INCONSTANCY IN CHROMOSOME COMPLEMENTS IN SPECIES OF *MARANTA* AND *CALATHEA*

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ABSTRACT

1. Nine different species of the family Marantaceae distributed under two genera *Calathea* and *Maranta* have been cytologically studied. The chromosome numbers counted for the different species are :

i)	*Calathea leopardina* Regel	$2n = 8$
ii)	*C. vanenheckei* Regel	$2n = 22$
iii)	*C. zebrina* Lindl.	$2n = 22$
iv)	*C. princeps* Regel	$2n = 22$
v)	*C. ornata* Koern.	$2n = 26$
vi)	*Maranta insignis* Hort.	$2n = 26$
vii)	*M. picta*	$2n = 26$
viii)	*M. leuconeura* E.Morr.	$2n = 26$
ix)	*M. kejeljani* E. Morr.	$2n = 33$

2. Detailed karyotype studies of all these species have been made. On the basis of cytological data, interrelationship between the two genera as well as their present taxonomic status have been discussed. Species with $2n = 8$ chromosomes have been considered as representing the most primitive condition.

3. Evidence of structural changes of chromosomes playing a rôle in speciation has been gathered specially from their karyotypes.

4. The significance of variation in chromosome number in different individuals of the same species, on the basis of the report of previous as well as the present one, has been discussed in relation to the origin of chromosomal biotypes in nature.

5. Occurrence of structural and numerical alterations in the somatic complements of different species has been noted. In view of ineffective sexual reproduction, their importance n the origin of biotypes and species through vegetative reproduction has been pointed out.

INTRODUCTION

Species of *Calathea* and *Maranta* propagate strictly through vegetative means. Flowers are either never produced or noted very scarcely in them. Even then, both the genera have got a number of species which are often cultivated specially in the tropical regions because of the ornamentation of their leaves. In addition to these, the importance of *Maranta arundinacea*, the arrowroot yielding plant, is well known. These two genera comprise the major part of the family Marantaceae.

A glance at the available cytological literature on the two genera reveals certain interesting facts (Venkatasubban, 1946 ; Sato, 1948 ; Simmonds, 1954). A number of species differ from each other with respect to their chromosome number. More interesting is the fact that even in a single species individuals with different chromosome numbers have been found such as *Calathea veitchiana*, *C. lietzei*, *C. zebrina*, *Maranta arundinacea* etc. Chromosome number as low as eight has been reported in *Calathea veitchiana*. In this species, different authors have reported different somatic numbers in the individuals studied by them (cf. Sato's report of eight chromosomes in *C. veitchiana* and Venkatasubban's report of twenty-six chromosomes in the same, *l.c.*).

The absence of any sexual reproduction in two such successful genera obviously makes them interesting materials for a study of the mechanism of speciation. Unfortunately no serious attempts have been made to study this aspect so far. In plants reproducing through asexual means certain peculiarities in the chromosome behaviour are noted which are correlated to the origin of species in such plants to a remarkable degree. It has been thought worthwhile to find out whether in the members of the family *Marantaceae* too the same type of behaviour is present. Moreover, the literature shows that a number of species growing in India still remain uninvestigated. Because of this, and also taking into account the fact that these two genera provide ample scope for cytological studies, the present investigation has been undertaken.

Fortunately, as the text would reveal, significant peculiarities in the chromosome behaviour of these species have been obtained which throw considerable light to an understanding of the method of speciation. From the records so far gathered including those of the previous authors, an attempt has been made here to suggest the mechanism of speciation operating in them and to work out the systematic status and the affinities of the two genera.

Materials and Methods

A. *Materials*

The following species of plants were the source of materials for the purpose of the present investigation :

1. *Calathea leopardina* Regel
2. *C. princeps* Regel
3. *C. vandenheckei* Regel
4. *C. zebrina* Lindl.
5. *C. ornata* Koern.
6. *Maranta insignis* Hort.
7. *M. leuconeura* E. Morr.
8. *M. picta*
9. *M. kegeljani* E. Morr.

Most of the species of the genera *Calathea* and *Maranta* are inhabitants of tropical America and are generally found in moist or swampy regions. But several species are cultivated in India as ornamental garden plants and also for commercial purposes. Ornamentation of their foliage is very diverse including stripes, spots, and various shades of colour on the upper and lower surfaces.

The materials were collected from a local nursery of Calcutta and were grown in a moist shady nursery of the University compound. For root-tips, rhizomes were placed in suitable earthenware pots in a mixture of sand and soil. Another set of plants was grown in garden plots for the initiation of flowers.

B. *Methods*

Study of somatic chromosomes presented much difficulty. Various metallic and non-metallic fixatives with varying proportions were used. Different types of pre-treatment chemicals were tried to get good results. Trials were given in Aesculin, Para-dichlorobenzene, Coumarin, and Newcomer's fluid (Newcomer, 1953). It was found that a mixture of Newcomer's fluid and Para-dichlorobenzene (aqueous) in the proportion of 1 : 1 yielded best results. But the main difficulty with the somatic chromosomes is their very weak stainability and to overcome this, a modified technique was applied. This was as follows :

Newcomer's fluid (Iso-propyl alcohol: Propionic acid: Ether: Acetone: Dioxan :: 6 : 3 : 1 : 1 : 1) and aqueous solution of Para-dichlorobenzene were mixed in the proportion of 1 : 1 just before treatment. Healthy root-tips were next treated in this mixture for $1\frac{1}{2}$ hours at 10°C. The materials were then hydrolysed and stained in a mixture of 2 per cent Aceto-orcein and N/HCl (9 : 1) by heating over a flame for a few seconds. Stained root-tips were next transferred to 1 per cent iron alum solution (aqueous) and heated for a few more seconds. The materials were then immediately placed in 1 per cent Aceto-orcein solution and squashed. Slides were sealed properly. The peak period of mitotic division was found to occur between 10 A.M. to 12 noon. Paraffin sections, 14μ thick, were also cut and stained following Newton's crystal violet technique.

The figures were drawn at a table magnification × 29,00 using a Zeiss compensating eye-piece of ×20 and a 1.3 apochromatic objective.

In the drawings, chromosomes with secondary constrictions have been drawn in outline.

Observations

All the different species are perennial herbs with rhizomatous stems. Leaves are borne in two rows, each leaf differentiated into an open sheath, stalk and a blade.

Nine species distributed under the two genera, *Calathea* and *Maranta*, have been cytologically examined in the present case. The somatic chromosome number in them has been found to range from as low as $2n = 8$ to as high as $2n = 33$. Nuclei with varying number of chromosomes in their complements, involving both structural and numerical alterations have been observed in all of them. That somatic number which occurs in the highest frequency, is taken as the normal number for the species.

Genus—*Calathea*

Five species were investigated. Of these, three are characterized by twenty-two, one by twenty-six and the remaining one by having only eight chromosomes in their somatic complements respectively.

The chromosomes show no marked size difference but a slow gradation in size is found within the complement of the different species. The number of chromosomes with secondary constrictions varies from two to eight. Chromosomes with supernumerary constrictions are found in two species. Size of the chromosomes ranges from 1.1μ to 3.4μ and on its basis three general groups can be recognized, viz., comparatively long, medium and short. Primary constrictions are mostly median to submedian in position.

All the different species of this genus reveal a gross similarity as regards the morphology of the chromosomes. So it will be convenient to describe the general chromosome types first. Their finer details will be described under the karyotype analysis for each species. Following are the main types:—

Type A—Represents medium sized chromosomes each having three constrictions, one primary and two secondary, of which one is nearly median in position and the other two in submedian positions at the two opposite ends.

Type A_1—Medium sized chromosomes each with three constrictions, one primary and two secondary, of which one is nearly submedian in position, another located at the middle of the shorter arm and the third nearly submedian in position at the distal end of the longer arm.

Type B—Medium sized chromosomes (comparatively long in one case) each with two constrictions, primary and secondary, one nearly median and the other nearly submedian, placed very near the former.

Type C—Comparatively long chromosomes each possessing two constrictions, primary and secondary, one nearly median and the other nearly subterminal at the distal end of the comparatively longer arm.

Type D—Medium sized chromosomes each with two constrictions, primary and secondary, both in submedian positions at the two distal ends. It differs from E in having the position of chromosome arm between the two constrictions much longer in size than the other two distal parts.

Type E—Medium sized chromosomes each with two constrictions, primary and secondary, both located in nearly submedian positions at the opposite ends of the chromosomes.

Type F—Medium sized (comparatively long in some cases) chromosomes with nearly submedian to submedian primary constrictions.

Type G—Short (comparatively medium sized in a few pairs) chromosomes with nearly median to median primary constrictions.

Type H—Short to very short chromosomes with median primary constrictions.

1. *C. leopardina* Regel ($2n = 8 = 2M^s + 4M + 2S$)

Herbaceous perennials with small root-stock and a few small leaves. Petioles short, leaf-surface with white patches along the mid-rib.

The somatic chromosome number in the normal plate is found to be $2n = 8$ (Fig. 1). Size difference is not marked and two groups can be recognised.

i) Three pairs of medium sized chromosomes, and
ii) One pair of short chromosomes.

Of these, only one pair of chromosomes is found to bear secondary constrictions. The size range varies between 1.6μ to 2.8μ.

Detailed karyotype analysis is shown in the following table (Table I, Fig. 2) :—

TABLE I

Karyotype analysis in C. leopardina

Type	Number	Special features
D	1 pair	Comparatively longer than other D types.
F	2 pairs	One pair slightly longer than the other.
G	1 pair	Common G type.

In addition to the normal karyotype, a variation plate with twelve chromosomes is also on record (Fig. 3). In the somatic prophase of the normal plate two chromosomes are found to be attached with the nucleolus (Fig. 4).

2. *C. princeps* Regel ($2n = 22 = 2L^s + 2M^s + 10M + 8S$)

Leaves long-petioled, long and narrow, upper sarface dark green and glossy ; lower surface pink.

Twenty-two chromosomes are present in the complements of normal somatic cells (Fig. 5). Size difference is comparatively marked, and on its basis, the chromosomes can be divided into the following general groups :—

i) One pair of comparatively long chromosomes,
ii) Six pairs of medium sized chromosomes, and
iii) Four pairs of short to very short chromosomes.

Of these, four chromosomes bear secondary constrictions. The size ranges from 1.2μ to 3.1μ.

Table II shows the detailed analysis of the karyotype (Fig. 6).

TABLE II

Karyotype analysis in C. princeps

Type	Number	Special features
C	1 pair	Normal C type.
F	1 ,,	Longer than other F type.
E	1 ,,	Common E type.
G	6 pairs	Two pairs comparatively longer than normal G type.
H	2 ,,	Common H type.

In addition to the normal karyotype, a cell with abnormal number of chromosomes ($2n = 20$) is also on record (Fig. 7).

3. *C. vandenheckei* Regel ($2n = 22 = 2L^s + 8M + 12S$)

Leaves large, ovate, long-petioled, upper surface dark green and glossy, lower surface pink. Pale yellow patches along the mid-rib conspicuous.

The normal somatic cells of the species contain $2n = 22$ chromosomes (Fig. 8). Beside one pair of comparatively long chromosomes, the rest are medium sized to short forming a graded series. Size difference makes the chromosomes divisible into three groups.

i) One pair of comparatively long chromosomes,
ii) Four pairs of medium sized chromosomes, and
iii) Six pairs of short to very short chromosomes.

Of these chromosomes, only one pair is seen to bear secondary constrictions. The size ranges from 1.2μ to 3.4μ. Detailed study of the chromosome morphology is revealed from the following table (Table III, Fig. 9) :—

TABLE III

Karyotype study in C. vandenheckei

Type	Number	Special features
B	1 pair	Longer than other B types.
F	3 pairs	Common F type.
G	4 ,,	,, G ,,
H	3 ,,	,, H ,,

Beside the normal karyotype, a variation plate with $2n = 24$ chromosomes is on record (Fig. 10). Late separation of chromosomes forming an apparent somatic bridge (Fig. 11) and lagging chromosomes are also observed (Fig. 11a).

4. *C. zebrina* Lindl. ($2n = 22 = 2M^{ss} + 4M^s + 4M + 12S$)

Leaves many, ovate-lanceolate, pale green with light black stripes diverging from the mid-rib.

$2n = 22$ chromosomes are found in cells with normal somatic complements (Fig. 12). Size difference is not marked and two general groups can be recognized.

i) Five pairs of medium-sized chromosomes, and

ii) Six pairs of short to very short chromosomes.

Three pairs of chromosomes are found to bear secondary constrictions, one pair of which possesses supernumerary constrictions. The size range varies between 1.2μ to 2.7μ. Detailed karyotype analysis is shown in Table IV (Fig. 13).

TABLE IV

Analysis of Karyotype in C. zebrina

Type	Number	Special features
A	1 pair	Normal A type.
D	1 pair	Shorter than common D type.
E	1 pair	,, ,, E ,,
F	2 pairs	Common F type
G	2 pairs	,, G ,,
H	4 pairs	,, H ,,

In addition to the normal karyotype, several variation plates, involving both structural and numerical changes in chromosomes are on record. Numbers both lower and higher than the normal $2n = 22$ plates are found viz., $2n = 20$, 23, 25, 26 and 30 (Figs. 14–18). Nuclei maintaining the normal number show structural alterations in some cases (Fig. 18a). Somatic irregularities namely, lagging and late separation of chromosomes are also observed.

5. *C. ornata* Koern. ($2n = 26 = 2M^{ss}+6M^{s}+18S$)

Leaves numerous, large, pink beneath, upper surface dark green with fine white stripes.

Normal somatic complement is found to contain twenty-six chromosomes (Fig. 19). Size difference is not so marked, and on its basis following two general groups can be recognized :—

i) Four pairs of medium sized chromosomes, and

ii) Nine pairs of short to very short chromosomes.

Of these, eight chromosomes bear secondary constrictions including one pair with supernumerary constrictions. The size ranges from 1.1μ to 2.8μ. Detailed morphology of the chromosomes is revealed in Table V (Fig. 20).

TABLE V

Karytype analysis in C. ornata

Type	Number	Special features
A_1	1 pair	Normal A_1 type.
B	1 ,,	Shorter than other B types.
E	2 pairs	One constriction in each of the chromosomes much pronounced.
G	7 ,,	A few pairs shorter than general G type.
H	2 ,,	Common H type.

Variation plates with different chromosome numbers, such as $2n = 19$, 24 and 30 are also on record (Figs. 21–23). Somatic irregularities such as, non-disjunction and lagging are observed in some cases.

Genus—*Maranta*

Four species belonging to this genus were studied. Of these, three are characterized by twenty-six and the other one by thirty-three chromosomes. Besides these, several variation plates are also on record.

The chromosomes show no well marked size difference within the complement, but they form a graded series. Secondary constrictions are found to occur in four to nine chromosomes. Two species reveal chromosomes with supernumerary constrictions. Size of the chromosomes ranges from 1.2μ to 4.1μ. They are mostly medium to short in size except in *M. kegeljani*, in which type A_1 is comparatively longer than in the rest of the species.

In the detailed karyotypes of the different species, the general chromosome types are described first on a comparative basis and the minor differences shown separately. The principal types are :—

Type A—Medium sized to comparatively long chromosomes each with three constrictions, one primary and two secondary, of which one is nearly median and the other two in submedian positions at the opposite ends.

Type A_1—Long chromosome having three constrictions, one primary and the other two secondary. One constriction is median and the other two are placed in submedian positions at the two arms. This type is much longer than the A type.

Type B—Medium sized chromosomes each with two constrictions, primary and secondary, one nearly median and the other nearly subterminal at the distal end of the comparatively longer arm.

Type C—Medium sized chromosomes each with two constrictions, primary and secondary, both located in nearly submedian positions at the opposite ends of the chromosomes.

Type D—Medium sized chromosomes with nearly submedian to submedian primary constrictions.

Type E—Short chromosomes with nearly median to median primary constrictions.

Type F—Very short chromosomes with median primary constrictions.

6. *M. insignis* Hort. ($2n = 26 = 4M^s + 4M + 18S$)

Leaves small, narrow, shortly petioled with undulating margin.

The somatic chromosome number in the normal plate is found to be $2n = 26$ (Fig. 24). Size difference is not marked and two groups can be recognised.

i) Four pairs of medium sized chromosomes.

ii) Nine pairs of short to very short chromosomes.

Four chromosomes are found to bear secondary constrictions. The size range varies between 1.2μ and 2.1μ. Detailed karyotype analysis is shown in the following table (Table VI, Fig. 25) :—

Table VI

Analysis of karyotype in M. insignis

Type	Number	Special features
B	1 pair	Common B type.
C	1 ,,	Slightly shorter than common C type.
D	2 pairs	Common D type
E	7 ,,	,, E ,,
F	2 ,,	,, F ,,

In addition to the normal karyotypes, a variation plate with $2n = 22$ chromosomes is on record (Fig. 26).

7. *M. leuconeura* E. Morr. ($2n = 26 = 2L^{s}+2M^{ss}+2M+20S$)

Leaves small, ovate, upper surface dark green with light patches.

Twentysix chromosomes are found in cells with normal somatic complements (Fig. 27). Size difference is present and on its basis, the following general groups can be recognized :

i) One pair of comparatively long chromosomes.
ii) Two pairs of medium sized chromosomes.
iii) Ten pairs of short to very short chromosomes.

Two pairs of chromosomes bear secondary constrictions including one pair with supernumerary constrictions. The size difference varies from 1.2μ to 3.1μ. Table VII shows the detailed analysis of the karyotype (Fig. 28).

TABLE VII

Karyotype analysis in M. leuconeura

Type	Number	Special features
A	1 pair	Comparatively longer in size and the arm at one end is also slightly longer than the general A type.
C	1 ,,	Common C type.
D	1 ,,	,, D ,,
E	7 pairs	Common E type forming a graded series.
F	3 ,,	Common F type.

Some nuclei with $2n = 26$ chromosomes show structural alterations in their complements (Fig. 29). Numerically altered nuclei ($2n = 28$) are also observed in a few cases (Fig. 30).

8. *M. picta* ($2n = 26 = 6M^{s}+6M+14S$)

Plants small, leaves ovate, very thin, pale green with beautiful dark spots on the upper surface.

The normal somatic complement is found to contain twentysix chromosomes (Fig. 31). Size difference is not marked and two general groups can be recognised.

i) Six pairs of medium sized chromosomes, and
ii) Seven pairs of short to very short chromosomes.

Of these, six chromosomes bear secondary constrictions. The size ranges between 1.2μ and 2.5μ. Detailed karyotype is revealed in Table VIII (Fig. 32).

TABLE VIII

Karyotype analysis in M. picta

Type	Number	Special features
B	1 pair	Common B type
C	2 pairs	One constriction in each of a pair of chromosomes is much shorter than the other.
D	3 ,,	Common D type
E	4 ,,	,, E ,,
F	3 ,,	,, F ,,

One variation plate with $2n = 33$ chromosomes is also noticed (Fig. 33).

9. *M. kegeljani* E. Morr. ($2n = 33 = 1L_1^{ss}+2L^{ss}+2L+6M+8M+16S$)

Leaves numerous, oblong, long petioled, yellowish green, margins parallel. Upper surface very glossy.

Thirty three chromosomes are found in the cells with normal somatic complements (Fig. 34). Size difference is comparatively marked and on its basis the following groups can be recognized :—

i) One long chromosome, the longest in the set,
ii) One pair of comparatively long chromosomes,
iii) Five pairs of medium sized chromosomes, and
iv) Ten pairs of short to very short chromosomes.

Altogether nine chromosomes are found to bear secondary constrictions. of these, three bear supernumerary constrictions. The size difference varies from, 1.2μ to 4.1μ. Detailed karyotype is described in the following table (Table IX Fig. 35) :—

TABLE IX

Analysis of karyotype in M. kegeljani

Type	Number	Special features
A_1	One only	Longest chromosome with supernumerary constriction.
A	1 pair	Common A type
B	1 ,,	,, B ,,
C	2 pairs	One constriction in each of a pair much pronounced.
D	2 ,,	Common D type
E	6 ,,	,, E ,,
F	4 ,,	,, F ,,

In addition to the normal karyotype, a large number of somatic nuclei with abnormal chromosome complements, involving both structural and numerical alterations, are also on record. Variations in chromosome number found are $2n = 20$, 26, 30, 36, 41, 42, 44 and 47 (Figs. 36–43). Lagging chromosomes at anaphase are also recorded in some cases (Fig. 44). Some $2n = 33$ complements exhibit structural alterations of chromosomes (Fig. 45).

DISCUSSION

1. *Variation in chromosome number and the origin of chromosomal biotypes.*

The two genera *Calathea* and *Maranta*, included under the tribes Phrynieae and Marantae respectively, are considered by taxonomists as very much related to each other (Engler and Prantl, 1930 ; Hutchinson, 1934). A number of species already included under the genus *Maranta* have later been transferred to the genus *Calathea*.

Cytological literature reveals that so far as the genus *Calathea* is concerned, multiples of four, eleven, twelve and thirteen chromosomes have been found in the complements of the different species (Venkatasubban, 1946 ; Sato, 1948). Eight chromosomes have only been reported in *C. veitchiana* by Sato (*l.c.*) and in the present report, *C. leopardina* has also been shown to possess $2n = 8$ chromosomes. Different species are also on record with $2n = 22$, 24 and 52 chromosomes respectively (vide Table X). Further, in each of the species of *C. lietzei* and

C. zebrina, plants have been found with $2n = 24$ and 26 chromosomes by Venkatasubban (*l.c.*). Individuals of *C. zebrina* reported in the present paper, on the other hand, show $2n = 22$ chromosomes indicating the presence of a large number of chromosomal biotypes in these species. Reports of chromosome numbers in *C. leopardina* ($2n = 8$), *C. vandenheckei* ($2n = 22$), *C. ornata* ($2n = 26$) and *C. princeps* ($2n = 22$) have been made for the first time in this paper.

TABLE X

Previous and present records of chromosome number in Calathea *and* Maranta

Species	Previous record		Present record ($2n$ No.)
	($2n$ No.)	Author	
I. *Calathea veitchiana*	8 26	Sato (1948) Venkatasubban (1946)	—
C. leopardina	—	—	8
C. mediopicta	22	Venkatasubban (1946)	—
C. insignis	22	Sato (1948)	—
C. vandenheckei	—	—	22
C. princeps	—	—	22
C. zebrina	24, 26	Venkatasubban (1946)	22
C. grandiflora	24	,, ,,	—
C. ornata	—	— —	26
C. lietzei	24, 26	Venkatasubban (1946)	—
C. lindeniana	26	,, ,,	—
C. makoyana	26	,, ,,	—
C. roseo-picta	26	,, ,,	—
C. taeniosa	52	Sato (1948)	—
II. *Maranta nitida-picta*	8	Venkatasubban (1946)	—
M. arundianacea			
v. variegatum	18	Sato (1948)	—
W. I. Arrowroot	48	Simmonds (1954)	—
M. bicolor	24	Venkatasubban (1946)	—
M. tigrina	24	,,	—
M. insignis	—	—	26
M. picta	—	—	26
M. leuconeura	—	—	26
v. *massangeana*	26	Venkatasubban (1946)	—
M. nitida	26	,, ,,	—
M. striata	26	Sato (1948)	—
M. kegeljani	—	—	33

The occurrence of different chromosome numbers in this genus does not necessarily indicate that they belong to different complexes. This is mainly borne out by the fact that even in the same species, different chromosomal biotypes such as, $2n = 22$, 24 and 26 found in different individuals, as noted in *C. lietzei* and *C. zebrina*, are in existence. This obviously implies that the different chromosome numbers noted in species of *Calathea* are all representatives of a common assemblage, representing in all probability a single evolutionary line. From the same stock, different species have evolved and their specific status has gradually been attained through continuous accumulation of new variations.

Evidently in this line of evolution, individuals of species with $2n = 8$ chromosomes approach more towards the ancestral forms. That species with $2n = 8$ chromosomes, such as, *C. veitchiana*, belong to the same evolutionary line, is also indicated by the occurrence of individuals with $2n = 26$ chromosomes in the same species (Venkatasubban, 1946). At the present state of our knowledge, therefore one can safely assume that *C. veitchiana* and *C. leopardina* represent more of the ancestral condition than the other species. That all these species belong to the same assemblage, is also evidenced by a gross resemblance in their general morphology of the chromosomes.

Similar to the genus *Calathea*, in species of *Maranta* too, different chromosome numbers have been reported in different species. The previous literature shows that chromosome numbers such as $2n = 8$, 24 and 26 are present in different species (Venkatasubban, 1946 ; Sato, 1948 ; Simmonds, 1954). In *M. arundinacea*, both $2n = 18$ and 48 chromosomes have been reported in different varieties. Of the species reported in the present paper, three are characterized by $2n = 26$ chromosomes and one with $2n = 33$ chromosomes. The occurrence of such widely different chromosome numbers even in the same genus is quite significant. It has already been emphasized that even in the same species as *M. arundinacea*, individuals are in existence with widely differing chromosome numbers. One of them is designated as a distinct variety. Esistence of individuals in the same species with different chromosome numbers finds parallel in species of *Calathea* though however in the latter genus such at occurrence has been noticed in a number of species. It is not unlikely that in other species of *Maranta* too a thorough search may reveal such chromosomal biotypes. In that case, as in *Calathea*, here also all the species may represent members of side branches of a single line of evolution with possibly *M. nitida-picta* with $2n = 8$ chromosomes approaching more towards the ancestral forms. The present investigation provides support to such an assumption. Of the four species investigated here, three, namely, *M. insignis*, *M. leuconeura* and *M. picta* contain $2n = 26$ chromosomes and one, that is *M. kegeljani*, $2n = 33$ chromosomes. Though the species differ with respect to minor details of karyotype even then, a gross resemblance in general morphology of chromosomes is noticed between them. The species of *Maranta* so far investigated represent in all probability a common line like the species of *Calathea*.

In this connection it is worth noting that investigations on other species of Calathea and Maranta by Venkatasubban (*l.c.*) led him to consider that at least two different evolutionary lines are running within the genera, one starting with the basic set of $n = 4$ and other with $n = 6$ chromosomes. So far as the present observation shows there is no reason to assume two different evolutionary lines within the two genera. *Calathea leopardina*, of the present report, with $2n = 8$ chromosomes does not show much difference in chromosome size from that of the other species. Further, within the same species of *Calathea veitchiana* both $2n = 8$ and $2n = 26$ chromosomes have been reported in different individuals (Venkatasubban, Sato, *l.c.*). Taking all these factors into account it seems better to consider all of them as representatives of a single line of evolution.

2. *Structural difference of chromosomes between different species of Maranta and Calathea.*

The problem naturally arises as to how such chromosomal biotypes originate. In this connection the means of propagation of the species seems worthy of note. They are all propagated through vegetative means and flowering and seed-setting are very rare. Even when flowering is noted, so far as the author is aware, setting of viable seeds is never observed. So the origin of such chromosomal biotypes through sexual reproduction is absolutely impossible.

It is significant to note that all the species of *Maranta* and *Calathea* show a characteristic peculiarity in the somatic cells, that is the presence of variable chromosome complement in the same tissue (vide Table XI). Such valrable complements involve both numerical and structural alteration of the norma complement. Such behaviour has been encountered in a large majority of the vegetatively reproducing plants so far cytologically studied here. On the basis of considerable evidence this behaviour has been claimed to play a significant rôle in speciation through the participation of the altered nuclei in the formation of daughter shoots (Sharma and Das, 1954 ; Mookerjea, 1955 ; Sharma, 1956 ; Bhattacharyya, 1957).

In *Maranta* and *Calathea* too, in the absence of sexual method of reproduction, this behaviour probably accounts for their speciation through vegetative means as noted in many other members of higher plant groups reproducing through asexual means.

TABLE XI

Difference in chromosome morphology, variations and length of chromatin matter in Calathea *and* Maranta

Species	Normal somatic number (2*n*)	Size difference in diploid complement (2*n*)	Variation in somatic number (2*n*)	Total amount of chromatin matter in haploid complement (accounted in length)
1. *Calathea leopardina.*	8	**$2M^s+4M+2S$	12	9.3μ
2. *C. vanenheckei*	22	$2L^s+8M+12S$	24	19.5μ
3. *C. princeps*	22	$2L^s+2M^s+10M+8S$	20	22.2μ
4. *C. zebrina*	22	$2M^{ss}+4M^s+4M+12S$	20, 22*, 23, 25, 26 & 30	18.0μ
5. *C. ornata*	26	$2M^{ss}+6M^s+18S$	19, 24 & 30	21.7μ
6. *Maranta insignis.*	26	$4M^s+4M+18S$	22	18.6μ
7. *M. picta*	26	$6M^s+6M+14S$	33	22.4μ
8. *M. leuconeura*	26	$2L^{ss}+2M^s+2M+20S$	26* & 28	20.7μ
9. *M. kegeljani*	33	$1L_1{}^{ss}+2L^{ss}+6M^s+4M+20S$	20, 26, 30, 33,* 36, 41, 42, 44 & 47	20.5μ (½ of the 2*n* number)

* Normal number but with structural alterations.
** L_1—Very long chromosome.
L — Long chromosome
M — Medium sized chromosome
S — Short chromosome
L^s, M^s — Long or medium sized chromosome with secondary constriction.
$L_1{}^{ss}$, L^{ss} M^{ss} — Very long, long or medium sized chromosome with supernumerary constrictions.

Now the problem arises regarding the way through which such abnormalities originate in the tissue. The only means that can be considered as responsible for their origin is mitotic irregularities. Non-disjunction, lagging etc., (as mentioned in the text) can possibly account for their origin. Though in case of other species, somatic reduction has been found to occur accounting for the origin of such abnormal number (Sharma, 1956), no evidence of such somatic reduction has been obtained in the present observation. However, unless a thorough search in other genera is made, it is not possible to state whether somatic reduction has played a prominent rôle in the origin of such abnormal numbers. Venkatasubban (1946), however, just suggested that so far as the number $2n = 22$ in *C. mediopicta* is concerned, it may be derived from the number $2n = 24$ by the fusion of four chromosomes in pairs as suggested by Sato (1939) in certain monocotyledonous members. But if the karyotypes of the different species of *Maranta* and *Calathea* shown in the present paper and the chromosome drawings given in the previous records are taken into consideration, no such indication of chromosome fusion seems to be evident. Further, in *Calathea veitchiana* both $2n = 8$ and $2n = 26$ chromosomes have been reported. Besides, if one is to assume chromosome fusion, then one is also to infer that eight chromosomes of *C. veitchiana* might have been derived from twenty-six chromosomes of the same species through continuous fusion of chromosome ends. But such an assumption seems to be highly speculative in view of the absence of any experimental evidence confirmatory to this statement.

It has already been pointed out that though the different species of the genera *Maranta* and *Calathea* show a good deal of resemblances in chromosome morphology and total amount of chromatin matter, minute karyotypic differences are there delimiting one species from another. Each and every species has got a distinct karyotype of its own. This obviously indicates the rôle of structural alteration of chromosomes in the evolution of the different species of these genera, as noted in a number of other plant species too (Bergner, Satina and Blakeslee, 1933; Bhaduri, 1944; Wilkinson, 1944; Goodspeed, 1945; Babcock, 1947; Chakravorti, 1951; Sharma and Ghosh, 1954; Sharma and De, 1956; Sharma and Bhattacharjee, 1957; and Stebbins, 1951). Such structural alteration seems to have affected mainly the chromosomes with more than one constrictions and such species differ with respect to the number of secondary constrictions present in them. The existence of chromosomes with supernumerary constrictions also indicates the evidence of structural changes undergone by these species.

It may be noted that in *Calathea vandenheckei*, only two chromosomes bearing secondary constrictions or satellites have been observed. The presence of such a low number of secondary constrictions in a species having a chromosome number as high as twenty-two seems to be interesting especially in view of the fact that in species with eight chromosomes also two secondary constrictions are present. It is not unlikely that structural changes involving amphiplasty have resulted into the loss of secondary constrictions in *C. vandenheckei*.

3. *Interrelationship between the genera* Calathea *and* Maranta.

This discussion will remain incomplete if the interrelationship between *Calathea* and *Maranta*, as far as can be traced from cytological data, is not pointed out. So far as the observations reveal, their members show a good deal of similarity in a number of respects. The chromosome number and its ranges are practically the same in both. The morphology of the chromosomes too indicates close resemblances. The complements of both are characterised by mostly medium to short chromosomes having not much of size difference in the complement. The primary constrictions mostly range from median to submedian in position. The range in the number of secondary constrictions too does not show much difference between these two genera. In view of these facts, it may safely be considered that so far as the cytological data are concerned they give ample evidence for their close relationship. Their inclusion within the same family Marantaceae by the taxonomists is fully justified (Engler and Prantl, Hutchinson *l.c.*). It has already been mentioned that a number of species of *Maranta* have, according to the recent nomenclature, been transferred to the genus *Calathea* (vide Index Kewensis upto 1950). All these facts indicate their affinities. However, the taxonomists have included these under two different tribes under the same family Marantaceae. In the absence of any data from other aspects of study it is not possible to state whether their inclusion under different tribes mainly on morphological grounds is justified or not. This much is certain that their inclusion within the same family finds full confirmation from their cytological data.

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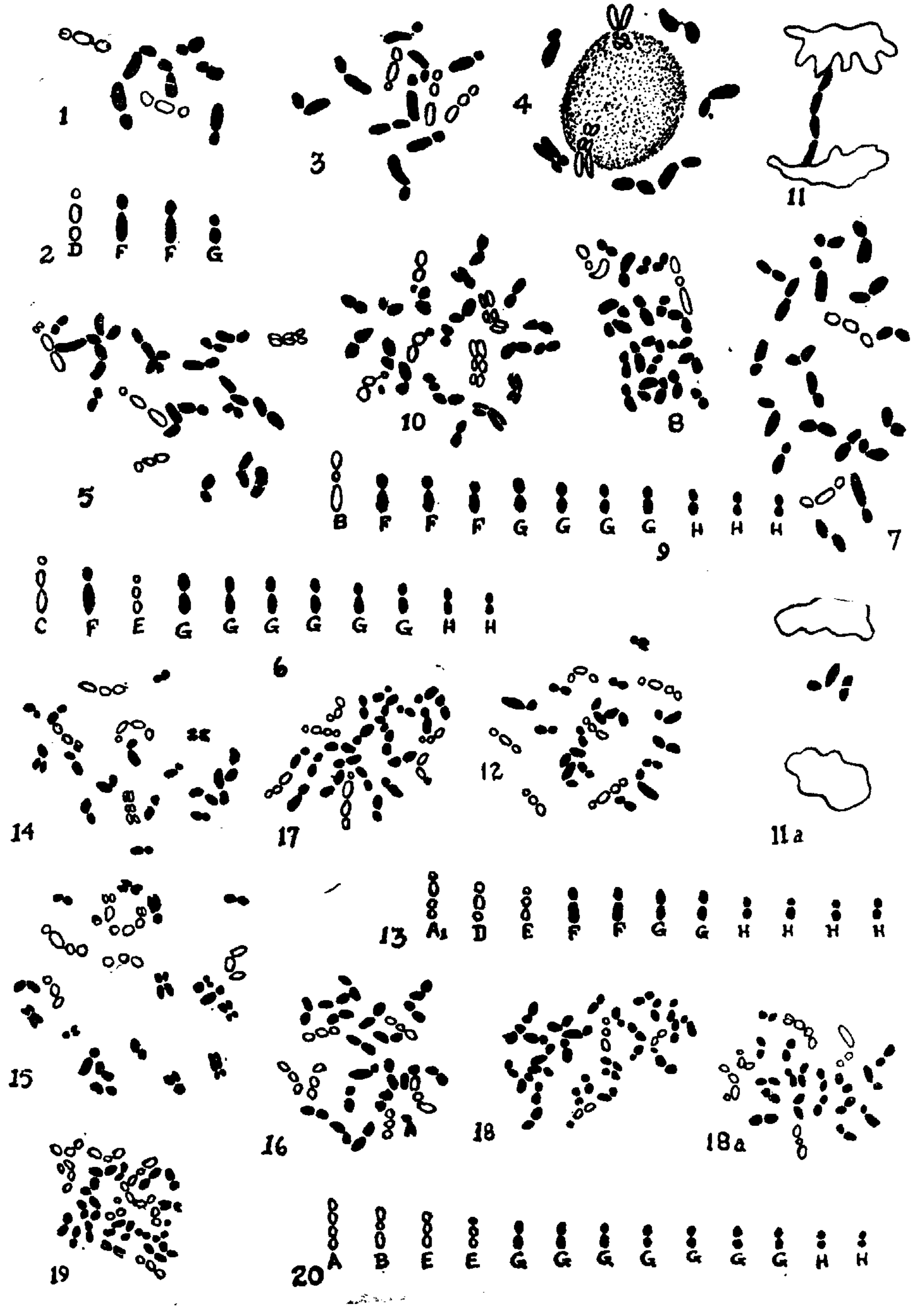


Text-fig. 1.

Figs. 1–3.—*Calathea leopardina*. Normal somatic metaphase ($2n = 8$), idiogram and variation metaphase with 12 chromosomes.

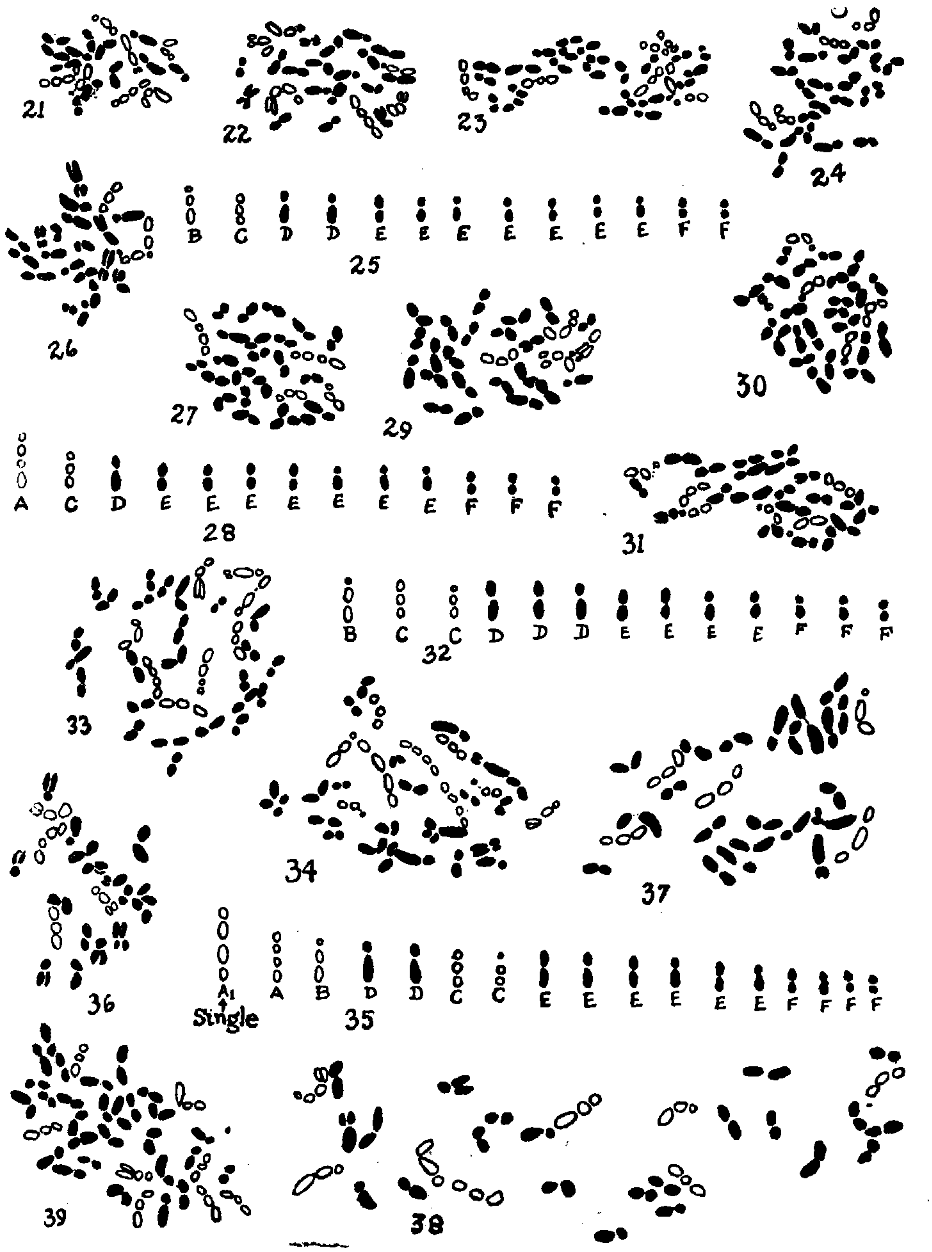
Fig. 4.—*C. leopardina*. Somatic prophase showing two chromosomes attached with the nucleolus.

Figs 5–7.—*C. princeps*. Normal somatic metaphase ($2n = 11$), idiogram and variation plate with 20 chromosomes respectively.

Figs. 8–11a.—*C. vandenheckei*. Normal somatic metaphase ($2n = 22$), idiogram, variation metaphase with 24 chromosomes, late separation and lagging chromosomes respectively.

Figs. 12–18a.—*C. zebrina*. Normal somatic metaphase ($2n = 22$), idiogram, variation metaphase with 20, 23, 25, 26, 30 and 22 (structural alteration) chromosomes respectively.

Figs. 19–20.—*C. ornata*. Normal somatic metaphase ($2n = 26$) and idiogram respectively.



TEXT-FIG. 2

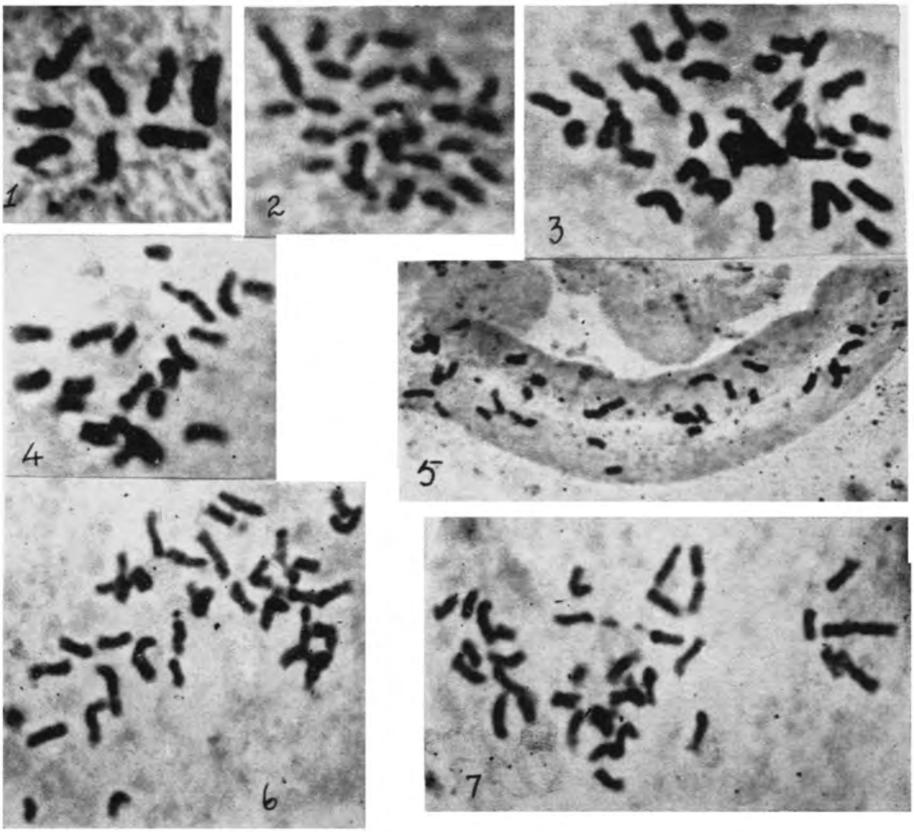
Figs. 21–23.—*Calathea ornata.* Variation metaphase with 19, 24 and 30 chromosomes respectively.

Figs. 24–26.—*Maranta leuconeura.* Normal somatic metaphase ($2n = 26$), idiogram and variation metaphase with 22 chromosomes respectively.

Figs. 27–30.—*M. leuconeura.* Normal somatic metaphase ($2n = 26$) idiogram, variation metaphase with 26 (structural alteration) and 28 chromosomes respectively

Figs. 31–33.—*M. picta.* Normal somatic metaphase ($2n = 26$), idiogram and variation metaphase with 33 chromosomes respectively.

Figs. 34–39.—*M. kegeljani.* Normal somatic metaphase ($2n = 33$), idogram, and variation plate with 20, 26, 30 and 36 chromosomes respectively.



Mp. 1.—*Calathea leopardina*. Normal somatic metaphase with 8 chromosomes.
Mp. 2.—*Maranta leuconeura*. Normal somatic metaphase with 26 chromosomes.
Mps. 3–7.—*Maranta kegeljani*. Somatic metaphase with 36, 20, 30, 36 and 33 chromosomes respectively.

TEXT-FIG. 3.

Figs. 40–45.—*Maranta kegeljani*. Variation metaphase with 41, 42, 44 and 47 chromosomes, lagging chromosomes and 33 chromosomes with structural alteration respectively.