Studies on the Cytology and Phylogeny of South Indian Grasses

I. Subfamilies Bambusoideae, Oryzoideae, Arundinoideae and Festucoideae

J. Christopher and A. Abraham

Department of Botany, University of Kerala,
Trivandrum, India

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Introduction

The family Gramineae is one of the largest and the most widely distributed among the flowering plants. Economically the grasses are probably of greater importance than any other family of plants. From Pre-Linnean days, systematists were engaged in the classification of grasses into tribes, subtribes, genera and species. The older classifications were based on morphological characters such as the structure of the inflorescence, the number of florets in the spikelets, etc. Very early in the history of taxonomy of grasses some investigators found that the important question of phylogenetic relationships could not be answered by a study of gross morphology alone. Therefore additional data from anatomy, cytology etc., have been used in their attempts to find out the phylogenetic and systematic relationships among species and genera. Several investigators (Avdulov 1931, Hunter 1934, Flovik 1938, Pilger 1954, Tischler 1954, Tateoka 1957, Stebbins 1956, 1961 etc.) have attempted to use cytological data as an aid in the classification of grasses.

While a great deal of work has been done on the temperate zone grasses, the tropical and sub-tropical species have received relatively less attention. In this family of about 620 genera (Hutchinson 1959) and over 10,000 species (Carnahan and Hill 1961) it is estimated that about 150 genera and 500 species occur in South India. The southern part of India lying between 8°N and 22°N latitude has a tropical climate. In the hill ranges of the Western Ghats, which extend from Cape Comorin in the south to the Tapti Valley in the north of Peninsular India, the rainfall is heavy due to South-east monsoon and this area has one of the richest floras to be met with anywhere.

The present work is concerned with a cytological study of grasses commonly occurring in South India. The main objective of this investigation was to re-examine the taxonomic status and inter-relationships of the various tribes and genera of the family Gramineae occurring in South India, making use of the additional evidence from cytology. In reporting the present work it was found advantageous to follow the system outlined by Stebbins and Crampton

(1961) according to which the family is divided into six subfamilies-Bambusoideae, Oryzoideae, Arundinoideae, Festucoideae, Eragrostoideae and the Panicoideae. The present paper deals with the cytology of twenty four species, belonging to sixteen genera, representing the subfamilies Bambusoideae, Oryzoideae, Arundinoideae and Festucoideae.

Materials and methods

Materials used in the present investigation were collected from different parts of Kerala and a few hilly regions in Madras State of Southern India,

Map of South India showing the important localities (1-15) from which collections were made.

during 1957-'62. The Western Ghats with its luxuriant vegetation provided the source for most of the species. The grasses were chiefly collected from

Ponmudi (1,500–3,000ft.), Aryankavu (3,000ft.), Malampuzha (1,500ft.), Kallikad (1,000 ft.), Mahendragiri (2,000 ft.), Marutvamala (1,500 ft.), Kodaikanal (6,000–7,000 ft.), Ootacamund (6,000–7500 ft.), Courtallam (1,000 ft.), Devicolam (6,000 ft.), Peermade (3,000–4,000 ft.), Thekkadi (3,000 ft.) and Munnar (3,500–5,000 ft.). In addition several collections were made from the plains in regions around Trivandrum. Somatic chromosomes were studied in cases where good root tips were available and for the study of meiosis flower bud materials were used. Micropreparations were made using the acetocarmine technique throughout this study.

Cytological observations

Subfamily I—Bambusoideae

The bamboos are quite distinct from all other grasses owing to the woody character of most species. Two species belonging to the genera *Bambusa* and *Dendrocalamus* of the tribe Bambuseae have been investigated in the present study.

Bambusa tulda Roxb.: A tufted bamboo found commonly in India, Burma and Siam. The trees reach a height of about 60 feet, with thornless, smooth, hollow stems.

There is no previous cytological report on this species. A few seedlings were obtained from the Public Gardens, Trivandrum and squash preparations of root tips showed 70 chromosomes which were small in size, ranging in length between 0.5μ and 2μ (Fig. 1).

Dendrocalamus strictus Nees: This is a deciduous densely tufted bamboo with long stems which are solid or with a small cavity. It grows gregariously over large areas and these bamboos are of great economic importance.

Richharia and Kotwal (1940) reported the somatic chromosome number in this species as $2n=72$. Parthasarathy (1946) reported its chromosome number as $n=35$ and $2n=70$. During the present study, 35 bivalents have been observed at diakinesis (Fig. 2). Meiosis was regular.

Subfamily II—Oryzoideae

The cytology of three species belonging to three genera of the tribe Oryzeae has been studied during this investigation.

Oryza granulata Nees et Arn.: It is a perennial grass common in hilly regions upto an altitude of 4,000 ft. The plants are about 3 feet high, slender and tufted and the racemes are borne on long peduncles. It was collected from Aryankavu.

Meiosis was regular and 12 bivalents were observed in pollen mother cells at metaphase I (Fig. 3). Mitosis has shown 24 chromosomes, six of which are about 4μ in length while the remaining 18 are about 2.5μ in length

Figs. 1-13. Photomicrographs of chromosomes of grasses. All figures are reproduced at a magnification of $\times 1,125$. 1, *Bambusa tulda* Roxb. $2n=70$. 2, *Dendrocalamus strictus* Nees. Diakinesis showing 36 bivalents. 3, first meiotic metaphase in *Oryza granulata* Nees et Arn.

and the constrictions are median or submedian (Fig. 4). Krishnaswamy *et al.* (1954) have also reported the chromosome number of this species as $n=12$ and $2n=24$.

Hygrophysa aristata (Retz.) Nees: It occurs in ponds and lakes all over India and Ceylon, especially in coastal areas and forms dense mats on the surface of water. Cytological study showed 24 chromosomes in root tip cells. The chromosomes are small in size, six of which are about 2.5μ in length while the remaining 18 range in length between 1μ and 1.5μ (Fig. 5). Ramanujam (1938) has also reported the chromosome number of this species as $2n=24$.

Leersia hexandra Swartz.: It is a gregarious perennial grass which occurs throughout India in swamps, ponds and lakes. This species showed a somatic chromosome count of $2n=48$. The chromosomes are very small and only about 1μ – 1.5μ in length with median or submedian constrictions (Fig. 6). Ramanujam (1938) has recorded the chromosome number of this species as $2n=48$. Brown (1948) has reported $n=24$ for this species from America.

Subfamily III—Arundinoideae

The cytology of 16 species and 3 varieties belonging to 8 genera has been studied.

Tribe I—Arundineae

The cytology of two species of this tribe has been studied during the present investigation.

Arundo donax Linn. (Spanish Reed): This species, a native of the Mediterranean region, is now widely distributed throughout the world. Material for the present study was collected from Veli.

Hunter (1934) reported $2n=110$ for this species. Somatic chromosome studies of the Veli material showed 72 chromosomes in root tip cells. The chromosomes are small-sized ranging in length between 1μ and 3μ with median or submedian constrictions (Fig. 7).

Arundo donax Linn. var. *versicolor* (Miller) Stokes: This is an ornamental variety with striped leaves often grown in gardens. There is no previous cytological report on this variety. This is a difficult cytological material, but 108 chromosomes were clearly counted in the root tip cells. The chromosomes range in length between 1μ (in 18 chromosomes) to 4.5μ (in 18), the remaining 36 chromosomes falling in the size range 2μ to 3μ (Fig. 8).

showing 12 bivalents. 4, *Oryza granulata* Nees et Arn. $2n=24$. 5, *Hygrophysa aristata* (Retz.) Nees. $2n=24$. 6, *Leersia hexandra* Swartz. $2n=48$. 7, *Arundo donax* Linn. $2n=72$. 8, *Arundo donax* Linn. var. *versicolor* (Miller) Stokes. $2n=108$. 9, *Phragmites karka* (Retz.) Trin. $2n=48$. 10, *Aristida setacea* Retz. $2n=44$. 11, *Aristida adscensionis* Linn. Diakinesis. $n=11$. 12, *Centotheca lappacea* (Linn.) Desv. $2n=24$. 13, *Thysanolaena maxima* (Roxb.) Ktze. $2n=24$.

Phramites karka (Retz.) Trin.: It is a very large grass with rather close-jointed hollow stems, which spreads widely by means of stolons. This species grows chiefly near the banks of rivers and lakes and was collected from Veli.

Ramanathan (1950) has reported the chromosome number of this species from India to be $2n=36$, while Tateoka (1956) has reported $2n=48$ for this species from Japan. The present study of mitosis has shown 48 chromosomes in root tip cells. Thirty six chromosomes are small-sized, ranging in length from 1μ – 2.5μ while 12 chromosomes are longer being, about 3.5μ in length (Fi. 9).

Tribe II—Aristideae

Cytology of two species belonging to the genus *Aristida* has been studied.

Aristida setacea Retz.: It is a sporadic grass growing on dry hilly ground in all localities, up to an altitude of 3,000 ft. There is no previous cytological report on this species. Mitosis showed 44 chromosomes which ranged in length between 1μ and 3μ with median or submedian constrictions (Fig. 10).

Aristida adscensionis Linn.: This is a densely tufted annual erect grass which occurs throughout the plains and low hills of India and all warm countries. Cytological studies showed 11 bivalents in pollen mother cells (Fig. 11). Meiosis was regular. Covas and Bocklet (1945) have reported the chromosome number of this species as $2n=22$.

Tribe III—Centothecae

The cytology of *Centotheca lappacea* (Linn.) Desv. has been studied. This is a perennial grass 1–5 ft. in height with a woody root stock, growing commonly in shady places and forests upto an altitude of 4,000 ft. It was collected from Aryankavu. Somatic chromosome studies show 24 chromosomes which are small-sized, about 1.5μ in length and nearly of uniform size (Fig. 12). Adulov (1931) has also reported the same somatic number for this species.

Tribe IV—Thysanolaeneae

The cytology of one species viz., *Thysanolaena maxima* (Roxb.) Ktze. has been studied during the present investigation. This species is found in tropical Asia and South America. It grows commonly on the banks of tanks and rivers, in the plains and low hills, throughout India. Material for the present study was collected from Veli.

There is no previous report on the chromosome number of this species. Preparations of root tip cells have shown 24 chromosomes which are small-sized, about 1.5μ to 2μ in length with median or submedian constrictions (Fig. 13).

Tribe V—Garnotieae

Cytology of three species and one variety belonging to the genus *Garnotia* has been studied during the present work. This is the first cytological report

on all these species.

Garnotia stricta Brongn.: It is an annual slender grass with the stems usually geniculate and branched at the base. This species is very common in the Western Ghats between altitudes of 3,000 and 6,000 ft. and was collected from Courtallam. Preparations of meiosis from bud materials fixed in the field showed 10 bivalents in pollen mother cells (Fig. 14).

Garnotia stricta Brongn. var. *khasiana* Stapf.: It is a perennial grass with erect reed-like stems about 3–4 ft. in height. This plant was also collected from Courtallam. Root tip cells showed 20 chromosomes which ranged in length between 1.5μ and 4μ (Fig. 15).

Garnotia arundinacea Hook.: It is a perennial grass with the stems as thick as a pigeon's quill. This species is very common in hilly regions between 2,000 and 6,000 ft. elevation and was collected from Peermade. Only mitosis could be studied and 20 chromosomes were observed (Fig. 16).

Garnotia elata (Arn.) Janowsky.: This perennial caespitose species with long narrow leaves was obtained from Marutvamala. It showed a somatic chromosome count of $2n=20$ (Fig. 17).

Tribe VI—Arundinelleae

The cytology of seven species belonging to two genera has been investigated.

Arundinella mesophylla Nees.: It is an annual erect grass with slender stems 1–2 ft. in height. The panicles are 3–4 inches long and the rachis is hairy with sessile spikelets. This grass commonly occurs in the Western Ghats between altitudes of 3,000 and 7,000 ft. and was collected from Devicolam. The cytology of this species is studied for the first time. Mitosis has shown 16 chromosomes which are about 2μ to 2.5μ in length (Fig. 18).

A. setosa Trin.: It is a perennial grass having densely tufted stems 1–3 ft. high and with a woody root stock. Ramanathan (1950) reported the chromosome number of this species to be $2n=20$. In materials collected from Marutvamala, however, only 8 bivalents were observed in pollen mother cells at metaphase I (Fig. 19).

A. nepalensis Trin.: This is a perennial grass with a woody, creeping root stock. It occurs in the Western Ghats between altitudes of 3,500 and 7,000 ft. and the material examined was collected from Peermade. De Wet (1958) reported the chromosome number of this species from Transvaal to be $2n=54$. The present study has shown 20 chromosomes in root tip cells. The chromosomes range in length between 2μ and 4μ (Fig. 20).

A. leptochloa (Nees) Hook.: This is a tall slender grass, about 2 ft. high with narrow leaves and produces pyramidal panicles. It usually occurs in the plains in moist places. This was collected from Kallikkad and the somatic chromosome number was found to be $2n=20$ (Fig. 21). The chromosomes are small-sized, being about 1.5μ to 2.5μ in length. This is the first cytological report on this species.

Figs. 14-29. Photomicrographs of chromosomes of grasses. All figures are reproduced at a magnification of $\times 1,125$. 14, first meiotic metaphase in *Garnotia stricta* Brongn. $n=10$. 15, mitosis in a root tip cell of *Garnotia stricta* var. *khasiana* Stapf. $2n=20$. 16, *Garnotia*

Another variety of this species was collected from Mahendragiri. It was found to be taller and more robust than the previous one. Squashes of root tip cells of this plant also showed 20 chromosomes (Fig. 22). Meiosis was regular. Fig. 23 illustrates 10 chromosomes at each pole during anaphase I.

A. ciliata (Roxb.) Nees.: A small annual grass, about 1 ft. high with narrow leaves covered with soft hairs. It occurs commonly in Central India, Nilgiris and China and was collected from Thekkadi. There is no previous cytological report on this species. Meiotic studies have shown 10 bivalents at metaphase I (Fig. 24).

A. pumila (Hochst.) Steud.: This is an ornamental species very common in the hills of India. The cytology of this species is also studied for the first time. Mitosis was examined in materials collected from Thekkadi and 20 chromosomes were observed. The chromosomes range in length between 1.5μ and 2.5μ with median or submedian constrictions (Fig. 25).

Jansenella griffithiana (C. Muell.) Bor. *Jansenella* Bor is a monotypic genus commonly found in moist localities, low banks of rivers and swampy fields. It is found in the Western Ghats between 3,000 and 5,000 ft. altitude and material for the present investigation was collected from Peermade. Cytology of this genus has not been studied previously. Smears of pollen mother cells fixed in the field showed 10 bivalents at metaphase I (Fig. 26). Meiosis was regular.

Subfamily IV—Festucoideae

This subfamily consists mostly of grasses of temperate climate. The cytology of 3 species belonging to 3 genera representing the tribes Festuceae and Aveneae has been studied during the present investigation.

Tribe I—Festuceae

The cytology of two species belonging to the genera *Poa* and *Briza* has been studied.

Poa annua Linn.: This is known as the "annual meadow grass" which is found in the hills of Southern India from 3,000 to 7,000 ft. altitude. Material for the present study was collected from Kodaikanal. Litardiere (1938) reported the chromosome number of this species as $2n=28$. The present study of meiosis confirms this report and fourteen bivalents were observed at metaphase I (Fig. 27). Meiosis was regular.

arundinacea Hook. $2n=20$. 17, *Garnotia elata* (Arn.) Janowsky. $2n=20$. 18, *Arundinella mesophylla* Nees. $2n=16$. 19, metaphase I of meiosis in a pollen mother cell of *Arundinella setosa* Trin. $n=8$. 20, *A. nepalensis* Trin. $2n=20$. 21, *A. leptochloa* (Nees) Hook. $2n=20$. 22, another variety of *A. leptochloa* (Nees) Hook. $2n=20$. 23, anaphase I in the above species showing regular separation of 10 chromosomes. 24, *Arundinella ciliata* (Roxb.) Nees. Metaphase I of meiosis showing 10 bivalents. 25, *Arundinella pumila* (Hochst.) Steud. $2n=20$. 26, *Jansenella griffithiana* (C. Muell.) Bor. First meiotic metaphase. $n=10$. 27, *Poa annua* (Linn.) meiosis. $n=14$. 28, *Briza maxima* Linn. First meiotic metaphase. $n=7$. 29, *Helictotrichon asperum* (Munro) Bor. diakinesis showing 14 bivalents.

Briza maxima Linn.: It is a wide-spread annual, easily recognisable by the very large spikelets. This grass commonly occurs in Ootacamund, Kodaikanal and Nilgiris between altitudes of 3,000 and 7,000 ft.

Kattermann (1933) reported a somatic count of 14 chromosomes for this species. The present count agrees with this report. Smear preparations of flower bud materials fixed from Kodaikanal showed regular meiosis with 7 bivalents in pollen mother cells at metaphase I (Fig. 28).

Tribe II—Aveneae

The cytology of only one species coming under this tribe has been studied.

Helictotrichon asperum (Munro) Bor.: It is a perennial grass, about 4 ft. in height with long, narrow leaves. The inflorescence is a long panicle about 12" long. It occurs in the hilly regions at high elevations between 3,000 and 7,500 ft. altitude. Material for the present study was collected from Munnar. Smear preparations of bud materials showed 14 bivalents in pollen mother cells (Fig. 29). This is the first chromosome count reported for this species.

Discussion

Subfamily I—Bambusoideae

Tribe Bambuseae

The present cytological investigation on this subfamily has been confined to two species, viz. *Bambusa tulda* ($2n=70$) and *Dendrocalamus strictus* ($n=36$). The chromosome numbers of 6 species of *Bambusa* and 5 species of *Dendrocalamus* are known so far (Darlington and Wylie 1955). It is clear from the previous records that most of the species of these two genera show a somatic number of 72 chromosomes. The exceptions are two species of *Dendrocalamus* and one species of *Bambusa* which are reported to have a somatic number of 70 chromosomes (Parthasarathy 1946). According to Parodi (1946), the basic number in this tribe is 12, in which case, the species with $2n=70$ chromosomes (including the present report for *Bambusa tulda*) are probably aneuploids.

Bews (1929), Prat (1936) and others are of the opinion that the bamboos, on account of the primitive characters of spikelets, stamens, fruits, etc. and possessing small chromosomes and the high basic number of 12, are the most primitive and ancestral to the other grass tribes. But the bamboos are highly advanced in many characters such as the leaf-epidermis (Hubbard 1948), leaf-anatomy (de Wet 1960), the reduction of the number of flowers in the spikelets in many species and also in vegetative characters. According to Hubbard (1948) and Stebbins (1956), on account of the long intervals between flowering periods, the bamboos have fewer generations than the other grasses and therefore less opportunity for change in structure and this would account for the

retention of certain primitive features among them. The infrequent flowering periods and high polyploid and aneuploid chromosome numbers, which is further confirmed by the present investigation, seem to indicate a very remote ancestry for this group of grasses.

Subfamily II—Oryzoideae

Tribe Oryzeae

The cytology of three species belonging to the genera *Oryza*, *Hygrorhiza* and *Leersia*, of this tribe has been studied during the present investigation. The chromosome numbers recorded are $2n=24$ in *Oryza granulata* Nees and *Hygrorhiza arista* Nees and $2n=48$ in *Leersia hexandra* Sw. Previous reports in this tribe show multiples of 12 only (Darlington and Wylie 1955).

The Oryzeae show a peculiar mixture of advanced and primitive characters and this tribe is differently classified by systematists. The Oryzeae are primitive in some respects, as for instance, in the prevalence of 6 stamens per floret as in the bamboos. But they are advanced in many ways, the spikelets being reduced to the one-flowered condition and the glumes often being entirely suppressed or replaced by two minute empty lemmas. Brown (1950) indicated that the internal leaf-anatomy of grasses belonging to the Oryzeae is almost similar to that of the Bambuseae and Reeder (1957) has emphasised certain similarities between them in embryo structure. Cytological evidence also shows that these two subfamilies are closely related as both have high polyploid numbers in multiples of 12.

Subfamily III—Arundinoideae

Tribe 1. Arundineae

The species studied during the present investigation are *Arundo donax* Linn. ($2n=72$), *A. donax* Linn. var. *versicolor* ($2n=108$) and *Phragmites karka* ($2n=48$). The basic number of all genera belonging to this tribe is reported as 12 (Darlington and Wylie 1955). According to Avdulov (1931), the Bambuseae, Oryzeae and the genus *Phragmites* are phylogenetically the oldest in the family and are characterised by small chromosomes with the basic number 12. *Phragmites* is of a very ancient origin as evidenced by palaeontological data (Bews 1929). *Arundo donax* var. *versicolor* ($2n=108$) has the highest number of chromosomes encountered during this investigation of South Indian grasses. No diploid species has yet been reported in this tribe and all previous reports are also of comparatively high polyploids. Stebbins and Crampton (1961) state that the subfamilies Oryzoideae and the Arundinoideae resemble each other in lodicules, leaf-epidermis, anatomy and chromosomes. The Bambuseae, Oryzeae and the Arundineae have chromosomes in multiples of 12 and it is probable that these three tribes have a common origin from the same ancestral stock.

Tribe 2. Aristideae

The cytology of two species belonging to the genus *Aristida* has been studied during this investigation (viz. *Aristida setacea* Retz., $2n=44$ and *A. adscensionis* Linn. $2n=22$). The previous reports on this genus show chromosome numbers in multiples of 9, 11 and 12 (Brown 1957 and de Wet 1960). Reeder (1957) and Stebbins and Crampton (1961) report many morphological similarities between this tribe and the Arundineae. This tribe is probably derived from the Arundineae which has the basic number 12. *Aristida* is one of the largest genera of grasses and it is a highly advanced genus ecologically also.

Tribe 3. Centotheceae

The cytological investigations on this tribe have been confined to only one species, viz. *Centotheca lappacea* Desv. ($2n=24$). The basic chromosome number in the two genera belonging to this tribe cytologically known so far is 12 (Darlington and Wylie 1955). De Wet (1960) studied the cytology of *Megastachya mucronata*, a species from South Africa, which is closely related to *Centotheca* and reported its chromosome number as $2n=48$. As this species resembles the Oryzeae in leaf-anatomy also, he concluded that the tribe Centotheceae might be looked upon as an off shoot of the primitive Oryzoid stock. The genus *Centotheca* has a very primitive character among the grasses in having many-flowered spikelets with perfect flowers only. The tribe Oryzeae is very primitive in many morphological characters. As the cytological situation in the Centotheceae is also similar to that in the Oryzeae in having chromosomes in multiples of 12, it is probable that the Centotheceae and the Oryzeae are closely related as suggested by de Wet (1960).

Tribe 4. Thysanolaeneae

The chromosome number of the monotypical *Thysanolaena maxima* Ktze. ($2n=24$) belonging to this tribe is reported for the first time. No other species of this tribe is cytologically known so far. There has been much difference of opinion regarding the taxonomic position of this genus. Hooker (1897) included this genus in the tribe Paniceae. Hubbard (1934) however included it as a separate tribe, Thysonolaeneae in the subfamily Pooideae. Blatter and Mc Cann (1935) placed this genus along with *Arundo* and *Phragmites* in the tribe Arundineae. The present study has shown that the basic chromosome number of this genus is also 12 as in the Arundineae. Therefore the present cytological findings suggest a close affinity of this tribe to the Arundineae which conforms to the classification of Stebbins and Crampton (1961).

Tribe 5. Garnotieae

The cytology of three species and one variety belonging to the genus *Garnotia* has been studied during the present investigation. There has been only one previous cytological report on this genus (*Garnotia scoparia*, $2n=20$,

Ramanathan 1950). The chromosome number of all species of this genus so far known is $2n=20$. Our knowledge about the cytology of this tribe is inadequate as no other genus has been studied so far.

Tribe 6. Arundinelleae

The cytology of seven species belonging to the genera *Arundinella* and *Jansenella* has been studied during the present investigation. Previous reports of chromosome numbers in this tribe are in multiples of three basic numbers 7, 9 and 10 (Darlington and Wylie 1955, Carnahan and Hill 1961). The chromosome numbers of the six species of *Arundinella* reported in the present study are in multiples of two basic numbers 8 (in two species) and 10 (in four species). The chromosome number of the monotypic *Jansenella griffithiana* is $2n=20$.

Hitchcock (1920) included this tribe in the Melinideae (Subfamily Panicoideae) on the basis of the spikelet characters. But Stapf (1917), Hubbard (1934) and Bor (1940) included the Arundinelleae in the subfamily Pooideae. Hackel (1887) placed two genera of this tribe, viz. *Tristachya* and *Trichopteryx* in the Aveneae on the basis of the similarity in the nature of the awns in *Arrhenatherum*, a member of the Aveneae and these two genera. According to Bews (1929), the Arundinelleae, though showing some connection with the Aveneae are more advanced than the majority of the species of the Aveneae in the reduction of the spikelets to two heteromorphous florets. The presence of small chromosomes with the basic numbers 8, 9 and 10 in this tribe is in marked contrast to the situation in the tribe Aveneae which have large chromosomes and the basic number 7. Therefore the present cytological findings confirm the systematic position assigned to this tribe by Stebbins and Crampton (1961).

Subfamily IV—Festucoideae

The present cytological studies have been confined to three species belonging to three genera representing the tribes Festuceae and Aveneae.

Tribe 1. Festuceae

The two species of this tribe studied during this investigation are *Poa annua* ($2n=28$) and *Briza maxima* ($2n=14$). The basic numbers reported in this tribe are 5, 7, 8 and 9 (Darlington and Wylie 1955, Carnahan and Hill 1961). The dominant basic number of this tribe is 7 which is also reported in the two species included in the present study. This tribe consists mostly grasses of temperate climates. The presence of the basic number 7 in the majority of the species shows that this tribe represents a separate line of evolution.

Tribe 2. Aveneae

In the tribe Aveneae, the basic numbers reported are 4, 6 and 7 (Darlington and Wylie 1955). The basic number 7 is encountered in only one species

studied during this investigation (*Helictotrichon asperum* Munro, $2n=28$). According to Brown (1950), the tribe Aveneae is characterised by large chromosomes and the basic number 7. De Wet (1960) reported that leaf-anatomy and embryo-anatomy of the typical members of the Aveneae like *Helictotrichon* are typically of the festucoid type described by Reeder (1957). This tribe is closely related to the Festuceae morphologically also. Therefore it is probable that the tribes Festuceae and Aveneae had a common origin and according to Bews (1929) the Aveneae is more advanced by the presence of longer glumes.

Summary

Cytological studies have been made of South Indian grasses with a view to re-examine the taxonomic status and inter-relationships of the various tribes and genera making use of the additional evidence from cytology. The present paper deals with the cytology of 24 species representing 16 genera. Of these, the cytology of 14 species has been studied for the first time.

The chromosomes of most of the species are very small, ranging in length between 1μ and 2.5μ . As reported by previous workers, the basic chromosome number of the grasses ranges from 5 to 12. Chromosome number in multiples of 8 which has been reported to be a rare occurrence in the grass family has been encountered in two species, viz. *Arundinella setosa* ($n=8$) and *A. mesophylla* ($2n=16$).

The presence of high polyploid and aneuploid chromosome numbers shows the role of polyploidy in the evolution of the bamboos. The Bambuseae, Oryzeae and the Arundineae are closely related as they have high polyploid numbers in multiples of 12. The Aristideae is a highly advanced tribe, probably derived from the Arundineae. The Centotheceae is closely related to the Oryzeae as suggested by de Wet (1960). The present cytological evidence shows that *Thysanolaena* is related to the Arundineae.

The present study has confirmed the systematic position assigned to the Arundinelleae by Stebbins and Crampton (1961). The Festuceae and the Aveneae which are closely related morphologically, have large chromosomes with the dominant basic number 7.

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