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CYTOLOGICAL EVOLUTION IN THE WOODY TAXA OF PACHMARHI HILLS

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ABSTRACT

The present analysis is based on cytological survey of as many as 116 wild woody species (comprised of 85 trees and 31 shrubs and woody climbers) from forests of the Pachmarhi hills between an altitudinal range of 200-1,350 m. Amongst these for 16 species chromosome numbers were first records whereas varied chromosome numbers were found for eleven species. Intraspecific polyploidy was recorded in *Grewia hainesiana* (3x, 4x), *Terminalia chebula* (2x, 4x, 6x), *Syzygium cumini* (4x, 6x) and *Lantana camara* (2x, 4x). The presence of B-chromosomes was noticed in *Hiptage benghalensis* (2n=60+0—4B), *Pongamia pinnata* (n=11+0—7B), *Tamarindus indica* (n=12+0—4b), *Plumbago capensis* (n=7+0—1B), *Terminalia arjuna* (n=12+0—2B) and *Trema orientalis* (n=20+0—1B). *Loranthus longiflorus* var. *amplexifolius* showed structural heterozygosity for interchanges leading to very reduced pollen fertility. Cytomixis was seen in 7 species leading to some element of pollen sterility. Intraspecific morphological and/or cytological variations were recorded for 19 species.

Analysis of the present cytological data revealed that (i) the incidence of polyploidy was fairly high (29.31%), (ii) habit-polyploidy correlation indicated higher incidence of polyploidy (32.94%) in trees than shrubs (19.35%) of which the deciduous elements had higher polyploid percentage than that of evergreen elements, (iii) in the montane subtropical forests 32% of woody taxa were polyploid against 26.92% in tropical dry deciduous forests. It is suggested that the woody taxa of central Indian forests of Pachmarhi hills are in a fairly active state of evolution as indicated by the higher incidence of euploidy, aneuploidy and cytological abnormalities.

Key Words : Woody taxa, Intraspecific polyploidy, Aneuploidy, Heterozygosity.

INTRODUCTION

The Indian state of Madhya Pradesh has the maximum forest area (16,457,000 hectares) in the country and also yields the maximum revenue (cf. Dwivedi 1980). The Pachmarhi hills falling in the state were purposely selected for chromosomal analysis of the woody taxa because these support both tropical and subtropical forests over an altitudinal range of 200-1, 350 m and are located in between the great Himalayas in the north and the mountain systems of south India. Pachmarhi town has more than 70% of plateau covered with dense forests but is under active biotic influence.

The flora of these hills by and large remained cytologically unexplored except for the studies of Vasudeva & Bir (1982) on Pteridophytes, Bir & Kumari (1977) on Legumes, Gill *et al.* (1980) on grasses, Gupta & Gill (1984) on composits, Saggoo & Bir (1982) on Acanthaceae, and Bir & Saggoo (1982) on Labiatae. One hundred and sixteen wild woody elements (85 tree species and 35 shrubby species)of forests of Pachmarhi hills were cytologically studied by the present writers during the years 1976-1981. The results were published from time to time

as far as individual taxa or groups were concerned (cf. Bir *et al.* 1979, 1980 1982a, b Gill *et al.* 1979a, b, 1981a, b, c, 1982, 1984; Bedi *et al.* 1980, 1981a, b, 1985; Singhal *et al.* 1980a, b, 1982, 1983a, b, 1985a, b, c, 1990; Bedi & Bir 1985; Singhal & Gill 1984, 1985, 1987, 1989, 1990). The present communication is intended to analyse these results with a view to have an over all picture about the evolutionary mechanisms operative in central Indian forest trees and other woody taxa.

MATERIAL AND METHODS

Wild woody plants from different forests formed the basis of our studies for recording the chromosome numbers and other meiotic pecularities. Young flower buds were fixed in Carnoy's fluid and squashes were prepared with 1% acetocarmine. For permanent record, desirable slides were mounted in euparal after dehydrating with ethyl alcohol. The well filled and stained pollen grains were scored as fertile following Mark's (1954) method.

SALIENT FEATURES

1. Two genera, *Boswellia serrata* (n=22) and *Buchanania lanzan* (n=11), and 14 species viz. *Grewia elastica* (n=9), *G. hainesiana* (2n=27, 36), *G. leptopetala* (n=9), *G. tiliaefolia* (n=9) *Zizyphus rugosa* (n=12), *Combretum ovalifolium* (n=26), *Schefflera venulosa* (n=24), *Gardenia latifolia* (n=11), *Xeromphis uliginosa* (n=11), *Diospyros melanoxylon* (n=15), *Schrebera swietenoides* (n=23), *Dolichandrone falcata* (n=20), *Fluegea leucopyrus* (n=28) and *Ficus tsiela* (n=13) are counted for the first time.
2. For 11 species varied and/or additional chromosome numbers are recorded for which, information together with comments, is provided in Table 1.
3. **Cytomorphological variations :**

Intraspecific morphological and/or cytological variations are recorded in as many as 19 species. The morphovariants with constant chromosome numbers are recorded in *Boswellia serrata* (n=22), *Butea monosperma* (n=19), *Dodonaea viscosa* (n=14), *Emblica officinalis* (n=52), *Litsea glutinosa* (n=24), *Loranthus longiflorus* (n=9), *Miliusa velutina* (n=9), *Mimusops hexandra* (n=12), *Plumeria rubra* (n=18), *Pongamia pinnata* (n=11), *Terminalia tomentosa* (n=12), *Wrightia tinctoria* (n=11), *W. tomentosa* (n=11) and *Xeromphis spinosa* (n=11).

In *Terminalia chebula* such variations also exist amongst the diploid (n=12) and tetraploid (n=24) individuals (Gill *et al.* 1982). On the other hand, morphological variation are well associated with changes in chromosome numbers and polyploidy level in *Grewia hainesiana* 3x, 4x; *Lantana camara* 2x, 4x; *Syzygium cumini* 4x, 6x; and *Terminalia chebula* 2x, 4x, 6x.

In these species, the increase in size of various vegetative and floral parts is correlated with increase in ploidy level. Gigantism associated with polyploidy is well known in several other woody taxa (Mehra 1976, Bir *et al.* 1982b, Bedi *et al.* 1985, Chatha & Bir 1987; Singhal & Gill 1989).

4. Polyploidy effects time and duration of flowering in *Syzygium cumini* and *Terminalia chebula*. In *S. cumini*, the polyploid (4x, 6x) individuals flower much earlier as compared to the diploids (cf. Gill *et al.* 1989, Gill & Singhal 1990) whereas in *T. chebula*, flowering is much earlier in the diploid as compared to polyploid (4x, 6x) individuals (cf. Gill *et al.* 1982).

TABLE 1 : Additional and/or varied Chromosome Number records for Woody Taxa of Pachmarhi hills

S. No.	Taxon	Present Record	Previous report/s	Remarks
1.	*Annona squamosa*	n=14	n=7, 8	First report of 4x and intraspecific polyploidy
2.	*Anacardium occidentale*	n=20	n=12, 21	First report of cytotype with n=20 from India
3.	*Cochlospermum religiosum*	n=6	n=7	New cytotype
4.	*Hiptage benghalensis*	n=30	n=21, 28, 29	New cytotype with highest chromosome number
5.	*Alangium salvifolium*	n=9	n=8, 11	New aneuploid cytotype
6.	*Kigelia pinnata*	n=21	n=20	New aneuploid cytotype
7.	*Leea indica*	n=24	n=10, 11, 12	First report of 4x cytotype and intraspecific polyploidy
8.	*Semecarpus anacardium*	n=29	n=30	New aneuploid cytotype
9.	*Stereospermum xylocarpum*	n=18	n=20	New aneuploid cytotype
10.	*Terminalia chebula*	n=36	n=12, 13, 14	First report of 6x cytotype
11.	*Zizyphus oenoplia*	n=12	n=10, 24	First report of 2x cytotype

*For previous reports reference is made to Darington & Wylie (1955), Index to Plant Chromosome Numbers (1956-1987), Löve & Löve (1961, 1974, 1975), Fedorov (1969), Kumar & Subramaniam (1987), IOPB Chromosome Number Reports in Taxon and SOCGI Plant Chromosome Number Reports in Cytol. & Genet. published from time to time.

5. By and large woody dicots are less amenable to chromosomal aberrations due to their small sized chromosomes. This is clearly borne out from the studies carried out on Indian forest trees and other woody taxa by Mehra (1976), Bir *et al.* (1982b), Chatha & Bir (1987) and Singhal & Gill (1989). Our work on the central Indian members also confirms that majority of the woody species show normal meiosis. Out of a total of 116 wild species, only nine (2 diploid and 7 polyploid) exhibit various meiotic irregularities.

From amongst 32 polyploid taxa (of Table 2), meiosis in only 7 species, namely, *Cordia dichotoma*(2n=48), *Emblica officinalis*(2n=104), *Grewia hainesiana*(2n=27), *Hiptage benghalensis* (2n=60) *Syzygium cumini* (2n=44, 66), *Terminalia belerica* (2n=48) and *T. chebula* (2n=48, 72) is abnormal. Frequently, multivalents, univalents and laggards are noticeable. Abnormal microsporogensis is consequently coupled with pollen sterility. Majority of the north and central Indian taxa of *Cordia dichotoma* (n=24) show abnormal meiotic behaviour (cf. Bedi *et al.* 1985). On the basis of chromosomal associations, Bedi *et al.* (1985) indicated its allohexaploid nature. A few individuals of *Emblica officinalis* show the presence of up to 3 quadrivalents. Gill *et al.* (1981c) suggested that formation of few quadrivalents in the species

is either due to segmental allopolyploidy or due to heterozygosity for chromosomal interchanges. The triploid cytotype of *Grewia hainesiana* (2n=27) shows abnormal meiosis manifested in the presence of univalents, laggards, irregular chromosome distribution during anaphases and abnormal microsporogenesis. Analysis of chromosomal association revealed its allotriploid nature and it seems to be an interspecific hybrid with *G. hainesiana* (4x) and *G. elastica* var. *elastica* (2x) as putative parents (Singhal *et al.* 1982). Cytologically, *Hiptage benghalensis* is quite variable having different cytotypes with 2n=42, 56, 58, 60 (Singhal *et al.* 1985a). The Pachmarhi individuals with 2n=60 and those studied from North India with 2n=56 (cf. Roy & Mishra 1962, Singhal *et al.* 1985a) show abnormal meiosis indicating the unbalanced polyploid nature of the species (Singhal *et al.* 1985a). Majority of the populations of *Terminalia belerica* from Pachmarhi hills (present studies) and North India (Mehra 1976) are tetraploid and show abnormal meiosis. Gill *et al.* (1982) suggested these to be segmental alloploids with genomic constitution AAÁÁ. Both the polyploid cytotypes (4x, 6x) of *T. chebula* show irregular meiosis characterized by the presence of few quadrivalents. On the basis of chromosomal associations Gill *et al.* (1982) suggested the tetraploid to be segmental allotetraploid (AAÁÁ) and hexaploid as allohexaploid with genomic constitution AAÁÁ BB. The tetraploid and hexaploid cytotypes of *Syzygium cumini* show abnormal meiosis. The presence of up to 5 quadrivalents in some trees of the Pachmarhi hills and up to 9 quadrivalents in the cultivated trees from Dehra Dun indicate the origin of these tetraploid trees through autotetraploidy followed by some chromosome rearrangements with genomic constitution AAÁÁ. On the other hand the origin of hexaploid trees involves another genome 'BB' through hybridization with chromosome rearrangements in set 'ÁÁ' in some populations (Gill *et al.* 1989, Gill & Singhal 1990).

Only two diploid species, *Loranthus longiflorus* var. *amplexifolia* (2n=18) and *Pongamia pinnata* (2n=22), show multivalent formation which could either be due to hybrid nature of the taxa or due to the existence of structural heterozygosity (cf. Bir *et al.* 1980, Singhal *et al.* 1990). *P. pinnata* is more amenable to these abnormalities as different plantations inclusive of the present one have multiple associations (Sarbhoy 1977, Bir & Kumari 1979, Singhal *et al.* 1990).

6. Cytomixis :

Migration of chromatin among PMCs has been reported in several woody species from this laboratory (Bedi *et. al.* 1985, Singhal & Gill 1985, Chatha & Bir 1987). In Pachmarhi region, the phenomenon of cytomixis in 7 species, namely, *Casearia graveolens* (2n=4x=84), *Cordia dichotoma* (2n=6x=48), *Dodonaea viscosa* (2n=2x=28), *Helicteres isora* (2n=2x=18) *Hiptage benghalensis* (2n=60), *Semecarpus anacardium* (2n=2x=58) and *Syzygium cumini* (2n=6x=66) is noticeable. Although incidence of cytomixis has been widely reported yet conflicting explanations have been put forward regarding the cause and significance of cytomixis. Woodworth (1931), Gelin (1934), Maheshwari (1950), Takats (1959) and Bhojwani & Bhatnagar (1974) believe that it is an artefact of fixation or degenerative effects. Pressure difference (Tarkowska 1965, Gervais 1973, Morisset 1978), nature and type of the cell wall (Vaarama 1941), intercellular connections being formed prior to meiosis by abnormal cytokinesis (Baquar & Husain 1969, Risueno *et al.* 1969, Pradhan & Sen 1971), unclear pores in the connecting

membrances (Bhandari *et al.* 1969), changes or disturbances of the hydrostatical state of individual part of sporogenous tissue (Cebotarev 1967), temperature effects leading to physiological disturbances (Narain 1979), etc. are the explanation given for cytomixis. But in all possibility it appears to be a natural phenomenon controlled by some genetic factors as has also been suggested by other workers (Gottschalk 1970, Bhagvandoss *et al.* 1973, Brown & Bertke 1974, Omara 1976, Bedi *et al.* 1985, Singhal & Gill 1985, 1989, Chatha & Bir 1987).

7. B-Chromosomes :

Since their first discovery in woody dicots by Mehra & Bawa (1968) from eastern Himalayas, B-chromosomes have now been recorded in large number of species (Mehra & Gill 1971, Jones 1975, 1981, Mehra 1976, Gill *et al.* 1981b Jones & Reese 1982, Bedi *et al.* 1985, Chatha & Bir 1987, Sandhu & Mann 1988, 1989, Singhal & Gill 1989). From amongst the woody taxa of the Pachmarhi hills, the presence of Bs has been recorded in six species, namely, *Hiptage benghalensis* 2n=60+0—4B, *Plumbago capensis*, 2n=14+0—1B, *Pongamia pinnata*, 2n=22+0—7B, *Tamarindus indica*, 2n=24+0—4B, *Terminalia arjuna* 2n=24+0—2B *and Trema orientalis*, 2n=40+0—1B. To date, Bs have been detected in 68 woody species and with the availability of more cytological data from different geographical regions on population basis the number of species with Bs is likely to increase. The earlier view that Bs are rare in woody members is, therefore, untenable. Earlier, Jones (1981) had rightly stated that Bs which appear to be widely represented are often found in those species and families which have attracted the attention of cytologists. The same seems to hold good for woody taxa.

8. Base number :

Basic chromosome numbers in woody genera analysed from the Pachmarhi hills are highly variable, x=6—25, 28, 30, 36, 46, 48, 60. The lowest number, x=6 is represented in *Cochlospermum, Plumbago* and *Shorea*, and the highest, x=60 is noticeable in *Eriolaena*. The base number for *Hiptage* cannot be ascertained correctly because of chromosomal variation (2n=42, 56, 58, 60). In majority of the genera, the basic numbers fall in the range of x=9-14 with the dominance of x=11 *(Alangium, Buchanania, Caesalpinia, Capparis, Carissa, Combretum, Flacourtia, Gardenia, Holarrhena, Ixora, Jatropha, Lantana, Mitragyna, Mussaenda, Ougeinia, Pongamia, Syzygium, Wendlandia, Wrightia, Xeromphis)* and x=12 *(Anacardium, Anogeissus, Caesalpinia, Capparis, Duranta, Glochidion, Helicteres, Leea, Litsea, Madhuca, Melastoma, Mimusops, Ougeinia, Phyllanthus, Pongamia, Schefflera, Tamarindus, Tectona, Terminalia, Zizyphus)*. The higher frequency of genera with x=11--14 has also been suggested for woody members from the Himalayas (Mehra 1972, Bir *et al.* 1982b) and south India (Chatha & Bir 1987). On the other hand, the herbaceous angiosperms, in general, have relatively low base numbers in the range of x=7-9 (Stebbins 1938, Grant 1963).

Majority of the woody genera analysed are monobasic indicating that for speciation in these genera the main factor has been euploidy rather than aneuploidy. Quite a many of the genera are dibasic with closely allied base numbers (*Caesalpinia*, x=11, 12; *Casearia* x=21, 22; *Emblica* x=13, 14; *Glochidion* x=12, 13; *Holarrhena* x=10, 11; *Kigelia* x=20, 21; *Lannea* x=14, 15; *Oroxylum* x=14, 15; *Ougeinia* x=11, 12; *Toona* x=13, 14) or completely unrelated

base numbers (*Firmiana* x=16, 20; *Lantana* x=11, 18; *Miliusa* x=9, 14; *Salix* x=19, 22; *Sterculia* x=18, 20; *Stereospermum* x=18, 20). Polybasic genera indicating dysploid series of base numbers (*Dodonaea* x=14, 15, 16; *Flacourtia* x=9, 10, 11; *Gmelina* x=18, 19,20; *Lagerstroemia* x=21, 23, 24, 25; *Plumbago* x=6, 7, 8) or scattered base numbers (*Bombax* x=36, 46, 48; *Capparis* x=9, 10, 11, 12, 19; *Combretum* x=11, 13, 14, 16; *Cordia* x=8, 14, 15, 18; *Duranta* x=8, 12, 17, 18; *Ehretia* x=8, 9, 10, 13, 15; *Flueggea* x=8, 13, 14; *Helicteres* x=9, 10, 12; *Melastoma* x=10, 12, 14; *Phyllanthus* x=7, 8, 9, 10, 12, 13; *Shorea* x=6. 7, 10 are not either rare.

Khosla & Sareen (1978, 1981) attributed the dibasic or polybasic nature of certain woody genera to some errors in chromosome countings. Also, Jong (1975) has questioned the dibasic nature of *Dipterocarpus*, *Hopea* and *Vatica*. We are also in agreement with these observations since quite variable chromosome number reports are available for woody members.

EVOLUTIONARY MECHANISMS

9. Polyploidy:

Out of a total of 136 (wild : 116, cultivated : 20) cytologically studied woody taxa from the Pachmarhi hills 32 are polyploids with 23.5% incidence of polyploidy. This figure is not significantly different from other regional estimates of Mehra (1972) for the Himalayas, Bir *et al.* (1982b) for Garhwal Himalaya and Chatha & Bir (1987) for South India (cf. Table 2). Thus there is no correlation between the incidence of polyploidy and the phytogeographical distribution of woody taxa.

Habit - polyploidy correlations have been tried by various workers. Baquar (1976) concluded that in the angiospermous flora of Pakistan, perennials have higher incidence of polyploidy than annuals. Bir & Kumari (1977) while analysing the legumes of Pachmarhi hills have also concluded that woody members have higher incidence of polyploidy as compared to herbaceous ones. Comparisons made for the studied species from the different region like the Garhwal Himalaya, south India and central India (cf. Table 3) reveal that except for some difference of higher incidence of polyploidy among shrubs of south India, incidence of polyploidy is almost the same for shrubs and trees. Wright (1976) has also pointed out that there is no correlation between polyploidy and habit.

With reference to the incidence of various grades of polyploidy amongst trees and

TABLE : 2 Incidence of polyploidy in woody taxa from different phytogeographical regions of India

Regions	Taxa Investigated		Incidence of polyploidy	Authors
	Total	Polyploid		
Himalayas	528	130	24.6	Mehra (1972)
Garhwal Himalayas	174	38	21.8	Bir et al. (1982 b)
South India	167	45	26.9	Chatha & Bir (1987)
Central India*	136	32	23.5	Writers

*Includes 20 cultivated taxa.

TABLE 3 : Habit-polyploidy correlation amongst trees and shrubs of different phytogeographical regions of India

Regions	Habit	Taxa investigated		Incidence of polyploidy
		Total	Polyploid	
Garhwal Himalayas	Trees	93	19	20.4
(Bir *et al.* 1982 b)	Shrubs	81	19	23.4
South India	Trees	64	15	23.4
(Chatha & Bir (1987)	Shrubs	103	30	29.1
central India	Trees	91	22	24.2
(Present work)	Shrubs	45	10	22.2

shrubs of different regions of India, it is clear that the tetraploids are by far the most common followed by hexaploids and octoploids (cf. Table 4). According to de Wet (1980) the tetraploids are the most successful polyploids because they combined the genomes of two closely allied taxa. In the Pachmarhi hills, the triploid cytotype (2n=27) is represented by *Grewia hainesiana* only and pentaploids amongst woody taxa are not so far recorded from any region of India.

In the Pachmarhi Hills, in comparison to evergreen woody elements the deciduous ones show higher incidence of polyploidy (cf. Table 5). On the other hand, Bedi *et al.* (1985) while analysing the combined results of the woody elements of Gamopetalae and Monochlamydeae from Garhwal Himalaya and Central India found that incidence of polyploidy is more in evergreen elements in comparison to deciduous ones. It is pertinent to mention that in this type of analysis, much depends upon the families and genera covered.

TABLE 4 : Incidence of various ploidy levels in trees and shrubs in different Phytogeographical regions of India

Regions	Habit	Ploidy levels			
		3x	4x	6x	8x and higher
Garhwal Himalaya	Trees	...	84.2%	5.3%	10.5%
(Bir *et al.* 1982 b)	Shrubs	...	78.9%	10.5%	10.5%
South India	Trees	...	66.7%	20.0%	13.3%
(Chatha & Bir (1987)	Shrubs	...	73.3%	13.3%	13.4%
central India	Trees	4.5%	68.2%	18.2%	9.1%
(Present work)	Shrubs	...	80.0%	...	20.0%

TABLE 5 : Incidence of polyploidy in evergreen and deciduous woody taxa from central India

Habit	Total Investigated taxa	Diploid	Polyploid	Incidence of Polyploidy
Evergreen	36	29	7	19.4%
Deciduous	66	42	24	36.3%
Total	102	71	31	30.4%

Wright (1976) also did not find any correlation between growth habit and the incidence of polyploidy. Another approach is to compare the incidence of polyploidy from the tropical dry deciduous forests and montane subtropical forests in the region. The woody elements of montane subtropical forests show higher incidence of polyploidy in comparison to those analysed from the tropical forests (cf. Table 6). Favarger (1967), Mehra (1972), Baquar (1976)

TABLE 6 : Incidence of polyploidy in the different forest type of central India

Forest type	Total Investigated taxa	Diploid	Polyploid	Incidence of Polyploidy
Tropical dry deciduous (400-750)	40	30	10	25.0%
Montane subtropical (750-1350 m)	62	41	21	33.8%
Total	102	71	31	30.9%

and Ehrendorfer (1980) suggested that there seem to be no direct relationship of polyploidy on one hand and ecological habit or distribution pattern on the other hand. Mehra (1972) suggested that as percentage of polyploidy varies considerably in different woody families and genera, the forests having preponderance of species belonging to genera and families having higher incidence of polyploidy or those lacking it, would obviously effect the percentage of polyploidy.

10. Intraspecific polyploidy :

The role of ploypoidy in the evolution is evident from the existence of intraspecific variation amongst woody taxa of India. Taking into consideration the present studies and those conducted by other workers* on the presently analysed 116 wild species, intraspecific polyploidy does exist in 19 species as mentioned below :

(i) 2x, 3x : *Melia azedarach*

(ii) 2x, 4x : *Annona squamosa, Jatropha curcas, Leea indica, Riccinus communis, Salix tetrasperma, Terminalia belerica, Trema orientalis, Wrightia tinctoria, Xeromphis dumetorum, Zizyphus oenoplia.*

(iii) 3x, 4x : *Grewia hainesiana, Lawsonia alba.*

(iv) 4x, 8x : *Emblica officinalis.*

(v) 2x, 4x, 6x : *Terminalia chebula, Toona ciliata.*

(vi) 2x, 3x, 4x, 6x : *Lantana camara.*

(viii) 2x, 3x, 4x, 5x, 6x : *Syzygium cumini*

(viii) 2x, 4x, 5x, 6x, 8x : *Zizyphus mauritiana*

Earlier, Mehra (1972), Bir *et al.* (1982b), Bedi *et al.* (1985), Chatha & Bir (1987), Sandhu & Mann (1988, 1989), and Singhal & Gill (1989) recorded several woody species showing intraspecific polyploidy. The number of such species is likely to increase with the availability

*For references see foot-note to Table 1 on page 310.

of more cytological data from the unexplored regions and also on studying members on population basis. Evidently, the taxonomy of these species with intraspecific cytotypes needs a second look.

11. Aneuploidy :

Role of aneuploidy in the evolution of woody taxa is evident from the existence of diversity in basic chromosome numbers within genera, several of these are dibasic or polybasic as referred to earlier. Additional aneuploid chromosome numbers have been added in 7 species, namely, *Anacardium occidentable* (n=20), *Alangium salvifolium* (n=9), *Cochlospermum religiosum* (n=6), *Hiptage benghalensis* (n=30), *Kigelia pinnata* (n=21), *Semecarpus anacardium* (n=29), *Stereospermum suaveolens* (n=18) and *Zizyphus oenoplia* (n=12). New aneuploid cytotypes have also been reported from other regions of India by Mehra (1972), Bir *et al.* (1982b), Bedi *et al.* (1985), Chatha & Bir (1987), Sandhu & Mann (1988, 1989) and Singhal & Gill (1989). Aneuploidy which is operative both at dipliod and at polyploid level exists in nearly one third of the presently analysed species. Of a total of 37 species showing intraspecific aneuploidy*, 16 species are polyploid and remaining 21 species are diploid as given below :

(a) Polyploid species :

Anacardium occidentable (2n=40, 42), *Bombax ceiba* (2n=72, 92, 96), *Citrus medica* (2n=18, 28), *Drypetes roxburghii* (2n=38, 40), *Duranta plumieri* (2n=34, 36), *Emblica officinalis* (2n=98, 104), *Hiptage benghalensis* (2n=42, 56, 58, 60), *Jacaranda mimosifolia* (2n=36, 66), *Lagerstromeia speciosa* (2n=44, 48, 50), *Lantana camara* (2n=32, 33, 38, 44), *Lawsonia indica* (2n=30, 32, 34, 36), *Petrea volubilis* (2n=14, 34), *Syzygium cumini* (2n=44, 46), *Toona ciliata* (2n=52, 66), *Trema orientalis* (2n=36, 40) and *Zizyphus mauritiana* (2n=40, 48).

(b) Diploid species :

Alangium salvifolium (2n=16, 18, 22), *Annona squamosa* (2n=14, 16) *Azadirachta indica* (2n=28, 30), *Cochlospermum religiosum* (2n=12, 14), *Dodonaea viscosa* (2n=28, 30, 32), *Ehretia laevis* (2n=18, 26), *Flacourtia indica* (2n=18, 22), *Kigelia pinnata* (2n=40, 42), *Leea indica* (2n=20, 22, 24), *Oroxylum indicum* (2n=28, 30), *Ougeinia oojeinensis* (2n=22, 24), *Pongamia pinnata* (2n=20, 22), *Quisqualis indica* (2n=22, 24, 26), *Rhus parviflora* (2n=28,30), *Semecarpus anacardium* (2n=58, 60), *Stereospermum suaveolens* (2n=36, 40), *Terminalia arjuna* (2n=24, 26), *T. belerica* (2n=24, 26), *T. chebula* (2n=24, 26), *Wrightia tinctoria* (2n=20, 22) and *Zizyphus oenoplia* (2n=20, 24).

The fore-going account shows the extent of cytological variabilities in woody taxa of central India that remained hitherto unexplored. The high incidence of euploidy and aneuploidy amongst the extant woody taxa indicates that this component of Indian flora is in an active state of evolution.

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*Based on previous reports (see foot-note to Table 1 on page 310)

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