Karyomorphological Studies on Three Species of *Kaempferia* L.

N. Omanakumari and P. M. Mathew

Department of Botany, University of Kerala
Kariavattom, Trivandrum, India.

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The genus *Kaempferia* L. (Zingiberaceae) is a small genus with about 36 species distributed mostly in the tropics (Hooker and Jackson 1895). The genus is well represented in the Indian sub-continent, where 22 species are reported to occur (Hooker 1894), bulk of them occurring in the northern parts of India. A few of the Indian species are economically important, being used in Ayurvedic medicines (Kirtikar and Basu 1975).

Cytology of 11 species are known so far (Federov 1969) and the information is restricted to somatic chromosome number reports only. In South India three species are found growing wild in the interior forest regions of the Western Ghats, viz *K. galanga*, *K. rotunda* and *K. angustifolia*, of which two of them (*K. galanga* and *K. rotunda*) are domesticated because of their medicinal value.

Materials and methods

Material of the present three species were collected from their wild sources in different regions of the forest ranges of Kerala, such as Ponmudi, Kulathupuzha and Sabarigiri. Somatic chromosomes were studied from root tip cells obtained from plants growing in the wild as well as those grown under green house condition. Young root tips were fixed in 3 : 1 Carnoy's fluid, and preparations made in acetocarmine, after pretreatment with 0.002 M 8-hydroxyquinoline. Karyotype analysis was done following the system proposed by Levan *et al.* (1964) and Stebbins (1958).

Observation

K. angustifolia Rosc.

Root tip cells of this species showed $2n=36$ chromosomes which ranged from 4.66 to 7.66 μm in length (Table 2 and Fig. 1). Sharma and Bhattacharyya (1959) have reported another cytotype ($2n=54$) in the species. The somatic chromosome complement consisted of one pair of M-type, 12 pairs of m-type, four pairs of sm-type and one pair of st-type chromosome (Table 2 and Fig. 1). Secondary constrictions were present on the long arm of 4th, 12th and 14th chromosomes, and the karyotype belonged to 2A category.

K. rotunda L.

Root tip cells showed 44 chromosomes ranging in length from 1.33 to 4.32 μm (Table 2 and Fig. 2) and this agrees with the count reported by Ramachandran (1969) for this taxon. The reported occurrence of taxa of the species with $2n=33$ (Chakravorti 1948) and $2n=54$ (Raghavan and Venkatasubban 1943) shows that this species also exist in at least three different cytotypes, all based on the same basic number $x=11$. The karyotype consisted of 4 pairs of M-type, 10 pairs of m-type and 6 pairs of sm-type and 2 of st chromosomes. Three of the longest chromosomes

Figs. 1-3. Idiograms of three species of *Kaempferia*. 1, *K. angustifolia*, $2n=36$. 2, *K. rotunda*, $2n=44$. 3, *K. galanga*, $2n=54$.

(1, 2, 3) and the 6th and 7th ones possessed secondary constrictions on their long arm. The karyotype belonged to 2A category.

K. galanga L.

Root tip cells showed 54 chromosomes which ranged in length from 2.66 to 5.98 μm (Fig. 3). The karyotype consisted of 2 pairs of M-type, 12 pairs of m-type, 10 pairs of sm-type and 3 pairs of st-type chromosomes (Table 2). Secondary constrictions were noticed on the long arm of 5 pairs of chromosomes (1, 2, 3, 10

Table 1. Chromosome numbers reported in the genus *Kaempferia*

Species	2n	Authors
<i>Kaempferia galanga</i>	54	Raghavan and Venkatasubban 1943
	44	Raghavan and Arora 1958
	22	Sharma and Bhattacharyya 1959
	54	Present study
<i>K. ovalifolia</i>	22	Sharma and Bhattacharyya 1959
<i>K. angustifolia</i>	36	Sharma and Bhattacharyya 1959
	54	
	36	Present study
	22	Chakravorti 1948
<i>K. atrovirens</i>	22	Venkatasubban 1946
<i>K. speciosa</i>	22	
<i>K. gibsoni</i>	24	Raghavan and Venkatasubban 1943
<i>K. gilberti</i>	36	Raghavan and Venkatasubban 1943
<i>K. cienkowskya</i>	28	Chakravorti 1948
<i>K. rotunda</i>	54	Raghavan and Venkatasubban 1943
	33	Chakravorti 1948
	44	Ramachandran 1969
		Present study
<i>K. brachystemon</i>	26	Mahanty 1970
<i>K. ethelae</i>	26	Mahanty 1970

Table 2. Details of karyotypes of three species of *Kaempferia*

Chromosome	Length of chromosome in μm		Total	RCL	r	Chromosome type
	Long arm	Short arm				
<i>K. angustifolia</i> Rosc.						
1	4.33	3.33	7.66	6.90	1.30	m
2	4.33	3.33	7.66	6.90	1.30	m
3	4.00	3.33	7.33	6.60	1.20	m
4	2.00+2.00	3.00	7.00	6.31	1.33	m
5	4.33	2.66	6.99	6.30	1.62	m
6	4.00	2.66	6.66	6.00	1.50	m
7	3.33	3.33	6.66	6.00	1.00	M
8	5.00	1.33	6.33	5.70	3.75	st
9	3.33	3.00	6.33	5.70	5.11	m
10	4.00	2.00	6.00	5.40	2.00	sm
11	4.00	2.00	6.00	5.40	2.00	sm
12	2.00+2.00	1.66	5.66	5.10	2.40	sm
13	3.33	2.33	5.66	5.16	1.42	m
14	1.66+1.66	2.00	5.32	4.79	1.66	m
15	3.00	2.00	5.00	4.50	1.50	m
16	3.00	2.00	5.00	4.50	1.50	m
17	2.66	2.33	4.99	4.49	4.14	m
18	3.33	1.33	4.66	4.20	2.50	sm
<i>K. rotunda</i> L.						
1	0.66+2.66	2.00	4.32	8.62	1.66	m
2	1.33+1.33	1.33	3.99	6.73	2.00	sm
3	1.66+0.66	1.66	3.98	6.73	1.39	m
4	2.00	1.66	3.66	6.70	1.20	m

Table 2. Continued

Chromosome	Length of chromosome in μm		Total	RCL	r	Chromosome type
	Long arm	Short arm				
5	2.00	1.33	3.33	5.63	1.50	m
6	1.00+1.00	1.33	3.33	5.63	1.50	m
7	1.00+1.00	1.33	3.33	5.63	1.50	m
8	1.66	1.66	3.32	5.62	1.00	M
9	2.00	1.00	3.00	5.00	2.00	sm
10	2.00	1.00	3.00	5.00	2.00	sm
11	1.99	1.00	2.99	5.00	1.99	sm
12	1.99	1.00	2.99	5.00	1.99	sm
13	1.33	1.00	2.33	3.90	1.33	m
14	1.00	1.00	2.00	3.37	1.00	M
15	1.00	1.00	2.00	3.37	1.00	M
16	1.00	1.00	2.00	3.37	1.00	M
17	1.33	0.66	1.99	3.36	2.01	sm
18	1.33	0.33	1.66	2.80	4.03	st
19	1.00	0.66	1.66	2.80	1.55	m
20	1.00	0.66	1.66	2.80	1.55	m
21	1.00	0.66	1.66	2.80	1.55	m
22	1.00	0.33	1.33	2.80	3.33	st
<i>K. galanga</i> L.						
1	1.66+1.66	2.66	5.98	5.71	1.24	m
2	2.00+1.33	2.33	5.66	4.89	1.42	m
3	2.00+1.33	2.00	5.33	4.61	1.66	m
4	3.33	1.00+1.00	5.33	4.61	1.66	m
5	3.33	1.00+1.00	5.33	4.61	1.66	m
6	3.33	1.00+1.00	5.33	4.61	1.66	m
7	3.33	2.00	5.33	4.61	1.66	m
8	3.33	2.00	5.33	4.61	1.66	m
9	3.33	2.00	5.33	4.61	1.66	m
10	1.00+2.33	1.33	4.66	4.03	2.50	sm
11	2.66	2.00	4.66	4.03	1.33	m
12	2.66	2.00	4.66	4.03	1.33	m
13	2.66	2.00	4.66	4.03	1.33	m
14	2.33	2.33	4.66	4.03	1.00	M
15	3.33	1.00	4.33	3.74	3.33	st
16	3.33	1.00	4.33	3.74	3.33	st
17	3.00	1.00	4.00	3.46	3.00	sm
18	3.00	1.00	4.00	3.46	3.00	sm
19	2.00	2.00	4.00	3.46	1.00	M
20	2.66	1.33	3.99	3.45	2.00	sm
21	2.66	1.33	3.99	3.45	2.00	sm
22	1.33+1.33	1.33	3.99	3.45	2.00	sm
23	2.66	1.00	3.66	3.16	2.66	sm
24	2.33	1.33	3.66	3.16	1.75	sm
25	2.33	1.00	3.33	2.88	2.33	sm
26	2.33	1.00	3.33	2.88	2.33	sm
27	2.00	0.66	2.66	2.30	3.03	st

and 22) and on the short arm of 3 pairs (4, 5 and 6). The karyotype was found to be fairly symmetrical, and belonged to 2A category.

Available literature (Table 1) shows that the species occur in different cytotypes in the Indian sub-continent such as $2n=54$, $2n=44$ and $2n=22$ constituting a polyploid series based on $x=11$.

Discussion

Chromosome reports available on *Kaempferia* show that a wide range of diploid chromosome numbers (Table 1) ranging from $2n=22$ — 54 occurs in the genus. The data indicate that the species of the genus fall under several basic series such as $x=9$, 11, 12, 13 and 14 of which $x=11$ is the most frequent one. It may be noted that species of *Kaempferia*, on morphological considerations, fall under apparently two types such as those showing morphological specialities characterized by the two lateral petaloid staminodes free from the deeply two-lobed labellum, and others with fused labellum and staminodes. The former morphologically less advanced species are Asiatic, and the latter advanced ones African (Mahanty 1970). Based on the above morphological distinction, some earlier taxonomists (Schumann 1904) had treated the African group of species as a subgenus of *Kaempferia* (*Cienkowskyia*). From the distribution of different basic chromosome numbers, it may be seen that the $x=11$ situation is deeply placed in the Asiatic group, while $x=14$ is exclusively present among the morphologically more advanced African group of species which possessed fused labellum and staminodes. The predominance of $x=11$ condition together with occurrence of species with different levels of polyploidy on this number may be suggestive of $x=11$ to be the earlier evolved chromosome constitution in the genus. Such a contention has been held by some of the earlier workers also (Sharma and Bhattacharyya 1959, Mahanty 1970). The concentration of $x=11$ among the relatively less advanced group of species referred to above appears to provide support to the possibility of $x=11$ being the original condition in the genus. The intermediate basic numbers $x=12$ and 13 occur among species which are morphologically closer to the less advanced Asiatic species, and it may be that the higher basic numbers $x=12$, 13 and 14 are the derived conditions from $x=11$ by ascending aneuploidy.

The chromosome numbers in two of the cytologically known species (Table 1) namely *K. angustifolia* ($2n=36$ and 54) and *K. gilberti* ($2n=36$) are in multiples of 9, and they do not fit with $x=11$ or any of its aneuploid derivatives mentioned above. Sharma and Bhattacharyya (1959) have considered $2n=54$ reported by them in materials of species *K. angustifolia* to be an aneuploid cytotype from those with $2n=55$. They have also suggested $2n=36$ observed by them in the same species as yet another cytotype from $2n=33$ arisen by chromosome duplication. According to this suggestion the above two species are also to be considered as ones belonging to the $x=11$ series.

Karyomorphologically this is a very inadequately investigated genus, and the data in the three species reported here are too insufficient to make a consideration on the nature and extent of structural alternations in chromosomes that have con-

tributed to speciation and evolution in the genus. The change of centromere from median to the submedian position, and increasing difference in size between chromosomes of a complement are two basic factors in the evolution of chromosome morphology (Stebbins 1950). The karyomorphological data of the three species reported here indicate that all of them have relatively unspecialized and symmetrical karyotypes (2A) so much so no gross interspecific karyotype variability is apparent among them. On critical examination of the karyotypes of the three species it reveals that karyotype asymmetry is progressively greater among the higher polyploids, as they show higher frequencies of sm- and st-type chromosomes (Table 3). Similarly intrakaryotypic size difference of chromosomeus which is usually brought about by differential deletion of segments of individual chromosomes as well as through occurrence and establishment of unequal translocations between nonhomologous chromosomes (Mathew and Thomas 1974) is also seen to be greater among the polyploids. The evidence thus indicates that the above factors which lead to karyotype specialization also have played some role, along with polyploidy, in the evolution of the genus *Kaempferia*.

Table 3. Centromeric positions and size difference between the longest and shortest chromosomes in three species of *Kaempferia*

Species	Chromosome number 2n	Frequency of types of chromosomes					Ratio of Longest/Shortest chromosome
		M	m	sm	st	t	
<i>K. angustifolia</i> Rosc.	36	1	12	4	1	0	1.06
<i>K. rotunda</i> L.	44	4	12	6	2	0	2.05
<i>K. galanga</i> L.	54	2	12	10	3	0	2.21

Summary

Detailed karyomorphology of three species of *Kaempferia* from South India has been studied, namely *K. angustifolia* ($2n=36$), *K. rotunda* ($2n=44$) and *K. galanga* ($2n=54$). Karyomorphological data indicate that karyotypes of all the three species are moderately asymmetrical (2A). Karyotype asymmetry has been more through structural rearrangement resulting in shift of centromere position.

Chromosomal evolution in the genus is discussed in the light of available cytological findings. The data show that species of the genus constitute different basic series such as $x=11, 12, 13$ and 14 of which $x=11$ is most predominant. Polyploidy and aneuploidy at polyploid levels have been most operative among $x=11$ species. The present karyomorphological data showed that structural alternation of chromosomes also have played some role along with polyploidy in the evolution of the genus.

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References

- Chakravorti, A. K. 1948. Multiplication of chromosome numbers in relation to speciation in Zingiberaceae. *Sci. and Cult.* **14** (4): 137–140.
- Federov, A. 1969. Chromosome Numbers of Flowering Plants. (by Z. Bolkhoshikh, V. Grif, T. Matvejeva and O. Zakharyeva. Leningrad).
- Hooker, J. D. 1892. *Flora of British India*, VI. London.
- and Jackson, B. D. 1895. *An Enumeration of The Genera and Species of Flowering Plants*. II. Oxford University Press, London.
- Kirtikar, K. R. and Basu, B. D. 1975. *Indian Medicinal Plants* IV. Periodical Experts D-42, Delhi.
- Levan, A., Fredga, K. and Sandberg, A. A. 1964. Nomenclature for centromeric positions on chromosomes. *Hereditas* **52**: 201–220.
- Mahanty, H. K. 1970. A cytological study of the Zingiberales with special reference to their taxonomy. *Cytologia* **35**: 13–49.
- Mathew, P. M. and Thomas, K. J. 1974. Cytological studies on *Chlorophytum*. *New Botanist* **1** (1/2): 34–45.
- Raghavan, T. S. and Venkatasubban, K. R. 1943. Cytological studies in the family Zingiberaceae with special reference to chromosome number and taxonomy. *Proc. Indian Acad. Sci., Sect. B.* **17** (4): 118–132.
- Raghavan, R. S. and Arora, C. M. 1958. Chromosome numbers in Indian medicinal plants. II. *Proc. Indian Acad. Sci., Sect. B.* **47** (6): 352–358.
- Ramachandran, K. 1969. Chromosome numbers in Zingiberaceae. *Cytologia* **34**: 213–221.
- Schumann, K. 1904. Zingiberaceae. In Engler, A. Das Pflanzenreich: **4**. Berlin (cited from Mahanty, H. K. 1970).
- Sharma, A. K. and Bhattacharyya, N. K. 1959. Cytology of several members of Zingiberaceae. *La Cellule* **59**: 297–346.
- Stebbins, G. L. 1950. *Variation and Evolution in Plants*. Columbia University Press, New York.
- , 1958. Longivity, habitat and release of genetic variability in higher plants. *Cold Spring Harb. Symp. Quant. Biol.* **23**: 365–378.
- Venkatasubban, K. R. 1946. A preliminary survey of chromosome numbers in Scitamineae of Bentham and Hooker. *Proc. Indian Acad. Sci. B.* **23** (6): 281–300.
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