TRIBE SISYMBRIEAE
OBSERVATIONS

Four genera *Alliarie, Arabidopsis, Descuriania* and *Sisymbrium* spread over 12 species, belonging to this tribe, have been studied during the course of the present investigation.

The plants belonging to this tribe are characterised by the presence of spreading or suberect sepals, readily dehiscent linear or cylindrical fruits, oblong seeds and incumbent radicle.
Figs. 53 - 57: Cytology of *Aliaria petiolaris* (n = 7)

- **Fig. 53**: Somatic chromosomes
- **Fig. 54**: Idiogram of somatic chromosomes
- **Fig. 55**: A PMC at diplotene
- **Fig. 56**: A PMC at metaphase I
- **Fig. 57**: A PMC at anaphase I

Scale 10 µm

(1 µm in Fig. 54)
ALLIARIA:

In the Kashmir valley, the genus Alliaria is represented by a single species, *A. petiolata*. The plants of this species are characterized by basal cordate and ovate (more or less triangular) cauline leaves, white flowers and black longitudinally striated seeds.

**Cytology:**

**Karyotype**

14 chromosomes were observed in all the dividing cells in the root tips of *A. petiolata* (Fig. 53). Of these 2 are median and 12 submedian (Fig. 54). The chromosome size in this species ranges from 1.28 μm to 2.29 μm. Total and mean chromatin length for this complement is 24.54 μm and 1.75 μm respectively. The ratio between the size of the longest and the smallest chromosome is 1.74. Individual chromosome metrics (haploid complement) have been summed up in table No. 27 (page 86).

**Meiosis:**

In all the pollen mother cells of this species, 7 bivalents were observed at diplotene (Fig. 55), diakinesis and metaphase I (Fig. 56) of meiosis. At diplotene a single bivalent was seen attached to the
Table No. 27: Chromosome metrics of haploid complement of Alliaria petiolata (2n = 14)

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Long arm (L)</th>
<th>Short arm (S)</th>
<th>Total (L+S)</th>
<th>Arm Ratio</th>
</tr>
</thead>
<tbody>
<tr>
<td>1.</td>
<td>1.45</td>
<td>0.84</td>
<td>2.29</td>
<td>0.58</td>
</tr>
<tr>
<td>2.</td>
<td>1.18</td>
<td>0.79</td>
<td>1.97</td>
<td>0.67</td>
</tr>
<tr>
<td>3.</td>
<td>1.07</td>
<td>0.84</td>
<td>1.91</td>
<td>0.78</td>
</tr>
<tr>
<td>4.</td>
<td>0.94</td>
<td>0.76</td>
<td>1.7</td>
<td>0.80</td>
</tr>
<tr>
<td>5.</td>
<td>0.86</td>
<td>0.79</td>
<td>1.65</td>
<td>0.91</td>
</tr>
<tr>
<td>6.</td>
<td>0.84</td>
<td>0.60</td>
<td>1.44</td>
<td>0.71</td>
</tr>
<tr>
<td>7.</td>
<td>0.81</td>
<td>0.47</td>
<td>1.28</td>
<td>0.56</td>
</tr>
</tbody>
</table>

Karyotypic Formula: 2M + 12SM

nucleolus. Chiasmata frequencies calculated at diplotene and metaphase I of this species have been summed up below.

Table No. 28: Chiasmata frequency in Alliaria petiolata (n = 7)

<table>
<thead>
<tr>
<th>Meiotic Fig. stage No.</th>
<th>No. of cells studied</th>
<th>Average</th>
<th>Per call</th>
<th>Per bivalent</th>
<th>Total</th>
<th>Interstitial</th>
<th>Terminal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Dip. 55</td>
<td>40</td>
<td></td>
<td>16.15</td>
<td>2.30</td>
<td>11.3</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per call</td>
<td>4.85</td>
<td></td>
<td></td>
<td>1.61</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per bivalent</td>
<td>0.69</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Met. I 56</td>
<td>35</td>
<td></td>
<td>13.35</td>
<td>1.90</td>
<td>12.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per call</td>
<td>0.65</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per bivalent</td>
<td>0.09</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Anaphase I segregations were also normal with 7 chromosomes moving to each pole (Fig. 57). Pollen stainability in this species was very high (98.9%).

**ARABIDOPSIS:**

Genus Arabidopsis is represented by six species namely *A. thaliana, A. himalaica, A. mollissima, A. stricta, A. wallichii* and *A. pumila* in Kashmir and adjoining areas. Plants of all these species, widely distributed in our area, are characterised by obovate-oblong to semiamplexicaule leaves with dentate margins. The flowers are white to lilac coloured except in *A. pumila* where they are yellow coloured. Important morphological features of these six species, included in the present study, are presented in table No. 29 (page 88).

**Cytology:**

**Karyotype**

Karyotypic details of four species (*A. mollissima, A. stricta, A. wallichii* and *A. pumila*) have been studied. Of these, *A. pumila* is tetraploid with $2n = 32$ and rest are diploid with $2n = 16$. The salient features of the somatic chromosomes of these four species are given in table No. 30 (page 89).
Figs. 58 - 61: Mitotic chromosomes of four species of Arabidopsis

Fig. 58: A. mollissima (2n = 16)
Fig. 59: A. stricta (2n = 16)
Fig. 60: A. wallichii (2n = 16)
Fig. 61: A. umila (2n = 32)

scale 10 μm
Table No. 30: Salient somatic chromosome details of four species of Arabidopsis

<table>
<thead>
<tr>
<th>Species</th>
<th>2n</th>
<th>Fig. No.</th>
<th>TCL</th>
<th>MCL</th>
<th>Longest (L)</th>
<th>Smallest (S)</th>
<th>L/S</th>
</tr>
</thead>
<tbody>
<tr>
<td>A. mollissima</td>
<td>16</td>
<td>58</td>
<td>19.68</td>
<td>1.23</td>
<td>1.68</td>
<td>0.94</td>
<td>1.78</td>
</tr>
<tr>
<td>A. stricta</td>
<td>16</td>
<td>59</td>
<td>21.73</td>
<td>1.35</td>
<td>1.72</td>
<td>1.09</td>
<td>1.57</td>
</tr>
<tr>
<td>A. wallichii</td>
<td>16</td>
<td>60</td>
<td>23.88</td>
<td>1.48</td>
<td>1.93</td>
<td>1.09</td>
<td>1.77</td>
</tr>
<tr>
<td>A. pumila</td>
<td>32</td>
<td>61</td>
<td>35.88</td>
<td>1.11</td>
<td>1.51</td>
<td>0.79</td>
<td>1.91</td>
</tr>
</tbody>
</table>

As is clear from the above table, the chromosome size in these four species ranges from 0.79 μm (smallest chromosome of A. pumila) to 1.93 μm (longest chromosome of A. wallichii). A. pumila, in keeping with its tetraploid nature, has the maximum chromatin length (35.88 μm).

Meiosis:

Meiotic details were studied in all the six species, A. thaliana (n = 5), A. himalaica (n = 8), A. mollissima (n = 8), A. stricta (n = 8), A. wallichii (n = 8) and A. pumila (n = 16). Pollen mother cell meiosis in all these species was found to be normal with their chromosomes forming bivalents only followed by regular anaphasic segregations. The chiasmata frequency and other details of these six species have been tabulated in table No. 31 (page 90).
Figs. 62 - 76: Meiosis in six species of *Arabidopsis*

Figs. 62 & 63: *A. thaliana (n = 5)*
- Fig. 62: Metaphase I
- Fig. 63: Anaphase I

Figs. 64 - 66: *A. himalaica (n = 8)*
- Fig. 64: Diplotene
- Fig. 65: Metaphase I
- Fig. 66: Anaphase I

Figs. 67 - 69: *A. mollissima (n = 8)*
- Fig. 67: Diplotene
- Fig. 68: Metaphase I
- Fig. 69: Anaphase I

Figs. 70 - 72: *A. stricta (n = 8)*
- Fig. 70: Diplotene
- Fig. 71: Metaphase I
- Fig. 72: Anaphase I

Figs. 73 - 75: *A. wallichii (n = 8)*
- Fig. 73: Diplotene
- Fig. 74: Metaphase I
- Fig. 75: Anaphase I

Fig. 76: Metaphase I in *A. pumila (n = 16)*

scale 10 μm
<table>
<thead>
<tr>
<th>Name of species</th>
<th>n</th>
<th>Meiotic Fig.</th>
<th>No. of</th>
<th>Chiasmata frequency</th>
<th>No. of Pollen</th>
<th>Name of species</th>
<th>n</th>
<th>Meiotic Fig.</th>
<th>No. of</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td>cells</td>
<td>scored</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td>cells</td>
<td>scored</td>
</tr>
<tr>
<td>A. thaliana</td>
<td>5</td>
<td>MI 62</td>
<td>Small chromosome size did not permit detailed analysis</td>
<td>93.9</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. himalaica</td>
<td>8</td>
<td>Dip. 64 40</td>
<td>16.88 2.11 2.25 0.28 14.63 1.83 1</td>
<td>1 - 2</td>
<td>95.52</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>MI 65 40</td>
<td>13.73 1.72 0 0 13.73 1.72</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. mollissima</td>
<td>8</td>
<td>Dip. 67 40</td>
<td>14.73 1.84 0.1 0.01 14.63 1.83 1 - 2</td>
<td>1 - 2</td>
<td>95.7</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>MI 68 40</td>
<td>11.28 1.41 0 0 11.28 1.41</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. stricta</td>
<td>8</td>
<td>Dip. 70 40</td>
<td>12.91 1.62 0.54 0.07 12.37 1.55 1 - 2</td>
<td>1</td>
<td>98.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>MI 71 36</td>
<td>9.43 1.18 0 0 9.43 1.18</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. wellichii</td>
<td>8</td>
<td>Dip. 73 40</td>
<td>16.02 2.01 1.73 0.22 14.29 1.79 1</td>
<td>1 - 2</td>
<td>98.6</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>MI 74 37</td>
<td>11.63 1.45 0 0 11.63 1.45</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>A. pumila</td>
<td>16</td>
<td>MI 76 35</td>
<td>27.41 1.71 0 0 27.41 1.71</td>
<td></td>
<td>96.23</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Figs. 77 - 79: Cytology of *Descuriania sophia* (n = 14)

- Fig. 77: Somatic chromosomes
- Fig. 78: A PMC at metaphase I
- Fig. 79: A PMC at anaphase I

scale 10 μm
While small size of bivalents in *A. thaliana* did not permit the study of chiasmata frequency, in *A. pumila* the low stainability at stages prior to metaphase I hindered critical analysis of the prophase I chromosomes.

**DESCURIANIA:**

This genus is represented by a single species, *D. sophia*, in our area. This species, widely distributed in Kashmir and adjoining parts, is locally known as "chare lachigh". It is used in the 'curing' of measles. In Kashmiri families, the bed of the patient suffering from measles is dusted with the seeds of this species. This is said to make the red rashes, characteristic of this disease, appear distinctly and rapidly, resulting in an early subsiding of fever.

The plants of this species are characterised by pinnatisect leaves, yellow flowers and reddish brown seeds.

**Cytology:**

**Karyotype**

28 chromosomes were counted in all the actively dividing root tip cells of this species (Fig. 77). The chromosome size ranges from 0.84 μm to 1.36 μm. Total and mean chromatin lengths of this complement are 30.34 μm and 1.08 μm respectively. The ratio between the size of
the longest and the smallest chromosome of this complement is 1.62.

Meiosis:

Due to low stainability of its chromosomes, prophase I stages could not be analysed. At metaphase I 14 bivalents were observed in all the cells scored (Fig. 78). At this stage, there were, on an average, a total of 25.43 chiasmata per cell of which 24.8 were terminal and 0.63 interstitial. Respective values for chiasmata frequency per bivalent work out to be 1.8, 1.78 and 0.04.

Anaphase I segregations were equal with 14 chromosomes moving to each pole (Fig. 79). 94.6% of the pollen produced by this species stained well with propionocarmine.

SISYMBRIUM:

In Kashmir valley and the adjoining areas, the genus Sisymbrium is represented by four species namely S. irio, S. loeselii, S. officinale and S. brassiciforme. Out of these, S. loeselii and S. irio are very widely distributed and are commonly found growing on road sides and shady moist places. S. officinale, an introduced species in Kashmir (Jafri, 1973), is very rare in this region growing at only a few places in Pahalgam. S. brassiciforme was
Figs. 80 - 82: Somatic chromosomes of three species of *Sisymbrium*

Fig. 80: *S. triflorum* (2n = 14)
Fig. 81: *S. tomentosum* (2n = 14)
Fig. 82: *S. officinale* (2n = 14)

scale 10 μm
collected from Ladakh.

The plants of this genus are characterised by lyrate to pinnatipartite leaves and yellow flowers. Morphological features of the four species included in the present study are summed up in table No. 32 (page 94).

Cytology:

Karyotype

Karyotypic details of three species namely S. irio, S. losselii and S. officinale have been studied. These three species are diploid with 2n = 14 chromosomes. The salient features of the somatic chromosomes of these three species are presented below.

Table No. 33 : Salient features of the somatic chromosomes of three species of Sisymbrium

<table>
<thead>
<tr>
<th>Species</th>
<th>2n</th>
<th>Fig. No.</th>
<th>TCL (μm)</th>
<th>MCL (μm)</th>
<th>Chromosome</th>
<th>Longest (L)</th>
<th>Smallest (S)</th>
<th>L/S</th>
</tr>
</thead>
<tbody>
<tr>
<td>S. irio</td>
<td>14</td>
<td>80</td>
<td>19.78</td>
<td>1.41</td>
<td>1.77</td>
<td>1.1</td>
<td>1.6</td>
<td></td>
</tr>
<tr>
<td>S. losselii</td>
<td>14</td>
<td>81</td>
<td>16.49</td>
<td>1.19</td>
<td>1.51</td>
<td>0.92</td>
<td>1.64</td>
<td></td>
</tr>
<tr>
<td>S. officinale</td>
<td>14</td>
<td>82</td>
<td>23.75</td>
<td>1.69</td>
<td>2.4</td>
<td>1.34</td>
<td>1.79</td>
<td></td>
</tr>
</tbody>
</table>

As is clear from the above table, in these species of Sisymbrium, the chromosome size ranges from 0.92 μm (smallest chromosome of S. losselii) to 2.4 μm (longest
Table No. 32: Morphological features of four species of *Sisymbrium*

<table>
<thead>
<tr>
<th>Morphological characters</th>
<th><em>S. irio</em></th>
<th><em>S. lesselii</em></th>
<th><em>S. officinale</em></th>
<th><em>S. brassiciforme</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Plant height</td>
<td>14 - 18 cms</td>
<td>25 - 100 cms</td>
<td>33 - 40 cms</td>
<td>45 - 60 cms</td>
</tr>
<tr>
<td>Leaf shape</td>
<td>Pinnate</td>
<td>Lyrate - pinnate partite</td>
<td>Pinatate-sect Lyrate</td>
<td></td>
</tr>
<tr>
<td>No. of flowers per raceme</td>
<td>16 - 23</td>
<td>62 - 75</td>
<td>33 - 35</td>
<td>35 - 50</td>
</tr>
<tr>
<td>Raceme length in fruit</td>
<td>10 - 13 cms</td>
<td>32 - 38 cms</td>
<td>10 cms</td>
<td>35 - 40 cms</td>
</tr>
<tr>
<td>Flower size (across)</td>
<td>3 mm</td>
<td>3 mm</td>
<td>6 - 7.5 mm</td>
<td>4 - 4.5 mm</td>
</tr>
<tr>
<td>Sepal size</td>
<td>2.5 - 3 mm</td>
<td>3.5 - 4 mm</td>
<td>2 mm</td>
<td>3 mm</td>
</tr>
<tr>
<td>Petal size</td>
<td>4 mm</td>
<td>7 - 8 mm</td>
<td>4 mm</td>
<td>6.5 - 7 mm</td>
</tr>
<tr>
<td>Stamen size</td>
<td>2 - 2.5 mm</td>
<td>3 - 3.5 mm</td>
<td>2 - 3 mm</td>
<td>3 - 3.5 mm</td>
</tr>
<tr>
<td>Anther size</td>
<td>0.5 - 1 mm</td>
<td>1 - 1.5 mm</td>
<td>0.5 mm</td>
<td>1.5 mm</td>
</tr>
<tr>
<td>Pedicel size</td>
<td>6 mm</td>
<td>7 - 9 mm</td>
<td>2 - 3 mm</td>
<td>7 - 9 mm</td>
</tr>
<tr>
<td>Style size</td>
<td>0.5 mm</td>
<td>1 - 1.5 mm</td>
<td>0.5 mm</td>
<td>1.5 mm</td>
</tr>
<tr>
<td>Siliquae size</td>
<td>45 - 50 mm</td>
<td>25 - 52 mm</td>
<td>15 - 18 mm</td>
<td>80 - 85 mm</td>
</tr>
</tbody>
</table>

Chromosome of *S. officinale* with the total chromatin length ranging from 16.49 μm (*S. lesselii*) to 23.75 μm (*S. officinale*).

Meiosis:

Meiotic details of all the four species *S. irio*
(n = 7), S. loeselii (n = 7), S. officinale (n = 7) and S. brassiciforme (n = 21) have been studied. All these species undergo normal meiosis characterised by the formation of bivalents only followed by regular anaphasic segregations. In S. brassiciforme, the chromosome count of n = 21 has been made for the first time. In none of the pollen mother cells of S. brassiciforme studied, were any multivalent associations observed. The only apparent abnormality observed was the stickiness of bivalents at metaphase I. This also did not impair the future course of meiosis in this species.

The chiasmata frequencies and other details of these four species have been tabulated in table No. 34 (page 96).

Due to very small size of bivalents at metaphase I, chiasmata frequency at this stage could be analysed only in S. officinale. In the other three species, the bivalents appear as highly condensed dots only at this stage.

DISCUSSION

Sisymbrieae is by far one of the well represented tribes of Brassicaceae in Kashmir and adjoining areas. According to Naqshi (1977) this tribe is represented by about 20 species in this part of the Indian subcontinent. In the present investigation 12 species representing four
Figs. 83 - 93: Meiosis in four species of *Sisymbrium*

Figs. 83 - 85: *S. irio* (n = 7)
- Fig. 83: Diploctene
- Fig. 84: Metaphase I
- Fig. 85: Anaphase I

Figs. 86 - 88: *S. laevis* (n = 7)
- Fig. 86: Diploctene
- Fig. 87: Metaphase I
- Fig. 88: Anaphase I

Figs. 89 - 91: *S. officinale* (n = 7)
- Fig. 89: Diploctene
- Fig. 90: Metaphase I
- Fig. 91: Anaphase I

Figs. 92 & 93: *S. brassiciforme* (n = 21)
- Fig. 92: Diakinesis
- Fig. 93: Anaphase I

scale 10 μm
**Table No. 34: Meiotic details of four species of *Sisymbrium***

<table>
<thead>
<tr>
<th>Name of species</th>
<th>Stage</th>
<th>Fig. No. scored</th>
<th>Meiotic cells</th>
<th>Total</th>
<th>Interstitial</th>
<th>Terminal</th>
<th>No. of Nucl-</th>
<th>Nucl- stain-</th>
<th>Ne. of pollen</th>
<th>Ne. of pollen per cell</th>
<th>%age</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>S. irio</em></td>
<td>Dip.</td>
<td>83</td>
<td>40</td>
<td>14.4</td>
<td>2.06</td>
<td>1.02</td>
<td>0.15</td>
<td>13.39</td>
<td>1.91</td>
<td>0 - 1</td>
<td>97.34</td>
</tr>
<tr>
<td></td>
<td>MI</td>
<td>84</td>
<td>Could not be studied</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>S. losellii</em></td>
<td>Dip.</td>
<td>86</td>
<td>40</td>
<td>12.49</td>
<td>1.78</td>
<td>0.94</td>
<td>0.13</td>
<td>11.55</td>
<td>1.65</td>
<td>1</td>
<td>97.7</td>
</tr>
<tr>
<td></td>
<td>MI</td>
<td>87</td>
<td>Could not be studied</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>S. officinale</em></td>
<td>Dip.</td>
<td>89</td>
<td>40</td>
<td>15.13</td>
<td>2.16</td>
<td>3.23</td>
<td>0.46</td>
<td>11.9</td>
<td>1.7</td>
<td>1</td>
<td>96.6</td>
</tr>
<tr>
<td></td>
<td>MI</td>
<td>90</td>
<td>40</td>
<td>12.38</td>
<td>1.77</td>
<td>0.00</td>
<td>0.00</td>
<td>12.38</td>
<td>1.77</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>S. brassiciforme</em></td>
<td>Dip.</td>
<td>92</td>
<td>35</td>
<td>44.18</td>
<td>2.1</td>
<td>8.09</td>
<td>0.39</td>
<td>36.09</td>
<td>1.72</td>
<td>1 - 2</td>
<td>95.9</td>
</tr>
</tbody>
</table>
genera of this tribe have been studied for cytological
details. These are Alliaria petiolata, Arabidopsis thaliana,
A. himalaica, A. mollissima, A. stricta, A. wallichii,
A. gumila, Descuriania sophia, Sisymbrium iria, S. losali,
S. officinale and S. brassiciforme.

TAXONOMY

The taxonomy of all the four genera of this tribe, included in the present study, is in a confusing state.
Alliaria is the smallest genus of this tribe, represented
by only two species namely A. petiolata and A. brachycarpa
(Jafri, 1973; Boisser, 1867); with another species,
A. officinalis, considered by Cavera and Grande (1913) as
a synonym of A. petiolata. While A. brachycarpa is
endemic to caucasian region (Jafri, 1973), A. petiolata
has a world wide distribution. In the Kashmir valley,
plants of this species inhabit altitudes ranging from
5,000 to 10,000 ft. So far, cytological details of only
A. petiolata have been studied.

Linnaeus (1753) had described the present day
Descuriania sophia under the name "Sisymbrium sophia". However, on the basis of distinct leaf characters,
Webb and Berth (1891) removed this species ("S. sophia")
from genus Sisymbrium and placed it in the genus
Descuriania as D. sophia.
Amongst the four genera, Alliaria, Arabidopsis, Descuriania and Sisymbrium, Arabidopsis is one such genus whose validity as a member of tribe Sisymbrieae is still a matter of doubt and controversy (Jafri, 1973). Morphologically this genus is closely similar to Microsium and Tollaria (both belonging to the tribe Sisymbrieae) on the one hand and Arabis (tribe Arabideae) on the other. Table No. 35 sums up the contrasting features of these four genera.

Table No. 35: Salient contrasting morphological and cytological details of Arabis (Arabideae) and three genera of tribe Sisymbrieae (Source: Darlington and Wylie, 1955; Fedorov, 1969; Jafri, 1973; Present work)

<table>
<thead>
<tr>
<th>Genus</th>
<th>Tribe</th>
<th>Radicle</th>
<th>Wet seeds/mucilaginous</th>
<th>Base non-mucilaginous numbers</th>
</tr>
</thead>
<tbody>
<tr>
<td>Arabis</td>
<td>Arabideae</td>
<td>Incumbent</td>
<td>Present</td>
<td>Non-mucilaginous 6, 7 and 8</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Arabidopsis</td>
<td>Sisymbrieae</td>
<td>Incumbent</td>
<td>Present</td>
<td>Mucilaginous 3, 5, 6 (But non-mucilaginous in A. septata)</td>
</tr>
<tr>
<td>Microsium</td>
<td>Sisymbrieae</td>
<td>Incumbent</td>
<td>Present</td>
<td>Non-mucilaginous Not known</td>
</tr>
<tr>
<td>Torularia</td>
<td>Sisymbrieae</td>
<td>Incumbent</td>
<td>Absent</td>
<td>Non-mucilaginous 7</td>
</tr>
</tbody>
</table>
As is clear from table No. 35 (page 98), these four genera differ from each other in very few characters. In view of this fact, taxonomic revaluation of these four genera is very much needed.

The taxonomic situation regarding the sympatrically growing species of Arabidopsis namely A. himalaica and A. mollissima too is very interesting. The plants of these species resemble in all morphological details except one i.e. the presence (A. himalaica) or absence (A. mollissima) of bracts. Except this minor difference similarity between these two species is so much that it is not possible to distinguish one from the other without a close scrutiny. Cytologically too, the two species have the same chromosome number (n = 8). As such it would be very interesting to establish the true validity of these species through controlled crossings. In case the two 'types' do not cross then these might have established reproductive barriers. On the other hand if these cross and produce fertile hybrids, it would be a pointer towards their close similarity and the presence or absence of bracts may turn out to be a single gene difference only. Whether these two species hybridise in nature or not, is not possible to detect.

Among the four species of genus Sisymbrium included
in the present study, *S. loeselii* alone is widely distributed in Kashmir valley and adjoining areas. Plants of this species, growing at altitudes ranging from 5,000 to 12,000 ft. are often found in diverse habitats. However, this adaptability often gets reflected in the phenotype of its plants, especially in plant size; plants as small as 25 cms and as tall as one metre are met with. Moreover, the plants of *S. loeselii* seem to be great colonisers. This wide variation in the morphological characters can only be possible if the genotype of this species is highly flexible. Khoshoo (1966) on the basis of his extensive work on *Sisymbrium*, has also commented that the genotypic dynamism confers an important advantage on the taxa enabling them to inhabit diverse habitats.

*Sisymbrium irio*, although not as widespread as *S. loeselii*, is a highly polymorphic species with respect to its leaf, flower and pedicel size. Some forms of this species are at times confused with the plants of *S. loeselii*. However, rocket shaped leaves and siliques overtopping the young buds in *S. irio* distinguishes it from *S. loeselii*.

**CHROMOSOME NUMBERS**

Out of the 12 species belonging to this tribe and included in the present study, cytological details of *Arabidopsis stricsta* have been studied for the first time.
New chromosome counts have been established for two species namely *Arabidopsis wallichii* and *Sisymbrium brassiciforme*.

Table No. 36 reveals that out of 127 species representing the four genera namely *Allaria*, *Arabidopsis*, *Descuriania* and *Sisymbrium*, chromosome numbers of only 52 (40.95%) are on record.


<table>
<thead>
<tr>
<th>Genus</th>
<th>Total number of species/number of species whose chromosome numbers are known</th>
<th>Base Nos.</th>
<th>Diploids</th>
<th>Polyploids</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allaria</td>
<td>2/1</td>
<td>7, 9?</td>
<td></td>
<td></td>
</tr>
<tr>
<td><em>Arabidopsis</em></td>
<td>15/7</td>
<td>3, 5, 6, 8 and 8</td>
<td>75</td>
<td>25</td>
</tr>
<tr>
<td><em>Descuriania</em></td>
<td>40/16</td>
<td>7, 10</td>
<td>56.2</td>
<td>43.8</td>
</tr>
<tr>
<td><em>Sisymbrium</em></td>
<td>70/28</td>
<td>7, 8 and 13</td>
<td>67.9</td>
<td>32.1</td>
</tr>
</tbody>
</table>

**Allaria**

The present observation of $2n = 14$ in *A. petiolata*, the only species of this genus present in the area of study,
confirms the earlier observations of Gohil and Kaul (1976a).
Before the report of $2n = 14$ in this species by Gohil and Kaul (1976a), only the polyploid cytotypes with $2n = 36$, 36-40, 42 and 43 (Fedorov, 1969) of this species had been isolated. It is quite apparent that despite such a wide variability in chromosome numbers, *A. petiolata* has been able to retain its distinct taxonomic identity.

**Arabidopsis**

Six species of this genus studied in the present investigation exist in three chromosomal races of $2n = 10$ (*A. thaliana*), 16 (*A. himalaica, A. mollissima, A. stricta* and *A. wallichii*) and 32 (*A. pumila*). The present observation of $2n = 10$ in *A. thaliana* confirms the earlier chromosome counts reported in this species by Manton (1932), Steintiz - Sears (1962, 1963), Joness (1976), and Klastarska and Ramal (1980). However, the report of *A. thaliana* with $2n = 6$ (Fedorov, 1969) indicates that this species exists in nature in two cytotypes with $2n = 6$ and 10.

As mentioned earlier, the cytological details of *A. stricta* ($2n = 16$) have been studied for the first time during the course of present investigation.

The present count of $n = 8$ in *A. wallichii* is at variance with the report of Naqsh and Javeid (1976).
of $n = 9$ in this species. Although during the present study plants of *A. wallichii* were collected from many geographically isolated areas, in none of these populations was $n = 9$ observed. Moreover, the population from Shankaracharya hills, studied by Naqshi and Javeid (1976), was also thoroughly scanned and in none of the plants of this population the earlier count was confirmed. In view of the fact that the critical and extensive study conducted during the present investigation has failed to confirm the earlier count of $n = 9$ by Naqshi and Javeid (1976), makes this count doubtful.

Within the genus *Arabidopsis*, only 25% of species investigated, so far, are polyploid (table No. 36, page 101). It is an indicator that although polyploidy has been effective in this genus, it has not played a very vital role in evolution within this genus.

**Daucuriania**

$2n = 28$ chromosomes in *D. sophia*, studied during the present investigation, confirm the earlier findings of Jaretzky (1928), Manton (1932), Löve and Löve (1956) and Mulligan (1961). However, Baez-Major (1934) and Manton (1932) have also reported two more cytotypes of this species with $2n = 20$ and 56 respectively, indicating thereby that *D. sophia* also exists in nature in three cytotypes with
2n = 20, 28 and 56. A somewhat similar situation is also met in *D. obtusa* (2n = 14 and 42), *D. pinnata* (2n = 14, 28 and 42) and *D. rachardsonii* (2n = 14, 28 and 42), (Fedorov, 1969). This is an indicator towards the existence of different cytotypes in various species of Descurriania. All these species of *Descurriania* seem to bear numerical changes in their chromosome complement without any drastic effect on their specific entities.

A perusal of available literature reveals that 43.8% (table No. 36, page 101) species of *Descurriania* are polyploid. It indicates that compared to *Arabidopsis*, polyploids have been more successful in *Descurriania*.

**Sisymbrium**

Out of the four species of this genus namely *S. iria*, *S. loselii*, *S. officinalis* and *S. brassiciformis*, studied during the present investigation, the chromosome count of 2n = 42 in *S. brassiciformis* is at variance with the earlier record of 2n = 14 (Fedorov, 1969) in this species. In the other three species, the present observations of 2n = 14 in conformity with the earlier reports (Järschény, 1932; Rohwedder, 1937; Wulff, 1937; Löve and Löve, 1956; Mulligan, 1957; Podlech and Dieterle, 1969 and Aryavand, 1978.)

The situation regarding *S. iria* is interesting. Although only its diploid race (2n = 14) could be isolated
during the present investigation, Khoshoo (1964) had isolated diploid, triploid, tetraploid, hexaploid and octaploid races in this species. Khoshoo (1964) is of the opinion that the wide variability in morphological features in this species is a result of both the differences in chromosome numbers as also the diverse habitats these occupy. As mentioned on page 104, during the course of present investigations, all the collections of *S. irio* made from diverse habitats, exhibiting enormous variability turned out to be diploid only and no other cytological race could be isolated. Since Khoshoo (1955, 1957a, 1957b, 1958a, 1958b, 1959a, 1959b, 1959c, 1959d, 1959e, 1960, 1964, 1965, 1966) made his studies on *S. irio* growing in Punjab, it was not possible to cover these populations in the present investigations.

**Base Numbers**

Tribe Sisymbrieae is multibasic with $x = 3, 5, 7, 8, 9, 11$ and $20$ on record (Darlington and Wylie, 1955; Fedorov, 1969; Gohil and Kaul, 1976). $x = 20$ has been recorded in a single genus *Camelina* (Darlington and Wylie, 1955). It is the highest base number recorded not only in the tribe Sisymbrieae but in the entire family Brassicaceae and appears to be a secondary base number only.
Alliaria

The present observation of $2n = 14$ in *Alliaria petiolata* supports the opinion expressed earlier by Gohil and Kaul (1976) of $x = 7$ in this genus. The still unconfirmed second base number (9?) for this genus (Darlington and Wylie, 1955) if confirmed will then become another base number for this genus. As discussed earlier (page 102), *Alliaria petiolata* exists in nature in various chromosomal races with $2n = 14, 36, 36 - 40, 42$ and $43$ (Fedorov, 1969). If $x = 9$ is one of the base numbers, then the cytotype with $2n = 36$ is a tetraploid and cytotypes with $2n = 36 - 40$ and $43$ represent aneuploid races based either on $x = 7$ or $9$ and the cytotype with $2n = 42$ represents a hexaploid form with $x = 7$.

The confusion regarding the base number/s for this genus can only be solved after the cytological details of *Alliaria brachycarpa*, the only other species of this genus, are known.

Arabidopsis

Out of the six species of this genus, studied in the present investigation, only *Arabidopsis thaliana* is based on series with $x = 5$, all the others have $x = 8$. However, the report of $2n = 6$ in *Arabidopsis thaliana* (Fedorov, 1969) and $2n = 12$ in *Arabidopsis tozophylla* (Fedorov, 1969) indicate that
Arabidopsis is tetrabasic with $x = 3, 5, 6$ and $8$.

The predominance of species of this genus with $x = 8$ (66.67%) indicates that 8 is the ancestral base number and all other numbers have originated from it by deletion of chromosomes. Since it is rather difficult to imagine the reduction in number to less than half of the primary number, that is from $x = 8$ to $x = 3$, it appears more plausible that this genus has more than one primary base numbers.

Descuriania

Except for a solitary report of *D. sophia* with $2n = 20$ (Baez - Major 1934) all the species of this genus are monobasic with $x = 7$. Cytotypes of *D. sophia* with $x = 7$ are also on record (Fedorov, 1969). This indicates that 7 is the only base number for the genus Descuriania. The presence of $2n = 20$ in one cytotype of *D. sophia* can be explained on the basis of either the presence of another base number ($x = 10$) or on the basis of its being an aneuploid.

Sisymbrium

All the four species, worked out presently, have $x = 7$. However, some species of this genus with $x = 8$ are also on record (Fedorov, 1969). At the same time the
presence of $2n = 26$ in 
*Sinapis littoralis* (Fedorov, 1969) can
be either due to the presence of a third base number ($x = 13$)
or its being hypotetraploid with $7$ as its base number.

The predominance of species (80%) with $x = 7$ in
*Sisymbrium* suggests that $7$ is the ancestral base number in
this genus.

**SOMATIC CHROMOSOMES**

Karyotypic details could be studied in only nine
species of this tribe. Due to the extremely small size of
chromosomes in other taxa, individual chromosome morphology
could be studied only in *Alliaria petiolata*. In this
species, the 14 chromosomes which make up its diploid
complement, are composed of 2 median and 14 submedian
chromosomes.

Some of the salient features regarding the somatic
chromosomes of these nine species have been summed up in
table No. 37 (page 109).

As is clear from table No. 37 (page 109), the
smallest chromosome has been observed in *Arabidopsis pumila*
(0.79 µm) and the longest in *Sisymbrium officinale* (2.4 µm).
In keeping with their tetraploid status both in
*Arabidopsis pumila* and *Daucus carota* ssp.*aphia*, the total
chromatin length is more than that found in the diploid
Table No. 37: Salient features of the somatic chromosomes of nine species of tribe Sisymbrieae.

<table>
<thead>
<tr>
<th>Species</th>
<th>2n</th>
<th>TCL (μm)</th>
<th>MCL (μm)</th>
<th>Shortest (S)</th>
<th>Longest (L)</th>
<th>L/S</th>
</tr>
</thead>
<tbody>
<tr>
<td>Allaria petiolata</td>
<td>14</td>
<td>24.54</td>
<td>1.75</td>
<td>1.28</td>
<td>2.29</td>
<td>1.74</td>
</tr>
<tr>
<td>Arabidopsis mollissima</td>
<td>16</td>
<td>19.68</td>
<td>1.23</td>
<td>0.94</td>
<td>1.68</td>
<td>1.78</td>
</tr>
<tr>
<td>A. stricta</td>
<td>16</td>
<td>21.73</td>
<td>1.35</td>
<td>1.09</td>
<td>1.72</td>
<td>1.57</td>
</tr>
<tr>
<td>A. wallichii</td>
<td>16</td>
<td>23.68</td>
<td>1.48</td>
<td>1.09</td>
<td>1.93</td>
<td>1.77</td>
</tr>
<tr>
<td>A. pumila</td>
<td>32</td>
<td>35.88</td>
<td>1.11</td>
<td>0.79</td>
<td>1.51</td>
<td>1.91</td>
</tr>
<tr>
<td>Descuriania sophia</td>
<td>28</td>
<td>30.34</td>
<td>1.08</td>
<td>0.84</td>
<td>1.36</td>
<td>1.62</td>
</tr>
<tr>
<td>Sisymbrium irio</td>
<td>14</td>
<td>19.78</td>
<td>1.41</td>
<td>1.10</td>
<td>1.77</td>
<td>1.60</td>
</tr>
<tr>
<td>S. loseellii</td>
<td>14</td>
<td>16.49</td>
<td>1.19</td>
<td>0.92</td>
<td>1.51</td>
<td>1.64</td>
</tr>
<tr>
<td>S. officinalis</td>
<td>14</td>
<td>23.75</td>
<td>1.69</td>
<td>1.34</td>
<td>2.4</td>
<td>1.79</td>
</tr>
</tbody>
</table>

species. However, in the tetraploid A. pumila, the total chromatin length is only about 1.2 times more than that found in the other two diploid species of Arabidopsis namely A. stricta and A. wallichii. At the same time, although Allaria petiolata has only 14 chromosomes, its total chromatin length is more than that found in other diploid taxa of this tribe. This is also evident from the fact that all its chromosomes could be studied individually for morphological details.

Arabidopsis

Amongst the taxa listed in table No. 37 (above),
Arabidopsis deserves a special mention. Because of the presence of a very low amount of nuclear DNA (lowest amongst the angiosperms found in *A. thaliana*), the genus, particularly *A. thaliana*, has attracted the attention of many cytogeneticists. The total DNA present in the haploid complement of *A. thaliana* is only about 50 times to what is found in *Escherichia coli* (Klasteraska and Ramel, 1980).

Compared to *A. thaliana* whose somatic chromosomes, as measured by Steinitz - Sears (1963) at anaphase I, range from 1.1 um to 3.7 um, the chromosomes in the species studied during the present investigation range from 0.79 um (smallest chromosome of *A. pumila*) to 1.48 um (longest chromosome of *A. wallichii*).

Keeping in view Stebbin's (1958) hypothesis that the karyotypic evolution has progressed with an increase in its asymmetry, it appears that of the three diploid species studied, *A. wallichii* is more primitive and *A. mollissima* is more advanced with *A. stricta* lying in between these two extremes. It is interesting to note that in these three species this trend is accompanied by a decrease in the total chromatin length.

*Sisymbrium*

In the three species of this genus, whose somatic
chromosomes have been studied, the chromosome size ranges from 0.92 \mu m (S. loeselii) to 2.4 \mu m (S. officinale). Although these three species are diploid with 2n = 14, total chromatin length is maximum in S. officinale (23.75 \mu m). Keeping in view the ratio between the size of the longest and the smallest chromosomes of these three species, the karyotype of S. officinale is more asymmetrical than the other two. However, on the basis of total chromatin length, S. irio, with minimum total chromatin length (19.78 \mu m) appears to be more advanced as compared to S. officinale (23.75 \mu m).

From the above discussion it appears that within this genus the evolution has progressed on two different lines.

MEIOSIS

In all the 12 species of this tribe, studied presently, meiosis was normal characterised by the formation of bivalents only. Although in diploid species this behaviour is expected, the perfect pairing of chromosomes in tetraploid Descuriania sophia (2n = 4x = 28) and Arabidopsis pumila (2n = 4x = 32) point towards the possibility of these two species being genomic allotetraploids.

The maximum ploidy level, amongst the taxa studied, was met in Sisymbrium brassiciforme. The 42 chromosomes of
this species regularly pair to form 21 bivalents only followed by regular anaphasic segregation. With \( x = 7 \) in this genus, this cytotype is a hexaploid. In nature hexaploids are usually formed either as a result of a cross between a tetraploid and a diploid parent followed by the doubling of chromosomes in \( F_1 \) or from a tetraploid only by the fertilization of an unreduced egg by a reduced pollen grain. In the present case the hexaploid becomes interesting because in this species so far only diploid (Fedorov, 1969) and hexaploid (present study) cytotypes have been isolated. There is no report of any tetraploid cytotype. The present observations and also the earlier one of hexaploids and diploids in this species point towards the fact that the tetraploid cytotype of this species should also be present in nature.