Cytological investigations of some polypetalous plants from District Sirmaur of Himachal Pradesh in the Western Himalayas, India

Sanjeev Kumar¹, Santosh Kumari and Raghbir Chand Gupta
Department of Botany, Punjabi University, Patiala 147 002, India

¹Author for correspondence: (koundelsanjeev@gmail.com)
Received May 29, 2012; accepted August 25, 2012

ABSTRACT. As a part of our programme to explore and evaluate genetic diversity of flowering plants of Western Himalayas, at present 180 species of Polypetalaec have been cytologically worked out for the first time from District Sirmaur of Himachal Pradesh in the Western Himalayas. New/ varied chromosome numbers are recorded for 37 species (39 cytotypes) belonging to 25 genera of 15 families of polypetalous plants. The taxa being cytologically worked out for the first time on world-wide basis include eight species as Callia alba (2n=32), Corydalis ramosa (2n=16), Geum elatum (2n=28), Heracleum canescens (2n=22), Pleuroserpentum brunonis (2n=22), Rhodiola wallichiana (2n=28), Saxifraga parnassifolia (2n=16), and Stellaria semivestita (2n=26). New intraspecific cytotypes have been recorded at present against previously known cytotypes of some soecies on world-wide basis in case of 13 species as, Cassia mimosoides var. wallichiana (2n=32), Duschesnea indica (2n = 28), Geum roylei (2n=28), Impatiens bicornuta (2n=14), I. laxiflora (2n=14, 16), Nassurtium officinale (2n=16), Pimpinella acuminata (2n=18), Potentilla atroruginea (2n=28), P. gerardiana (2n=28), Sibbaldia cuneata (2n=28), Sibbaldia micropetala (2n=14, 28), Sida cordifolia (2n=16), Saxifraga diversifolia (2n=16), Stellaria monosperma (2n=26) and Stellaria media (2n=26). Likewise, ten species have been cytologically worked out for the first time from India as: Berberis vulgaris (2n=28), Bergenia ciliata (2n=34), Chaerophyllum aromaticum (2n=22), Epilobium palustre (2n=36), Geranium ocellatum (2n=36), Potentilla argyrophylla (2n=56), Saxifraga brunonis (2n=16), Saxifraga sibirica (2n=16), Sedum multicaule (2n=28), and Thalictrum minus (2n=14). Moreover for 4 species, varied cytotypes are being reported on India basis as: Potentilla kleiniana (2n=14), Sida cordata (2n=16) Silene vulgaris (2n=48), and Trifolium repens (2n=16).

KEYWORDS: Chromosome number, Intraspecific cytotypes, Polypetalaec, Sirmaur (H.P.), Western Himalayas

Sirmaur is the south-eastern district of Himachal Pradesh forming distinct phyto- geographical pocket of Western Himalayas and lies between latitude 30°22’30" and 31°01’20" north and longitude 77°01’12" and 77°49’40" east, occupying an area of 2.826 km² with altitudinal ranges from 400-3,630 m. In this area subclass Polypetalaec is represented by 59 families, 194 genera and 334 species including cultivated ones (Kaur and Sharma 2004). Since the area of investigation i.e. district Sirmaur (H.P.) is new to study, all the species have been cytologically worked out for the first time from this part. A perusal of literature shows total absence of cytological picture of this vast diverse flora except for single report by (Bala et al. 2010) on Erigeron karvinskianus, (2n=36) of the family Asteraceae of Gamopetalaec. To study the genetic diversity at intra- and interspecific levels and to further enrich the chromosomal database of angiospermic species from India, the present meiotic studies based programme of polypetalous plants has been carried out around the whole year covering maximum localities of this part of the Western Himalayas. Though 180 species of polypetalaec have been cytologically studied by us from this region, the present paper deals with the meiotic studies on 37 species with new /varied chromosome counts.

MATERIALS AND METHODS
For meiotic studies, flower buds were collected from various localities of the District Sirmaur of Himachal Pradesh (Table 1). Smears of appropriate sized flower buds were made after fixing these in the Carnoy’s solution, using standard acetocarmine technique. Pollen fertility was counted by mounting mature pollen grains in glycerol-acetocarmine (1:1) mixture. Well-filled pollen grains with stained nuclei were taken as apparently fertile, while shrivelled and unstained pollen grains were counted as sterile. Photomicrographs of pollen mother cells and pollen grains were made from freshly prepared slides using Nikon 80i eclipse Digital Imaging System. Voucher specimens are deposited in the Herbarium, Department of Botany, Punjabi University, Patiala (PUN).

RESULTS AND DISCUSSION
It is interesting to note that present study has brought to light newer chromosomal reports in 37 species (39 cytotypes) growing wild and belonging to 25 genera and 15 families from different localities with altitudinal range of 400-3,630 m from district Sirmaur of H.P. in the Western Himalayas. The data regarding locality with altitude, accession number, present chromosome number, ploidy level, nature of meiotic course and pollen fertility of these species have been given in Table 1. The previous chromosome reports are based on chromosome number compilations by Fedorov (1974), Kumar and Subramaniam (1986), Index to Plant Chromosome Numbers from 1970 onwards, various Journals, proceeding volumes and internet. For convenience sake families, genera and species, all are alphabetically arranged in the Table 1 as well in the text. Further, in case of any plant species...
Table: Data showing location, altitude, accession number, present meiotic chromosome number, meiotic course, ploidy level and pollen fertility in polypetalous taxa from District Sirmaur (H. P.) of Western Himalayas, India.

<table>
<thead>
<tr>
<th>Family</th>
<th>Taxon</th>
<th>Location/longitude/latitude/Altitude (m)</th>
<th>Accession Number (PUN)</th>
<th>Meiotic Chromosome number (2n)</th>
<th>Meiotic Course*</th>
<th>Ploidy Level (x)</th>
<th>Pollen Fertility (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Family: Apiaceae</strong></td>
<td>1. Chaerophyllum aromaticum L.</td>
<td>Rajgarh, 30°51' N 77° 18'E/1,650m</td>
<td>55246</td>
<td>22</td>
<td>A</td>
<td>2x</td>
<td>65.67</td>
</tr>
<tr>
<td></td>
<td>2. Heracleum canescens Lindl.</td>
<td>Chapdhar, 30°51' N 77° 23'E/2,600m</td>
<td>56180</td>
<td>22</td>
<td>A</td>
<td>2x</td>
<td>76.25</td>
</tr>
<tr>
<td></td>
<td>3. Pimpinella acuminata C.B. Clarke</td>
<td>Rajgarh, 30°51' N 77° 18'E/1,650m</td>
<td>55248</td>
<td>18</td>
<td>A</td>
<td>2x</td>
<td>69.64</td>
</tr>
<tr>
<td></td>
<td>4. Pleurospermum brunnonis Benth. ex C. B. Clarke</td>
<td>Tisri, 30°52' N 77° 10'E/3,000m</td>
<td>56030</td>
<td>22</td>
<td>A</td>
<td>2x</td>
<td>73.17</td>
</tr>
<tr>
<td><strong>Family: Balsaminaceae</strong></td>
<td>5. Impatiens bicornuta Wall.</td>
<td>Haripurchar, 30°46' N 77° 32'E/2,600m</td>
<td>52542</td>
<td>14</td>
<td>N</td>
<td>2x</td>
<td>96.14</td>
</tr>
<tr>
<td></td>
<td>6. I. laxiflora Edgew.</td>
<td>Ganduri, 30°52' N 77° 10'E/2,600m</td>
<td>52540</td>
<td>14</td>
<td>N</td>
<td>2x</td>
<td>97.72</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rajgarh, 30°51' N 77° 18'E/1,650m</td>
<td>52538</td>
<td>16</td>
<td>N</td>
<td>2x</td>
<td>94.23</td>
</tr>
<tr>
<td><strong>Family: Berberidaceae</strong></td>
<td>7. Berbeis vulgaris L.</td>
<td>Shillai, 30°40' N 77° 42'E/2,000m</td>
<td>55129</td>
<td>28</td>
<td>N</td>
<td>2x</td>
<td>97.54</td>
</tr>
<tr>
<td><strong>Family: Brassicaceae</strong></td>
<td>8. Nasturtium officinale R. Br.</td>
<td>Nahan, 30°33' N 77° 17'E/900m</td>
<td>55248</td>
<td>16</td>
<td>N</td>
<td>2x</td>
<td>98.87</td>
</tr>
<tr>
<td><strong>Family: Caesalpiniaceae</strong></td>
<td>9. Cassia mimosoides L. var. wallichiana Baker</td>
<td>Rohanat, 30°45' N 77° 40'E/1,450m</td>
<td>56180</td>
<td>32</td>
<td>N</td>
<td>4x</td>
<td>97.29</td>
</tr>
<tr>
<td><strong>Family: Caryophyllaceae</strong></td>
<td>10. Silene vulgaris (Moench) Garcke</td>
<td>Shillai, 30°40' N 77° 42'E/2,000m</td>
<td>54434</td>
<td>48</td>
<td>A</td>
<td>4x</td>
<td>78.12</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Haripurchar, 30°46' N 77° 32'E/2,600m</td>
<td>54412</td>
<td>26</td>
<td>N</td>
<td>2x</td>
<td>97.32</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tisri, 30°52' N 77° 10'E/3,000m</td>
<td>54419</td>
<td>26</td>
<td>N</td>
<td>2x</td>
<td>94.27</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tisri, 30°52' N 77° 10'E/3,000m</td>
<td>54425</td>
<td>26</td>
<td>N</td>
<td>2x</td>
<td>93.28</td>
</tr>
<tr>
<td><strong>Family: Crassulaceae</strong></td>
<td>11. Stellaria monosperma Buch.-Ham.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>12. S. media (L.) Vill.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>13. S. semivestita Edgew.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><strong>Family: Geraniaceae</strong></td>
<td>14. Rhodiola wallichiana (Hook) Fu</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>15. Sedum multicaule Wall ex Lindl.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td>17. Trifolium repens L.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family: Fumariaceae</td>
<td>18. Corydalis ramosa wall.</td>
<td>Chapdhar, 30° 51' N 77° 23'E/ 2,400m</td>
<td>56177</td>
<td>16</td>
<td>N</td>
<td>2x</td>
<td>98.00</td>
</tr>
<tr>
<td>---------------------</td>
<td>--------------------------</td>
<td>-------------------------------------</td>
<td>------</td>
<td>----</td>
<td>---</td>
<td>---</td>
<td>------</td>
</tr>
<tr>
<td>Family: Malvaceae</td>
<td>19. Sida cordata (Burm.f.)</td>
<td>Shillai, 30°40' N 77° 42'E/ 1,800m</td>
<td>55244</td>
<td>16</td>
<td>N</td>
<td>2x</td>
<td>97.13</td>
</tr>
<tr>
<td></td>
<td>Bosc. Waalk.</td>
<td>Raigah, 30°51' N 77° 18'E/ 1,650m</td>
<td>55245</td>
<td>16</td>
<td>N</td>
<td>2x</td>
<td>98.90</td>
</tr>
<tr>
<td>20. S. cordifolia L.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family: Onagraceae</td>
<td>21. Epilobium palustre L.</td>
<td>Bhanganimata, 30°46' N 77° 33'E/ 2,800m</td>
<td>55240</td>
<td>36</td>
<td>N</td>
<td>2x</td>
<td>91.98</td>
</tr>
<tr>
<td>Family: Malvaceae</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family: Ranunculaceae</td>
<td>22. Caltha alba Cambess.</td>
<td>Tisri, 30°52' N 77° 10'E/ 3,000m</td>
<td>54538</td>
<td>32</td>
<td>A</td>
<td>4x</td>
<td>72.45</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tisri, 30°52' N 77° 10'E/ 3,000m</td>
<td>56173</td>
<td>14</td>
<td>N</td>
<td>2x</td>
<td>97.24</td>
</tr>
<tr>
<td>Family: Rosaceae</td>
<td>23. Thalictrum minus L.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family: Saxifragaceae</td>
<td>24. Duchesnea indica (Andr.) Focke</td>
<td>Haripurdhar, 30°46' N 77° 32'E/ 2,600m</td>
<td>54860</td>
<td>28</td>
<td>N</td>
<td>4x</td>
<td>95.38</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Jamnala, 30° 51’ N 77° 22'E/ 2,800m</td>
<td>55631</td>
<td>28</td>
<td>N</td>
<td>4x</td>
<td>95.74</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Tisri, 30°52' N 77° 10'E/ 3,000m</td>
<td>55655</td>
<td>28</td>
<td>N</td>
<td>4x</td>
<td>94.27</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Rohanat, 30°45' N 77° 40'E/ 1,450m</td>
<td>54875</td>
<td>56</td>
<td>N</td>
<td>8x</td>
<td>94.45</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Saini, 30°04’ N 77° 23'E/ 1,400m</td>
<td>54867</td>
<td>28</td>
<td>N</td>
<td>4x</td>
<td>96.23</td>
</tr>
<tr>
<td>25. Geum roylei Wall.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>26. G. elatum Wall.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>27. Potentilla argyrophylla Wall ex Lehm.</td>
<td>Haripurdhar, 30°46' N 77° 32'E/ 2,600m</td>
<td>55699</td>
<td>28</td>
<td>N</td>
<td>4x</td>
<td>95.12</td>
<td></td>
</tr>
<tr>
<td>28. P. atrosanguinea Lodd. ex D. Don</td>
<td>Shillai, 30°40' N 77° 42'E/ 2,000m</td>
<td>55698</td>
<td>14</td>
<td>N</td>
<td>2x</td>
<td>96.14</td>
<td></td>
</tr>
<tr>
<td>29. P. gerardiana Lindl. ex Lehmm.</td>
<td>Shillai, 30°40' N 77° 42'E/ 2,000m</td>
<td>55067</td>
<td>28</td>
<td>N</td>
<td>4x</td>
<td>97.16</td>
<td></td>
</tr>
<tr>
<td>30. P. kleiniana Wight &amp; Arn.</td>
<td>Churpaek, 30°40' N 77° 42'E/ 3,630m</td>
<td>54913</td>
<td>14</td>
<td>N</td>
<td>2x</td>
<td>94.16</td>
<td></td>
</tr>
<tr>
<td>31. Sibbaldia cuneata Hornem.</td>
<td>Churpaek, 30°40' N 77° 42'E/ 3,630m</td>
<td>54914</td>
<td>28</td>
<td>N</td>
<td>4x</td>
<td>95.17</td>
<td></td>
</tr>
<tr>
<td>32. S. micropetala (D. Don) Hand.-Mazz.</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Family: Saxifragaceae</td>
<td>33. Bergenia ciliata (Haw.) Sternb.</td>
<td>Shillai, 30°40' N 77° 42'E/ 2,000m</td>
<td>55060</td>
<td>34</td>
<td>N</td>
<td>2x</td>
<td>96.35</td>
</tr>
<tr>
<td>34. Saxifraga diversifolia Wall.</td>
<td>Churpaek, 30°52' N 77° 20'E/ 3,250m</td>
<td>55070</td>
<td>16</td>
<td>A</td>
<td>2x</td>
<td>68.67</td>
<td></td>
</tr>
<tr>
<td>35. S. brunonis Ser.</td>
<td>Tisri, 30°52’ N 77° 10'E/ 3,000m</td>
<td>56179</td>
<td>16</td>
<td>A</td>
<td>2x</td>
<td>76.28</td>
<td></td>
</tr>
<tr>
<td>36. S. parnassifolia D. Don</td>
<td>Haripurdhar, 30°46' N 77° 32'E/ 2,600m</td>
<td>56171</td>
<td>16</td>
<td>A</td>
<td>2x</td>
<td>75.32</td>
<td></td>
</tr>
<tr>
<td>37. S. sibirica L.</td>
<td>Churpaek, 30°40' N 77° 42'E/ 3,630m</td>
<td>55092</td>
<td>16</td>
<td>A</td>
<td>2x</td>
<td>70.13</td>
<td></td>
</tr>
</tbody>
</table>

Meiotic course *N= Normal; *A= Abnormal
having same chromosome number reported by large number of authors, at the most only latest references have been mentioned in the text. Brief observations for each species are discussed below.

The Apiaceae

1. Chaerophyllum aromaticum L. The present chromosome count of 2n=11II=22 (Fig. 1A) for the species was reported here for the first time in India and found to be in conformity with the earlier reports of 2n=22 from Poland (Skalsinska 1974), Slovakia (Ferakova 1976), Dutchland (Pashuk 1987) and Russia (Albers and Pröbsting 1998).

2. Heracleum canescens Lindl. The species was found on open grassy slopes between the altitudinal range of 2,000-2,700 m. It was characterized as hairy herb with slender stem bearing 1-2 pinnate leaves, sessile leaflets and white flowers. The flowering and fruiting was seen during July-September. The species was cytologically worked out for the first time on world-wide basis showing the chromosome count of 2n=11II=22 (Fig. 1B).

3. Pimpinella acuminata C.B. Clarke The present chromosome count of 2n=9II=18 (Fig. 1C) was added as a new aneuploid cytotype at diploid level on world-wide basis for the species. Earlier it was known to have 2n=20 from India (Mehra and Dhawan 1971) and outside India from Nepal (Carbonnier and Farille 1980; Cauwet-Marc 1982).

4. Pleurospermum brunonis Benth. ex C.B. Clarke The species was found on grassy hills between the altitudinal range of 3,000-3,630 m. It was a short stemmed herb with 2-4 pinnate, linear leaves and white flowers. The flowering and fruiting was seen during the months of July-September. The species was cytologically worked out for the first time on world-wide basis showing 2n=11II=22 (Fig. 1D) at diploid level.

The Balsaminaceae

5. Impatiens bicornuta Wall. The present chromosome count of 2n=14 (Fig. 1E) for the species was added as a new cytotype on world-wide basis. The species was already known to have 2n=16 in a Nepal population (Malla et al. 1978) alongwith 2n=18 from Nepal (Akiyama et al. 1990; Wakabayashi 1992).

6. Impatiens laxiflora Edgew. The present chromosome counts of 2n=14 and 16 (Figs. 1F and 1G) for the species added as a new cytotypes on world-wide basis as the species was earlier known to have 2n=12 (Kaur et al. 2010) from Dalhousie, different area of Western Himalayas in India.

The Berberidaceae

7. Berberis vulgaris L. The gametic number of 2n=28 (Fig. 1H) for the species was reported for the first time from India and found to be in conformity with the earlier reports of 2n=28 from Poland (Pogan et al. 1980), Russia (Magulaev 1984), Mediterranean region (Verlaque et al. 1987) and Czech Republic (Měšíček 1992).

The Brassicaceae

8. Nasturtium officinale R.Br. The present chromosome count of 2n=16 (Fig. 1I) was added as a new diploid cytotype on world-wide basis as the species was earlier known to have tetraploids of 2n=32 from Czech Republic (Javouková-Jarolimová 1992; Krahulcová 1992), Caribbean (Diosdado et al. 1993) and Pakistan (Khatoon and Ali 1993).

The Caesalpiniaceae

9. Cassia mimosoides L. var. wallichiana Baker The present chromosome count of 2n=32 (Fig. 1J) was added as a new tetraploid cytotype for the variety on world-wide basis as the same variety was previously known to have diploid cytotype with 2n=16 from Pachmari Hills (M.P.) of central India (Bir et al. 1980; Bir and Kumari 1982).

10. Silene vulgaris (Moench) Garcke. The present chromosome count of 2n=48 (Fig. 1K) was added as a new tetraploid cytotype for the species from India and conforms to the previous reports of 2n=48 from Africa (Degraeve 1980) and Israel (Horovitz and Dolverger 1983). The species was also known to have diploid cytotype with 2n=24 from India (Gupta et al. 2009) and Bulgaria (Baltsisberger 2006).

11. Stellaria media (L.) Vill. The present chromosome count of 2n=26 (Fig. 1L) was added as a new diploid cytotype for the species in the world-wide basis as it is previously known to have intraspecific cytotypes at euploid and aneuploid levels, based on different basic numbers i.e., 2n=18 from Russia (Krasnikov and Schaulo 1990); 2n=40 from Finland (Halkka 1985) and Cameroon (Morton 1993); 2n=42 from Finland (Arohonka 1982) and the Mediterranean region (Lara Ruiz 1993) and 2n=44 from India (Sidhu and Bir 1983) and from Russia (Parfenov and Dmitrieva 1988) and Argentina (Slavik et al. 1993).

12. Stellaria monosperma Buch.-Ham. (=S. crispata Wall. ex Edgew.) The present chromosome count of 2n=26 (Fig. 1M) was added as a new diploid cytotype for the species on world-wide basis as it is previously known to have only tetraploid cytotype with 2n=52 from eastern part of India (Chatterjee 1975).

13. Stellaria semivestita Edgew. The species was found on grassy hills between the altitudinal range of 3,000-3,300m. It was a stout, hairy herb having leaves recurved from base and wooly flowers. The flowering and fruiting
Fig. 1. Meiotic chromosomes in certain species of the Himalayas. A). Chaerophyllum aromaticum - PMC at metaphase I (2n=22); B). Heracleum canescens - PMC at metaphase I (2n=22); C). Pimpinella acuminata - PMC at Diakinesis (2n=18); D). Pleurospermum brunonis - PMC at metaphase I (2n=22); E). Impatiens bicornuta - PMC at metaphase I (2n=14); F). Impatiens laxiflora - PMC at Diakinesis (2n=14); G). Impatiens laxiflora - PMC at Diakinesis (2n=16); H). Berbeis vulgaris - PMC at anaphase I (2n=28); I). Nasturtium officinale - PMC at anaphase I (2n=16); J). Cassia mimosoides var. wallichiana - PMC at metaphase I (2n=32); K). Silene vulgaris - PMC at anaphase I (2n=48); L). Silene media - PMC at Diakinesis (2n=26); M). Stellaria monosperma - PMC at metaphase I (2n=26); N). Silene semivestita - PMC at metaphase I (2n=26); O). Rhodiola wallichiana - PMC at metaphase I (2n=28); P). Sedum multicaule - PMC at metaphase I (2n=28); Q). Geranium ocellatum - PMC at Diakinesis (2n=56); R). Trifolium repens - PMC at metaphase I (2n=16); S). Corydalis ramosa - PMC at metaphase I (2n=16); T). Sida cordata - PMC at anaphase I (2n=16); U). Sida cordifolia - PMC at metaphase I (2n=16); V). Epilobium palustre - PMC at metaphase I (2n=36); W). Caltha alba - PMC at metaphase I (2n=32); X). Thalictrum minus - PMC at Diakinesis (2n=14). Bar=10μm.
is seen during the months of July-October. The species is cytologically worked out for the first time on world-wide basis showing 2n=26 (Fig. 1N) at diploid level.

**The Crassulaceae**

14. Rhodiola wallichiana (Hook) Fu The species was found on open moist grassy slopes between the altitudinal range of 3,000-3,500 m. It was characterized as a perennial herb with linear leaves and pale yellow flowers in compact terminal cluster born on erect stem. The flowering and fruiting were seen during the months of June-September. The species was cytologically worked out for the first time on world-wide basis showing the chromosome count of 2n=28 (Fig. 1O) and was at tetraploid level (genus being polybasic with x=5 to 9).

15. Sedum multicaucale Wall ex Lindl. The present chromosome count of 2n=28 (Fig. 1P) was added as a new tetraploid cytotype for the species in India and conforming to the earlier reports of 2n=28 and 84 from Eastern Himalayas and Japan (Wakabayashi and Ohba 1999).

**The Geraniaceae**

16. Geranium ocellatum Cambess. The gametic number of 2n=56 (Fig. 1Q) for the species was reported here for the first time in India and conforming to the earlier reports of 2n=56 from Western Africa (Hedberg and Hedberg 1977) and Cameroon (Morton 1993).

**The Fabaceae**

17. Trifolium repens L. The present chromosome count of 2n=8II=16 (Fig. 1R) was added as a new diploid cytotype in India and was in conformity with the earlier reports of 2n=16 studied from outside India (Daniela et al. 2003). The species also exhibited 2n=32 in Chinese population (Yang and Zhou 1999; Yang et al. 2003; Chen 1997). The species also exhibited 2n=14 in Byelarus (Dmitrieva 2000); and outside India from Nigeria (Ugborogho 1982) and Taiwan (Cheng and Tsai 1999). The species was also reported to have another tetraploid (2n=32) cytotype based on x=8 reported in India (Hazra and Sharma 1972).

**The Onagraceae**

20. Sida cordifolia L. The present chromosome count of 2n=16 (Fig. 1U) was added as a new diploid cytotype for the species in the world-wide basis as the species was previously known to have 2n=28, tetraploid based on different basic number of x=7 from India (Sidhu et al. 1990); and outside India from Nigeria (Ugborogho 1982) and Taiwan (Cheng and Tsai 1999). The species was also reported to have another tetraploid (2n=32) cytotype based on x=8 reported in India (Hazra and Sharma 1972).

21. Epilobium palustre L. The gametic number of 2n=36 (Fig. 1V) for the species was reported for the first time in India and was in conformity with the earlier reports of 2n=36 in Russia (Krasnikov and Schaulo 1990), Belarus (Semerenko 1990) and Czech Republic (Javurková-Jarolimová 1992).

**The Ranunculaceae**

22. Caltha alba Cambess. (=Caltha palustris L. var. alba (Camb. ex. Jacq. Hook. f. and Thomson) The species was found on rocky slopes between the altitudinal range of 3,000-3,500m. It was characterized as perennial herb with thick rootstock, orbicular leaves and creamy flowers. The flowering and fruiting was seen during the months of May-June. The species was cytologically studied for the first time on world-wide basis showing chromosome count of 2n=16III=32 (Fig. 1W) at tetraploid level.

23. Thalictrum minus L. The gametic chromosome number of 2n=14 (Fig. 1X) in the species in India was reported here for the first time and was in conformity with the earlier report of 2n=14 of the species in Russia (Magulaev 1984).

**The Rosaceae**

24. Duchesnea indica (Andr.) focke (=Fragaria indica Andr.) The present chromosome count of 2n=28 (Fig. 2A) was added as a new tetraploid cytotype for the species on world-wide basis as it was previously known to have polyploidy at 12x level with 2n=84 from Nepal and Japan (Naruhashi et al. 1986), and China (Zhao et al. 1990; Xu et al. 1992).

25. Geum roylei Wall. (=Geum urbanum L.) The present chromosome count of 2n=28 (Fig. 2B) was added as a new tetraploid cytotype for the species on world-wide basis as it was previously known to have triploids of 2n=21 in Byelarus (Dmitrieva 2000); and hexaploids of 2n=42 in England and Ireland (Al-Bermani et al. 1993), Mediterranean region (Baltisberger et al. 1993), Sweden (Lovkvist and Hultgard 1999) and Bulgaria (Baltisberger et al. 1993).
26. *Geum elatum* Wall. The present chromosome count of 2n=28 (Fig. 2C) was added as a new tetraploid cytotype on world-wide basis as it previously known to have hexaploid with 2n=42 (Sharma and Sarkar 1967-1968) and octaploid with 2n=56 (Kumar and Singhal 2011).

27. *Potentilla argyrophylla* Wall ex Lehm. The gametic chromosome number of 2n=56 (Fig. 2D) for the species was reported for the first time in India and was in conformity with the earlier reports of the octoploid cytotypes with 2n=56 in Japan (Shimtomai 1930; Zhukova 1967).

28. *Potentilla atrosanguinea* Lod. The present chromosome count of 2n=28 (Fig. 2E) was added as a new tetraploid cytotype for the species on world-wide basis as it was previously known to have higher ploidy levels as 2n=56 (8x), 74(aneuploid at 10x), 84(12x) in India (Goswami and Matfield 1978) and 2n=63(9x) in Russia (Zhukova 1967).

29. *Potentilla gerardiana* Lindl. ex. Lehm. The present
chromosome count of 2n=28 (Fig. 2F) was added as a new tetraploid cytotype for the species on world-wide basis as it was previously known to have diploid cytotype with 2n=14 in Russia (Krogulevich 1978; Probato娃 and Sokolovskaya 1981), Japan (Iwatsubo and Naruhashi 1991) and octoploid cytotypes with 2n=56 from different part of Western Himalayas in India (Mehra and Dhawan1966).

30. Potentilla kleiniana Wight et Arn. The gametic chromosome number of 2n=14 (Fig. 2G) for the species in India was recorded here for the first time and was in conformity with the earlier report of 2n=14 in Japan (Shimotomai 1929). The species was also known to have tetraploid cytotypes with 2n=28 in India (Arora1961; Subramanian 1987) and Japan (Ikeda 1989).

31. Sibbaldia cuneata Hornem. (=S. parviflora Edgew.) The present chromosome count of 2n=28 (Fig. 2H) was added as a new tetraploid cytotype for the species on world-wide basis as it was previously known to have diploid cytotype with 2n=14 from Russia (Guiniochet and Lefranc 1981).

32. Sibbaldia micropetala (D. Don) Hand.-Mazz, (=Potentilla micropetala (D. Don) Hand.-Manz. Two cytotypes of the diploid (2n=14) and tetraploid (2n=28) levels have been collected from the same locality. The present chromosome count of 2n=14 (diploid; Fig. 2I) was reported for the first time in India and was in conformity with earlier report of 2n=14 in Yunnan Province of the People’s Republic of China (Mesicek and Sojak 1993), whereas 2n=28 (Fig. 2J) was added as a new tetraploid cytotype for the species on world-wide basis. The species has also been known to have octoploid cytotype of 2n=56 in some other part of the Western Himalayas (Mehra and Dhawan 1966).

The Saxifragaceae

33. Bergenia ciliata (Haw.) Sternb. (=Saxifraga ligulata Wall.) The gametic chromosome number of 2n=34 (Fig. 2K) in the species was reported here for the first time in India and is in conformity with the earlier report of 2n=34 from Nepal (Hamel 1948).

34. Saxifraga brunonis Ser. (=Hirculus brunonianus Losinsk.) The gametic chromosome number of 8n (Fig. 2L) in the species was reported here for the first time in India and was in conformity with the earlier reports of diploid cytotypes of 2n=16 in Japan (Wakabayashi and Ohba 1988).

35. Saxifraga diversifolia Wall. The present chromosome count of n=8 or 2n=16 (Fig. 2M) was added as a new aneuploid cytotype at diploid level for the species on world-wide basis as it was previously known to have 2n=20 in India (Mehra and Dhawan 1971) and in Nepal (Malla et al. 1984).

36. Saxifraga parnassifolia D. Don (=Saxifraga diversifolia var. parnassifolia (D.Don) Ser) The species was found on grassy rocks between an altitudinal range of 2,600-3,000 m. It was characterized by erect stem with crowded basal ovate leaves and yellow flowers. The flowering and fruiting is seen during July to September. The species was cytologically studied for the first time on world-wide basis to document the chromosome number of 8n and 2n=16 (Fig. 2N).

37. Saxifraga sibirica L. The gametic chromosome number of n=8 (Fig. 2O) for the species in India was reported here for the first time and was in conformity with the earlier reports of 2n=16 in Manchuria (Mura et al. 1984) and Russia (Krogulevich 1978).

Intraspecific variabilities of chromosome numbers in 16 species of higher plants grown in the Western Himalaya in India were counted, documented and compared with the past documentations of chromosome numbers of the same species grown elsewhere on the basis of: 1. Diploids against polyploids -- Saxifraga ciliata, 2x (n=8) against 4x (2n=28 and 2n=32); Stellaria monosperma, 2x (n=13) against 4x (2n=52); 2. Diploids and tetraploids against octoploids - Saxifraga ciliata, 2x and 4x (n=7, n=14) against 8x (2n=56); 3. Tetraploids against diploids -- Cassia obtusifolia var. wallichiana, 4x (n=16) against 2x (2n=16); Saxifraga cuneata, 4x (n=14) against 2x (2n=14); 4. Tetraploids against diploids and others polyploids -- Duchesnea indica, 4x (n = 14) against 2x (2n=14), 6x (2n=42), 12x (2n=84); Potentilla germandiana, 4x (n=14) against 2x (2n=14), 8x (2n=56); 5. Tetraploids against triploids and other polyploids -- Geum roylei, 4x (n=14) against 3x (2n=21), 6x (2n=42); 6. Tetraploids against higher polyploids -- Potentilla atrorubens, 4x (n=14) against 8x (2n=56), 9x (2n=63), 10x (2n=74), 12x (2n=84); 7. Presently worked out diploids against others diploids with different base numbers -- Impatiens bicornuta, 2x (n=7) different from 2x (2n=16, 2n=18); Saxifraga diversifolia, 2x (n=8) against 2x (2n=20); Impatiens laxiflora, 2x (n=7, n=8) against 2x (2n=12); 8. Diploids against others diploids with different base numbers and polyploids -- Nasturtium officinale, 2x (n=8) against 2x (2n=14), 4x (2n=32, 2n=33, 2n=34, 2n=36), 6x (2n=48), 8x (2n=64, 2n=66); Pimpinella acuminata, 2x (n=9) against 2x (2n=20), 4x (2n=40); Stellaria media, 2x (n=13) against 2x (2n=18), 4x(2n=40, 2n=42, 2n=44).

ACKNOWLEDGEMENTS. The authors are grateful to the University Grants Commission, New Delhi for providing financial assistance under the Rajiv Gandhi National Fellowship Scheme and DRS SAP III as well as Department of Science and Technology, New Delhi for help under FIST programme. We are also highly thankful to the Joint Director and other staff of Herbarium of Botanical Survey of India, Dehradun for their help in the identification of the plant species.
LITERATURE CITED


Mehra, P. N. and Dhawan, H. 1971 In IOPB chromosome number reports XXXIV Taxon 20:785-797.


Semerenko, L. V. 1990. Chromosome numbers of some flowering plants from the Berezinsky Biosphere Reservation (the Byelorussian Soviet Socialist Republic).


