POLYGONUM L.
INTRODUCTION

The first monograph on the genus *Polygonum*, titled "Monograph of the North American species of the genus *Polygonum*" was compiled by Small (1895). Before Small (1895), Meisner (1826) recognised *Bistorta*, *Fagopyrum*, *Persicaria*, *Avicularia*, *Tiniaria*, *Aconogonon* and *Amblygonon* as sections of the genus *Polygonum* L.

Bentham and Hooker (1883) divided *Polygonum* L. into 10 sections namely: *Tephis*, *Avicularia*, *Pseudomollia*, *Persicaria*, *Tovara*, *Cephalophilon*, *Aconogonon*,
Pseudopolyg onella, Tiniaria and Pleuropterus.

Britton and Brown (1915) raised the sections Tovara, Persicaria, Historta, Tracaulon (Polygonum sagittatum) and Tiniaria to generic level. The genus Polygonum s. s. as delimited by Britton and Brown (1915) was based on Polygonum aviculare and its closest allies.

Löve and Löve (1956a) on the basis of extensive cytogenetical studies in this group divided the 13 sections, usually included in Polygonum L. sensu lato, into 6 genera namely: Historta Mill., Pleuropteropyrum Gross., Bilderdia Dum., Reynoutria Hout., Persicaria Mill. and Polygonum L. sensu stricto.

Doida (1957, 1958, 1960a, 1962a and 1962b) classified the various species of Polygonum into 7 groups and discussed intergeneric differentiation and the direction of evolution in this genus on the basis of his investigations on number of pollen grains per pollen sac, pollen morphology and karyological studies. Besides this, help was also sought from external morphology of the plants.

Hooker (1885) described 70 species of Polygonum from the Indian subcontinent; of these 39 were from
Jammu and Kashmir State. Blatter (1928) gave an illustrative account of 31 species of *Polygonum* collected from Kashmir valley and its neighbourhood. Stewart (1972) listed 71 species of *Polygonum* from West Pakistan and Kashmir, of which 37 have been reported from Kashmir valley. Kitamura (1960) was able to collect 29 species of *Polygonum* from Hindskush and Karakorum. Timson (1963) studied the taxonomy of some species of *Polygonum*. Tutin, Heywood, Burges, Valentine, Walters and Webb (1964) described 36 species of *Polygonum* from Europe. Dalci (1972 and 1974) studied the taxonomy of section Persicaria in United States east of Rocky mountains. Munshi and Javeid (1975) were able to collect *Polygonum maritimum*, a new record for India, from Kashmir. Brooks and Mertens (1971) and McDonald (1980) studied biosystematics of a number of species of *Polygonum* of America.

Cytological investigations in the species of *Polygonum* were initiated by Jaretzky (1928) followed by Löve and Löve (1942, 1943, 1948, 1954, 1956a,b, and 1966), Polya (1948), Löve (1951), Doida (1960 and 1961a) and Engell (1973 and 1978). Karyological studies in the species of *Polygonum* have been made by Omura and Kono (1960), Sharma and Chatterji (1960) and Shahay and Sharma (1978). Pollen morphology of various
Fig. 38 - Plants of *Polygonum affine*.
species of *Polygonum* has been studied by Wodehouse (1931), Hedberg (1946) and Nair (1965).

Out of over 300 species grouped under the genus *Polygonum* sensu lato, chromosome numbers of 135 are on record (Darlington and Wylie, 1955; Fedorov, 1969; Ornduff, 1970, 1971, 1972, 1974 and 1977). The genus *Polygonum* sensu lato is pentabasic with \( x = 8, 10, 11, 12 \) and 17 (Darlington and Wylie, 1955 and Doida, 1961).

*Polygonum aviculare, P. plebejum, P. tripetrocarpum, Persicaria hydropiper, P. orientale, P. perfoliata* and *Pleuropteropyrum alpinum* represent cytological complexes existing in two or more than two cytotypes. *Bistorta vivipara* is a polyploid complex with chromosome numbers ranging from \( 2n = 77 \) to 132 (Fedorov, 1969 and Engell, 1973).

**OBSERVATIONS**

1. **Morphology:**
   1. *Polygonum affine*; (Fig. 38).

   Perennial with a tortuous branched rhizome from which 10 - 20 cm tall flowering stems arise. Leaves chiefly radical, 3-4 cm long, ovate, subsessile. Ochrea tubular with a hairy mouth. Inflorescence a short
Fig. 39 - Plant of *Polygonum alpinum*.
Fig. 40 - Plant of *Polygonum amplexicaule*. 
peduncled, denseflowered solitary raceme. Flowers bracteate, pedicellate. Perianth pentasect, white or pink, each segment 3-4 cm long, ovate. Stamens 8, exerted; ovary trigonous; styles three, long, free; stigma capitate. Nut enclosed, trigonous, elliptical, brown, smooth, 3-4 mm long.

Flowering period: June - September.

2. *P. alpinum*: (Fig. 39).

Perennial with branched, fistular rhizome from which 60-200 cm tall branched flowering stems arise. Leaves 6-30 cm long, short petiolated. Cohrea tubular upper part deciduous. Inflorescence thyrsoid panicle. Flowers bracteate, pedicellate. Perianth pentasect, 1-1.5 mm long, white, 3 inner segments obovate. Stamens 8, filaments short. Ovary trigonous; styles 3, long; stigma capitate. Nut exerted, trigonous, concave, light brown, granulate 3.5 mm long.

Flowering period: June - July.

3. *P. amplexicaule*: (Fig.40).

Perennial, 20-80 cm tall herbs. Root stock stout and branched. Leaves petiolate or sessile, amplexicaule, lanceolate to ovate, 9-20 cm long, serrulate.
Fig. 41 - Plant of *Polygonum hydropiper*. 
Ochrea lacerate, glabrous, with prominent veins.

Inflorescence a long peduncled, terminal and axillary racemes. Flowers bracteate, pedicellate. Perianth segments five, less than 0.5 mm long; elliptic, acute, white, pink or dark pink. Stamens 8, in two whorls, inner whorl exerted. Ovary trigonous, styles 3, long, free; stigma capitate. Nut trigonous, concave, black, lustrous 5 mm long.

Flowering period: June - September.

4. P. hydropiper—(Fig. 41).

Annual, 30-80 cm long herbs. Stems slender, fistular, glabrous, erect and unbranched or decumbent and branched. Leaves subsessile, lanceolate, gland dotted. Ochrea loose tubular, glabrous, with short hairs arising from mouth. Inflorescence a filiform, decurved, interrupted, flexuous, long, terminal and axillary racemes. Flowers bracteate, pedicellate. Perianth segments 5, outer segments three, 1 - 1.5 mm long elliptic to ovate; inner two 0.5 - 0.8 mm long, elliptic. Stamens 7-8 in two whorls; ovary trigonous, styles 3 connate below; stigma capitate. Nut 3 mm long, enclosed, trigonous, concave, dark brown, granulate, with an apical beak.

Flowering period: June - September.
Fig. 42 - Plant of *Polygonum lapathifolium*.
Fig. 43 - Plant of *Polygonum nepalense*. 
5. *P. lapathifolium*—(Fig. 42).

Annual, branched, 30 - 100 cm tall herbs. Stems glabrous with dots. Leaves petiolate, lanceolate. Cauline leaves 10 - 15 cm, ramal leaves 6 - 8 cm long. Ochrea loose, truncate, tubular, eciliate with many prominent veins. Inflorescences both terminal and axillary, dense flowered, panicked racemes. Flowers bracteate, pedicellate. Perianth segments four or five, 1.8 mm long, pinkish white, ovate, obtuse. Stamens six, not exerted. Ovary biconvex, styles two, free, hooked; stigma capitate. Nut 2 - 2.5 mm long enclosed, orbicular, biconcave, dark brown, smooth, lustrous with a beak.

Flowering period: June - September.

6. *P. nepalense*—(Fig. 43).

Annual, branched herbs. Stem erect and 4 - 34 cm tall, or decumbent and 20 - 80 cm long, hairy. Leaves 2 - 8 cm long, hairy, ovate to deltoid ovate or lanceolate. Petioles winged. Ochrea tubular, nerved, truncate with hairs. Inflorescence terminal corymbose heads with a large involucral bract. Flowers minute, bracteate, pedicellate. Perianth pentad, segments 1 mm long, elliptic, blue or white. Stamens 5 - 6. Ovary biconcave; styles 2, long, connate at the base; stigma capitate. Nut covered, 2 mm
Fig. 44 - Plant of Polygonum orientale.
broad, ovoid-orbicular, biconvex, brown, lustrous.
Flowering period: July - September.

7. *P. orientale* - (Fig. 44).

Annual, branched, robust, 50-150 cm tall. Stems grooved, fistular, softly pubescent bearing 4-25 cm long petiolate, ovate leaves. Ochrea truncate, hirsute with 1 cm or longer hairs arising from the dilated, recurved, oblique mouth. Inflorescence a long terminal, dense flowered erect or filiform raceme. Flowers bracteate, pedicellate. Perianth segments five, outer segments ovate, inner elliptical, dark, pink, 4-5 mm long. Stamens 7 exerted; ovary biconvex; styles two, short, connate below; stigma capitate. Nut enclosed, orbicular, biconcave, black, granulate, 3 mm in diameter. Flowering period: June - August.

II. CYTOLOGY:

Somatic chromosomes of five species of *Polygonum* were studied during the present investigation; four of these are diploid and one a tetraploid. In all these species the chromosomes are small ranging in size from 0.66 - 2.06 μm in length. These are either median or submedian or subterminal in all the
Fig. 45 - Mitotic chromosomes of *Polygonum amplexicaule*.

Fig. 46 - Idiogram of the chromosomes of *P. amplexicaule*. 
species worked out. In general, the submedian type of chromosomes were found to be most common in the species studied. The karyotypic details of five species of Polygonum are given.

(a) Karyotype

1. *P. amplexicaule*:

As pointed out earlier, plants of this species bearing beautiful inflorescences with flowers of different colours inhabit subalpine meadows and forests of the valley of Kashmir. These colour variants, found under the same environmental conditions, retained the difference even when transplanted to the experimental plots of University Botanical Gardens. In addition to variation in their flower colour, it was found that these plants also differ in their chromosome count. The plants bearing white inflorescences have 24 chromosomes, those having light pink flowers have 22 chromosomes and those with dark pink flowers have 44 chromosomes in their root tip cells. Although the chromosome number of each of these types was confirmed both from the root tip cells as also from the study of their male meiosis, karyotypic details could be studied only in the variety with white flowers. In other two cytotypes good preparations were not available for studies as their rhizomes failed to produce many healthy root tips in the laboratory.
Fig. 47 - Somatic chromosomes of *Polygonum hydropiper*.

Fig. 48 - Idiogram of the chromosomes of *P. hydropiper*.
Of the 24 chromosomes present in the actively dividing root tip cells of plants with white flowers (Fig. 45), two are median, twenty submedian and two subterminal. These 24 chromosomes can be grouped into 12 pairs of two chromosomes each. The pairs of median and subterminal chromosomes occupy second and eighth positions respectively in the idiogram (Fig. 46). In none of these chromosomes could a satellite or a secondary constriction be observed.

The longest chromosome of this complement measures 1.89 μm in length and the smallest is 1.2 μm long. TCL of this complement is 36.7 μm and MCL is 1.53 μm. The ratio between the size of the longest and smallest chromosome of the complement is 1.5.

Karyotypic formula: 2 M × 20 SM × 2 ST.

2. P. hydropiper:—(Figs. 47 and 48).

In all the actively dividing root tip cells of this species only twenty chromosomes are present (Fig. 47). These 20 chromosomes are of three types. Eight chromosomes are median, ten submedian and two subterminal. These twenty chromosomes can be arranged into ten pairs of two chromosomes each. The four pairs of median chromosomes of this complement occupy fourth, fifth,
Fig. 49 - Mitotic chromosomes of *Polygonum lapathifolium*.

Fig. 50 - Idiogram of the chromosomes of *P. lapathifolium*.
sixth and tenth positions and the subterminal pair of chromosomes occupies ninth position in order of length in the idiogram (Fig. 48).

The longest chromosome of this complement measures 2.06 µm in length and the smallest is 1.03 µm long. The ratio between the size of the longest and the smallest chromosome of this complement is 2. TCL and MCL for this complement are 28.39 µm and 1.42 µm respectively.

Karyotypic formula: 8 M + 10 SM + 2 ST.

5. *P. lapathifolium* - (Figs. 49 & 50).

Based upon the position of centromere the 22 chromosomes (Fig. 49) comprising this karyotype can be grouped into three types. Two chromosomes are median, eighteen submedian and two subterminal. These 22 chromosomes can be grouped into 11 perfect pairs. The pair of subterminal chromosomes and the pair of median chromosomes occupy seventh and eleventh positions respectively in order of length in the idiogram of this complement (Fig. 50).

The longest and smallest chromosome of this complement measure 1.89 µm and 1.03 µm respectively.
Fig. 51a. - Mitotic chromosomes of *Polygonum nepalense*.

Fig. 51b. - Idiogram of the chromosomes of *P. nepalense*. 
The ratio between the size of the longest and the smallest chromosome of this complement is 1.83. TCL and MOL of this complement is 31.14 μm and 1.41 μm respectively.

Karyotypic formula: 2 M + 18 SM + 2 ST.

4. P. nepalense: (Fig. 51).

This species with 48 chromosomes (Fig. 51a) is a tetraploid. Based upon the position of centromere, its chromosomes can be grouped into three types. 40 chromosomes are submedian and four each are median and subterminal. These 48 chromosomes can conveniently be grouped into 12 groups of four chromosomes each. The group of four median chromosomes occupies eleventh and the group of subterminal chromosomes occupies sixth position in order of length in the idiogram (Fig. 51b).

The longest chromosome of this complement measures 1.72 μm in length and the smallest chromosome is only 1.03 μm long. The ratio between the size of the longest and the smallest chromosome of this complement is 1.66. TCL of this complement is 63.08 μm and MOL is 1.31 μm.

Karyotypic formula: 4 M + 40 SM + 4 ST.
Fig. 52 a. - Mitotic chromosomes of *Polygonum orientale*.
Fig. 52 b. - Idiogram of the chromosomes of *P. orientale*.
5. *P. orientale*- (Fig. 52).

All the actively dividing root tip cells of this species have twenty-two chromosomes (Fig. 52a). Of these six are median and sixteen submedian. These 22 chromosomes can be grouped into eleven pairs of two chromosomes each. The six median chromosomes form three pairs which occupy first, sixth and tenth positions in the idiogram (Fig. 52b). In none of the chromosomes of this species could the satellite or secondary constriction be observed.

The largest chromosome of this complement measures 1.2 μm in length while as the smallest is 0.86 μm long. The ratio between the longest and the smallest chromosome of this complement is 1.4 and the TCL and MCL for this complement are 23.2 μm and 1.05 μm respectively. Karyotypic formula: 6 M + 16 SM.

(b) *Male meiosis*

1. *P. affinis*-

In this species plants collected from the same locality had two different chromosome numbers. Some plants had *n* = 11 and others *n* = 12. Both these
Figs. 53-56. - Meiotic chromosomes of Polygonum affine.

Fig. 53 - 55 - Pollen mother cells at diplotene, metaphase I and telophase II respectively of the cytotype with n = 11. Mark the micromolecule at telophase II (Fig. 55).

Fig. 56 - Pollen mother cell of the cytotype with n = 12 at diplotene of meiosis.
races were growing side by side and in both of them
the chromosome pairing was perfect, resulting in the
formation of eleven or twelve bivalents at diplotene,
diakinesis and metaphase I. At diplotene of meiosis
in the cytotype with \( n = 11 \), a large deeply stained
nucleolus was prominent (Fig. 53). In some pollen
mother cells of this species (\( n = 11 \)) occasionally
a quadrivalent was also observed. However, frequency
of cells having a quadrivalent was very low. At
metaphase I of meiosis, the bivalents, which were
rod-shaped, oriented at the equatorial plate (Fig. 54).
At this stage too some pollen mother cells had one
quadrivalent and sometimes even two univalents and ten
bivalents were also observed. This minor anomaly in the
pairing behaviour of the chromosomes of this cytotype
resulted in slightly disturbed anaphase segregation in
a few cells. It mostly led to the formation of laggards.
These laggards which formed micronuclei were observed
at telophase II also (Fig. 55). In the plants having
\( n = 12 \) the pairing was perfect and 12 bivalents were
always found (Fig. 56). In none of the pollen mother
cells of this race could a quadrivalent or any other
association be observed. This normal pairing led to
clear anaphase I and II segregations.
Figs. 57 - 59 - Meiotic chromosomes of *Polygonum alpinum*.

**Fig. 57** - A pollen mother cell at diplotene with 10 bivalents.

**Fig. 58** - A pollen mother cell at metaphase I with 10 bivalents.

**Fig. 59** - A pollen mother cell at anaphase I with 10 chromosomes at each pole.
Pollen stainability in the two races was 65% (n = 11) and 64% (n = 12) respectively. The low pollen stainability of the former can be explained on the basis of anomalies observed during its meiosis. The seed set in both these races was very poor and the few seeds obtained did not germinate in the laboratory.

2. *P. alpinum*—

The pairing of chromosomes in *P. alpinum* was perfect and 10 bivalents were always found at diplotene (Fig. 57) and metaphase I (Fig. 58). At diplotene three bivalents were found attached to a large, round, uniformly stained nucleolus. The bivalents had one or two chiasmata at diplotene and at metaphase I. The mean chias mata frequency at diplotene of meiosis in this species is tabulated below (Table 9).

Table 9: Mean chias mata frequency at diplotene in *P. alpinum*.

<table>
<thead>
<tr>
<th></th>
<th>Interstitial</th>
<th>Terminal</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per cell</td>
<td>0</td>
<td>12</td>
<td>12</td>
</tr>
<tr>
<td>Per bivalent</td>
<td>0</td>
<td>1.2</td>
<td>1.2</td>
</tr>
</tbody>
</table>
Meiotic chromosomes of *Polygonum amplexicaule*.

(Cytotype with $n = 11$)

**Fig. 60** - A pollen mother cell at diplotene with eleven bivalents. Mark the two nucleolar bivalents.

**Fig. 61** - A pollen mother cell at late anaphase I with eleven chromosomes at each pole.

**Fig. 62** - A pollen mother cell at anaphase I with a chromatin bridge.
At metaphase I the bivalents, most of which were rod-shaped, lined at the equatorial plate. In some of the pollen mother cells at diplotene and at metaphase I two bivalents exhibited some sort of secondary association. The anaphase I (Fig. 59) and II segregation of chromosomes was normal with ten chromosomes moving to either pole. 86% of the pollen produced by these plants stained positively with acetocarmine and these plants set abundant seed. However, only 4% of the seed set by these plants germinated in the laboratory.

3. *P. amplexicaule*:

As pointed out earlier plants of this species have different chromosome numbers. In all, three different chromosomal races could be isolated. Although karyotypic details could not be studied in all of them, pollen mother cell meiosis has been scanned. Two of the cytotypes having \( n = 11 \) and \( n = 12 \) are diploids and one with \( n = 22 \) a tetraploid. Details of male meiosis in these three cytotypes are described.

(i) Plants with \( n = 11 \):

All the plants having light pink flowers had \( n = 11 \). The pairing of chromosomes in this cytotype was
Figs. 63 - 65 - Meiotic chromosomes of *Polygonum amplexicaule*. Cytotype with $n = 12$.

**Fig. 63** - A pollen mother cell at diplotene with twelve bivalents.

**Fig. 64** - A pollen mother cell at metaphase I with twelve bivalents.

**Fig. 65** - A pollen mother cell at anaphase I with 12 chromosomes at each pole.
perfect and eleven bivalents were found at diplotene. At this stage two bivalents were found attached to a large round nucleolus (Fig. 60). At metaphase I the eleven bivalents oriented at the equatorial plate followed by equal anaphase I (Fig. 61) and II segregations. In some of the pollen mother cells of this cytotype chromatin bridges were observed at anaphase I (Fig. 62). The seed set was poor and only 3% of the seeds produced by the plants of this cytotype germinated in laboratory.

(ii) Plants with \( n = 12 \)-

The cytotype with white flowers was also diploid but with the chromosome number \( n = 12 \). The pairing of chromosomes in this cytotype too was perfect and twelve bivalents were found at diplotene (Fig. 63) and metaphase I (Fig. 64). In some pollen mother cells at diplotene up to three bivalents were seen attached to a large nucleolus (Fig. 63). In some cells at this stage two of the bivalents associated with the nucleolus showed a tendency to remain together (Fig. 63). None of the diplotene bivalents had more than two chiasmata. The chiasmata frequency at diplotene and metaphase I in this cytotype is given in table 10.
Table 10: Mean chiasmata frequency in *P. amplexicaule* (n = 12).

<table>
<thead>
<tr>
<th>Stage</th>
<th>Interstitial</th>
<th>Terminal</th>
<th>Total</th>
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</thead>
<tbody>
<tr>
<td><strong>Diplotene</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per cell</td>
<td>2</td>
<td>12</td>
<td>14</td>
</tr>
<tr>
<td>Per bivalent</td>
<td>0.16</td>
<td>1</td>
<td>1.16</td>
</tr>
<tr>
<td><strong>Metaphase I</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Per cell</td>
<td>0</td>
<td>13</td>
<td>13</td>
</tr>
<tr>
<td>Per bivalent</td>
<td>0</td>
<td>1.08</td>
<td>1.08</td>
</tr>
</tbody>
</table>

At metaphase I also two bivalents had the tendency to remain together. The anaphase I segregation of chromosomes was perfect with 12 chromosomes moving to either pole (Fig. 65). The second meiotic division was also regular. Although 96.78% of the pollen produced by these plants stained with acetocarmine, the seed set in this cytotype too was poor. Only 6% of the seed produced by these plants germinated under experimental conditions.

(iii) Plants with n = 22:

The plants with dark pink flowers were tetraploid with n = 22. Despite the ploidal nature of
Figs. 66 - 67 - Meiotic chromosomes of
Polygonum amplexicaule.
Cytotype with n = 22.

Fig. 66 - A pollen mother cell at
diplotene with 18 bivalents
and two quadrivalents.

Fig. 67 - A pollen mother cell at
telophase I with laggards.
this cytotype, in most of the pollen mother cells studied, the 44 chromosomes paired to form 22 bivalents. Rarely, in some cells multivalent associations were also observed, but the number of multivalents per cell or the total number of cells having these multivalents was not much. The maximum number of multivalents observed in any cell was limited to two quadrivalents only (Fig. 66). At metaphase I the 22 rod-shaped bivalents oriented at the equatorial plate. Anaphase I segregation in most of the cells observed was normal with 22 ( ) 22.

As pointed out above the meiosis proceeded normally in most of the cells scanned. However, in some pollen mother cells chromatin bridges and laggards were observed at anaphase I, telophase I (Fig. 67), anaphase II and telophase II. The laggards usually formed micronuclei in these cells.

4. P. orientale

The pairing of chromosomes in this species was perfect and eleven bivalents were observed at diplotene and at metaphase I of meiosis. In cells at diplotene two bivalents were found attached to a round and uniformly stained nucleolus (Fig. 68). The maximum number of chiasmata per bivalent at diplotene was only two in this species and these too were found at the terminal
Figs. 68 - 70 - Meiotic chromosomes of Polygonum orientale.

Fig. 68 - A pollen mother cell at diplotene with 11 bivalents.

Fig. 69 - A pollen mother cell at metaphase I with 11 bivalents.

Fig. 70 - A pollen mother cell at anaphase - I with 11 chromosomes at each pole.
regions. The chiasmata frequency in the pollen mother cells of this species, at diplotene is given below (Table 11).

Table 11: Mean chiasmata frequency at diplotene in *P. orientale*.

<table>
<thead>
<tr>
<th></th>
<th>Interstitial</th>
<th>Terminal</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Per cell</td>
<td>0</td>
<td>16</td>
<td>16</td>
</tr>
<tr>
<td>Per bivalent</td>
<td>0</td>
<td>1.45</td>
<td>1.45</td>
</tr>
</tbody>
</table>

At metaphase I these bivalents were rod-shaped (Fig. 69) and anaphase I segregation was normal with 11 chromosomes moving to each pole (Fig. 70). Cytokinesis was of the simultaneous type. These plants set abundant seed; 53% of which germinated under experimental conditions.
Fig. 71 - The frequency of various ploidy levels in the genus *Polygonum*.
III. DISCUSSION

As pointed out earlier, the genus *Polygonum* sensu lato represents the biggest assemblage of the family Polygonaceae. Of the over 300 species of this genus chromosome numbers of about 130 (43.3%) are on record (Darlington and Wylie, 1955; Fedorov, 1969; Ornduff, 1968; Moore, 1970, 1971, 1972 and 1974). This genus is pentabasic with \( x = 8, 10, 11, 12 \) and 17 (Darlington and Wylie, 1955 and Doida, 1960b and 1961a). Polyplody in this genus ranges from triploidy to eleventh-ploidy. Diploids (43.5%) are most common followed by tetraploids (37%), hexaploids (10%), octaploids (2%) and decaploids (2%). The frequency of oddploids like triploids and heptaploids, etc. is very low (Fig.71). It is worth pointing out here that in species of *Polygonum* no pentaploid has so far been isolated. As is clear from this data polyplody as a cytogenetical phenomenon seems to be very well established in this genus. The extremely low frequency of oddploids can be explained on the basis of: (i) compatibility barriers between various cytotypes at different polyploidy levels and (ii) the sterility imposed by the odd number of chromosomes. As far as the point of compatibility barriers is concerned these have been shown to be very strong in this family and are one of the main reasons for the rarity of natural hybrids in this genus or even in the
species or the cytotypes which are sympatric. This has been shown by the study of Timson (1965) on a number of species of *Polygonum* and by McDonald (1980) on the basis of his studies in *Polygonum hydropiperoides* complex from United States. Timson's (1965) attempts at artificial hybridization in species of *Polygonum* also failed. Similar situation prevails in *P. amplexicaule* and *P. affine* both of which have been studied during the present investigations.

Regarding the second point i.e. the sterility imposed by odd number of chromosomes in 3x, 5x, 7x etc. coming in their way of getting established, it is worth noting that all the polyploids isolated in this genus have efficient means of vegetative propagation and as such this does not seem to be that important a reason. In *Polygonum* too, as has been shown in other taxa (Stebbins, 1950 and 1971), there seems to be a direct relationship between polyploidy and perennial behaviour or efficient means of vegetative propagation. One of the species of *Polygonum* namely *P. viviparum*, having efficient means of vegetative propagation exists in 6 races with 2n = 66, 77, 88, 99, 110 and 132 (Fedorov, 1969; Engell, 1973 and 1978).

Seven species of *Polygonum* included in the
present study exist in ten cytotypes. Of these eight are diploid and only two (one cytotype each of P. amplexicaule and P. napalense) are tetraploid (Fig. 71).

As is evident from table 12 (Page 62) the chromosome numbers of the species investigated belong to the base numbers \( x = 10, 11 \) and 12 only. Another point that emerges from the table 12 is that while as the chromosome counts of P. affine, P. hydropiper, P. lapataifolium, P. nepalense and P. orientale are the same as reported by earlier workers, the chromosome numbers observed in P. amplexicaule are at variance from the earlier count. 

Love and Love (1969) had recorded \( 2n = 20 \) chromosomes in P. amplexicaule. During the course of present investigations three different chromosome numbers were observed from different plants of P. amplexicaule growing sympatrically in a number of allopatric populations. These were \( n = 11, 12 \) and 22. Plants with these different chromosome numbers could easily be identified by their flower colour alone. Since these numbers were counted from plants growing sympatrically from a number of populations studied from different localities and over a number of years, it can
Table 12: Chromosome counts of species of Polygonum studied. References to earlier counts have been drawn from Fedorov (1969) and Moore (1971 and 1977).

<table>
<thead>
<tr>
<th>Species</th>
<th>Present count (n)</th>
<th>Previous counts (2n)</th>
<th>Authority</th>
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<td><em>P. affine</em></td>
<td>11</td>
<td>22</td>
<td>Jeretzky, 1928.</td>
</tr>
<tr>
<td><em>P. alpinum</em></td>
<td>10</td>
<td>20</td>
<td>Jeretzky, 1928.</td>
</tr>
<tr>
<td></td>
<td></td>
<td>22</td>
<td>Skolovskaya and Strelkova, 1948.</td>
</tr>
<tr>
<td>caule*</td>
<td>12</td>
<td>24</td>
<td></td>
</tr>
<tr>
<td></td>
<td>22</td>
<td></td>
<td></td>
</tr>
<tr>
<td>*P. hydro-</td>
<td>20</td>
<td>20</td>
<td>Jeretzky, 1928.</td>
</tr>
<tr>
<td>pipere*</td>
<td></td>
<td></td>
<td>Doida, 1960a (Var. Maximowleziij (Royal) Maximo</td>
</tr>
<tr>
<td></td>
<td>22</td>
<td>22</td>
<td>Timson, 1965.</td>
</tr>
<tr>
<td></td>
<td>20,22</td>
<td></td>
<td>Sharma and Chatterji, 1960.</td>
</tr>
<tr>
<td>*P. lapathi-</td>
<td>22</td>
<td>22</td>
<td>Jaretzky, 1927b.</td>
</tr>
<tr>
<td>folium*</td>
<td></td>
<td></td>
<td>Doida, 1960a (<em>P. nodosum</em>).</td>
</tr>
<tr>
<td></td>
<td>22,24</td>
<td></td>
<td>Löve and Löve, 1942. (<strong>P. nodosum</strong>).</td>
</tr>
<tr>
<td><em>P. nepalense</em></td>
<td>48</td>
<td>48</td>
<td>Doida, 1961a and 1962b.</td>
</tr>
<tr>
<td><em>P. orientale</em></td>
<td>11</td>
<td>22</td>
<td>Jaretzky, 1928.</td>
</tr>
<tr>
<td></td>
<td>44</td>
<td></td>
<td>Sharma and Chatterji, 1960.</td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td>Menshikova, 1964.</td>
</tr>
</tbody>
</table>
easily be concluded that plants with $n = 11, 12$ and $22$ are well established and do not represent some intermediate stages in evolution. This is also confirmed from the meiotic behaviour of their chromosomes as also the fact that there is total lack of any evidence of hybridization between these three cytotypes. As such *P. amplexicaule*, itself appears to be tribasic with $x = 10, 11$ and $12$. Similarly in *P. affine* plants having $n = 11$ and $12$ were found growing sympatrically making the species dibasic. Jaretzky (1928) had also reported $2n = 22$ and $24$ for this species. A perusal of chromosome numbers of the species of this genus reveals that the presence of more than one chromosome race, apparently belonging to different base numbers, in a species is quite common and has so far been recorded in over 18 taxa (Fedorov, 1969; Ornduff, 1968 and Moore, 1970, 1971 and 1974). Although some of these may represent aneuploid races only, the mere fact that most of the species exhibiting such numerical alterations have efficient means of vegetative propagation, has helped in establishing of these cytotypes.
Karyotypic details have been studied in only five species of this genus. The chromosomes of this genus are extremely small in size and in the five species investigated both the longest and smallest chromosomes measuring 2.06 µm and 0.86 µm respectively in length were found in *P. hydropiper*; the smallest chromosome measuring 0.86 µm was also found in *P. orientale*. Of the five species studied *P. nepalense* is the only tetraploid, the rest being diploid. Tables 13 and 14 sum up the data regarding the salient features of the chromosomes of the species of *Polygonum* investigated.

**Table 13: Karyotypic formulae of the species of *Polygonum* investigated.**

<table>
<thead>
<tr>
<th>Name of the species</th>
<th>Karyotypic formula</th>
</tr>
</thead>
<tbody>
<tr>
<td><em>P. amplexicaule</em></td>
<td>2M ♦ 18SM ♦ 4ST.</td>
</tr>
<tr>
<td><em>P. hydropiper</em></td>
<td>4M ♦ 14SM ♦ 2ST.</td>
</tr>
<tr>
<td><em>P. lapathifolium</em></td>
<td>2M ♦ 18SM ♦ 2ST.</td>
</tr>
<tr>
<td><em>P. orientale</em></td>
<td>6M ♦ 16SM.</td>
</tr>
<tr>
<td><em>P. nepalense</em></td>
<td>4M ♦ 40SM ♦ 4ST.</td>
</tr>
</tbody>
</table>
Table 14: Salient features of the somatic chromosomes of the species of *Polygonum* investigated.

<table>
<thead>
<tr>
<th>Name of the species</th>
<th><em>P. amplexicaula</em></th>
<th><em>P. hydropiper</em></th>
<th><em>P. lapathifolium</em></th>
<th><em>P. orientale</em></th>
<th><em>P. nepalense</em></th>
</tr>
</thead>
<tbody>
<tr>
<td>Chromosome count (2n)</td>
<td>24</td>
<td>20</td>
<td>22</td>
<td>22</td>
<td>48</td>
</tr>
<tr>
<td>TCL (µm)</td>
<td>36.7</td>
<td>24.77</td>
<td>31.14</td>
<td>23.2</td>
<td>63.08</td>
</tr>
<tr>
<td>MGL (jam)</td>
<td>1.52</td>
<td>1.23</td>
<td>1.41</td>
<td>1.05</td>
<td>1.31</td>
</tr>
<tr>
<td>Size of the longest chromosome (µm)</td>
<td>1.89</td>
<td>2.06</td>
<td>1.89</td>
<td>1.2</td>
<td>1.72</td>
</tr>
<tr>
<td>Size of the smallest chromosome (µm)</td>
<td>1.2</td>
<td>0.86</td>
<td>1.03</td>
<td>0.86</td>
<td>1.03</td>
</tr>
<tr>
<td>Longest/Smallest chromosome ratio</td>
<td>1.57</td>
<td>2.51</td>
<td>1.83</td>
<td>1.4</td>
<td>1.66</td>
</tr>
</tbody>
</table>

As is clear from the table 13, species of *Polygonum* have median, submedian or subterminal chromosomes. The karyotypes of all these species are symmetrical. Submedian chromosomes are most frequent, followed by median and subterminal. In all the diploid species studied the chromosomes of various complements could be arranged into perfect pairs and in the tetraploid species *P. nepalense* the grouping was of four chromosomes each.
Fig. 72 - Idiograms of mitotic chromosomes of five species of *Polygonum* studied:

a. *P. amplexicaule*.
b. *P. hydropiper*.
c. *P. lapathifolium*.
d. *P. nepalense*.
e. *P. orientale*. 
In the case of diploid species the perfect pairing speaks of complete homomorphicity and in *P. nepalense* it is an indicator towards the possible autoploid nature of this species. However, the nature of polyploidy cannot be judged from karyotypic studies alone and since meiotic behaviour of the chromosomes of *P. nepalense* could not be studied, it is very difficult to comment on the type of polyploidy involved in the origin of this species. Another point that emerges from Table 13 and Fig. 72 is the "apparent absence" of satellited or secondarily constricted chromosomes in these species. Since these regions are known to be the sites for the organization of nucleoli and the fact that in all the species whose meiosis has also been studied (*P. affine*, *P. alpinum*, *P. amplexicaule* and *P. orientale*) the nucleoli and nucleolar bivalents were very prominent at diplotene, it can be assumed that either these regions have escaped notice because of the extremely small size of chromosomes or else these regions are not so well differentiated in these species. However, in view of the fact that earlier workers have observed these regions in species of *Polygonum* the first reason seems to be more valid.
Two of the species, *Polygonum hydropiper* and *P. orientale*, whose karyotypes have been studied in the present work, were also investigated earlier by Sharma and Chatterji (1960). These workers studied material from eastern part of the country. It is difficult to compare the karyotypes of the present collections of *P. hydropiper* and *P. orientale* with the one described by Sharma and Chatterji (1960) as even the chromosome numbers of their's and the collections included in the present study are different. While as Sharma and Chatterji (1960) have recorded $2n = 22$ for *P. hydropiper* and $2n = 24$ for *P. orientale*, the plants of these two species collected from Jammu and Kashmir have $2n = 20$ and 22 respectively. Doida (1960a) had also given the drawings of the somatic chromosomes of these species as also of *P. lapathifolium* (Syn. *P. nodosum* Pers.). Since the chromosome counts of these species as reported by Doida (1960a) and those of the cytotypes included in the present study are similar, the two are compared (Table 15). Doida (1960a) had not described the chromosome types and for this comparison chromosomes of these species have been measured from his drawings (Figs. 2, 12 and 13) and classified according to the standard used in the present work.
Table 15: Salient features of karyotype of *P. hydropiper*, *P. lapathifolium* and *P. orientale* compared with those drawn by Doida (1960a)

<table>
<thead>
<tr>
<th></th>
<th><em>P. hydropiper</em></th>
<th><em>P. lapathifolium</em></th>
<th><em>P. orientale</em></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Doida Pre-1960a</td>
<td>sent (Fig.2) work</td>
<td>Doida Pre-1960a</td>
</tr>
<tr>
<td>Total no. of chromosomes</td>
<td>20</td>
<td>22</td>
<td>22</td>
</tr>
<tr>
<td>No. of median chromosomes</td>
<td>2</td>
<td>4</td>
<td>Nil</td>
</tr>
<tr>
<td>No. of submedian chromosomes</td>
<td>18</td>
<td>14</td>
<td>22</td>
</tr>
<tr>
<td>No. of subterminal chromosomes</td>
<td>Nil</td>
<td>2</td>
<td>Nil</td>
</tr>
<tr>
<td>No. of satellite chromosomes and their nature</td>
<td>2</td>
<td>Nil</td>
<td>Nil</td>
</tr>
</tbody>
</table>

As is clear from table 15 although the chromosome counts of *P. hydropiper*, *P. lapathifolium* and *P. orientale* as studied by Doida (1960a) and in the present study, are the same, still there are differences in their...
karyotypes. These differences in the three species could be because of absolutely different localities of the collections. These differences in karyotypes and the fact that in these three species and also in many other species of this genus cytotypes with different "base numbers" have been isolated, point towards the fact that in addition to euploidy, aneuploidy and chromosomal repatterning have also played vital roles in bringing about differences in the species of this genus. Once evolved these variations are able to survive as in most of the species of Polygonum sexual and asexual propagation go hand in hand. So while as former guarantees variability, the latter is able to conserve it.

As far as the meiotic behaviour of chromosomes in species investigated during the course of present study is concerned, it was found to be more or less normal in nearly all the taxa. Detailed studies of meiotic chromosomes in species of Polygonum in particular and Polygonaceae in general is not easy as very few pollen mother cells are produced in each anther. In addition to this small size of the flowers also makes it difficult. As pointed out earlier, in all the species investigated a well stained nucleolus was observed at diplotene of
male meiosis. The number of nucleolar bivalents varied from 2 (P. orientale and P. amplexicaule, n = 11) to 3 (in other species).

In plants of P. affine having n = 11 and P. amplexicaule, n = 22, occasional quadrivalents were observed at diplotene and at metaphase I of meiosis. While as in the latter case, the formation of a quadrivalent can be explained on the basis of the tetraploid status of the plants, in the former these appear to be formed as a result of translocations. In case of P. alpinum, two bivalents had a tendency towards remaining together which again indicates some sort of segmental homology between the chromosomes of these two bivalents. In such species these anomalies upset further course of meiosis and as a result of this some anaphasic disturbances were noticed.

Although one is likely to get tempted to hypothesize that the tetraploid cytotypes of P. amplexicaule (2n = 4x = 44) could have originated by the doubling of chromosomes of plants with n = 11, it cannot be said with certainty in the absence of detailed karyotypic analysis of both the cytotypes. It would be worth pointing out here that while as in the plants having n = 11 flowers are light pink in colour, those with n = 22 have dark pink flowers.