

Karyotype Analysis of Five Taxa of *Polygonatum*

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Population karyological analysis of five taxa belonging to three species of *Polygonatum* from Kashmir showed that all the taxa differed in their karyotypic details. The cytotype $2n=28$ of *P. multiflorum* seems to have been evolved from the cytotype $2n=22$ either by fragmentation and fusion of the chromosomes or by the intraspecific hybridization followed by diminution of chromosomes. In *P. verticillatum* the basic set of the karyotype of cytotype $2n=30$ does not tally with that of the karyotype of cytotype $2n=60$. The cytotype $2n=30$ of *P. verticillatum* also shows karyotypic polymorphism. The species seem to be cytologically flexible and have tendency for the establishment of the heterokaryotypic states.

Key Words: *Polygonatum*, Cytotype, Karyotype

Introduction

Polygonatum Mill, belongs to tribe Polygonateae of family Liliaceae. The genus comprises of 50 species which grow in North temperate regions (Airy Shaw 1973), Hooker (1894) reported seven species in the Western Himalayas. Stewart (1972) reported only three species in Kashmir. The present communication describes details of karyotypic analysis of five taxa of the three species from Kashmir.

Materials and Methods

The materials were collected from various places in Kashmir (cf. table 1). The tech-

nique adopted is the same as described earlier (Pandita & Mehra 1981). Photomicrographs were taken at a constant magnification of $\times 1360$. The terminology of Levan et al. (1964) was employed for nomenclaturing the centromeric position. Total form percentage (TF%) was calculated by the formula of Huziwara (1962). The chromosomes were grouped into the following size categories:

F = $10\mu\text{m} - 8.01\mu\text{m}$ G = $8\mu\text{m} - 6.01\mu\text{m}$

H = $6\mu\text{m} - 4.51\mu\text{m}$ I = $4.50\mu\text{m} - 3.01\mu\text{m}$

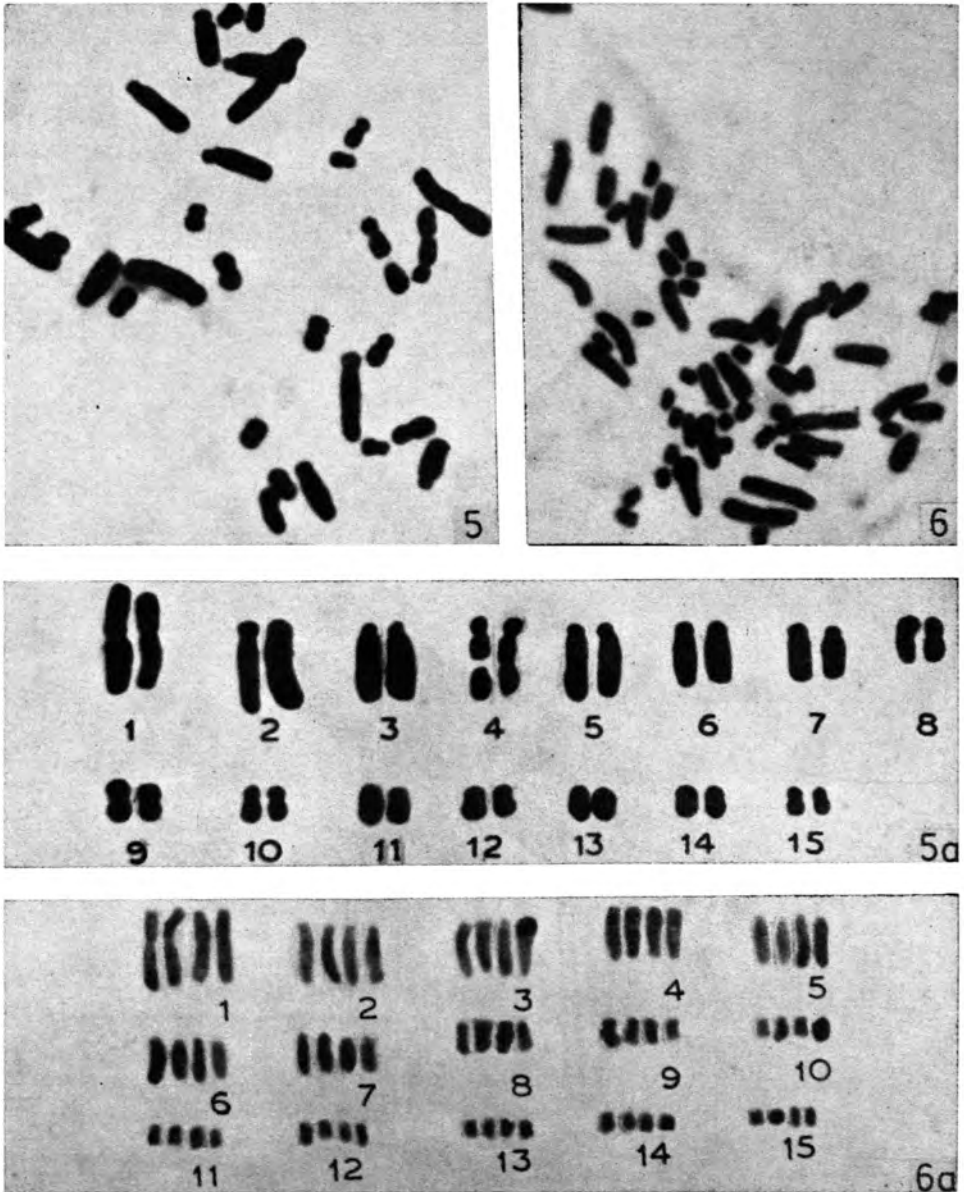
J = $3\mu\text{m} - 2.01\mu\text{m}$ K = $2\mu\text{m} - 1.01\mu\text{m}$

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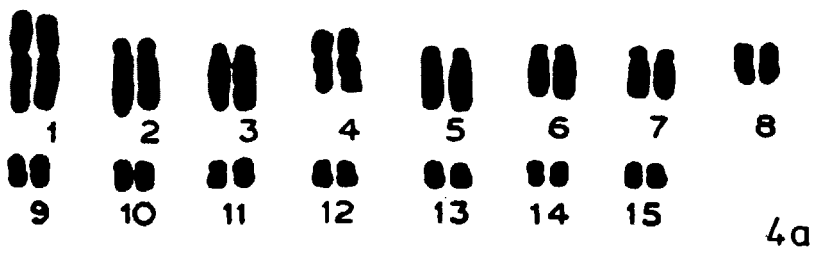
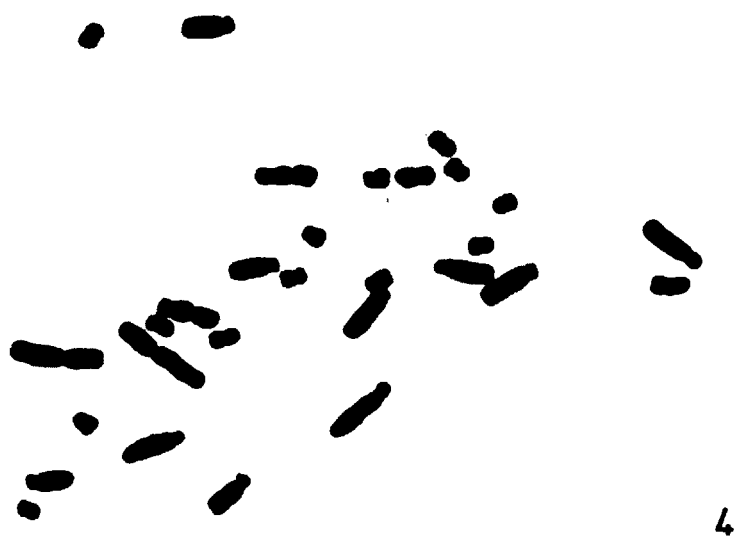
Table 1

Taxon	Collection number	Locality & altitude	Present report number $2n$	Figure number	Previous reports
<i>Polygonatum geminiflorum</i> Decne	T-207	Gulmarg 2700 m	30	1, 1a	$2n=30$: Mehra & Sachdeva 1971, 1976, Mehra & Pandita 1978
<i>P. multiflorum</i> Allioni	T-152	Pulwama Kellar 2400 m	22	2, 2a	$2n=18$: Berg 1933, Tischler 1934, Polya 1950, Therman 1953a, Gadella & Khiphuis 1963, 1966, Zhukova 1967, Abramova 1970, Mojovsky 1970, Lovka et al. 1971, Skalinska et al. 1971
	T-164	Jawahar Lal Tunnel 2700 m	22		
T-192	Pahalgam 2800 m	22			$n=10$: Sorsa 1963b $n=11$, $2n=22$: Mehra & Pathania 1960, Koul & Gohil 1973, Mehra & Sachdeva 1976, Mehra & Pandita 1978
T-196	Kangan 2300 m	22			$2n=24$: Bonicke 1911 $2n=18$, 24: Eigsti 1942
T-199	Gulmarg 2800 m	22			$2n=18$, 20, 28: Suomalainen 1947 $2n=28$: Abramova 1970
T-242	Ahrabal 2500 m	28		3, 3a	$2n=30$: Nowakowska & Zegllicka 1972 $2n=18$, 30: Dark 1939
T-244	Zojilla 3000 m	28			
<i>P. verticillatum</i> Allioni	T-61	Gulmarg 2800 m	30	4, 4a	$2n=24$: Mattick (in Tischler 1950) $2n=27$, 28: Berg 1933
	T-62	Neelpanch 2700 m	30		$n=14$: Polatschek 1966, Laane 1971 $2n=28$: Tischler 1934, Sokolovskaya & Stralkova 1948, Majovsky et al. 1970, Lovka et al. 1971, Skalinska & Pogan 1971, Sulek 1977
T-111	Sonamarg 2900 m	30			
T-155	Zojilla 3350 m	30		5, 5a	$2n=28$, 30, 60: Mehra & Sachdeva 1976 $2n=28$, 60, 86-91: Therman 1953 $2n=30$: Koul & Gohil 1973, Mehra & Pandita 1978
T-231	Ahrabal 2700 m	30			$2n=60$: Sachdeva & Malik 1977, Mehra & Pandita 1979
T-240	Ahrabal 2750 m	60		6, 6a	$2n=30$, 64: Kumar 1959 $2n=30$, 84: Dark (cf. Maude 1939) $2n=66$: Mehra & Pathania 1960 $2n=C90$: Suomalainen 1947

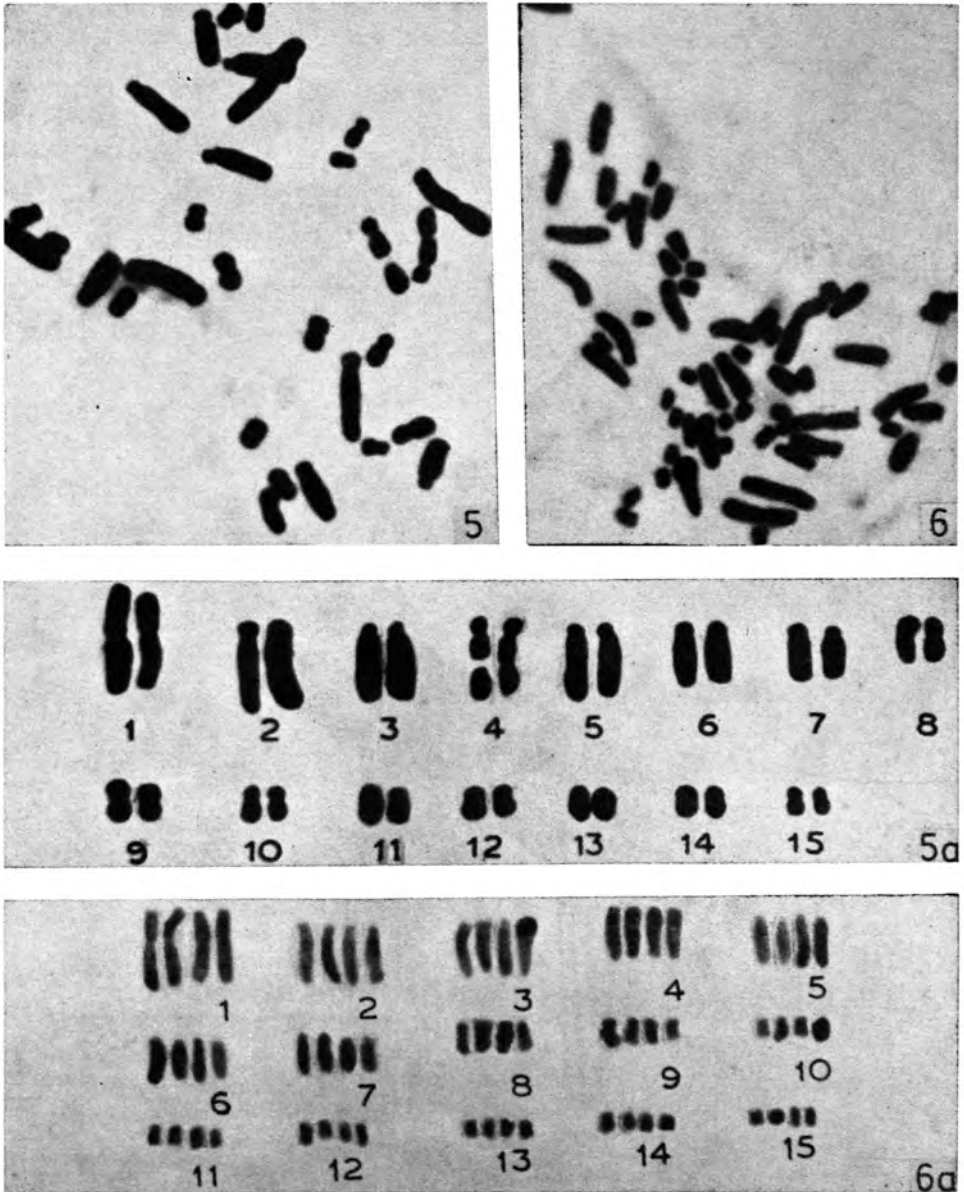
cf. Darlington and Wylie (1955); Fedorov (1969); Moore (1973); Love & Love (In IOBP Chromosome number reports up to 1981, and some other references cited in bibliography)



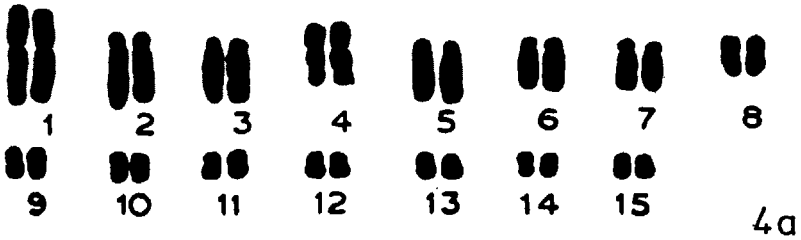
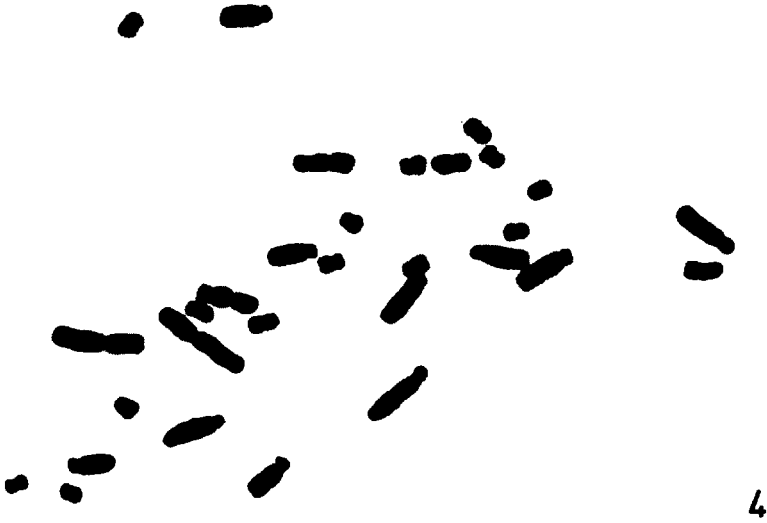
Figures 5-6a. *P. verticillatum*. 5, $2n=30$ (Zojila population); 5a, Karyogram of Fig. 5; 6, Root tip cell showing $2n=60$; 6a, Karyogram of Fig. 6



Figures 3a-4a. 3a, Karyogram of Fig. 3, 4-4a. *P. verticillatum*; 4, Cytotype 2n=30 (Ahrabal population); 4a, Karyogram of Fig. 4



Figures 5-6a. *P. verticillatum*. 5, $2n=30$ (Zojila population); 5a, Karyogram of Fig. 5; 6, Root tip cell showing $2n=60$; 6a, Karyogram of Fig. 6



Figures 3a-4a. 3a, Karyogram of Fig. 3, 4-4a. *P. verticillatum*; 4, Cytotype $2n=30$ (Ahrabal population); 4a, Karyogram of Fig. 4

Table 1 lists the species, their areas of collection, altitudes, figure numbers and cytological information.

Observations

P. geminiflorum Decne: The plant grows in Kashmir hills at an altitude of about 2700 m. Root-tip cells revealed $2n=30$ (figure 1). Karyotype consists of $4M + 14m + 12st$ chromosomes which fall into five size categories F, G, H, I and J. They could be arranged into 15 pairs (figure 1a). Chromosome size ranges from $8.74\mu m$ to $2.13\mu m$. Total chromatin length is $130.44\mu m$ and $TF\%$ is 31.22. Detailed karyotypic formula is: $2F^m + 6G^{st} + 6H^{st} + 2I^m + 4J^m + 2J^m + 8J^m$.

P. multiflorum All.: The species is widespread in Kashmir hills at an altitude of 2300–3000m. The present study revealed two cytotypes with $2n=22$ and 28.

The cytotype $2n=22$ (figure 2) consists of $2m + 18sm + 2st$ chromosomes which fall into four size categories F, G, H and I. They could be arranged into 11 pairs (figure 2a). Chromosome size ranges from $8.23\mu m$ to $3.08\mu m$. Total chromatin length is $129.5\mu m$ and $TF\%$ is 29.09. Detailed karyotypic formula is $4F^{sm} + 2F^{st} + 4G^{sm} + 2H^m + 2H^{sm} + 8I^{sm}$.

The cytotype with $2n=28$ (figure 3) consists of $2M + 4m + 10sm + 12st$ chromosomes which fall into four size categories G, H, I and J. Twenty-eight chromosomes could be arranged into 14 pairs (figure 3a). Chromosome size ranges from $6.39\mu m$ to $2.06\mu m$. Total chromatin length is $116.17\mu m$ and $TF\%$ is 29.62. Detailed karyotypic formula is $2G^{st} + 6H^{st} + 2H^{em} + 2I^{sm} + 4I^{st} + 6I^{sm} + 2J^m + 4J^m$.

The two cytotypes showed differences in their habitat and some morphological features as depicted in table 2 and figure 7.

Table 2 Analysis of various characters of two cytotypes of *P. multiflorum*

Characters	$2n=22$	$2n=28$
Habitat	Moist shaded places	Exposed forest on slopes
Plant height	35–55 cm	15–30 cm
Leaf :		
Length	6–9 cm	3–5 cm
Breadth	3–5 cm	1–1.7 cm
Stomatal size	$37 \times 36 \mu m$	$32 \times 31 \mu m$

P. verticillatum All.: The species is distributed in Kashmir hills at an altitude of 2000–3000 m. It exists in two cytotypes $2n=30$ (figures 4, 5) and $2n=60$ (figure 6). The latter was collected only from Ahrabal. The taxon $2n=30$ shows flexibility in the karyotype.

Populations of Ahrabal and Gulmarg area have the karyotype consisting of $4M + 16m + 10st$ chromosomes (figure 4), which fall into five size categories F, G, H, I and J and could be arranged into 15 pairs (figure 4a). Fourth pair of the karyogram is secondarily constricted. Chromosome size ranges from $9.55\mu m$ to $2.77\mu m$. Total chromatin length is $128.35\mu m$ and $TF\%$ is 31.18. Detailed karyotypic formula is: $2F^m + 4G^{st} + 2H^m + 6H^{st} + 2I^m + 4J^m + 10J^m$.

Karyotype of Zojila and Sonamarg populations consists of $4M + 14m + 12st$ chromosomes, which fall into five size categories F, G, H, I and J and could be arranged into 15 pairs (figures 5, 5a). Fourth pair of karyogram carries (figure 5a) a secondary constriction. Chromosome size ranges from $9.77\mu m$ to $2.35\mu m$. Total chromatin length is $153.23\mu m$ and $TF\%$ is 28.50. Detailed karyotypic formula is: $2F^m + 2F^{st} + 8G^{st} + 2H^{st} + 4I^m + 2I^m + 10J^m$.

Taxon with $2n=60$ (figure 6) has karyotype consisting of $16M+12m+16sm+16st$ chromosomes, which fall into five size categories G, H, I, J and K, and arranged into fifteen groups, each group of four chromosomes (figure 6a). Chromosome size ranges from $7.35\mu m$ to $1.02\mu m$. Total chromatin length is $196.77\mu m$ and TF% is 30.04. Detailed karyotypic formula is: $4G^m+4H^{sm}+4H^{st}+4H^m+4I^m+12I^{st}+8J^{sm}+16K^m+4K^{sm}$. Meiosis in this taxon exhibits abnormalities.

The morphological differences in the two cytotypes are pronounced as observed in table 3 and figure 8.

Table 3 Analysis of various characters of two cytotypes of *P. verticillatum*

Characters	$2n=30$	$2n=60$
Habitat	Shaded forest where soil is rich in humus	Shaded forest slopes
Plant height	35-50 cm	52-70 cm
Leaf :		
Shape	Lanceolate & acuminate	Linear & acuminate
Length	6-10 cm	9-12 cm
Breadth	0.6-1.0 cm	1.2-1.6 cm
Stomatal size	$30 \times 26 \mu m$	$35 \times 30 \mu m$
Peduncle	Whorled, 2-3 fid	Whorled, always 2 fid
Pollen size	$35 \times 30 \mu m$	$41 \times 36 \mu m$

Discussion

Five taxa belonging to three species of *Polygonatum* have been karyotypically worked out. The number $2n=30$ for *P. geminiflorum* as well as its karyotype is in agreement with the findings of Mehra and Sachdeva (1976).

Two cytotypes were found with $2n=22$, 28 in *P. multiflorum*. The size of the chromosomes in the two cytotypes differs. Those in the taxon with $2n=22$ are large-

sized. In the other taxon there is addition of 3 small chromosome pairs. This number may have been evolved through intraspecific hybridization, followed by diminution in size or through fragmentation and fusion of the chromosomes of cytotype $2n=22$, since the total chromatin length is higher in cytotype $2n=22$ than the cytotype $2n=28$. Total form percentage is almost the same in both. Detailed karyotypic studies in cytotype $2n=22$ are at variance with those of Mehra and Pathania (1960), who reported two pairs of large chromosomes with secondary constriction, while Mehra and Sachdeva (1976) observed one secondary constriction only in one of the chromosomes constituting a large pair. No secondary constriction was observed in any of the two taxa studied from Kashmir.

The two cytotypes in *P. verticillatum* ($2n=30$ and 60) have been found to occur sympatrically at some places in the hills of Kashmir. The karyotypes of different populations of the cytotype $2n=30$ show slight variation in their karyotypic details. Secondary constriction in the chromosomes of a pair is common to both. However, difference in size of chromosomes was marked.

The cytotype $2n=60$ appears to be an autotetraploid because of karyotypic picture, where four similar chromosomes fall in a group. There is also a general reduction in the size of chromosomes.

A morphological comparison of the presently worked out cytotypes revealed that there is increase in the plant height, length of internodes, leaf and stomatal size in *P. verticillatum* with increase in chromosomal number from $2n=30$ to $2n=60$ (figure 8). But reverse is the case in *P. multiflorum* where the cytotype with $2n=22$ is bigger than the one with $2n=28$ (figure 7). The general morphology of the flower remains unaffected.

All the five taxa differ in their karyotypic details. The genus is reported to have markedly different chromosome numbers which is also supported by the present investigation (cf. table 1). The karyotypes too are characterised by marked variation in chromosome size. It, thus, appears that during the evolution of different species and geographical races, considerable alterations have

occurred both in the number and structure of chromosomes. A general tendency of the species is the establishment of the heterokaryotypic states.

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