Cytogenetics of the Indian Jasmines, III. Meiosis¹

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I. Introduction

In part I of the paper, morphological description of four varieties and forms of *J. sambac* and eight other species was attempted and the relationship between the simple, trifoliolate and the imparipinnately compound leaved species was discussed. A detailed study of the somatic chromosomes was made and the close resemblance of the karyotype of the simple leaved species to the trifoliolates, was indicated in the second part. The cytology of eight *Jasminum* species and four varieties of *J. sambac* has been given now. Previous work was confined only to the determination of chromosome numbers in this genus.

II. Materials and methods

The species (both wild and cultivated) and varieties described in parts I and II of the paper have been utilised. For meiotic studies flower buds were mostly fixed in acetic alcohol (1:3 mixture) between 7 and 8 AM. and left overnight in Karpechenko's modification of Navaschin's fluid. The materials were dehydrated in alcohol, cleared in chloroform and embedded in paraffin. Sections were cut at 14 μ thickness and stained in Haidenhein's iron-alum haematoxylin and Newton's iodine-gentian-violet. Mordanting the slides in an 1% aq. solution of chromic acid for 12 hours before staining in gentian violet, improved the stainability of the chromosomes. Temporary acetocarmine smears were also used in the study. Pollen stainability in an 1% aq. solution of iodine in Potassium iodide, and also in acetocarmine and glycerine (1:1 mixture) was considered as a criterion of fertility.

III. Observations

a) Tapetal cells

The tapetal cell to start with consists of a prominent nucleus and cytoplasm with large vacuoles, and becomes binucleate at the time the pollen mother cells are about to enter upon meiotic stages. These two nuclei sometimes fuse and form a single large binucleolated one. The most frequent behaviour is for the two nuclei to divide again, the resulting four nuclei fusing immediately. A nucleolus is thus organised ultimately in which can

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be seen eight nucleoli indicating the fusion of eight nuclei. This is completed by the time the tetrads are formed. The tapetum acts as a parietal layer only and does not invade the anther sac.

b) Meiosis

1) *Jasminum sambac* var. *sujimallige* ($2n=26$). Each pollen mother cell is polygonal in outline and they fit closely together. Just at the commence-

Figs. 1-20. 1-9. *Jasminum sambac* var. *sujimallige*. 1. Diakinesis in PMC. 2. Metaphase-I. 3. Anaphase-I. 4. Interphase. 5-10. Homeotypic division. 11-17. *J. sambac* var. *adukkumalli*. 18-20. *J. sambac* var. *virupakshi*. 1-3, 11, 18, 19. $\times 1850$. 4-10, 12, 20. $\times 1100$. 13-17. $\times 850$.

ment of diakinesis, they become spherical. Sometimes pollen mother cells occur in groups connected by cytoplasmic strands (fig. 29).

Diakinesis. The 26 chromosomes form 13 bivalents. Two ring bivalents are met with each with two terminal chiasmata. In the eleven rod bivalents, the homologues were found connected by one terminal chiasma. Two of the rod bivalents are attached to the nucleolus. The spacing of the bivalents is fairly regular (fig. 1).

Metaphase-I. A normal bipolar spindle is formed (fig. 2). The bivalents are seen to be secondarily associated.

Anaphase-I. Anaphase is normal. The bivalents disjoin regularly and the chromosomes reach the poles without presenting any abnormal features such as bridge formation, fragmentation etc. (fig. 3).

Interphase. After the chromosomes have reached the poles, each group organises a telophase nucleus. No partition wall is formed between the daughter nuclei (fig. 4).

Homeotypic division. A normal spindle is formed at Anaphase-II. The second division is regular and normal (fig. 5). The tetrads are either tetrahedral or isobilateral (figs. 6 and 7). The pollen grain usually consists of one to five germ pores, and the mature grain is binucleate (fig. 10).

In a few pollen mother cells, formation of dyads are seen (fig. 8). In these dyad cells, the homeotypic division may fail in either both or any one of them (fig. 9).

2) *J. sambac* var. *virupakshi* ($2n=26$). Thirteen bivalents are counted at diakinesis (fig. 18). The bivalents are similar to those observed in *sujimallige*. Metaphase-I and Anaphase-I proceed in the usual manner in the majority of pollen mother cells. However, instances indicating early disjunction in two to four bivalents are seen. At late anaphase and metaphase-II 13/13 distribution is observed (fig. 19). The second division is regular and normal in about 15% of the pollen mother cells (fig. 20). Normally furrowing of cytoplasm begins after the four daughter nuclei are organised, resulting in four uninucleate cells or tetrads. Several cases of defective cytokinesis are noticed, coupled with suppression of the homeotypic division in some cases. At late telophase-I furrowing may commence simultaneously from both the sides and completely separate the two daughter nuclei (fig. 23). After the first division the two daughter nuclei may be organised and separated by an incomplete furrow of the cytoplasm. The constriction or furrowing may commence from both sides giving rise to a dumb-bell shaped cell or it may be confined to one side so that the pollen mother cell appears bent (figs. 21 and 22). Fig. 24 shows irregular cytokinesis separating the interphase nuclei in a haphazard manner. After the first division, the pollen mother cell without forming any cell wall, may directly be converted into a pollen grain (fig. 25). In such cases the two nuclei are seen to be closer. Cases are also found in which cytokinesis takes place not with reference to the equator of the spindles but with reference to the equator of the pollen mother cell resulting in a cell with two nuclei and the other enucleate (figs.

26 and 27). In some cases a dyad is seen with one of the cells binucleate, while the other is uninucleate. This might have arisen through the homeotypic division taking place in one of the cells of the dyad while it fails in the other (fig. 28). Such dyads may directly form into two celled pollen grains, one of them being binucleate.

3) *J. sambac* var. *adukkumalli* ($2n=26$). At diakinesis 13 bivalents are noticed. The configurations of the bivalents are similar to those observed in *sujimallige* (fig. 11). A compact metaphase plate and a bipolar spindle is formed at metaphase (fig. 12). Meiosis is regular and normal. Frequently dyads are separated as a first step to the formation of tetrads. After the tetrads are formed the cell wall of the microspores get highly thickened and all of them are held together (fig. 16). The free pollen grains are of varied shapes and show shrivelled walls (figs. 17 a and b). Monads, dyads and triads are also met with (figs. 13 to 15).

4) *J. sambac* var. *gundumalli* ($2n=39$). The pollen mother cells at diakinesis show trivalents, bivalents, and univalents. The more frequent configuration is the chain of three. Three bivalents are attached to the nucleolus. The following table gives the frequency of association at diakinesis.

Table 1

S. No.	Association of chromosomes per pollen mother cell	No. of pollen mother cells
1	3 III+10 II+10 I	3
2	4 III+ 9 II+ 9 I	4
3	6 III+ 7 II+ 7 I (Fig. 31)	8
4	6 III+ 9 II+ 3 I (Fig. 30)	
5	7 III+ 6 II+ 6 I	2
6	8 III+ 5 II+ 5 I	2
7	10 III+ 3 II+ 3 I	1
Total		20

Mean number of trivalents per cell=5.6

At metaphase a normal bipolar spindle is formed. The chromosomes form a loose equatorial plate and the univalents lie away from it. The bi-

Table 2

Distribution of chromosomes at anaphase—I	20	21	22	23
	19	18	17	16
	(fig. 32)			
No. of p. m. cells (30)	11	9	8	2

valents separate first at anaphase, and the trivalents disjoin giving two and one distribution. Random distribution of the univalents results. The following table gives the distribution of chromosomes at late anaphase.

Figs. 21-29. 18-28. *J. sambac* var. *virupakshi*. 29. *J. sambac* var. *sujimallige*. $\times 1100$.

A typical homeotypic division is wanting. In rare cases a tetrad results. Dyads of unequal sizes (figs. 33 and 34) dumb-bell shaped pollen mother cells, also result. Suppression of cytokinesis and the homeotypic division and thickening of the cell wall of the tetrad cells take place (figs. 35 to 38). Microspores of abnormal sizes and shapes result (figs. 39 a-d).

5. *J. malabaricum* ($2n=26$). The thirteen bivalents counted at diakinesis are similar to those observed in *sujimallige* (fig. 40). The meiosis is regular and normal. Table 3 gives a summary of the various secondary associations met with at first metaphase.

6. *J. sessiliflorum* ($2n=26$). 13 bivalents are observed at diakinesis (fig. 42). One ring bivalent is noticed. Two bivalents form the nucleolar pair. Secondary association is evident at metaphase-I and II. Meiosis is regular.

7. *J. rigidum* (cultivated: $2n=26$). The thirteen bivalents observed at diakinesis are similar to those as seen in *sujimallige* (fig. 43). Meiosis is regular.

8. *J. angustifolium* (cultivated: $2n=52$). The meiosis of this plant is like that of a typical diploid. At diakinesis 26 bivalents are formed (fig. 44). Four ring and twenty two rod bivalents are noticed. Four bivalents are attached to the nucleolus. Different kinds of secondary association are evident at metaphase-I (fig. 45).

Figs. 30-39. *J. sambac* va. *gundumalli*. 30, 31. $\times 1850$. 32-38. $\times 1100$. 39. $\times 850$.

The wild *J. angustifolium* is similar in morphological characters to that of the cultivated one and apart from determining the chromosome number ($2n=52$) no separate study of meiosis was done.

9. i) *J. auriculatum* (wild: $2n=26$). The bivalents are similar to those observed in *J. sessiliflorum*. (fig. 46). Meiosis is regular and normal.

ii) *J. auriculatum* (cultivated: $2n=26$). The meiosis is regular as in the wild form.

Table 3

No. of secondary associations	No. of bivalents in association				No. of cases	Total
1	1	2	3	4	3	3
2	11	1	—	—	2	6
	10	—	1	—	4	
3	7	3	—	—	10	10
5	3	5	—	—	3	9
	4	3	1	—	2	
	5	1	2	—	4	
6 (fig. 41)	3	2	2	—	2	2
						30

10. i) *J. flexile* (wild: $2n=26$). The meiosis is regular. The thirteen bivalents resemble those observed in *J. sessiliflorum* (fig. 47).

ii) *J. flexile* (cultivated: $2n=52$). Twenty six bivalents are counted at diakinesis (fig. 48). Two ring bivalents are noticed. Four rod bivalents are attached to the nucleolus. Occasionally one to four quadrivalents are seen in addition to bivalents. The quadrivalents are in chains of four. The mean number of quadrivalents formed is

Figs. 40-50. Chromosomes at diakinesis. 40, 41. *J. malabaricum*. $n=13$. 42. *J. sessiliflorum*. $n=13$. 43. *J. rigidum*. $n=13$. 44, 45. *J. angustifolium*. $n=26$. 46. *J. auriculatum*. $n=13$. 47. *J. flexile*. $n=13$. 48. *J. flexile*, cultivated. $n=26$. 49. *J. calophyllum*. $n=13$. 50. *J. grandiflorum*. $n=13$. $\times 2470$.

2.8 per p. m. cell. However it was seen that the quadrivalents desynap at mid-diakinesis and form two bivalents so that at late diakinesis and metaphase only 26 bivalents are seen. The rest of the stages of meiosis are regularly gone through.

11. *J. calophyllum* ($2n=26$). The meiosis is regular. Thirteen bivalents are counted at diakinesis (fig. 49). The bivalents resemble those observed in *J. sessiliflorum*.

12. *J. grandiflorum* ($2n=26$). The meiosis is regular. Thirteen bivalents are noticed at diakinesis (fig. 50). Two ring bivalents and eleven rod ones are seen. Two bivalents form the nucleolar pair.

13. *J. officinale* ($2n=26$). The meiosis is regular as in *J. grandiflorum*.

The diameter of the pollen grains and pollen fertility of the species and varieties examined are given below (table 4).

Table 4

S. No.	Name of species	Variety	Mean diameter in micrometer divisions.	S. D.	Pollen fertility %
1	2	3	4	5	6
1.	<i>J. sambac</i>	1. <i>Sujimallige</i> (green)	11.7	2.88 ± 0.19	95.8
		2. <i>Sujimallige</i> (purple)	11.79	2.09 ± 0.14	94.8
		3. <i>Sujimallige</i> (two whorls of corolla)	11.8	1.28 ± 0.09	97.2
		4. <i>Sujimallige</i> (run wild)	11.38	1.42 ± 0.92	98.2
		5. <i>Kasturimalli</i>	11.24	2.03 ± 0.13	96.3
		6. <i>Manmathabanam</i>	11.36	1.55 ± 0.11	93.2
		7. <i>Virupakshi</i>	8.0	1.17 ± 0.08	13.7
		8. <i>Adukkumalli</i>	7.22	0.78 ± 0.05	8.9
		9. <i>Moonadukumalli</i>	9.44	1.55 ± 0.11	89.3
		10. <i>Gundumalli</i> ($2n=39$)	—	—	1.3
2.	<i>J. malabaricum</i>		8.44	0.66 ± 0.05	95.3
3.	<i>J. sessiliflorum</i>		9.52	1.15 ± 0.08	94.6
4.	<i>J. rigidum</i> (cultivated)		10.38	1.12 ± 0.08	96.0
5.	— do — (wild)		11.06	1.13 ± 0.08	96.8
6.	<i>J. angustifolium</i> ($2n=52$)		11.02	2.14 ± 0.14	98.0
7.	<i>J. auriculatum</i> (wild)		8.57	0.97 ± 0.07	96.6
8.	<i>J. auriculatum</i> (cultivated)		8.29	1.83 ± 0.12	94.6
9.	<i>J. flexile</i> ($2n=26$)		11.97	1.48 ± 0.10	95.6
10.	<i>J. flexile</i> ($2n=52$)		12.24	2.72 ± 0.17	87.2
11.	<i>J. calophyllum</i>		10.74	1.49 ± 0.10	98.6
12.	<i>J. grandiflorum</i>		9.06	0.79 ± 0.05	90.5
13.	<i>J. officinale</i>		8.94	0.65 ± 0.04	91.0

IV. Discussion and conclusion

1) *The behaviour of the tapetal nuclei.* The tapetal cells of the jasminum species are uninucleate to begin with and their growth takes place even before the nuclei of the pollen mother cells enter into the early meiotic stages. Division is mitotic. Some workers have reported amitotic division of the tapetal nuclei (Rocen 1927). Cooper (1935) found that the tapetal nuclei in *Portulaca oleracea* multiply through mitotic division. He (1933) also recognised three types of tapetal cells (1) in which the tapetal cells remain uninucleate (2) in which they are binucleate, and (3) where they become plurinucleate. The present observation in jasminums belongs to the third type and shows the tapetal nuclear fusion resulting in a multinucleolate nucleus.

2) *Protoplasmic strands.* The pollen mother cells occur as a closely packed cylindrical column pressed against the tapetum. Each pollen mother cell is irregularly polygonal and at about diakinesis they round off and separate from one another. In the species and varieties of jasminum examined, the pollen mother cells occur as singles or in groups. The latter seems to be the more common. In such cases the pollen mother cells are connected by protoplasmic strands. These were visible right from the prophase up to the tetrad formation. Except the triploid, the diploid and tetraploid jasminum species show regular tetrad formation and high percentage of pollen fertility. The protoplasmic strands were observed in the diploid, triploid and tetraploid species examined. Though the functions of the connecting strands are not known, they do not seem to interfere with the meiotic process or reduce pollen fertility as was observed by Baldwin (1933) in *Sedum ternatum*.

3) *Abnormalities of cytokinesis.* Normally cross wall formation takes place at the end of the first division in monocots and at the end of the second division in dicots. Yasui (1931) has mentioned irregularities in cytokinesis, in an interspecific hybrid of *Papaver* and Janaki Ammal (1934) in *Solanum melongena*. Ellison (1937) has also observed failure of cell wall formation in *Avena* and believed it to be due to the hybridity of the plants concerned, since it was not observed in any of the parental pure species. In the F_2 generation of *Triticum durum* $\times$ *T. vulgare* Sapehin (1933) observed plants which contained binuclear, and sometimes tri and tetra nuclear microspores. In a monosomic plant of *Pennisetum purpureum* ($2n=24$) irregular cytokinesis and its total suppression sometimes were observed (Krishnaswamy and Raman 1954).

The abnormality of cytokinesis in *Jasminum* has been exhibited in the following manner.

Cytokinesis taking place after division I and its failure at the end of the second division.

Cytokinesis taking place in an irregular manner resulting in haphazard

and incomplete division of the pollen mother cell.

Separation of daughter cells of unequal sizes.

Formation of pollen grains of different shapes and sizes.

The abnormality is great in the varieties, *adukkumalli* ($2n=26$) and *virupakshi* ($2n=26$). In these the first division of the meiosis is normal, but results in low fertility of the pollen grains. These varieties exhibit floral abnormality as fasciation, petaloidy of anthers, multiple flowers, and whorling of petals and abnormal cytokinesis. These floral abnormalities are not found in *sujimallige* which is 95.8% pollen fertile and seed setting. A forma of *sujimallige* which has one whorl extra and var. *moonadukkumalli* which has three whorls, have normal meiosis and high pollen fertility. The former sets seed while the latter does not. All these are propagated vegetatively. Barber (1941) reports in *Uvularia* that the application of high temperature during meiosis results in suppression of wall formation. No abnormal increase in temperature or dry wind prevailed during the time of these observations in *Jasminum*. Therefore it is difficult to suggest either one or the other of the above mentioned causes as responsible for the abnormality in cytokinesis in the *sambac* varieties.

4) *The secondary association of chromosomes.* It was in *Oryza sativa* that this phenomenon was first observed and reported upon (Kuwada 1910). The first important application of this phenomenon was made by Darlington and Moffet (1930) for the elucidation of ancestral homology in the *Pomoideae*. From a study of secondary pairing in this group the authors found that the basic number was 7, and from this the existing polyploid forms of *Pomoideae* arose. Lawrence (1931) from his studies on *Dahlia* was led to the conclusion that secondary association is characteristic of allopolyploids just as multivalent formation is true of autopolyploids. Heilborn (1936) considers that no credence should be placed on secondary association as indicative of ancestral homology and that it is purely a physical phenomenon.

In the case of autopolyploids, secondary association will be seen only if the chromosomes fail to form multivalents. With reference to plants like *Raphano-brassica* and *Primula kewensis* which are fertile, their ploidy could only be inferred from such a criterion as secondary association. *Oryza sativa* is essentially a diploid in its behaviour. However, secondary association findings have revealed that it is a secondarily balanced polyploid (Nandi 1936). In the first meiotic division of *Tricyrtis latifolia* ($n=13$) and *Dicentra spectabilis* ($n=8$), Matsuura (1935) found two bivalents were regularly approximated and inferred that these two species are not true diploids, but only secondarily balanced ones from the basic number 12 and 7 respectively. Meurman (1933) found that *Acer platanoides* is a secondarily balanced species from the basic number 12.

In *J. malabaricum*, maximum number of secondary association was found to give twice, seven groups of chromosomes; two groups of 3 bivalents,

two groups of 2 bivalents and three bivalents separate. The same is true for the different species which exhibit the same diploid chromosome number ($2n=26$). From this it will follow that the ancestral form of *J. malabaricum* should have had the following constitution.

AAA BBB CC DD E F G

The diploid chromosome complement may be represented as:

AA A'A' A''A'' BB B'B' B''B'' CC C'C' DD D'D' EE FF GG

Secondary association has its own limitations. Structural changes, fragmentation etc. may influence the nature of the association. In spite of this, the results obtained from secondary association studies have been of great use in determining ancestral homology.

5) *The nucleolar behaviour.* That the 26 chromosomed jasminum species are secondary polyploids, probably derived from a 7 chromosomed ancestor, —a conclusion reached by maximum association of bivalents at metaphase-I is also corroborated by the nucleolar behaviour. It is generally admitted that the number of nucleoli that originate in the telophase is an indication of the degree of polyploidy. Often however, the nucleoli fuse at telophase so that in the resting stage a single large nucleolus is seen. Therefore the ploidy of a plant could be inferred from the number of satellited chromosomes, which however, cannot always be recognised, but the attachment of particular chromosomes to the organising nucleolus gives the clue in such cases. In the 26 chromosomed species, the attachment of two bivalents to the nucleolus at diakinesis is seen. At first telophase and at interphase two chromosomes are attached to the nucleolus. These indicate that in the monoploid complement two chromosomes are responsible for the organisation of the nucleolus. In other words, in the somatic complement four sat-chromosomes must be responsible. This means that the 26 chromosomed species are tetraploids, though functioning diploids. Nandi (1936) found the occurrence of 2 and 4 bivalents attached to the nucleolous in the secondary tetraploid and octoploid species of rice.

In *J. angustifolium* and *J. flexile* 26 bivalents are formed of which 4 form the nucleolar pair. This indicates that these may be allooctoploids. In the triploid *gundumalli*, three bivalents are attached to the nucleolus. Trivalents are formed in this and is therefore an autopolyploid in the sambac.

6) *Polyploidy in the genus.* In the species of jasminum examined there are indications as to the existence of intraspecific autopolyploid races. This inference was drawn from the occurrence of trivalents in *J. sambac* var. *gundumalli* ($2n=39$) and quadrivalents in the cultivated *J. flexile* ($2n=52$).

J. angustifolium ($2n=52$), a tetraploid, is a distinct, stable and fertile species, has probably originated by hybridisation between two 26 chromosomed species, as revealed by the absence of multivalents and presence of secondary association. The 26 chromosomed species have shown a maximum association

of 7 and this would mean that these are allotetraploids derived from a 7 chromosomed ancestor.

The triploid gundumalli. Triploid species and races have been found in a large number of genera which are multiplied by bulbs, stolons, rhizomes etc. The triploid may arise in hybrids between tetraploid and diploid parents. Müntzing (1938) has described a number of cases in which the triploid has arisen as one of the twin plants. The triploid can arise in a diploid population either by dispermy (Rhoades 1936; Ramanujam 1937) or fusion of a diploid gamete with a haploid one.

Among the collections of the sambac varieties only *moonadukkumalli* ($2n=26$) resembles the triploid *gundumalli* in all vegetative characters. The karyotype in these two plants does not show any difference excepting the number. In the meiosis of the triploid, a mean number of 5.6 trivalents per pollen mother cells is observed. It is therefore likely that the triploid in question is an autotriploid. There are ample opportunities in the sambac varieties for the formation of unreduced and other polyploid gametes, through abnormalities of cytokinesis. Yet only a triploid is existing and no other polyploid. In the absence of this evidence it is probable that the triploid *gundumalli* would have arisen due to the fusion of a diploid gamete with a haploid one.

The origin of the tetraploid J. flexile. The meiosis of the diploid *J. flexile* is regular and normal and no indications of the formation of unreduced gametes were observed. However, the frequency of the formation of unreduced gametes might be very low. The frequent occurrence of somatic tetraploidy has also a bearing upon the origin of tetraploids. *Primula kewensis* arose as a bud sport. It is also likely that the tetraploid *J. flexile* arose as a bud sport from a diploid and established itself as a distinct race. Morphologically the diploid and the tetraploid differ. The size of the leaflets in the cultivated species is half as that of the wild one. The collections of *J. flexile* found in the Madras Herbarium, Coimbatore reveal two forms, one with large leaves and the other small leaved. The latter is similar to the tetraploid. The other wild forms seem to be the same collected at different localities. There may be other diploid forms of *J. flexile* with morphological characters similar to the tetraploid. However, the comparison of the karyotype in the diploid and tetraploid show great similarity. In the tetraploid *J. flexile* fruits are set and seedlings raised from them revealed 52 chromosomes in the root tip cells. There are, however, cases where autotetraploids have established themselves as stable species. They show regular meiosis and bivalents have been found instead of multivalents (Upcott 1939). It may be considered therefore that primarily allopolyploidy and secondarily autopolyploidy have been responsible for speciation in the genus.

7) *Speciation in the genus.* Senn (1938) has studied the chromosome number and morphology of 35 species of *Lathyrus* and concluded "that lack

of positive evidence from interspecific hybridisation and the great uniformity of chromosome number makes the determination of the evolutionary history of the genus difficult". Babcock and Navaschin (1930) suggested that close similarity of the chromosomes is associated with a common phylogenetic origin. Baldwin (1938) from a study of about 30 species of *Kalanchoe* considered that chromosome morphology "is of slight taxonomic value". In an exhaustive account dealing with the cytogenetics and speciation in *Crepis*, Babcock (1947) considered five different processes of genetic change, namely reciprocal translocation, gene mutation, interspecific hybridisation, polyploidy, and apomyxis, to have played more or less important roles. Anderson and Sax (1936) attributed structural changes, hybridisation and genic differentiation as factors of general evolutionary importance in the *Tradescantias*. In some genera like *Pinus* and *Quercus* differentiation of species appear to have been entirely by gene mutation, since in their gross structure the chromosomes of all the species are so similar as to be indistinguishable (Stebbins 1950). In *Paeonia* the chromosomes of the different species look exactly alike as to the size and form but possess differences in gross structure such as translocation and inversion which become evident only when they pair with each other in species hybrids (Stebbins 1938). Warburg (1938) had taken into consideration five cytological criteria namely, 1) chromosome morphology, 2) size of the chromosome complement, 3) chromosome number, 4) distribution and frequency of chiasmata and 5) chromosome behaviours of meiosis in respect of such phenomena as secondary association and irregular divisions in elucidating the taxonomy and the possible evolution of the species within the genus *Geranium*. Heilborn (1928) has found marked aneuploidy in *Carex* and suggested that fragmentation is likely to have played an important part in the origin of the numbers. From the above it would appear that in speciation, chromosome number, chromosome morphology, interspecific hybridisation followed by amphidiploidy, structural changes like segmental interchange, duplication, inversion, deletion of a portion of the chromosome, gene mutation, and fragmentation are involved. Applying these processes to the genus *Jasminum*, the following inferences may be drawn.

A majority of the species exhibit a diploid chromosome number of 26. The different species, however exhibited not much disparity in the size of the chromosomes. Though the chromosome morphology in all the species appear to be similar, there is variation as to the position of the chromosome constrictions. On the hypothesis of Lewitsky (1931) and of Levan (1935) primitive species would exhibit only chromosomes having median or submedian constrictions, while the advanced ones may show terminal or sub-terminal ones even in allied species. Therefore two closely related species may show differences in their chromosome morphology with or without differences in their chromosome numbers.

It may be that those in which there is neither differences in the number,

nor in the size of the chromosome are likely to have been subjected to structural changes in their chromosomes. However, formation of rings was not seen in any of the species. Structural changes on the other hand can also take place without the formation of rings. Clarke and Anderson (1935) have recorded reciprocal translocation without ring formation in *Maize*. The structural changes might have been due to gene mutation also. Taylor (1945) studied the chromosome number and morphology in 129 species of the *Oleaceae* and concluded "that polyploidy within the genera and species is rare and appears to have played a minor role in speciation". The genus *Jasminum* conforms in this respect with the characteristics of the family *Oleaceae* of which it is a member.

The prevalence of a common chromosome number ($2n=26$) in the majority of the jasminums and of approximately the same size, would afford scope for successful interspecific crossing. It is possible that the different lines of affinity would be better explained by the analysis of chromosome pairing in experimentally produced interspecific hybrids. Attempts at inter-specific hybridisation between the naturally seed forming species have not been so far successful.

V. Summary

Meiosis has been found to be normal in all the species. Abnormalities of cytokinesis were observed in the horticultural varieties of *J. sambac*, namely *virupakshi*, *adukkumalli* and *gundumalli*. The nuclei in the tapetal cells of all the species are plurinucleolate. There was no indication of persistent nucleolus during meiosis, though its persistence was observed in root tip mitosis. The pollen mother cells have been found to occur in groups connected by protoplasmic strands. The presence of these do not seem to interfere with the meiotic process. Their occurrence in all the species appears to be a general feature.

Evidence from secondary association shows that the 26 chromosomed species are likely to be in the nature of allotetraploids derived from the basic number 7.

One autotriploid of *J. sambac* var. *gundumalli* and one autotetraploid *J. flexile* have been described, and their possible origin discussed in the light of the available data.

The probable origin of the various species in *Jasminum* have been discussed in which polyploidy and gene mutation may have played a major role.

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