Karyomorphological Studies in *Chlorophytum* Ker-Gawl.

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The genus *Chlorophytum* Ker-Gawl. belongs to the tribe Anthericineae of sub-family Asphodeleae of Liliaceae (Engler and Prantl 1930). It comprises of about 234 species distributed in the tropical and sub-tropical regions, majority being in Africa. In India, fifteen species have been described so far (Hooker 1892, Santapau and Fernandes 1955). This genus has been studied in detail from cyto-taxonomic and cytogeographic points of view by Pahuja and Kumar (1969), Baldwin and Speese (1951), Sheriff (1967, 1971), Sheriff and Chennaveeraiah (1975), Mukherjee (1975), Naik (1977) and others. These studies reveal the existence of two basic chromosome numbers of 7 and 8 in this genus and the role of polyploidy in the speciation processes. Hence, an attempt has been made to detect the relationships based on chromosome number and morphology of six species of *Chlorophytum* Ker-Gawl.

Materials and methods

During monsoon, live plants of the following species have been collected and planted in the MACS nursery:

<i>Species</i>	<i>Locations</i>
<i>C. laxum</i> R. Br.	around Poona
<i>C. tuberosum</i> Baker	Poona University Campus
<i>C. attenuatum</i> Baker	Konkan region
<i>C. comosum</i> Jacques	Garden plant
<i>C. orchidastrum</i> Lindl.	Purandhar Fort
<i>C. glaucum</i> Dalz.	Bhimashankar

Root tips have been collected from the potted plants at 9.30 am, and pretreated with α -bromonaphthalene for two hours at 4°C. Slides are prepared according to the procedure of Sharma and Mookherjee (1955). Camera lucida drawings have been sketched at bench level. Numerical sequence of individual chromosomes in the complement is given according to the criteria adopted by Sears (1958) and Riley (1963). Karyotype symmetry has been analysed using Stebbins' (1958) system of classification based on relative arm-lengths and arm-ratios.

Results

Quantitative data on mean total chromosomal length of haploid complement, graded arm-ratios have been summarized in Table 1. Idiograms and photomicrographs of somatic metaphase plates of these species are presented in Plates 1 and 2.

It is evident from the table that in *C. laxum*, *C. tuberosum* and *C. attenuatum* the chromosome number observed is $2n=16$, in *C. comosum* it is $2n=28$ and in *C. glaucum* and *C. orchidastrum* it is $2n=42$. Total chromosome length of the haploid complement is maximum in the last two species and minimum in the species with $2n=16$. Ratio of longest/shortest chromosomes appears to be minimum in $2n=16$, intermediate in $2n=28$ and maximum in $2n=42$. This suggests roughly the extent of deviations in individual chromosome lengths, maximum

Table 1. Total chromosome lengths, arm ratios and karyotypic symmetries in *Chlorophytum* species

Species	2n	Total chromosomal length μ of haploid set		Longest/ shortest chromosome	No. of chromosomes with arm-ratios (short arm/long arm)					Karyotypic symmetry (Stebbins' notations)
		Range	Mean		0.01- 0.20	0.21- 0.40	0.41- 0.60	0.61- 0.80	0.81- 1.0	
<i>C. laxum</i>	16	51.75- 68.50	61.95 $\pm$ 2.01	1.42	—	—	1	5	2	2a
<i>C. tuberosum</i>	16	64.50- 91.25	75.53 $\pm$ 2.75	1.72	—	3	3	1	1	2a
<i>C. attenuatum</i>	16	52.63- 72.13	60.73 $\pm$ 1.80	1.75	—	1	6	1	—	2a
<i>C. comosum</i>	28	92.12-125.12	99.31 $\pm$ 3.30	1.88	1	4	6	1	2	2a
<i>C. orchidastrum</i>	42	86.13-150.38	114.82 $\pm$ 6.36	2.12	—	7	6	5	3	2b
<i>C. glaucum</i>	42	116.50-184.0	144.43 $\pm$ 7.52	2.25	1	5	6	4	5	2b

being in *glaucum* and *orchidastrum* and minimum in *laxum*. Number of chromosomes with median centromeres appears to be higher in *C. glaucum* and *C. orchidastrum*. Among the species with $2n=16$, such chromosomes are relatively more in *C. laxum* (Plate 1). Chromosomes with

Plate 1. Idiograms of (1) *C. laxum*, (2) *C. tuberosum*, (3) *C. attenuatum*, (4) *C. comosum*, (5) *C. glaucum* and (6) *C. orchidastrum*

subterminal centromeres are also relatively more in number, in *orchidastrum*, *glaucum* and *comosum*. By using Stebbins' notations (1958), *C. glaucum* and *C. orchidastrum* appear to have relatively more differences as these species belong to 2b grade. Further details on karyotype asymmetries are given in Table 2.

The difference between longest and shortest chromosomes (L-S) is maximum in *glaucum* and minimum in *laxum*. Similar trends are observed for number of heterobrachial chromosomes. Coefficient of variability for chromosome length appears to be least in *laxum*.

Among the six *Chlorophytum* species studied, only in *attenuatum* and *orchidastrum* there are two pairs of SAT chromosomes, whereas in rest of the species one pair may be observed (Table 3, Plates 1, 2). SAT chromosome is one of the longest chromosomes in *tuberosum* and *attenuatum* (sequence No. II). Similarly, in *comosum* and *orchidastrum* the sequence number is XII. In other species sequence number varies in the complement. It is also interesting to note that the SAT chromosomes with same sequence number have closer arm ratios (S/L). For SAT 2, it is clearly seen that the arm ratios for *laxum*, *attenuatum*, *orchidastrum* and *glaucum* are more or less similar. In all these species SAT-knob is attached to the short arm of the chromosome except for *attenuatum* where both the SAT chromosomes indicate SAT-knob being attached to the long arms (see idiograms).

Table 2. Karyotypic asymmetries in *Chlorophytum* species

Species	Longest chromosome L μ	Shortest chromosome S μ	Difference L-S μ	No. of chromosomes			Coeff. of vari- ability for length
				Homobra- chial	Heterobrachial		
					SMC	STC	
<i>C. laxum</i>	8.78±0.28	6.20±0.31	2.58	1	7	—	0.1325
<i>C. tuberosum</i>	11.63±0.95	6.75±1.69	4.88	—	5	3	0.1828
<i>C. attenuatum</i>	9.96±0.10	5.69±0.08	4.27	—	8	—	0.1875
<i>C. comosum</i>	9.79±0.32	5.22±0.19	4.57	1	8	5	0.1670
<i>C. orchidastrum</i>	7.64±0.13	3.60±0.07	4.04	2	19	—	0.1907
<i>C. glaucum</i>	10.00±1.41	4.45±0.17	5.55	1	14	6	0.2043

SMC—sub-median chromosomes

STC—sub-terminal chromosomes

Discussion

Karyomorphology and symmetry

Present observations on the karyomorphology of six *Chlorophytum* species clearly suggest the chromosomes with median or submedian centromeres to be more in *C. laxum*. This is also supported by relatively less values for longest/shortest chromosome ratio. This ratio appears to be highest in *C. glaucum* (Table 1). Broad estimation of karyotype symmetry also corroborates the same. Even the coefficient of variability of individual chromosomes in the complement (calculated by processing length deviations of individual chromosomes over mean length of the respective complement) also fortifies these observations.

Presence of secondary constrictions has been reported in *C. comosum*, *C. attenuatum*, *C. malabaricum* and other species by Sheriff (1967), Sheriff and Chennaveeraiah (1975) and Naik (1977), though in the present studies such situations could not be noted. This might have been due to the possibility of existence of different biotypes under the same species or the observational errors.

SAT chromosomes observed in these six species vary in their sequence numbers as also in the arm-ratios. In *C. tuberosum* and *C. attenuatum* one of the longest chromosomes (sequence number II) is the SAT chromosome and the SAT-knob is attached to the long arm in *attenu-*

Plate 2. 1, somatic metaphase plate of *C. laxum*. $\times 1200$. 2, somatic metaphase plate of *C. tuberosum*. $\times 1230$. 3, somatic metaphase plate of *C. attenuatum*. $\times 1300$. 4, somatic metaphase plate of *C. comosum*. $\times 1830$. 5, somatic metaphase plate of *C. glaucum*. $\times 1660$. 6, somatic metaphase plate of *C. orchidastrum*. $\times 1300$.

atum, whereas in *C. laxum* shortest chromosome (sequence number VIII) carries the satellite attached to the short arm. These observations agree with those reported by Naik (1976). Likewise in *comosum* and *orchidastrum* the sequence number of the SAT chromosome is XII. Only in *attenuatum* SAT-knob is attached to the long arm (Plate 1). Sheriff (1971) observed similar situation in *C. arundinaceum*. Sheriff (1971) and Sheriff and Chennaveeraiah (1975) noted interstitial satellites in *C. comosum*, *C. attenuatum* and other hexaploid species. These observations support the possibility of existence of different biotypes or cytotypes.

Basic chromosome number

Out of the six species studied, three species, viz. *C. laxum* ($2n=16$), *C. tuberosum* ($2n=16$) and *C. attenuatum* ($2n=16$) appear to have $x=8$ as basic chromosome number whereas other three species *C. comosum* ($2n=28$), *C. orchidastrum* ($2n=42$) and *C. glaucum* ($2n=42$) have the basic number 7. Chromosome numbers in these species reported earlier have thus been con-

Table 3. Comparison of SAT chromosomes in *Chlorophytum* species

Species	SAT-1					
	SAT chromosome length					
	Sequence No.	Total	Long arm L	Short arm S	SAT	Arm ratio S/L
<i>C. laxum</i>	—	—	—	—	—	—
<i>C. tuberosum</i>	II	11.58	7.54	2.14	1.90	0.54
<i>C. attenuatum</i>	II	9.75	5.43	3.28	1.04*	0.51
<i>C. comosum</i>	—	—	—	—	—	—
<i>C. orchidastrum</i>	V	6.33	3.09	2.01	1.23	0.95
<i>C. glaucum</i>	—	—	—	—	—	—

Species	SAT-2					
	SAT chromosome length					
	Sequence No.	Total	Long arm L	Short arm S	SAT	Arm ratio S/L
<i>C. laxum</i>	VIII	6.21	3.18	1.00	2.03	0.95
<i>C. tuberosum</i>	—	—	—	—	—	—
<i>C. attenuatum</i>	IV	7.15	3.49	2.32	1.34*	0.48
<i>C. comosum</i>	XII	6.07	3.06	2.06	0.95	0.98
<i>C. orchidastrum</i>	XII	5.31	2.67	1.52	1.12	0.99
<i>C. glaucum</i>	XVII	5.65	2.65	1.05	1.95	0.88

* SAT-knob attached to the long arm.

firmed. Sheriff and Chennaveeraiah (1972) have noted $2n=16$ in *C. glaucum* collected from Daulatabad in Maharashtra and have also reported $2n=42$, 84 in *C. attenuatum* from different localities. It is rather interesting to note that in *C. laxum* from Liberia, Baldwin and Speese (1951) have reported the diploid number as $2n=14$. On the contrary, Sheriff (1967), Datta and Mitra (1968) and the present work reveal the chromosome number in *C. laxum* as $2n=16$. This suggests the possibility of different cytotypes under the species. It also suggests that presence or lack of one pair of chromosomes might not have affected the distinguishing characters of the species. In other words, the earlier suggestions of the basic number in *Chlorophytum* species, which is to be secondary and might have been derived from $x=4$ (Naik 1977), have obvious importance. This is confirmed by the earlier reports of $2n=8$ by Strasburger (1888) in *C. sternbergianum* Roxb.

Polyploidy in Chlorophytum

Based on the chromosome numbers reported, the *Chlorophytum* species with $x=7$ appear to be more in number as compared to those with $x=8$. This suggests that the species with $x=7$ have been relatively more adapted to climatic conditions, or the allotetraploids or polyploids of $x=7$ have developed the fixity and fluidity to withstand the climatic changes ultimately resulting in the survival of numerous species with $x=7$. On the contrary, species with $x=8$ are mostly restricted to the arid or semi-arid conditions. Thus, polyploidy appears to have played major role in the speciation process in the genus *Chlorophytum*. However, it is essential to study additional species to draw such conclusions.

Geographical distribution of Chlorophytum species

Chlorophytum species with $x=8$ at diploid level and with $x=7$ at diploid as also tetraploid or even higher levels are distributed from Africa to India and Australia. Majority of these species have been reported from Africa, indicating the same as the centre of origin.

Geographical distribution of *Chlorophytum* species in Africa, Madagascar, Indian sub-continent, Australia and Brazil suggests that the ancestral species might have existed over the undivided Gondwana land. Subsequently, Gondwana rifts and continental drifts have separated the landmasses into Africa, Madagascar, Indian part and South America alongwith the flora and fauna present. This also suggests the possibility of parallel evolution resulting in the formation of similar species in the separated landmasses. Similar observations have been reported on *Gossypium* and honey bees by Deodikar (1978).

Thus, *C. laxum* reported from Africa, India and Australia might be one of the ancestral living species, as it has more or less symmetrical karyotype with median or sub-median chromosomes. In spite of its distribution, the variations in chromosome numbers as discussed above might have taken place in the course of evolution or speciation processes during the post Cretaceous period. This indicates the possibility of $x=8$ being the basic number of the genus which might have been derived even earlier from $x=4$ as species with $2n=8$ have already been reported from Africa, the centre of origin of *Chlorophytum*.

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Summary/Abstract

Chromosome morphology of six *Chlorophytum* species reveal symmetrical karyotypes in *C. laxum* ($2n=16$) and asymmetrical in *C. glaucum* and *C. orchidastrum* ($2n=42$). Remaining three species, viz. *C. tuberosum*, *C. attenuatum* ($2n=16$) and *C. comosum* ($2n=28$) appear to be intermediate in the karyotype symmetry. In *C. attenuatum* and *C. orchidastrum* two pairs of SAT chromosomes with variations in their sequence numbers and arm ratios have been observed, whereas in rest of the species only one SAT pair could be observed. Tentative basic chromosome number for the genus has been suggested to be $x=8$ and 7, possibly derived as secondary number from $x=4$. Role of polyploidy in the speciation process, centre of origin and geographical distribution in relation to karyomorphology have been discussed.

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