A Cytotaxonomic Study of the West Himalayan Polygonateae

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Received July 27, 1959

Introduction

As at present constituted the Liliaceous tribe Polygonateae includes nine genera—Krause (1930) and Hutchinson (1934). Of these three namely *Polygonatum* Miller, *Disporum* Salisb., ex D. Don, and *Smilacina* Desf. are commonly met with in the Western Himalayas at altitudes ranging from 2,000–3,000 metres. The Western Himalayas are taken as representing all the area east of Kashmir uptil the western borders of the Kingdom of Nepal.

In recent years noteworthy cytotaxonomical contributions on the Polygonateae have appeared in Japan by Hasegawa (1932, 1933), Matsuura and Suto (1935) and Sato (1942); in Europe by Suomalinen (1947), Therman (1950, 1953a, 1953b, 1956); and in the United States by Eigsti (1942), Ownbey (1944) and Jones (1951). In India except for the taxonomic studies on the flora of the Himalayas made by the pioneers of the nineteenth century—Royle (1839), Hooker (1894) Collett (1921)—the tribe Polygonateae has remained neglected taxonomically and untouched cytologically.

In the present study cytology of the members of the three genera occurring in the Western Himalayas has been worked out. In subsequent publications it is hoped to bring out the cytotaxonomy of members of the Polygonateae from Darjeeling and Sikkim areas which represent the eastern wing of the Himalayas.

Polygonatum Miller: The previous work on the genus *Polygonatum* has been that of Baker (1875) who while revising the sub-family Asparagaceae (of the Liliaceae) placed *Polygonatum* in the tribe Convallarieae of this sub-family and ascribed twenty three species to it. From this the number was increased to forty five by Hua (1892) from the extensive collections that he made in S. W. China and in the province of Yun-nan. Now about one hundred and ten species are listed in the Index Kewensis (1895) and its Supplements (1886–1950).

Baker (1875) divides the genus *Polygonatum* on the basis of leaf arrangement into three sections viz. i) *Alternifolia*, ii) *Oppositifolia*, iii) *Verticillata*. In all thirteen species are reported from the Himalayas. Of the three occurring in the Western Himalayas, one i. e. *Polygonatum multiflorum* All. belongs to the section *Alternifolia* and the other two i. e. *Polygonatum verticillatum* All. and *Polygonatum sibiricum* Red. (= *P. cirrhifolium* Royle)

belong to the section *Verticillata*, there being no *W.* Himalayan species belonging to the section *Oppositifolia*.

Disporum Salisb. ex D. Don: In the genus *Disporum* thirty two species have been recorded in the Index Kewensis (1895) and its Supplements (1886-1950). Recently Jones (1951) has split the genus on the basis of vegetative and floral characters into two sections, i) *Eudisporum* and ii) *Prosartes*. The North American species find their place in the section *Prosartes* whereas the Asian species belong to the section *Eudisporum*. Of the three species of *Disporum* occurring in the Himalayas only one i. e. *Disporum cantoniense* (Lour.) Merr. (= *D. pullum* Salisb.)¹ occurs in its western range.

Smilacina Desf. (= *Tovaria* Neck. non Ruiz et Pavon): In all forty two species have been recorded for *Smilacina* in the Index Kewensis (1895) and its Supplements (1886-1950).

Baker (1875) divides the genus *Smilacina* on the basis of the inflorescence into two sections, i) *Racemosa* and ii) *Paniculata*. Four species of *Smilacina* are reported from the Himalayas. The one species occurring in the *W.* Himalayas viz. *Smilacina purpurea* Wall. (= *S. pallida* Royle) belongs to the section *Racemosa*.

Material and methods

Collections were made from the following three areas: 1) Dalhousie, 2) Simla, 3) Mussoorie. Dalhousie is extreme west and Mussoorie extreme east of the collection area, whereas Simla is midway between these two stations. The distance between Dalhousie and Mussoorie is about four hundred kilometres. The specific localities are given in Table 1 in each case.

Table 1.

Genus and species	Collection area	Specific locality	Height of locality in metres.
<i>Polygonatum multiflorum</i>	Dalhousie	i) Dan Kund	2,500-3,000
		ii) Kala Top	
	Simla	i) Narkanda	3,000-3,500
		ii) Huttoo	
<i>P. verticillatum</i>	Dalhousie	i) Dan Kund	2,500-3,000
		ii) Kala Top	
<i>P. sibiricum</i>	Mussoorie	i) Gun Hill	2,000
		ii) Savoy Hotel	
<i>Disporum cantoniense</i>	Mussoorie	i) Below Woodstock School	2,000
<i>Smilacina purpurea</i>	Simla	i) Narkanda, Huttoo	3,000-3,500

The flower buds were fixed in all cases in Carnoy's fixative (100 parts absolute alcohol, 50 parts chloroform, and 16 parts glacial acetic acid). The

¹ *D. pullum* Salisb. and *D. cantoniense* (Lour.) Merr. have been cited as synonyms by Merrill (1919). Since *D. pullum* was a nomen nudum the valid name to be used is *D. cantoniense* according to the International Code of Botanical Nomenclature.

rhizomes of those species whose somatic number could not be worked out at the localities where they grew, were carefully packed in moss, brought down to Amritsar and sown in pots for root tips. The somatic number in all cases was worked out by the oxyquinoline technique of Tjio and Levan (1950), the root tips being treated with 0.003 M. solution of 8-hydroxyquinoline for four hours and then squashed in acetic orcein or acetic lacmoid, both of which gave excellent results. Due to heat in the plains none of the Polygonateae flowered at Amritsar; all the meiotic material, therefore, had to be brought from the mountains and as a consequence the flower buds were preserved in the fixative from about a fortnight to a month before smearing. Neither orcein nor lacmoid gave satisfactory staining with pollen mother cells thus preserved and so aceto-carmin was used which gave fairly good results.

The idiograms were drawn on graph paper ruled in 1 mm. squares as recommended by Battaglia (1955a) and then traced on to white paper. The primary constriction in all cases was represented by 2 mm. gap and the secondary constrictions by 1 mm. gap. In determining chromosome morphology the terminology of Battaglia (1955b) is employed i. e. a median centromere giving an arm ratio in the chromosome of 1:1, a submedian centromere giving an arm ratio of more than 1:1 but less than 1:3, a subterminal centromere giving an arm ratio of 1:3 or more and terminal centromere giving an arm ratio of 0:1. In describing the chromosomes, however, the simpler terms median chromosome, submedian chromosome, subterminal chromosome and terminal chromosome are given preference over the cumbersome isobrachial, heterobrachial, hyperheterobrachial and monobrachial chromosomes mentioned by the same author. In discussing the symmetry of the karyotype the terms symmetrical and asymmetrical are used as defined by Stebbins (1950).

The photographs are at different magnifications for the three genera the idea being to display the chromosomes of each preparation to the best advantage. This disparity in magnifications has been compensated for in the explanatory diagrams which have been drawn to a uniform scale. They were drawn by projecting the negatives from an enlarger and varying the latter's height to get the same magnification on the easel.

For taking the photographs Kodak process panchromatic glass plates P. 200 were used in conjunction with a Wratten G filter No. 15. In making the prints 'Agfa Brilliant' paper developed in 'Rodinal' 1:20 gave excellent results.

Observations

Polygonatum Miller

Polygonatum multiflorum All. The chromosome number of this species was determined from root tip mitoses, pollen mitoses and from pollen mother

Fig. 1. *Polygonatum multiflorum*, root tip mitosis showing $2n=22$. Chromosomes with secondary constrictions are shown clear.

cells.

The somatic number as determined from root tips is $2n=22$. The karyotype is of the symmetrical type (Fig. 1; Fig. 11) with five pairs of long (A-E) and six pairs short (F-K) chromosomes. The size range of the chromosomes is from $8\frac{1}{2}\mu$ to 3μ (Fig. 6).

Of the five pairs of long chromosomes three pairs (A, B and C) possess submedian primary constriction and two pairs (D and E) have subterminal primary constriction. One pair of long chromosomes with submedian primary constriction (C) has a secondary constriction in the short arm situated submedianly cutting off a large distal segment. Another pair of long chromosomes with a subterminal primary constriction (E) has a secondary constriction situated submedianly in the long arm cutting off a large distal segment. The remaining six pairs of short chromosomes all possess submedian primary constriction and none of

them has any secondary constriction.

The meiosis of this species is perfectly normal showing eleven bivalents

Fig. 2. *Polygonatum verticillatum*, root tip mitosis showing $2n=66$. The 3 very long submedian chromosomes are cross hatched. The 2 long submedian chromosomes are shown clear. The 11 long subterminal chromosomes are close stippled; the 6 medium-sized submedian chromosomes are loose stippled; the 11 medium sized subterminal chromosomes are hatched and the 33 short chromosomes are shown black.

at metaphase-I (Fig. 12).

The number $2n=22$ and $n=11$ for *P. multiflorum* is a new report.

The European material of *P. multiflorum* investigated by Therman (1953, 1953a) has $2n=18$ chromosomes and the idiogram has been drawn by the author. It consists of six pairs of long and three pairs of short chromosomes. One pair of long chromosomes with a submedian primary constriction and one pair of long chromosomes with a subterminal primary constriction (chromosomes F and B of her Fig. 1, p. 279) have a secondary constriction each.

It is obvious that the karyotype of this material resembles that of Himalayan *P. multiflorum* in that one pair of long chromosomes with submedian primary constriction and one pair of long chromosomes with subterminal primary constriction have each a secondary constriction and thus is related to the 'Latifolium type' of the section *Alternifolia* according to Therman's (1953a) classification. However, the Himalayan *P. multiflorum* has five

pairs of long and six pairs of short chromosomes while the European *P. multiflorum* has in contrast six pairs of long and three pairs of short chromosomes. The longest chromosome in the complement of European *P. multiflorum* is $10\frac{1}{2}\mu$, the longest in the Himalayan *P. multiflorum* is $8\frac{1}{2}\mu$. The shortest chromosomes in both the Himalayan and European *P. multiflorum*s are of about the same size i. e. $3\frac{1}{2}\mu$.

The other numbers recorded for the species are $2n=20, 24, 28$, and 30 (vide Darlington and Wylie 1955). Obviously considerable alterations have occurred both in the number and structure of chromosomes in the evolution of different geographical races and the species has become hetero-karyotypic.

Polygonatum verticillatum All. The chromosome number of this species was studied from the root tip mitoses and pollen mother cells. The somatic number from root tip is $2n=66$ (Fig. 13). The karyotype is of the sym-

Fig. 3. *Polygonatum sibiricum*, root tip mitosis showing $2n=36$. Chromosomes with secondary constriction are shown clear.

metrical type with a gradual transition from the very long to the very short chromosomes (Fig. 2 and Fig. 13). The size range of the chromosomes is from $9\frac{1}{2}\mu$ to $1\frac{3}{4}\mu$ (Fig. 7). The karyotype shows three very long chromo-

Fig. 4. *Disporum cantoniense*, root tip mitosis showing $2n=16$. The SAT chromosome pair is shown clear.

median primary constriction and eleven (close stippled) have subterminal primary constriction. The seventeen medium sized chromosomes consist of six (loose stippled) with submedian primary constriction and eleven (hatched) with subterminal primary constriction. The thirty three short chromosomes are with submedian primary constriction.

One pair of long chromosomes with subterminal primary constriction (close stippled) has a secondary constriction situated subterminally in the long arm cutting off a small interstitial segment; the pair of long chromosomes with submedian primary constriction (clear) has a secondary constriction in the long arm situated submedianly cutting off a distal segment,

somes (cross hatched in Fig. 2) thirteen long chromosomes (closely stippled and clear in Fig. 2) seventeen medium-sized chromosomes (hatched and loosely stippled in Fig. 2) and thirty three short chromosomes (black in Fig. 2).

The three very long chromosomes (cross hatched) are with submedian primary constriction. Of the thirteen long chromosomes, two (clear) are with sub-

Fig. 5. *Smilacina purpurea*, pollen mitosis showing $n=18$. The SAT chromosome is drawn clear.

Figs. 6-10. 6, idiogram of *Polygonatum multiflorum*, $2n=22$. 7, idiogram of *Polygonatum verticillatum*, $2n=66$. This has been drawn taking the average lengths of the six categories of chromosomes. 8, idiogram of *Polygonatum sibiricum*, $2n=36$. 9, idiogram of *Disporum cantoniense*, $2n=16$. 10, idiogram of *Smilacina purpurea*, $2n=36$.

while one pair of medium sized chromosomes with subterminal primary constriction (hatched) has a secondary constriction situated submedianly in the long arm cutting off an interstitial segment. Thus there are three pairs of chromosomes with a secondary constriction. The idiogram (Fig. 7) has been drawn taking the average lengths of the six categories of chromosomes i. e. i) the three very long submedian, ii) the two long submedian, iii) eleven long subterminal, iv) six medium-sized submedian, v) eleven medium-sized subterminal and vi) the thirty three short. All the chromosomes with secondary constriction have been drawn in this idiogram.

The pollen mother cells of this clone had a highly irregular meiosis showing chromatin bridges, univalents, and multivalents. A common type of metaphase shows $1_v + 1_{iv} + 1_{III} + 17_{II} + 19_I + 2/2 = 66$ (Fig. 14). Some of the bivalents were loosely associated while others were secondarily associated.

The chromosome number $2n=66$ for *P. verticillatum* is again a new report not having been recorded so far in any species of *Polygonatum*. The number so far reported for *P. verticillatum* are $2n=27, 28, 30, 60, 84, 86$ -

Figs. 11-13. Photomicrographs. 11, *Polygonatum multiflorum*, $2n=22$. $\times 2600$. 12, *Polygonatum multiflorum*, $n=11$. $\times 1800$. 13, *Polygonatum verticillatum*, $2n=66$. $\times 1800$.

91 (vide Darlington and Wylie, 1955).

Polygonatum sibiricum Red. (= *P. cirrhifolium* Royle). The chromosome number of this species was determined from root tip and pollen mitoses and from pollen mother cells. The root tip mitoses showed $2n=36$ chromosomes (Fig. 15). The karyotype is of the asymmetrical type (Fig. 3 and Fig. 15) with eight pairs of long (A-H) and ten pairs of short (I-R) chromosomes. The size range of the chromosomes is from $6\frac{1}{2}$ – 2μ (Fig. 8). The karyotype is asymmetrical not only in the size difference between the long and short chromosomes but even in chromosome morphology. All the eight pairs of long chromosomes have subterminal primary constriction. One pair of long chromosomes (E) has a secondary constriction situated submedianly in the short arm cutting off a small distal segment, while one pair of long chromosomes (H) has a secondary constriction situated submedianly in the long arm cutting off a short distal segment. Of the ten pairs of short chromosomes, seven pairs (I, J, K, N, O, P, Q) are with median primary constriction and three pairs (L, M, and R) have submedian primary constriction.

Meiosis is perfectly normal showing eighteen bivalents, there being a clear cut size difference between the eight large and the ten small bivalents (Fig. 16).

The chromosome number $2n=36$ and $n=18$ is a new record for *P. sibiricum*, the numbers so far reported being $2n=20, 21$ and 26 (vide Darlington and Wylie, 1955).

Disporum Salisb. ex D. Don

Disporum cantoniense (Lour.) Merr. (= *D. pullum* Salisb.) The chromosome number of this species was determined only from root tips. No flower buds could be had as the plant was collected rather late in the season. The somatic number is $2n=16$ (Fig. 18). The karyotype is of the symmetrical type with eight long and eight medium sized chromosomes (Fig. 4, and Fig. 18). The size range of the chromosomes is from $15\frac{1}{2}$ – 6μ (Fig. 9).

From among the eight chromosomes three pairs (A, B and C in Fig. 4 and Fig. 9) are with submedian primary constriction and one pair (D) is with a subterminal primary constriction. This pair has also a secondary constriction situated subterminally in the short arm cutting off a microsatellite at the distal end and is thus a SAT pair. Of the eight medium sized chromosomes two pairs (F and H) are with submedian primary constriction and the other two pairs (E and G) are with subterminal primary constriction.

Hasegawa (1932) in the Japanese form of *Disporum cantoniense* also reports $2n=16$, with four pairs of long and four pairs of medium sized chromosomes. In so far as the medium sized chromosomes are concerned their morphology is identical in the Japanese and the Himalayan forms. But there are two noteworthy differences in the set of long chromosomes. Whereas in the Japanese form there are two pairs of submedian and two pairs subterminal chromosomes, in the Himalayan form there are three pairs of submedian and one pair of subterminal chromosomes. Moreover, in the

Figs. 14, 15. 14, photomicrograph of meiotic behaviour at metaphase I of *Polygonatum verticillatum*. All critical associations have been labelled. $\times 1140$. 15, photomicrograph of somatic chromosomes $2n=36$ of *Polygonatum sibiricum*. One short chromosome indicated by an arrow is lodged at one end of the long chromosome. $\times 2100$.

Japanese form Hasegawa (1932) reports that the two pairs of subterminal chromosomes are SAT chromosomes, while in the Himalayan taxon there is only one pair of SAT chromosomes and that pair is with a subterminal primary constriction.

Smilacina Destf.

Smilacina purpurea Wall. (= *S. pallida* Royle). The chromosome number of this species could only be determined from pollen mitoses. The haploid complement consists of eighteen chromosomes (Figs. 5, 17). The karyotype is of the symmetrical type (Fig. 5 and Fig. 17) with ten long (A-J) and eight comparatively shorter (K-R) chromosomes. The size range of the chromosomes is from $12-4\mu$ (Fig. 10).

One long chromosome (I) has a secondary constriction situated

submedianly in the short arm cutting off a large distal satellite.

The chromosome number $n=18$ for *S. purpurea* is reported for the first time and tallies with the number reported for other species of the genus: *S. amplexicaulis* $2n=36$ (Rettenbury, 1948); *S. japonica* $2n=36$ (Tahara,

Figs. 16-18. 16, photomicrograph of meiosis of *Polygonatum sibiricum* showing 18 bivalents at diakinesis. Note the marked size difference between the 10 small and 8 large bivalents. $\times 1600$. 17, photomicrograph of pollen mitosis of *Smilacina purpurea* showing $n=18$. $\times 1900$. 18, photomicrograph of somatic chromosomes $2n=16$ of *Disporum cantoniense*. $\times 1850$.

1933); *S. sessilifolia* $2n=36$ (Cave 1948); *S. stellata* $2n=36$ (Stenar 1935); *S. racemosa* $2n=36$ (Therman 1956).

Discussion

Polygonatum. It is thus seen that the three W. Himalayan species of *Polygonatum* have chromosome numbers that are not only new reports for the species concerned but are also new records for the genus. So far as the chromosome number $2n=22$ and $n=11$ for *P. multiflorum* is concerned the only other report of such a number was for *P. hondoense* in which Matsuura (1935) and Matsuura and Suto (1935) reported the haploid complement to consist of eleven chromosomes. Since the commonest chromosome number for *Polygonatum* is $2n=20$ and the same is met with in all the Japanese *Polygonatums* investigated, the number $n=11$ for *P. hondoense* remained uncorroborated and was regarded as doubtful, which perhaps led Darlington and Wylie (1955) to put a mark of interrogation against it in their "Chromosome Atlas of Flowering Plants", and Delay (1950-51) in her "Nombres Chromosomiques Chez les Phanerogames" makes no mention at all of *P. hondoense*. With the present report of $2n=22$ and $n=11$ for *P. multiflorum*, the possibility of *P. hondoense* having $n=11$ as reported by Matsuura (1935) and Matsuura and Suto (1935) is placed on firmer footing and not only that but a new secondary base number $x=11$ for *Polygonatum* is established.

Therman (1953a) crossed *P. officinale* ($2n=20$) with *P. multiflorum* ($2n=18$). In the meiosis of the hybrid she found eight bivalents while the remaining three chromosomes formed a group of three. She explained this behaviour by assuming that eight *P. officinale* chromosomes are homologous or homeologous with eight *P. multiflorum* chromosomes and the remaining group of three chromosomes are formed by the pairing of the two chromosomes of the former with a single one of the latter at the homologous regions. She believes that the number nine has arisen by "an unequal interchange between two chromosomes in a ten chromosomal set and a loss of the smaller of the resulting chromosomes". It would be most interesting to cross the Himalayan *P. multiflorum* $2n=22$ on the one hand with *P. officinale*, and on the other with the European *P. multiflorum* $2n=18$, to see the relationships between the genomes of the three taxa.

The karyotype of *P. verticillatum* $2n=66$ is highly suggestive of a polyploid origin of this clone. A study of meiosis reveals pentavalents, quadrivalents, trivalents, bivalents, and univalents and appears to be an autoallopolyploid. In *P. verticillatum* with $2n=66$ if we ignore the size difference for a moment and concern ourselves only with chromosome morphology, we find that there are eleven chromosomes with submedian primary constriction, twenty two chromosomes with subterminal primary constriction and thirty three small chromosomes with submedian primary constriction. This suggests that the base number for this clone may well be eleven. In the European

forms of *P. verticillatum* the commonest number that has been observed by Therman (1953a, 1953b) is $2n=28$.

P. verticillatum and *P. sibiricum* are the two species of *Polygonatum* from the W. Himalayas belonging to the section Verticillata. The karyotype of *P. sibiricum* is highly asymmetrical as compared to that of *P. verticillatum*. Stebbins (1950) has pointed out that, "speaking generally, the statement can be made that plants with asymmetrical karyotypes are usually specialised morphologically, sometimes in vegetative parts, sometimes in flowers or fruits, and sometimes in both" (pp. 461-462). *P. sibiricum* does not show any significant specialization in the flowers or fruits as compared with *P. verticillatum*. But in the vegetative parts *P. sibiricum* is certainly more specialized than *P. verticillatum*. The leaves of *P. sibiricum* have slender revolute sensitive tips by which it coils round the adjoining plants and thus covers a wider area. Not only is the karyotype of *P. sibiricum* more asymmetric than that of *P. verticillatum* but there is a marked difference in the absolute size of their chromosomes as well. The longest chromosome in *P. sibiricum* is $6\frac{1}{2}\mu$ whereas that of *P. verticillatum* is $9\frac{1}{2}\mu$. Delaunay (1926, vide Stebbins 1950 p. 466) in the genus *Muscari* of the Liliaceae found that species which show greater morphological specialization have a smaller absolute chromosome size than the related primitive species. This appears to be true for *P. sibiricum* as well, vis-a-vis *P. verticillatum*.

The two species, *P. multiflorum* and *P. verticillatum*, in view of the diversity of chromosome numbers in their different taxa (euploid and aneuploid) as well as in the morphology of karyotype, seem to be in an active state of karyological evolution. This seems to be true to a certain extent also of *P. sibiricum* and other species of *Polygonatum* previously investigated by other workers. To what extent this intraspecific karyological evolution is associated with morphological differentiation or reproductive isolation would indeed be an interesting aspect of study in the field of incipient speciation.

Disporum. The one species of *Disporum* occurring in the W. Himalayas viz. *D. cantoniense* agrees in the chromosome number with its counterpart in Japan. In chromosome morphology however there is a considerable difference between the two taxa. It is obvious that the two geographical forms of *D. cantoniense* are evolving at the diploid level by a repatterning of the chromosomes more or less on the same lines as in the various populations of the four species of the genus *Holocarpha* reported by Clausen (1951). Whether or not Himalayan and Japanese forms of *D. cantoniense* have developed intraspecific crossability barriers also as in the species of *Holocarpha* is not known, since to date no attempts have been made to cross the two forms.

Jones (1951) from his comprehensive study of the genus *Disporum* divides it into two sections, 1) *Eudisporum* and 2) *Prosartes*, on the character differences between the berry, pubescence, ovules, inflorescence, perianth seg-

ments, stigma, leaves and geographic distribution. All the Asian species belong to the section *Prosartes*.

Of the cytologically investigated species of *Disporum* all the three Asian species have $2n=16$ chromosomes, whereas of the five North American species *D. maculatum* has $2n=12$ (Ownbey 1953); *D. smithii* has $2n=16$ (Jones 1951); *D. hookeri* and *D. lanuginosum* have $2n=18$ (Jones 1951); *D. trachycarpum* has $2n=22$ (Jones 1951). Not only do the American *Disporums* have different base numbers from the Asian ones but the absolute chromosome size of the American *Disporums* is considerably smaller than that of the Asian species. Unfortunately Jones (1951) has neither described the karyotype of North American species which he worked out, nor is it possible to get a clear picture of the karyotype from his drawings. However, one can get a good idea of the karyotype of one North American species viz. *D. maculatum* ($2n=12$) worked by Ownbey (1953). The karyotype is asymmetrical consisting of ten long and two short chromosomes. The long chromosomes consist of two pairs with submedian primary constriction, two pairs are with subterminal primary constriction and one pair is with terminal primary constriction. The two small chromosomes are with submedian primary constriction. The available cytological data serves to justify the segregation of the genus *Disporum* into the sections *Eudisporum* and *Prosartes* and indicates the latter to be more highly evolved.

Smilacina. The finding of $n=18$ for *Smilacina purpurea* conforms to the number reported earlier for other species of the genus. Darlington and Wylie (1955) have suggested the base number for the genus to be $x=9$ on the basis of which all the investigated species are tetraploid. The centre of distribution of the genus is in South China and an investigation of the species in this region or in the adjoining area of the Eastern Himalayas might reveal the existence of diploid forms.

Summary

1. The cytology of *Polygonatum* Miller, *Disporum* Salisb. ex D. Don, and *Smilacina* Desf., the three common genera of the tribe Polygonateae occurring in the Western Himalayas, has been worked out.

2. *Polygonatum multiflorum* All. has $2n=22$ and $n=11$ chromosomes. The karyotype is symmetrical and agrees in certain respects with that of the European *P. multiflorum* worked out by Therman which has $2n=18$.

3. *Polygonatum verticillatum* All. has $2n=66$ chromosomes, differing from the numbers previously reported for the species. The karyotype is of the symmetrical type. Meiosis is highly irregular. It is suggested to be an autoallopolyploid.

4. *Polygonatum sibiricum* Red. (= *P. cirrhifolium* Royle) has $2n=36$ and $n=18$ chromosomes. The karyotype is highly asymmetrical.

5. In the *Polygonatums* studied the numbers are new records not only

for the species concerned but also for the genus.

6. *Disporum cantoniense* (Lour.) Merr. (= *D. pullum* Salisb.) has $2n=16$ chromosomes. Its karyotype is different from the Japanese form which however has the same chromosome number.

7. *Smilacina purpurea* Wall. (= *S. pallida* Royle) has $n=18$ chromosomes.

Acknowledgements

We are thankful to Major General and Mrs. A. S. Pathania for their help in the collection of plant material from the Dalhousie area and to Captain R. S. Katoch and Mian Dharam Singh Ji with whose co-operation the collection of material from Narkanda and Huttoo (Simla area) was facilitated.

Our thanks are also due to Messrs. Mahatta & Co., New Delhi for their inestimable help in supplying photographic material during these days of severe import restrictions.

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