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Cytology of woody species

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Abstract. Cytological studies have been made on 59 woody species of Polypetalae. Two genera (*Gynocardia odorata*, $n = 23$; *Pahudia martabanica*, $n = 12$) and 9 species (*Talauma candollei*, $n = 19$; *Cratoxylon polyanthum*, $n = 11$; *Sterculia villosa*, $n = 20$; *Grewia hirsuta*, $n = 9$; *Millettia brandisiana*, $2n = 22 + 0\text{–}2B$; *Phanera glauca*, $n = 14$; *Terminalia oliveri*, $n = 12$; *Psidium coriaceum*, $2n = 77$; *P. pumilum*, $n = 11$) are counted for the first time. Additional and/or varied chromosome numbers are recorded for 8 species. Presence of *B*-Chromosomes has been detected in *Crataeva nurvala* ($n = 13 + 0 - 3B$), *Erythrina caffra* ($n = 21 + 0\text{–}3B$) and *Millettia brandisiana* ($2n = 22 + 0\text{–}2B$). Existence of some multivalents in the tetraploid taxa of *Eugenia jambolana* ($2n = 44$) and *Hydnocarpus laurifolia* ($2n = 48$) indicates their segmental alloploid nature. But the presence of cent per cent trivalents (11_{III}) in the triploid cytotype of *Eugenia uniflora* ($2n = 33$) reveals the autotriploid nature. Presence of some univalents in diploid taxa of *Millettia brandisiana* ($2n = 22$) may be due to asynapsis and/or desynapsis. Variation in chromosome number in PMCs and some pollen sterility in *Hydnocarpus kurzii* seems to be the cònsequence of cytomixis. Abnormalities in microsporogenesis in one of the cultivated trees of *Firmiana pallens* ($2n = 40$) are due to spindle irregularities.

Keywords. Chromosome number; alloploid; desynapsis; asynapsis; cytomixis; cytokinesis.

1. Introduction

Attempts on the chromosome counts of forest species growing in the New Forest, Dehra Dun have been made in the past by Rao (1954, 1967) and Nanda (1962). Inspite of the fact that they have determined the chromosome numbers of more than 160 species, several species remain uncovered by them. Also, because of the fact that chromosome countings were made through microtome sectioning, the reports in some cases are contradictory and needs reinvestigation. In view of the above mentioned lacunae and utility of cytological data for future tree breeding programmes, the present studies on the exotic and introduced woody species in the Forest Research Institute, Dehra Dun were undertaken. The present study which includes 59 woody species of Polypetalae is a part of our project on the chromosome analysis of country flora.

2. Material and methods

Materials for meiotic studies were collected from the plants cultivated at Forest Research Institute, Dehra Dun. For meiotic studies, appropriate sized flower buds were fixed in Carnoy's fluid with acetic acid component saturated with iron acetate. Anthers were squashed in 1% acetocarmine and slides were made permanent in euparal. Pollen fertility was estimated with 1:1 glycero-acetocarmine mixture.

3. Observations

Information on chromosome number, ploidy level, pollen fertility and previous reports of the presently investigated species are summarised in table 1. Only species with results of cytological interest are dealt herewith.

3.1 *Crataeva nurvala* Buch. Ham.

Meiotic studies in the species show normal 13 bivalents and 30–35 % pollen sterility. In addition, 8·4 % of the observed PMCs in this cultivated taxon reveal variable (1–3) number of *B*-chromosomes (figure 3), average frequency of which works out to be 0·13. Pairing between two *B*'s is occasional.

3.2 *Hydnocarpus kurzii* (King) Warburg

During meiosis, most of the PMCs show 12 large sized bivalents. The phenomenon of cytomixis which occurs from early prophase I to *T*-II exist in 21·7 % of the PMCs. Consequent to the chromatin transfer, PMCs with increased (figure 6) as well as decreased chromosome numbers result. Extra chromatin material generally lag at *A*-I/*T*-I. Some pollen sterility (13 %) is probably the consequence of cytomixis.

3.3 *H. laurifolia* (Dennst.) Sleumer

The chromosome number $2n = 48$ (figure 7) is confirmed from the PMCs. Multivalents and univalents are present in 8·6 % of the PMCs at diakinesis and *M*-I, with the most common configuration being $2_{IV} + 20_{II}$. Inspite of the formation of quadrivalents (1–4) and trivalents (0–1), involving 12·3 % and 0·2 % of the chromosomes, respectively, distribution of chromosomes during anaphases and pollen fertility is not seriously affected.

3.4 *Firmiana pallens* (Wall. ex King) Koster

Most of the cultivated individuals of this species show the same chromosome number $n = 20$ (figure 10) and regular meiosis. But one tree which is morphologically indistinguishable from the other cultivated trees growing in close vicinity have meiotic irregularities associated with very high pollen sterility (81 %). In this tree, inspite of normal chromosomal pairing, laggards at anaphases and telophases, tripolar distribution of chromosomes at *A*-I (figure 12) and scattered chromosomes during *A*-II (figure 11) are of common occurrence. Laggards are more frequent at *A*-II/*T*-II (38·1 % PMCs) as compared to *A*-I/*T*-I (29·0 % PMCs). Microsporogenesis is also irregular due to the formation of monads (11·8 %, figure 13d, e), dyads (5·5 %, figure 13b, c), triads (7 %, figure 13a) and polyads (14 %, figure 13f). Some of the polyads have large number of microspores few of which are binucleate. Binucleate microspores in dyads and monads are not uncommon.

3.5 *Erythrina caffra* Thunb.

During meiosis 21 bivalents are regularly constituted at *M*-I. Inspite of the regular bivalent formation, laggards are present at *A*-I (figure 21) in some PMCs. Some of the

Table 1. Data on chromosome numbers in the presently studied species.

Taxa	Chromosome number	Ploidy level	Pollen fertility (% age)	Previous reports*
1	2	3	4	5
Dilleniaceae				
Dillenia indica Linn.	$2n = 28$ (figure 1)	$4x$	100	$2n = 48$: Mehra (1976) $2n = 54$: vide Fedorov (1969)
Magnoliaceae				
Magnolia grandiflora Linn.	$n = 57$	$6x$	77	$2n = 112–114$: Morinaga *et al* (1929) $2n = 114$: Janaki Ammal, (1952a); Yamakava vide Fedorov (1969); Koul and Gohil (1973)
Michelia fuscata Blume	$n = 19$	$2x$	100	$2n = 38$: Janaki Ammal (1952a); Nanda (1962); Raven vide Fedorov (1969); Mehra (1976)
Talauma candollei Blume	$n = 19$ (figure 2)	$2x$	–	
Annonaceae				
Polyalthia suberosa Benth. & Hook. f.	$n = 9$	$2x$	100	$2n = 18$: Pancho (1971)
Capparidaceae				
Crataeva nurvala Buch.-Ham. (= *C. lophosperma* Kurz)	$n = 13 + 0\text{-}3B$ (figure 3)	$2x$	66	$2n = 26$: Raghavan and Arora (1958)
Flacourtiaceae				
Gynocardia odorata R. Br.	$n = 23$ (figure 4)	$2x$	63	
Homalium tomentosum Benth.	$n = 11$ (figure 5)	$2x$	100	$2n = 20$: Rao (1967)
Hydnocarpus kurzii (King) Warburg (= *Taraktogenos kurzii* King)	$n = 12$ (figure 6)	$2x$	87	$2n = 24$: Rao (1954); Mangenot and Mangenot (1962); Nanda (1962)
H. laurifolia (Dennst.) Sleumer (= *H. wightiana* Blume)	$2n = 48$ (figure 7)	$4x$	100	$2n = 24$: Nanda (1962) $2n = 48$: Hâmacher (1947)
Oncoba spinosa Forsk.	$n = 11$ (figure 8)	$2x$	100	$2n = 22$: Krishnan (1980)
Pittosporaceae				
Pittosporum rhombifolium A. Cunn. ex Hook.	$n = 12$	$2x$	100	$2n = 24$: Gros (1965)
Guttiferae				
Cratoxylon polyanthum Korth.	$n = 11$ (figure 9)	$2x$	–	
Hypericum chinense Linn.	$n = 21$	$6x$	94	$2n = 42$: Sareen *et al* (1974a, 1980)
Theaceae				
Schima wallichii Choisy	$n = 18$	$2x$	86	$2n = 30$: Malla *et al* (1977a) $2n = 36$: Mehra (1972)
Dipterocarpaceae				
Shorea talura Roxb.	$n = 7$	$2x$	–	$2n = 14$: Roy and Jha (1961, 1965a)

Table 1. (*Continued*)

Taxa	Chromosome number	Ploidy level	Pollen fertility (% age)	Previous reports*
1	2	3	4	5
Sterculiaceae				
Firmiana pallens (Wall. ex King) Koster. (= *Sterculia pallens* Wall. ex King)	$2n = 40$ (figures 10–13)	$2x$	19	$2n = 40$: Nanda (1962); Mehra and Sareen (1973a)
Pterospermum suberifolium Lam.	$n = 19$	$2x$	95	$2n = 38$: Poty and Hamel (1968)
Sterculia acerifolia A. Cunn. (= *Brachychiton acerifolium* F. Muell.)	$n = 20$	$2x$	100	$2n = 40$: Poty and Hamel (1968)
S. villosa Roxb.	$n = 20$ (figure 14)	$2x$	100	
Tiliaceae				
Grewia hirsuta Vahl	$n = 9$ (figure 15)	$2x$	72	
Malpighiaceae				
Byrsonima crassifolia H. B. & K.	$n = 12$ (figure 16)	$2x$	–	$2n = 20$: Nanda (1962) $2n = 24$: Fouët (1966); Bawa (1973) $2n = 28$: Rao (1954)
Malpighia glabra Linn.	$n = 20$	$4x$	90	$2n = 20, 40$: Pandey and Pal (1980) $2n = 40$: Pal (1964); Sarkar *et al* (1980)
Stigmaphyllon periplocaefolium (Desf.) A. Juss.	$n = 10$	$2x$	–	$2n = 20$: Pal (1964)
Rutaceae				
Geijera parviflora Lindl.	$n = 81$	$18x$	92	$2n = 108$: Smith-White (1954) $2n = 144$: Rao (1967)
Simaroubaceae				
Ailanthus grandis Prain	$n = 32$ (figure 17)	$2x$	99	$2n = 62$: Mehra and Khosla (1969)
Ochnaceae				
Ochna squarrosa Linn.	$n = 12$ (figure 18)	$4x$ (aneu.)	79	$2n = 28$: Mehra and Khosla (1969)
Burseraceae				
Protium serratum (Wall. ex Colebr.) Engl. (= *Bursera serrata* Roxb. ex Colebr.)	$n = 11$	$2x$	100	$2n = 22$: Ghosh (1961, 1969); Mehra (1976)
Meliaceae				
Chukrasia tabularis A. Juss.	$n = 13$	$2x$	67	$2n = 26$: Rao (1967); Mehra (1972); Mehra *et al* (1972c)
Heynea trijuga Roxb. (= *Trichilia connaroides* W. & A.)	$n = 14$	$2x$	100	$2n = 24$: Nanda (1962) $2n = 28$: Rao (1967); Mehra and Sareen (1969); Mehra *et al* (1972c)
Melia dubia Cav. (= *M. composita* Willd.)	$n = 14$	$2x$	29	$2n = 28$: Mehra and Khosla (1969); Mehra (1972); Mehra *et al* (1972c); Datta and Samanta (1977)
Hippocastanacaae				
Aesculus assamica Griff.	$n = 20$	$2x$	97	$2n = 40$: Arora (1961); Rao (1967); Mehra *et al* (1972b)

Table 1. (*Continued*)

Taxa	Chromosome number	Ploidy level	Pollen fertility (% age)	Previous reports*
1	2	3	4	5
Sapindaceae				
Koelreuteria formosana Hayana	$n = 16$ (figure 19)	$2x$	–	$2n = 22$: Bowden (1945b); $2n = 30$: Nanda (1962)
Nephelium longana Camb. (= *Euphoria longana* Lam.)	$n = 15$	$2x$	77	$2n = 30$: Bhaduri and Bose (1949); Guervin (1961a); Mehra *et al* (1972b)
Leguminosae				
Dalbergia latifolia Roxb.	$n = 10$	$2x$	82	$2n = 20$: Atchison (1951); Mehra and Hans (1971, 1972); Mehra (1972); Sanjappa and Dasgupta (1981)
Erythrina caffra Thunb.	$n = 21 + 0\text{-}3B$ (figures 20, 21)	$2x$	77	$2n = 42$: Atchison (1947b); Krukoff (1969)
Indigofera pulchella Roxb. (= *I. cassioides* Rottl. ex DC.)	$n = 8$	$2x$	–	$2n = 16$: Patil (1958); Bir and Sidhu (1966, 1967); Mitra and Datta (1967); Rao (1967); Bir and Kumari (1977); Sareen and Trehan (1977)
Lonchocarpus neuroscapha Benth.	$n = 11$	$2x$	100	$2n = 22$: Atchison (1949a)
Millettia brandisiana Kurz	$2n = 22 + 0\text{-}2B$ (figure 22)	$2x$	97	
M. ovalifolia Kurz	$n = 11$	$2x$	100	$2n = 20$: Atchison (1951); Sanjappa and Dasgupta (1977) $2n = 22$: Pal (1960); Sareen *et al* (1974a, 1980); Sanjappa and Dasgupta (1977); Bir and Kumari (1979)
Wisteria sinensis (Sims) DC. (= *W. chinensis* DC.)	$n = 8$	$2x$	51	$2n = 16$: Roscoe (1927); Bir and Kumari (1975)
Bauhinia acuminata Linn.	$n = 13$ (figure 23)	$2x$	100	$2n = 28$: Pantulu (1942); Atchison (1951); Sharma and Raju 1968; Bir and Kumari (1979)
B. galpini N. E Brown	$n = 14$	$2x$	100	$2n = 28$: Atchison (1951); Rao (1954); Sharma and Raju (1968)
Pahudia martabanica Prain	$n = 12$ (figure 24)	$2x$	100	
Peltophorum africanum Sond.	$n = 13$	$2x$	98	$n = 26$: Turner and Fearing (1959); Bir and Kumari (1979)
Phanera glauca Wall. (= *Bauhinia glauca* Wall. ex Benth.)	$n = 14$ (figure 25)	$2x$	57	

Table 1. (*Continued*)

Taxa	Chromosome number	Ploidy level	Pollen fertility (% age)	Previous reports*
1	2	3	4	5
Saraca indica Linn.	$n = 12$	$2x$	86	$2n = 24$: Pantulu (1943); Atchison (1951); Simmonds (1954); Mehra and Hans (1971, 1972); Bir and Kumari (1979); Sanjappa and Dasgupta (1981)
Rosaceae				
Stranvaesia glaucescens Lindl.	$n = 17$	$2x$	–	$2n = 34$: Mehra and Sareen (1969); Mehra *et al* (1973)
Philadelphaceae				
Deutzia scabra Thunb.	$n = 65$	$10x$	–	$2n = 130$: Sax (1931b); Schoennagel (1931)
Combretaceae				
Terminalia arjuna Bedd.	$n = 12$	$2x$	100	$2n = 24$: Janaki Ammal and Sobti (1962); Sanjappa (1979); Gill *et al* (1982) $2n = 26$: Sen (1955)
T. myriocarpa Heurck & Muell. Arg.	$n = 12$	$2x$	100	$2n = 24$: Mehra and Khosla (1969, 1972); Gill *et al* (1982)
T. oliveri Brandis	$n = 12$	$2x$	100	
Myrtaceae				
Eugenia jambolana Lam. (= *Syzygium cumini* (Linn.) Skeels	$2n = 44$ (figures 26, 27)	$4x$	86	$2n = 22$: Mehra and Khosla (1969, 1972); $2n = 22, 66$: Gill (1973); $2n = 33, 55$: Roy and Jha (1962) $2n = 44, 46, 66$: Bhaduri and Islam (1949); $2n = 66$: Mehra and Khosla (1969, 1972); Mehra (1972)
E. uniflora Linn.	$n = 11$ (figure 28)	$2x$	100	$2n = 22$: Bhaduri and Islam (1949); Simmonds (1954)
	$2n = 33$ (figures 29–32)	$3x$	54	$2n = 33$: Singhal *et al* (1983)
Psidium coriaceum Berg.	$2n = 77$ (figure 33)	$7x$	20	
P. pumilum Vahl	$n = 11$ (figure 34)	$2x$	100	
Barringtoniaceae				
Barringtonia acutangula (Linn.) Gaertn.	$n = 13$	$2x$	–	$2n = 24$: Mehra and Singh (1962) $2n = 26$: Sobti and Singh (1961); Roy and Jha (1965 b; Rao, 1967); Mehra (1976)
Lythraceae				
Heimia myrtifolia Cham. et Schl.	$n = 8$	$2x$	100	$2n = 16$: Dollon and Hamel (1967); Graham (1971)

Table 1. (*Continued*)

Taxa	Chromosome number	Ploidy level	Pollen fertility (% age)	Previous reports*
1	2	3	4	5
Sonneratiaceae				
Duabanga sonneratioides Buch.-Ham. (= *D. grandiflora* (R. Br.) Buch.-Ham.)	$n = 24$	4x	100	$2n = 36$: Nanda (1962); $2n = 48$: Roy and Thakur (1961); Rao (1967); Mehra and Bawa (1969); Mehra (1972)

* Darlington and Wylie (1955); Index to plant chromosome numbers (1956–1974); Löve and Löve (1961, 1974, 1975); Fedorov (1969) and selected references from Biological Abstracts.

PMCs (17·7 %) in this tree show up to 3B-chromosomes (figure 20) with an average frequency of 0·30. Pollen fertility reduces to 77 %.

3.6 *Millettia brandisiana* Kurz

Eleven bivalents are regularly consitituted at M-I. In a few PMCs, however, two chromosomes are represented as univalents which sometime lag during A-I/T-I. PMCs with more than one nucleolus of unequal size are also present. Up to 2B's are also recorded in 16 % of the PMCs (figure 22) with an average frequency of 0·19.

3.7 *Eugenia jambolana* Lam.

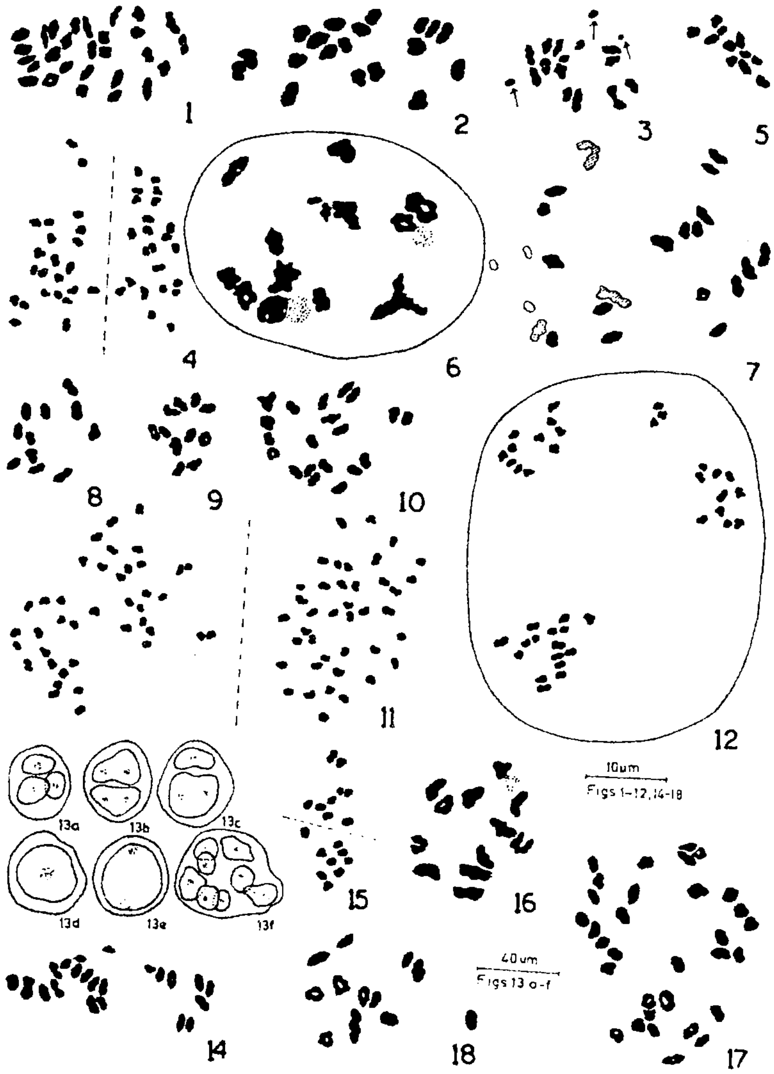
The presently studied cultivated taxon is found to be tetraploid ($2n = 44$) and shows irregular meiosis due to multivalents and univalents (table 2). The most common configuration is with $4_{IV} + 14_{II}$ (figure 26). PMCs with $9_{IV} + 1_{III} + 2_{II} + 1_{I}$ (figure 27) were also observed. Pollen fertility reduces to 86 %.

3.8 *Eugenia uniflora* Linn.

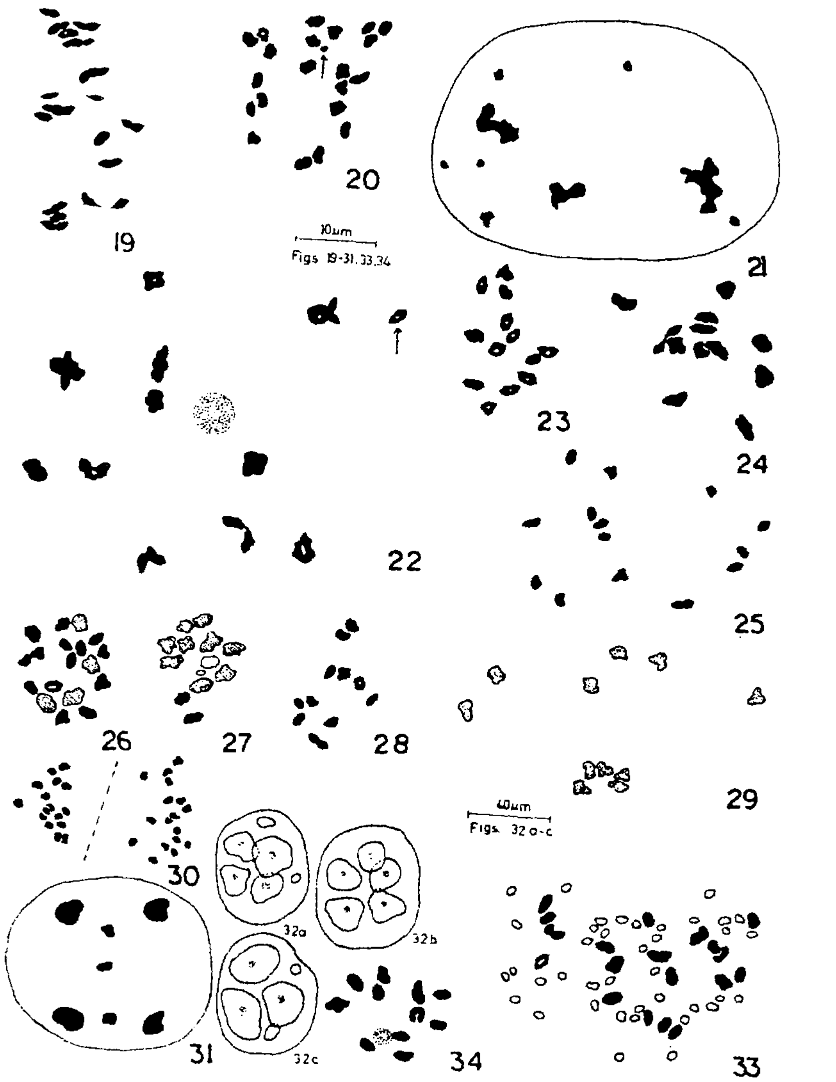
Two cytotypes, diploid ($2n = 22$, figure 28) and triploid ($2n = 33$) are recorded presently from the cultivated individuals. Meiosis in the diploid taxon is normal with

Table 2. Chromosomal associations in *Eugenia jambolana*.

PMCs analysed (12)	*Configurations*			
	IV	III	II	I
Range	0–9	0–1	2–22	0–1
Total	36	1	190	1
Average frequency/PMC	3·0	0·1	16·8	0·1
Percentage of chromosomes involved	27·3	0·7	71·8	0·2



Figures 1–18. Meiosis in pollen mother cells. **1.** *Dillenia indica*, *M*-I with 28_{II}. **2.** *Talauma candollei*, *M*-I with 19_{II}. **3.** *Crataeva nurvala*, *M*-I with 13_{II} and $3B$'s marked with arrows. **4.** *Gynocardia odorata*, *A*-I showing 23 : 23 distribution. **5.** *Homalium tomentosum*, *M*-I with 11_{II}. **6.** *Hydnocarpus kurzii*, PMC at diakinesis with two nucleoli and extra chromatin material due to cytomixis. **7.** *H. laurifolia*, *M*-I with $2n = 48 = 2_{IV} + 1_{III} + 17_{II} + 3_{I}$. **8.** *Oncoba spinosa*, *M*-I with 11_{II}. **9.** *Cratoxylon polyanthum*, *M*-I with 11_{II}. **10-13.** *Firmiana pallens*. **10.** *M*-I with 20_{II}. **11.** Mixed *A*-II with 40 : 40 chromosomes in two groups. **12.** *A*-I showing tripolar distribution of chromosomes. **13a-f.** Abnormal microsporogenesis. **a.** triad. **b.** dyad with two nuclei in each unit. **c.** dyad with unequal units and large unit showing two nuclei. **d.** monad. **e.** monad with two nuclei. **f.** polyad with one unit showing two nuclei. **14.** *Sterculia villosa*, *M*-I with 20_{II}. **15.** *Grewia hirsuta*, *A*-I showing 9 : 9 distribution. **16.** *Banisteria laevifolia*, diakinesis showing 12 bivalents. **17.** *Ailanthus grandis*, *M*-I with 32_{II}. **18.** *Ochna squarrosa*, *M*-I with 12_{II}.



Figures 19–34. Meiosis in pollen mother cells. **19.** *Koelreuteria formosana*, *M*-I with 16_{II}. **20, 21.** *Erythrina caffra*. **20.** PMC at *M*-I showing $21_{II}+1B$. **21.** Laggards at late *A-I*. **22.** *Millettia brandisiana*, diakinesis showing $11_{II}+1B$. **23.** *Bauhinia acuminata*, *M*-I with 13_{II}. **24.** *Pahudia martabanica*, *M*-I with 12_{II}. **25.** *Phanera glauca*, *M*-I with 14_{II}. **26, 27.** *Eugenia jambolana*. **26.** *M*-I with $2n = 44 = 4_{IV}+14_{II}$. **27.** *M*-I with $2n = 44 = 9_{IV}+1_{III}+2_{II}+1_{I}$. **28–32.** *E. uniflora*. **28.** Diploid cytotype. PMC at *M*-I showing 11_{II}. **29–32.** Triploid cytotype. **29.** *M*-I with $2n = 33 = 11_{III}$. **30.** *A*-I showing 16:17 chromosome distribution. **31.** *T*-II showing laggards. **32 a–c.** Abnormal microsporogenesis. **a.** tetrad with two micropollens. **b.** polyad. **c.** triad with two micropollens. **33.** *Psidium coriaceum*, *M*-I with $2n = 77 = 19_{II}+39_{I}$. **34.** *P. pumilum*, *M*-I with 11_{II}.

cent per cent pollen fertility. But in the triploid it is highly irregular and is characterised by the presence of trivalents and univalents, unequal distribution of chromosomes, laggards, etc. Analysis of chromosome association reveals that the number of trivalents, bivalents and univalents ranges from 0–11, 0–3 and 0·3 with the average frequency being 10·6, 0·4 and 0·4 respectively. The most common configuration is of 11 trivalents (62·7 % PMCs, figure 29) which is the maximum possible number of trivalents in a triploid with $2n = 33$. Distribution of chromosomes during *A*-I is quite irregular with the most common type being 22:11. PMCs with 16:17 (figure 30), 15:18, 14:19 and 13:20 distribution are also not uncommon. Laggards which vary from 1–5 are recorded in about 50 % of the PMCs at *A*-I/*T*-I and 60 % of the PMCs at *A*-II/*T*-II (figure 31). In some of the PMCs, chromosomes remain scattered and fail to reach the poles. Consequent to this, microsporogenesis is quite abnormal resulting in the formation of tetrads (41·3 %, figure 32a) and triads (5·8 %, figure 32c) with micropollen and polyads (9·0 %, figure 32b). Pollen malformation which is quite high (46 %) includes 25 % micropollen.

3.9 *Psidium coriaceum* Berg

The chromosome count of $2n = 77$ (figure 33) for the species is confirmed from the microsporocytes. Meiosis in the taxa is highly abnormal leading to high pollen sterility (80 %). Analysis of chromosomal association reveals that the number of bivalents and univalents ranges from 17–23 and 31–43, respectively, with average frequency of $20{\cdot}6_{II} + 35{\cdot}7_{I}$.

4. Discussion

Consequent to the present investigations on the woody species from the New Forest, Dehra Dun already covered by some workers (Rao 1954, 1967; Nanda 1962), two genera (*Gynocardia odorata*, $n = 23$; *Pahudia martabanica*, $n = 12$) and 9 species (*Talauma candollei*, $n = 19$; *Cratoxylon polyanthum*, $n = 11$; *Sterculia villosa*, $n = 20$; *Grewia hirsuta*, $n = 9$; *Millettia brandisiana*, $2n = 22 + 0–2B$; *Phanera glauca*, $n = 14$, *Terminalia oliveri*, $n = 12$; *Psidium coriaceum*, $2n = 77$ and *P. pumilum*, $n = 11$) are counted for the first time. Additional and/or varied chromosome numbers are recorded in 12 species which include 8 species already counted from the same area by earlier workers. The information along with comments about these reports are given in table 3.

Presence of *B*-chromosomes has been noticed in *Crataeva nurvala* ($2n = 26 + 0–3B$), *Erythrina caffra* ($2n = 42 + 0–3B$) and *Millettia brandisiana* ($2n = 22 + 0–2B$). Incidentally, all the three species are at diploid level.

As many as 6 species, namely, *Hydnocarpus laurifolia* (2*x*, 4*x*), *Malpighia glabra* (2*x*, 4*x*), *Geijera parviflora* (12*x*, 16*x*, 18*x*), *Eugenia jambolana* (2*x*, 3*x*, 4*x*, 5*x*, 6*x*), *E. uniflora* (2*x*, 3*x*) and *Duabanga sonneratioides* (3*x*, 4*x*) show intraspecific polyploid cytotypes. Among these, additional cytotypes have been recorded for *H. laurifolia* ($2n = 4x = 48$), *Geijera parviflora* ($2n = 18x = 162$) and *Eugenia uniflora* ($2n = 3x = 33$). Constitution of multivalents in tetraploid taxa of *Hydnocarpus laurifolia* ($2n = 48$) and *Eugenia jambolana* ($2n = 44$) indicates the segmental alloploid nature. On the other hand, meiosis in the triploid cytotype of *Eugenia uniflora* ($2n = 33$) is characterized by cent per cent trivalent (11_{III}) formation on the basis of which Singhal *et al* (1983) suggested the cytotype to be an autotriploid originated through the involvement of unreduced (diploid) and reduced (haploid) gametes. Meiosis in *Psidium coriaceum* ($2n = 77$) which is a very high polyploid (7*x*) is also abnormal. The presence of high frequency of univalents and complete absence of

Table 3. Variable chromosome records.

Taxa	Present record ($2n =$)	Previous reports ($2n =$)	Comments
*Homalium tomentosum**	22	20	Aneuploidy at diploid level.
*Hydnocarpus laurifolius**	48	24,48	First report of tetraploid cytotype from India.
*Byrsonima crassifolia**	24	20,24,28	Refutes the earlier reports of $2n = 20,28$.
*Geijera parviflora**	162	108,144	Additional report of polyploid cytotype ($18x$).
Ailanthus grandis	64	62	Aneuploidy at diploid level.
Ochna squarrosa	24	28	Aneuploidy at tetraploid level.
Dillenia indica	56	48,54	First report of tetraploid cytotype on $x = 14$.
*Heynea trijuga**	28	24	Earlier report of $2n = 24$ proves to be erroneous.
*Koelreuteria formosana**	32	22,30	First report of cytotype with $n = 16$.
Bauhinia acuminata	26	28	Aneuploid at diploid level.
*Duabanga sonneratioides**	48	36,48	Earlier report of $2n = 48$ confirmed.
*Eugenia uniflora**	22,33	22	First report of triploid cytotype and intraspecific polyploidy for the species.

* Species earlier counted from the New Forest, Dehra Dun.

multivalents in this unbalanced polyploid indicate its alloploid nature. Existence of only two univalents in some PMCs during diakinesis and *M*-I in *Millettia brandisiana* ($2n = 22$) which is a normal diploid might be the consequence of asynapsis and/or desynapsis.

The phenomenon of cytomixis with the involvement of chromatin transfer and constitution of hypo-and hyperploid PMCs is confirmed in *Hydnocarpus kurzii*. Since the species is normal diploid, the phenomenon seems to be under some genetic control as proposed by Brown and Berkre (1974) and Omara (1976).

Meiotic abnormalities like scattered or unoriented chromosomes, unequal distribution and laggards at anaphases, partial or complete failure of cytokinesis in one of the cultivated trees of *Firmiana pallens* which is a normal diploid ($2n = 40$) appear to be the result of some sort of spindle irregularities. Since both the trees with and without such irregularities grow side by side under the same conditions, these might be under some genetic factors as is the case with *Cephalotaxus drupacea* var. *pedunculata* (Khoshoo 1957) and *Grewia hainesiana* (Singhal *et al* 1982).

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