenish | orange                |
| 0101                       | yellow                     | gray to black              | black               | orange                |
| 0501                       | colourless to light yellow | colourless to gray         | 7%yellow, 93%black  | yellow to orange      |
| 0504                       | orange                     | colourless                 | yellow              | red                   |
| 0508                       | light yellow to yellow     | colourless                 | yellow              | orange-red to red     |
| 0514                       | deep yellow to orange      | light yellow to yellow     | yellow              | orange                |
| 0524                       | orange                     | colourless                 | yellow              | orange to orange-red  |
| 0613                       | colourless to light yellow | colourless                 | yellow              | deep yellow to orange |
| 0616                       | light yellow to yellow     | colourless                 | yellow              | yellow to orange      |
| 0618                       | light yellow to yellow     | colourless                 | yellow              | yellow to orange      |
| 0621                       | light yellow to yellow     | colourless                 | yellow              | yellow to orange      |
| 0926                       | yellow                     | colourless                 | yellow              | orange-red            |
| 0929                       | yellow                     | colourless                 | yellow              | orange                |
| 1016                       | colourless to light yellow | colourless                 | yellow              | orange                |
| 1019                       | colourless to light yellow | colourless                 | yellow              | orange                |
| 1037                       | colourless                 | colourless                 | yellow              | light yellow          |
| 9009                       | yellow                     | colourless                 | yellow              | orange to orange-red  |
| 9347                       | yellow                     | colourless                 | yellow              | orange-red to red     |
| 9359                       | light yellow               | colourless                 | yellow              | orange                |
| 9361                       | light yellow to yellow     | colourless                 | yellow              | orange to orange-red  |
| 9910                       | yellow                     | colourless to light yellow | yellow              | orange                |
| 9913                       | yellow                     | colourless                 | yellow              | yellow to orange      |
| 9914                       | deep yellow to orange      | colourless                 | yellow              | red                   |
| 9917                       | light yellow               | colourless                 | yellow              | orange                |
| 9923                       | colourless to light yellow | colourless                 | yellow, black edges | yellow to orange      |
| 9927                       | light yellow to yellow     | colourless                 | yellow              | orange-red to red     |

### Comparison of flower variation

Especially in the south and the north of the Anatolian Diagonal the genetic and phenotypic diversity of the investigated populations reach a remarkably high level. Although it is not possible to consider all populations of *Crocus* in this large area, our findings help to draw a much clearer picture of the complex situation of crocuses in the Anatolian Diagonal. In Fig. 4 all 26 investigated populations are presented by a selection of six flower variants of dried specimens. At a first glimpse on this figure one can see already how different they are. In our opinion, this is the only useful way to compare flower variations in *Crocus*. Trying to compare and remember the flower variants of a locality is already difficult, but from location to location it is impossible. Trying this by using photographs or herbarium vouchers is also rather difficult or impossible because one needs several or many good collections, which then have to be observed at the same developmental stage. In the following we consider major visible attributes of the flowers of each population to see if they correspond to the genetic sub-divisions (groups) of Tab. 3.

The Malatya group (HKEP 9913, 9914, 9917) which is the first group in the E & NE-Anatolian cluster (Tab. 3) is characterised by a significant greenish-turquoise zone above the perianth-tube, which is intensified in dried specimens. The flowers are deep bluish-violet without or with very little veining.

In the connected second group (Gümüşhane-Erzurum group, HKEP 0611, 0618 1036, and 1019) this greenish-turquoise zone is by far not so well developed. Indeed, only three specimens of population 0618 have traces of it. Instead, the yellow throat is marked, especially in population 1019 which means, these two genetic groups are easily separable by flower parameter.

In the third group (Pontic group, HKEP 1018 (flowers missing), 1016, and 0621) striped flowers are most frequent and separates this group from the first two. Population 1016 has a deep brownish-violet striping near the perianth tube on a deep bluish-violet flower, population 0621 has a much lighter ground-colour and the spot near the perianth-tube is much more bluish and elongated up the segment, which separates it well from 1016.

The Artvin group (HKEP 9361 and 9359) is represented by two easily distinguishable species. Population 9361 is also profusely striped and feathered on a light to deep bluish ground whereas population 9359 has an invariable soft lilac ground colour with one prominent deep violet vein accompanied by small vertical ones. These features make them easily separable from the Pontic group. Both groups are striped and feathered profusely, which separates them from the Malatya and Gümüşhane-Erzurum group. Taking all this into account it is clearly visible that only the few flower parameters compared confirm the genetic groupings of the E & NE Anatolian cluster.

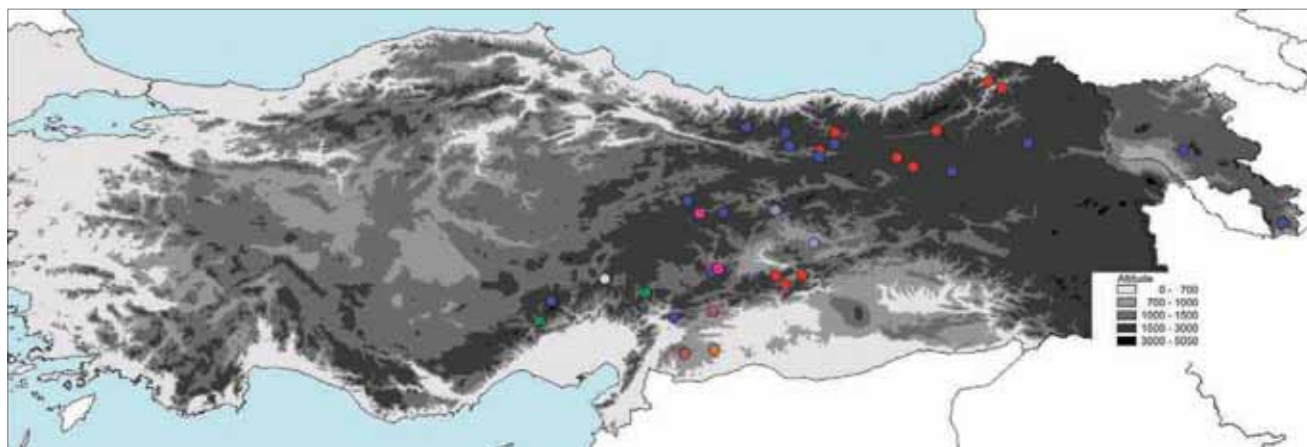


Fig. 3: Distribution of genetic groups (colours for Tab. 3 and Fig. 3 are the same).

The *adamii*-west and *adamii*-east sub-clusters (Tab. 3) are genetically not yet sufficiently separated, so groups and some taxa are still without names. Specimens of the first group of this cluster (populations HKEP 0926 and 9927, part of *adamii*-west) have dark blue but only occasionally bluish-violet ground colour. Noticeable is the often diffuse and tight dark blue speckling and striping especially in the centre of the outer segment and the lack of a brown zone or striping towards the perianth tube.

The species of the next group (populations HKEP 0504 and 9009, part of *adamii*-west) are easy to distinguish. Population 9009 has a soft lilac-rosy ground colour with outer segments repeatedly buff-coloured and thin vertical violet stripes accompanied by much thinner ones. Population 0504 has a comparable striping but the ground colour is creamy-white to soft lilac. Remarkable in both are the rather pointed and narrow segments, which separates them well from the first group of the *adamii* cluster (west).

The next group is only represented by population HKEP 0613 because no flowers of the other three populations (HKEP 1026, 1026, 1029) are available. So, a comparison with those is not possible. Despite this it is obvious that in this population no dark spots towards the perianth tube exist, only yellowish to greenish areas without borders.

The next sub-cluster (*adamii*-east) is represented by crocuses (HKEP 0616, 1037) having more violet-tinged flowers than those of HKEP 0613 which are deep blue. The colours and markings near the perianth tube are also rather different. In population 0616 and 1037 beneath a yellow throat spots of different colours are present. Most variable in this respect is population 1037. It is also strange to see, how deeply coloured the dried specimens of this population are compared to the living ones documented in Fig. 7. As in the E & NE Anatolian cluster the groupings of the *adamii* cluster (*adamii*-west and *adamii*-east sub-cluster) are comparatively well separable by flower characteristics.

Population 0514 has an outstanding genetic position which is not reflected in the flowers. Instead, they are extremely variable in all attributes (compare specimens 3 and 4 in Fig. 7) which makes it difficult to distinguish it from others.

The Munzurense group (populations HKEP 9347 and 9910) consists only of two species which are obviously very similar.

A closer investigation of this connection is unfortunately not possible because the locality of HKEP 9910 was destroyed meanwhile. Remarkable of these populations are the mostly greyish-blue colour and significantly rounded segments at the apex. Spots near the apex are rarely present but a bluish-greenish-brownish zone may exist. This makes the flowers of *C. munzurense* (HKEP 9347) and population HKEP 9910 easily distinguishable from others.

The flowers of the *pseudonubigena* cluster (populations HKEP 0001, 0101, 0501) also have their peculiarities. The ground colour of all of them is rather bright, either white or soft lilac. The striping is less intense developed and sometimes reduced to a prolonged spot from the throat upwards in the middle of the outer segments or is even totally missing. The segments are rather narrow and on occasion acute, which gives a firm expression of the flower.

The *tauri* cluster is represented by obviously phenotypically different populations. Population HKEP 0929 is defined by us as the epitype of *C. tauri*. Five of the shown dried specimens have no stripes but a significant dark brown or violet spot near the perianth tube. The other one (population 9923) has white or soft lilac flowers always with bluish or greenish stripes near the perianth tube mostly only extended to half of the segment. Results of chloroplast *trnL-F* analysis from 9923 are also different from 0929, which means they are readily separable.

The last two populations have outstanding phylogenetic positions. Population HKEP 0524 is very colourful but also very variable. The segments are more or less rounded on top, the striping is mostly absent, if present then thinly. The ground colour is a deep violet blue with all kinds of darker spots near the perianth tube usually prolonged and thinned in the middle of the outer segment, peaked at top. Population HKEP 0508 has a white ground colour with dissimilar stripes. Either they are striped all over the segment or they only have one stripe in the middle of the outer segment frequently accompanied by thinner ones. There are no intensified spots near the perianth tube.

Conclusion of all these flower comparisons is that we found a high degree of correlation between phylogenetic groups and flower parameters, which is even true also for sub-clusters.

**Table 3:** Genetic sub-divisions of the basic Adami-cluster for the analysed populations<sup>1</sup>.

| cluster              | sub-cluster             | population identity            |
|----------------------|-------------------------|--------------------------------|
| E & NE-Anatolian     | Malatya group           | 9913, 9914, 9917               |
|                      | Gümüşhane-Erzurum group | 0618, (1036), 1019,            |
|                      | Pontic group            | (1018), 1016, 0621             |
|                      | Artvin group            | 9359, 9361,                    |
| adamii               | adamii-west             | 0926, 9927                     |
|                      |                         | 9009, 0504,                    |
|                      |                         | 0613, (1025), (1026), (1029),  |
|                      | adamii-east             | 0616, 1037, (adamii 7183BGBM), |
| outstanding position |                         | 0514                           |
| munzurense           |                         | 9347, 9910                     |
| pseudonubigena       |                         | 0101, 0501, 0001               |
| tauri                |                         | 0929, (1034), (1035), 9923     |
| outstanding position |                         | 0524, 0508                     |

<sup>1</sup> detailed genetic results of the Adami-Cluster (HARPKE et al. 2013) will be published elsewhere

### Comparison of morphological variation

To see if a comparison of quantitative morphological and phenotypic parameters to the genetic groupings reveals a similar outcome we use the parameters and their values in Tab. 4. It should be mentioned here that we introduced a more detailed description of the corm tunic than previously used. Reasons are interesting findings investigating more than 170 annulate corm tunics from populations in Turkey, the Balkans and Italy, which are to be published elsewhere.

Likewise to the flower comparison the Malatya group presents itself very homogenous, especially concerning the corm tunic parameters (Tab. 4). Population HKEP 9914 differs from 9913 and 9917 having shorter filaments and by red and long style-branches and styles which are mostly longer than stamen.

The corm tunics of the Gümüşhane-Erzurum group are astonishingly uniform but very different to the Malatya group. The same can be realized for the proportions of segments (mean length of outer segment divided by mean width of outer segment). They are 2.75/2.78 for the Gümüşhane-Erzurum group and clearly less than for the Malatya group which has between 3.13 and 3.38.

The two species of the Pontic group are similar in many morphological parameters like segment-proportion, length of filaments and anthers, leaf-number, leaf-diameter, leaf-ribs, length of style-branches and style-length compared to stamen but differ widely in corm tunic parameters (Tab. 4). Here, on one hand the phylogenetic grouping is confirmed but on the other hand it shows that two different species are involved.

The Artvin group is similar to the Pontic group. Most parameter-values are similar but the corm tunic is very different in the Artvin group. In population HKEP 9361 it consists of thin fibre-like bands occasionally with rings at base whereas in population 9359 it is coriaceous with splits into broad segments of >5 mm and well developed also coriaceous rings.

All populations of the adamii-west sub-cluster (HKEP 0926, 9927, 9009, 0504, 0613) are also astonishingly congruent concerning their corm tunic, most remarkable are the sub-splits of the tunic which are few but present in 4 of 5 populations. Most

of the other investigated populations lack these sub-splits. Significant differences are observable between the northern populations (0926, 9927) and the southern ones (9009, 0504). This is especially true for the colour of cataphylls, bracts and bracteoles, the proportion of the segments, and in some degree to the style-length according to stamen.

The eastern investigated populations of the adamii sub-cluster (HKEP 0616, 1037) are similar in colour of cataphylls, bracts, and bracteoles, the leaf-diameter, number of leaf-ribs, and length of styles according to stamens. Very different are their corm tunics, the dimension of the white stripe, and the length of filaments and anthers which clearly also separate them as distinct taxa which also means their genetic relationship is hardly reflected by the compared parameters.

The next crocus (HKEP 0524) has an outstanding position in the phylogenetic tree, which can hardly be seen comparing morphological parameters. Only two distinguish it clearly from most other investigated populations, the unusually high number of leaf-ribs (4 on average on both sides of the blade) which is the highest number of all populations investigated, and rather short style-branches.

The taxa of the munzurense cluster (HKEP 9347, 9910) are in many respects equal, e.g., in corm tunics, length of anthers, number of leaves, leaf-diameter and style-branches. Different are the flower proportions, the dimension of the white stripe and styles according to stamens. Very different is the average length of filaments, in 9347 only 2.7 mm, which is the shortest one of all investigated populations. In contrast, 9910 has an average length of 5.1 mm, which is almost double of those of 9347.

The pseudonubigena cluster (HKEP 0101, 0501, 0001) is well separated from all other groups, as it is the only one having non-yellow anthers, which gives this parameter more taxonomical weight than thought previously. More or less equal in this group are corm tunics, colour of cataphyll/bract/bracteole, length of filaments, dimension of the white stripe, number of leaf-ribs, and length of styles according to stamen. Different are segment proportions (3.13–4.93), length of anthers (7.7–10.4 mm), and average leaf-number (almost 5 in 0101, 3.2 in 0501 and 0001). It shows that these phylogenetically combined populations are quite different to each other and well separable as species.

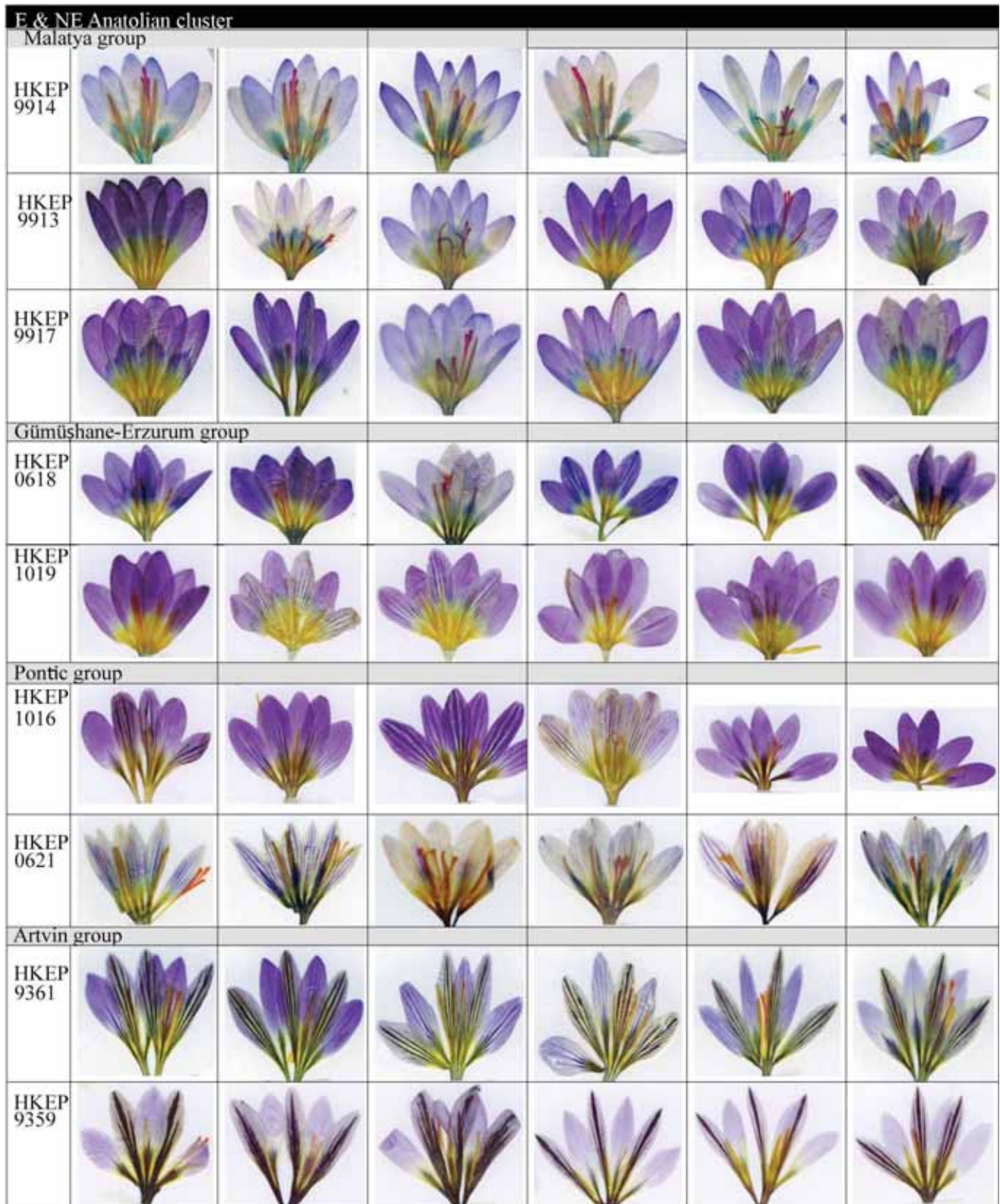
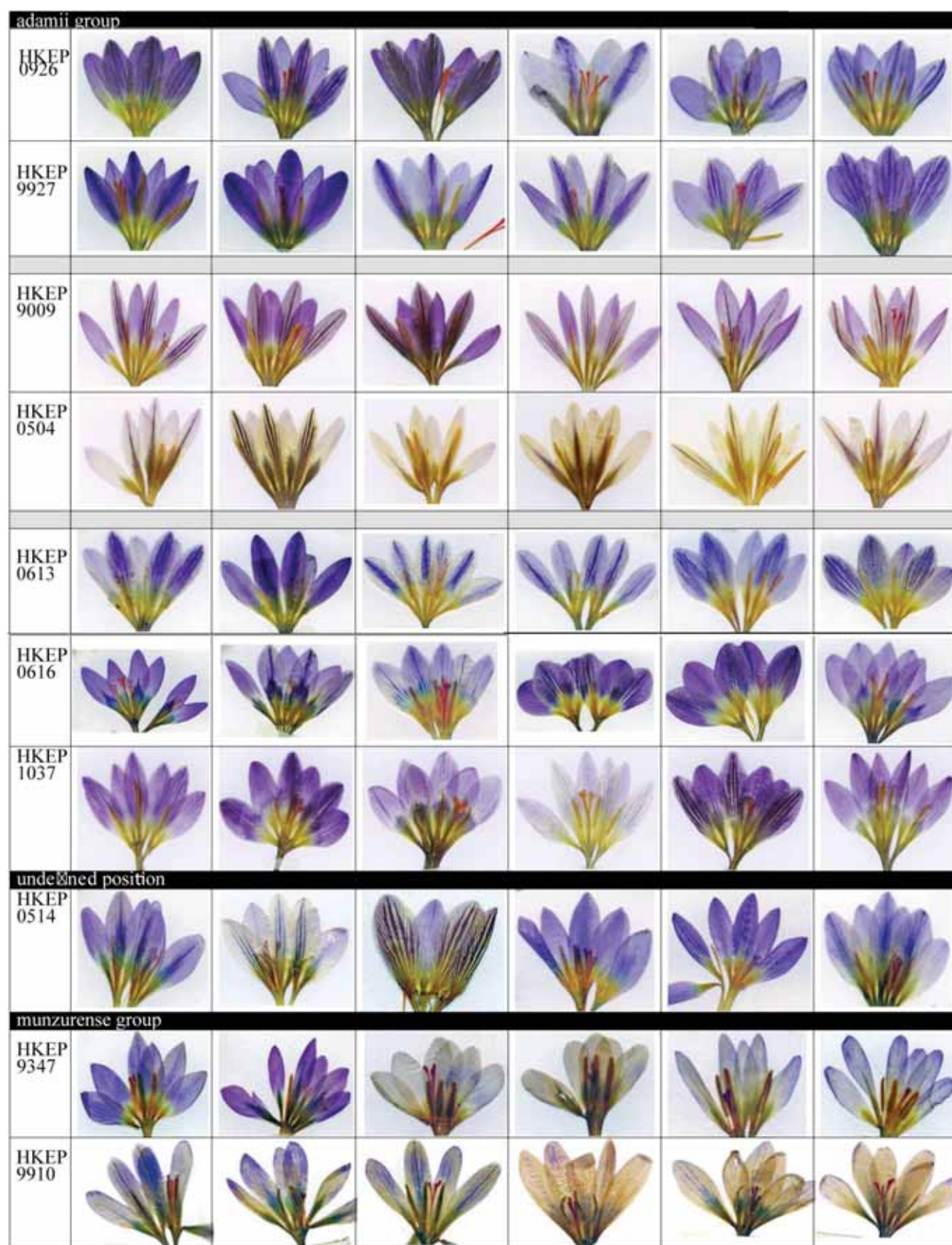


Fig. 4: Compilation of flower variations according to genetic groups.



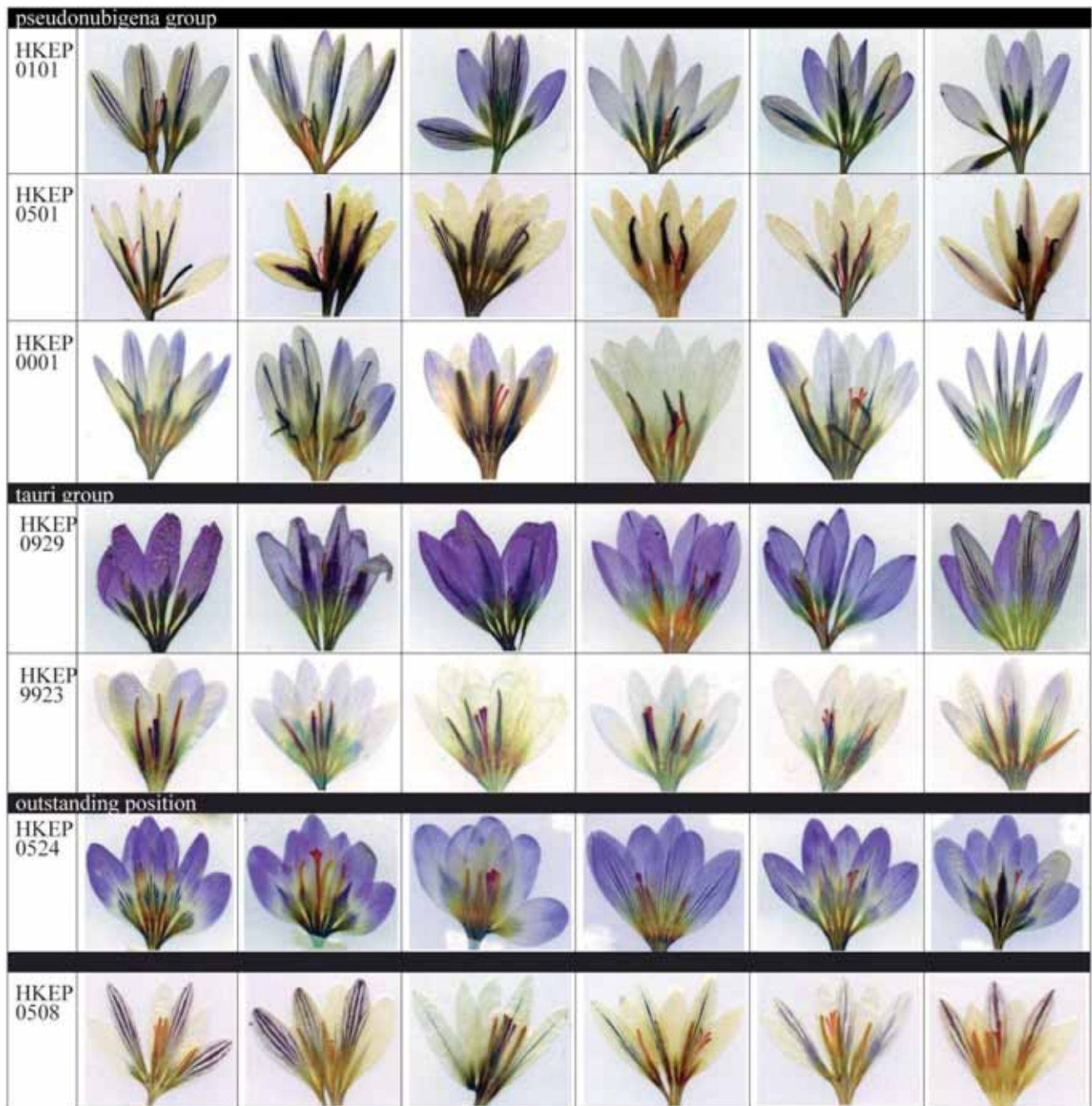


Fig. 4 (continued): Compilation of flower variations according to genetic groups.

The tauri cluster (HKEP 0929, 9923) is rather uniform morphologically. The corm tunic parameter are almost identical, leaf-number, leaf-diameter, leaf-ribs, colour of cataphylls, bracts, bracteoles, segment proportion, and length of anthers are also similar. Different are average length of filaments, length of style-branches and length of styles compared to stamen, which separates the two populations like the flower parameters do.

The last two taxa of Tab. 3 (HKEP 0524 and 0508) have phylogenetically an outstanding position. Almost in every consid-

ered parameter they are different, which fits well to the finding of the flower comparison, and shows that they are in general quite different to each other and to the other investigated populations.

The conclusion from all these comparisons is that the phylogenetic grouping has a high degree of equivalence in flower variation and morphological/phenotypic parameters, which thus can provide a backbone for the identification and determination of the taxa in the field.

**Table 4:** Compilation of mean values and phenotypic parameters of the investigated populations according to genetic groups (different shades)

| HKEP | outer | inner | splits<br>mm | sub-<br>splits | neck (mm)   | rings         | col.<br>cat.<br>bract<br>bracte. | segm.<br>L. out.<br>w. out.<br>(mm) | l.<br>fila.<br>(mm) | col.<br>fila. | l.<br>anth.<br>(mm) | col.<br>anth. | leaf<br>no.<br>mean | white<br>stripe <sup>1</sup> | leaf<br>diam.<br>(mm) | leaf<br>ribs<br>no. | col.<br>conn. | l.<br>style-<br>bran. | col.<br>style     | l.<br>style<br>acc.<br>stam. <sup>2</sup> |
|------|-------|-------|--------------|----------------|-------------|---------------|----------------------------------|-------------------------------------|---------------------|---------------|---------------------|---------------|---------------------|------------------------------|-----------------------|---------------------|---------------|-----------------------|-------------------|-------------------------------------------|
| 9914 | c     | so    | >5           | ab             | tribri 3-7  | pr, few, nt   | silv                             | 3.22                                | 4.36                | y-or          | 10.71               | yellow        | 3.55                | 1/3->                        | 1.5-2                 | 1-2(3)              | c             | 7.14                  | red               | +0.65                                     |
| 9913 | c     | so    | >5           | ab             | tribri 3-7  | pr, large, nt | silv                             | 3.38                                | 5.17                | y             | 09.69               | yellow        | 3.47                | 1/3                          | 1-2                   | 2                   | c             | 6.39                  | yellow to orange  | +0.32                                     |
| 9917 | c     | so    | >5           | ab             | tribri 5-8  | pr, nt        | silv                             | 3.13                                | 5.13                | ly            | 10.10               | yellow        | 3.66                | 1/3                          | 1-2                   | 2(3)                | c             | 5.09                  | orange            | +0.17                                     |
| 0618 | m     | m     | 2-5          | pr, few        | tri 5-8     | pr, few, nt   | silv                             | 2.75                                | 3.58                | ly-y          | 08.45               | yellow        | 3.18                | 1/4-1/3                      | 1-1.5                 | 2                   | c             | 5.15                  | yellow to orange  | +0.58                                     |
| 1019 | m     | m     | 2-5          | pr, few        | tribri 5-7  | pr, few, nt   | silv                             | 2.78                                | 4.50                | c-ly          | 09.73               | yellow        | 4.25                | 1/4-1/3                      | 1.5-2.5               | 2(3)(4)             | c             | 5.21                  | yellow to orange  | +0.09                                     |
| 1016 | fb    | m     | fb           | fb             | bri 7-10    | ab            | silv/r.b                         | 2.73                                | 4.33                | c-ly          | 11.47               | yellow        | 3.17                | 1/4-1/3                      | 2-2.5                 | 2                   | c             | 6.82                  | orange            | +0.25                                     |
| 0621 | c     | so    | >5           | ab             | tribri 3-5  | pr, c, nt     | s/ag.b.                          | 3.00                                | 4.59                | ly-y          | 11.53               | yellow        | 3.73                | <1/3                         | 1.5-2                 | 2(3)                | c             | 7.77                  | yellow to orange  | +0.28                                     |
| 9361 | fb    | m     | fb           | fb             | tribri 2-6  | pr, few, nt   | silv                             | 3.30                                | 3.21                | ly-y          | 10.67               | yellow        | 3.74                | <1/4                         | 1                     | 2                   | c             | 8.92                  | or. to orange-red | +0.91                                     |
| 9359 | c     | so    | >5           | ab             | tribri 5-8  | pr, c, nt     | s/ag.b.                          | 3.43                                | 3.00                | ly            | 09.58               | yellow        | 4.31                | 1/3->                        | 1-1.5                 | 1-2                 | c             | 8.19                  | orange            | +0.94                                     |
| 0926 | c/m   | m     | 2-5          | pr, few        | tribri 5-9  | pr, few, nt   | silv                             | 2.56                                | 3.74                | y             | 10.16               | yellow        | 3.32                | <1/3                         | 1-2                   | 2-3                 | c             | 8.48                  | orange-red        | +0.71                                     |
| 9927 | c/m   | m     | 2-5          | pr, few        | tribri 3-7  | pr, m, nt     | silv                             | 2.78                                | 3.75                | ly-y          | 09.79               | yellow        | 3.68                | 1/3                          | 1-2                   | 2(3-4)              | c             | 6.19                  | orange-red to red | -0.44                                     |
| 9009 | c/m   | m     | 2-5          | pr, few        | tribri 9-12 | pr, c/m, nt   | s/ag.b.                          | 5.00                                | 3.81                | y             | 09.03               | yellow        | 4.10                | 1/3->                        | 1-1.5                 | 2                   | c             | 6.70                  | or. to orange-red | -0.26                                     |
| 0504 | c/m   | m     | 2-5          | pr, few        | tribri 5-7  | pr, few, nt   | ag.b.p.                          | 5.00                                | 3.90                | or            | 12.10               | yellow        | 3.43                | <1/3-                        | 1.5                   | (1)2                | c             | 4.31                  | red               | -1.00                                     |
| 0613 | m     | m     | 2-5          | ab             | tri 5-10    | pr, nt        | silv                             | 3.00                                | 4.00                | c-ly          | 10.16               | yellow        | 4.03                | <1/3-                        | 1.5                   | 2(3)                | c             | 7.14                  | yellow to orange  | -0.03                                     |
| 0616 | m     | m     | 2-5          | ab             | tri 2-6     | pr, few, nt   | silv                             | 2.67                                | 3.10                | ly-y          | 09.63               | yellow        | 3.63                | <1/3-                        | 1.5-2                 | 2(3)                | c             | 5.94                  | yellow-orange     | +0.43                                     |
| 1037 | c     | so    | 2-5          | pr, few        | tribri 5-8  | pr, c, nt     | silv                             | 2.78                                | 4.43                | y             | 08.14               | yellow        | 3.14                | 1/6-1/4                      | 1.5-2                 | (2)3                | c             | 4.94                  | light yellow      | +0.57                                     |
| 0514 | c     | so    | >5           | ab             | tri 3-5     | pr, c, nt     | silv                             | 2.90                                | 2.87                | y-or          | 08.07               | yellow        | 4.29                | 1/4-1/3                      | 2-2.5                 | (3)4(5)             | ly-y          | 5.33                  | orange            | -0.14                                     |
| 9347 | m     | m     | 2            | ab             | tribri 5-7  | pr, few, nt   | silv                             | 2.63                                | 2.70                | y             | 10.27               | yellow        | 3.13                | 1/3->                        | 1.5                   | 2-3                 | c             | 6.27                  | orange-red to red | -0.39                                     |
| 9910 | m     | m     | 2            | ab             | tribri 3-4  | pr, nt        | silv                             | 3.63                                | 5.07                | y             | 09.56               | yellow        | 3.30                | <1/3-                        | 1.5-2                 | 3-4                 | c-ly          | 6.06                  | orange            | +0.39                                     |
| 0101 | c/m   | so    | 2-5          | ab             | tri 4-10    | pr, few, nt   | silv                             | 3.13                                | 4.10                | y             | 10.39               | black         | 4.92                | 1/4-1/3                      | 1-2                   | 2                   | gr-bl         | 6.64                  | orange            | -0.87                                     |
| 0501 | c     | so    | 2-5          | ab             | tri 3-6     | pr, c, nt     | silv                             | 4.00                                | 4.13                | c-ly          | 07.72               | 7ye93 bla     | 3.17                | <1/3-                        | 1                     | (1)2                | c-gr          | 5.71                  | yellow to orange  | -0.81                                     |
| 0001 | c     | so    | 2-5          | ab             | tribri 5-9  | pr, few, nt   | silv                             | 4.93                                | 4.70                | ly-y          | 08.10               | y/gr/g/bl     | 3.24                | <1/3-                        | 1-1.5                 | 1-2                 | c             | 7.86                  | orange            | -0.79                                     |
| 0929 | m     | m     | 2-5          | pr, few        | tribri 5-9  | pr, few, nt   | silv                             | 2.67                                | 3.23                | y             | 09.94               | yellow        | 3.62                | <1/3-1/3                     | 1-1.5                 | 2                   | c             | 6.21                  | orange            | +0.01                                     |
| 9923 | c     | c     | >5           | ab             | tribri 3-7  | pr, c, nt     | silv                             | 2.80                                | 5.00                | c-ly          | 09.58               | y/bl edge     | 3.58                | 1/3                          | 1-2                   | (1)2(3)             | c             | 8.00                  | yellow to orange  | -0.23                                     |
| 0524 | m     | m     | 2            | ab             | tri 2-4     | pr, few, nt   | silv                             | 2.20                                | 5.63                | or            | 08.50               | yellow        | 4.30                | <1/3                         | 1                     | (1)2                | c             | 4.45                  | or. to orange-red | +0.17                                     |
| 0508 | c     | so    | 2-5          | ab             | tribri 5-7  | pr, c, nt     | silv                             | 4.40                                | 3.49                | ly-y          | 08.65               | yellow        | 3.16                | 1/3->                        | 1-1.5                 | 2                   | c             | 5.73                  | orange-red to red | -0.13                                     |

Explanatory notes: corm tunic: c = coriaceous, m = membranous, fb = fibrous bands, so = softer, pr = present, tri = triangles, tribri = triangles forming a bristly neck, nt = no teeth, colour of cataphylls: silv. = silvery, r.b. = rarely brown, ag.b. = aging brown, p = persistent, col. = colour; cat. = cataphylls; bracte. = bract; segm. = segments; l. out = length of outer segments; w. out = width of outer segments; l. fila. = length of filaments; col. fila. = colour of filaments; l. anth. = length of anthers; col. anth. = colour of anthers, bla = black, gr = grey, g = greenish; leaf no. mean = mean leaf number; leaf diam. = leaf diameter; col. conn. = colour of connectives, c = colourless, ly = light yellow, y = yellow, gr = greyish, bl = black; colour of styles: or = orange; l. style-bran. = mean length of style-branches; col. style = colour of style; l. style acc. = length of style according to stamen;

<sup>1</sup> in dimension of the leaf diameter; <sup>2</sup> mean-values

## Description of new species

### 1. *Crocus kartaldagensis* KERNDORFF & PASCHE, species nova

**H o l o t y p u s :** Turkey, Mesopotamia, Gaziantep Province, west of Gaziantep in the foothills of the Kartal Dağı 900–1100 m, 15.3.2005, HKEP 0101 (Gatersleben, GAT 7448).

Cormus 1–1.5 cm diameter, tunicae exteriores coriaceae usque ad papyraceas, collum 4–10 mm longum. Cataphyllae argenteae-albae. Folia 3–4.5–8, virida, 1–2 mm diameter, complanata ad apicem, glabra, 2 costis in omni sulco in folio inferiore. Folia breviora quam flores sub anthesi. Faux lutea. Perianthii tubus albus, profunde violaceus ad apicem. Segmenta externa 19–34 mm, plerumque 26 mm longa ( $n = 41$ ), 5–11 mm, plerumque 8 mm lata ( $n = 40$ ). Segmenta interna 17–23 mm, plerumque 24 mm longa, 5–10 mm, plerumque 8 mm lata ( $n = 40$ ). Segmenta interiora 17–33 mm, plerumque 24 mm longa, 5–10 mm, plerumque 8 mm lata ( $n = 41$ ). Segmenta externa et interna intus alba usque ad lilacina. Segmenta externa cum vel sine virgis dilutis, sed macula basilari saturate brunnea-violacea, interdum elongatus versus apicem. Segmenta interna semper sine striis. Prophyllum abest. Bractea et bracteola adsunt, argentea, recutita, conspicua. Filamenta 1–4–6 mm longa ( $n = 38$ ), lutea glabra. Antherae sagittatae, nigrae, 7–9.8–12 mm longae ( $n = 40$ ). Antherarum connectivum plerumque luteolum, raro nigrum vel griseum, pollen flavum. Stylus aurantiacus, divisus in partes tres, saepe buccinatus ad apicem, rami stigmatici 3–6.9–11 mm longi ( $n = 36$ ). Capsula et semina non visa. Chromosomatorum somaticorum numerus 18.

Corm 1–1.5 cm in diameter, outer tunics coriaceous to papery, the inner ones papery, neck 4–10 mm long, consistent of triangles; splits of tunics both from the neck down and the basis up into segments of wider than 2 mm, no further splits, rings present, more or less papery, smooth or slightly pronged, no teeth. Cataphylls silvery-white. Leaves 3–4.5–8, green, 1–2 mm in diameter, ends flattened, glabrous, white stripe  $<1/3$  to  $1/3$  of leaf-diameter, 2 ribs underneath. Leaves at anthesis shorter than flowers. Throat yellow, no hair. Perianth tube white, deep violet near the apex. Outer segments between 19 and 34 mm but usually 26 mm long ( $n = 41$ ), between 5 and 11 mm but usually 8 mm wide ( $n = 40$ ). Inner segments between 17 and 33 mm but usually 24 mm long, between 5 and 10 mm but usually 8 mm wide ( $n = 41$ ). Inside all segments are white to lilac. Outer segments with or without faint striping but with an intense brown-violet spot near the perianth tube which can be significantly elongated in direction to the apex (Fig. 8e–h). Inner segments always without striping, the brownish-violet spot near the perianth tube is never elongated. Prophyll absent. Bract and bracteole present, silvery, skinny, conspicuous. Length of filaments 1–4–6 mm ( $n = 38$ ), yellow, no hair. Anthers arrow-shaped, black, 7–9.8–12 mm long ( $n = 40$ ). Connective mostly yellowish and clearly visible, rarely black or greyish, pollen yellow. Style orange, divided into 3 branches, often trumpet shaped at the upper end, branches 3–6.9–11 mm long ( $n = 36$ ). Style length according to stamen is 93% shorter to equal, 7% longer ( $n = 40$ ). Capsule and seeds not seen. Chromosome number  $2n = 18$ .

Molecular analyses showed *Crocus romuleoides* (HKEP 0501) and *C. pseudonubigena* (HKEP 0001) as closest relative to *Crocus kartaldagensis*.

**Distribution and habitat.** Until now *C. kartaldagensis* is only known from the type locality in the foothills of the Kartal Mountains (hence *kartaldagensis*) west of Gaziantep. The plant grows together with *Quercus coccifera*, *Juniperus*, *Colchicum*, *Romulea bulbocodium* var. *leichtliniana*, *Gagea*, *Hyacinthus orientalis*, *Paliurus spina-christi*, etc.

### 2. *Crocus romuleoides* KERNDORFF & PASCHE, species nova

**H o l o t y p u s :** Turkey, Mesopotamia, Adyaman Province, Güz Dağı 900–1200 m, 15.3.2005, HKEP 0501 (Gatersleben, GAT 7381).

Cormus ca. 1 cm diameter, tunicae exteriores coriaceae, interiores molles, collum 3–5 mm longum. Cataphyllae argenteae-albae. Folia pauca, 2–2.3–5 ( $n = 30$ ), virida, tenuissima, plus minusve 1 mm diameter, glabra, breviora quam flores sub anthesi, 1 costa, raro 2 costis in omni sulco in folio inferiore. Corolla fauce flava. Perianthii tubus albus, nonnumquam violaceus ad apicem. Segmenta externa 16–24 mm, plerumque 20 mm longa, 3–7 mm, plerumque 5.3 mm lata ( $n = 30$ ). Segmenta interna 8–22 mm, plerumque 17 mm longa, 3–6 mm, plerumque 5 mm lata ( $n = 30$ ). Segmenta externa et interna intus alba. Segmenta externa plerumque cum colore diluto et maculis, interdum striata non attingentia apicem. Segmenta interna macula minore, sed semper macula diluta caerulea versus basim. Prophyllum abest. Bractea et bracteola adsunt, argentea, pariter longa. Filamenta 3–4.1–6 mm longa ( $n = 30$ ), sine colore usque ad flavum, glabra. Antherae 5–7.4–11 mm longae ( $n = 26$ ), 93% nigrantes, 7% luteae, sagittatae, rotundatae ad apicem. Connectivum sine colore usque ad griseum, pollen flavum. Stylus luteus usque ad aurantiacum, divisus in ramos tres, rami stigmatici 3–5.7–9 mm ( $n = 21$ ). Stigma antheris brevior vel aequalis (93%), longior (7%) ( $n = 24$ ). Capsula et semina non visa. Chromosomatorum somaticorum numerus 18.

Corm about 1 cm in diameter, tunics coriaceous, the inner ones softer, neck 3–5 mm long, built of broad triangles, splits of tunics mainly from the basis up into segments of 2 mm, rarely with subsplits of  $<1$  mm, rings present, smooth-edged to slightly pronged, no teeth. Cataphylls silvery-white. Leaves few, 2–3.2–5 ( $n = 30$ ), green, very thin, more or less one mm in diameter, glabrous, white stripe  $1/3$  or less of leaf-diameter, one rib, rarely two ribs underneath. Leaves at anthesis shorter than flowers. Throat yellow, no hair. Perianth tube white, sometimes violet near apex. Outer segments between 16 and 24 mm but usually 20 mm long ( $n = 30$ ), between 3 and 7 mm but usually 5.3 mm wide ( $n = 30$ ). Inner segments between 8 and 22 mm but usually 17 mm long, between 3 and 6 mm but usually 5 mm wide ( $n = 30$ ). The inside of all segments is white. Outer segments normally with faint colouring and markings, sometimes more intensely striped but never reaching the apex. Inner segments with less markings but always with a faint bluish spot towards the perianth tube (Fig. 8i–l). Prophyll absent. Bract and bracteole present, silvery, of equal length. Length of filaments 3–4.1–6 mm ( $n = 30$ ), colourless to light yellow, no hair. Anthers short, 5–7.4–11 mm long ( $n = 26$ ), 93% black, 7% yellow, no intermediates, broadly arrow-shaped with rounded tips. Connective colourless to grey, pollen yellow. Style yellow to orange, divided into 3 branches, mostly not extended at the upper end, branches 3–5.7–9 mm long ( $n = 21$ ). Style length according to stamen is 93%

shorter to equal, 7% longer ( $n = 24$ ). Capsule and seeds not seen. Chromosome number  $2n = 18$ .

*Crocus romuleoides* is a rather interesting new crocus. According to molecular analysis it is most closely allied to *Crocus kartaldagensis* (HKEP 0101), and *C. pseudonubigena* B. MATHEW (HKEP 0001).

**Distribution and habitat.** Until now *C. romuleoides* (*Romulea*-like) is only known from the type locality in the Güz mountains in the Province Adiyaman. It is a rather tiny but impressive crocus, which opens flat like a star in full sun giving the impression of a white flowering *Romulea*. The plant grows together with *Quercus*, *Helleborus vesicarius*, *Crocus graveolens*, grasses, etc.

### 3. *Crocus marasensis* KERNDORFF & PASCHE, species nova

**Holotypus:** Turkey, Amanus, Kahramanmaraş Province, environs of Kahramanmaraş 900–1100 m, 18.3.2005, HKEP 0504 (Gatersleben, GAT 7132).

Cormus 1–1.5 cm diameter, subglobosus; tunicae papyraceae usque ad dilute coriaceas. Cataphyllae argenteae, atrobrunneae et persistentes similes Croco flavo. Folia 2–3.4–5, virida, 1.5 mm diameter, glabra, 1–2 costis in omni sulco in folio inferiore; breviora quam flores sub anthesi. Faux flava, glabra. Perianthii tubus albus, violaceus prope apicem. Segmenta externa 17–33 mm, plerumque 26 mm longa ( $n = 30$ ), 4–7 mm, plerumque 5.7 mm lata ( $n = 30$ ). Segmenta interna 16–33 mm, plerumque 24 mm longa, 4–8 mm, plerumque 6.2 mm lata ( $n = 30$ ). Segmenta interna et externa intus alba. Segmenta externa extus alba, semper macula prominente subfusca-purpurea, aut sine virgis aut extenta in mediam virgam, gracilia futura in apicem vel proprie 5 oblongis violaceis virgis in apicem segmentorum. Segmenta interna cum macula brunneola-caerulea sine strias. Prophyllum abest. Bractea et bracteola argentea, recutita. Filamenta 3–3.9–6 mm longa ( $n = 30$ ), aurantiaca, glabra. Antherae valde longae, 6–12.1–17 mm ( $n = 30$ ), luteae, sagittatae. Connectivum sine colore, pollen flavum. Stylus perluteus usque ad aurantiacum, divisus in ramos tres, rami stigmatici 2–4.3–7 mm longi. Longitudo stylorum brevior quam antherae (100%) ( $n = 30$ ). Capsula 1–1.5 cm longa, ovoidea. Semina non visa. Chromosomatorum somaticorum numerus 22.

Corm 1–1.5 cm in diameter, subglobose; tunics papery to slightly coriaceous, the inner ones papery, neck 5–7 mm long, built of broad triangles; splits of tunics into segments of > 2 mm, very rarely with subsplits; rings present, papery, irregularly pronged, no teeth. Young cataphylls silvery, getting persistently dark brown with age, comparable to those of *C. flavus*. Leaves few, 2–3.4–5, green, 1.5 mm in diameter, broadest in the middle, glabrous, white stripe <1/3–1/3 of leaf-diameter, 1(2) ribs underneath. Leaves mostly shorter than flowers at anthesis. Throat yellow, no hair. Perianth tube white, near apex violet. Outer segments between 17 and 33 mm but usually 26 mm long ( $n = 30$ ), between 4 and 7 mm but usually 5.7 mm wide ( $n = 30$ ). Inner segments between 16 and 33 mm but usually 24 mm long, between 4 and 8 mm but usually 6.2 mm wide ( $n = 30$ ). The inside of all segments is white. The outside of the outer segments is white, always with a prominent brownish-purple spot from the perianth tube upwards, either without striping or prolonged into

one middle stripe getting thinner towards the apex or overlaid by 5 longitudinal violet strips to the top of the segments. Inner segments only with the brownish-blue spot, never elongated or with stripes (Fig. 7e–h). Prophyll absent. Bract and bracteole present, silvery, skinny. Length of filaments 3–3.9–6 mm ( $n = 30$ ), orange, no hair. Anthers very long, 6–12.1–17 mm long ( $n = 30$ ), yellow, acutely arrow-shaped but lower tips short, of a weak consistence and bent aside. Connective colourless, pollen yellow. Style dark yellow to orange, divided into 3 branches, only with tips somewhat thickened, branches comparatively short, 2–4.3–7 mm long. Style length compared to stamen always shorter (100%) ( $n = 30$ ). Capsule 1–1.5 cm long, ovoid. Seeds not seen. Chromosome number  $2n = 22$ .

*Crocus marasensis* (after the city of Kahramanmaraş) is a very distinct and interesting crocus in several aspects. It was found by J. Lepsa and W. Näcke in 1998 and given the collection number JLWN 9807. They recognised its speciality but were unable to identify it with the keys given by MATHEW (1982). They sent herbarium material to us for identification. From this it was clear that more investigations would be necessary to determine its status. We made field studies of this very remarkable crocus. Until now it is only known from the type locality and the population we could investigate is not very large. Therefore we assume that the plant is rather rare. It is the only crocus with an annulate corm tunic having persistent cataphylls like species of series *Flavi* and *Crocus* (Fig. 7f). The corm tunics and their rings are intermediate between coriaceous and papery. Remarkable are the unusually long and acutely arrow-shaped anthers and the short styles which never overtop the stamen. Its closest relatives based on molecular ITS-analysis are crocuses of the "adamii-west sub-cluster" (Tab. 3).

**Distribution and habitat.** Until now *C. marasensis* is only known from the type locality in the surroundings of the city of Kahramanmaraş. The plant grows in clearings and edges of shrubs woods together with *Pinus brutia*, *Styrax officinalis*, *Juniperus*, *Scilla* etc.

### 4. *Crocus pelitensis* KERNDORFF & PASCHE, species nova

**Holotypus:** Turkey, Antitaurus, Adana Province, Karanfil Dağ, 900–1100 m, 20.3.2005, HKEP 0508 (Gatersleben, GAT 23076).

Cormus 1 cm diameter. Tunicae coriaceae, interiores molles, non membranaceae, tunicae dissectae in segmenta 2–5 mm, subfissurae absunt, collum conspicuum, setosum, 6–8 mm longum, constans ex triangulis latis prope basim, abrupte expansa in segmentis longis acutis; annuli adsunt, coriacei, cum margine integra vel leviter divaricata, dentes absunt. Cataphyllae argenteae-albae. Folia 2–2.3–5, virida, 1–1.5-mm diameter, glabra, 2 costis in omni sulco in folia inferiore. Folia breviora ad anthesim quam flores. Faux lutea, perianthii tubus albus, interdum violaceus ad apicem. Segmenta externa 16–32 mm, plerumque 22 mm longa ( $n = 31$ ), 4–8 mm, plerumque 5.7 mm lata ( $n = 31$ ). Segmenta interna 16–29-mm, plerumque 21 mm longa, 5–9mm, plerumque 6.7 mm lata ( $n = 31$ ). Segmenta interna et externa intus alba. Segmenta externa plus minusve striis violaceis oblongis. Faux lutea. Segmenta interna sine virgis, sed macula fusca-violacea ad basim. Prophyllum abest. Bractea et bracteola adsunt, argentea, recutita. Filamenta 2–3.7–5mm longa ( $n = 31$ ), pallide lutea



Fig. 5: Colour photographs of *Crocus malatyensis* (a-d), HKEP 9913 (e-h), HKEP 9917 (i-l), HKEP 0618 (m-p), *C. aerius* (q-t).



Fig. 6: Colour photographs of *C. ponticus* (a-d), *C. fibroannulatus* (e-h), *C. artvinensis* (i-l), HKEP 0926 (m-p), *C. sivasensis* (q-t).

usque ad lutea. Antherae breves, 6-8.7-10 mm longae (n = 31), luteae, sagittatae. Connectivum sine colore, pollen flavum. Stylus rubroaurantiacus, divisus in ramos tres, non dilatatus ad apicem, rami stigmatici 4-5.7-8 mm longi. Stigma antheris brevior vel aequalis 71%, longior 29% (n = 31). Capsula et semina non visa. Chromosomatorum somaticorum numerus 22.

Corm about 1 cm in diameter; tunics coriaceous, the inner ones softer but not membranous: splits into segments of 2-5 mm, no sub-splits present, neck conspicuous, bristly, 6-8 mm long, consistent of broadly based triangles abruptly expanded into long acute stripes; rings present, coriaceous, whole-edged or very slightly pronged, no teeth. Cataphylls silvery-white even on drying. Leaves few, 2-3.2-5 green, 1-1.5 mm in diameter, glabrous, white stripe 1/3 to >1/3 of leaf-diameter, 2 ribs underneath of each side of the blade. Leaves at anthesis shorter than flowers. Throat yellow, no hair. Perianth tube white, sometimes violet near the apex. Outer segments between 16 and 32 mm but usually 22 mm long (n = 31), between 4 and 8 mm but usually 5.7 mm wide (n = 31). Inner segments between 16 and 29 mm but usually 21 mm long, between 5 and 9 mm but usually 6.7 mm wide (n = 31). Inside all segments are white. Outside of outer segments is white, more or less intensively striped violet longitudinally. No dark spot near the perianth tube but the yellow of the throat shining through. Inner segments without striping but with a small brownish-violet spot near the perianth tube (Fig. 9i-l). Prophyll absent. Bract and bracteole present, silvery, skinny. Filaments rather short, 2-3.7-5 mm (n = 31), light yellow to yellow, no hair?. Anthers short, 6-8.7-10 mm (n = 31), yellow, acutely arrow-shaped. Connective colourless, pollen yellow. Style orange-red, divided into 3 branches, not widened at apex; branches 4-5.7-8 mm long. Styles according to stamen in 71% shorter to equal, in 29% longer (n=31). Capsule and seeds not seen. Chromosome number 2n = 22.

*Crocus pelitensis* is named after the Pelites, glossy, clay-rich iron-containing clastic sediments, where we found it flowering for the first time in 1990. It was a beautiful sight, the white crocuses growing in crevices filled with blackish soil, wide open in the sun on a brownish-red rather glossy stony background. We found it in several localities in the same area but mostly on calcareous rocks.

According to molecular analysis *C. pelitensis* is most closely allied to *C. berytius*.

**Distribution and habitat.** *C. pelitensis* is known to us from the type locality in the Karanfil Dağ and several other localities mainly on calcareous rocks in the Antitaurus, Adana Province. The plant prefers black humus pockets under *Pinus*, *Juniperus*, *Crataegus*, *Acantholimon*, *Astragalus*, thistles and grasses.

##### 5. *Crocus schneideri* KERNDORFF & PASCHE, species nova

**Holotypus:** Turkey, Cappadocia, Kayseri Province, Tahtalı Dağları 2000-2300 m, 3.5.2005, HKEP 0514 (Gatersleben, GAT 7240).

Cormus ca. 1 cm diameter. Tunicae coriaceae, internae molles, collum brevissimum, 2-4 mm longum, fissura tunicarum plerumque in segmentis latioribus quam 5 mm, sine subfissuris; annuli adsunt, pauci, coriacei, margine plena vel leviter divaricati, dentes absunt. Cataphyllae argenteae-albae. Folia 3-4.3-7,

subulata, atrovirida, 2-2.5 mm diameter, glabra, (3)4(5) costis in omni sulco in folio inferiore, evoluta infirma sub anthesi. Corolla fauce lutea usque ad aurantiacam. Perianthii tubus albus, pallide caeruleus vel virgis pallide caeruleis ad apicem. Segmenta externa 19-29 mm, plerumque 24 mm longa (n = 31), 5-13 mm, plerumque 8 mm lata (n = 31). Segmenta interna 18-28 mm, plerumque 23 mm longa, 5-12 mm, plerumque 8 mm lata (n = 31). Segmenta externa et interna intus pallide caerulea, raro alba, interdum dilute venosa caerulea. Latera externa segmentorum exteriorum pallide caerulea cum nervatura saturate caerulea vel magis intense pinnatinervia, sine macula fusca ad basim. Latera externa segmentorum interiorum pallide caerulea, generaliter sine macula significata. Prophyllum abest. Bractea et bracteola adsunt, argentea, recutita. Filamenta 2-2.9-5 mm longa (n = 30), saturate lutea usque ad aurantiaca. Antherae 5-8.1-10 mm longae, luteae, perlatas et complanatas ad apicem. Connectivum latum, pallide luteum usque ad luteum, pollen flavum. Stylus aurantiacus usque ad rubroaurantiacum, divisus in partes tres, distinctus lobatus et fimbriatus ad apicem, rami stigmatici 2-5.3-8 mm longi. Stigma antheris brevior usque ad aequalem 80%, longior 20%. Capsula et semina non visa. Chromosomatorum somaticorum numerus 20.

Corm around 1 cm in diameter, tunics coriaceous, the inner ones softer, neck very short, 2-4 mm long; splits of tunics mostly into segments broader than 5 mm, no subsplits present; rings present, few, coriaceous; whole-edged or very slightly pronged, no teeth. Cataphylls silvery-white. Leaves 3-4.3-7 (n = 31), subulate, dark green, comparatively broad, 2-2.5 mm in diameter, glabrous, white stripe small, 1/4 of leaf-diameter rarely broader, ribs underneath many (3)4(5); leaves poorly developed at anthesis. Throat yellow to orange, no hair. Perianth tube white, bluish or bluish striped near apex. Outer segments between 19 and 29 mm but usually 24 mm long (n = 31), between 5 and 13 mm but usually 8 mm wide (n = 31). Inner segments between 18 and 28 mm but usually 23 mm long, between 5 and 12 mm but usually 8 mm wide (n = 31). Inside all segments are pale blue, rarely white, sometimes with a faint darker blue veining. Outside of outer segments is light blue with a darker blue veining or more intense feathering, no dark spots near the perianth tube but the yellow of the throat shining through. Outside of inner segments pale blue generally without significant markings or spots but the yellow of the throat shining through (Fig. 7q-t). Prophyll absent. Bract and bracteole present, silvery, skinny. Length of filaments 2-2.9-5 mm (n = 30), deep yellow to orange, no hair. Anthers short 5-8.1-10 mm long, yellow, not distinctly arrow-shaped, very broad and flattened significantly at top with a notch in the middle. Connective broad, light yellow to yellow, pollen yellow. Style orange to orange-red, rather broad, divided into 3 branches which are mostly so tight together that it gives the impression of being undivided; they are significantly lobed and fringed at the upper end, branches 2-5.3-8 mm long. Styles 80% shorter to equal and 20% longer according to stamen (n = 31). Capsule and seeds not seen. Chromosome number 2n = 20.

*Crocus schneideri* is a distinct crocus genetically as well as morphologically (Tab. 3, 4). It is named to honour Ingo Schneider, a dedicated lover of crocuses for almost all his life, a friend and the investigator of chromosomes of our studied crocus populations for which we thank him very much.

Concerning the results of ITS analysis it occupies a yet unresolved isolated position in the large “Adami-cluster”.

**Distribution and habitat.** Until now *C. schneideri* is only known from two localities in the Tahtalı mountains in the Kayseri Province. The plant grows together with *Juniperus excelsa*, *Centaurea*, *Hyacinthus orientalis* subsp. *chionophila*, *Berberis crataegina*, *Gagea*, *Ornithogalum*, *Iberis*, *Globularia*, *Salvia aethiopis*, *Arum dioscoridis*, *Geranium tuberosum*, *Erysimum* etc.

## 6. *Crocus munzurensis* KERNDORFF & PASCHE, species nova

**Holotypus:** Turkey, Upper Euphrates, Erzincan Province, Munzur Dağları 900–1200 m, 16.3.2005, HKEP 9347 (Gatersleben, GAT 7190).

Cormus 1–1.5 cm diameter, tunicae exteriores et interiores membranaceae, collum setosum, 5–7 mm longum. Cataphyllae argenteae-albae. Folia 2–3.1–4 (n = 23), atrovirida, 1.5 mm diameter, matura valde ciliata et hirsuta, 2–3 costis in omni sulco in folio inferiore. Folia evoluta infirma ad anthesim, nonnulla attingentia flores in basi. Saepe segmenta late rotundata ad apicem. Faux saturate lutea usque ad aurantiacam. Perianthii tubus albus, violaceus ad apicem. Segmenta externa 15–28 mm, plerumque 22 mm longa (n = 23), 5–11 mm, plerumque 8 mm lata (n = 23). Segmenta interna 15–26 mm, plerumque 20 mm longa, 4–10 mm plerumque 8 mm lata (n = 23). Segmenta externa et interiora intus pallide caerulea-lilacina. Segmenta externa extra leviter caerulea raro bubalina, praecipue sine aut modo signis dilutis. Segmenta externa et interiora similia, maculis minoribus brunneolis versus basim. Prophyllum abest. Bractea et bracteola adsunt, argentea, longitudo aequalis, conspicua, plerumque attingentes segmenta. Filamenta 2–2.7–4 mm longa (n = 23), lutea, glabra. Antherae 8–10.3–12 mm longae, luteae, sagittatae. Connectivum prominens, album usque ad pallidum luteum, pollen flavum. Stylus rubroaurantiacus usque ad rubrum, divisus in ramos tres, expansus et fimbriatus ad apicem, rami stigmatici 3–6.3–10 mm longi. Stigma antheris plerumque paulo brevior vel aequalis (83%), longior 17% (n = 23). Capsula et semina non visa. Chromosomatorum somaticorum numerus 20.

Corm 1–1.5 cm in diameter, outer and inner tunics membranous, neck bristly, 5–7 mm long, built of elongated triangles; splits of tunics mainly from basis upwards into segments broader than 2 mm, no subsplits, rings present, papery, few and poorly developed, smooth-edged to slightly pronged, no teeth. Cataphylls 3–4 silvery white. Leaves 2–3.1–4 (n = 23) dark green, 1.5 mm in diameter, strongly ciliated and hairy when mature, white stripe 1/3 to > 1/3 of leaf-diameter, 2–3 ribs underneath each side of the blade. Leaves mostly poorly developed but some reaching the flower at anthesis. Throat deep yellow to orange, no hair. Perianth tube white, violet near the apex. Frequently the segments are broadly rounded at the apex. Outer segments between 15 and 28 mm but usually 22 mm long (n = 23), between 5 and 11 mm but usually 8 mm wide (n = 23). Inner segments between 15 and 26 mm but usually 20 mm long, between 4 and 10 mm but usually 8 mm wide (n = 23). Inside all segments are uniformly bluish-lilac. Outside of outer segments bluish or rarely buff-coloured, mainly without or only with faint markings. Few individuals have violet feathers. Inner segments like the outer with less markings brownish towards the perianth tube, often the yellow throat shining through (Fig. 8a–d). Prophyll absent. Bract and bracteole present, silvery, skinny, of equal length, conspicuous, mostly reaching the segments. Length of filaments 2–2.7–4

mm (n = 23), yellow, no hair. Anthers 8–10.3–12 mm long, yellow, arrow-shaped. Connective broad, white to yellowish, pollen yellow. Style orange-red to red, divided into 3 branches, significantly expanded and fringed at the apex, branches 3–6.3–10 mm long. Styles are mostly shorter to equal according to stamen (83%), 17 % are longer (n = 23). Capsule and seeds not seen. Chromosome number 2n = 20. *Crocus munzurensis* is closely related to the species of HPEK9910.

**Distribution and habitat.** Until now *C. munzurensis* is only known from the type locality in the Munzur Mountains in central Turkey (hence munzurensis), Erzincan Province. The plant grows together with *Quercus*, *Gagea*, *Hyacinthella*, *Iris galatica*, *Ophrys*, *Biarum*, *Iris reticulata*, *Sternbergia clusiana* etc.

In 1999, we have been in parts of the Anatolian Diagonal to make field studies for comparative purposes (KERNDORFF et al. 2006). One of the visited mountain ranges was the Munzur Dağları in Central Anatolia, which also lies in the middle of the Anatolian Diagonal. Earlier, at the end of April 1993 we found a crocus population in this mountain stock long after dehiscence, so we could not identify it. From the long (30 cm) strongly ciliated and hairy leaves, an unusual feature in the genus, one could expect something special. The plant and its suggested name was already mentioned in our part 1 of “*C. biflorus* in Anatolia” (KERNDORFF & PASCHE 2004b). When we returned to this locality years later we were lucky to find a few flowering plants, which proofed our assumption of an up-to-now unknown species. Unfortunately, there were not enough flowering specimens to make detailed field studies of this population. In 2005, we revisited this locality a third time and made sufficient field studies to generate the description of this new taxon.

## 7. *Crocus malatyensis* KERNDORFF & PASCHE, species nova

**Holotypus:** Turkey, Mesopotamia, Malatya Province, Maden Dağları, 900–1100 m, 17.3.2005, HKEP 9914 (Gatersleben, GAT 23075).

Cormus subglobosus, ca. 1 cm diameter, tunicae coriaceae, interiores molles; collum setosum, 3–7 mm longum. Cataphyllae 3–4, argenteae-albae, Folia 3–3.6–6, atrovirida, 1.5–2 mm diameter, glabra, 1–2(3) costis in omni sulco in folio inferiore. Folia evoluta infirma ad anthesim, numquam attingentia flores ad florationem. Faux saturate flava, rare punctata violacea, glabra. Perianthii tubus albus, brunneolus ad apicem. Segmenta externa 19–39 mm, plerumque 28 mm longa (n = 33), 6–12 mm, plerumque 9 mm lata (n = 33). Segmenta interna 17–33 mm, plerumque 27 mm longa, 6–11 mm, plerumque 9 mm lata (n = 33). Segmenta externa et interna albida usque ad pallida lilacina-caerulea sine maculis. Latera segmentorum exteriorum rosea-lilacina sine macula, raro cum virgis dilutis vel macula pallide caerulea ad apicem. Latera interiora segmentorum interiorum pallide rosea-lilacina, macula intensa ad apicem. Prophyllum abest. Bractea et bracteola adsunt, argentea, raro conspicua. Filamenta 3–4.4–7 mm longa (n = 33), glabra, lutea. Antherae 8–10.7–14 mm longae, luteae, late sagittatae, rotundatae ad apicem, incisione profunda in medio. Connectivum latum, album usque ad pallide flavum, pollen flavum. Stylus divisus in partes tres, rami stigmatici 3–7.1–10 mm longi (n = 28). Styli antheras superantes vel aequilongi (93%), breviores



Fig. 7: Colour photographs of *C. albocoronatus* (a-d), *C. marasensis* (e-h), HKEP 0616 (i-l), *C. roopiae* (m-p), *C. schneideri* (q-t).

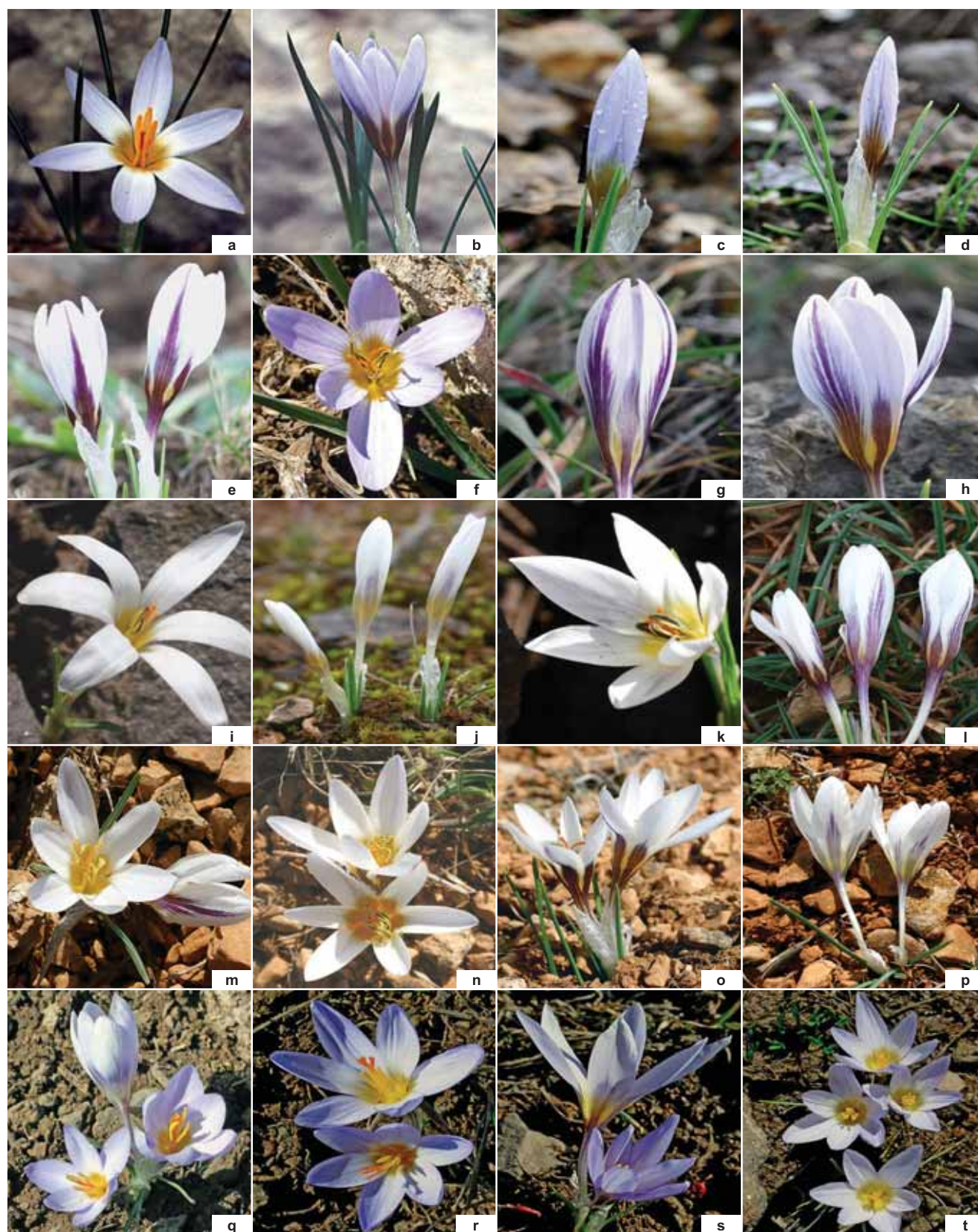


Fig. 8: Colour photographs of *C. munzurense* (a-d), *C. kartaldagensis* (e-h), *C. romuleoides* (i-l), *C. pseudonubigena* (m-p), *C. tauri* epitype (q-t).

7% (n = 31). Capsula et semina non visa. Chromosomatorum somaticorum numerus incognitus est.

Corm subglobose, around 1 cm in diameter, tunics coriaceous, the inner ones softer, neck bristly 3–7 mm long, consistent of elongated triangles split downwards; splits of main tunic upwards few mostly into segments > 2 mm, no subsplits; rings present, coriaceous to papery, smooth-edged to very slightly pronged, no teeth. Cataphylls 3–4, silvery white. Leaves 3–3.6–6 dark green, 1.5–2 mm in diameter, glabrous, white stripe 1/3 to > 1/3 of leaf-diameter, 1–2(3) ribs underneath. Leaves poorly developed at anthesis, never reaching the flower. Throat deep yellow, rarely with small dark violet spots, no hair. Perianth tube white, only slightly brownish near the apex. Outer segments between 19 and 39 mm but usually 28 mm long (n = 33), between 6 and 12 mm but usually 9 mm wide (n = 33). Inner segments between 17 and 33 mm but usually 27 mm long, between 6 and 11 mm but usually 9 mm wide (n = 33). Inside all segments are whitish to pale lilac-blue without markings. The outside of the outer segments is also pale (rosy-) lilac with no markings, rarely with very few faint lilac stripes or a small bluish spot at the apex, comparable to some variants of *C. vernus*. There is always a significant and more or less intense bluish-turquoise spot above the yellow of the throat which is shining through. The outside of the inner segments is pale (rosy-)lilac without markings but with a similar intense spot near the apex alike the outer segments (Fig. 5a–d). Prophyll absent. Bract and bracteole present, silvery, rarely conspicuous. Length of filaments 3–4.4–7 mm (n = 33), yellow, no hair. Anthers 8–10.7–14 mm long, yellow, broadly arrow-shaped rounded at the top with a variably deep notch in the middle. Connective broad, white to yellowish, pollen yellow. Style divided into 3 branches, these mostly pressed tightly together giving the impression of being entire, branches 3–7.1–10 mm long (n = 28). Style-length according to stamen is frequently longer to equal (93%), 7% are shorter (n = 31). Capsule and seeds not seen. Chromosome number unknown.

*Crocus malatyensis* has rather large flowers of a distinct pale lilac with a tint of rosy. Significant is the bluish-turquoise spot of the segments near the perianth tube that is always present. Crocuses from localities HKEP9913 and HKEP9917 are the closest relatives in molecular analyses.

**Distribution and habitat.** Until now *C. malatyensis* is only known from the type locality in the province of Malatya, therefore it was named *malatyensis*. The plant grows together with *Quercus*, *Juniperus*, *Crataegus*, *Gagea*, *Ranunculus*, *Muscari comosum*, *Verbascum*, *Ophrys*, *Crocus pallasii* subsp. *turcicus*, *Colchicum* etc.

## 8. *Crocus kangalensis* KERNDORFF & PASCHE, species nova

**Holotypus:** Turkey, Cappadocia, Sivas Province, environs of Kangal, 1400 m, 28.3.1999, HKEP 9923 (Gatersleben, GAT 7390).

Cormus 0.8–1.5 cm diameter, tunicae exteriores et interiores coriaceae, collum setosum, 3–7 mm longum. Cataphyllae 3–4, argenteae-albae. Folia atrovirida, 3–3.6–5 (n = 31), 1–2 mm diameter, glabra, (1)2(3) costis in omni sulco in folio inferiore. Folia non evoluta ad anthesin, interdum attingentia flores ad florationem vel superantia flores. Faux pallida usque ad saturate luteam, saepe ma-

culis cordi similibus in omni segmento similis Croco kotschyano. Perianthii tubus albus. Segmenta externa 22–36 mm, plerumque 29 mm longa (n = 31), 7–12 mm, plerumque 9 mm lata (n = 31). Segmenta interna 20–34 mm, plerumque 27 mm longa, 7–13 mm, plerumque 9 mm lata (n = 31). Segmenta externa et interna intus alba usque ad pallida lilacina, sine maculis. Lateralia segmentorum exteriorum plane alba usque ad pallida lilacina, sine vel raro macula diluta pallida caerulea. Segmenta interna eadem colore, generaliter sine macula. Prophyllum abest. Bractea et bracteola adsunt, argentea, recutita, raro conspicua. Filamenta 4–5–7 mm longa, lutea, glabra. Antherae 7–9.6–13 mm longae (n = 31), flavae, interdum margine nigrae ad apicem, sagittatae. Connectivum latum, sine colore usque ad luteum, pollen flavum. Stylus saturate luteus usque ad aurantiacum, divisus in partes tres, late buccinatus et fimbriatus ad apicem, rami stigmatici 4.5–8–13 mm longi (n = 50). Stigma antheris brevior vel aequalis 90%, longior 10%. Capsula et semina non visa. Chromosomatorum somaticorum numerus 18.

Corm 0.8–1.5 cm in diameter; outer and inner tunics coriaceous, neck 3–7 mm long, bristly, consistent of elongated triangles; tunic splits are mainly from the neck downwards, less from the basis up into segments broader than 2 mm, no sub-splits, rings present, many, smooth-edged, no teeth. Cataphylls 3–4, silvery white. Leaves dark green, 3–3.6–5 (n = 31), 1–2 mm in diameter, glabrous, white stripe 1/3 of leaf-diameter, (1)2(3) ribs underneath. Leaf development at anthesis very different (no leaves – reaching the flower – overtopping the flower). Throat light to deep yellow often only formed as heart-shaped spots on each segment, with the white of the segment surrounding, similar to those of *C. kotschyanus*, no hair. Perianth tube white. Outer segments between 22 and 36 mm but usually 29 mm long (n = 31), between 7 and 12 mm but usually 9 mm wide (n = 31). Inner segments between 20 and 34 mm but usually 27 mm long, between 7 and 13 mm but usually 9 mm wide (n = 31). Inside all segments are white to very pale lilac, without markings. Outside of outer segments plain white to pale lilac, without or very rarely with faint bluish markings. Inner segments of the same colour but generally without markings, the yellow of the throat is shining through (Fig. 9a–d). Prophyll absent. Bract and bracteole present, silvery and skinny, rarely conspicuous. Length of filaments 4–5–7 mm (n = 17), yellow, no hair. Anthers 7–9.6–13 mm long (n = 31), yellow, sometimes thinly black-edged in the upper part, broadly arrow-shaped, rarely canalculated. Connective broad, colourless to yellow, pollen yellow. Styles dark yellow to orange, divided into 3 branches, broadly trumpet-shaped and fringed at the apex, often tightly together giving the impression being entire, branches 4.5–8–13 mm long (n = 50). Style length according to stamen is 90% shorter to equal, 10% longer (n = 31). Capsule and seeds not seen. Chromosome number 2n = 18.

*Crocus kangalensis* is a member of the “tauri cluster” (table 3) but is a more distant relative of *C. tauri* than, e.g., populations HKEP 1034 and 1035 (table 1b).

**Distribution and habitat.** *C. kangalensis* is clearly a member of the Irano-Turanian steppe floral elements. It seems to be rather local and is until now only known to us from the type locality around Kangal (hence *kangalensis*) in the Sivas Province. The plant is, in our opinion, in great danger due to a rapidly increasing agricultural use of the land in this area. It grows together with *Onobrychis cornuta*, *Convolvulus*, *Iris danfordiae*, *Iris galatica*, grasses, thistles, etc.

**9. *Crocus sivasensis* KERNDORFF & PASCHE, species nova**

**H o l o t y p u s :** Turkey, Cappadocia, Sivas Province, SE of Sivas, 1500-1800 m, 28.3.1999, HKEP 9927 (Gatersleben, GAT 7391).

Cormus 1 cm diameter, subglobosus, tunicae coriaceae usque ad membranaceas, collum setosum, 3-7 mm longum. Cataphyllae 3, argenteae-albae. Folia 2-3.7-5 (n = 34), atrovirida, 1-2 mm diameter, glabra, 2 costis (raro 3-4) in omni sulco in folio inferiore. Folia non bene evoluta ad anthesin, raro attingentia segmenta. Faux lutea, glabra. Perianthii tubus pallide caeruleus-violaceus, atrans versus apicem. Segmenta externa 20-33 mm, plerumque 25 mm longa (n = 34), 7-12 mm, plerumque 9 mm lata (n = 34). Segmenta interna 19-33 mm, plerumque 24 mm longa, 7-13 mm, plerumque 9 mm lata (n = 34). Segmenta externa et interna pallide lilacina-caerulea sine macula. Latera externa segmentorum exteriorum albida usque ad saturata violacea-caerulea sine macula, arcte venosa vel virgis distinctis atrovioleaceis, sine maculis, sed zona diffusa fuscata versus apicem. Latera externa segmentorum interiorum omnino eiusdem coloris, sed generaliter sine maculis, versus basim zona diffusa fuscata. Prophyllum abest. Bractea et bracteola adsunt, argentea, recutita, non conspicua. Filamenta 3-3.8-5 mm longa (n = 16), pallide lutea usque ad lutea, glabra. Antherae 7-9.8-12 mm longae, luteae, sagittatae, incrassatae distinctae ad apicem. Connectivum album usque ad pallide flavum, pollen flavum. Stylus divisus in partes tres, rami stigmatici 2-5.5-9 mm longi, expansi et fimbriati ad apicem. Styli antheris breviores vel aequilongi 97%, longiores 3% (n = 34). Capsula et semina non visa. Chromosomatorum somaticorum numerus est 36.

Corm around 1 cm in diameter, subglobose, tunics coriaceous to membranous, the inner ones membranous, neck bristly, 3-7 mm long, consistent of elongated triangles; splits of tunics at basis into segments of > 2mm, sub-splits present but few, rings present, papery, smooth-edged to slightly pronged, no teeth. Cataphylls 3, silvery white. Leaves 2-3.7-5 (n = 34), dark green, 1-2 mm in diameter, glabrous, white stripe 1/3 of leaf-diameter, 2 (rarely 3 or 4) ribs underneath. Leaves not or poorly developed at anthesis, very rarely reaching the segments. Throat yellow, no hair. Perianth tube light bluish-violet, near the apex darker. Outer segments between 20 and 33 mm but usually 25 mm long (n = 34), between 7 and 12 mm but usually 9 mm wide (n = 34). Inner segments between 19 and 33 mm but usually 24 mm long, between 7 and 13 mm but usually 9 mm wide (n = 34). Inside all segments are very light to light lilac-blue without markings. The outside of outer segments is whitish to deep violet-blue, without markings, tightly veined or distinctly feathered deep violet, no spots but rarely with a diffuse darker zone towards the apex. The outsides of inner segments are equally coloured as the outer ones but generally without markings, towards perianth tube is a more or less diffuse darker zone, often the yellow throat shining through (Fig. 6q-t). Prophyll absent. Bract and bracteole present, silvery, skinny, not conspicuous. Length of filaments 3-3.8-5 mm (n = 16), light yellow to yellow, no hair. Anthers 7-9.8-12 mm long, yellow, arrow-shaped with a distinct thickening at the apex. Connective white to yellowish, pollen yellow. Style divided into 3 branches frequently tightly pressed together, giving the impression of being entire, branches very variable 2-5.5-9 mm long, expanded and fringed at the apex. Style 97 % shorter to equal according to stamen, 3 % longer (n = 34). Capsule and seeds not seen. Chromosome number 2n = 36.

Molecular analysis revealed HKEP 0926 as closest relative. *C. albocoronatus* KERND. & PASCHE (HKEP 9009), HKEP 0504, and HKEP 1029 are genetically near allies.

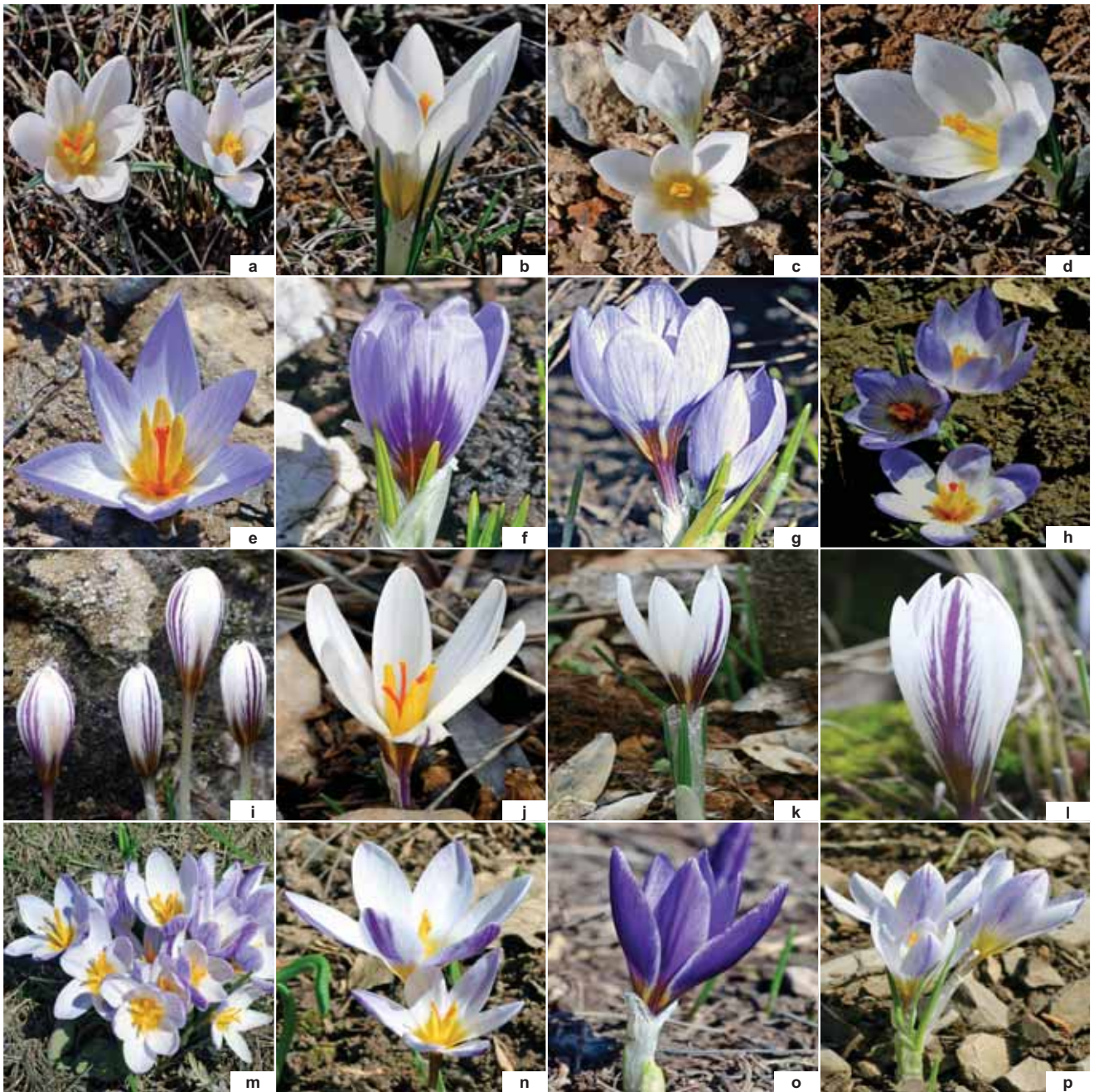
**D i s t r i b u t i o n a n d h a b i t a t .** *C. sivasensis* grows on mountains in the province of Sivas (hence *sivasensis*). It is until now only known from the type locality and another locality in the same area. The plant grows together with *Crocus danfordiae*, *Colchicum triphyllum*, *Quercus*, *Crataegus*, *Juniperus*, *Ornithogalum* etc.

**10. *Crocus ponticus* KERNDORFF & PASCHE, species nova**

**H o l o t y p u s :** Turkey, Lazistan, Rize Province, Gül Dağı, 1900-2100 m, 20.3.2006, HKEP 0621 (Gatersleben, GAT 7134).

Cormus 1-2 cm diameter, tunicae coriaceae, interiores molles, collum 4-6 mm longum. Cataphyllae albidae, etiam brunnescentes dum iuvenes. Folia 3-3.7-6, atrovirida, 1.5 (2) mm diameter, glabra, 2 costis in omni sulco in folio inferiore. Folia attingentia flores ad anthesin. Faux pallide lutea usque ad salmonem coloratam, glabram. Perianthii tubus albus, brunneolus-violaceus ad apicem. Segmenta externa 20-33 mm, plerumque 25 mm longa (n = 32), 6-10 mm, plerumque 8 mm lata (n = 32). Segmenta interna 19-32 mm, plerumque 23.5 mm longa, 4-11 mm, plerumque 8 mm lata (n = 32). Segmenta externa et interna intus caerulea-lilacina, nervatura plus minusve intente caerulea. Latera externa segmentorum exteriorum pallide caerulea-lilacina, macula brunneola ad basim. Latera externa segmentorum interiorum omnino eiusdem coloris, nervatura diluta et pallide caerulea. Prophyllum abest. Bractea et bracteola adsunt, argentea, recutita, plerumque conspicua. Filamenta 3-4.6-9 mm longa (n = 32), plerumque pallide lutea, interdum salmonea, glabra. Antherae 9-11.5-15 mm longae, luteae, anguste sagittatae, incrassatae vel acutae ad apicem. Connectivum angustum, album usque ad pallidum flavum, pollen flavum. Stylus divisus in partes tres, luteus usque ad aurantiacum vel salmonem coloratum. Rami stigmatici 6-7.8-11 mm longi. Styli antheris longiores vel aequilongi 87%, breviores 13% (n = 32). Capsula et semina non visa. Chromosomatorum somaticorum numerus 18.

Corm 1-2 cm in diameter, tunics coriaceous, the inner ones softer, neck 4-6 mm long, consistent of broad triangles, splits of tunics into segments of > 2 mm, no sub-splits, rings present, smooth-edged, no teeth. Cataphylls whitish but turn to brown even when young. Leaves 3-3.7-6, dark green, 1.5 (2) mm in diameter, glabrous, white stripe < 1/3 – 1/3 of leaf-diameter, 2 ribs underneath on each side of the blade. Leaves reaching the flowers at anthesis. Throat light yellow to salmon-coloured, no hair. Perianth tube white, near the apex brownish-violet. Outer segments between 20 and 33 mm but usually 25 mm long (n = 32), between 6 and 10 mm but usually 8 mm wide (n = 32). Inner segments between 19 and 32 mm but usually 23.5 mm long, between 4 and 11 mm but usually 8 mm wide (n = 32). Inside all segments are light bluish-lilac with a more or less intense blue veining. Outside of outer segments light bluish-lilac with a brownish spot near the perianth tube, which can be prolonged by a soft bluish veining with a pronounced central stripe, thinning out towards the apex of the segment. Outside of inner segments equally coloured, markings faint and very pale blue (Fig. 6a-d). Prophyll absent. Bract and bracteole present, sil-



**Fig. 9:** Colour photographs of *C. kangalensis* (a-d), *C. berytius* (e-h), *C. pelitensis* (i-l), HKEP 1025 (m-p).

very, skinny, in many individuals conspicuous. Length of filaments 3-4.6-9 mm ( $n = 32$ ), mainly light yellow but sometimes salmon-coloured, no hair. Anthers 9-11.5-15 mm long, yellow, narrowly arrow-shaped, thickened or acute at apex. Connective narrow, white to light yellow, pollen yellow. Style divided into 3 branches which can be tightly pressed together, yellow to orange or salmon-coloured, in some individuals expanded and fringed,

branches 6-7.8-11 mm long. Style length according to stamen is 87% longer to equal, 13% shorter ( $n = 32$ ). Capsule and seeds not seen. Chromosome number  $2n = 18$ .

*Crocus ponticus* is most closely allied to populations HKEP 1016 and HKEP 1018. Remarkable of this distinct new crocus is the often salmon-coloured throat and the equally coloured styles, which is unique in the genus.

**Distribution and habitat.** *C. ponticus* is obviously an Euxine element confined to the alpine zone of Lazistan. Until now it is only known from the type locality in the north-eastern part of the Pontic range (hence *ponticus*) in the Rize Province. The plant grows above the tree line together with short grasses, *Rosa*, *Juniperus*, *Acantholimon*, *Scilla*, *Verbascum*, *Gagea* etc.

### 11. *Crocus berytius* KERNDORFF & PASCHE, species nova

**Holotypus:** Turkey, Antitaurus, Kahramanmaraş Province, Berit Dağ, 1900-2300 m, 4.5.2005, HKEP 0524 (Gatersleben, GAT 7382).

Cormus 1-1.5 cm diameter, tunicae exteriores et interiores membranaceae, collum 2-4 mm longum. Cataphyllae argenteae-albidae. Folia 3-4.2-5, atrovirida, glabra, virga alba minus quam 1/3 diameter, (1)2 costis in omni sulco in folio inferiore. Folia evoluta infirma ad anthesin, raro attingentia flores. Faux lutea, raro suffusa brunneola, glabra. Perianthii tubus albus, brunneolus-violaceus prope apicem. Segmenta externa 15-32 mm, plerumque 10 mm lata (n = 56). Segmenta interna 13-31 mm, plerumque 21 mm longa, 5-14 mm, plerumque 9 mm lata (n = 56). Segmenta externa et interna intus pallide caerulea, nervatura intente caerulea, comparanda C. aereo et C. fibroannulato. Latera externa segmentorum exteriorum pallide lilacina-caerulea, interdum nervaturis tenuibus atrocaeruleis. Basis segmentorum exteriorum macula violacea vel brunneola-violacea. Latera externa segmentorum interiorum eiusdem coloris, sed sine vel cum nervatura diluta. Prophyllum abest. Bractea et bracteola adsunt, argentea, recutita, raro conspicua. Filamenta 2-4.8-7 mm longa (n = 56), saturate lutea usque ad aurantiaca, glabra. Antherae 6-8.8-12 mm longae (n = 56), luteae, late sagittatae, cum incisura ad apicem. Connectivum latum, argenteum-album, pollen flavum. Stylus aurantiacus usque ad aurantiacum-rubrum, divisus in partes tres, rami stigmatici expansi et fimbriati ad apicem, 2-4.5-7 mm longi. Styli antheris longiores vel aequilongi 82%, breviores 18% (n = 55). Capsula et semina non visa. Chromosomatorum somaticorum numerus 18.

Corm 1-1.5 cm in diameter, outer and inner tunics membranous, neck short 2-4 mm long, consistent of short triangles; splits of tunics mainly from basis upwards into segments of > 2 mm, sub-splits present, rings present but very few and poorly developed, smooth-edged or slightly pronged, no teeth. Cataphylls silvery white. Leaves 3-4.2-5 dark green, glabrous, narrow about 1 mm or less in diameter, white stripe < 1/3 of leaf-diameter, (1) 2 ribs underneath. Leaves not or poorly developed at anthesis, rarely reaching the segments. Throat yellow, rarely tinged brownish, no hair. Perianth tube white, near the apex brown-violet. Outer segments between 15 and 32 mm but usually 22 mm long (n = 56), between 7 and 15 mm but usually 10 mm wide (n = 56). Inner segments between 13 and 31 mm but usually 21 mm long, between 5 and 14 mm but usually 9 mm wide (n = 56). Inside all segments are light blue with an intense deeper blue veining all over the segment comparable to those of *C. aereus* and *C. fibroannulatus*. Outside of outer segments is light lilac-blue with or without fine darker blue veining. If veined then the whole segment. Near the perianth tube is a dark violet or brownish-violet spot which can be prolonged to half of the segments with strongly serrated edge. Outside of inner segments equally coloured but with none or more faint veining; towards the perianth tube is the same spot as with the outer ones

but less distinct, often the yellow throat shining through (Fig. 9e-h). Prophyll absent. Bract and bracteole present, silvery, skinny, rarely conspicuous. Length of filaments 2-4.8-7 mm (n = 56), deep yellow to orange, no hair. Anthers 6-8.8-12 mm long (n = 56), yellow, broadly arrow-shaped with a notch on top. Connective broad, silvery-white, pollen yellow. Style orange to orange-red, divided into 3 branches, often standing closely together, giving the impression of being entire; ends of branches expanded and significantly fringed at the apex, branches 2-4.5-7 mm long. Style length according to stamen is 82 % longer to equal and 18 % shorter (n = 55). Capsule and seeds not seen. Chromosome number 2n = 18.

According to molecular analysis *C. berytius* is less closely related to all the other species in the basic “Adami-cluster” except for *C. pelitensis* (Tab. 3).

**Distribution and habitat.** *C. berytius* grows in the Berit mountains (hence *berytius*) in central Turkey. It is until now only known from the type locality in the Kahramanmaraş Province. The plant grows together with *Astragalus*, *Acantholimon*, *Juniperus* trees, *Corydalis rutifolia* subsp. *erdellii*, *Ornithogalum*, *Anemone blanda*, *Crocus kotschyanus* etc.

### 12. *Crocus tauri* MAW

**Holotypus:** S. Turkey, near the Cilician Gates off the Taurus, Aucher-Eloy, exsic. Nos. 2128 and 2654 in Herb. De Cand., G. Maw, Synops. Genus *Crocus* in Gard. Chron., new ser., vol. xvi, p. 749 (1881).

### *Crocus tauri* (KERNDORFF & PASCHE) ex MAW

**Epitypus:** Turkey, Upper Euphrates, Malatya Province, Ağırmeze Dağı, 1800-2000 m, 23.3.2009, HKEP 0929 (Gatersleben, GAT 7147).

Cormus subglobosus, 1.5-2 mm diameter. Tunicae exteriorae et interiorae membranaceae. Tunica dissecta in segmenta >2-5 mm, subfissurae absunt. Collum 6-12 mm longum, setosum, formatum per triangulos elongatos. Annuli adsunt, membranacei, pauci, serrati. Cataphyllae 3-5, argenteae albae. Folia 2-3.6-5 (n=37), 1.5-2 mm lata, glabra. 2 costis in omni sulco in folio inferiore. Segmenta externa 20-24-30 mm longa, 7-9-12 mm lata. Segmenta interna 18-22-29 mm longa, 6-8-10 mm lata (n ad unum omnes =37). Proportio segmentorum exteriorum longitudo/latitudo = 2,7. Segmenta externa et interna intus atrocaerulea usque ad violacea sine macula. Latera externa segmentorum exteriorum et interiorum atrocaerulea usque ad violacea cum macula inconspicua et zona fuscata ad basem. Faux saturate lutea usque ad aurantiacam, glabram. Perianthii tubus albus, violaceus-caeruleus prope segmenta. Filamenta lutea, lata facta ad basem, longitudo media 3 mm. Connectivum sine colore, plerumque potius latum. Stylus luteus usque ad aurantiacum, divisus in ramos tres, filiformis, incrassatus ad apicem, longitudo plus minusve 6,2 mm. Stigma antheris 8% aequalis, 19% longior, 8% brevior (n=35). Capsula et semina non visa. Chromosomatorum somaticorum numerus 18.

Corm subglobose, 1.5-2 mm in diameter. Outer and inner tunics membranous. Tunics split into segments of >2-5 mm, no subsplits. Neck 6-12 mm long, bristly, formed by elongated triangles. Rings present, membranous, few, saw-toothed. Cata-

phylls 3-5, silvery white. Leaves 2-3.6-5 (n = 37), 1.5-2 mm wide, stiffly erect, no hair. White stripe <1/3 to 1/3 of leaf-diameter. Ribs underneath 2 on both sides of the blade. Outer segments 20-24-30 mm long, 7-9-12 mm wide. Inner segments 18-22-29 mm long, 6-8-10 mm wide (n for all = 37). Proportion of outer segment length/width = 2.7. Inside all segments are deep blue to violet without markings. Outside of outer and inner segments deep blue to violet with inconspicuous markings and darker zone near the base. Throat deep yellow to orange, no hair. Perianth tube white, violet-blue near segments (Fig. 8q-t). Prophyll absent. Bract and bracteole present, silvery. Filaments yellow, broadened at base, median length 3 mm. Connectives colourless, mostly rather broad. Styles yellow to orange, 3-branched, filiform, thickened at top, mean length 6.2 mm. Style-length according to stamen is 8 equal, 19 longer, 8 shorter (n = 35). Capsule and seed unknown. Chromosome number  $2n = 18$ .

## Supplementary comment

In the course of our investigations in the Anatolian Diagonal we found another rather pale blue crocus with a normally whitish to pale yellow throat in the alpine region of the Palandöken Mountains south of Erzurum (HKEP 1037, Fig. 7m-p). It resembles *C. roopiae* WORONOW, described in the Flora of the U.S.S.R. from the Kars area in north-eastern Turkey (Not. Syst. Ex Herb. H.B.P.V. (1924), Grossheim, Fl. Kavk. I (1928), 248, type in Tiflis). This one was put into synonymy by MATHEW (1982) as being a form of *C. biflorus* subsp. *tauri*. According to our phylogenetic results it belongs to the adami-east sub-cluster and not to the tauri cluster. Although it has identical sequences to *C. adamii* ArmGet\_1\_2, *C. adamii* Arm Van, and *C. adamii* MP9676 (see Tab. 1b) it is a phenotypically and even morphologically differentiable “form” of *C. adamii* (see Tab. 2a-d, Tab. 4, Fig. 7). More investigations are necessary to determine the taxonomical status of this crocus.

## Acknowledgements

The work for this paper was supported by scanned copies of herbarium specimens of Brian Mathew (formerly Kew) and the Geneva herbarium for which we are very thankful. We are indebted to Ingo Schneider (Wustermark) for chromosome counts and DFG for financial support of molecular work. We are especially thankful to Mr. Bernd Rier for his great support writing the Latin diagnoses. Last but not least we thank our families for the great interest, help and patience at any time.

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Autor(en)/Author(s): Kerndorff Helmut, Pasche Erich, Blattner Frank R., Harpke Dörte

Artikel/Article: [Crocus biflorus Miller \(Liliiflorae, Iridaceae\) in Anatolia — Part IV 159-186](#)