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Chromosome Studies in the Family Magnoliaceae

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The family Magnoliaceae is comparatively small, consisting of nine genera and little over hundred species distributed over the tropical and temperate regions of the northern hemisphere. Of them, fifty taxa belong to Asia (Janaki Ammal 1952). In India, six genera occur in the Himalayas and are mostly characterised by their woody nature. Their distribution ranges up to 3000 mt. in the Eastern Himalayas, though a few species occur profusely in the higher altitudes. Some of the high altitude species such as, *Magnolia grandiflora* L., have been acclimatized in the plains as well. Chromosome counts have been made in ten species and Janaki Ammal (1952) has dealt with the Himalayan species on an extensive scale It is remarkable that the entire family with different genera such as, *Magnolia*, *Michelia*, *Talauma* etc. is characterised by a basic set of 19 chromosomes with occasional polyploidy.

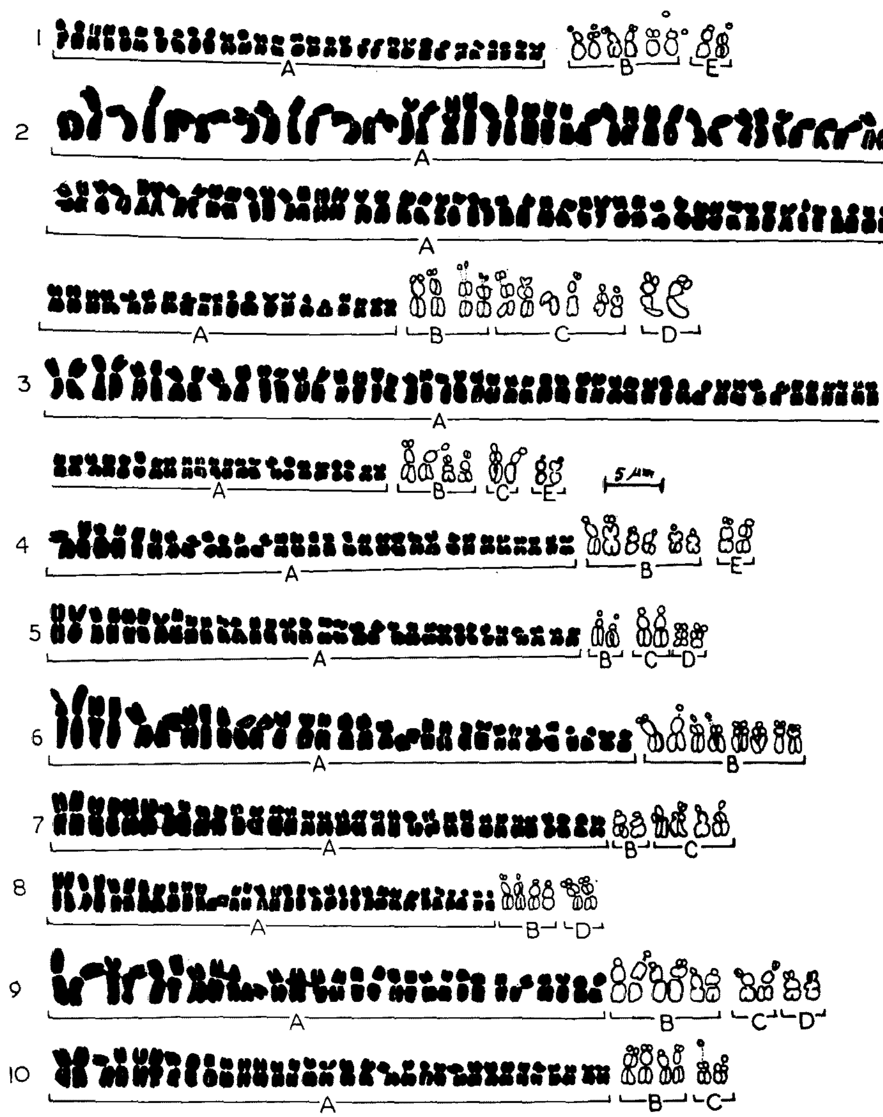
The uniformity of chromosome number in this primitive family (Maneval 1914, Whitaker 1953, Hutchinson 1973), combined with the fact that it has a large number of species, makes it an ideal subject for chromosome analysis since with the application of pretreatment techniques, minute details of the chromosome structure can be clarified.

In view of the fact that such an analysis has not been carried out in this family which is otherwise characterised by uniform chromosome number, the present investigation was undertaken to analyse the role of the structural alterations of chromosomes in the evolution of the species.

Materials and methods

Chromosome studies of ten species belonging to three genera of the family Magnoliaceae have been carried out. Most of the species were collected from the Silviculture Centre of the Forest Department, West Bengal, Takdah and Mannibhanjang and from Ghosh's Nursery, Darjeeling. However, *Magnolia coco*, *M. grandiflora*, *Michelia champaca* and *Talauma mutabilis* were cellected from Calcutta.

Young, healthy root tips were pretreated at 4–5°C for 2–3 minutes and then kept at 10–15°C for 2–3 hours either in a mixture of saturated aqueous solution of paradichlorobenzene and 0.002M 8-hydroxyquinoline in a proportion of 4 : 1 or saturated aqueous solution of isopsoraline. The root tips were washed in distilled water and fixed in a mixture of 95% ethanol and concentrated hydrochloric acid (3 : 1) for 8–15 minutes, washed in acetic-ethanol (1 : 2) three times and kept in 45% acetic acid for 5 minutes. The fixed materials were stained according to the usual aceto-orcein: normal HCl (9 : 1) schedule and squashed in 45% acetic acid.



Figs. 1–10. Comparative idograms of 1, *Magnolia coco*. 2, *M. grandiflora*. 3, *M. liliflora* 4, *M. pterocarpa*. 5, *Michelia champaca*. 6, *M. fuscata*. 7, *M. kishopa*. 8, *M. lanuginosa*. 9. *Talauma hodgsoni*. 10, *T. mutabilis*.

Meiotic studies were carried out from fixed flower buds following the aceto-carmine technique.

The outlined drawings of the chromosomes in the idiograms are with secondary constrictions (Figs. 1–10).

Table 1. Comparative account of karyotypes of the family Magnoliaceae

Name of the taxa	Chromosome number		Karyotype formula	Total chromatin length (n) in μm	Total short arm (n) length in μm	Range of chromosome length in μm	TF%
	n	2n					
1 *Magnolia coco* D.C.		38	30A+6B+2E	42.04	17.87	3.37–1.54	42.50
2 *M. grandiflora* Linn.		114	102A+4B+6C+2D	179.13	74.22	5.48–1.59	39.08
3 *M. liliflora* Desr.		76	68A+4B+2C+2E	96.44	39.63	4.23–1.54	41.09
4 *M. pterocarpa* Roxb.		38	30A+6B+2E	44.54	19.78	3.46–1.59	44.40
5 *Michelia champaca* Lin.	19	38	32A+2B+2C+2D	47.50	19.99	3.56–1.54	42.08
6 *M. fuscata* Blume		38	32A+4C+2D	48.18	21.35	3.56–1.73	44.31
7 *M. kishopa* Ham		38	34A+4B	60.20	26.83	5.38–1.97	44.56
8 *M. lanuginosa* Wall		38	32A+2B+4C	49.59	21.77	4.01–1.92	43.89
9 *Talauma hodgsonii* Hllk. f.		38	28A+6B+2C+2D	64.81	28.62	5.19–2.31	44.16
10 *T. mutabilis* Blume	19	38	32A+4B+2C	49.89	21.86	3.85–1.92	43.81

Observations

The somatic chromosome numbers among the genera range from 2n=38 to 2n=114, the most common are being 2n=38. The chromosome length among the genera ranges from 1.54 to 5.48 μm. In *Magnolia* four species have been worked out, of which two show 2n=38 chromosomes whereas *M. liliflora* Desr. has 2n=76 and *M. grandiflora* L. 2n=114 chromosomes. The other two genera *Michelia* and *Talauma* show constancy in chromosome number (2n=38) in all the species studied so far. The variation of chromosome length in *Magnolia* is 1.54 to 5.48 μm, in *Michelia* 1.54 to 5.38 μm and in *Talauma* 1.97 to 5.19 μm. Total chromatin length of the haploid complement (n) among the genera ranges from 42.04 (*Magnolia coco* DC) to 179.13 μm (*M. gramdiflora* L.).

Studies on meiotic chromosomes have been carried out in *Michelia champaca* L. and *Talauma mutabilis* Blume. In both the species clear 19 bivalents were obtained without any meiotic irregularities (Figs. 17, 18).

The somatic chromosomes of different species have been grouped into five different types (Fig. 1a) according to the size and nature of the primary and secondary constrictions. From the centromeric index (F%), (Sikka and Sharma 1979) and TF% (Huziwara 1962)

$$\left(=\frac{\text{Total short arm length (n)}}{\text{Total chromatin length (n)}}\times 100\right)$$

(vide Table 1), the following types can be distinguished:

Type A Chromosomes are comparatively medium to large in size and with median to submedian primary constrictions (5.48 to 1.54 μm).

Type B Chromosomes are with two constrictions—primary and secondary. One is nearly median and the other bears a satellite in subterminal position (4.23 to 2.12 μm).

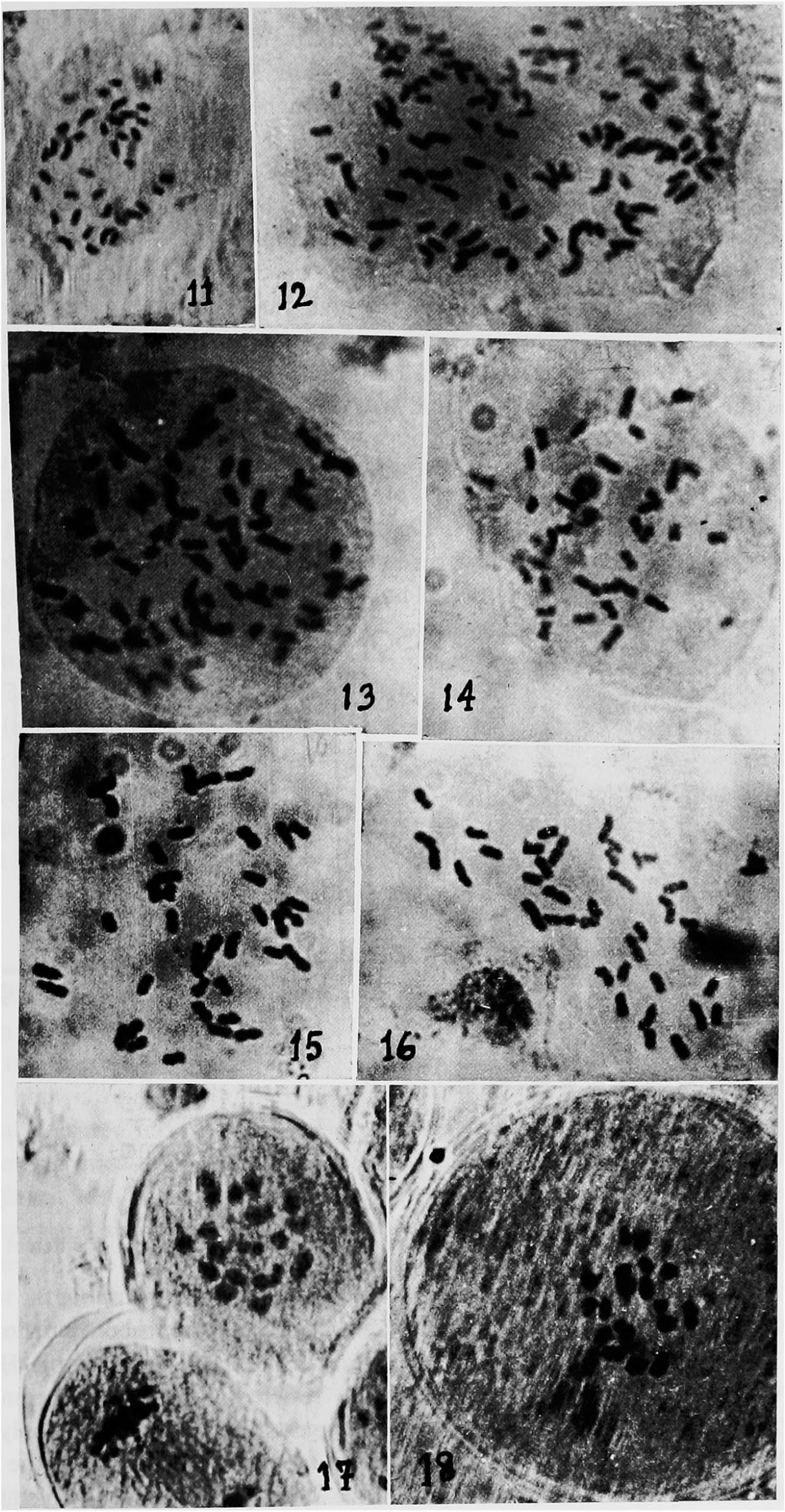
Type C Chromosomes are with two constrictions, primary and secondary, one is nearly median and the other is submedian in position (3.85 to 2.12 μm).

Type D Chromosomes are also with two constrictions, primary and secondary, one is nearly median and the other is submedian in position. Two short segments are equal in size (4.41 to 2.04 μm).

Type E Chromosomes are with two constrictions, one is nearly median and the other is a satellite in extremely subterminal position (3.00 to 2.69 μm).

Figs. 11–16. Microphotographs of somatic chromosomes. 11, *Magnolia coco*, 2n=38. ×350 approx. 12, *M. grandiflora*, 2n=114. ×750 approx. 13, *M. liliflora*, 2n=76. ×1000. 14, *Michelia champaca*, 2n=38. ×1000 approx. 15, *Talauma hodgsonii*, 2n=38. ×1000 approx. 16, *T. mutabilis*, 2n=38. ×1000 approx)

Figs. 17–18. Meiotic metaphase I. 17, *Michelia champaca*, n=19. ×600 approx. 18, *Talauma mutabilis*, n=19. ×600 approx.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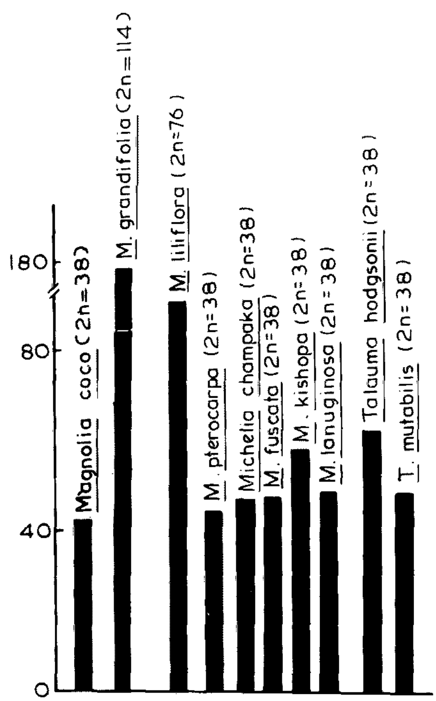
Discussion

In the study of chromosome counts in the family Magnoliaceae, Janaki Ammal (1952) recorded polypoid species to occur in the higher altitudes of the Himalayas. An exception was noted in *Magnolia globosa* (2n=38) growing at 3000 mt. In the present investigation, in the 10 species of Magnoliaceae belonging to the three genera, a basic set of 19 chromosomes has been found to be common. Very high chromosome numbers were noted in *Magnolia grandiflora* (2n=114) and *M. liliflora* (2n=76), occurring at 2000 mt., *M. grandiflora* on the other hand has been acclimatized in the plains as well. Possibly its high chromosome number allows it a wide range of tolerance. The other two species of *Magnolia* viz., *M. pterocarpa* (2n=38) and *M. coco* (2n=38) confirm the repotrs of Janaki Ammal (1952). *M. coco* was initially studied under the name *Michelia pumila* Andr., a synonym, and the same chromosome number was noted.



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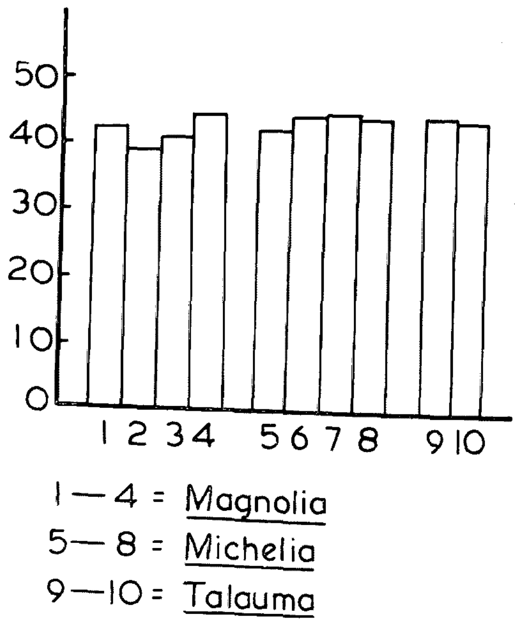

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Figs. 19–20. Histograms. 19, total chromatin length of haploid complement of different species. 20, FT%.

In *Michelia* and *Talauma* no polyploid has been recorded in both previous and present investigations though their distribution ranges from plains to the Himalayas. Polyploidy is restricted only to *Magnolia*. Such a uniformity in chromosome number, with rare occurrence of polyploids, suggests the minor role of polyploidy and almost absense of aneuploidy in evolution of species. An analysis of the karyotypes has shown certain important features. The chromosome complement, in general, is graded in the three genera, ranging from long to short chromosomes. Primary constrictions are mostly median to submedian in position. Such a gross uniformity in karyotypes fully confirms the homogeneity of the family as far as could be judged by the species studied. This is further confirmed by total amount of chromatin length (vide histogram, Fig. 19) as well as TF% value (vide TF% graph, Fig. 20) of different species. The species differ from each other in the nature and number of chromosomes with secondary constrictions which may vary from six to twelve. The occurrence of six chromosomse with secondary constrictions in diploids and twelve in hexaploids indicates that along with polyploidy, there have been structural changes in chromosomes as well, possibly associated with hybridisation. Such a uniformity in chromosome number, with minute difference in karyotype principally involving the secondary constriction region, finds parallel to some extent in the genus *Lilium* of monocotyledons (Stewart 1947, Sen 1978).

A feature worthnoting in the karyotypes of *Magnolia grandiflora* and *M. liliflora* is the overall chromosome size. In both though the karyotypes fall in the same patterns with others, there is a slight increase in overall chromosome size (vide idiogram, Figs. 1–10). This is more marked in *M. grandiflora* as compared to *M. liliflora*. The former is hexaploid and the latter tetraploid in nature. Such an overall increase in size with increased chromosome number is unexpected. Ample cases have been recorded, where on the contrary, there has been a steady diminution of chromosome size along with polyploidy (Stebbins 1971 and Sharma 1972, 1974). Such increase in chromosome size might have been related to the extent of coiling of the chromosomes. These two species, therefore, may serve as an example where increased chromosome number has been associated with an overall increase in chromosome size. The mechanism through which such a situation is brought about the extent of its adaptive value need to be worked out through further researches.

Summary

Chromosome study has been carried out on ten species belonging to three genera of the family Magnoliaceae, with the application of improved techniques. Only two species, namely *Magnolia liliflora* (2n=76) and *M. grandiflora* (2n=114) show high chromosome numbers, the rest showing 2n=38 chromosomes. The general features include uniformity of chromosome number, graded karyotypes, with mostly metacentric chromosomes and the size ranging from medium to small. The plants, with high chromosome number in the polyploid species, have long chromosomes and show no reduction in chromosome size. The species differ from one another in the type and number of chromosomes with secondary constrictions. Minor structural alterations of chromosomes have probably played the most important role in the evolution of genus and species rather than polyploidy and aneuploidy.

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