CHROMOSOME STUDIES IN SPECIES OF *DRACAENA* WITH SPECIAL REFERENCE TO THEIR MEANS OF SPECIATION

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Introduction

A good deal of discussion has been held by taxonomists as regards the delimitation of the two families, Liliaceae and Amaryllidaceae. Engler and Prantl (1930) consider specially the superior or inferior nature of the ovary in conjunction with other minor characters as a principal identifying characteristic of the two families. On the other hand authorities like Hutchinson (1944) regard the inflorescence character, whether scapose-umbellate or not, as a distinguishing feature of these two groups of plants.

It is also well known that the boundaries of families have been much reduced in Hutchinson's classification, and a number of new families has been established in his system, which is claimed to be natural and phylogenetic. The boundaries of Liliaceae and Amaryllidaceae too have been much reduced by Hutchinson and a number of genera has been grouped under a new family Agavaceae by him. Genera such as *Polyanthes*, which was formerly placed under Amaryllidaceae by Engler and Prantl, as well as *Dracaena, Yucca, Agave*, etc., have all been included under this new family.

Cytological data so far obtained on *Polyanthes* (Sharma and Ghosh, 1954), *Yucca, Agave* (Sato, 1935, 1942), etc. give full support to Hutchinson's standpoint. Chromosomes of *Agave*, *Yucca* and *Polyanthes* are all characterised by extreme size difference in their complements. A number of them are very large and in contrast the rest are extremely small in size. There is no gradation, and their size difference is abrupt. Large chromosomes in general are located mostly in the periphery of the plate. All these facts taken together, as well as the external morphological features which led Hutchinson to include them under one family, seem to justify their inclusion under a common taxonomic assemblage.

The systematic position of the genus *Sansevieria* has however been debated at length. Some authors include it under Liliaceae, some under a separate family Haemodoraceae, whereas Hutchinson includes it under Agavaceae. Cytological studies on the different species of the genus (Roy, 1956) have not given any support to Hutchinson's standpoint, and the data so far gathered fully justify its inclusion into a separate family Haemodoraceae.

As regards the genus *Dracaena*, very few species have yet been worked out (Sato, 1935, 1942; McKelvey and Sax, 1933; Whitaker, 1934; Bowden, 1940, 1945; Guard

and Hobbs, 1941). Even of these few species which have been attempted by cytologists, merely the gross morphology of the chromosomes has been described, and data are still lacking on the detailed karyotypes. The figures of chromosomes of these species presented in the dissertation embodying the results led the authors to doubt the justification of its inclusion under the family Agavaceae. None of the chromosome characters mentioned above which characterise the chromosomes of *Agave*, *Polyanthes* etc. could be traced in these figures.

It was therefore desired to make a detailed study on the karyotypes of as many species of *Dracaena* as available to throw light on its debated interrelationships. At the same time it was expected that if such an investigation was successfully carried out, then chromosomes of different species of *Dracaena* might be used as identifying criteria for the species as done in a number of other genera (Babcock, Stebbins and Jenkins, 1937; Babcock, 1942; Sharma and Bhattacharya, 1956, and Stebbins 1950). We were also encouraged by the fact that on casual observation it was noted that chromosomes of *Dracaena* responded well to some of the modern techniques for karyotypic analysis and yielded well clarified chromosome structures. In previous years such a study was much hampered because of the non-availability of the adequate techniques for the purpose.

Another object was also kept in view while contemplating investigation on the species of *Dracaena*. All the species are uniformly characterised by the vegetative means of reproduction. Flowers in most of the species are not, or are very rarely, formed and in no case has seed-setting been recorded. This fact raises the problem as to how new species of this genus originate.

Recently studies on chromosome behaviour in vegetatively reproducing plants have yielded some interesting facts. In all of them so far studied, the somatic tissues have been found to be characterised by inconstancy in the chromosome complement, and the chromosome number occurring in the highest frequency in such cases had to be considered as the normal number of the species (Sharma and Sharma, 1956).

Evidence has been brought forward showing that such regular inconstancies of chromosome complement which characterise this category of plants help in their speciation (Sharma, 1956). These altered nuclei enter into the growing tips of the daughter shoots and thus gradually form new individuals with different genomic constitution from the mother plant.

As all the species of *Dracaena* are exclusively propagated through vegetative means, it was also considered as an ideal material for the study of speciation from this aspect. As seed setting is never noted, meiotic study was considered irrelevant and so was not performed. Further, there is no scope for the study of meiosis, as flowering is very rarely noted even in old plants in India.

With the above end in view the present investigation was undertaken. In the following paper, results of a detailed study on the structure and behaviour of chromosomes of the somatic tissue of twenty-one species and varieties of *Dracaena* have been included, and attempts have been made to utilise the data in tracing the interrelationship and indicating the means of speciation of this genus.

Materials and Methods

I. *Materials*

For karyotype analysis and other possible cytological investigations, twenty-one species of the genus *Dracaena*, Linn. of the family Liliaceae were collected from different commercial Nurseries of Calcutta. The different species collected for the present investigation are listed below:

1. *Dracaena albicans* (Horticultural species)
2. *D. argenteo-striata* Hort.
3. *D. baptistii* Hort.
4. *D. barronii* (Horticultural species)
5. *D. chelsonii* Hort.
6. *D. gayii* (Horticultural species)
7. *D. godseffiana* Hort.
8. *D. goldieana* Hort.
9. *D. hendersonii* Hort.
10. *D. hendersonii Sport.*
11. *D. hookeriana* K. Koch.
12. *D. "Mrs. Hoskins"* (Horticultural species)
13. *D. metallica* Hort.
14. *D. nigro-rubra* Hort.
15. *D. norwoodensis* (Horticultural species)
16. *D. sanderiana* Hort.
17. *D. shephardi* (Horticultural species)
18. *D. splendens* Hort.
19. *D. thalioides* Hort.
20. *D. victoria* Hort.
21. *D. voluta* (Horticultural species)

For studies of somatic chromosomes from both root-tips and stem-tips, small saplings raised from cuttings were grown in small earthenware pots in a suitable mixture of clay and sawdust.

II. *Methods*

Chromosomes were studied from root-tips and stem-tips.

(*a*) *Root-tips:* Several techniques were tried in order to obtain the best configurations. The techniques mainly involved a prefixation of freshly cut root-tips at low temperature in—

(1) Coumarin—saturated solution.
(2) Oxyquinoline—0·002 mol. solution.
(3) Aesculin—1% solution; and
(4) Paradichlorobenzene—saturated solution,

for varying periods of time e.g. two hours, two and a half hour and three hours—followed by a mild heating in a mixture of 2% aceto-orcein

solution and normal hydrochloric acid in the proportion of 9:1 and then smearing in 1% aceto-orcein solution (Tjio and Levan, 1950; Sharma and Ghosh, 1950; Sharma and Bal, 1953; Sharma & Mookerjea, 1955).

The best result was however obtained by pre-fixation with para-dichlorbenzene for three hours and heating in the above-mentioned mixture of aceto-orcein and normal HCl for about six seconds. After heating, the root-tips had to be kept as such in the said mixture for about six minutes for intensification of the stain. Only the minute meristematic portion of a root-tip was separated and smeared in 1% aceto-orcein solution by pressing with a thin cover glass, above which a blotting paper was used for exerting uniform pressure, good scattering of cells, and removal of excess fluid in which the tissue was smeared.

Generally, after smearing, the slides had to be kept sealed overnight to get clear staining of chromosomes.

(*b*) *Stem-tips*: Stem-tips were also treated with saturated solution of paradichlorobenzene for three hours. After that the stem-tips were kept in acetic alcohol (1:2) solution for about two hours for clearance of the cytoplasm of cells. The tips were smeared by the method stated above.

Observations were made under oil immersion with 1·3 apochromatic objective and X12·5 eye-piece, and drawn with camera lucida at a table magnification of X 3,000 approximately.

Observations

General

As all the species of *Dracaena* propagate by the vegetative method and are rarely found to produce flowers, meiotic behaviour of chromosomes could not be studied in these species.

The present observations on the somatic chromosomes of *Dracaena* may be grouped into two categories: (*a*) anomaly in *chromosome number* in the same or related species and (*b*) the *karyotype analysis*.

A. *Chromosome number*

In the present investigation the normal chromosome number in different species was found to vary from 16 to 84. Of these, the most frequently occurring numbers are 2n=30, 32.

In this connection it may be mentioned that Sato (1942) reports the chromosome number in *D. thalioides* as 2n=40. In the present investigation a very few plates were noticed to possess this number. In most cases the number was 32.

In almost every species, variations in the chromosome number were found in different metaphase plates even of the same somatic tissue of both stem and root-tips. The chromosome numbers occurring in the maximum number of cells have been regarded as normal numbers and the others as variations. This variation has been found to

occur in high frequency, generally in about 30 to 45% of the cases. The normal numbers of chromosomes (2n) for each species are tabulated below:

Table I

D. albicans	..	34	*D. "Mrs. Hoskins"*	..	28
D. argenteo-striata	..	34, 40	*D. metallica*	..	30
D. baptistii	..	20, 40	*D. nigro-rubra*	..	30
D. barronii	..	38	*D. norwoodensis*	..	42
D. chelsonii	..	34	*D. sanderiana*	..	32
D. gayii	..	30	*D. shephardi*	..	30
D. godseffiana	..	84	*D. splendens*	..	30
D. goldieana	..	42	*D. thalioides*	..	32
D. hendersonii	..	32	*D. victoria*	..	28
D. hendersonii sport	..	32	*D. voluta*	..	28
D. hookeriana	..	16			

B. *Karyotype*

The chromosomes of most of the species show a gross similarity in their chromosome complements in spite of the fact that minute karyotypic differences are present, characteristic for each species.

The total amount of chromatic matter is slightly different in different species (Fig. 1).

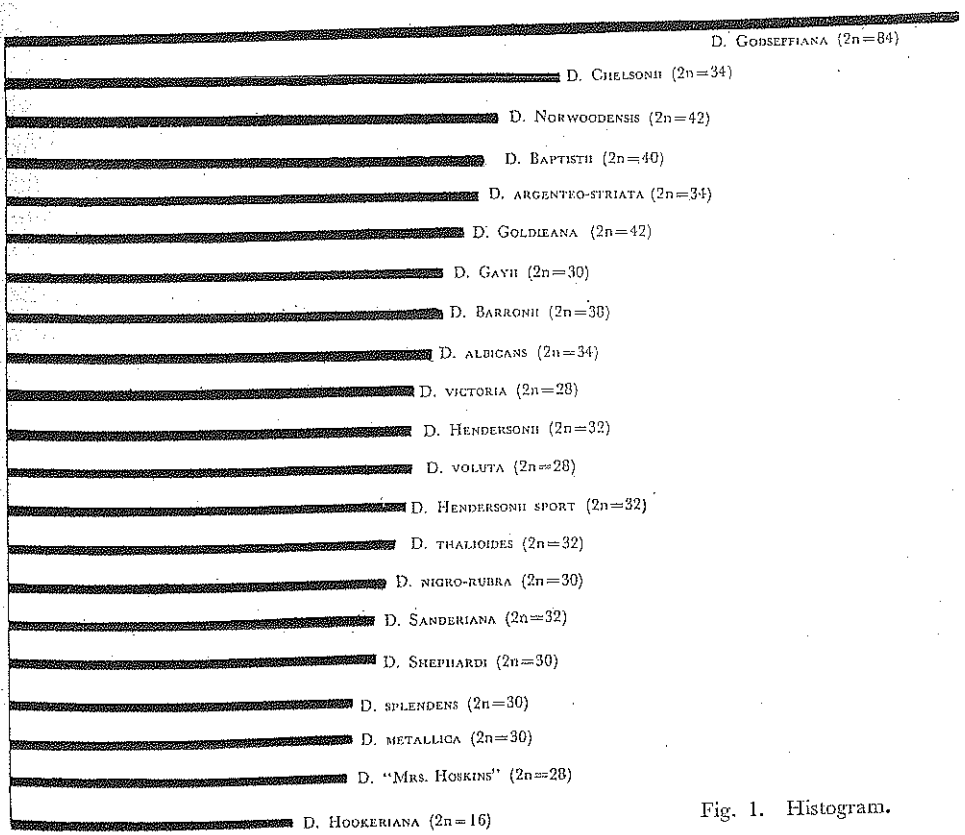


Fig. 1. Histogram.

Size-differences of chromosomes (which range from 1·00μ to 5·00μ) are also not very marked and the lengths of chromosomes are in a more or less graded series in each species. The primary constrictions are median, submedian and nearly subterminal. The number of chromosomes with secondary constrictions, most of which bear satellites, is generally four in a complement, rarely it is six, eight or twelve. All these facts show a homogeneity in the complements of different species. The following table will indicate these features.

Table II

Species	Total chromatic length (haploid)	Primary constrictions	Number of secondary constrictions in 2n complement
D. albicans ..	36·60 μ	median & submedian	four
D. argenteo-striata ..	40·85 μ	median, submedian & subterminal	four and eight
	46·17 μ		
D. baptistii ..	26·30 μ	median, submedian and subterminal	six and twelve
	41·20 μ		
D. barronii ..	37·62 μ	median & submedian	four
D. chelsonii ..	47·25 μ	median, submedian & subterminal	six
D. gayii ..	37·85 μ	median, submedian & subterminal	eight
D. godseffiana ..	81·06 μ	median, submedian & subterminal	eight (including two super-numerary)
D. goldieana ..	39·43 μ	median, submedian & subterminal	six
D. hendersonii ..	34·84 μ	median, submedian & subterminal	four
D. hendersonii sport ..	34·32 μ	median, submedian & subterminal	four
D. hookeriana ..	24·05 μ	median & submedian	four
D. "Mrs. Hoskins" ..	28·89 μ	median & submedian	four
D. metallica ..	29·34 μ	median & submedian	eight
D. nigro-rubra ..	32·21 μ	median & submedian	four (including two super-numerary)
D. norwoodensis ..	42.20 μ	median & submedian	eight
D. Sanderiana ..	31·76 μ	median, submedian & subterminal	four
D. shephardi ..	31·72 μ	median, submedian & subterminal	four
D. splendens ..	29·42 μ	median & submedian	four
D. thalioides ..	33·23 μ	median & submedian	four
D. victoria ..	32·21 μ	median, submedian & subterminal	six
D. voluta ..	34·81 μ	median & submedian	six

On the basis of length, the chromosomes of the *Dracaena* species studied here may generally be classified into four groups: long, medium, short and very short. They may further be classified into following types (Fig. 2):

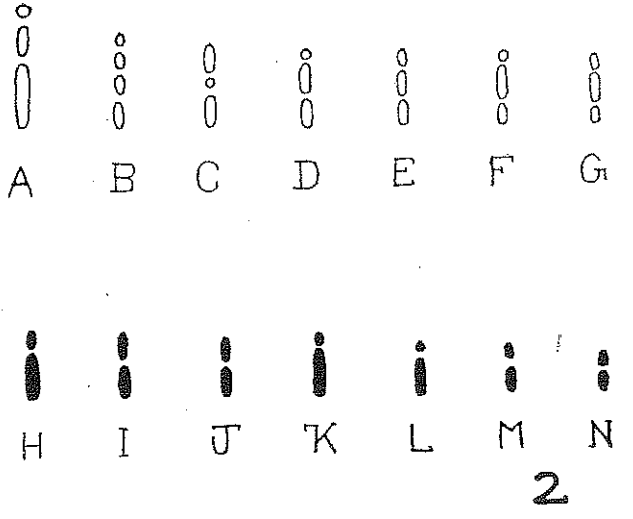


Fig. 2. Idiogram showing types of chromosomes present.

Long Chromosomes

Type A (3·50 μ to 5·00 μ approx.). A long chromosome with a nearly submedian primary constriction and a satellite at the distal end of the shorter arm.

Type B (3·15 μ to 3·50 μ approx.). A long chromosome having, in addition to a primary and a secondary constriction, located at nearly median and submedian positions, a satellite at the distal end of the short arm.

Type C (3·5 μ approx.). A long chromosome provided with two constrictions, primary and secondary, located at nearly median positions very close to each other.

Type D (2·50 μ to 4·00 μ approx.). A long chromosome with a nearly median primary constriction and a satellite at the distal end of one of the arms.

Type E (3·00 μ to 5·00 μ approx.). A long chromosome with two constrictions, primary and secondary, one nearly median and the other nearly submedian.

Type F (2·50 μ to 3·73 μ approx.). A long chromosome with a submedian primary constriction and a satellite at the distal end of the longer arm.

Type G (3·16 μ approx.). A long chromosome with two constrictions, primary and secondary, located at submedian positions at opposite ends of the chromosome.

Type H (2·50 μ to 3·50 μ approx.). A long chromosome with a nearly subterminal primary constriction.

Type I (2·67 μ to 4·00 μ approx.). Long chromosomes with median to submedian primary constrictions.

Medium Chromosomes

Type J (2·07 μ to 3·34 μ approx.). Medium-sized chromosomes with median to submedian primary constrictions.

Type K (2·00 μ to 3·30 μ approx.). Medium-sized chromosomes with nearly subterminal primary constrictions.

Short Chromosomes

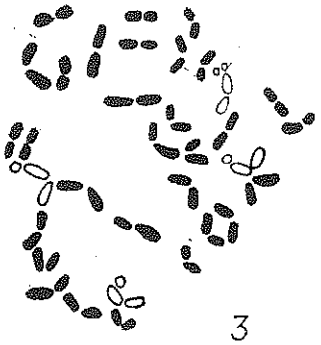
Type L (1·67 μ to 2·80 μ approx.). Short chromosomes with nearly subterminal primary constrictions.

Type M (1·67 μ to 2·67 μ approx.). Short chromosomes with nearly median to submedian primary constrictions.

Very Short Chromosomes :

Type N (1·16 μ to 2·00 μ approx.). Very short chromosomes with median to submedian primary constrictions.

On the basis of the above description of chromosome-types, the karyotypes of the different species may be represented in the following way:



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Figs. 3 and 4. *Dracaena albicans* (2n=34), somatic metaphase and idiogram respectively.

(1) *D. albicans* (a horticultural species) (2n=34):

The normal somatic chromosome number of the species is found to be thirty-four. The size ranges from 1·50 μ to 3·67 μ. The different types of chromosome in the complement may be represented as 2D, 2F, 10J, 12M, 8N. Of these, two pairs of chromosomes possess secondary constrictions.

On the basis of their morphology, the chromosomes can be clearly distinguished into the following types (Figs. 3 & 4):

1. Two pairs of long chromosomes, one of D and one of F types.
2. Five pairs of medium sized chromosomes of J type.
3. Six pairs of short chromosomes of M type.
4. Four pairs of very short chromosomes of N type.

No variation from the normal chromosome complement has been noticed in this species.

(2) *D. argenteo-striata* Hort. (2n=34, 40):

In the normal somatic complement thirty-four chromosomes are recorded. Complements with forty chromosomes have also been recorded to occur in very high frequency. Among these chromosomes two pairs bear satellites. Size among the chromosomes ranges from 1·83 μ to 5·10 μ approximately. The types of chromosomes present are, 2A, 2D, 2I, 4J, 2K, 6L, 4M, 12N.

A detailed study of the karyotype shows the presence of the following types of chromosomes (Figs. 5 & 6):

1. Three pairs of long chromosomes, one pair of A, one of D, and one of I type.
2. Three pairs of medium-sized chromosomes of which one pair is of K and two of J type.
3. Five pairs of short chromosomes, of which two pairs are of M type and three pairs are of L type.
4. Six pairs of very short chromosomes of N type.

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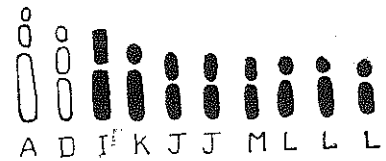

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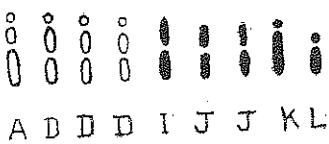

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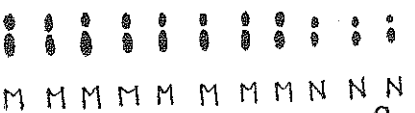

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Figs. 5 to 8. *D. argenteo-striata*

Figs. 5 and 6. Somatic metaphase (2n=34) and idiogram.

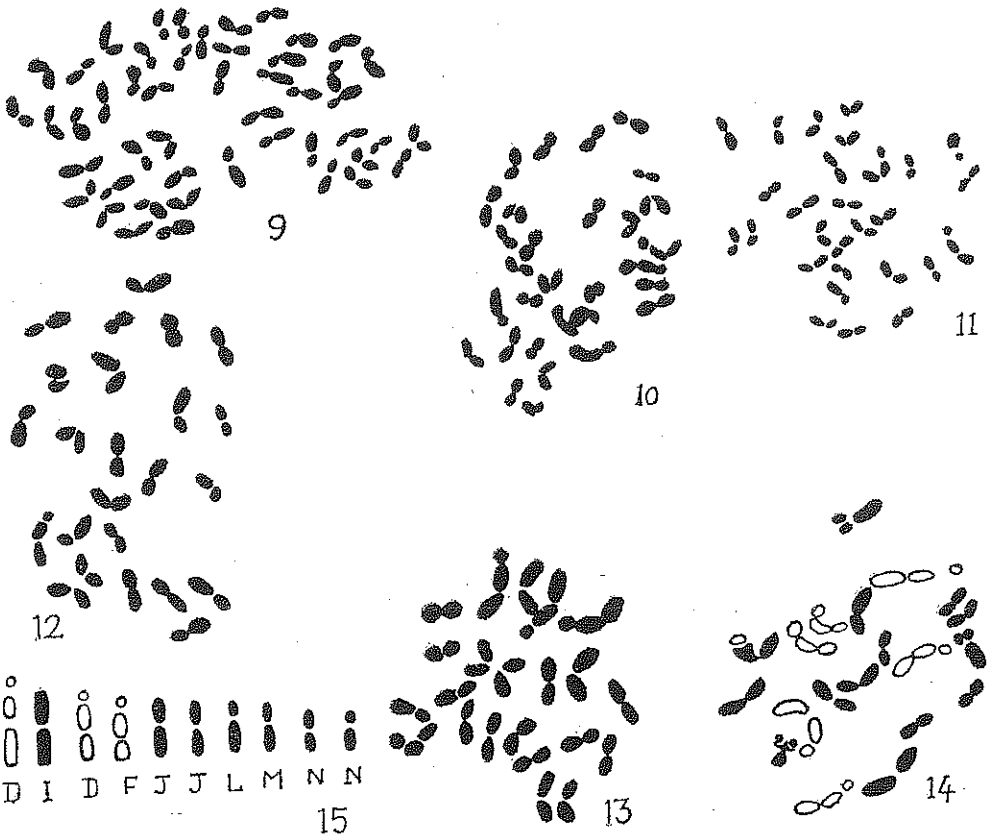
Figs. 7 and 8. Somatic metaphase (2n=40) and idiogram.

The karyotype of the complement with forty chromosomes (Figs. 7 & 8) may be represented as 2A, 6D, 2I, 4J, 2K, 2L, 16M, 6M.

A detailed study of the karyotype shows the presence of the following types of chromosomes:

1. Six pairs of long chromosomes, one of A, three of D and one of I type.
2. Three pairs of medium-sized chromosomes of which two pairs are of J and one pair of K type.
3. Nine pairs of short chromosomes of which one pair is of L type and eight pairs of M type.
4. Three pairs of very short chromosomes of N type.

In addition to the normal chromosome complements described above, abnormal ones with variant numbers of chromosomes e.g. 48, 30, 28, 24 and 22 have been recorded (Figs. 9 to 13).



Figs. 9-13. *D. argenteostriata* Variant somatic metaphase with 48, 30, 28, 24 and 22 chromosomes respectively.

Figs. 14 and 15. *D. baptistii* (2n=20).—Somatic metaphase and idiogram.

(3) *D. baptistii* Hort. (2n=20 & 40):

The normal somatic nuclei of the species have been found to contain twenty chromosomes. In addition to normal narrow roots, at times some broad roots were found to develop which contained forty chromosomes in a normal complement. Size difference amongst them is present, ranging from 1·8μ to 4·0 μ.

In short, the karyotype may be represented as 4D, 2F, 2I, 4J, 2L, 2M, 4N. Of these, six chromosomes are seen to bear secondary constrictions.

A detailed study of the chromosomes, together with the relative size, divides them into the following types (Figs. 14 & 15):

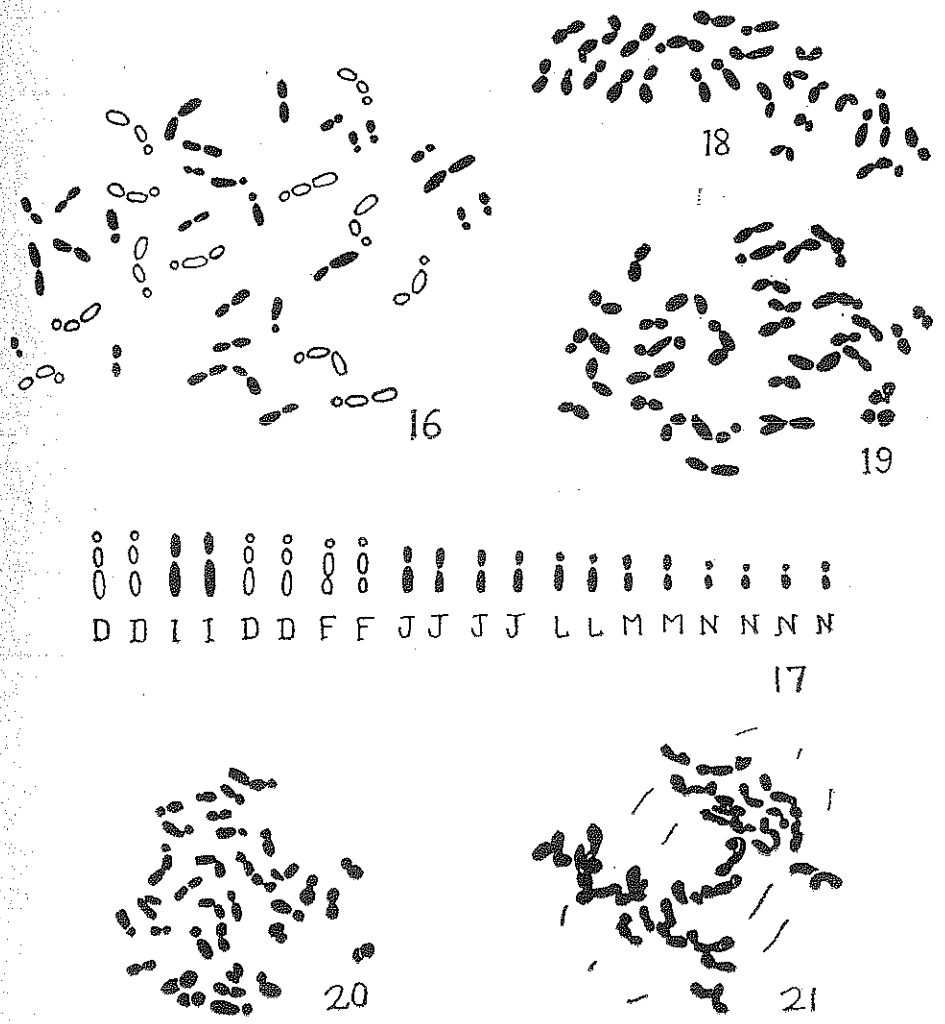
1. Four pairs of long chromosomes, of which two are of D, one of F and one of I type.
2. Two pairs of medium-sized chromosomes of J type.
3. Two pairs of short chromosomes, one of L and one of M type.
4. Two pairs of very short chromosomes of N type.

The karyotype of the complement with forty chromosomes (Figs. 16 & 17) may, in short, be represented as 8D, 4F, 4I, 8J, 4L, 4M, 8N.

A detailed study of the karyotype shows the presence of the following types of chromosomes:

1. Eight pairs of long chromosomes, four of D type, two of F type and two of I type.
2. Four pairs of medium-sized chromosomes of J type.
3. Four pairs of short chromosomes, two of L and two of M types.
4. Four pairs of very short chromosomes of N type.

In addition to the normal complements described above, somatic nuclei with varying number of chromosomes, such as twenty-six, thirty-two and thirty-four (Figs. 18 to 20)



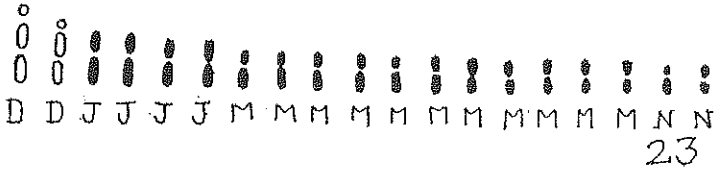
Figs. 16 to 21. *D. baptistii*—somatic metaphase with 40 chromosomes, idiogram and variant metaphase with 26, 32 and 34 chromosomes and irregular cell division respectively.

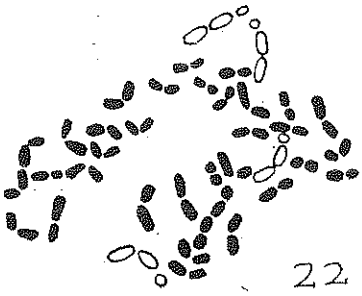
are also on record. Irregularity in somatic cell division at the stage of early anaphase has often been noticed (Fig. 21).

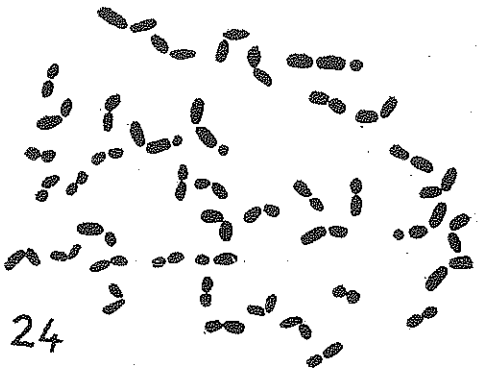
(4) *D. barronii* (a horticultural species) (2n=38):

The normal somatic nuclei of the species have been found to contain thirty-eight chromosomes. Size difference amongst them is present, which ranges from 1·0 μ to 3·34 μ approximately.

Broadly, the karyotype may be represented as 4D, 8J, 22M, 4N. Of these, four chromosomes bear secondary constrictions.







Figs. 22 to 24. *D. barronii* (2n=38)—somatic metaphase, idiogram and variant nuclei with 42 chromosomes respectively.

A detailed study of the karyotype shows the presence of the following types of chromosomes (Figs. 22 & 23):

1. Two pairs of long chromosomes of D type.
2. Four pairs of medium-sized chromosomes of J type.
3. Eleven pairs of short chromosomes of M type.
4. Two pairs of very short chromosomes of N type.

In addition to the normal complement described above, somatic nuclei with varying number of chromosomes such as forty-two have been observed in many cases (Fig. 24).

(5) *D. chelsonii* Hort. (2n=34):

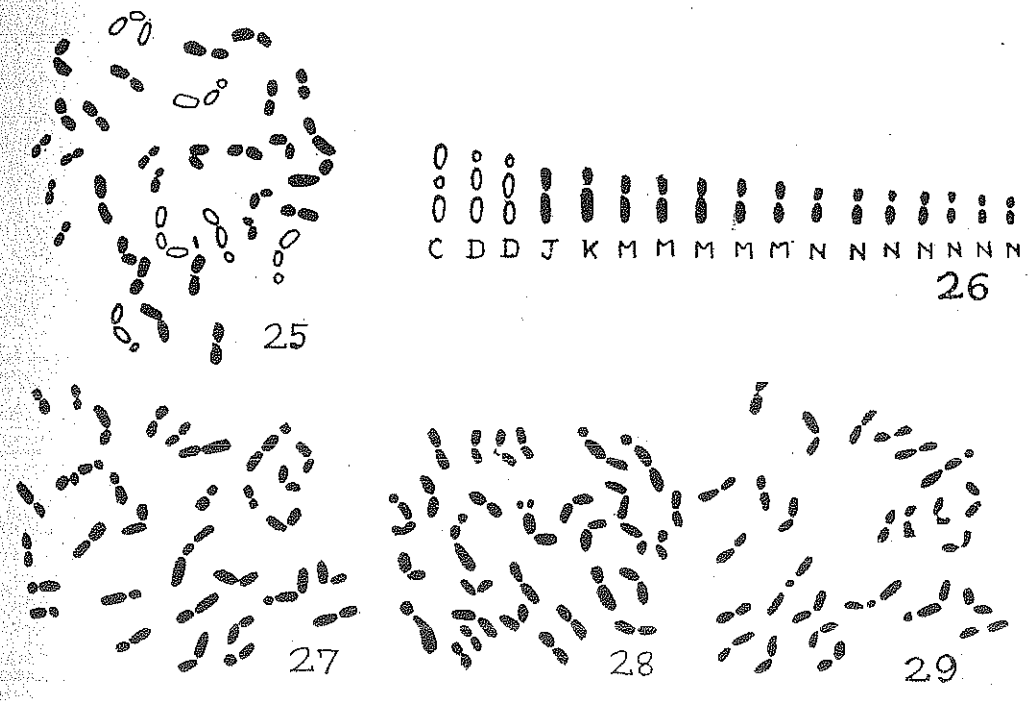
The normal somatic nuclei of the species have been found to contain thirty-four chromosomes. Size difference amongst them is present. The size ranges from 1·0 μ to 3·15 μ.

The karyotype of this species may be represented as 2C, 4D, 2J, 2K, 10M, 14N. Of these, six chromosomes have secondary constrictions.

A detailed study of the karyotype shows the presence of the following types of chromosomes (Figs. 25 & 26):

1. Three pairs of long chromosomes, one of C and two of D types.
2. Two pairs of medium-sized chromosomes, one of J and one of K types.
3. Five pairs of short chromosomes of M type.
4. Seven pairs of very short chromosomes of N type.

In addition to the normal complement of chromosomes described above somatic nuclei with varying number of chromosomes such as thirty-two, thirty and twenty-six have also been recorded both in root tips and stem tips (Figs. 27 to 29).



Figs. 25 to 29. *D. chelsonii* (2n=34)—normal somatic metaphase, idiogram and variant nuclei with 32, 30 and 26 chromosomes respectively.

(6) *D. gayii* (A horticultural species) (2n=30):

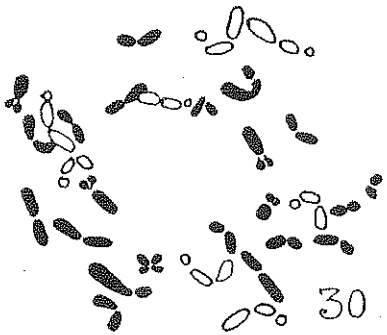
The normal somatic nuclei of this species have been found to contain thirty chromosomes. The size range varies from 1·16 μ to 3·83 μ approximately.

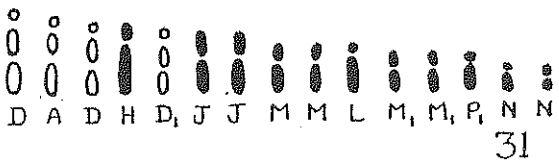
Broadly, the karyotype may be represented as 4D, 2A, 2H, $2D_1$, 4J, 4M, 2L, $4M_1$, $2L_1$, 4N. Of these, eight chromosomes are seen to bear secondary constrictions.

A detailed study of the chromosomes, together with the relative size, divides them into the following types (figs. 30 & 31):

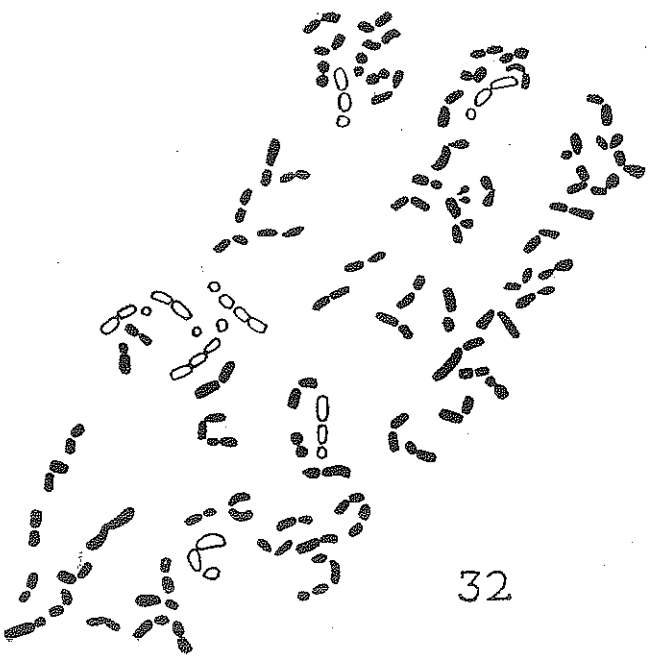
1. Five pairs of long chromosomes, of which three pairs are of D and D_1 types (D and D_1 are similar in morphology but D_1 is smaller than D), one pair is of A type and one pair is of H type.
2. Two pairs of medium-sized chromosomes of J type.
3. Six pairs of short chromosomes, of which two pairs are of M type, one pair of L type and two pairs of M_1 type. M and M_1 types are similar in morphology, but M_1 is smaller than M.
4. Two pairs of very short chromosomes of N type.

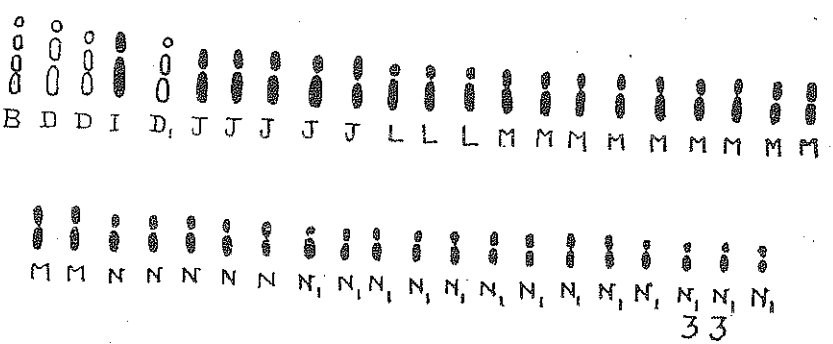
No variation from the normal chromosome complement has been noticed in this species.





Figs. 30 and 31. *D. gayii* (2n=30)—somatic metaphase and idiogram respectively.





Figs. 32 and 33. *D. godseffiana* (2n=84)—somatic metaphase and idiogram.

(7) *D. godseffiana* Hort. (2n=84):

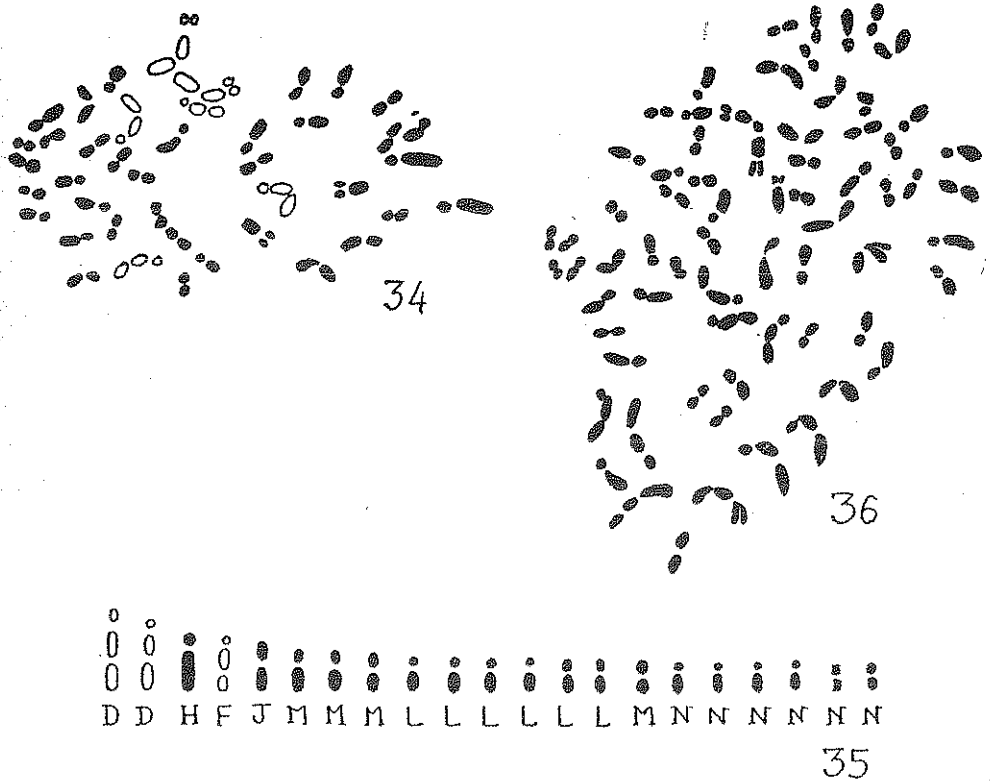
The normal somatic nuclei of this species have been found to contain eighty-four chromosomes. Size difference amongst them exists, which ranges from 1·17 μ to 3·50 μ approximately.

The karyotype of this species may be represented as 2B, 4D, 2I, $2D_1$, 10J, 6L, 22M, 10N, 26 N_1. Of these, eight chromosomes bear secondary constrictions.

A detailed study of the karyotype shows the presence of the following types of chromosomes (Figs. 32 & 33):

1. Five pairs of long chromosomes, including one pair of B, two pairs of D, one pair of I and one pair of D_1 types. D and D_1 types are morphologically similar, but D_1 is shorter than D.
2. Five pairs of medium-sized chromosomes of J type.
3. Fourteen pairs of short chromosomes, three of L and eleven of M types.
4. Eighteen pairs of very short chromosomes of N and N_1 types, of which N_1 is smaller than N.

No variation from the normal chromosome complement has been noticed in this species.



Figs. 34-36. *D. goldieana* (2n=42)—somatic metaphase (2n=42), idiogram and variant plate with 68 chromosomes.

(8) *D. goldieana* Hort. (2n=42):

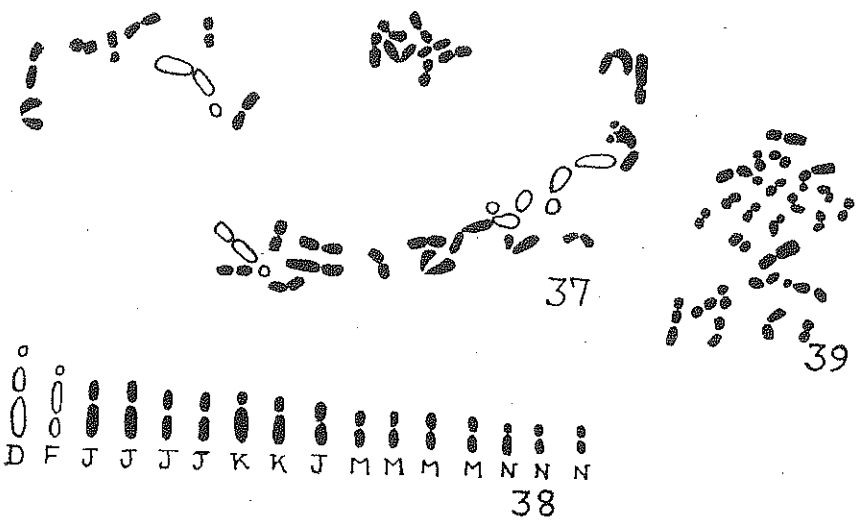
The normal somatic nuclei of the species have been found to contain forty-two chromosomes. Size difference amongst them is present, which ranges from 1·33 μ to 3·67 μ approximately.

In short, the karyotype may be represented as 4D, 2H, 2F, 2J, 8M, 12L, 12N. Of these, six chromosomes bear secondary constrictions.

A detailed study of the karyotype shows the presence of the following types of chromosomes (Figs. 34 & 35):

1. Four pairs of long chromosomes, of which two pairs are of D, one of H and one of F type.
2. One pair of medium-sized chromosomes of J type.
3. Ten pairs of short chromosomes, of which four are of M type and six are of L type.
4. Six pairs of very short chromosomes of N type.

In addition to the normal complement described above, somatic nuclei with varying number of chromosomes, such as sixty-eight, have been observed quite frequently. (Fig. 36).



Figs. 37 to 39. *D. hendersonii* (2n=32)—somatic metaphase, idiogram and variant plate with 24 chromosomes respectively.

(9) *D. hendersonii* Hort. (2n=32):

The normal somatic nuclei of the species have been found to contain thirty-two chromosomes. Size difference amongst them is present, which ranges from 1·20 μ to 4·00μ approximately.

The karyotype may broadly be represented as 2D, 2F, 10J, 4K, 8M, 6N. Of these, four chromosomes bear secondary constrictions.

A detailed study of the karyotype shows the presence of the following types of chromosomes (Figs. 37 & 38):

1. Two pairs of long chromosomes, of which one pair is of D type and the other of F type.
2. Seven pairs of medium-sized chromosomes of which five are of J and two of K type.
3. Four pairs of short chromosomes of M type.
4. Three pairs of very short chromosomes of N type.

In addition to the normal complement described above, somatic nuclei with twenty-four chromosomes have been recorded (Fig. 39).

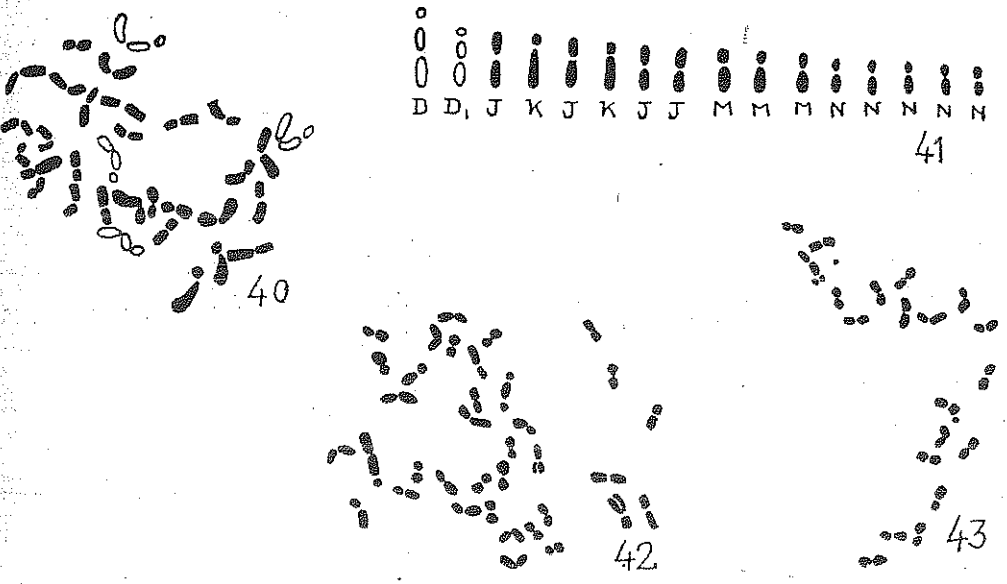
(10) *D. hendersonii Sport.* (a horticultural variety) (2n=32):

The normal somatic nuclei of the species have been found to contain thirty-two chromosomes. Size difference amongst them is present which ranges from 1·30 μ to 3·50 μ approximately.

The karyotype may shortly be represented as 2D, 2D$_1$, 8J, 4K, 6M, 10N. Of these, four chromosomes have secondary constrictions.

A detailed study of the karyotype shows the presence of the following types of chromosomes (Figs. 40 & 41):

1. Two pairs of long chromosomes, one of D and one of D$_1$ type. D and D$_1$ types are similar, but D$_1$ is smaller than D.
2. Six pairs of medium-sized chromosomes, of which four are of J and two of K types.
3. Three pairs of short chromosomes of M type.
4. Five pairs of very short chromosomes of N type.



Figs. 40 to 43. *D. hendersonii*—normal somatic metaphase with 32 chromosomes, idiogram and variation plates with 34 and 20 chromosomes.

In addition to the normal chromosome complement described above, somatic nuclei with varying number of chromosomes, such as thirty four and twenty have also been recorded (Figs. 42 & 43).

11. *D. hookeriana* K. Koch. (2n=16):

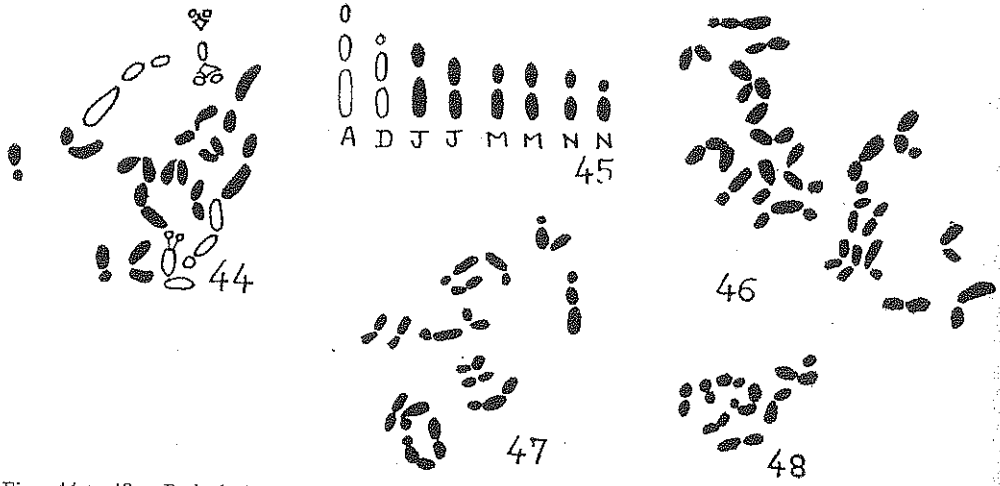
The normal somatic nuclei of the species have been found to contain sixteen chromosomes. Size difference amongst them is present which ranges from 1·87 μ to 5·00 μ approximately.

Broadly, the karyotype may be represented as 2A, 2D, 4J, 4M, 4N. Of these, four chromosomes bear secondary constrictions.

A detailed study of the karyotype shows the presence of the following types of chromosomes (Figs. 44 & 45):

1. Two pairs of long chromosomes, of which one pair is of A type and the other of D type.
2. Two pairs of medium-sized chromosomes of J type.
3. Two pairs of short chromosomes of M type.
4. Two pairs of very short chromosomes of N type.

In addition to the normal chromosome complement, which has been described above, somatic nuclei with varying number of chromosomes such as twenty-one, sixteen and eight are also in record (Figs. 46 to 48).



Figs. 44 to 48. *D. hookeriana* (2n=16)—somatic metaphase, idiogram and variation nuclei with 21, 16 and 8 chromosomes respectively.

(12) *D.* '*Mrs. Hoskins*' (a horticultural species) (2n=28):

The most frequently occurring somatic complements of the species have been found to contain twenty-eight chromosomes. Size difference amongst them is present, which ranges from 1·36 μ to 3·20 μ approximately.

The karyotype of the complement may be represented as 4D, 8J, 8M, 8N. Of these, four chromosomes have secondary constrictions.

A detailed study of the karyotype shows the presence of the following types of chromosomes (Figs. 49 & 50):

1. Two pairs of long chromosomes of D type.
2. Four pairs of medium-sized chromosomes of J type.
3. Four pairs of short chromosomes of M type.
4. Four pairs of very short chromosomes of N type.

In addition to the normal complement described above, somatic nuclei with varying number of chromosomes such as thirty-eight, thirty one and eighteen, have also been recorded (Figs. 51 to 53).

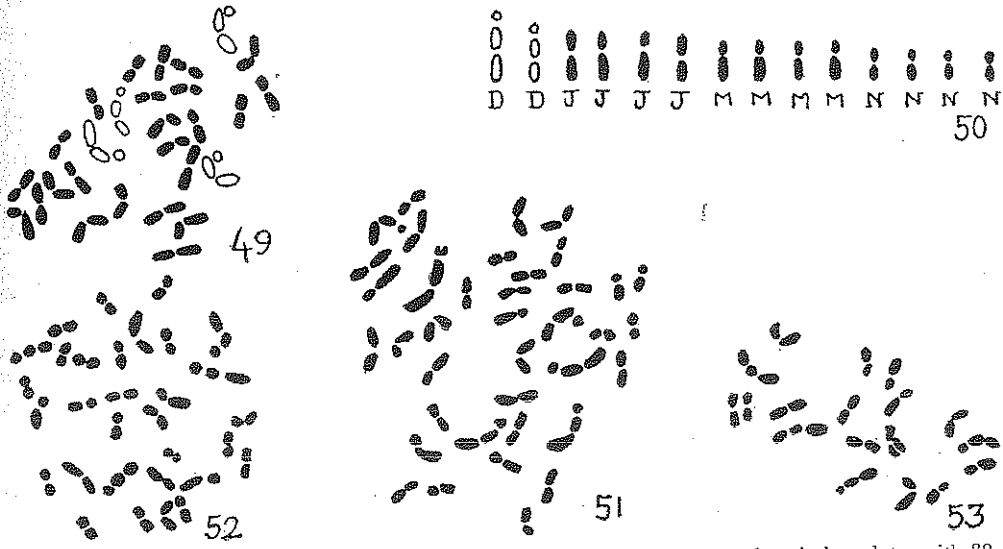
(13) *D. metallica* Hort. (2n=30):

The normal somatic nuclei of this species have been found to contain thirty chromosomes. Size difference is present amongst them, which ranges from 1·25 μ to 3·00 μ approximately.

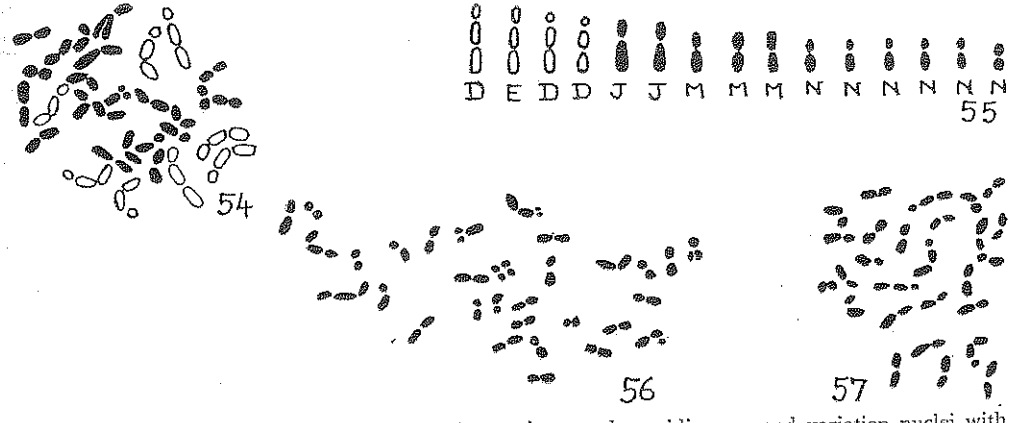
The karyotype of this species may be represented as 6D, 2E, 4J, 6M, 12N. Of these, eight chromosomes bear secondary constrictions.

A detailed study of the karyotype shows the presence of the following types of chromosomes (Figs. 54 & 55):

1. Four pairs of long chromosomes of which three pairs are of D and one of E type.
2. Two pairs of medium-sized chromosomes of J type.
3. Three pairs of short chromosomes of M type.
4. Six pairs of very short chromosomes of N type.



Figs. 49 to 53. *D. Mrs. Hoskins* (2n=28)—somatic metaphase, idiogram and variation plates with 38, 31 and 18 chromosomes respectively.



Figs. 54 to 57. *D. metallica* (2n=30)—normal somatic metaphase, idiogram and variation nuclei with 32 and 26 chromosomes respectively.

In addition to the normal complement described above somatic nuclei with varying number of chromosomes such as thirty-two and twenty-six have also been recorded (Figs. 56 & 57).

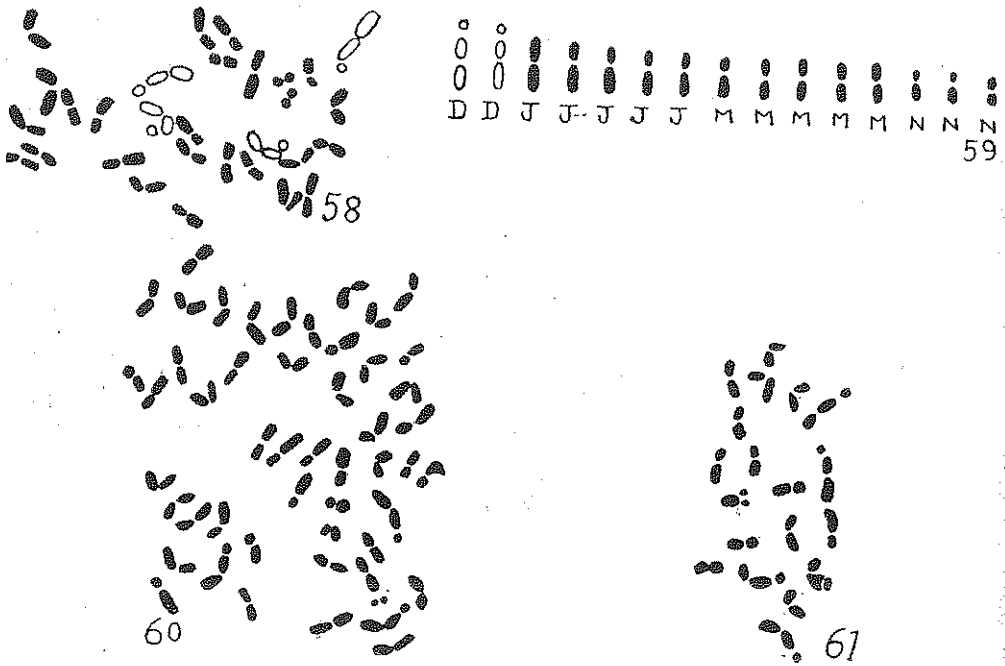
(14) *D. nigro-rubra* Hort. (2n=30):

The normal somatic complement of this species has been found to contain thirty chromosomes. Size difference is present amongst them which ranges from 1·30 μ to 3·20 μ approximately.

The karyotype of this species may shortly be represented as 4D, 10J, 10M, 6N. Of these, four chromosomes bear secondary constrictions.

A detailed study of the karyotype shows the presence of the following types of chromosomes (Figs. 58 & 59):

1. Two pairs of long chromosomes of D type.
2. Five pairs of medium-sized chromosomes of J type.
3. Five pairs of short chromosomes of M type.
4. Three pairs of very short chromosomes of N type.



Figs. 58 to 61. *D. nigro-rubra* (2n=30)—normal somatic metaphase, idiogram and variation nuclei with 50 and 20 chromosomes respectively.

In addition to the normal complement described above somatic nuclei with varying number of chromosomes such as fifty and twenty have often been noticed (Figs. 60 & 61).

(15) *D. norwoodensis* (a horticultural species) (2n=42):

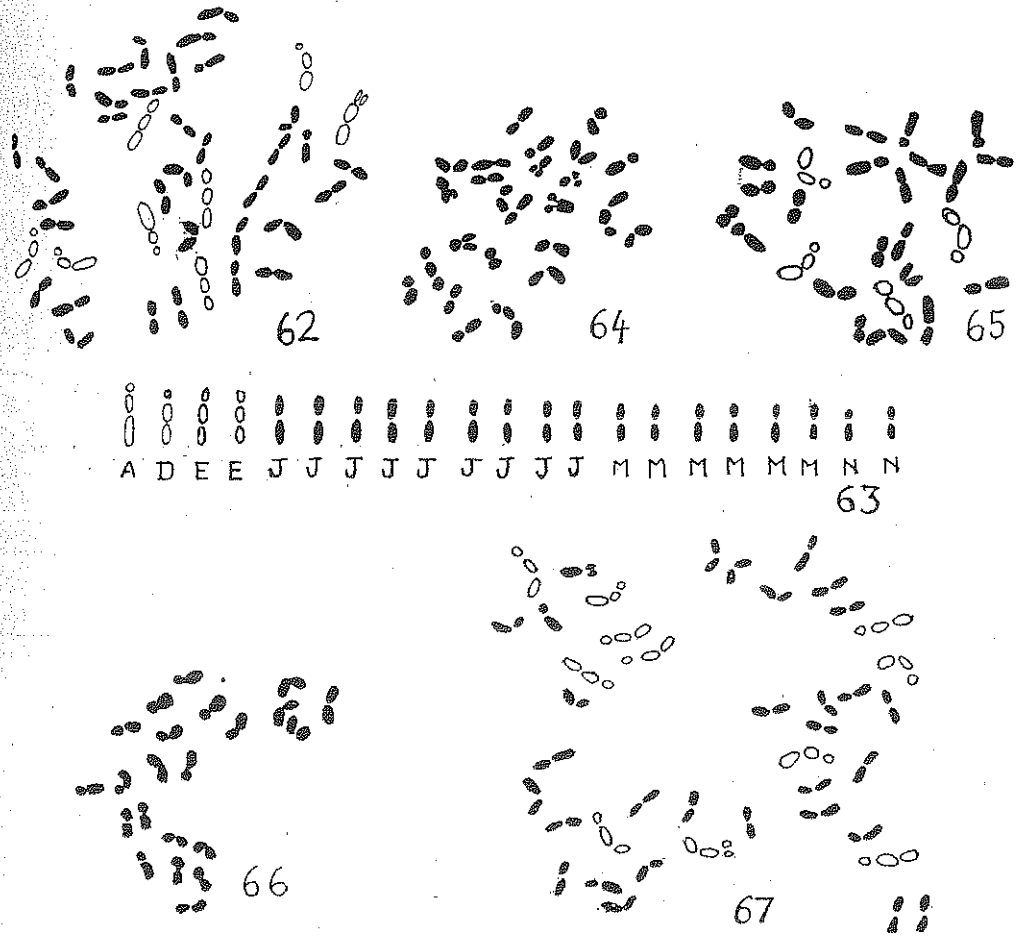
The normal somatic nuclei of this species have been found to contain forty-two chromosomes. Size difference is present amongst them, which ranges from 1·5 μ to 2·75 μ approximately.

In short, the karyotype may be represented as 2A, 2D, 4E, 18J, 12M, 4N. Of these eight chromosomes are with secondary constrictions.

A detailed study of the karyotype shows the presence of the following types of chromosomes (Figs. 62 & 63):

1. Four pairs of long chromosomes, one of A, one of D and two of E type.
2. Nine pairs of medium-sized chromosomes of J type.
3. Six pairs of short chromosomes of M type.
4. Two pairs of very short chromosomes of N type.

In addition to the normal complement described above, somatic nuclei with varying number of chromosomes such as twenty-eight, twenty-six and twenty-two and nuclei with the same number but with different karyotype have often been encountered (Figs. 64 to 67).



Figs. 62 to 67. *D. norwoodensis* (2n=42)—normal somatic metaphase, idiogram and variation nuclei with 28, 26 and 22 chromosomes and the normal number with altered karyotype respectively.

(16) *D. sanderiana* Hort. (2n=32):

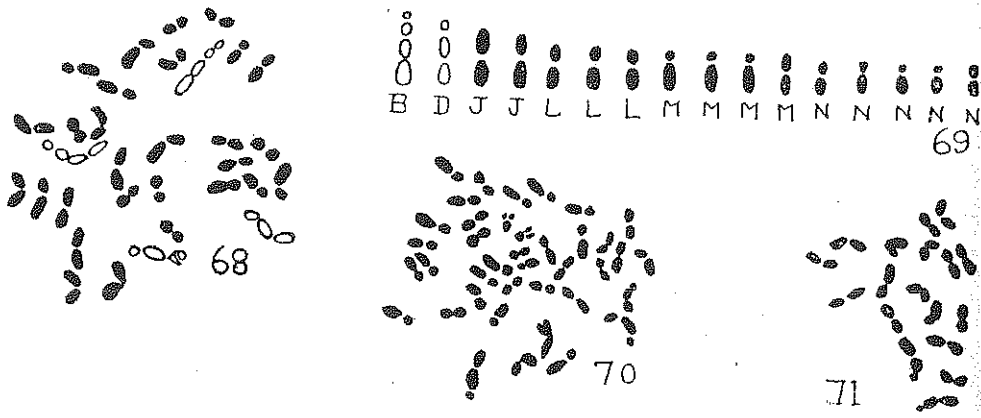
The normal somatic nuclei of this species have been found to contain thirty-two chromosomes. Size difference is present amongst them, which ranges from 1·50 μ to 3·20 μ approximately.

The karyotype of this species may be represented as 2B, 2D, 4J, 6L, 8M, 10N. Of these, four chromosomes bear secondary constrictions.

A detailed study of the karyotype shows the presence of the following types of chromosomes (Figs. 68 & 69):

1. Two pairs of long chromosomes, of which one is of B type and the other of D type.
2. Two pairs of medium-sized chromosomes of J type.
3. Seven pairs of short chromosomes, of which three are of L and four of M type.
4. Five pairs of very short chromosomes of N type.

In addition to the normal chromosome complements described above, somatic nuclei with varying number of chromosomes such as thirty-eight and eighteen have also been noticed (Figs. 70 & 71).



Figs. 68-71. *D. sanderiana* (2n=32)—normal somatic metaphase, idiogram and variation nuclei with 38 and 18 chromosomes respectively.

(17) *D. shephardi* (a horticultural species) (2n=30):

The normal somatic nuclei of this species have been found to contain thirty chromosomes. Size difference is present amongst them, which ranges from 1·30 μ to 4·00 μ approximately.

In short, the karyotype may be represented as 2D, 2G, 10J, 2L, 10M, 4N. Of these, four chromosomes bear secondary constrictions.

A detailed study of the karyotype of this species shows the presence of the following chromosome types (Figs. 72 & 73):

1. Two pairs of long chromosomes, one of D and the other of G type.
2. Five pairs of medium-sized chromosomes of J type.
3. Six pairs of short chromosomes of which one pair is of L and five pairs of M type.
4. Two pairs of very short chromosomes of N type.

No variation in the number of chromosomes in somatic nuclei has been noticed in this species.

(18) *D. splendens* Hort. (2n=30):

The normal somatic nuclei of this species have been found to contain thirty chromosomes. Size difference is present amongst them, which ranges from 1·50 μ to 3·50 μ approximately.

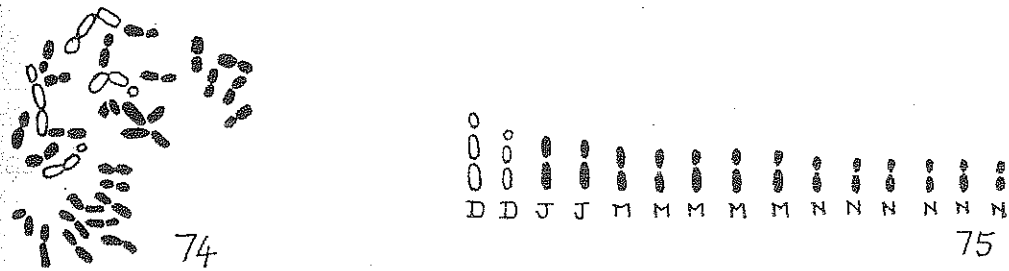
The karyotype of this species may be represented as 4D, 4J, 10M, 12N. Of these, four chromosomes bear secondary constrictions.

A detailed study of the karyotype shows the presence of the following chromosome types (Figs. 74 & 75):

1. Two pairs of long chromosomes of D type.
2. Two pairs of medium-sized chromosomes of J type.
3. Five pairs of short chromosomes of M type.
4. Six pairs of very short chromosomes of N type.

In addition to such a normal complement of thirty chromosomes, somatic nuclei with varying number of chromosomes such as twenty-two have often been noticed (Fig. 76).

Figs. 72 and 73. *D. shephardii* (2n=30)—somatic metaphase and idiogram.



Figs. 74-75. *D. splendens* (2n=30)—normal somatic metaphase, and idiogram.

(19) *D. thalioides* Hort. (2n=32):

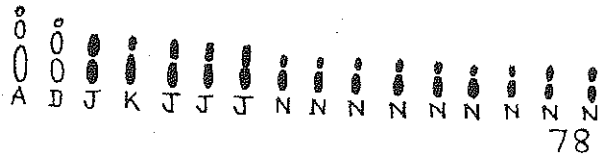
The normal somatic nuclei have been found to contain thirty-two chromosomes. Size difference is present amongst these chromosomes, which ranges from 1·67μ to 3·50 μ approximately.

The karyotype of this species may broadly be represented as 2A, 2D, 8J, 2K, 18N. Of these, four chromosomes bear secondary constrictions.

A detailed study of the karyotype of this species shows the presence of the following types of chromosomes (Figs. 77 & 78):

1. Two pairs of long chromosomes, one of A type and the other of D type.
2. Five pairs of medium-sized chromosomes, four of J and one of K type.
3. Nine pairs of very short chromosomes of N type.

In addition to the normal complement of thirty-two chromosomes, described above, somatic nuclei with varying number of chromosomes such as forty, thirty, twenty-six and eight in root tip and stem tip have often been noticed (Figs. 79 to 82).



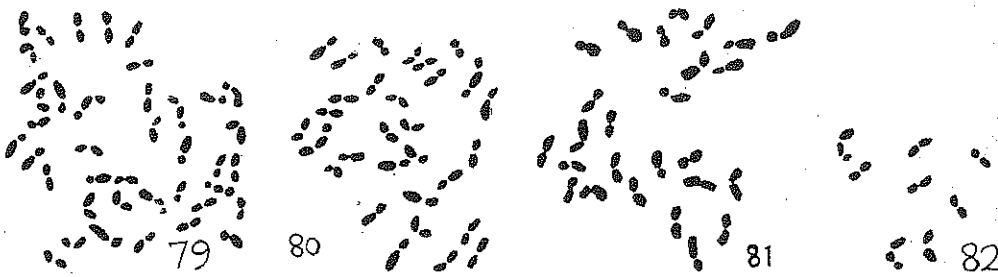


Fig. 76. *D. splendens*—Variation metaphase (2n=22).

Figs. 77 to 82. *D. thalioides* (2n=32)—normal somatic metaphase, idiogram and variation nuclei with 40, 30, 26 and 8 chromosomes.

(20) *D. victoria* Hort. (2n=28):

The normal somatic complement has been found to contain twenty-eight chromosomes. Slight size difference is present amongst them, which ranges from 1·16 μ to 4·30 μ.

The karyotype of this species may broadly be represented as 2E, 4D, 2I, 4K, 6J, 6M, 4N. Of these four chromosomes bear secondary constrictions.

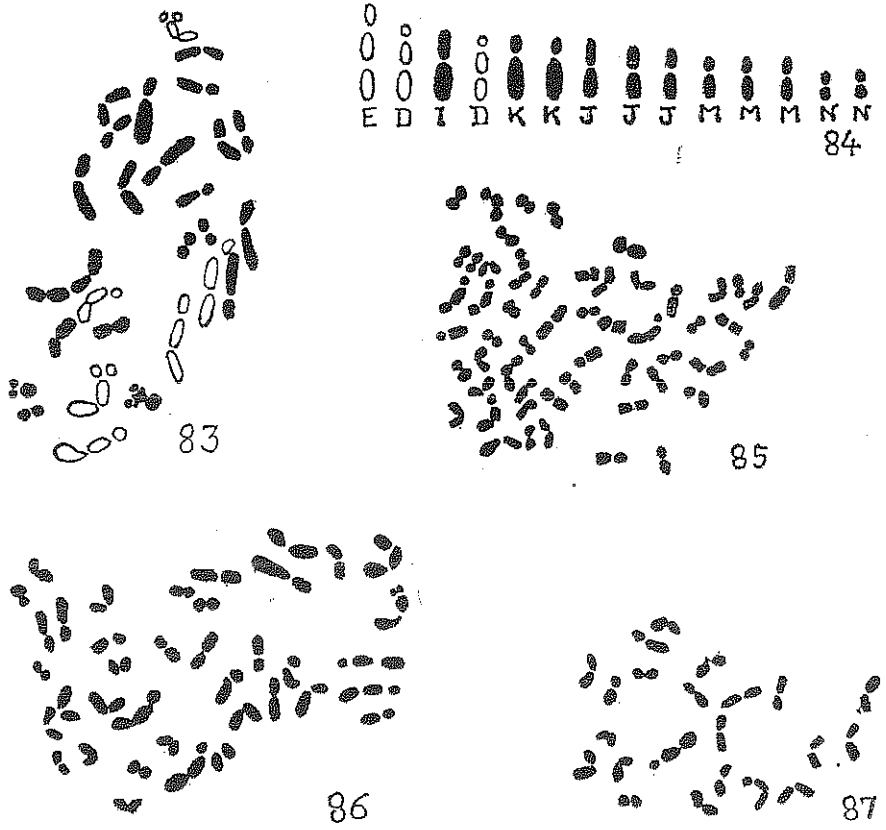
A detailed study of the karyotype of this species shows the presence of the following types of chromosomes (Figs. 83 & 84):

1. Four pairs of long chromosomes, of which one is of E, two of D and one of I type.
2. Five pairs of medium-sized chromosomes, of which four are of K type and one of J type.
3. Three pairs of short chromosomes of M type.
4. Two pairs of very short chromosomes of N type.

In addition to the normal complement described above, somatic nuclei with varying number of chromosomes such as fifty-five, thirty-eight, and twenty-two have often been encountered (Figs. 85 to 87).

(21) *D. voluta* (a horticultural species) (2n=28):

The normal somatic nuclei of this species have been found to contain twenty-eight chromosomes. Size difference amongst them is present, which ranges from 1·50 μ to 3·75 μ approximately.



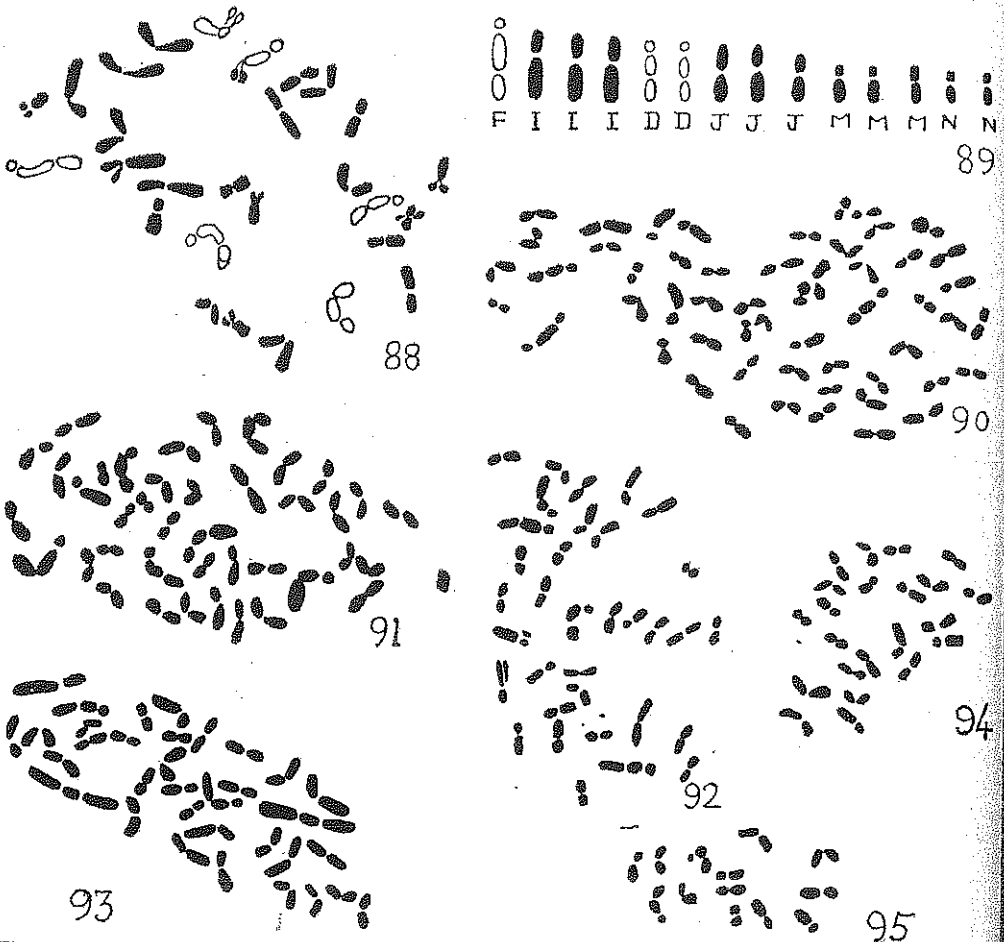
Figs. 83 to 87. *D. victoria* (2n=28)—normal somatic metaphase, idiogram and variation nuclei with 55, 38 and 22 chromosomes respectively.

The karyotype of this species may broadly be represented as 4D, 2F, 6I, 6J, 6M, 4N. Of these chromosomes, six bear secondary constrictions.

A detailed study of the karyotype shows the presence of the following chromosome types (Figs. 88 & 89):

1. Six pairs of long chromosomes, of which one is of F type, three of I type and two of D type.
2. Three pairs of medium-sized chromosomes of J type.
3. Three pairs of short chromosomes of M type.
4. Two pairs of very short chromosomes of N type.

In addition to the normal complement described above, somatic nuclei with varying number of chromosomes such as fifty-four, forty, thirty-four, twenty-two and twelve have also been recorded (Figs. 90 to 95).



Figs. 88 to 95. *D. voluta* (2n=28)—normal somatic metaphase, idiogram and variation nuclei with 54, 40, 34, 22 and 12 chromosomes respectively.

Discussion

1. *Different series of chromosome numbers in the genus Dracaena:*

Previous work on different species of *Dracaena* indicates thirty-eight as the lowest chromosome number so far reported in the genus (*vide* Darlington and Wylie, 1955). Of the nine species cytologically recorded five show the chromosome number as thirty-eight (McKelvey and Sax, 1933; Whitaker, 1934; Sato, 1935, 1942; Bowden, 1940). Of the rest, one is characterised by thirty-nine chromosomes, one by forty and the other two by one hundred and fourteen chromosomes (Sato, 1935, 1942). The last two records have been considered by Sato (1935) to represent the approximate number. It is

interesting that in *D. fragrans* Whitaker (1934) recorded thirty-eight chromosomes, whereas in the same species Guard and Hobbs (1941) recorded forty-two chromosomes. The discrepancies reported obviously indicate the presence of chromosomal biotypes in a species.

On the basis of the previous literature alone it appears that nineteen is possibly the basic number of chromosomes from which all other types have been derived. This is mainly based on the fact that in a majority of the species the 2n chromosome number has been found to be thirty-eight. Further as thirty-eight and forty-two chromosomes have been found in the same individual, apparently it seems that complements of forty-two chromosomes are derivatives of those with thirty-eight chromosomes. If that be the case, then the thirty-nine and forty chromosomes too noted in other species may be derivatives of the same.

The present investigation on twenty-one species of *Dracaena* shows on the other hand the occurrence of very different chromosome numbers in different species of the genus. Further the lowest chromosome number noted here is 2n=16 in *D. hookeriana*. Of these twenty-one species, *D. thalioides* was previously investigated by Sato (1942) and in individuals studied by him forty chromosomes were observed. The present work on the other hand records thirty-two chromosomes in individuals growing here.

It has already been pointed out that widely different chromosome numbers have been recorded in different species in the preceding text. On the basis of chromosome number, for the sake of convenience, these species can be divided under different categories.

In six species namely *D. voluta*, *D. victoria*, *D. Mrs. Hoskins*, *D. goldieana*, *D. norwoodensis*, and *D. godseffiana*, chromosome numbers which are multiples of seven have been recorded. The chromosome numbers of these species are 2n=28, 28, 28, 42, 42 and 84 respectively. This series can therefore be regarded as comprised of at least those species starting with a basic set of seven chromosomes.

Next come under discussion those species which show multiples of eight chromosomes in their complements. The representatives of this series are *D. hookeriana* (2n=16), *D. sanderiana* (2n=32), *D. thalioides* (2n=32), *D. hendersonii* (2n=32) and *D. hendersonii sport* (2n=32). *D. hookeriana* is the species where the lowest chromosome number in the genus *Dracaena* has been recorded.

Another line is represented by species like *D. baptistii* (2n=20, 40), *D. gayii* (2n=30), *D. metallica* (2n=30), *D. nigro-rubra* (2n=30), *D. shephardi* (2n=30), *D. splendens* (2n=30) and *D. argenteo-striata* (2n=40, 34) in which the chromosome numbers are multiples of ten.

Similarly a series with seventeen chromosomes in the haploid set is represented by three species, namely *D. albicans*, *D. chelsonii* and *D. argenteo-striata* with 2n=34 chromosomes.

Though *D. barronii* is the only species studied here showing 2n=38 chromosomes, chromosome numbers with multiples of nineteen have been reported by a number of authors as already mentioned. Therefore it can be assumed that the line with nineteen chromosomes in the haploid set is represented in a number of species.

Certain limitations are however needful in assuming lines with different chromosome numbers in the basic series so far studied and outlined above. For example, *D. thalioides*, as it shows 2n=32 chromosomes in the individual studied here, has been included within the series where species are characterized by chromosome complements with multiples of eight. On the other hand Sato's report (1942) of forty chromosomes in the same species naturally brings it into the series having chromosome numbers as multiples of ten. Of course, the number forty may represent a pentaploid level of eight chromosomes constituting the basic complement. In any case, in view of the fact that a lower chromosome number (that is 2n=32) than 2n=40 has been reported in this species it has been included in the series with eight chromosomes in the basic set. It may be argued that forty chromosomes have later been derived from 2n=32 through numerical changes.

Similarly, it is difficult to state whether *D. goldieana* with 2n=42 chromosomes should be included in the series showing multiples of seven or in that showing multiples of nineteen chromosomes, where both thirty-eight and forty-two chromosomes have been reported in *D. fragrans* (Whitaker, 1934; Guard and Hobbs, 1941). But in consideration of the fact that in no individual of *D. goldieana* chromosome numbers other than forty-two have been observed, this has been included, in the present paper, in the line characterized by seven chromosomes in the haploid set.

2. *Relationship between the different series so far outlined:*

It must however be pointed out that the different series outlined above are not entirely independent of each other, though no doubt each of them resembles a homogeneous assemblage. Every line is related to the other specially as regards their origin. At the first instance, this assumption is borne out by the fact that practically all the species of *Dracaena* are characterized by karyotypes which have a good deal of similarity with one another. No doubt karyotypic differences are there which can easily account for specific differences.

Secondly the occurrence of biotypes with different chromosome numbers in the same species (vide Table IV) gives further support to this assumption. It seems not unlikely that a particular number, being derived from another through aneuploidy, goes on producing polyploid species in nature for a certain length of time. After a certain lapse of period other such numerical changes in the series initiate another line which goes on producing new species through further polyploidy and other changes. In that case polyploidy and aneuploidy seem to have played the most significant role in the evolution of different species of *Dracaena*. This statement does not necessarily underrate in any way the role played by structural changes in speciation of *Dracaena* as every species of this genus is characterized by a distinct karyotype.

A glance at the histogram (Fig. 1) showing the total amount of chromatin matter in length of different species of *Dracaena* reveals a general homogeneity between all these species. The total amount is not often markedly different in one from the other. The differences that are often noted are to some extent due to the difference in chromosome number. In only one species, *D. godseffiana*, the total chromatin matter seems

Table III. *Table showing the present and past reports on chromosome numbers of different species*

Species & Varieties	Chromosome no. reported by previous authors (2n)	Name of the authors	Year	Chromosome number reported by present authors (2n)
D. albicans ..	—	—	—	34
D. arborea ..	38	McKelvey & Sax	1933	—
D. argentea-striata ..	—	—	—	34, 40
D. baptistii ..	—	—	—	20, 40
D. barronii ..	—	—	—	38
D. cannaefolia ..	114	Sato	1935	—
D. chelsonii ..	—	—	—	34
D. congesta ..	114	Sato	1935	—
D. cylindrica ..	39	Sato	1942	—
D. deremensis ..	38	Sato	1942	—
D. draco ..	38	Bowden	1940	—
D. fragrans ..	38	Whitaker	1934	—
	40	Guard & Hobbs	1941	
D. gayii ..	—	—	—	30
D. godseffiana ..	—	—	—	84
D. goldieana ..	—	—	—	42
D. hendersonii ..	—	—	—	32
D. hendersonii sport ..	—	—	—	32
D. hookeriana ..	—	—	—	16
D. 'Mrs. Hoskins' ..	—	—	—	28
D. metallica ..	—	—	—	30
D. nigro-rubra ..	—	—		30
D. norwoodensis ..	—	—	—	42
D. sanderiana ..	—	—	—	32
D. shephardii ..	—	—	—	30
D. splendens ..	—	—	—	30
D. terminalis ..	38	Sato	1935	—
D. thalioides ..	40	Sato	1942	32
D. victoria ..	—	—	—	28
D. voluta ..	—	—	—	28

to be markedly different from the rest. But in this particular species, the chromosome number too is very high, being 2n=84.

A study of their karyotype indicates general resemblance in gross morphology of the chromosomes between different species. In all, fourteen general types of chromosomes could be worked out, and every species is characterised by some of the types out of these fourteen in total. The number of secondary constrictions too does not markedly vary, and the range in number is from four to eight. As regards primary constrictions in all of them, these are mainly median, submedian and nearly subterminal in position.

All these facts clearly suggest that the species of the genus *Dracaena* indeed represent a homogeneous assemblage in which different series of chromosome numbers have been derived one from the other, at certain stages of evolution,

In spite of the general resemblances in karyotype, minor differences in the details of morphology of chromosomes can always be traced between one species and another (vide idiogram table). These small differences may account for species differences and fully justify the status of all these taxonomic units as distinct species.

It may be recalled that in a few species such as *D. nigro-rubra* and *D. godseffiana* chromosomes with supernumerary constrictions have been recorded. The presence of these multiple constrictions brings further proof that structural changes of chromosomes have played a distinct role in the evolution of the species.

3. *Means of Origin of Biotypes:*

It has already been emphasized that in a number of species of *Dracaena* different chromosome numbers have been reported in different individuals of the same species,

Table IV. *Table showing the frequency of 'normal' and 'variant' number of chromosomes in different species*

Species & varieties	Chromosome no.	Number of times noticed per 100 plates	The most frequently occurring no.
D. albicans ..	34	100	34
D. argenteostriata ..	48	5	34 (or 40)
	40	32	
	34	36	
	30	5	
	28	9	
	24	5	
	22	8	
D. baptistii ..	40	41	40, 20
	34	3	
	32	13	
	26	4	
	20	39	
D. barronii ..	42	30	38
	38	70	
D. chelsonii ..	34	40	34
	32	16	
	30	16	
	26	28	
D. gayii ..	30	100	30
D. godseffiana ..	84	100	84
D. goldieana ..	68	10	42
	42	90	
D. hendersonii ..	32	65	32
	24	35	

Table IV. (*Contd.*)

Species & varieties	Chromosome no.	Number of times noticed per 100 plates	The most frequently occurring no.
D. hendersonii sport ..	34	3	
	32	89	32
	20	8	
D. hookeriana ..	20	12	
	16	83	16
	8	5	
D. 'Mrs. Hoskins' ..	38	35	
	31	5	
	28	50	28
	18	10	
D. metallica ..	32	20	
	30	64	30
	26	16	
D. nigro-rubra ..	50	15	
	30	60	30
	20	25	
D. norwoodensis ..	42	44	42
	28	18	
	26	26	
	22	12	
D. sanderiana ..	38	15	
	32	80	32
	18	5	
D. shephardii ..	30	100	30
D. splendens ..	30	75	30
	22	25	
D. thalioides ..	40	4	
	32	76	32
	30	4	
	26	12	
	8	4	
D. victoria ..	55	9	
	38	20	
	28	60	28
	22	11	
D. voluta ..	54	4	
	40	3	
	34	30	
	28	55	28
	22	4	
	12	4	

that is, the existence of chromosomal biotypes is recorded. It is yet to be seen how far these biotypes have different ecological distributions, as noted in some other genera (Banach, 1950; Leoncini, 1951; Löve, 1954; Haskel, 1954; Janaki Ammal, 1957).

It is worthy of note that all the species of *Dracaena* are exclusively propagated through vegetative means. Sexual propagation is ineffective as no viable seeds are produced and even flowering in practically all cases is scarcely noted. The spontaneous origin of such chromosomal biotypes, therefore, needs some other explanation than sexual reproduction. Reproduction through sexual means being ineffective, the latter cannot naturally have contributed to the origin of biotypes.

In this connection, the chromosomal behaviour noted in the somatic tissue of all the species of *Dracaena* is worth consideration. In all of them considerable variation in the number and structure of chromosomes has been recorded in the somatic tissue (vide Table IV). That is, in general, the somatic tissues represent a *chromosome mosaic*, in which one particular number dominates, which is otherwise regarded as the normal 2n number for the species.

The possibilities of such variation with regard to speciation are immense, especially in plants where sexual reproduction is obsolete. Recently such behaviour has been recorded in a large number of vegetatively reproducing plants where it has been found to be a constant feature occurring in high frequency in all the individuals (Duncan, 1945; Vaarama, 1949; Sachs, 1952; Snoad, 1954; Sharma and Bal, 1954; Sharma and Das, 1954; Sharma and Bhattacharyya, 1956; Mookerjea, 1955a & b, 1956). Even cases have been brought forward where a particular chromosome complement present as one of the variations in one taxonomic variety, resembles exactly the normal karyotype for another allied variety (Sharma and Das, 1954), obviously suggesting the origin of the latter from the former through vegetative reproduction. On the basis of a number of such evidences, it has therefore been claimed (Sharma, 1956) that in plants where sexual reproduction is ineffective, such variant nuclei take part in the formation of the new daughter shoots, which gradually give rise to new individuals on being detached from the mother plant. Such individuals thus become different in chromosome constitution from the original variety. This method provides them with a new and effective means of speciation, not being dependent on the complex process of sexual reproduction and fertilization.

In *Dracaena* too a large number of karyotypic variations in the same somatic tissue has been recorded; and coincident with this phenomenon, a large number of chromosomal biotypes are present in some species. Further, within the same genus, different chromosome numbers have been recorded in a number of species. In the absence of the sexual method of reproduction all these facts can easily be explained if it is considered that cells showing such somatic mutations, or rather the variant nuclei, enter into the formation of the new daughter shoots and thus contribute to the origin of new individuals with different genomic constitution. This statement is further substantiated by the fact that in the stem tip too, variation in number in a high frequency has been noted. Speciation in *Dracaena* therefore seems to be aided to a large extent by its vegetative means of reproduction.

Summary

Detailed study of the structure and behaviour of chromosomes in the somatic tissue of twenty-one species of the genus *Dracaena* has been made and the "normal" chromosome numbers of all these species have been reported for the first time in this paper.

The previous and the present records suggest that most of the species possess a number of chromosomal biotypes. These biotypes mainly differ with respect to their chromosome numbers.

Relationship between species showing multiples of different series of chromosome numbers, viz. eight, ten, thirteen, seventeen and nineteen has been indicated.

On the basis of the fact that a general resemblance in gross morphology of chromosomes and similarity in total amount of chromatin length are present amongst different species of the genus *Dracaena*, it has been suggested that the species of this genus represent a homogeneous assemblage in spite of the fact that inconstancy in chromosome number is noted within a species.

The different lines have mainly been assumed to have come out through continued production of aneuploid numbers during evolution. The presence of a number of chromosomal biotypes indicates that such aneuploid numbers often arise.

Minor differences in details of chromosome morphology, and the presence of supernumerary constrictions in certain species, have been regarded as proving that structural changes of chromosomes have also played a distinct role in evolution of the species.

As the different species of *Dracaena* are propagated exclusively through vegetative means, the only explanation for the origin of biotypes which can be suggested is that the recorded variant nuclei enter into the formation of new daughter shoots from which new individuals originate with different genomic constitutions. As flowers are scarcely noted and sexual reproduction is entirely ineffective with respect to propagation, this seems to be the only way through which speciation is effected here.

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