Zusammenfassung

30 Hartholz-Arten aus dem Himalaja (18 der Aceraceae, 2 der Hippocastanaceae, 8 der Sapindaceae und 2 der *Staphyleaceae*) wurden zytologisch untersucht. Alle Arten besitzen kleine Chromosomen und zeigen eine normale Meiose. — 8 Gattungen haben nur 1 Chromosomengrundzahl, 2 Gattungen haben 3 Grundzahlen. — Eine einheitliche Chromosomengrundzahl wurde gefunden bei den Aceraceae ($x = 13$), den Hippocastanaceae ($x = 20$) und den Staphyleaceae ($x = 13$). Diese Tatsache trennt diese Familien von der Familie der Sapindaceae, die $x = 7$, 10—16 Chromosomen hat. — Acer *osmastonii* ist als Bastard zwischen A. *campbellii* und A. laevigatum anzusehen, wofür die Blattmorphologie, die geographische Verbreitung, die Blütezeit und die hohe Pollensterilität sprechen. — Bei Acer villosum besitzen die Bäume von Nainital 0 bis 2 B-Chromosomen, unterscheiden sich aber morphologisch nicht von der übrigen Population, die diese nicht hat.

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Cytomorphology of Himalayan Fagaceae

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Introduction

The Fagaceae represents the most important source of timber among the broad leaved species of Northern hemisphere. Fagus, Castanea and Quercus are the significant genera in this respect, the last excelling conifers in the number of species and importance in certain areas. The oak wood has been regarded as invaluable for its strength, durability (even under water) and alround usefulness. Quercus alba, Q. borealis in U.S.A. and Q. robur, Q. *sessiliflora* in the British Isles and Southern Europe are the important timber species. Quercus *suber* and its variety occidentalis are the chief sources of commercial cork from the Mediterranean. Some of the scrubby Quercus species in the arid regions help to control soil erosion.

The family comprises 8 genera and 900 species (WILLIS, 1966). It is best represented in North America where largest number of species thrive, while Europe and Asia rank second and third respectively. KING (1889) has given an illustrated account of 82 species of Quercus and 22 species of Castanopsis from the Indo-Malayan region. HOOKER (1885) described 58 species of Quercus and 16 species of Castanopsis in his 'Flora of British India'. He treated these genera under tribe Quercineae of the Order Cupuliferae. The species of Quercus were described under different sections based chiefly on the character of leaves (entire or serrate and lobed), nature of male spikes (pendulous or erect), shape of fruit and arrangement of scales of the cupule (imbricate or zonate). Some of these sections

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Figure 1. — *Quercus semecarpifolia,* Natural forest Narkanda 2700 m. (W. Himalayas).

Figure 2. — *Quercus semecarpifolia,* straight thick bole and bark pattern. Narkanda 2700 m (W. Himalayas).

have been given generic ranks, such as *Pasania* and *Lithocarpus,* by later workers.

The representatives of this family in India are widely distributed, occurring in the temperate and subtropical Himalayas from Kashmir in the west to Assam and NEFA in the east. None is met in South India. PEARSON and BROWN (1932) mention the following eight species to be of commercial importance. (i) *Quercus semecarpifolia,* (ii) *Q. serrata,* (iii) *Q. dilatata,* (iv) *Q. incana,* (v) *Q. semiserrata,* (vi) *Q. lamellosa,* (vii) *Castanopsis indica* and (viii) *C. hystrix.* All of them are tall trees with good clean bole and wide girth *(Figs. 1, 2* for *Quercus semecarpifolia).* Unlike the North American and European species of *Fagaceae,* the Indian members have received little attention as far as utilization, silviculture and tree improvement is concerned. The availability of other good, patent and easily accessible timber species has prevented these trees from being exploited and gaining commercial reputation. In view of the exhaustible forest reserves, it is time to think seriously about the improvement of those trees which are potential timbers, but at present are relatively little appreciated.

A good amount of research work dealing with cytology, hybridization and speciation in *Quercus* has been done in North America and Europe. Important contributions in this regard have been made by GHIMPU (1929), JARETZKY (1930), SAX (1930), VIGNOLI (1933), NATIVIDADE (1937), FOURAGE (1939), DUFFIELD (1940), Santamour (1962) and STAIRS (1964). The present communication deals with the cytology of some members of *Fagaceae* occurring in the Himalayas. Such a study is a prerequisite to any attempt at breeding of better varieties.

Materials and Methods

Flower buds of trees growing in wild (except for a few cultivated ones) were fixed in CARNOY's fluid. The anthers were squashed in one percent acetocarmine. The somatic numbers were worked out from leaf tips pretreated with 0.003M 8-hydroxyquinoline. The slides were made permanent in Euparal. Pollen fertility was determined from the ability of the pollen to stain with glycero-carmine. All figures as well as photomicrographs are at a uniform magnification of ×1360. Voucher specimens have been deposited in the Herbarium of the Department of Botany, Panjab University, Chandigarh (India).

Observation and Discussion

The chromosome numbers of 23 species and 10 varieties along with their flowering and fruiting periods, previous reports, if any, and source of material, have been summarized in *Table 1.* From this table, the uniformity in chromosome number, n = 12, is explicit. All are at the diploid level. Meiosis is normal but for the fact that many of the species show early disjunction of one or more bivalents due to loose pairing of chromosomes. The pollen fertility is almost 100% in all the taxa, exception being the population of *Castanopsis tribuloides* growing in Khasia and Jaintia hills at Sohararim 1500 m., which exhibits cytomixis resulting in 5% pollen malformation. Generally speaking, the fruit set in almost all of these species is not high and some of the acorns in the female spikes are abortive.

Intraspecific morphological variation:

Observations extending over several years in the field have revealed the existence of intraspecific morphological variations in four species. These were found to be consistent in individuals/populations of these species.

In *Quercus lamellosa* three types from Darjeeling hills and one from the Khasia and Jaintia hills have been

Table 1. — List of species with chromosome number, flowering and fruiting time, reports by previous authors and source of material.

Name	Source	Flowering and fruiting period	Chromosome number	Fig. number	Previous reports
Quercus semecarpifolia Sm.	Narkanda 2700 m. Nainital: Cheena Peak 2550 m. Darjeeling: Lloyd Bot. Garden 1800 m.	5—6; 7—8	n = 12	6	n = 12 (Mehra and Singh 1962)
Q. dilatata Lindl.	Simla: Kufri 2600 m. Nainital 1950 m.	3—5; 8—10	n = 12	7	
Q. incana Bartr.	Simla: Glen 1800 m. Darjeeling: Lebong 1350 m.	3—5; 9—12	n = 12	13	n = 12 (Mehra and Singh 1962) 2n = 24 (Vignoli 1933)
Q. serrata Thunb.	Darjeeling: Peshoke 900 m.	3—4; 10—12	n = 12	21	
Q. lamellosa Sm.	Darjeeling: Senchal lake 2100 m.	3—4; 10—11	n = 12 2n = 24	11 10	
Q. semiserrata Roxb.	Assam: Digboi 150 m.	3—4; 6—7	n = 12 2n = 24	18 19	
Q. semiserrata var. *mannii*	Assam: Digboi 150 m.	3—5; 6—8	n = 12	20	
Q. lineata Bl. var. *oxydon* Wenzig	Darjeeling: Ramam 2100 m.	3—4; 9—10	n = 12	14	
Q. lineata var. *lobbii* Wenzig	Khasia & Jaintia hills: Sohrarim 1500 m.	4; 7—8	n = 12	16	
Q. lineata var. *thomsoniana* A. DC.	Darjeeling: Rangirum 1350 m.	3—4; 9—10	n = 12	15	
Quercus lanuginosa D. Don	Nainital: The Pines 1800 m.	4—5; 10—12	n = 12	8	2n = 24 (Vignoli 1933)
Q. griffithii Hook. f. & Th.	Khasia & Jaintia hills: Shillong Peak 1800 m.	3—4; 7—8	n = 12	12	
Q. glauca Thunb.	Nainital: Bhowali 1600 m. Darjeeling: Peshoke 900 m.	3—4; 7—9	n = 12	9	
Q. robur L.	Darjeeling: Mall Road 1900 m. (cult.)	3—4; not seen	n = 12	17	2n = 24 (Duffield 1940; Gadella and Kliphuis 1966)
Pasania pachyphylla (Kurz) Schottkey	Darjeeling: Tiger hill 2500 m.	5—6; 9—11	n = 12 2n = 24	27	
P. fenestrata (Roxb.) Chatterjee	Darjeeling: Lopchu 1500 m.	8—10; 4—5	n = 12	23	
P. dealbata (Hook. f. & Th.) Chatterjee	Khasia & Jaintia hills: Shillong Peak 1800 m.	7—8; 1—2	n = 12	22	
P. spicata (Sm.) Chatterjee com. nov. mss.	Darjeeling: Badamtam 1000 m.	2—4; 8—10	n = 12		
P. spicata var. *microcalyx* Bl.	Khasia & Jaintia hills: Mawsamai 1000 m.	8; 4	n = 12	31	
P. spicata var. *brevipetiolata* A. DC.	Darjeeling: Mahanadi 1300 m.	4; 7—9	n = 12	29	
P. spicata var. *gracilipes* Miq.	Khasia & Jaintia hills: Nongpoh 550 m.	5; 9—10	n = 12	30	
P. milroyia (Purk.) A. Das N. Comb.	Assam: Digboi 150 m.	9—10; 7—8	2n = 24	26	
Pasania lappacea (Roxb.) Schottkey	Khasia & Jaintia hills: Barapani 1000 m.	8; 3—4	n = 12	24	
P. listeri (King) Schottkey	Assam: Digboi 150 m.	1—2; 6—7	2n = 24	25	
Lithocarpus acuminata (Roxb.) Rehder (= *Quercus acuminata* Roxb.)	Darjeeling: Lloyd Bot. Garden 1800 m. (cult.)	9—10; 3—4	n = 12 2n = 24	33 32	
Castanopsis indica A. DC.	Darjeeling: Rungit 300 m.	7—8; 10—12	n = 12	35	
C. hystrix A. DC.	Darjeeling: Observatory hill 1900 m.	3—5; 8—10	n = 12	34	
C. tribuloides A. DC.	Nainital: Bhowali 1600 m.	7—9; 9—10	n = 12	37	
C. tribuloides var. *echidnocarpa* King.	Assam: Digboi 150 m.	3—4; 6—7	n = 12	38	
C. tribuloides var. *ferox* King.	Darjeeling: Sonada 1800 m.	4—5; 9—11	n = 12	39	
C. tribuloides var. *longispina* King.	Khasia & Jaintia hills: Barapani 1000 m.	3—4; 8—10	n = 12	40	
Castanea vulgaris Lam. (= *C. sativa* Miller)	Khasia & Jaintia hills: Shillong 1500 m. (cult.)	5; 8—9	n = 12	41	2n = 24 (Jaretzky 1930)

Table 2. — Morphological variation in *Quercus lamellosa (Fig. 3).*

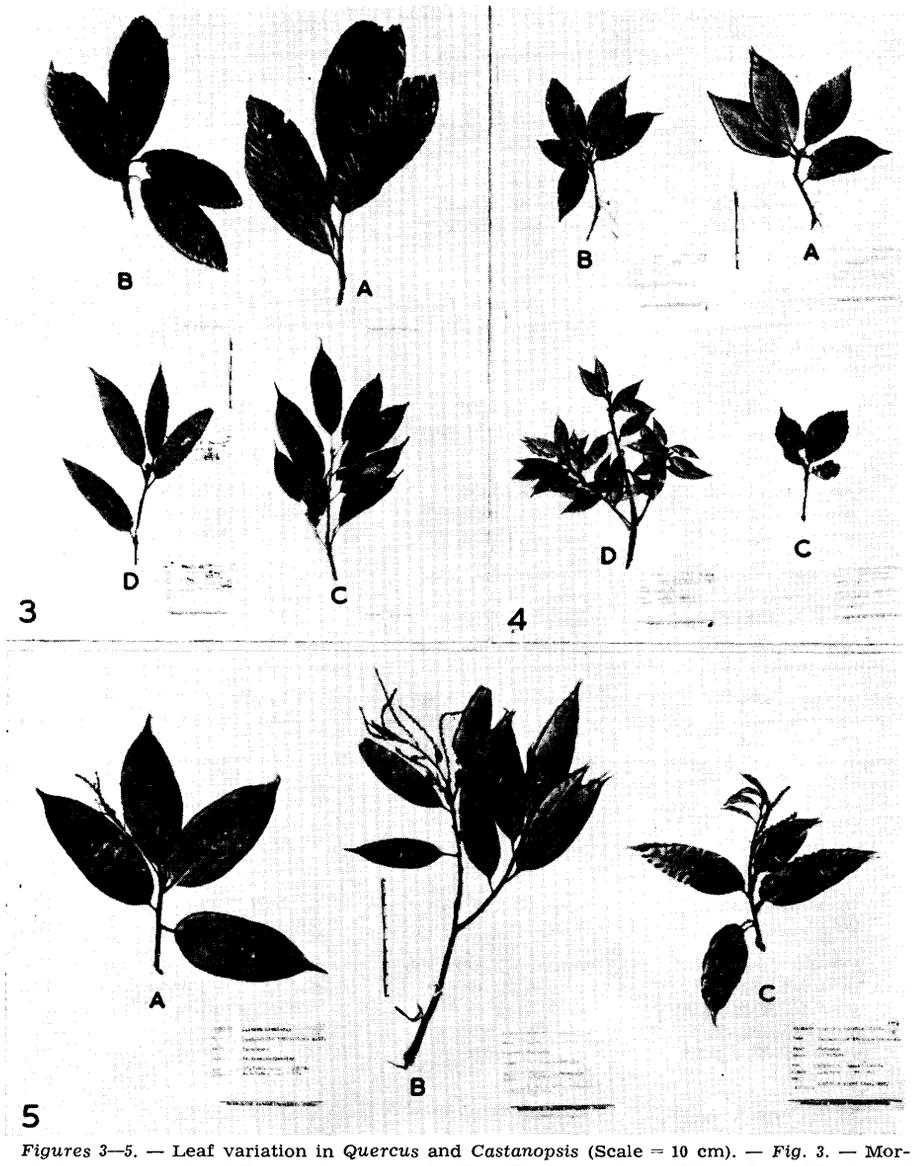
Character	A	B	C	D
Habit and habitat	Lofty tree up to 30 m in Darjeeling hills, very common.	Large tree from 20—25 m in Darjeeling hills, common.	Medium-sized tree upto 20 m in Darjeeling hills, not common.	Small tree up to 12 m in Khasia and Jaintia hills, not common.
Branch	Lenticels up to 1 mm in length, 3 per unit area.	Lenticels up to 1 mm in length, 3—4 per unit area.	Lenticels up to 0.5 mm in length, 5—6 per unit area.	Lenticels almost absent.
Leaf				
(Petiole)	Up to 35 mm, stout, never grooved or very shallowly grooved.	Up to 30 mm, stout, shallowly grooved.	Up to 12 mm, slender, deeply grooved.	Up to 18 mm, slender, shallowly grooved.
(Blade)	Ovate-obovate, 240—280 × 80—105 mm, acumen short.	Ovate, 180—225 × 50—80 mm, acumen short.	Ovate, 90—120 × 30—38 mm, acuminate.	Lanceolate, 150—170 × 30—40 mm, acuminate.
(Nerves)	Very prominent, 18, distance between nerves 8—15 mm.	Prominent, 16, distance between nerves 5—15 mm.	Less prominent, 13, distance between nerves 3—8 mm.	Inconspicuous, 18, distance between nerves 4—8 mm.
(Marginal teeth)	Conspicuous, distantly set, becoming closer towards apex.	Conspicuous, distantly set, becoming closer toward apex.	Inconspicuous, closely set.	Conspicuous, regularly set.

Table 3. — Morphological variation in *Quercus lineata* var. *lobbii (Fig. 4)* (Sohrarim forest — Khasia and Jaintia hills).

Character	A	B	C	D
Branch	Covered with thick mat of brown tomentum.	Covered with brown tomentum.	Covered with dark brown tomentum.	Covered with thick mat of dark brown tomentum.
Leaf				
(Petiole)	Up to 12.5 mm in length.	Upto 11 mm in length.	Up to 7 mm. in length.	Up to 11 mm in length.
(Blade)	120—150 × 45—55 mm, nerves 15—17 straight or slightly arching, serrate, teeth 13—15, acute.	90—120 × 35—45 mm, nerves 15—16 straight or slightly arching, serrate, teeth 12, acute.	60—90 × 30—50 mm, nerves 7—9, arching, serrate, teeth 8, obtuse.	55—80 × 10—25 mm, nerves 12—15, almost straight, serrate, teeth 13, closely set acute.
Vegetative scales	Hairy, linear, up to 12.5 mm.	Slightly hairy, lanceolate up to 15 mm.	Slightly hairy, lanceolate, up to 8 mm.	Hairy, linear, up to 8 mm.

Table 4. — Morphological variation in *Castanopsis tribuloides* var. *typica (Fig. 5).*

Character	A	B	C
Habit and habitat	Large trees up to 25 m in Darjeeling hills, quite common.	Moderate-sized trees 15—20 m in height in Darjeeling hills, common.	Small trees up to 10 m in Khasia and Jaintia hills (Sohrarim, 1500 m), common.
Branch	Lenticels 5—7 per unit area.	Lenticels 3—4 per unit area.	Lenticels 2—3 per unit area.
Leaf			
(Petiole)	10 mm, deeply grooved.	13 mm, shallowly grooved.	8 mm, deeply grooved.
(Leaf base)	Equal.	Slightly unequal.	Unequal.
(Blade)	Ovate, 130—150 × 40—55 mm, nerves conspicuous, 11—13, midrib raised.	Ovate, lanceolate, 100—150 × 25—30 mm, nerves less conspicuous, 11—13, midrib raised.	Ovate, 100—120 × 25—35 mm, nerves less conspicuous, 11—12, midrib depressed.
Male spike	Base smooth, slightly pubescent.	Base smooth, pubescent.	Base corky, pubescent.
Cytological behaviour	Meiosis normal.	Meiosis normal.	Cytomixis in some of the PMC's resulting in 5% pollen sterility.



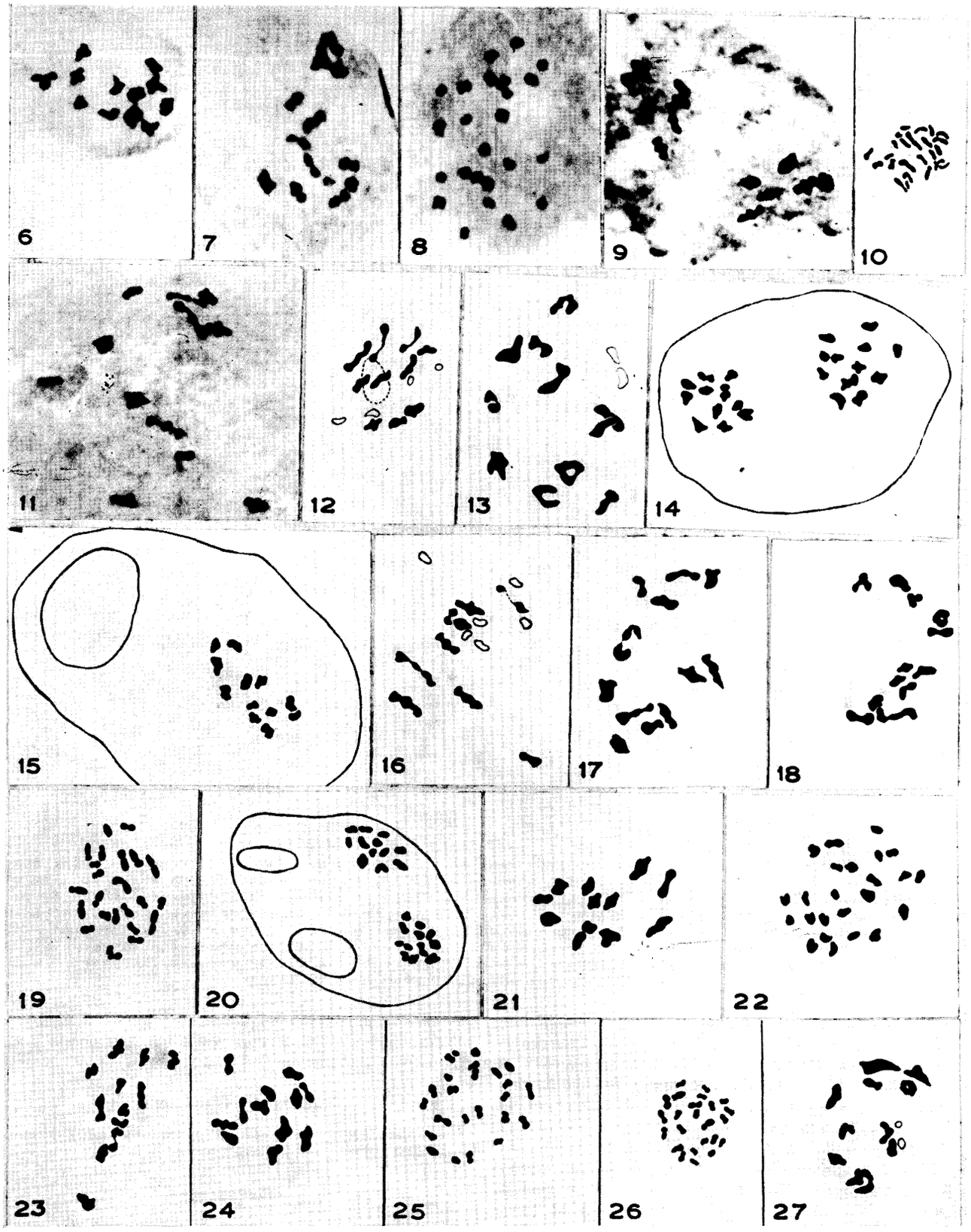
Figures 3—5. — Leaf variation in *Quercus* and *Castanopsis* (Scale = 10 cm). — *Fig. 3.* — Morphological variants of *Quercus lamellosa.* A—C. — Darjeeling hills, 1900 m. D. — Khasia and Jaintia hills, 1500 m. — *Fig. 4.* — Morphological variants of *Quercus lineata* var. *lobbii.* A—D. — Sohrarim Forest, 1500 m — Khasia and Jaintia hills. — *Fig. 5.* — *Castanopsis tribuloides* var. *typica.* A—B. — Darjeeling hills, 1900 m. C. — Sohrarim Forest, 1500 m — Khasia and Jaintia hills.

detected *(Table 2, Fig. 3).* In Darjeeling hills all the three types have sympatric distribution but they differ in the size of leaves, number and distance of veins and the extent of groove in the petiole. The variability may be genic. In *Q. lineata* var. *lobii (Table 3, Fig. 4),* the four types differ in leaf morphology, nature of pubescence of branches and scales. All these types grow in the same forest under similar ecological conditions. In *Pasania pachyphylla,* trees growing in dense forests where light is scanty and moisture content high, are slender, have fewer lenticels on branches, possess only silghtly hairy axillary buds and bear yellowish green and slightly coriaceous leaves, compared to the plants that grow in exposed environments, particularly facing southern slopes. In *Castanopsis tribuloides* three types of variations have been noticed and these are mentioned in detail in *Table 4 (Fig. 5).* Type C from Khasia and Jaintia hills shows cytomixis and differs slightly from Type B from Darjeeling hills in respect of the size and grooved nature of the petiole, unequal leaf base, depressed and inconspicuous nerves. The Darjeeling and Khasia and Jaintia hills have different ecological conditions which may be responsible for such differences.

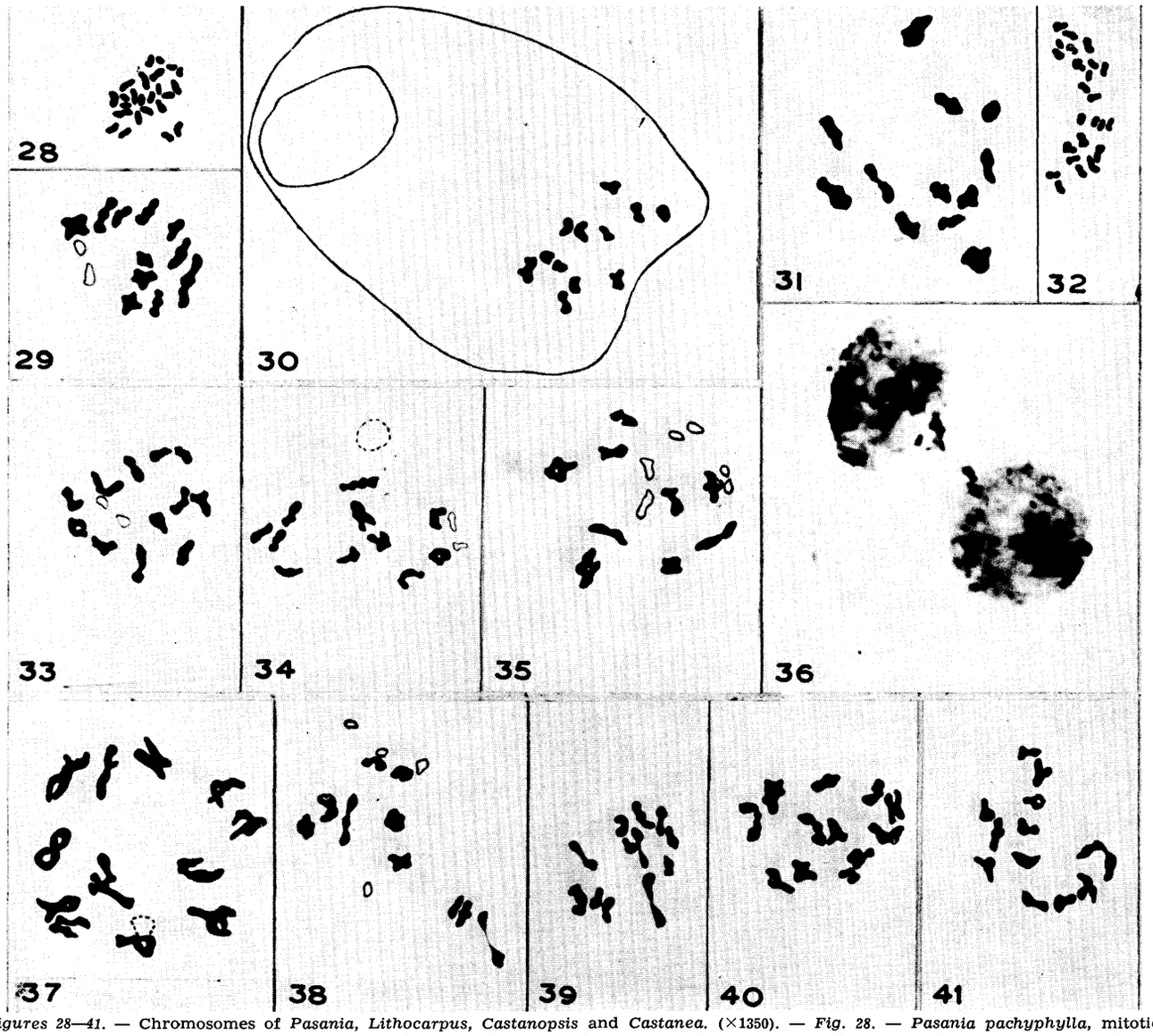
Rarity of Polyploidy in Fagaceae:

Except for *Nothofagus* (x = 13, Armstrong and Wylie, 1965) all the other genera of *Fagaceae* consistently show x = 12. All the presently investigated species of this family are diploid and so are the others worked out earlier, with few exceptions. Sax (1930) ascertained 2n = 48 in *Quercus dentata* while Santamour (1962) reported n = 12 and 2n = 24 in the same species. Chopra and Shanks (1961) established diploid and tetraploid races in *Q. macrocarpa.* Johnsson (1946) detected triploid seedlings of *Q. robur,* but adult trees of this constitution have never been discovered in nature.

Much of the diversity in form has been achieved in *Fagaceae* at the diploid level possibly as a result of repatterning of chromosomes and gene mutations. The base



Figures 6—27. — Chromosomes of *Quercus* and *Pasania* (×1350). — *Fig. 6.* — *Quercus semecarpifolia,* methaphase I, n = 12. — *Fig. 7.* — *Q. dilatata* metaphase I, n = 12. — *Fig. 8.* — *Q. lanuginosa,* anaphase I, n = 12. — *Fig. 9.* — *Q. glauca,* metaphase I, n = 12, $11_{II} + 2_{I}$. — *Figs 10—11.* — *Q. lamellosa.* — *Fig. 10.* — Somatic metaphase, 2n = 24. — *Fig. 11.* — Meiotic metaphase I, n = 12. — *Fig. 12.* — *Q. griffithii,* diakinesis, n = 12, two bivalents showing early disjunction. — *Fig. 13.* — *Q. incana,* metaphase I, n = 12, $10_{II} + 2_{I}$. — *Fig. 14.* — *Q. lineata* var. *oxydon,* metaphase II, n = 12. — *Fig. 15.* — *Q. lineata* var. *thomsoniana,* metaphase II, n = 12. — *Fig. 16.* — *Q. lineata* var. *lobbii,* metaphase I, n = 12, $9_{II} + 6_{I}$. — *Fig. 17.* — *Q. robur,* metaphase I, n = 12. — *Figs. 18—19.* — *Q. semiserrata.* — *Fig. 18.* — Meiotic metaphase I, n = 12. — *Fig. 19.* — Mitotic metaphase, 2n = 24. — *Fig. 20.* — *Q. semiserrata* var. *mannii,* anaphase II, n = 12. — *Fig. 21.* — *Q. serrata,* metaphase I, n = 12. — *Fig. 22.* — *Pasania dealbata,* meiotic mixed anaphase I, 2n = 24. — *Fig. 23.* — *P. fenestrata,* metaphase I, n = 12. — *Fig. 24.* — *P. lappacea,* metaphase I, n = 12. — *Fig. 25.* — *P. listeri,* mitotic metaphase, 2n = 24. — *Fig. 26.* — *P. milroyia,* mitotic metaphase, 2n = 24. — *Fig. 27.* — *P. pachyphylla,* metaphase I, n = 12, $11_{II} + 2_{I}$.



Figures 28—41. — Chromosomes of *Pasania, Lithocarpus, Castanopsis* and *Castanea.* (×1350). — *Fig. 28.* — *Pasania pachyphylla,* mitotic metaphase, 2n = 24. — *Fig. 29.* — *P. spicata* var. *brevipetiolata,* metaphase I, n = 12, $11_{II} + 2_{I}$. — *Fig. 30.* — *P. spicata* var. *gracilipes,* metaphase II, n = 12. — *Fig. 31.* — *P. spicata* var. *microcalyx,* metaphase I, n = 12. — *Figs. 32—33.* — *Lithocarpus acuminata.* — *Fig. 32.* — Mitotic metaphase, 2n = 24. — *Fig. 33.* — Meiotic metaphase I, n = 12, $11_{II} + 2_{I}$. — *Fig. 34.* — *Castanopsis hystrix,* diakinesis, n = 12, one bivalent shows early disjunction. — *Fig. 35.* — *Castanopsis indica,* metaphase I, n = 12, $9_{II} + 6_{I}$. — *Figs. 36—37.* — *C. tribuloides.* — *Fig. 36.* — Two PMC's showing cytomixis. — *Fig. 37.* — Diakinesis, n = 12. — *Fig. 38.* — *C. tribuloides* var. *echidnocarpa,* metaphase I, n = 12, $10_{II} + 4_{I}$. — *Fig. 39.* — *C. tribuloides* var. *ferox,* metaphase I, n = 12. — *Fig. 40.* — *C. tribuloides* var. *longispina,* metaphase I, n = 12. — *Fig. 41.* — *Castanea vulgaris,* metaphase I, n = 12.

number and chromosome size has remained constant and hybridization occurs without much affecting pollen fertility as in *Quercus.* If the hybrids are fertile, the chances of polyploidy after hybridization obviously become limited and speciation is due to gene mutation or reshuffling of chromosomes. Duffield (1952) inferred this on the basis of his experimental studies of hybridization in pines. The experimental hybrids were highly fertile indicating homology of the chromosomes. Khoshoo (1959) reached a similar conclusion while discussing the apparent rarity of polyploidy in gymnosperms. Polyploid complexes as pointed out by Stebbins (1950, p. 357) are only possible when species have diverged considerably in respect of chromosomes. Mehra (1960, 1968) opined that there always exists an optimum in respect of chromosomal sets which can function successfully within the cytoplasm in every species. In *Fagaceae* it seems to have reached at the diploid level. Hybridization, which is frequent between the related species in zone of overlap has doubtlessly played a significant role in causing morphological variation, and possibly speciation within the genus *Quercus.*

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Summary

Cytomorphological studies of 23 species and 10 varieties have been conducted from the Himalyas, Khasia and Jaintia hills, and Assam. Out of these, 18 species and 10 varieties are investigated for the first time. All have n = 12 or 2n = 24. They are diploid and show normal meiosis except one population of *Castanopsis tribuloides* which shows cytomixis. Morphological variability has been detected in *Quercus lamellosa, Q. lineata* var. *lobbii, Pasania pachyphylla* and *Castanopsis tribuloides.* Polyploidy is rare in

this family and it seems the optimal in respect of chromosomal sets (genomes) has been reached at the diploid level.

Zusammenfassung

23 Arten und 10 Varietäten aus dem Himalaja und angrenzenden Gebieten wurden untersucht, davon 18 Arten und 10 Varietäten erstmalig. Alle sind diploid (2n = 24 Chromosomen) und zeigen mit Ausnahme einer Population von *Castanopsis tribuloides* eine normale Meiose. Morphologische Variabilität fand sich bei *Quercus lamellosa, Q. lineata* var. *lobbii, Pasania pachyphylla* und *Castanopsis tribuloides*. Polyploide gibt es in der Familie der *Fagaceae* nur selten.

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A Chromatographic Study of Foliage Polyphenols in Pine Hybrids (Subsection Sylvestres)[1])

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The application of paper and thin-layer chromatography of phenolic compounds has been especially useful in plant genetics research. A series of studies on interspecific hybridization in *Baptisia* showed that species-specific compounds were of use in evaluating hybrid populations involving up to four species (Alston and Turner, 1963 a), that the cumulative inheritance of flavonoid compounds was consistent in the hybrids (Alston and Hempel, 1964), and that chromatography more clearly defined the structure of hybrid swarms than did morphological characteristics (McHale and Alston, 1964). In forest tree species, chromatographic techniques have been used for identifying hybrids in *Betula* (Clausen, 1962, 1963; Dugle, 1966), *Prunus* (Hasegawa and Shirato, 1963), and *Picea* (Hanover and Wilkinson, 1970). Hoff (1968) reported on the identification of the hybrid of *Pinus monticola* and *P. flexilis* by paper chromatography of foliage polyphenols.

In an earlier study (Thielges, 1969), the interspecific relationships among species of the Subsection *Sylvestres* Loud. of the genus *Pinus* were investigated by two-dimensional paper chromatography of foliage polyphenols. Through the analyses of large numbers of individual tree samples collected from populations located throughout the range of each species, discrete and consistent chromatographic patterns were established for each of the taxa included in the study. These results provided the basis for the present study on the inheritance of foliage polyphenols and the evaluation of this chromatographic technique for the verification of interspecific hybrids in *Sylvestres*.

Materials and Methods

Foliage samples of artificial hybrid progenies representing several species combinations were collected from test plantings at Norfolk, Connecticut, Washington's Crossing, New Jersey, and Maple, Ontario, Canada. In addition, samples of natural hybrids were supplied by collectors in Canada and France. Reciprocal crosses, backcrosses, and F_2 progenies were included in the study. Information on these progenies is supplied in *Table 1*.

Preliminary experiments indicated qualitative differences in foliage polyphenol content due to foliage age and season of collection. Therefore, only year-old (1965 growth) foliage was sampled and all collections were made in June and July, 1966. Prior analyses of samples collected from natural stands and replicated plantings of the same geographic seed sources revealed quantitative but not qualitative variation in polyphenol content (Thielges, 1968). This

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