

and paracentric inversions and cryptic structural hybridity. These have resulted in alterations in number and morphology, and repatterning of chromosomes without significant changes in the karyotype.

It has been concluded that in the gymnosperms the various organs (including the nucleus) seem to have advanced at different rates. As such it is not possible to form a rigid evolutionary series taking all characters into consideration. However, in general, cytological data follow the taxonomic groupings and in the various families (except *Cycadaceae* and *Podocarpaceae*) a single basic number can be recognised. In these two families the basic numbers in the present day genera form a dysploid series resulting from fragmentation and/or fusion of centromeres. Judging from our present day understanding of the karyotypic evolution in plants in general, it is tempting to speculate that the probable ancestral karyotype in these families was low-numbered and symmetrical.

The various genera in a family may or may not resemble one another in their basikaryotype which remains generally constant within genera except in *Podocarpus* and *Dacrydium*. However, in the later genera basikaryotype remains constant only in some sections. The inter- and intraspecific differentiation is due to changes in absolute size of the chromosome complement and/or number, nature and location of secondary constrictions and satellites. Furthermore, apart from gene mutations, such differentiation involves other changes like segmental interchanges, inversions and cryptic structural hybridity.

The decrease in chromosome number and absolute size of chromosomes of a complement seems to be generally correlated with the phylogenetic advancement in conifers. Similarly the increase in asymmetry can also be correlated in some cases with specialization in habitat, habit and morphology.

In comparison to angiosperms, the gymnosperms are cytogenetically extremely stable. Such stability is also found in their habitat preferences, habit, morphology and pollination, and reproductive systems etc.

In the end avenues for further work have been pointed out.

The above are among the notable works that have appeared in recent years on the topic. We may now proceed to make some explanatory remarks on the present paper.

Apart from the original papers, the following works have been consulted while preparing the present list:

MAUDE (1939), DARLINGTON and JANAKI AMMAL (1945), LÖVE and LÖVE (1948), KANEZAWA (1949), SATÔ (1949, pp. 162—169), DELAY (1950—1951), STIFF (1952), DARLINGTON and WYLIE (1955), CAVE et al (1956—1959 and supplement) and KHOSHOO (1959).

Generally the data from older morphological works, which in most cases have either been doubtfully reported or have turned out to be incorrect after using improved techniques, have not been quoted. Only authentic reports of the natural polyploids have been included (KHOSHOO, 1958, 1959). Cytological data on hybrids have also been included.

The arrangement of the families is adapted after TAKHTAJAN (1953) and that of genera within families after SAX and SAX (1933) for *Cycadales* and after LI (1953) for *Coniferales*.

The validity of the specific names in *Ephedra* has been checked from the Index Kewensis (1895—1950) and that of the *Coniferales* mostly from DALLIMORE and JACKSON (1948). The species of conifers marked with an asterisk are not given in DALLIMORE and JACKSON (1948) but are included in the Index Kewensis (1895—1950).

At present out of about 67 genera, 55 (82%) genera and out of about 635 species, 264 (42%) species have been cytologically studied. After a perusal of all these data, the writer feels that work along the following lines is important and needs particular attention.

1. The following genera urgently need a cytological study, since no work has been done so far on them.

- Taxaceae* : *Austrotaxus*, *Nothotaxus*.
- Pinaceae* : *Cathaya* (cf. CHUN and KUANG, 1958).
- Taxodiaceae* : *Glyptostrobus*.
- Cupressaceae* : *Fitzroya*, *Neocallitropsis*, *Octoclinis*, *Diselma*, *Papuacedrus*, *Pilgerodendron*, *Fokienia*, *Heyderia*, *Arceuthos*.

2. Cytogenetic studies are needed on interspecific and intergeneric hybrids. Such studies have been almost altogether neglected so far, even though very important and valuable work is being done on the breeding of conifers all over the world. The urgent need for such data has been already emphasised by the present writer (KHOSHOO, 1958, 1959). Such studies would also go a long way to elucidate the cytogenetic basis of the species and the generic relationships. It is needless to mention here that some probable cases of intergeneric hybrids are already on record in the literature: *Ceratozamia* × *Zamia* (CHAMBERLAIN, 1926), four hybrids involving *Tsuga*, *Picea* and *Keteleeria* (CAMPO-DUPLAN and GAUSSEN, 1949) and *Cupressus* × *Chamaecyparis* (OSBORN, 1940).

3. Critical cytogenetic work is needed on the polyploid trees and species and also on the polyploid seedlings often discovered in nurseries.

4. More work is needed to supplement the existing state of knowledge on the following genera:

- Cycadaceae* : *Cycas*, *Macrozamia*, *Encephalartos*, *Zamia*.
- Araucariaceae* : *Araucaria*, *Agathis*.
- Taxaceae* : *Amentotaxus*, *Torreya*.
- Pinaceae* : *Keteleeria*, *Abies*, *Pseudotsuga*, *Larix*.
- Cupressaceae* : *Libocedrus*, *Juniperus*.
- Ephedraceae* : *Ephedra*.
- Welwitschiaceae* : *Welwitschia*.
- Gnetaceae* : *Gnetum*.

There are several foresters and forest-tree breeders in the world to whom the viable seeds of the species of the above genera are easily available. I will feel deeply grateful to anyone sending me the viable seeds of these, in particular of the totally unworked genera listed earlier.

Lastly, it is my most pleasant duty to express my indebtedness to PROFESSORS W. LANGNER (Schmalenbeck), P. MAHESHWARI (Delhi) and P. N. MEHRA (Chandigarh) for their continued encouragement and advice. To DR. M. L. STIFF (Lafayette), I am deeply grateful for allowing me to quote his valuable unpublished work on the cytology of conifers.

Table of Chromosome Numbers

| Species | Chromosome number | | Reference | Species | Chromosome number | | Reference |
|--------------------------|-------------------|--------|--|------------------------------------|-------------------|----|--------------------------------|
| | n | 2n | | | n | 2n | |
| I. CYCADALES | | | | | | | |
| 1. Cycadaceae | | | | | | | |
| <i>Cycas</i> (x=11) | | | | <i>australis</i> | 13 | 26 | HAIR and BEUZENBERG, 1958b. |
| <i>circinalis</i> | — | 22 | SAX and BEAL, 1934. | <i>brownii (robusta)</i> | — | 26 | FLORY, 1936. |
| <i>revoluta</i> | — | 22 | SAX and BEAL, 1934. | <i>species</i> | — | 26 | FLORY, 1936. |
| <i>rumphii</i> | — | 22, 24 | NAKAMURA, 1929 | 4. Podocarpaceae | | | |
| <i>Bowenia</i> (x=9) | | | | <i>Phyllocladus</i> (x=9) | | | |
| <i>serrulata</i> | — | 18 | SAX and BEAL, 1934. | <i>alpinus</i> | 9 | 18 | HAIR and BEUZENBERG, 1958a, b. |
| <i>spectabilis</i> | — | 18 | RESENDE and RIJO, 1948. | <i>glaucus</i> | 9 | 18 | HAIR and BEUZENBERG, 1958a, b. |
| <i>Macrozamia</i> (x=9) | | | | <i>trichomanoides</i> | 9 | 18 | HAIR and BEUZENBERG, 1958a, b. |
| <i>miquelii</i> | — | 18 | SAX and BEAL, 1934. | <i>Pherosphaera</i> | | | |
| <i>moorei</i> | — | 18 | SAX and BEAL, 1934. | (x=13) | | | |
| <i>tridentata</i> | — | 18 | SAX and BEAL, 1934. | <i>hookeriana</i> | 13 | 26 | HAIR and BEUZENBERG, 1958a. |
| <i>Stangeria</i> (x=8) | | | | <i>fitzgeraldi</i> | 13 | 26 | HAIR and BEUZENBERG, 1958a. |
| <i>paradoxa</i> | — | 16 | SAX and BEAL, 1934. | <i>Microcachrys</i> (x=15) | | | |
| <i>Encephalartos</i> | | | | <i>tetragona</i> | 15 | 30 | HAIR and BEUZENBERG, 1958a. |
| (x=8 [?], 9) | | | | <i>Saxegothaea</i> (x=12) | | | |
| <i>altensteinii</i> | — | 16 | SAX and BEAL, 1934. | <i>conspicua</i> | 12 | 24 | HAIR and BEUZENBERG, 1958a. |
| — | — | 18 | RESENDE, 1940. | <i>Acmopyle</i> (x=10) | | | |
| <i>barteri</i> | 9 | — | BERRIE, 1959. | <i>pancheri</i> | 10 | 20 | HAIR and BEUZENBERG, 1958a. |
| <i>caffer</i> | — | 18 | VIVEIROS, 1951. | <i>Dacrydium</i> (x=9-12, 15) | | | |
| <i>cycadifolius</i> | — ca. | 18 | RESENDE and RIJO, 1948. | <i>araucarioides</i> | 10 | 20 | HAIR and BEUZENBERG, 1958a. |
| <i>horridus</i> | — | 18 | RESENDE, 1940. | <i>balansae</i> | 10 | 20 | HAIR and BEUZENBERG, 1958a. |
| <i>latifrons</i> | — | 18 | RESENDE, 1940. | <i>bidwillii</i> | 9 | 18 | HAIR and BEUZENBERG, 1958a, b. |
| <i>lehmanii</i> | — | 18 | VIVEIROS, 1951. | <i>biforme</i> | 12 | 24 | HAIR and BEUZENBERG, 1958a, b. |
| <i>villosus</i> | — | 18 | VIVEIROS, 1951. | <i>colensoi</i> | 10 | 20 | HAIR and BEUZENBERG, 1958a, b. |
| <i>Dioon</i> (x=9) | | | | <i>cupressinum</i> | 10 | 20 | HAIR and BEUZENBERG, 1958a, b. |
| <i>edule</i> | — | 18 | VIVEIROS, 1951. | <i>elatum</i> | 10 | 20 | HAIR and BEUZENBERG, 1958a. |
| <i>spinulosum</i> | — | 18 | SAX and BEAL, 1934. | <i>franklinii</i> | 15 | 30 | HAIR and BEUZENBERG, 1958a. |
| <i>Microcycas</i> (x=13) | | | | <i>guillauminii</i> | 10 | 20 | HAIR and BEUZENBERG, 1958a. |
| <i>calcoma</i> | — | 26 | SAX and BEAL, 1934. | <i>intermedium</i> | 15 | 30 | HAIR and BEUZENBERG, 1958a, b. |
| <i>Ceratozamia</i> (x=8) | | | | <i>kirkii</i> | 11 | 22 | HAIR and BEUZENBERG, 1958a, b. |
| <i>mexicana</i> | — | 16 | SAX and BEAL, 1934. | <i>laxifolium</i> | 15 | 30 | HAIR and BEUZENBERG, 1958a, b. |
| <i>Zamia</i> (x=8, 9) | | | | <i>lycopodioides</i> | 10 | 20 | HAIR and BEUZENBERG, 1958a. |
| <i>floridana</i> | — | 16 | SAX and BEAL, 1934. | <i>taxoides</i> | 10 | 20 | HAIR and BEUZENBERG, 1958a. |
| <i>loddigesii</i> | — | 18 | RESENDE and RIJO, 1948. | <i>Podocarpus</i> (x=10-13, 17-19) | | | |
| <i>media</i> | — | 16 | SAX and BEAL, 1934. | Section 1. <i>Dacrycarpus</i> | | | |
| II. GINKGOALES | | | | | | | |
| 2. Ginkgoaceae | | | | | | | |
| <i>Ginkgo</i> (x=12) | | | | <i>dacrydioides</i> | 10 | 20 | HAIR and BEUZENBERG, 1958a, b. |
| <i>biloba</i> | 12 | 24 | SAX and SAX, 1933; RESENDE and RIJO, 1948; TANAKA et al, 1952; LEE, 1954; NEWCOMER, 1954; POLLOCK, 1957; CZEIKA and SCHIMAN, 1960. | | | | |
| III. CONIFERALES | | | | | | | |
| 3. Araucariaceae | | | | | | | |
| <i>Araucaria</i> (x=13) | | | | | | | |
| <i>angustifolia</i> | | | | | | | |
| (<i>brasiliana</i>) | — | 26 | FLORY, 1936; STIFF, 1952. | | | | |
| <i>bidwillii</i> | — | 26 | FLORY, 1936. | | | | |
| <i>cunninghamii</i> | — | 26 | FLORY, 1936. | | | | |
| <i>excelsa</i> | — | 26 | STIFF, 1952. | | | | |
| <i>Agathis</i> (x=13) | | | | | | | |
| <i>alba</i> | — | 26 | ZINNAI, 1948. | | | | |

| Species | Chromosome number | | Reference | Species | Chromosome number | | Reference |
|------------------------------------|-------------------|--------|--|------------------------------|-------------------------------------|--------|--|
| | n | 2n | | | n | 2n | |
| <i>imbricatus</i> | 10 | 20 | HAIR and BEUZENBERG, 1958a. | Subsection B. | | | |
| <i>vieillardii</i> | 10 | 20 | HAIR and BEUZENBERG, 1958a. | <i>elatus</i> | — | 34—36 | HAIR and BEUZENBERG, 1958a. |
| Section 2. <i>Microcarpus</i> | | | | <i>macrophyllus</i> | 19 | 38 | FLORY, 1936; TAHARA, 1941; MEHRA and KHOSHOO, 1956b. |
| <i>ustus</i> | 18 | 36 | HAIR and BEUZENBERG, 1958a. | <i>neriifolius</i> | — | 38 | FLORY, 1936. |
| Section 3. <i>Nageia</i> | | | | | — | 33 | HAIR and BEUZENBERG, 1958a. |
| <i>blumei</i> | 10 | 20 | HAIR and BEUZENBERG, 1958a. | <i>novae-caledoniae</i> | — | 37 | HAIR and BEUZENBERG, 1958a. |
| <i>nagi</i> | 13 | 26 | HAIR and BEUZENBERG, 1958a. | <i>polystachyus</i> | — | 33 | HAIR and BEUZENBERG, 1958a. |
| | 12 | 24 | ISHIKAWA, 1916; STIFF, 1952. | Subsection C. | | | |
| Section 4. <i>Afrocarpus</i> | | | | <i>salignus</i> | 19 | 38 | STIFF, 1952; HAIR and BEUZENBERG, 1958a. |
| <i>falcatus</i> | 12 | 24 | FLORY, 1936; MEHRA and KHOSHOO, 1956b; HAIR and BEUZENBERG, 1958a. | Subsection D. | | | |
| <i>gracilior</i> | 12 | 24 | MEHRA and KHOSHOO, 1956b; HAIR and BEUZENBERG, 1958a. | <i>acutifolius</i> | — | 38 | STIFF, 1952. |
| Section 5. <i>Polypodiopsis</i> | | | | | 17 | 34 | HAIR and BEUZENBERG, 1958a, b. |
| <i>comptonii</i> | 10 | 20 | HAIR and BEUZENBERG, 1958a. | <i>alpinus</i> | 19 | 38 | STIFF, 1952. |
| <i>minor</i> | 10 | 20 | HAIR and BEUZENBERG, 1958a. | <i>hallii</i> | 17 | 34 | HAIR and BEUZENBERG, 1958a, b. |
| <i>palustris</i> | 10 | 20 | HAIR and BEUZENBERG, 1958a. | <i>nivalis</i> | 19 | 38 | SNOAD, 1952; STIFF, 1952; HAIR and BEUZENBERG, 1958a, b. |
| <i>vitiensis</i> | 10 | 20 | HAIR and BEUZENBERG, 1958a. | | | | HAIR and BEUZENBERG, 1958a, b. |
| Section 6. <i>Sundacarpus</i> | | | | <i>var. erectus (niva-</i> | | | |
| <i>amarus</i> | 19 | 38 | HAIR and BEUZENBERG, 1958a. | <i>lis</i> × <i>hallii</i>) | 2 _{III} + 15 _{II} | 36 | BEUZENBERG, 1958a, b. |
| Section 7. <i>Stachycarpus</i> | | | | <i>totara</i> | 17 | 34 | HAIR and BEUZENBERG, 1958a, b. |
| Subsection A. <i>Euprumnopitys</i> | | | | Subsection F. | | | |
| <i>andinus</i> | 19 | 38 | FLORY, 1936; HAIR and BEUZENBERG, 1958a. | <i>longefoliolatus</i> | — | 37, 38 | HAIR and BEUZENBERG, 1958a. |
| <i>ferrugineus</i> | 18 | 36 | HAIR and BEUZENBERG, 1958a, b. | 5. Cephalotaxaceae | | | |
| <i>spicatus</i> | 19 | 38 | HAIR and BEUZENBERG, 1958a, b. | <i>Cephalotaxus</i> (x=12) | | | |
| Section 8. <i>Eupodocarpus</i> | | | | <i>drupacea</i> | 12 | — | SUGIHARA, 1940; MEHRA and KHOSHOO, 1956b. |
| Subsection A. | | | | <i>var. pedunculata</i> | 12 | 24 | STIFF, 1952; KHOSHOO, 1957a, b. |
| <i>elongatus</i> | — | 24 | STIFF, 1952. | <i>fortunei</i> | 12 | — | SAX and SAX, 1933. |
| | 11 | 22 | HAIR and BEUZENBERG, 1958a. | 6. Taxaceae | | | |
| <i>henkelii</i> | 10, 11 | 20, 22 | HAIR and BEUZENBERG, 1958a. | <i>Amentotaxus</i> (x=11) | | | |
| | 11 | 22 | MEHRA and KHOSHOO, 1956b*). | <i>argotaenia</i> | 11 | — | SUGIHARA, 1943b. |
| <i>latifolius</i> | 10 | 20 | HAIR and BEUZENBERG, 1958a. | <i>Torreya</i> (x=11) | | | |
| | | | | <i>macrosperma*</i> | 11 | — | NAKAJIMA, 1942. |
| | | | | <i>nucifera</i> | 11 | — | TAHARA, 1940a; HIRAYOSHI, 1942; HIRAYOSHI and NAKAMURA, 1942. |
| | | | | <i>Taxus</i> (x=12) | | | |
| | | | | <i>baccata</i> | | | |
| | | | | <i>(wallichiana)</i> | 12 | 24 | DARK, 1932; SAX and SAX, 1933; SUGIHARA, 1946; STIFF, 1952. |
| | | | | <i>canadensis</i> | 12+1B | — | DARK, 1932. |
| | | | | | 12 | — | SAX and SAX, 1933. |

*) These authors worked this species under the name *P. latifolius* from the material collected from Forest Research Institute, Dehra Dun (India). However, DR. NETTA E. GRAY is of the opinion that these plants are actually *P. henkelii*.

| Species | Chromosome number | | Reference | Species | Chromosome number | | Reference | |
|--------------------------------|-------------------|--|--|--------------------------------------|--|---------------|--|--|
| | n | 2n | | | n | 2n | | |
| <i>cuspidata</i> | 12 | 24 | DARK, 1932; SAX and SAX, 1933. | <i>libani</i> | 12 | — | SAX and SAX, 1933. | |
| <i>hunnewelliana</i> | 12 | — | SAX and SAX, 1933. | <i>Larix</i> (x=12) | | | | |
| <i>media</i> | 12 | — | SAX and SAX, 1933. | <i>decidua (europaea)</i> | 12 | — | SAX and SAX, 1933. | |
| | | | | | — | 24, 48 | CHRISTIANSEN, 1950. | |
| | | | | <i>decidua</i> × <i>occidentalis</i> | — | 36 | SYRACH LARSEN and WESTERGAARD, 1938; KNABEN, 1953. | |
| 7. Pinaceae | | | | <i>eurolepis</i> | 12 | — | H. J. SAX, 1932. | |
| <i>Keteleeria</i> (x=12) | | | | <i>gmelinii (dahurica)</i> | — | 24 | WOYCICKI, 1906. | |
| <i>dauriana</i> | 12 | — | SUGIHARA, 1943a; WANG, 1948. | | — | 36 | MANŽOS and POZDNIJAKOV, 1960. | |
| <i>(evelyniana)</i> | | | | <i>leptolepis (kaempferi)</i> | 12 | — | SAX and SAX, 1933. | |
| <i>Abies</i> (x=12) | | | | <i>occidentalis</i> | 12 | — | SAX and SAX, 1933. | |
| <i>balsamea</i> | 12 | — | MIYAKE, 1903. | <i>polonica*</i> | — | 24 | HRUBY, 1933. | |
| <i>cephalonica</i> | 12 | — | SAX and SAX, 1933. | <i>sibirica</i> | — | 24 | KIELLANDER, 1948. | |
| <i>concolor</i> | 12 | — | SAX and SAX, 1933. | <i>sudetica*</i> | — | 24 | HRUBY, 1933. | |
| <i>magnifica</i> | — | 24 | STIFF, 1952. | <i>Pseudolarix</i> (x=12) | | | | |
| <i>nordmanniana</i> | 12 | — | SAX and SAX, 1933. | <i>amabilis</i> | 22 | 44 | SAX and SAX 1933; STIFF, 1952. | |
| <i>pindrow</i> | 12 | — | MEHRA and KHOSHOO, 1956a. | <i>Pinus</i> (x=12) | | | | |
| <i>veitchii</i> | 12 | — | SAX and SAX, 1933. | <i>armandi</i> | 12 | 24 | STIFF, 1952; SANTAMOUR, 1960. | |
| <i>Pseudotsuga</i> (x=13) | | | | <i>ayacahuite</i> | 12 | — | SANTAMOUR, 1960. | |
| <i>douglasii</i> | — | 24(?) | DURRIEU-VABRE, 1958. | <i>banksiana</i> | 12 | 24 | SAX and SAX, 1933; STIFF, 1952. | |
| <i>taxifolia</i> | 13 | — | SAX and SAX, 1933; ZENKE, 1953. | <i>bungeana</i> | 12 | — | SAX and SAX, 1933. | |
| <i>Tsuga</i> (x=12) | | | | <i>canariensis</i> | — | 24 | BOWDEN, 1945; MEHRA and KHOSHOO, 1956a. | |
| <i>canadensis</i> | 12 | — | SAX and SAX, 1933. | <i>caribaea</i> | — | 24 | MEHRA and KHOSHOO, 1956a. | |
| <i>caroliniana</i> | 12 | — | SAX and SAX, 1933. | <i>as elliotii</i> | — | 24, 36, 48 | MERGEN, 1958. | |
| <i>diversifolia</i> | 12 | — | SAX and SAX, 1933. | <i>cembra</i> | 12 | — | SANTAMOUR, 1960. | |
| <i>Picea</i> (x=12) | | | | <i>cembroides (edulis)</i> | 12 | 24 | STIFF, 1952; SANTAMOUR, 1960. | |
| <i>abies</i> | 12 | 24 | SAX and SAX 1933; ANDERSSON, 1947 | <i>clausa</i> | — | 24 | STIFF, 1952. | |
| | — | 24, ±28, 36, 48 | } KIELLANDER, 1950. } ILLIES, 1953, 1958. | <i>contorta</i> | — | 24 | LANGLET, 1934. | |
| | — | 24, 28—30, 30—36, 36, 37, 48, 60—70 | | | <i>densiflora</i> | 12 | — | HIRAYOSHI, 1942; HIRAYOSHI and NAKAMURA, 1942. |
| | | | | | | — | 24, 48 | ZINNAI, 1952. |
| | | | | | <i>densiflora</i> × <i>thunbergii</i> | 12 | — | HIRAYOSHI, NAKAMURA and KANO, 1943. |
| <i>asperata</i> | 12 | — | SANTAMOUR, 1960. | <i>echinata</i> | 12 | — | SAX and SAX, 1933. | |
| <i>bicolor</i> | 12 | — | SANTAMOUR, 1960. | <i>flexilis</i> | 12 | — | SAX and SAX, 1933. | |
| <i>engelmannii</i> | 12 | — | SANTAMOUR, 1960. | <i>gerardiana</i> | — | 24 | MEHRA and KHOSHOO, 1956a. | |
| <i>glauca</i> | 12 | 24 | SAX and SAX, 1933; STIFF, 1952. | <i>halepensis</i> | — | 24 | MEHRA and KHOSHOO, 1956a. | |
| <i>jezoensis</i> | 12 | — | SANTAMOUR, 1960. | <i>jeffreyi</i> | 12 | 24 | SAX and SAX, 1933; STIFF, 1952. | |
| <i>koyamai</i> | 12 | — | SANTAMOUR, 1960. | <i>khasya</i> | — | 24 | MEHRA and KHOSHOO, 1956a. | |
| <i>likiangensis</i> | | | | <i>koraiensis</i> | 12 | — | SANTAMOUR, 1960. | |
| <i>(balfouriana)</i> | 12 | — | SANTAMOUR, 1960. | <i>lambertiana</i> | — | 24 | MEHRA and KHOSHOO, 1956a. | |
| <i>mariana</i> | 12 | — | SAX and SAX, 1933. | <i>luchuensis</i> | — | 24 | SHIBATA et al, 1955. | |
| <i>mariana</i> × <i>glauca</i> | 12 | — | LITTLE and PAULEY, 1958. | <i>massoniana</i> | — | 24 | STIFF, 1952. | |
| <i>maximowiczii</i> | 12 | — | SANTAMOUR, 1960. | | | | | |
| <i>montigena</i> | 12 | — | SANTAMOUR, 1960. | | | | | |
| <i>omorika</i> | 12 | — | SANTAMOUR, 1960. | | | | | |
| <i>orientalis</i> | 12 | — | SANTAMOUR, 1960. | | | | | |
| <i>pungens</i> | 12 | — | SAX and SAX, 1933. | | | | | |
| <i>rubens</i> | 12 | — | SANTAMOUR, 1960. | | | | | |
| <i>sitchensis</i> | — | 24 | THOMAS, 1945. | | | | | |
| <i>smithiana</i> | 12 | — | MEHRA and KHOSHOO, 1956a. | | | | | |
| <i>Cedrus</i> (x=12) | | | | | | | | |
| <i>atlantica</i> | — | 24 | STIFF, 1952. | | | | | |
| <i>deodara</i> | 12 | — | MEHRA and KHOSHOO, 1956a. | | | | | |

| Species | Chromosome number | | Reference | Species | Chromosome number | | Reference |
|---|-------------------|--------|---|------------------------------|-------------------|------------|---|
| | n | 2n | | | n | 2n | |
| <i>merkusii</i> | 12 | — | MEHRA and KHOSHOO, 1956a. | <i>Athrotaxis</i> (x=11) | | | |
| <i>montezumae</i> | — | 24 | STIFF, 1952. | <i>cupressoides</i> | 11 | 22 | GULLINE, 1952. |
| <i>monticola</i> | 12 | — | SANTAMOUR, 1960. | <i>laxifolia</i> | 11 | 22 | GULLINE, 1952. |
| <i>mugo</i> | 12 | 24 | SAX and SAX, 1933; STIFF, 1952. | <i>selaginoides</i> | 11 | 22 | GULLINE, 1952. |
| <i>nigra</i> | 12 | 24 | SAX and SAX, 1933; MEHRA and KHOSHOO, 1956a. | <i>Cryptomeria</i> (x=11) | | | |
| <i>palustris</i> | — | 24 | MATHEWS, 1932. | <i>japonica</i> | 11 | 22 | SAX and SAX, 1933; MEHRA and KHOSHOO, 1956a. |
| <i>parviflora</i> | 12 | — | SAX and SAX, 1933. | | — | 22, 33, 44 | } CHIBA, 1950; ZINNAI and CHIBA, 1951; SAITO and HASHIZUME, 1958. |
| <i>patula</i> | — | 24 | BOWDEN, 1945. | | | | |
| <i>peuce</i> | 12 | 24 | SAX and SAX, 1933; STIFF, 1952. | <i>Taxodium</i> (x=11) | | | |
| <i>pinaster</i> | — | 24 | MEHRA and KHOSHOO, 1956a. | <i>distichum</i> | — | 22 | STEBBINS, 1948. |
| <i>pinea</i> | — | 24 | STIFF, 1952; LANE, 1955. | <i>mucronatum</i> | — | 22 | MEHRA and KHOSHOO, 1956a. |
| <i>ponderosa</i> | 12 | 24 | SAX and SAX, 1933; MEHRA and KHOSHOO, 1956a. | <i>Metasequoia</i> (x=11) | | | |
| <i>pungens</i> | — | 12 | SAX and SAX, 1933. | <i>glyptostroboides</i> | — | 22 | STEBBINS, 1948. |
| <i>radiata</i> | — | 24 | MEHRA and KHOSHOO, 1956a. | <i>Sequoiadendron</i> (x=11) | | | |
| | — | 24, 48 | RODGER, 1953—54. | <i>giganteum</i> | — | 22 | BUCHHOLZ, 1939; JENSEN and LEVAN, 1941. |
| <i>resinosa</i> | 12 | — | SAX and SAX, 1933. | <i>Sequoia</i> (x=11) | | | |
| <i>rigida</i> | 12 | — | SAX and SAX, 1933. | <i>sempervirens</i> | 33 | 66 | HIRAYOSHI and NAKAMURA, 1943; STEBBINS, 1948; STIFF, 1952. |
| <i>roxburghii</i> | 12 | 24 | SETHI, 1928; MEHRA and KHOSHOO, 1956a. | | | | |
| <i>sabiniana</i> | — | 24 | STIFF, 1952. | | | | |
| <i>strobos</i> | 12 | — | SAX and SAX, 1933. | | | | |
| <i>sylvestris</i> | 12 | 24 | SAX and SAX, 1933; STIFF, 1952. | | | | |
| <i>tabulaeformis</i> | 12 | — | SAX and SAX, 1933. | | | | |
| <i>taeda</i> | — | 24 | SHIBATA et al, 1955. | | | | |
| <i>thunbergii</i> | 12 | 24 | SAX and SAX, 1933; STIFF, 1952. | | | | |
| <i>virginiana</i> | 12 | — | SAX and SAX, 1933; STIFF, 1952. | | | | |
| <i>wallichiana</i> (<i>griffithii</i>) | 12 | 24 | MEHRA and KHOSHOO, 1956a; SANTAMOUR, 1960. | | | | |
| 8. Sciadopityaceae | | | | | | | |
| <i>Sciadopitys</i> (x=10) | | | | | | | |
| <i>verticillata</i> | 10 | 20 | SAX and BEAL, 1934; TAHARA, 1937, 1940b; HIRAYOSHI, 1942; HIRAYOSHI and NAKAMURA, 1942. | | | | |
| 9. Taxodiaceae | | | | | | | |
| <i>Cunninghamia</i> (x=11) | | | | | | | |
| <i>konishii</i> | 11 | 22 | HIRAYOSHI and NAKAMURA, 1942; STIFF, 1952. | | | | |
| <i>lanceolata</i> | 11 | 22 | SUGIHARA, 1941a; MEHRA and KHOSHOO, 1956a. | | | | |
| <i>Taiwania</i> (x=11) | | | | | | | |
| <i>cryptomerioides</i> | 11 | 22 | SUGIHARA, 1941b; STIFF, 1952. | | | | |
| 10. Cupressaceae | | | | | | | |
| | | | | <i>Actinostrobus</i> (x=11) | | | |
| | | | | <i>pyramidalis</i> | — | 22 | MEHRA and KHOSHOO, 1956a. |
| | | | | <i>Callitris</i> (x=11) | | | |
| | | | | <i>calcarata</i> | — | 22 | MEHRA and KHOSHOO, 1956a. |
| | | | | <i>cupressiformis</i> | — | 22 | MEHRA and KHOSHOO, 1956a. |
| | | | | <i>glauca</i> | — | 22 | MEHRA and KHOSHOO, 1956a. |
| | | | | <i>morrisoni</i> | — | 22 | MEHRA and KHOSHOO, 1956a. |
| | | | | <i>propinqua</i> | — | 22 | MEHRA and KHOSHOO, 1956a. |
| | | | | <i>robusta</i> | — | 22 | MEHRA and KHOSHOO, 1956a. |
| | | | | <i>verrucosa</i> | — | 22 | MEHRA and KHOSHOO, 1956a. |
| | | | | <i>Widdringtonia</i> (x=11) | | | |
| | | | | <i>cupressoides</i> | — | 22 | MEHRA and KHOSHOO, 1956a. |
| | | | | <i>Libocedrus</i> (x=11) | | | |
| | | | | <i>bidwillii</i> | 11 | 22 | HAIR and BEUZENBERG, 1958b. |
| | | | | <i>chilensis</i> | — | 22 | STIFF, 1952; HUNZIKER, 1958. |
| | | | | <i>plumosa</i> | 11 | 22 | LANE, 1955; HAIR and BEUZENBERG, 1958b. |

| Species | Chromosome number | | Reference | Species | Chromosome number | | Reference |
|--|-------------------|----|--|--|-------------------|---------------|---|
| | n | 2n | | | n | 2n | |
| <i>Tetraclinis</i> (x=11) | | | | <i>communis</i> | 11 | 22 | SAX and SAX, 1933; LÖVE and LÖVE, 1948; JØRGENSEN et al, 1958. |
| <i>articulata</i> | — | 22 | MEHRA and KHOSHOO, 1956a. | <i>formosana</i> | — | 22 | STIFF, 1952. |
| <i>Cupressus</i> (x=11) | | | | <i>horizontalis</i> | 11 | 22 | ROSS and DUNCUN, 1949. |
| <i>arizonica</i> | 11 | 22 | MEHRA and KHOSHOO, 1956a; HUNZIKER, 1958. | <i>monosperma</i> | — | 22 | STIFF, 1952. |
| <i>cashmeriana</i> | 11 | — | MEHRA and KHOSHOO, 1956a. | <i>phoenicea</i> | 11 | 22 | STIFF, 1952; MEHRA and KHOSHOO, 1956a. |
| <i>dupreziana</i> | 11 | — | QUÉZEL, 1955. | <i>procera</i> | — | 22 | MEHRA KHOSHOO, 1956a. |
| <i>forbesii</i> | — | 22 | STIFF, 1952. | <i>rigida</i> | 11 | — | SAX and SAX, 1933. |
| <i>funnebris</i> | 11 | 22 | MEHRA and KHOSHOO, 1956a; HUNZIKER, 1958. | <i>sabina</i> | — | 22—24 | REESE, 1952. |
| <i>glabra</i> | — | 23 | HUNZIKER, 1958. | <i>squamata meyeri</i> | — | 44 | JENSEN and LEVAN, 1941. |
| <i>lusitanica</i> | 11 | 22 | CÂMARA and DE JESUS, 1946; MEHRA and KHOSHOO, 1956a; HUNZIKER, 1958. | <i>virginiana</i> | 11 | 22 | SAX and SAX, 1933; LÖVE and LÖVE, 1948; ROSS and DUNCUN, 1949; MEHRA and KHOSHOO, 1956a. |
| <i>macnabiana</i> | — | 22 | STIFF, 1952. | | — | 22, 23 | STIFF, 1951, 1952. |
| <i>macrocarpa</i> | — | 22 | STIFF, 1952; HUNZIKER, 1958. | <i>virginiana</i> × <i>horizontalis</i> | 11 | 22 | ROSS and DUNCUN, 1949. |
| <i>sempervirens</i> | — | 22 | MEHRA and KHOSHOO, 1956a; HUNZIKER, 1958. | <i>utahensis</i> | — | 22 | STIFF, 1952. |
| <i>torulosa</i> | 11 | 22 | MEHRA and KHOSHOO, 1956a; HUNZIKER, 1958. | | | | |
| <i>Chamaecyparis</i> (x=11) | | | | IV. EPHEDRALES | | | |
| <i>lawsoniana</i> | 11 | — | SAX and SAX, 1933. | 11. Ephedraceae | | | |
| <i>obtusa</i> | 11 | 22 | HIRAYOSHI, 1942; HIRAYOSHI and NAKAMURA, 1942; SHIBATA et al, 1955. | <i>Ephedra</i> (x=7) | | | |
| <i>pisifera</i> | 11 | — | SUGIHARA, 1938; STIFF, 1952. | <i>altissima</i> | 14 | 28 | RESENDE, 1937; MEHRA, 1946. |
| var. <i>pisifera</i> | — | 20 | SHIBATA et al, 1955. | <i>americana</i> | 7 | 14 | FLORIN, 1932; RESENDE, 1937; HUNZIKER, 1955. |
| var. <i>squarrosa</i> | — | 22 | SHIBATA et al, 1955. | <i>as andina</i> | — | 14, 28, 30 | } HUNZIKER, 1953, 1955. |
| × <i>Cupressocyparis</i> (x=11) | | | | <i>as rupestris</i> | — | 14 | |
| <i>leylandii</i> | — | 22 | STIFF, 1952. | <i>breana</i> | — | 14, 28 | HUNZIKER, 1953, 1955; KRAPOVICKAS, 1954. |
| <i>Thujaopsis</i> (x=11) | | | | <i>distachya</i> | — | 28 | FLORIN, 1932; RESENDE, 1937. |
| <i>dolabrata</i> | 11 | — | SUGIHARA, 1939. | <i>equisetina</i> | — | 14 | FLORIN, 1932. |
| <i>Thuja</i> (x=11) | | | | <i>foliata</i> | 7 | — | MEHRA, 1946. |
| <i>occidentalis</i> | 11 | 22 | SAX and SAX, 1933; MEHRA and KHOSHOO, 1956a. | <i>fragilis (campylo- poda)</i> | 7 | — | GEITLER, 1929. |
| <i>plicata</i> | 11 | — | SAX and SAX, 1933. | <i>frustillata</i> | — | 14 | KRAPOVICKAS, 1954; HUNZIKER, 1955. |
| <i>standishii</i> | 11 | — | SAX and SAX, 1933. | <i>gerardiana</i> | 7 | — | MEHRA, 1946. |
| <i>Biota</i> (x=11) | | | | <i>intermedia</i> | 14 | 28 | MEHRA, 1946. |
| <i>orientalis (Thuja orientalis)</i> | 11 | 22 | SAX and SAX, 1933; MEHRA and KHOSHOO, 1956a. | <i>likiagensis</i> | 14 | — | MEHRA, 1946. |
| <i>Juniperus</i> (x=11) | | | | <i>multiflora</i> | — | 14 | KRAPOVICKAS, 1954; HUNZIKER, 1955. |
| <i>bermudiana</i> | 11 | — | MEHRA and KHOSHOO, 1956a. | <i>nebrodensis (major)</i> | 7 | 14 | GEITLER, 1929; FLORIN, 1932; MARTINEZ VAZQUEZ, 1959. |
| <i>chinensis pfitzeriana</i> | 22 | — | SAX and SAX, 1933. | <i>ochreatea</i> | — | 14 | KRAPOVICKAS, 1954; HUNZIKER, 1955. |

| Species | Chromosome number | | Reference |
|------------------|-------------------|----|---|
| | n | 2n | |
| <i>saxatilis</i> | 14 | — | MEHRA, 1946. |
| <i>sinica</i> | 14 | 28 | RESENDE, 1937; MEHRA, 1946. |
| <i>triandra</i> | 7 | 14 | HUNZIKER, 1953, 1955; KRAPOVICKAS, 1954. |
| <i>tweediana</i> | 7 | 14 | HUNZIKER, 1953, 1955; KRAPOVICKAS, 1954. |

V. WELWITSCHIALES

12. Welwitschiaceae

| | | | |
|---------------------------|---|--------|------------------|
| <i>Welwitschia</i> (x=21) | | | |
| <i>mirabilis</i> | — | 42 | FLORIN, 1932. |
| | — | 42, 84 | FERNANDES, 1936. |

VI. GNETALES

13. Gnetaceae

| | | | |
|----------------------|----|---|----------------------|
| <i>Gnetum</i> (x=22) | | | |
| <i>gnemon</i> | 22 | — | FAGERLIND, 1941. |
| <i>ula</i> | 22 | — | MEHRA and RAI, 1957. |

Summary

This paper consolidates the information on the chromosome numbers of 264 species (42%) and some hybrids in the gymnosperms. The investigated species belong to 55 genera (82%) covering all the 13 living families of the group. This leaves nearly 387 species and 12 genera totally unworked. The latter urgently need a cytological study. After reviewing the recent important cytological contributions, the writer has put forward some suggestions for future work. It is requested that omissions, if any, may be pointed out to the writer so that the list becomes complete and up-to-date. Furthermore, he will feel deeply grateful to anyone who can send him viable seeds of any species of the totally unworked or the partially worked out genera listed in the first part of the paper.

Zusammenfassung

Titel der Arbeit: *Chromosomenzahlen bei Gymnospermen*.

Die vorliegende Publikation faßt die Kenntnisse über die Chromosomenzahlen von 264 Spezies (42%) und einigen Hybriden bei den Gymnospermen zusammen. Die untersuchten Arten gehören 55 Gattungen (82%) an und entstammen allen der 13 lebenden Familien dieser Gruppe. Es bleiben dabei etwa 387 Spezies und 12 Gattungen vollständig unbearbeitet, die noch unbedingt zytologisch untersucht werden müssen. Nach einem Überblick über wichtige neuere zytologische Beiträge macht Verfasser Vorschläge für künftige Arbeiten. Es wird gebeten, womöglich vorhandene Lücken dem Autor mitzuteilen, damit die Liste vervollständigt werden kann. Ferner wäre er sehr dankbar für keimfähige Samenproben von den Arten aus den Gattungen des ersten Teils der Arbeit, die bisher noch vollständig unbearbeitet geblieben oder nur teilweise untersucht worden sind.

Résumé

Titre de l'article: *Nombres chromosomiques chez les Gymnospermes*.

Cet article confirme et vérifie les renseignements sur les nombres chromosomiques de 264 espèces (42%) et quelques hybrides de Gymnospermes. Les espèces étudiées appar-

tiennent à 55 genres (82%) appartenant à l'ensemble des 13 familles du groupe qui existe actuellement. 387 espèces et 12 genres n'ont pas été étudiés. L'étude cytologique paraît tout à fait nécessaire. Après avoir passé en revue les publications récentes et importantes sur ce sujet, l'auteur fait des propositions pour les travaux futurs. Si certaines omissions sont remarquées, l'auteur souhaite qu'elles lui soient signalées afin qu'il puisse compléter et mettre à jour cette liste. De plus, il sera profondément reconnaissant à ceux qui pourront lui envoyer des graines viables de toutes les espèces appartenant aux genres qui, d'après la première partie de l'article, n'ont fait l'objet d'aucune étude ou ont été incomplètement explorés.

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