nehmende Differenzierung an, so daß die für Isoenzym-Allele diskutierte Neutralitäts-Hypothese durch unsere Resultate nicht gestützt werden kann.

Schlagworte: Fichtenherkünfte, geographische Variation, Isoenzym-Gene, genetische Identitätswerte.

Summary

Geographical variation among 8 provenances of the Swedish spruce population (Picea abies) was approached by the analysis of genetic polymorphisms at 2 EST and 2 LAP loci in the endosperm of dormant seeds. The resulting gene frequency distributions indicate highly polymorphic patterns within populations but only a minor differentiation between individual populations. Clinal variations from north to south, however, were observed in several cases.

Genetic identity and genetic distance values between all pairs of the 8 provenances calculated for better comparisons of the obtained data show an increasing degree of genetic differentiation in parallelism to increasing distance between populations. All results obtained are not in accord with the neutrality hypothesis concerning most isozyme variants.

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Cytology of some Himalayan trees

Thalamiflorae

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Introduction

The Himalayas are exceedingly rich in woody species which inhabit varied types of forests. About 180 species of this region are exploited as commercial timbers. Cytological studies on these forest trees which are a prerequisite to the employment of cytogenetical techniques for their improvement, have remained almost completely neglected in the past. Chromosomal constitution of even some of the most appreciated timber species was unknown. The senior author and his associates undertook cytomorphological exploration of the Himalayan hardwoods in 1962. Some parts of this work have already been published or communicated (MEHRA et al., 1962—1972). The present investigations pertain to tree species of ten families falling under the Thalamiflorae of BENTHAM and HOOKER (1862), a group of taxa of immense evolutionary significance. These include three timbers of great value, Shorea robusta, Michelia champaca and Bombax ceiba, in addition to five less important woods.

Material and Methods

The material was obtained chiefly from forests of Nainital and Simla Hills in the Western and Darjeeling Hills in the Eastern Himalayas. Flower buds were fixed in Carnoy's fluid. Anther squashes were made in 1% acetocarmine for obtaining meiotic preparations. Somatic number was determined from tapetal cells or squashes of leaf-tips made in acetolacmoid, following their pretreatment with 0.003 M solution of 8-hydroxyquinoline. The photomicrographs and camera lucida drawings are at a uniform magnification of ×1360. The voucher specimens have been deposited in the Panjab University Herbarium.

Results

Cytological data on 21 species have been summarised in Table 1. The meiosis was normal in all the taxa excepting the one mentioned in the body of the paper. Regular pairing and disjunction of chromosomes was observed, followed by wall formation, which resulted in normal tetrads with well filled stainable pollen grains.

MAGNOLIACEAE: The family is very important in Indian forestry as it contains valuable tall timber trees with fine straight bole. The four species of Michelia studied here, like others of this genus, are all diploid. M. kisopa and M. *montana* are worked out for the first time. *M. Champaca* is a high class constructional timber. Magnoliaceae is a

Table 1. — List of investigated species with chromosome numbers and supplementary data

Species	Source	Chromosome number	Figure number	Previous findings
MAGNOLIACEAE				
**Michelia champaca* L.	Chandigarh, 280 m	n = 19	7	2n = 38: JANAKI-AMMAL, 1952
M. kisopa BUCH.-HAM.	Nainital, 1,950 m	n = 19 2n = 38	8	
M. lanuginosa WALL.	Darjeeling, 2,000 m	n = 19		2n = 38: JANAKI-AMMAL, 1952
M. montana BL.	Darjeeling: Sukna, 150 m	n = 19	9	
MENISPERMACEAE				
Cocculus laurifolius DC.	Nainital: Dogaon, 1,000 m Simla: Devdhar, 1,200 m	n = 13 2n = 26 2n = 26	10 1 11—13	2n = 26: BOWDEN, 1945
BERBERIDACEAE				
Berberis aristata DC.	Simla, 2,000 m	n = 14	2	
B. vulgaris L. var. *brachybotrys* EDGEW.	Simla: Khadrala, 2,700 m	n = 14	14	
FLACOURTIACEAE				
Flacourtia indica (BURM. f.) MERR. var. *sapida* ROXB.	Kalka: Jawali, 600 m	n = 11	15	
Xylosma longifolium CLOS.	Simla: Tatapani, 760 m	n = 10	16	
TERNSTROEMIACEAE				
Eurya acuminata DC.	Darjeeling Jalapahar, 2,300 m	n = 23	17	
Gordonia axillaris D. DIETR.	Darjeeling, 2,000 m	2n = 30	18	
G. excelsa BL.	Darjeeling, 2,000 m	2n = 30		2n = 30: BEZBARUAH, 1971.
DIPTEROCARPACEAE				
**Shorea robusta* GAERTN. f.				
Moist sal.	Ambala: (Kalesar, 300 m	n = 7		n = 7 or 2n = 14: RAO 1954; ROY & JHA, 1956, '65; NANDA, 1962.
Dry sal.	Hoshiarpur: Gagret, 600 m	n = 7		
MALVACEAE				
**Kydia calycina* ROXB.	Nainital: (Ratighat, 1,400 m	n = 49	3	
BOMBACACEAE				
**Bombax ceiba* L.	Chandigarh, 280 m	n = 46	4	2n = c. 72: JANAKI-AMMAL in DARLINGTON & WYLIE, 1955.
STERCULIACEAE				
Sterculia pallens WALL.	Nainital: Dogaon, 1,000 m	n = 20	19	n = 20: NANDA, 1962.
**Pterygota alata* (ROXB.) R. BR.	Patiala, 250 m	n = 20		n = 20: NANDA, 1962.
**Pterospermum acerifolium* WILLD.	Chandigarh, 280 m	n = 19		n = 19: PATHAK *et al.*, 1949
TILIACEAE				
**Grewia laevigata* VAHL.	Nainital: Mangoli, 1,200 m	n = 9	5	
**G. oppositifolia* ROXB.	Nainital: (Jeolikote, 1,400 m	n = 9	6	
ELAEOCARPACEAE				
Elaeocarpus lancaefolius ROXB.	Darjeeling, 2,000 m	n = 15	20	

* Commercial timber.

monobasic family on x = 19 according to our present knowledge. This base number was considered to have been compounded from x = 7 and x = 12 by DARLINGTON and MATHER (1949), and RAVEN and KYHOS (1965). Many more species of this family should be worked out cytologically to arrive at a final conclusion.

MENISPERMACEAE: *Cocculus laurifolius* is the only tree member of this family occuring in India. The species was found to be variable in morphological features as well as in meiotic behaviour *(Table 2, Fig. 21)*. A population at Nainital showed normal meiosis with an unequivocal distribution of 13 : 13 chromosomes at anaphase-I *(Fig. 10)*. Somatic metaphases revealed 26 chromosomes, of which 14 were metacentric and 12 acrocentric *(Fig. 1)*. BOWDEN (1945) reported identical somatic number but did not study morphology of the chromosomes. Trees investigated from Simla, however, showed abnormal meiosis, with multivalents, chains and laggards suggesting translocations. The types of chromosome associations observed were $1_{VII} + 1_{IV} + 7_{II} + 1_{I}$ at diakinesis *(Fig. 11)* and $3_{IV} + 6_{II} + 2_{I}$ at metaphase-I *(Fig. 12)*. Laggards were common at anaphase-I *(Fig. 13)*. The well filled pollen amounted to only 78%.

BERBERIDACEAE: Both *Berberis aristata* and *B. vulgaris* var. *brachybotrys* possess n = 14. These taxa have been investigated for the first time.

FLACOURTIACEAE: *Flacourtia indica* var. *sapida* with n = 11 is the first chromosome number report. Eleven bivalents were observed at metaphase-I which were never well spread in the small pollen mother cells *(Fig. 15)*. *Xylosma longifolium* has been investigated for the first time; it showed n = 10, thereby suggesting x = 10 as the base number for the genus.

TERNSTROEMIACEAE: *Eurya acuminata* is chromosomally uninvestigated previously. The present determination of n = 23 does not fall in line with earlier reports of n = 21, 22 (DARLINGTON & WYLIE, 1955; CAVE *et al.*, 1965) in the other species of the genus. DARLINGTON and WYLIE (l. c.) suggested x = 21 for *Eurya*. The discordant chromosome numbers recorded in this genus probably reveal it to be polybasic. *Gordonia axillaris* and *G. excelsa* showed uniformity in chromosome number (2n = 30). The former species is cytologically reported for the first time, while the previous chromosome record in the latter is confirmed.

DIPTEROCARPACEAE: This family in the orient perhaps furnishes more timber than produced by all the other families put together. *Shorea robusta* is a first grade timber of India. It yields the best sleeper wood in the country and is a most valuable constructional timber. The two types studied presently fall under the categories of dry and moist sal (CHAMPION, 1936). These showed no substantial mor-

Table 2. — Comparative features of two taxa of *Cocculus laurifolius*.

Character	Taxon with normal meiosis	Taxon with abnormal meiosis
Locality	Nainital	Simla
Habit	Trees not exceeding 5 m in height	Trees upto 6 m in height
Leaves	8.0—15.0 × 2.2—3.0 cm	7.0—10.0 × 3.0—3.5 cm
Petiole	0.8—1.2 cm	0.5—0.7 cm
Male inflorescence	Axillary tufts, 1.0—2.5 cm long. Flowers few.	Axillary racemes, 4.0—6.0 cm long. Flowers numerous.
Pollen size	8.45—13.0 μ	7.8—13.65 μ
Stainable pollen	100%	78%

Fig. 1. — *Cocculus laurifolius:* 2n = 26, somatic metaphase. — *Fig. 2* — *Berberis aristata:* n = 14, metaphase-1. — *Fig. 3.* —*Kydia calycina:* n = 49, diakinesis. — *Fig. 4.* — *Bombax ceiba:* n = 46, metaphase-1. — *Fig. 5.* — *Grewia laevigata:* n = 9, metaphase-1. — *Fig. 6.* — *Grewia oppositifolia:* n = 9, metaphase-1.

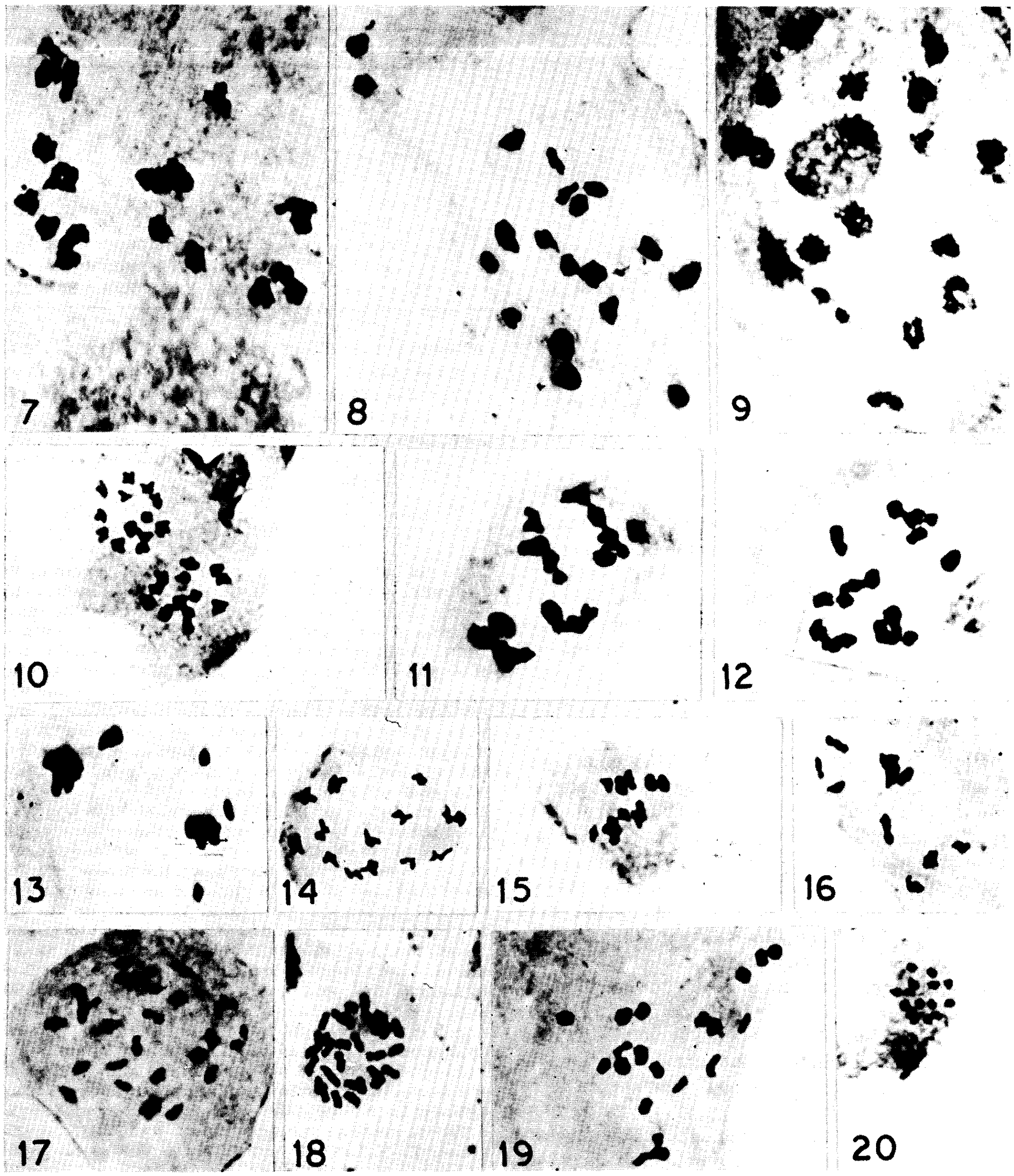

Fig. 7. — *Michelia champaca:* n = 19, metaphase-1. — *Fig. 8.* — *Michelia kisopa:* n = 19, metaphase-1. — *Fig. 9.* — *Michelia montana:* n = 19, diakinesis. — *Figs. 10—13.* — *Cocculus laurifolius: Fig. 10.* — n = 13, anaphase-1. *Fig. 11.* — 2n = 26, diakinesis. *Fig. 12.* — 2n = 26, metaphase-1. *Fig. 13.* — Laggards at anaphase-1. — *Fig. 14.* — *Berberis vulgaris* var. *brachybotrys:* n = 14, metaphase-1. — *Fig. 15.* — *Flacourtia indica* var. *sapida:* n = 11, metaphase-1. — *Fig. 16.* — *Xylosma longifolium:* n = 10, metaphase-1. — *Fig. 17.* — *Eurya acuminata:* n = 23, metaphase-1. — *Fig. 18.* — *Gordonia axillaris:* 2n = 30, somatic metaphase. — *Fig. 19.* — *Sterculia pallens:* n = 20, metaphase-1. — *Fig. 20.* — *Elaeocarpus lancaefolius:* n = 15, metaphase-1.

phological differences, and consistently revealed n = 7, thus confirming the previous reports.

MALVACEAE: The genus *Kydia* is previously unworked cytologically. *K. calycina* showed n = 49 *(Fig. 3)* which is a multiple of one of the base numbers, x = 7, in the family Malvaceae, but it is premature to comment on the base number of the genus unless other species are known cytologically.

BOMBACACEAE: *Bombax ceiba* is a very light, soft timber, employed for match boxes, plywood etc. Janaki-Ammal (in Darlington and Wylie, l. c.) ascertained 2n = ca. 72 in this species. The current examination revealed unequivocally n = 46 in a number of PMC's. Another previously reported species, *B. brevicuspe,* shows still higher number 2n = ca. 150 (cf. Cave *et al.,* 1958). The chromosome data at hand are insufficient to decide about the base number of the genus.

STERCULIACEAE: The present findings of n = 20 in *Sterculia pallens* and *Pterygota alata,* and n = 19 in *Pterospermum acerifolium* confirm the previous reports in these species. Darlington and Wylie (l. c.) presumed x = 10 as base number for *Sterculia* which number has not

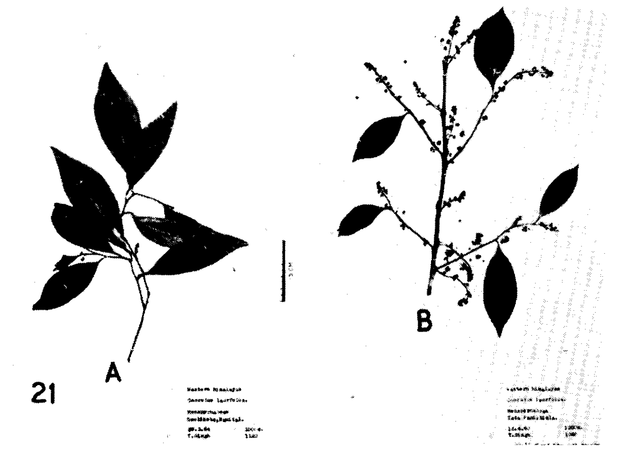

Fig. 21. — *Cocculus laurifolius:* A. — Taxon with normal meiosis. — B. — Taxon with abnormal meiosis.

yet been recorded in any species of this genus or of *Pterygota* (earlier included in *Sterculia).*

TILIACEAE: *Grewia* is the largest genus in this family, comprising nearly 150 species. *G. oppositifolia* and *G. laevigata,* each with n = 9, are studied for the first time.

ELAEOCARPACEAE: *Elaeocarpus lancaefolius* showed n = 15. This is the first chromosome report for the species and is suggestive of x = 15 as the base number of the genus *Elaeocarpus.*

Discussion

The presently investigated taxa, except the genus *Michelia,* possess small chromosomes. This is in agreement with the usually small size of chromosomes in hardwoods. The diminutive size of chromosomes which restricts the number of chiasmata in long lived trees is compensated by increase in chromosome number to ensure adequate recombination and in turn variability. The suggested base numbers of the woody genera under study, ranging from x = 7 to x = 21, are summarised in *Table 3.* The occurrence of high chromosome numbers in the two genera *Bombax (B. ceiba,* n = 46) and *Kydia (K. calycina,* n = 49) either reveal 'cryptic polyploidy' or suggest very high base numbers. The high basic chromosome numbers in general encountered in a large majority of tree genera seem to be of palaeopolyploid origin.

Strikingly enough, none of the species in *Table 1* shows polyploidy on the existing base numbers. This may not be due to their woody habit, but is perhaps correlated with their inherent tendency not to form polyploids.

Acknowledgements

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Summary

Twenty one tree species of Thalamiflorae inclusive of eight commercial timbers, have been studied. New chromosome numbers have been recorded in ten species and two varieties. *Xylosma longifolium* (n = 10) and *Kydia calycina* (n = 49) furnish first chromosome reports for their respective genera. The chromosomes are small in all species except the genus *Michelia,* in which they are moderately large. None of the species shows polyploidy on the existing base numbers.

Key words: Himalayan trees, Thalamiflorae, chromosome numbers.

Table 3. — Base numbers in genera.

Base number	Genus
x = 7	*Shorea*
x = 9	*Grewia*
x = 10	*Xylosma*
x = 11	*Flacourtia*
x = 13	*Cocculus*
x = 14	*Berberis*
x = 15	*Gordonia*
x = 19	*Michelia, Pterospermum*
x = 20	*Sterculia, Pterygota*
x = 21	*Eurya* (also showing n = 22, 23).

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