Karyotyping in *Sternbergia clusiana* and *S. colchiciflora* (Amaryllidaceae) from Turkey

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Ünal, F., Yüzbaşioğlu, D. and Duman, H. 1997. Karyotyping in *Sternbergia clusiana* and *S. colchiciflora* (Amaryllidaceae) from Turkey. — *Hereditas 126*: 277–280. Lund, Sweden. ISSN 0018-0661. Received April 23, 1997. Accepted June 23, 1997

The cytological features including chromosome counts and detailed chromosome measurements were reported in *Sternbergia clusiana* (Ker-Gawl.) Ker-Gawl. and *S. colchiciflora* Waldst. and Kit. from Turkey. Total lengths, relative lengths, long/short arm ratios of mitotic chromosomes were calculated. Total length of chromosomes ranged from 26.32 to 10.10 μm in *S clusiana* and from 12.19 to 3.75 μm in *S. colchiciflora*. Arm ratios ranged from 1.13 to 20.85 and from 1.05 to 9.92 in *S. clusiana* and *S. colchiciflora*, respectively. The karyotype formula is made up of two metacentric, two submetacentric, one subtelocentric, and five acrocentric chromosomes in *S. clusiana*, and of two metacentric, one submetacentric, one submetacentric, four subtelocentric, two acrocentric, and one ±submetacentric chromosome in *S. colchiciflora*. Satellites were detected on the short arms of Chromosomes 7 and 9 in *S. colchiciflora* and Chromosome 10 in *S. clusiana*.

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Sternbergia Waldst. and Kit. is mainly a Mediterranean genus and extends to the Caucacus, North Persia and the mountains of Central Asia in the East and to Hungary and Rumania in the North (DAVIS et al. 1984). This genus is cultivated since it has beatiful golden-yellow and white (only in *S. candida*) flowers. Cultivation has contributed to spreading its range in some countries where it is not native.

The genus *Sternbergia* is known by seven species. Two of them are vernal (*S. fischeriana* (Herbert) Rupr. and *S. candida* Mathew and T. Baytop) and five are autumnal (*S. lutea* (L.) Ker-Gawl. ex Sprengel, *S. sicula* Tineo ex Guss., *S. greuteriana* Kamari and Artelari, *S. clusiana* (Ker-Gawl.) Ker-Gawl. and *S. colchiciflora* Waldst. and Kit.). From Greece, KAMARI and ARTELARI (1990) and ARTELARI and KAMARI (1991) have described four species and studied them karyosystematically. They found that both *S. greuteriana* and *S. sicula* are diploid with chromosome number $2n = 22 + 0 - 1$ B, while *S. lutea* has both diploid ($2x = 22$) and triploid ($3x = 33$) numbers. They have reported $2n = 20$ chromosomes in *S. colchiciflora*. In Turkey, on the other hand, this genus had been represented by six species (DAVIS et al. 1984). Four of them, *S. lutea*, *S. sicula*, *S. fischeriana*, and *S. candida*, have previously been investigated, and chromosome numbers, chromosome forms, detailed karyologic measurements, and C-banding distributions were given (YÜZBAŞIOĞLU et al., 1997; ÜNAL in press). While *S. sicula* is diploid with chromosome number 22, *S. lutea* has both diploid (22) and triploid (33) numbers. Both species show great similarity in karyotypic formulae and localization of constitutive heterochromatin, which is centromeric in all chromosomes of *S. lutea* and in most of *S. sicula* (YÜZBAŞIOĞLU et al., 1997). These similarities are coincident with their morphological characteristics as well. Based on these results, *S. sicula* was reconsidered as a subspecies of *S. lutea*, not a distinct species. On the other hand, *S. fischeriana* and *S. candida*, which is endemic to Turkey, were also close to each other in both chromosome numbers, forms, and C-banding distributions. Both species had $2n = 20 + 0 - 1$ B chromosomes. C-bands were found to be predominantly telomeric on 5 of the chromosomes in *S. candida*, and on 6 in *S. fischeriana* (ÜNAL in press). We report here chromosome numbers, forms, and detailed karyotypic measurements in the remaining two species in Turkey, which are similar morphologically.

MATERIALS AND METHODS

The two species studied of *Sternbergia*, *S. clusiana* and *S. colchiciflora*, are presented in Table 1. In *S. clusiana*, leaves are 8–20 mm wide, perianth segments are obovate or oblanceolate, 3.7–7.5 × 0.5–3.3 cm. In *S. colchiciflora*, leaves are 1–4 mm wide, perianth segments are linear or narrowly oblanceolate, 2–5 × 0.1–0.5 cm. Bulbs of these species were collected from wild and potted in the laboratory. Root tips, 3–5 mm in length, were pre-treated in 0.05% colchicine for 3 h and fixed in 3:1 absolute alcohol:acetic acid. Roots were hydrolysed in 1N HCl at 60°C for 12 min and stained in Feulgen. Squashes were made in 45% acetic acid or 1% lactopropionic orcein when they were not stained sufficiently. After removing of coverslips, air-dried slides were mounted in depex. Preparations

Table 1. *Localities and chromosome numbers of Sternbergia populations used for karyologic studies*

Species	Locality	Collector number (year)	Number of bulbs examined	Chromosome number (2n)
S. clusiana	B6 K. Maraş: Göksun, Değirmendere, 1200–1300 m, steppe	M. Ekici 1744 (1995)	20	20
S. colchiciflora	A3 Bolu: Abant Gölü, 1325–1330 m, edges of field	A. Uçar 2427 (1995)	8	20
	C3 Konya: Beyşehir, Kurucaova, 1150 m, clearings of oak	H. Duman 5686 (1994)	10	20

were examined using Prior microscope. Photographs were taken with a Centon DF-300 camera on Agfa ST 8 sound film sat at 12 ASA.

Measurements were based on 2 prometaphase and 3 metaphase plates in *S. clusiana* and 5 metaphases in *S. colchiciflora*. Chromosomes were classified according to the nomenclature of LEVAN et al. (1964). The satellites of nucleolar chromosomes were also measured and considered for the total chromosome

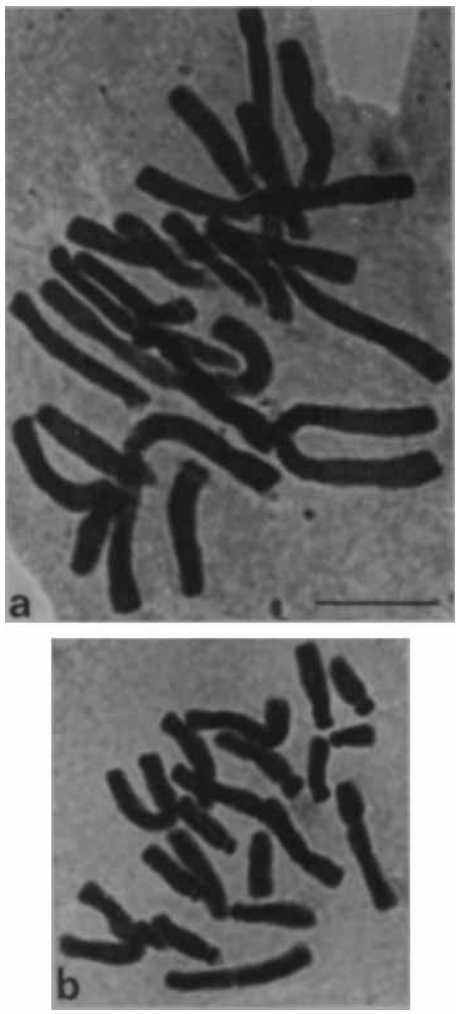


Fig. 1a and b. Somatic chromosomes in *Sternbergia clusiana* (**a**) and *S. colchiciflora* (**b**).—Bar = 10 μm.

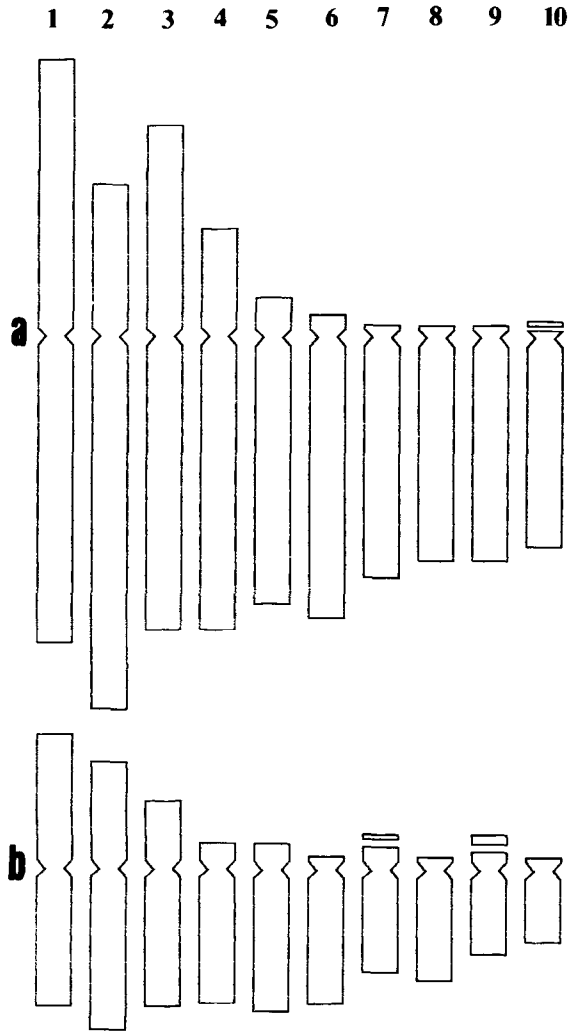


Fig. 2a and b. Idiograms of somatic chromosomes in *Sternbergia clusiana* (**a**) and *S. colchiciflora* (**b**).—Bar = 2 μm.

Table 2. *Measurements (μm) of somatic chromosomes of two species in the genus Sternbergia*

Species	Chromosome pair no.	Chromosome arms		Satellite length	Total length ±SE	Arm ratio (r) (L/S)	Relative length (%)	Chromosome type
		long arm (L)	short arm (S)					
S. clusiana	1	13.95	12.37	–	26.32 ± 0.20	1.13	16.37	m
	2	16.84	6.84	–	23.68 ± 0.23	2.46	14.73	sm
	3	13.16	9.47	–	22.63 ± 0.24	1.39	14.07	m
	4	13.16	4.74	–	17.90 ± 0.15	2.78	11.13	sm
	5	12.11	1.84	–	13.95 ± 0.11	6.58	8.68	st
	6	12.63	1.05	–	13.68 ± 0.13	12.03	8.51	t
	7	11.05	0.53	–	11.58 ± 0.11	20.85	7.20	t
	8	10.00	0.53	–	10.53 ± 0.15	18.87	6.55	t
	9	10.00	0.53	–	10.53 ± 0.14	18.87	6.55	t
	10	9.47	0.40	0.13	10.00 ± 0.14	17.87	6.22	t
	Total				160.80			
S. colchiciflora	1	6.25	5.94	–	12.19 ± 0.78	1.05	15.85	m
	2	7.19	4.38	–	11.57 ± 0.67	1.64	15.04	m
	3	6.25	3.44	–	9.69 ± 0.72	1.82	12.60	sm
	4	6.88	1.25	–	8.13 ± 0.38	5.50	10.57	st
	5	6.88	1.25	–	8.13 ± 0.13	5.50	10.57	st
	6	6.25	0.63	–	6.88 ± 0.48	9.92	8.95	t
	7	4.69	0.94	0.31	5.94 ± 0.24	3.75	7.72	st
	8	5.00	0.63	–	5.63 ± 0.23	7.94	7.32	t
	9	3.75	0.75	0.50	5.00 ± 0.24	3.00	6.50	±sm
	10	3.12	0.63	–	3.75 ± 0.24	4.95	4.88	st
	Total				76.91			

lengths and arm ratios. Karyotypes and idiograms were arranged in order of decreasing lengths.

RESULTS AND DISCUSSION

All the observed somatic cells of *S. clusiana* (Fig. 1a, 2a) and *S. colchiciflora* (Fig. 1b, 2b) have confirmed $2n = 20$ chromosomes (ÖZHATAY 1983), although $2n = 22$ is also published for *S. colchiciflora* (MOORE 1974). This is the first report including both photographic results and detailed measurements of chromosomes.

Total lengths of chromosomes vary between 26.32 and 10.00 μm in *S. clusiana* and between 12.19 and 3.75 μm in *S. colchiciflora* (Table 2). There is twofold variation in total haploid lengths in these two species: 79.91 μm and 160.80 μm in *S. colchiciflora* and *S. clusiana*, respectively. However, relative lengths of chromosomes are similar in both species.

Arm ratios in metacentric and submetacentric chromosomes are ranged from 1.13 to 2.78 in *S. clusiana*, and from 1.05 to 1.82 in *S. colchiciflora*. In the other chromosomes, arm ratios are between 6.58 and 20.85 in *S. clusiana* and between 3.00 and 9.92 in *S. colchiciflora*. In the light of these values, the karyotype formula of *S. clusiana* is two metacentric, two submetacentric, one subtelocentric, and five acrocentric chromosomes. *S. colchiciflora* has two metacentric, one submetacentric, four subtelocentric, two acrocentric, and one ±submetacentric chromosomes. Both species have two pairs of chromosomes which are identical in terms of long and short arm lengths: Chromosomes 4 and 5 in *S. colchiciflora*, Chromosomes 8 and 9 in *S. clusiana*. ÖZHATAY (1983) reported different types of chromosomes from those obtained here. However, they were the same in both species.

In this study, satellites were observed on the short arms of one member of Chromosome 10 in *S. clusiana* and Chromosome 7 in *S. colchiciflora*. In *S. colchiciflora*, in addition, both representatives of Chromosome 9 have satellites on their short arms (Fig. 2). This might result either from variable factors such as time of hydrolysis and techniques of preparations or from varietal differences. However, ÖZHATAY (1983) did not observe satellite in either species. Such differences have been reported in some varieties of *Lens culinaris* (SINHA and ACHARIA 1972) and *Lathyrus* (FOUZDAR and TANDON 1975).

When we compare *S. clusiana* and *S. colchiciflora* and the other three species (*S. lutea*, *S. fischeriana*, *S. candida*) and one subspecies (*S. lutea* ssp. *sicula*) of *Sternbergia*, *S. clusiana* has the biggest total haploid length whereas *S. colchiciflora* has the smallest. Other taxa are between these two. While *S. lutea* ssp. *lutea* resembles *S. lutea* ssp. *sicula* and *S. fischeriana* resem-

bles *S. candida* from a karyological point of view (YÜZBAŞIOĞLU et al. 1997; ÜNAL in press), *S. clusiana* and *S. colchiciflora* are found to be the two taxa that have least similarities karyologically in *Sternbergia* from Turkey.

ACKNOWLEDGEMENTS

The authors thank the Gazi University and the Scientific and Technical Research Council of Turkey (TÜBİTAK) for the financial support under grants No. FEF 05/94-4 and TBAG-AY/43, respectively. They also thank M. Ekici and A. Uçar for providing the materials.

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