CYTOLOGY OF CONIFERS. II

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(With Eight Text-figures)

(*Received* 20 *July* 1955)

In the first communication the writers have described the cytological situation in forty-one species distributed within the Abietaceae, Taxodiaceae and Cupressaceae. In the present paper four species of *Podocarpus* and one species of *Cephalotaxus* are included.

Very little cytological work has been done on genera of Podocarpaceae and Taxaceae. Sax & Beal (1934), in their paper on cycad chromosomes, casually reported that *Podocarpus* has twenty pairs of chromosomes. In 1936 Flory reported the karyotypes of five species of *Podocarpus*. The diploid chromosome numbers reported by him are 24, 38 and 40. Since then nothing has been added except a solitary report of Tahara (1941) on *P. macrophyllus*, wherein there are 19 bivalents at meiosis.

Sax & Sax (1933) worked out five species of *Taxus*, covering also the species worked out by Dark (1932). They also reported the karyotype in *Cephalotaxus fortunii*. Sugihara (1940) reported the number in *C. drupacea*. All the species of *Taxus* and *Cephalotaxus* have $n = 12$.

Material and method

The material of *Podocarpus gracilior, P. latifolia, Cephalotaxus drupacea* and its var. *pedunculata* was secured through Messers M. B. Raizada and R. N. Khoshoo from the Forest Research Institute (Dehradun). Seeds of *Podocarpus falcatus* were secured from Bangalore and were germinated in sand. *P. macrophyllus* was collected from local Company Gardens.

Somatic chromosomes were studied from squashes of young leaves of male trees in all the cases except *P. falcatus*, in which case root-tips were available. Cytological methods were the same as in the previous paper. The taxonomic arrangement is the same as given by Dallimore & Jackson (1948). All diagrams have been drawn at an approximate magnification of $\times 3000$ and have been reduced to half in publication.

Observations

Podocarpus

Section Stachycarpus.

Podocarpus falcatus R. Brown (*P. elongata* Carr.) has 24 chromosomes (Fig. 1) in root-tips. Eight chromosomes are median or submedian and sixteen are subterminal. There appear to be no chromosomes with a terminal centromere. Out of the eight median-submedian chromosomes four are larger than the rest.

Flory (1936) has also observed the same number for this species, but he reported only four median chromosomes.

P. gracilior Pilger possesses 24 chromosomes (Fig. 2). Two are clearly with median, fourteen with subterminal, while eight appear to have terminal centromeres. The chromosomes are smaller in size than in *P. falcatus*. In pollen mother cells 12 bivalents (Fig. 3) have been observed. Meiosis is perfectly normal.

P. andinus is the third species of this section which is cytologically known. Flory (1936) reported $2n=40$ in this species. He noted a preponderance of terminal chromosomes.

Section Eupodocarpus

P. latifolia R. Brown (*P. thunbergii* Hook.) has only 22 chromosomes (Fig. 4). There appear to be ten with median, eight with subterminal and four with apparently terminal centromeres. The chromosome size is about the same as in *P. gracilior*. At meiosis 11 bivalents (Fig. 5) have been counted. Meiosis is perfectly normal.

P. macrophyllus D. Don var. *Maki* Siebold (*P. chinensis* Wallich) possesses 38 chromosomes (Fig. 6). The centromeres could not be located with certainty, nevertheless most of the chromosomes appear to possess them in a subterminal or terminal position. There are size differences between the chromosomes of the complement. The general size of the complement is the same as in *P. gracilior* and *P. latifolia*. Crystal-violet smears of pollen mother cells reveal 19 bivalents (Fig. 7). Meiosis is normal.

Flory (1936) reported 38–40 chromosomes in *P. macrophyllus*. An analysis of the plates with 38 chromosomes showed only six median-submedian, fourteen subterminal and eighteen terminal chromosomes. The same species has been worked out by him under the name *P. chinensis* and found to have 'nearly' 40 chromosomes in root-tips. Many of the chromosomes are with terminal centromere.

Tahara (1941) observed in *P. macrophyllus* 19 bivalents at meiosis and 38 chromosomes in the root-tips.

P. neriifolius is the third species of this section which possesses 38 chromosomes (Flory, 1936). There are four with median or submedian and thirty-four with apparently terminal centromeres.

Cephalotaxus

Cephalotaxus drupacea Sieb. & Zucc. and *C. drupacea* var. *pedunculata* Miquel (*C. pedunculata* Sieb. & Zucc.) (Fig. 8) both possess 12 bivalents in pollen mother cells. Sugihara (1940) also reported the same number in the normal plants of *C. drupacea*.

Mitotic chromosomes of this species have been worked out by Sax & Sax (1933) from endosperm. Out of twelve chromosomes one has a subterminal centromere and the remainder have median or submedian centromeres. The subterminal chromosome has a satellite on its short arm.

Conclusions

Table 1 summarizes all the cytological work done so far, including the present studies, on Podocarpaceae and Taxaceae. It is apparent from this table that both these families are very imperfectly known cytologically. It is not safe to conclude on the base number or numbers in Podocarpaceae, since only one genus out of seven is even partially known. Furthermore, the family as a whole and the genus *Podocarpus* in particular is taxonomically complex and morphologically very variable.

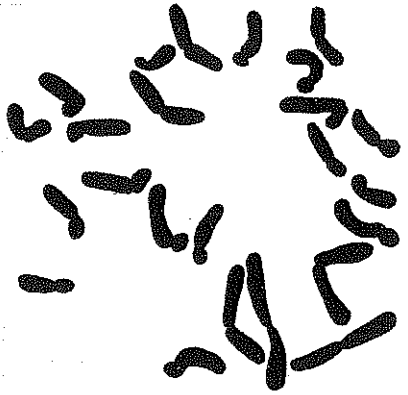

Fig. 1. *Podocarpus falcatus*, $2n=24$.

Fig. 2. *P. gracilior*, $2n=24$.

Fig. 3. *P. gracilior*, $n=12$. Diakinesis, nucleolus unshaded.

Fig. 4. *P. latifolia*, $2n=22$.

Fig. 5. *P. latifolia*, $n=11$. Metaphase I.

Fig. 6. *P. macrophyllus*, $2n=38$.

Fig. 7. *P. macrophyllus*, $n=19$. Metaphase I.

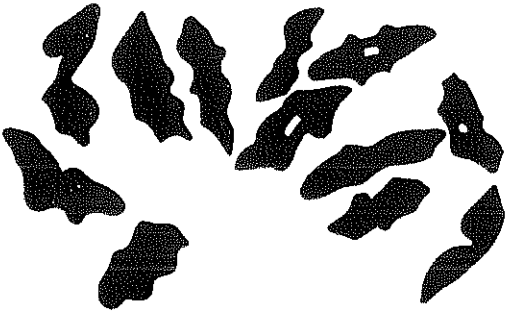

Fig. 8. *Cephalotaxus drupacea*, var. *pedunculata*, $n=12$. Metaphase I.

Table 1. *Résumé of cytological work on Podocarpaceae and Taxaceae*

Name of genus	Total no. of species	No. of species worked out	Chromosome number	No. of terminal chromosomes	No. of subterminal chromosomes	No. of median submedian chromosomes	Authority
PODOCARPACEAE:							
Podocarpus	64	6	Details given below				
Sec. Stachycarpus							
P. falcatus			$2n=24$	—	20	4	Flory (1936)
			$2n=24$	—	16	8	Authors
P. gracilior			$n=12$	—	—	—	Authors
			$2n=24$	8	14	2	Authors
P. andinus			$2n=40$	—	—	—	Flory (1936)
Sec. Eupodocarpus							
P. latifolius			$n=11$	—	—	—	Authors
			$2n=22$	4	8	10	Authors
P. neriifolius			$2n=38$	34	—	4	Flory (1936)
P. macrophyllus			$2n=38$–40	18	14	6	Flory (1936)
			$n=19$	—	—	—	Tahara (1941), authors
			$2n=38$	—	—	—	Tahara (1941), authors
as *chinensis*			$2n=40$	—	—	—	Flory (1936)
Unworked genera: *Acmopyle, Dacrydium, Microcachrys, Pherosphera, Phyllocladus,* and *Saxegothaea*							
TAXACEAE:							
Cephalotaxus	5	2	$n=12$	—	1	11	Sax & Sax (1933)
		1	$n=12$	—	—	—	Sugihara (1940), authors
Taxus	9	5	$n=12$	— 1	1	10	Sax & Sax (1933)
		2	$n=12$	—	—	—	Sax & Sax (1933)
Unworked genera: *Amentotaxus, Austrotaxus,* and *Torreya*							

The genus *Podocarpus* has five sections. The cytologically known species fall into only two of these. In the section Stachycarpus the lowest number is $2n=24$ and the highest number $2n=40$, and in the section Eupodocarpus the lowest is $2n=22$ while the highest is the same as Stachycarpus. Taking the genus as a whole the numerical series is $2n=22$, 24, 38 and 40. In the lowest number there are ten median-submedian centromeres, while in the highest number there is a preponderance of terminal chromosomes. For such a situation three explanations are possible.

The number of chromosomes could have increased by a process of fragmentation of median-submedian chromosomes at the centromeric region. This would require the origin of new centromeres *de novo*. A second explanation could be the reduction in chromosome number. This would involve loss of centromeres after the essential genes had been translocated to the other chromosomes of the complement. The third explanation could be that the base number may be 12 as in Taxaceae, and that from it on one side the number was reduced to 11 and on the other increased to 20 during the course of evolution. This seems not improbable on comparison with the chromosomal condition in the Coniferales in general.

The present evidence does not reveal that the increase in chromosome number in *Podocarpus* is due to simple polyploidy, particularly because of the great preponderance of terminal chromosomes in species having $2n=38$ or 40 as compared to those with $2n=24$. Perhaps when the family is known better both cytologically and morphologically the situation will become clearer.

Taxus and *Cephalotaxus* have the same chromosome number, but their karyotypes differ (see Table 1). Morphologically *Cephalotaxus* has been segregated in a distinct family Cephalotaxaceae.

SUMMARY

Chromosome numbers in *Podocarpus falcatus* ($2n=24$), *P. gracilior* ($n=12$, $2n=24$), *P. latifolia* ($n=11$, $2n=22$) and *P. macrophyllus* var. *Maki* ($n=19$, $2n=38$) have been recorded. Nothing conclusive can be said as to whether the chromosome number has increased or decreased or both increased and decreased during the course of evolution of the genus.

Cephalotaxus drupacea and its var. *pedunculata* both have $n=12$.

The writers are grateful to Messrs M. B. Raizada and R. N. Khoshoo for sending the material used in this investigation.

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