

FOUR CENTRAL ASIAN CROCUS SPECIES (LILIACEAE)

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Crocus alatavicus Regel & Semenov ($2n = 20$), *C. michelsonii* B. Fedtsch. ($2n = 20$) and *C. korolkowii* Regel & Maw ($2n = 20$) are three closely related species representing the eastern extremity of the area of distribution of the genus in Central Asia. The allied but rather more distinct *C. caspius* Fisch. & Mey. ($2n = 24$) occupies an area a little to the west in the Caspian Sea region. The species are defined, a key is provided and their chromosome morphology is investigated.

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چهارگونه *Crocus* (Liliaceae) از آسیای مرکزی

از : ماتیو و برایتون

گیاهان

Crocus alatavicus Regel & Semenov ($2n = 20$),

C. michelsonii B. Fedtsch. ($2n = 20$)

C. korolkowii Regel & Maw ($2n = 20$)

گونه‌هایی وابسته بیکدیگر هستند که انتهای شرقی ناحیه جغرافیایی این جنس را در آسیای مرکزی مشخص مینمایند. گونه وابسته دیگرول نسبتاً مشخص ($2n = 24$) *C. caspius* Fisch. & Mey. منطقه کمی بطرف غرب را در ناحیه دریای خزر اشغال مینماید. گونه‌های فوق تعریف، کلید نامگذاری و تحقیقات کروموزمی انجام شده در باره آنها عنوان میگردد.

Introduction

The genus *Crocus* has an entirely Old World distribution, ranging from Portugal and Morocco in the west, east to Russian Kirgizia and Sinkiang Province of western China in the Dzungarian Ala-Tau and Tien Shan Mountains. There are approximately 100 species, the majority of which occur in the Balkans and Turkey, the numbers diminishing rapidly on either side of this area. 9 species are known in the area covered by the Flora Iranica (Wendelbo & Mathew 1975) while in Afghanistan there is one only, *C. korolkowii*, which also occurs in adjacent areas of the Soviet Union. Russia east of the Caspian, possesses this species plus two others, *C. michelsonii* and *C. alatavicus*. The first of these inhabits the Kopet Dag range of both the Iranian and Russian sides of the border while *C. alatavicus* occurs in the USSR from Tashkent eastwards as far as the Chinese Tien Shan mountains. These three species are undoubtedly very closely allied and can be considered to represent a distinct group within the genus together with *C. caspius* which is morphologically related enough to be included here, although it is the most distinct of the four species. It occupies an area a little to the west of the other three, in the Caspian region of northern Iran and adjacent areas of Russian Azerbaijan. It is a lowland species whereas the others are mountain plants.

As indicated in a previous paper (Mathew 1976), most of the characters used to subdivide the genus *Crocus* are not entirely reliable, but to avoid them altogether would result in a mere list of species with no attempt at a classification. The group at present under discussion demonstrates this well, for the four species reviewed here cut across three of the groupings of Maw (1886).

Maw followed Goldbach (1817), Gay (1831) and Herbert (1847) in dividing the genus initially on the presence or absence of a membranous prophyll subtending the pedicel, giving rise to Division 1, *Involucrati* and Division 2, *Nudiflori* respectively.

C. korolkowii, *C. alatavicus*, *C. michelsonii* and *C. caspius* all belong to the latter Division but from this point on the classification breaks down, for Maw's subordinate groups rely on the type of corm tunic and time of flowering (autumn or spring). Taking the first of these features, the tunic, he recognised four Sections, namely 1. *Reticulati* (fibrous, the fibres netted, or reticulate), 2. *Fibro-membranacei* (membranous or fibrous with vertical veins or parallel fibres), 3. *Annulati* (membranous or coriaceous with basal rings of tissue, or "annuli"), 4. *Intertexti* (fibrous, the fibres interwoven, or plaited). Within these Sections, autumn- or spring-flowering groups were recognised. Of the four Sections, *Intertexti* is the most clearly defined with no species showing intermediate types of corm tunic. The *Annulati* Section is reasonably distinct although in three of the species the membranous tunic is split into parallel strips at its lower end and the basal rings of tissue are not as strikingly obvious as in the rest of the species. Thus, the dividing line between the *Annulati* and *Fibro-membranacei* is somewhat obscured by these species. Similarly, the division between the latter Section and the *Reticulati* is clouded by a few species in which the more or less parallel fibres join together at the apex of the tunic giving a slightly reticulated appearance. However, with all the species involved in these two Sections it is possible to assign them to one or the other without too much difficulty. The main problem is that in certain cases two very closely allied species fall into different Sections of the genus because their corm tunics are slightly different, thus giving the impression, that they are little related.

The four species under discussion here, which in the opinion of the authors form a natural group within the genus, fall into Division *Nudiflori* as mentioned above. If, however, the rest of Maw's classification was applied, *C. korolkowii* and *C. alatavicus* would belong to Section *Fibro-membranacei*, Spring-flowering group, *C. caspius* to *Fibro-membranacei*, Autumn-flowering group, and *C. michelsonii* to *Reticulati*, Spring-flowering group. It is obvious therefore

Table 1. Details of the *Crocus* collections, together with their chromosome number.

Species	Kew Cytology No.	Collector or Source	Locality	Chromosome No. ($2n =$)
<i>C. alatavicus</i>	70.189		USSR: Tashkent Area	20
—	70.297	Marr 985	USSR: Ala-Tau Mts.	20
—	72.58	Boussard	USSR: Alma-Ata Botanic Garden	20
—	72.1490	Prasil CRJ-02	USSR: Alma-Ata Botanic Garden	20
—	72.1417	Frunze	USSR: Frunze Botanic Garden	20
—	72.1590	Alma-Ata	USSR: Alma-Ata Botanic Garden	20
<i>C. korolkowii</i>	72.191	M. Prasil s. n.	USSR: near Tashkent	20
—	71.336	Dushanbe	USSR: Dushanbe Botanic Garden	20
—	70.130	Furse 6584	Afghanistan: Salang Pass	20
—	70.154	Furse 6208	Afghanistan: Faisabad	20
—	71.2615	Grey-Wilson & Hewer 706	Afghanistan: Salang Pass	20
<i>C. michelsonii</i>	70.175	Furse 5159	Iran: W. of Bojnurd	20
—	70.1448	Furse 5175	Iran: W. of Bojnurd	20
—	70.119	Furse 5194	Iran: NW. of Quchan	20
—	69.1318	Furse 7497	Iran: N. of Quchan	20
<i>C. caspius</i>	69.1118	Furse 5081	Iran: Farahabad near Sari	24
—	69.1413	Archibald 2309	Iran: Alborz Mts., Mazandaran	24
—	69.1445	Furse 5035A	Iran: Sefid Rud above Rasht	24
—	70.186	Furse 5032	Iran: Rasht	24
—	74.1252	Ingham 2	Iran: Amol — Tehran	24

that this method of subdividing the genus is not entirely satisfactory. The taxonomic and cytological studies at the Royal Botanic Gardens, Kew based on a collection of plants from natural populations will include a re-classification of the genus, to be published at a later date.

To summarise, the features of *C. korolkowii* and its three allied species are as follows:

- (a) Absence of a prophyll subtending the pedicel.
- (b) Bract and bracteole both present.
- (c) Corm tunic ± membranous to fibrous with fibres parallel or reticulate.
- (d) Style 3-branched, the branches usually short and expanded at the apex.
- (e) Anthers yellow.

(f) Seed surface rugose or ruminant (Murley, 1951).

(g) Leaves proteranthous or synanthous; flowers produced in autumn or spring.

(h) Chromosome number $2n = 20$ or $2n = 24$ (Brighton et al., 1973).

(i) Plants of N. Iran, N. Afghanistan and adjacent areas of USSR, China and Pakistan.

The only other species which occur east of longitude 45° E are *C. biflorus* Mill., *C. almehensis* Brickell & Mathew, *C. speciosus* M. Bieb., *C. cancellatus* Herb., *C. pallasii* Goldb. subsp. *haussknechtii* (Boiss. & Reut. ex Maw) Mathew (in press) and *C. gilanicus* Mathew. The first three are members of the *Nudiflori* but differ from the four species under discussion here in having

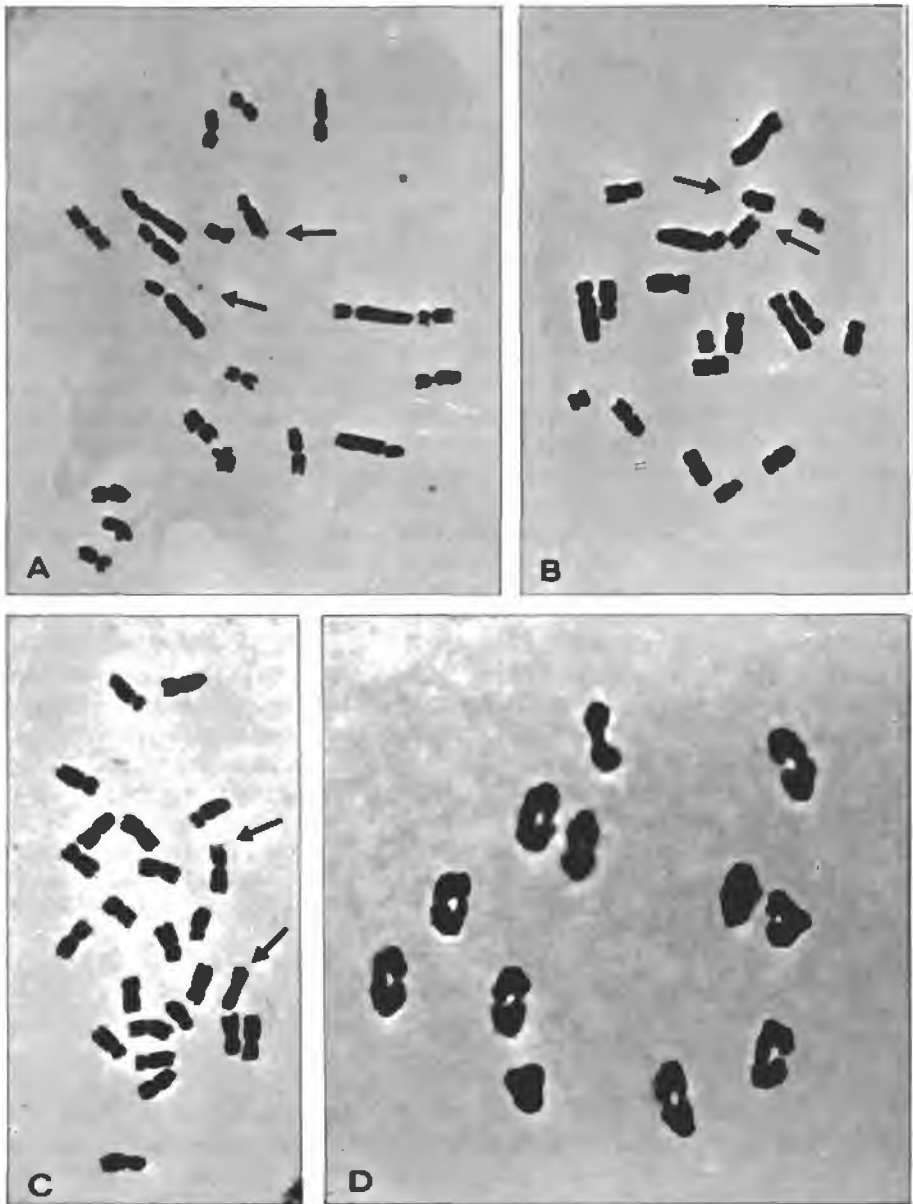


Fig. 1. A. *C. alatavicus* $2n = 20$. — B. *C. korolkowii* $2n = 20$. — C. *C. caspius* $2n = 24$. — D. First metaphase of meiosis in *C. caspius*; 12 bivalents. — Arrows indicate satellites or secondary constrictions.

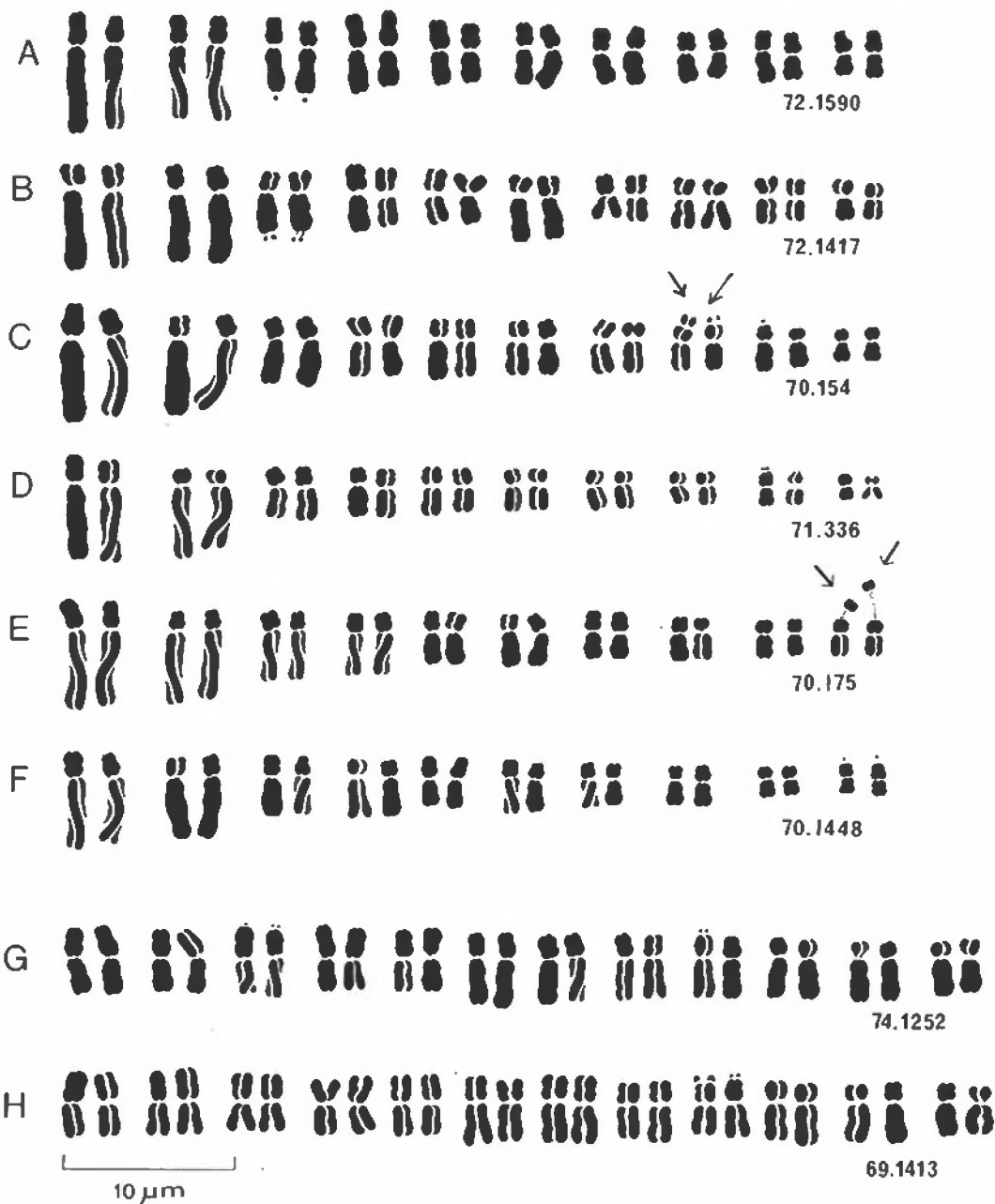


Fig. 2. Karyotypes of *Crocus* species. — A, B. *C. alataevicus* $2n = 20$. — C, D. *C. korolkowii* $2n = 20$. — E, F. *C. michelsonii* $2n = 20$. — G, H. *C. caspius* $2n = 24$.

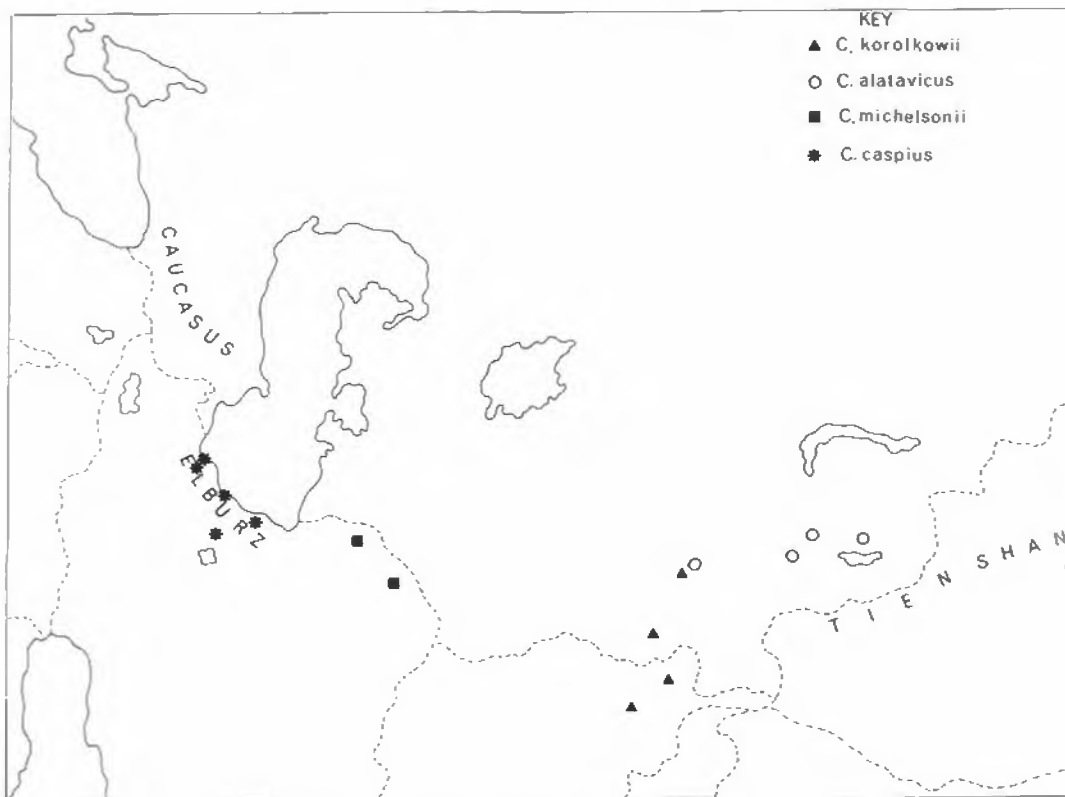


Fig. 3. Distribution map of *Crocus* collections which have been studied cytologically.

distinct rings of tissue on their corm tunics, so that they would be accommodated in Maw's Section *Annulati*. *C. cancellatus* is also a nudiflorous species but is instantly recognised by its very coarsely fibrous-reticulate tunic and autumnal flowers with hysteranthous leaves. *C. pallasii* subsp. *haussknechtii* and *C. gilanicus* belong to the Division *Involucrati* and are thus unrelated to *C. korolkowii* and its allies.

Cytology

The cytological observations for this paper have

been made from root-tip squashes which were prepared using the method previously described (Brighton et al., 1973).

Chromosome counts of $2n = 20$ have been recorded for *C. korolkowii* by Mather (1932), Brittingham (1934), Pathak (1940), Karasawa (1940) and Zakharyeva & Makushenko (1969). Karasawa also reported that it had a regular meiosis, forming ten bivalents at first metaphase. Zakharyeva & Makushenko have shown counts of $2n = 20$ for *C. alatavicus* and $2n = 24$ for *C. caspius*. Their material was from Dushanbe and Alma-Ata Botanic Gardens.

The origins of the plants examined cytologically at the Royal Botanic Gardens, Kew are given in Table 1, where the results are also summarised, and the distribution of these is shown on the map (Fig. 3).

Key to *C. korolkowii* and its allies

1. Flowers yellow with or without brown lines, speckling or suffusion externally

1. *C. korolkowii*

Flowers not yellow, but sometimes yellow in the throat 2

2. Flowers autumnal; corm tunics rather membranous without distinct fibres, splitting longitudinally towards the base 4. *C. caspius*

Flowers vernal; corm tunics fibrous 3

3. Leaves 4–6(–8), grey-green; throat of perianth not yellow; fibres of corm tunic netted

3. *C. michelsonii*

Leaves 8–20, green; throat of perianth yellow; fibres of corm tunic parallel or at most very obscurely netted towards the top of the corm

2. *C. alatavicus*

1. *C. korolkowii* Regel ex Maw

Regel ex Maw, Gard. Chron. Ser. 2, 13: 531 (1880). – Syntypes: USSR, Kara Tau mountains near Boroldai, Korolkow (LE); between Tashkent and Karak-Ati, Korolkow & Krause (LE); Dargam near Samarkand, Fedtschenko (LE); valley of river Sarawschan, Fedtschenko (LE).

Corm tunic rather membranous at first, later splitting into many separate parallel fibres, these occasionally anastomosing towards the apex of the tunic. Cataphylls 3–5, papery, white or veined greenish or brownish at the apex. *Leaves* (7–)10–20, synanthous, usually shorter than the flower at anthesis but extending considerably later, 1.5–3 mm wide, green, glabrous or sparsely scabrid on the margins of the lamina and keel with one or more raised and conspicuous veins on each side. *Flowers* vernal, (1–)3–5, bright yellow, the outer 3 segments often suffused brown or bronze externally, es-

pecially towards the base; throat glabrous, the same colour as the segments. Bract and bracteole exerted from the cataphylls, about 4–10 cm long, subequal or the bracteole narrower. *Perianth* tube about 4–13 cm long; segments \pm equal, 2–4 cm long, 0.6–1.3 cm wide, elliptic to oblanceolate, subacute to obtuse. *Filaments* 0.4–0.6 cm long, glabrous or sparsely pubescent at the base, yellow. Anthers 0.9–1.3 cm long including the basal lobes, yellow. *Style* about equalling or exceeding the stamens, yellow or orange, dividing into 3 orange branches, each somewhat expanded and papillose at the apex. *Capsule* 1.3–2.1 cm long, 0.7–1 cm wide, cylindrical or ellipsoid, carried at or just below ground level when mature; seeds ca 3 mm long, subglobose or ellipsoid, sometimes somewhat trigonous through compression in the capsule; raphe and caruncle rather indistinct; testa rugose, reddish-brown. $2n = 20$.

Flowering period. February–March.

Habitat. In open rocky or grassy places, 1200–3150 m.

Distribution. N. & E. Afghanistan; Pakistan (Chitral); USSR: Uzbekistan and Tadjikistan north as far as the Kara-Tau mountains and probably east to about longitude 72° E.

Cytology. The five collections of *C. korolkowii* which were studied cytologically came from the USSR and Afghanistan. The chromosome constitution of these plants was the same. They had $2n = 20$ chromosomes and a karyotype which consisted of two pairs of large acrocentrics, six pairs of sub-median chromosomes and two pairs of small acrocentrics. Small satellites were visible on the larger of these two latter pairs, where they occurred on the short arms (Fig. 1 B, Fig. 2 C & D). In one collection (70.154) secondary constrictions were observed in the short arms of one pair of sub-median chromosomes (arrowed Fig. 2 C).

2. *C. alatavicus* Regel & Sem.

Regel & Semenov in Bull. Soc. Nat. Mosc. 41,



Fig. 4. *Crocus korolkowii*.

1: 434 (1868). — Type: USSR, Ala-Tau mountains, Aral-djel, 7000 ft., Semenov (LE).

C. alatavicus var. *ochroleucus* Baker in Gard. Chron. N. S. 9: 234 (1878).

C. alatavicus var. *porphyreus* Baker, l. c.

C. alatavicus var. *albus* Regel, Descr. Pl. Nov., Fasc. 7: 212 (1879).

C. alatavicus var. *typicus* Regel, l. c.

This species is similar to *C. korolkowii* and morphologically there appears to be little difference. However, the two are immediately distinguishable because *C. alatavicus* has white flowers, usually speckled or stained on the exterior. This is usually grey or blackish-violet but it can be a rather more claret colour or is occasionally absent altogether, with the exterior of the flower creamy or yellowish. The throat of the flower is yellow. *C. korolkowii* and *C. alatavicus* are geographically distinct although their area of

distribution are contiguous.

The distinctions between *C. alatavicus* and *C. michelsonii* have been noted (Mathew 1975) and are repeated here under the description of the latter species.

Chromosome number of *C. alatavicus* $2n = 20$.

Flowering period. (February—) March– May.

Habitat. Mountain meadows near melting snow, 1800–2300 m.

Distribution. USSR: Kazakhstan, Kirgizia, ?Uzbekistan, from Tashkent east to the Dzungarian Ala-Tau; W. China, in Tien Shan mountains.

Cytology. All our specimens of *C. alatavicus* have been collected in the USSR or sent from Botanic Gardens there. In each case the plants had $2n = 20$ chromosomes and the karyotypes were the same, consisting of two large pairs of

acrocentrics with small satellites on the long arms and seven pairs of median or sub-median chromosomes which exhibit an even gradation in size (Fig. 1 A, Fig. 2 A & B). The position of the satellites on the long arms distinguishes this species from the other two in this group which have $2n = 20$ chromosomes: *C. korolkowii* and *C. michelsonii* have satellites or secondary constrictions on the short arms of smaller acrocentrics.

3. *C. michelsonii* B. Fedtsch.

B. Fedtschenko in Flora Turkmenii 1(2): 328 (1932), sine descr. lat.: in Flora USSR 4: 506 (1935). — Type: USSR: Turkmenistan, Kopet Dag in the vicinity of Kheirabad meteorological station, Paschinski (LE).

Corm tunic fibrous, the fibres distinctly reticulated. Cataphylls usually 3, white tinged green near the apex. *Leaves* 4–7, synanthous, roughly equalling or overtopping the flowers at anthesis, 1.5–2 mm wide, grey-green, very sparsely ciliate on the margins of the lamina and keel; keel with at least one raised conspicuous vein on each side. *Flowers* vernal, 1–2(–3), whitish, heavily suffused with lilac-blue especially on the outside and becoming dark towards the base of the segments: throat glabrous, white or lilac. Bract and bracteole exerted from the cataphylls, 4–6.5 cm long, subequal in length but the bracteole rather narrower. *Perianth* tube 4–8.8 cm long; segments \pm equal, 2.5–4 cm long, 0.5–1 cm wide, oblanceolate, subacute. *Filaments* 0.6–0.8 cm long, glabrous, white or pale lilac. *Anthers* 0.8–1.3 cm long including the basal lobes, yellow. *Style* equalling or just exceeding the anthers, white, dividing into 3 whitish stigmatic arms, each somewhat expanded at the apex with a papillose, lateral rather than apical stigmatic surface. *Capsule* ellipsoid, about 1.5 cm long and 0.8 cm wide, carried at ground level when mature; seeds about 3 mm long, subglobose or somewhat trigonously compressed; raphe and caruncle indistinct; testa rugose, dark maroon. $2n = 20$.



Fig. 5. *Crocus alatavicus*.

Flowering period. March–April.

Habitat. Open stony hills, 1200–2300 m.

Distribution. Kopet Dag range of NE. Iran and adjacent USSR.

Cytology. *C. michelsonii* had $2n = 20$ chromosomes which were constant in the four collections studied, all of which came from Iran. The karyotype consisted of two pairs of larger acrocentric chromosomes and acrocentrics or sub-medians which graded evenly down in size (Fig. 2 E & F). Small satellites occurred on the smallest pair of sub-medians and in one collection (70.175) these were quite large (arrowed, Fig. 2 E).

Although superficially rather similar to *C. alatavicus* because of its colouring, *C. michelsonii* is distinct from it morphologically. The

markedly reticulated fibres of the corm tunics and the fewer rather greyish-green leaves make it easily recognisable, while the white style and stigma and absence of any yellow colour in the throat further serve to separate it. Although it is stated in the Flora USSR 4, transl. ed.: 387 (1968) that the stigma is orange, this is an error of translation from the latin description on page 570 of the same work.

Generally it can be said that the external suffusion of colour on the perianth segments is bluish in *C. michelsonii* and greyish or blackish-violet in *C. alatavicus*, although both are variable in this respect and there may be little difference between some of the colour forms of both species (Mathew, 1972). The two species are geographically separated by at least 1000 km.

4. *C. caspius* Fisch. & C. A. Mey.

Fischer & C. A. Meyer, Bull. Soc. Nat. Mosc. 11: 252 (1838). — Type: USSR, Talysh region near Sialakenti in the vicinity of Lenkoran, and near Astara, Hohenacker (K, LE).

C. boryanus Herb., Journ. Hort. Soc. London 2: 291 (1847), p. p.

Corm tunic membranous, splitting longitudinally, but not distinctly fibrous. Cataphylls about 3, whitish tinged with green towards the apex, rather prominently close-veined. *Leaves* 2–6 (–9), synanthous, equalling or exceeding the flowers at anthesis, extending later, 1–2 mm wide, green, glabrous, keel with one or more raised veins on each side. *Flowers* autumnal, 1(–2), white or pale pinkish-lilac, internally deep yellow towards the base of each segment; throat pubescent, deep yellow. Bract and bracteole subequal from the cataphylls, 4–9.3 cm long, exerted or the bracteole rather narrower

than the bract. *Perianth* tube about 4–18 cm long, segments \pm equal, 2–4 cm long, 0.6–1.5 cm wide, obovate, subacute or obtuse. *Filaments* 0.7–1.3 cm long, deep yellow, pubescent especially towards the base. *Anthers* 1.2–1.6 cm long including the basal lobes, yellow. *Style* well exceeding the stamens, orange, dividing into 3 orange stigmatic arms, each expanded at the apex with a papillose lateral rather than apical stigmatic surface. *Capsule* about 1–1.2 cm long, \pm globose, carried at or just below ground level at maturity; seeds ca 2 mm long, subglobose or slightly angular, raphe and caruncle poorly developed; testa finely rugose, dark brown. $2n = 24$.

Flowering period. September–November.

Habitat. In woods and scrub, -25 to +160 m.

Distribution. Caspian Talysh and Alborz foothills of Iran and adjacent Russian Azerbaijan, from approximately longitude 49° E to 55° E.

Cytology. *C. caspius* is completely different from the other species in this group in that it has $2n = 24$ chromosomes. The karyotype is more symmetrical, consisting of metacentrics and sub-medians which do not vary much in size. Five pairs of metacentrics and seven pairs of sub-medians can be distinguished and small satellites were observed on one pair of metacentrics and also on the short arms of one pair of sub-medians (Fig. 1 C, Fig. 2 G & H).

Meiosis was examined in this species and was regular, forming twelve bivalents at first metaphase (Fig. 1 D). There was usually one chiasma per arm and these were terminally located thus producing rod shaped or ring bivalents. The latter were formed with greater frequency. Occasionally three chiasmata were observed in one bivalent. In this case there was one terminal chiasma in one arm and terminal and interstiti-

Fig. 6. *Crocus michelsonii* (above). — *Crocus caspius* (below).



al chiasmata in the other. Interstitial chiasmata were also observed in some cells but never in more than four bivalents per cell. Twenty-eight metaphase I cells were analysed and the mean chiasma frequency per cell was found to be 20.45

The capsule of *C. caspius* differs from the other species mentioned here in being more or less subglobose and this together with the membranous non-fibrous corm tunic, make the species recognisable even in the fruiting stage. The white or lilac flowers with a yellow throat make it necessary to compare the species only with *C. alatavicus*, but from this it can be immediately separated by the normally fewer leaves, the autumnal flowering and the pubescent throat to the perianth.

Discussion

Of the four species reviewed here *C. caspius* is the most distinct both morphologically and cytologically. It is not difficult to distinguish from the other species but on the other hand it does possess several features which make its inclusion quite justified. The characters already listed above, as the necessary requirements for membership of the "*C. korolkowii* group" are sufficient, but in addition there are some interesting but as yet poorly understood features concerning the fruiting stage which may be important in the intrageneric classification of *Crocus*.

The four species dealt with here have capsules which at maturity are only raised to ground level. In many other species the subterranean pedicel elongates rapidly just before capsule maturity, elevating it to several centimetres above ground. Seed dispersal by ants in some species of *Crocus* has been observed in the wild by Mathew, but no information is available for any of the four species under discussion here. The surface architecture of the *Crocus* seed has been shown to vary enormously (Culling 1974; Baytop, Mathew & Brighton 1975) but it is not known if there is any correlation between the method of seed dispersal, seed morphology and

the position of the capsule at maturity. Intensive field studies are necessary in order to determine whether these characters are inter-related or arbitrary.

Further field work, in particular population studies, is also necessary to determine how cytologically stable these four species are. From our few samples they would seem to vary only slightly, especially when one considers the great range of variability which is found in this genus. Species of *Crocus* are known to exhibit intra-specific variation both of the chromosome number and karyotype; for example *C. cancellatus*, has five different numbers and ten different cytotypes (Brighton, in press).

Since *C. alatavicus*, *C. michelsonii* and *C. korolkowii* are morphologically and geographically distinct it seems preferable to maintain them at species level in spite of their very close relationship.

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