Excerpt from:
P. K. Khosla (ed.), 1982.
Improvement of forest biomass: symposium proceedings. Indian Council of Agricultural Research; Indian Society of Tree Scientists. Solan, India. 472 pp.

Evolutionary Status of the Woody Taxa of Garhwal Himalaya

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Chromosome numbers have been worked out for 174 woody taxa (93 tree species and the rest shrubs and climbers). Presence of B-chromosomes and aneuploid numbers have been noted in a number of taxa. Abnormal meiosis consequence to multivalent formation is observed only in a few diploid and polyploid taxa. The low incidence of multivalent formation is attributable to the small size of the chromosomes.

Genus *Limonia* and a large number of species are worked out for the first time.

Within the woody taxa themselves both large and small sized chromosome species have been noted. In *Punica granatum*, *Cornus macrophylla* and three species of *Viburnum*, 1 to 3 bivalents are relatively larger than the other bivalents of the complement.

In majority of the genera investigated basic chromosome numbers range from x=3 to 14, with the preponderance of x=3, 9, 11 and 12.

The incidence of polyploidy is 21.84 per cent and most of the polyploid taxa are at 4 x level. There is no specific correlation between the growth habit and ploidy level. Also no correlation has been found in the distribution of polyploidy taxa at different altitudinal clines.

INTRODUCTION

The Himalaya represent one of the most recent mountain systems of the world and phytogeographically the flora of these mountains is of great interest because of the similarities of their western elements with Europe and the eastern members with China (particularly Yunnan province), Burma and Malaya. Evidently, the forests of the great Himalayan mountain system envisage interest of the evolutionists because these mountains not only support tropical, subtropical and temperate vegetation but also contain several characteristic and endemic taxa. From national view point the Himalaya are important from the fact that they support the largest area of forests in India.

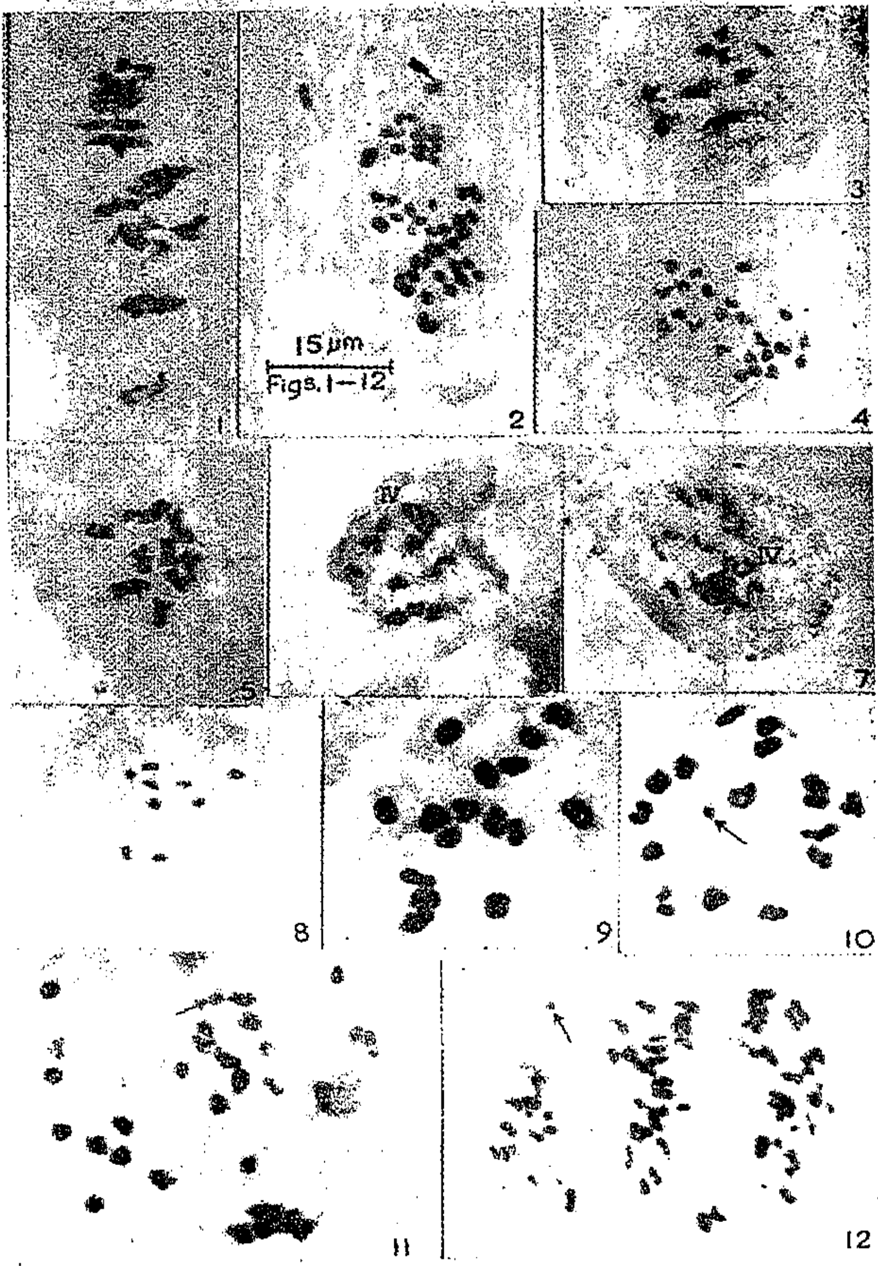
A perusal of literature shows that inspite of the great economic importance of the forests of the Himalaya, the cytological studies on the woody taxa have rather been a neglected field for a long time. It is only in 1962 that the work on the cytology of the Himalayan trees was begun by a team led by P.N. Mehra at Chandigarh. The results were published in a series of papers from that school (Gill, 1973, 1979; Hans, 1970 a,b, 1971, 1972; Khosla, 1973, 1975, 1978; Khosla *et al.*, 1973; Mehra, 1972; Mehra and Bawa, 1968, 1969; Mehra and Gill, 1968, 1971, 1974; Mehra and Hans, 1969, 1971, 1972; Mehra and Khosla, 1969, 1972, 1973; Mehra and Sareen, 1969, 1973a,b,c; Mehra and Singh, 1962; Mehra *et al.*, 1972a,b,c, 1973; Sareen *et al.*, 1974; etc.) and later on consolidated in the form of a monograph by Mehra (1976). But all this work concerned Simla, Mussoorie, Nainital, Darjeeling and Dibrugarh-Digboi areas of the Himalaya and still vast regions of the mighty range remained uninvestigated. One such region is of the Garhwal Himalaya with Yamnotri-Barkot-Chakrata as the western limit and Badrinath-Valley of flowers (Hem Kund Sahib)-Joshimath Srinagar-Pauri as the eastern limit including the forests of the Doon valley bounded on the southwest by Shiwaliks. Administratively, the region falls within the Chamoli, Dehra Dun, Pauri, Tehri and Uttarkashi districts of the state of Uttar Pradesh, India and lies between 29°26′ to 31°28′ N latitude and 77°49′ to 80°6′ E longitude. Cytological studies on the woody taxa of the forests of the above delimited region of the Himalaya falling within an altitudinal range of 400 to 4,650 m were undertaken between the years 1978 to 1980 as a part of an integrated research project on the woody taxa of the Northern, Central and Southern India.

MATERIAL AND METHODS

For meiotic studies wild materials were primarily used for making acetocarmine squashes of the young flower buds after fixation in Carnoy's fluid. Through usual dehydration in ethanol, desired slides were mounted in euparal. Depending upon the distribution, several populations of each taxon from different localities were analysed for determining the genetic variability.

OBSERVATIONS

Consequential to intensive chromosomal studies on 174 woody species (93 trees, and 81 shrubs and climbers) new chromosome numbers were recorded for a large number of taxa (see Bedi *et al.*, 1980, 1981a,b; Bir *et al.*, 1979; Gill *et al.*, 1972a,b, 1981a; Singhal *et al.*, 1980a,b). In as many as 11 species varied chromosome numbers are recorded. The meiotic counts of some of the species are illustrated in figures 1 to 12. The information along with comments is given in table I. This stressed the need for intensive studies in restricted areas for the proper understanding of the flora of our country. Details of results obtained for 130 species have been published elsewhere (see Bir *et al.*, 1982; Gill *et al.*, 1982) while the chromosomal data on the remaining 44 species are contained in table II



EXPLANATION TO FIGURES

Figures 1-12 : Meiotic chromosome in some woody taxa.

1. *Schizandra grandiflora* : M–I, n=14 ; 2. *Semecarpus anacardium* with 30_{II} at M–I ; 3. *Abelia triflora* : M–I, n=9 ; 4. *Ardisia solanacea* : M–I n=23 ; 5. *Viburnum nervosum* : M–I, n=9 ; 6. *Solanum torvum* : M–I, showing $1_{IV}+10_{II}$ (2n=24) ; 7. *Broussonetia papyrifera* : Diakinesis showing $1_{IV}+11_{II}$ (2n=26) ; 8. *Limonia crenulata* with 9 bivalents at M–I ; 9, 10. *Meliosma pungens* : 16_{II} at M–I in Fig. 9 and 16_{II} +IB at M–I in fig. 10 ; 11. *Caryopteris grata* : Diakinesis with n=30+IB ; 12. *Euphorbia royleana* : Diakinesis, n=60+IB.

TABLE I : Varied chromosome records*

S. No.	Taxa	Present record	Previous report/s**	Remarks
1.	*Schizandra grandiflora*	n=14 (Fig. 1)	n=7	First report of tetraploid
2.	*Hypericum oblongifolium*	n=23	n=21, 22, 24	Aneuploid
3.	*Zizyphus oenoplia*	n=12	n=10, 24	First report of 2x with n=12
4.	*Semecarpus anacardium*	n=29 (Fig. 2)	n=30	Aneuploid
5.	*Campylotropis stenocarpa*	n=11	n=9	First report of n=11
6.	*Osbeckia stellata*	n=19	n=10	Aneuploid at 4x
7.	*Abelia triflora*	n=9 (Fig. 3)	n=18	First report of diploid
8.	*Myrsine semiserrata*	n=46	n=22	First report of tetraploid
9.	*Vallaris heynii*	n=11	n=10	Aneuploid
10.	*Phlogacanthus thyrsiflorus*	n=25	n=21	New report of n=25
11.	*Osyris arborea*	n=20	n=15	New base number for genus is purposed

*Earlier, for *Ardisia solanacea* Roxb. Raghavan (1959) recorded n=c. 23. We have counted the unequivocal presence of 23 bivalents at M-I (Fig. 4) for the species.

**For previous reports reference is made to Darlington and Wylie (1955), Index to Plant Chromosome Numbers (1956-1974), Chromosome number reports published in Taxon, Löve and Löve (1961, 1974, 1975), Fedorov (1969) and selected references from Biological Abstracts.

TABLE II: Chromosome numbers in certain Garhwal Himalayan woody elements

S. No.	Taxon	Locality	PUN Accession number	Chromosome number*	Ploidy level
1	2	3	4	5	6
Family : FLACOURTIACEAE					
1.	*Casearia elliptica* Willd.	Dehra Dun : Sahansradhara, 500 m	23032	n=21	Diploid
2.	+ *Flacourtia cataphracta* Roxb. ex. Willd.	Dehra Dun : Asarori, 600 m	26333	n=11	Diploid
3.	*F. indica* (Burm. f.) Merr.	Dehra Dun : Daak Pathar, 500 m	26310	n=11	Diploid

Family : STERCULIACEAE					
4.	*Firmiana pallens* (Wall. ex King) Koster.	Dehra Dun : Daat, 600 m	23134	n=20	Diploid
5.	*Helicteres isora* Linn.	Dehra Dun : Lachiwala, 600 m	23129	n=9	Diploid
6.	+*Sterculia villosa* Roxb.	Saharanpur : Mohand, 400 m	22808	n=20	Diploid
Family : TILIACEAE					
7.	+*Grewia elastica* Royle var. *vestita* Wall.	Dehra Dun : Lachiwala, 600 m	20805	n=9	Diploid
8.	+*G. hainesiana* Hole	Dehra Dun : Daat, 600 m	23004	n=18	Tetraploid
9.	*G. laevigata* Vahl	Dehra Dun : Daat, 600 m	23247	n=9	Diploid
10.	*G. oppositifolia* Buch.-Ham. ex Roxb.	Dehra Dun : Daat, 600 m	23027	n=9	Diploid
Family : MALPIGHIACEAE					
11.	*Hiptage benghalensis* (Linn.) Kurz	Dehra Dun : Daat, 600 m	23075	2n=56+0-1B	Tetraploid ?
Family : HIPPOCASTANACEAE					
12.	*Aesculus indica* Colebr. ex Wall.	Mussoorie : 1,850 m	23035	n=20	Diploid
Family : ANACARDIACEAE					
13.	*Semecarpus anacardium* Linn. f.	Dehra Dun : Daat, 600 m	—	n=30	Diploid
Family : LEGUMINOSAE					
14.	+*Indigofera hebepetala* Benth. ex Baker	Yamnotri, 3,300 m	26322	n=8	Diploid
15.	*I. gerardiana* R. Garh.	Chakrata : Jadi, 2,400 m	23441	n=24	Hexaploid
Family : ROSACEAE					
16.	*Cotoneaster acuminata* Lindl.	Yamnotri, 3,300 m	26326	n=17	Diploid
Family : COMBRETACEAE					
17.	*Terminalia belerica* Roxb.	Dehra Dun : Daat, 600 m	—	2n=48	Tetraploid

18. *T. chebula* Roxb.	Dehra Dun : Bansiwala, 600 m	23033	n=12	Diploid
19. *T. tomentosa* W. & A.	Saharanpur : Mohand, 400 m	25734	n=12	Diploid
Family : MYRTACEAE				
20. *Eugenia jambolana* Lam.	Dehra Dun : Sahansradhara, 500 m	23074	2n=44	Tetraploid
21. *E. operculata* Roxb.	Dehra Dun : Asarori, 600 m	23013	n=11	Diploid
Family : LYTHRACEAE				
22. *Lagerstroemia parviflora* Roxb.	Rishikesh : Narender Nagar, 600 m	26032	n=25	Diploid
Family : CAPRIFOLIACEAE				
23. *Abelia triflora* R. Br.	Chakrata : Deoban, 2,700 m	24286	n=9	Diploid
24. +*Viburnum nervosum* Don	Chakrata : Deoban, 2,700 m	25514	n=9	Diploid
Family : RUBIACEAE				
25. *Adina cordifolia* Hook. f.	Saharanpur : Mohand, 400 m	25639	n=22	Tetraploid
26. *Randia tetrasperma* Bdnth. & Hook. f.	Mussoorie : Camel's back road, 1,850 m	25530	n=11	Diploid
	Mussoorie : Kempty Fall, 1,350 m	25533	n=11	Diploid
27. *Spermadictyon suaveolens* Roxb.	Mussoorie : Kempty Fall, 1,350 m	24144	n=11	Diploid
Family : EBENACEAE				
28. *Diospyros malabarica* Kost.	Saharanpur : Mohand, 400 m	23787	n=15	Diploid
29. *D. montana* Roxb.	Saharanpur : Shahjahanpur, 400 m	25643	n=15	Diploid
Family : OLEACEAE				
30. *Jasminum arborescens* Roxb. var. *latifolia* Roxb.	Dehra Dun : Daat, 600 m	25484	n=13	Diploid

31. *J. humile* Linn.	Uttarkashi en route Yamnotri, 2,700 m	: 25516	n=13	Diploid
Family : VERBENACEAE				
32. *Caryopteris grata* (Wall.) Benth.	Mussoorie, 1,850 m	: 25659	n=30+ 0-6B	Hexaploid
Family : SANTALACEAE				
33. *Osyris arborea* Wall.	Mussoorie Jharipani, 1,500 m	: 25499	n=20	Diploid
Family : EUPHORBIACEAE				
34. *Andrachne cordifolia* Muell.—Arg.	Chamoli Gobind Ghat, 1,800 m	: 25537	n=12	Diploid
35. *Daphniphyllum himalayanse* Muell.—Arg.	Mussoorie, 1,850 m	: 25627	n=16	Diploid
36. *Dryptetes roxburghii* Wall.	Dehra Dun Lachiwala, 600 m	: 25683	n=20	Hexaploid
37. *Euphorbia royleana* Boiss.	Dehra Dun Sahia, 1,300 m	: 26247	n=60+ 0-2B	12-ploid
38. *Flueggea microcarpa* Bl.	Dehra Dun Lachiwala, 600 m	: 25824	n=13	Diploid
Family : ULMACEAE				
39. *Celtis australis* Linn.	Chamoli Gobind Ghat, 1,800 m	: 25695	n=10	Diploid
Family : MORACEAE				
40. *Maclura cochinchinensis* (Lour.) Cr.	Dehra Dun Daat, 600 m	: 25480	n=14	Diploid
Family : JUGLANDACEAE				
41. *Juglans regia* Linn. var. *kumaonica* C. DC.	Mussoorie en route Kempty Fall, 1,700 m	: 25607	n=16	Diploid
Family : FAGACEAE				
42. *Quercus incana* Roxb.	Mussoorie, 1,850 m	: 25631	n=12	Diploid
Family : SALICACEAE				
43. *Salix elegans* Wall.	Chamoli Gobind Dham, 3,000 m	: 24274	2n=38	Diploid
	Chamoli Kedarnath, 3,200 m	: 25490	n=19	Diploid

44. +*S. oxycarpa* Anders	Chamoli Badrinath, 3,500 m	: 24275	n=19	Diploid
	Mussoorie, 1,850 m	: 25469	n=19	Diploid

*For previous reports reference is made to Darlington and Wylie (1955), "Index to Plant Chromosome Numbers" (1956-1974), Chromosome number reports published in Taxon, Löve and Löve (1961, 1974, 1975), Fedorov (1969) and selected references from Biological Abstracts.

+Species worked out for the first time.

The main points of interest are :

1. The course of meiosis in all the taxa is normal except for only 8 species details of which follow. Frequently, the formation of quadrivalents is noticed in *Sorbus foliolosa* (Wall.) Spach., 2n=68 (4x) and *Emblica officinalis* Gaertn., 2n=104 (8x). In the former the quadrivalent formation is due to segmental allopolyploid nature of the taxon (for details see Gill *et al.*, 1982) and for the low frequency of quadrivalents in the latter the possibility of heterozygosity for translocations cannot be ruled out since these are not easily detectable in the woody species because of small size and high number of chromosomes (Bir *et al.*, 1982). High pollen sterility in *Grewia hainesiana* Hole, 2n=18 (4x) is attributed to the spindle abnormalities. *Cordia dichotoma* Forst f., 2n=48 (6x) where in addition to normal bivalents (10·06/PMC), hexavalent, quadrivalents, trivalents and univalents with average frequency of 0·06, 6·19, 0 50 and 1·25/PMC, respectively, are also constituted. This species is in all probability, a segmental allohexaploid.

Structural hybridity due to reciprocal translocation has been recorded in *Viburnum mullaha* Buch.—Ham. ex Don (2n=18), *Solanum torvum* Sw. (2n=24), *Macaranga indica* Wt. (2n=22) and *Broussonetia papyrifera* Vent. (2n=26). All of these are diploid taxa. Details on the paring behaviour of chromosomes during meiosis and pollen fertility of these species are provided in table III (also see Bir *et al.*, 1982).

TABLE III : Woody taxa showing structural heterozygosity

S. No.	Taxa	Chromosome number 2n	Range* per PMC		Average* per PMC		Pollen fertility
			IV	II	IV	II	
1.	*Viburnum mullaha*	18	0-1	7-9	0·29	8·42	83%
2.	*Solanum torvum*	24 (Fig. 6)	0-1	10-12	0·27	11·46	80%
3.	*Macaranga indica*	22	0-1	9-11	0·53	9·94	63%
4.	*Broussonetia papyrifera*	26 (Fig. 7)	0-1	11-13	0·28	12·44	82%

*On the basis of analysis of at least 20 PMCs

By and large, there is a good seed production in majority of the investigated species resulting in their regular regeneration in undisturbed conditions. So far, we have not detected any means of vegetative propagation in the studied woody taxa, except for *Dalbergia sissoo* Roxb. which flourishes exceedingly well in the riverain tracts of Doon valley and regenerates through root buds. Here, there is also regular regeneration through seeds because the species is sexual with n=10 (2x).

2. The highest grade of polyploidy is obtained in *Euphorbia royleana* Boiss., n=60 (12x).

3. *Limonia* Linn. is worked out for the first time with n=9 (Fig. 8) in *L. crenulata* Roxb., which is a diploid sexual. The genus is thus, based on x=9.

4. Intraspecific polyploidy is recorded in *Trema orientalis* Bl., n=10, 20 (2x, 4x).

5. Sterile hybrid taxa are exceedingly rare. Presently, only two examples namely, *Hiptage benghalensis* (Linn.) Kurz, 2n=56 (4x?) and *Sorbus foliolosa* (Wall.) Spach. 2n=68 (4x) are recorded.

6. Presence of B-chromosomes has been noticed in five species which are at different levels of polyploidy and the number of Bs in these species varies from 0 to 8. The accessory chromosomes may or may not remain unpaired (for details see Table IV). As earlier surmised by Gill *et al.* (1981c) now the incidence of B-chromosomes in polyploid taxa is fairly high.

TABLE IV : Taxa with B-chromosomes

S. No.	Taxa	Chromosome number 2n	Ploidy level	Range for Bs	Meiotic behaviour	Pollen fertility
1.	*Cocculus laurifolius*	26	2x	0-3	Occasionally paired	100%
2.	*Hiptage benghalensis*	56	4x ?	0-1	—	62%
3.	*Meliosma pungens*	32 (Figs. 9, 10)	4x	0-3	Remain unpaired	—
4.	*Punica granatum*	16	2x	0-4	Remain unpaired	100%
5.	*Caryopteris grata*	60 (Fig. 11)	6x	0-6	Show tendency for pairing	95%
6.	*Euphorbia royleana*	120 (Fig. 12)	12x	0-2	Remain unpaired	—

7. In *Lyonia ovalifolia* (Wall.) Drude (n=12), two distinct forms but with the same chromosome numbers have been detected. Trees with

small leaves grow around Yamnotri (2,700 m) and those with large sized leaves are met with around Mussoorie (1,950m) and Gobindghat (2,100m) and Sona Chati (2,100 m). To us this appears to be a good case for taxonomic segregation because of marked differences in morphological characters but this has been kept pending till comparison with type material is made.

8. The phenomenon of cytomixis is noticed in *Helicteres isora* Linn., *Hiptage benghalensis* (Linn.) Kurz, *Glycosmis pentaphylla* Correa, *Caragana brevispina* Royle, *Cotoneaster acuminata* Lindl., *Hydrangea hortensis* Sieb., *Philadelphus coronarius* Linn., *Symplocos chinensis* (Lour.) Druce, *Quercus semecarpifolia* Smith and *Salix elegans* Wall. This results in differences in pollen size and pollen abortion even to the extent of 56 per cent in *Hiptage benghalensis*.

DISCUSSION

Incidence of structural hybridity, B-chromosomes and aneuploid numbers in a number of taxa of Garhwal region is significant from evolutionary view point.

Mehra (1972), Mehra and Bawa (1969) and Khosla (1978) on the basis of their studies on the meiotic chromosomes of the Himalayan hardwoods, have concluded that in contrast to conifers, the hardwoods generally show small sized chromosomes. From the present studies also this feature is clear. However, amongst the presently studied taxa the classification on the basis of chromosome size could be examplified (compare figs. 1, 9, 10, with 4, 7, 8) as follows :

(a) Large sized chromosomes :

(i) Trees : *Melicsma pungens* (n=16), *Saraca indica* (n=12), *Terminalia belerica* (n=24), *T. chebula* (n=12), *T. tomentosa* (n=12) and *Cordia dichotoma* (n=24).

(ii) Shrubs ; *Schizandra grandiflora* (n=14), *Sambucus nigra* (n=18), *Viburnum cotinifolium* (n=9), *V. cylindricum* (n=9), *V. mullaha* (n=9) and *Sarcococca pruniformis* (n=14).

(b) Small sized chromosomes :

(i) Trees : *Toona serrata* (n=28), *Aesculus indica* (n=20), *Lagerstroemia parviflora* (n=25), *Oroxylum indicum* (n=15), *Premna barbata* (n=19) and *Broussonetia papyrifera* (n=13).

(ii) Shrubs : *Capparis zeylanica* (n=20), *Osbeckia stellata* (n=19), *Clerodendrum viscosum* (n=26), *Phlogacanthus thyrsiflorus* (n=25) *Ardisia solanacea* (n=23).

Comparing the above data with habit of the woody species it is clear that there is no relationship between the habit, whether trees, shrubs or climbers and the chromosome size or their numbers.

It is interesting to note that in *Punica granatum* (n=8), *Cornus macrophylla* (n=11) and in three species of *Viburnum* (n=19), one to three bivalents are definitely larger as compared to the others. Marked differences in the size of a pair of somatic chromosomes has been demonstrated in *Punica granatum* (Gill *et al.*, 1981b) and *Cornus macrophylla* (Mehra, 1976). In case of *Morus alba* the two large chromosomes have been referred as allosomes concerned with sex determination (Tahara, 1910; Osawa, 1920; Sinoto, 1929). But the position in the present taxa exhibting chromsomal size differences is different. All of these are with bisexual flowers. The two and three small sized bivalents in *Semecarpus anacardium* (n=30) and *Sarcococca pruniformis* (n=14) respectively, are the regular members of the complement. The presence of relatively large or small sized chromosomes could be the consequence of simple or unequal reciprocal translocations (Stebbins, 1950).

Basic numbers in the presently studied 124 genera are quite variable, x=5-25, 30, 35 as is clear from the information given below :

x=5 : *Spiraea* (1)

x=6 : *Euphorbia* and *Indigofera* (2)

x=7 : *Annona*, *Dryptetes*, *Euphorbia*, *Hypericum*, *Indigofera*, *Schizandra*, and *Spiraea* (7)

x=8 : *Abelia*, *Caragana*, *Cordia*, *Ehretia*, *Euphorbia*, *Euonymus*, *Hypericum*, *Indigofera*, *Lonicera*, *Loranthus*, *Meliosma*, *Millettia*, *Mimosa*, *Myrica*, *Polyalthia*, *Prunus*, *Punica*, *Spiraea* and *Viburnum* (19)

x=9 : *Abelia*, *Andrachne*, *Campylotropis*, *Capparis*, *Citrus*, *Clausena*, *Cornus*, *Ehretia*, *Euphorbia*, *Flacourtia*, *Glycosmis*, *Gouania*, *Grewia*, *Helicteres*, *Hypericum*, *Limonia*, *Lonicera*, *Loranthus*, *Miliusa*, *Polyalthia*, *Prunus*, *Spiraea*, *Viburnum* and *Wickstroemia* (24)

x=10 : *Capparis*, *Caryopteris*, *Celtis*, *Cornus*, *Dalbergia*, *Desmodium*, *Ehretia*, *Euphorbia*, *Flacourtia*, *Helicteres*, *Holarrhena*, *Hypericum*, *Millettia*, *Osbeckia*, *Rhamnus*, *Trema*, *Vallaris* and *Viburnum* (18).

x=11 : *Adina*, *Andrachne*, *Caesalpinia*, *Campylotropis*, *Capparis*, *Carissa*, *Cocculus*, *Coffea*, *Cornus*, *Desmodium*, *Eugenia*, *Euphorbia*, *Excoecaria*, *Flacourtia*, *Holarrhena*, *Macaranga*, *Millettia*, *Pavetta*, *Randia*, *Rhamnus*, *Sapium*, *Spermadictyon*, *Symplocos*, *Trewia*, *Vallaris*, *Viburnum*, *Wendlandia*, *Wrightia* and *Xeromphis* (29).

x=12 : *Andrachne*, *Ardisia*, *Caesalpinia*. *Capparis*, *Cinnamomum*, *Clerodendrum*, *Desmodium*, *Euphorbia*, *Excoecaria*, *Glochidion*, *Hedera*, *Helicteres*, *Hypericum*, *Litsea*, *Loranthus*, *Lyonia*, *Machilus*, *Millettia*, *Mimosa*, *Pentapanax*, *Phoebe*, *Quercus*, *Rhamnus*, *Saraca*, *Solanum*, *Terminalia* and *Zizyphus* (27).

x=13 : *Acer*, *Andrachne*, *Broussonetia*, *Clerodendrum*, *Cocculus*, *Crateva*, *Ehretia*, *Emblica*, *Euphorbia*, *Flueggea*, *Garuga*, *Glochidion*, *Jasminum*, *Mimosa*, *Rhamnus*, *Terminalia* and *Toona* (17).

x=14 : *Bauhinia*, *Berberis*, *Boehmeria*. *Clerodendrum*, *Cordia*, *Debregeasia*, *Emblica*, *Flueggea*, *Lannea*, *Maclura*, *Miliusa*, *Mimosa*, *Morus*, *Oroxylum*, *Sarcococca*, and *Toona* (16).

x=15 : *Clerodendrum*, *Cordia*, *Cotinus*, *Diospyros*, *Ehretia*, *Lannea*, *Oroxylum*, *Pistacia*, and *Rhus* (9)
x=16 : *Daphniphyllum*, *Firmians*, *Juglans*, *Prinsepia*, *Spondias* and *Zanthoxylum* (6)
x=17 : *Cotoneaster*, *Rhamnus*, *Sorbus*, *Spiraea*, and *Zanthoxylum* (5)
x=18 : *Cordia*, *Hydrangea*, *Sambucus*, *Sterculia*, and *Zanthoxylum* (5)
x=19 : *Buddleja*, *Cocculus*, *Capparis*, *Gmelina*, *Populus*, *Premna*, *Salix*, and *Sambucus* (8)
x=20 : *Aesculus*, *Firmiana* and *Sterculia* (3)
x=21 : *Capparis*, *Casearia* and *Phlogacanthus* (3)
x=22 : *Casearia*, *Lagerstroemia*, *Nyctanthes*, and *Salix* (4)
x=23 : *Ardisia*, *Celastrus*, *Clerodendrum*, *Lagerstroemia*, *Myrsine*, *Nyctanthes* and *Olea* (7)
x=24 : *Lagerstroemia* (1)
x=25 : *Lagerstroemia* and *Phlogacanthus* (2)
x=30 : *Semecarpus* (1)
x=35 : *Excoecaria* (1)

It is clear that the lowest number is represented in *Spiraea* (x=5) and the highest is found in *Excoecaria* (x=35) while for the genus *Hiptage*, due to great intraspecific chromosomal variation the basic chromosome number could not be derived. In majority of the genera the basic numbers range from 8-14 with the dominance of x=11 (29 genera), followed by x=12 (27 genera), x=9 (24 genera) and x=8 (19 genera). The higher frequency of woody genera with x=11 to 14 from the tropical and temperate regions has been recorded by several workers (Stebbins, 1938 ; Grant, 1958 ; Mangenot and Mangenot, 1962 ; Mehra and Bawa, 1969 ; Mehra, 1972 ; Bawa, 1973 ; Khosla, 1975, 1978 ; Khosla and Sareen, 1978, 1981). On the other hand, herbaceous angiosperms in general, have relatively low base numbers in the range of x=7-9 (Stebbins, 1938 ; Grant 1963).

Analysis of data for the present genera shows that as many as 75 genera (60·0%) are monobasic. The speciation in these genera has not taken place through aneuploidy, rather polyploidy could be the major factor for the phenomenon. The remaining 23 dibasic and 26 polybasic genera have either closely allied or distantly selected base numbers. It is quite appropriate to mention here that all the genera analysed presently are not strictly woody. These have herbaceous members also. On a broad comparison of the data on the base numbers in woody and herabaceous elements, it is quite apparent that although diversity in base numbers does exist in the woody genera yet this diversity is not to that extent as seen in the herbaceous genera. Woody dicots, thus exhibit relative constancy in base numbers which are usually high.

Out of 174 investigated species, the incidence of polyploidy amongst trees and shrubs is nearly the same (cf. Table V). Earlier, Wright (1976) did not find any correlation between growth habit and ploidy incidence.

For the Himalayan cytologically known hardwoods, in 1972 Mehra has recorded that the incidence of polyploidy is 24·6 per cent. There are no marked differences in the presently obtained figures, from the earlier results (cf. Table V).

TABLE V : Habit polyploidy correlation of woody taxa from Garhwal Himalaya

Habit	Total investigated taxa	Diploid	Polyploid	Incidence of polyploidy
Shrubs	81	62	19	23·46%
Trees	93	74	19	20·45%
Total	174	136	38	21·84%

Most of the polyploid taxa are at tetraploid level (Table VI). Hexaploids are 5·26 per cent in trees and 10·53 per cent in shrubs. Incidence of ploidy levels at 8x and higher levels is not very significant (only about 10%). So from the data given in table VI one inevitable conclusion that emerges is that there is no specific correlation between the growth habit and ploidy level amongst woody taxa. Although quite a number of species are overlapping in different altitudinal zones as tropical, subtropical, warm and cold temperate forests, yet analysis of results for these forest zones (cf. Table VII) indicates that there is no marked correlation between the polyploid taxa and altitude. There is nearly the same incidence of polyploidy amongst taxa from tropical and subtropical zone (22·44%) on one hand and warm temperate zone (20·29%) on the other (cf. Table VII). From cold temperate zone the worked out taxa are few and hence much significance can not be attached to considerably higher percentage of polyploidy (28·57%) met with there.

TABLE VI : Incidence of various ploidy levels in the presently investigated woody taxa from Garhwal Himalaya

Habit	Polyploidy Levels		
	4x	6x	8x and Higher
Shrubs	78·94%	10·53%	10·53%
Trees	84·21%	5·26%	10·53%
Total	81·58%	7·89%	10·53%

TABLE VII : Analaysis of cytological results of woody taxa from Garhwal Himalaya

Region	Total investigated taxa	Diploid	Polyploid	Incidence of polyploidy
Tropical and sub-tropical up to 1,500 m	98	76	22	22·44%
Warm temperate 1,500-2,700 m	69	55	14	20·29%
Cold temperate 2,700-3,600 m	7	5	2	28·57%
Total	174	136	38	21·84%

From the foregoing account it is clear that :

(i) Contrary to the earlier surmise the woody taxa are also in an active state of evolution and not somewhat static.

(ii) At least in the investigated region, for the woody taxa there is no such inference that the incidence of polyploidy is greater in tropics (or tropical regions) as was drawn by Manton (1953, 1969) and Mehra (1961) in case of ferns.

ACKNOWLEDGEMENTS

We are thankful to U.G.C., New Delhi for financial assistance in the form of a research project entitled "Cytogenetical investigations on some hardwoods from Northern, Central and Southern India" (Grant No. 017/Bio. Scs./76) which made the present studies possible. Throughout the conduct of present work we received time to time advice and helpful criticism from Professors A.K. Sharma and Archana Sharma of Calcutta University and Dr. T.N. Khoshoo, Director, N.B.R.I., Lucknow (now Secretary, Department of Environment, Government of India, New Delhi). We express our gratitude to them.

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