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Cytological Studies in Indian Cyperaceae
I. Tribe Scirpeae

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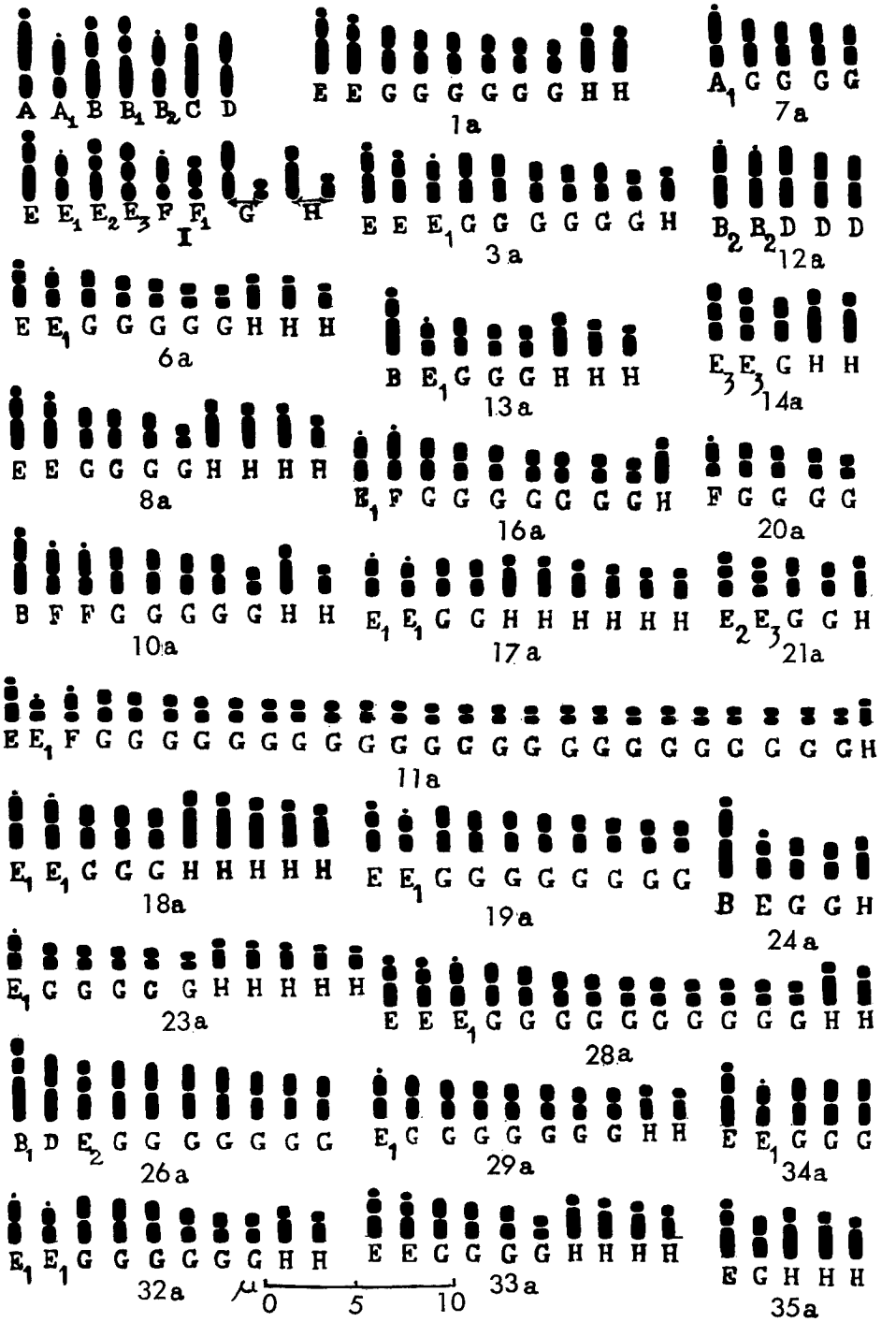
Introduction

The family Cyperaceae, though constituting a significant percentage of the monocotyledones, has not been given due attention by taxonomists. Holttum (1948), in his review on the spikelet in Cyperaceae, suggested strongly the need for a comprehensive survey and detailed comparative studies in the family. It falls in the Glumifloral complex both in Hutchinson's (1959) and Engler and Prantl's (1889-1897) systems of classification but the way through which it has been derived differs significantly in the two.

Its origin has been traced through Juncaceae, the latter again being considered as a reduced derivative of Liliaceous groups in Hutchinson's (1959) system. In Engler and Prantl's (l.c.) classification, on the other hand, though Cyperacae and Graminaceae have been grouped together under Glumiflorae, yet Juncaceae has been placed along with Liliaceae and allied families in Liliiflorae. Snell (1936) and Blaser (1940) claimed that members of Graminaceae are not close allies of Cyperaceae on certain morphological consideration. Holttum (l.c.) regarded Juncaceae to be either an unrelated group or derived from Cyperaceae (and not *vice versa*) and it is quite likely that the ancestry of primitive Liliiflorae may be traced to Cyperaceae as well.

Discrepant opinions have also been put forward regarding the delimitation and evolution within the family. The three principal subfamilies namely Scirpoideae, Rhynchosporoideae and Caricoideae have often been suggested as constituting three independent families, namely, Cyperaceae restricted to the subfamily Scirpoideae ; Rhynchosporaceae and Caricaceae (cf. Lawrence 1951). Holttum regards Scirpoideae as the most primitive of the tribes of Cyperaceae from which Rhynchosporoideae can be traced through several lines and further evolution has led to Caricoideae.

This brief resumé regarding the systematic status and affinities of the family shows that from a taxonomic stand point it is an interesting one. Cytological data is badly needed to provide clues for the solution of these taxonomic problems. Excepting in the genus *Carex*, where extensive cytological works have been carried out, data on other genera are rather meagre (Beaman *et al.* 1962, Battaglia 1954, Bernardini 1959, Böcher 1938a, b, Dietrich 1964, Favarger and Huynh 1964, Gadella and Kliphuis 1964, Harms 1964, Hedberg



Indian Cyperaceae I: explanation of figures in the text.

and Hedberg 1964, Holmen 1952, Larsen 1955, Löve and Löve 1966, Löve and Ritchie 1966). Further cytological interest is seen in the possibility of the occurrence of diffuse centromere or polycentric chromosomes in some of the genera (Davies 1956, Håkansson 1958, Mori 1957, Sharma and Bal 1956, Strandhede 1959). The family holds ample promise for a detailed cytological investigation, particularly of the representatives growing in India. A detailed investigation on the Indian representatives has been undertaken and the results on the members of Scirpeae have been embodied in the present paper and on Cypereae in a subsequent one.

Materials and methods

The present investigation has been carried out on thirty different species with three varieties and two types belonging to four genera of the tribe Scirpeae under the family Cyperaceae, collected from different parts of Eastern India.

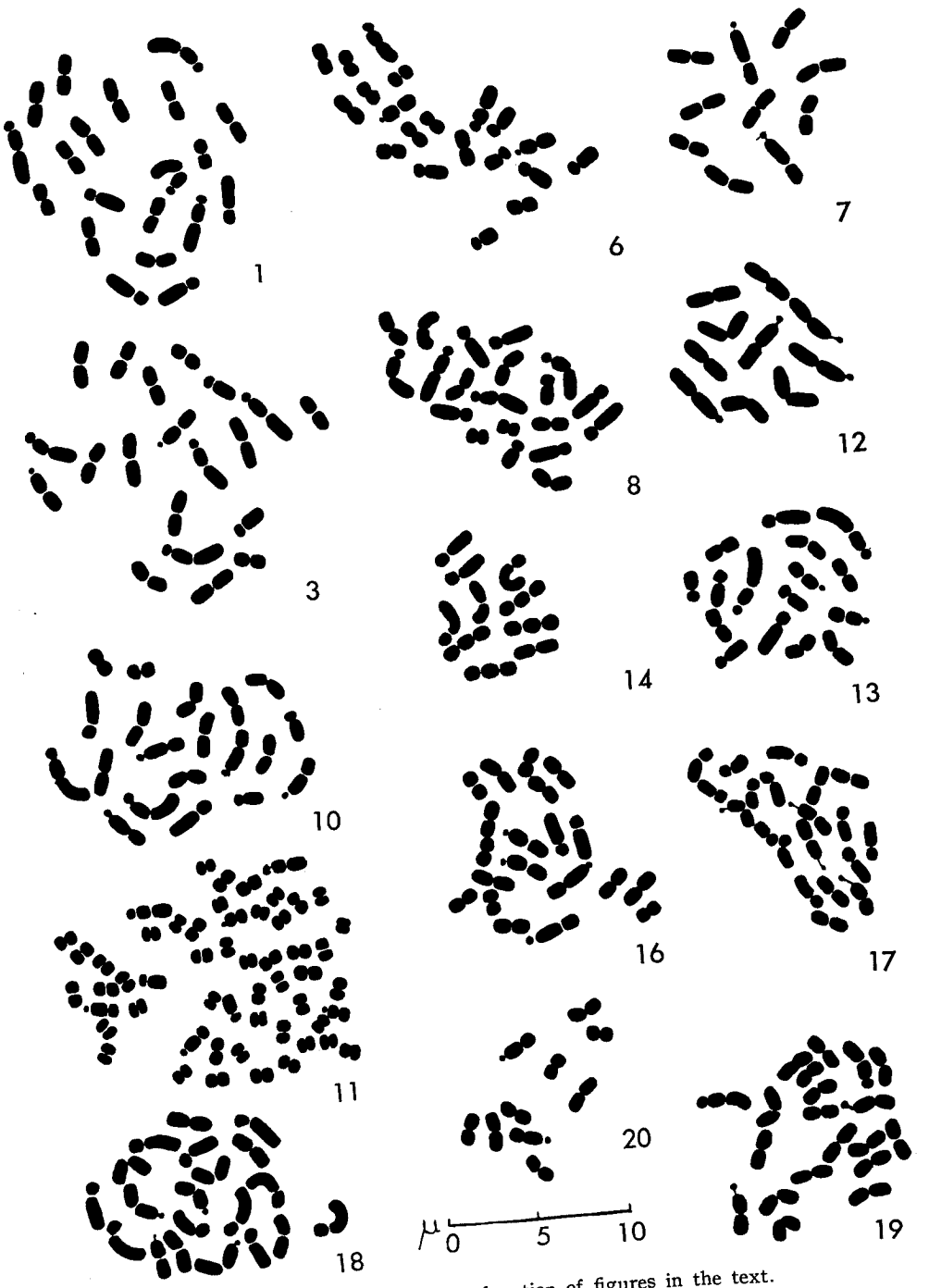
Somatic studies were made from the root tips of the plants collected from the field and grown in suitable earthenware pots within the experimental gardens attached to the Department of Botany of the University of Calcutta.

For satisfactory temporary squash preparations trials were made with various pretreating chemicals used in different concentrations and proportions. The response of chromosomes to these chemicals varies from genus to genus as well as within the species of the same genus. The healthy root tips, for better penetration of the pretreating fluid, were first suctioned through a suction pump and then kept in these chemicals at 2–4°C for 5–10 minutes, and finally transferred to comparatively higher temperature for different periods of treatment.

For the genus *Scirpus* as a whole, pretreatment with a saturated aqueous solution of aesculine at a temperature of 8–10°C for 3–4 hours gave well scattered metaphase plates. A mixture of aqueous solutions of aesculine and isopsoralene in the proportion 1:1 was effective for pretreatment in *Scirpus* at 8–10°C for 3–4 hours. A mixture of the saturated aqueous solutions of aesculine, p-dichlorobenzene and isopsoralene used in the proportion 1 : 1 : 1 at 8–10°C for 2 1/2 to 3 1/2 hours proved to be satisfactory in the species of the genera *Eleocharis*, *Fimbristylis* and *Lipocarpha*.

After pretreatment, the root tips were fixed in a mixture of acetic acid-ethyl alcohol (1 : 2) for one to two hours, then heated in a mixture of 2% acetic orcein-(N) HCl (9 : 1) solution for 5–6 seconds and kept in it for 24 hours. A pinch of ferric acetate crystals was also added to it to intensify staining. They were finally squashed in 45% acetic acid for observation.

For temporary smear preparations inflorescences of suitable size were fixed in acetic acid-ethyl alcohol (1 : 1) for 1 hour, transferred to 70% ethyl alcohol and smeared in a drop of 2% acetic-carmine solution. For scattering of the meiotic chromosomes inflorescences were pretreated with 0.002 M



Indian Cyperaceae I: explanation of figures in the text.

oxyquinoline solution at a temperature of 8-10°C for 30 minutes to 1 hour followed by fixation in acetic acid-ethyl alcohol mixture (1 : 1), wherever necessary.

The mitotic figures were drawn at a table magnification of approximately ×3,000 using a Zeiss microscope with a compensating eye piece of ×20, an apochromatic objective and an aplanatic condenser. In all cases, idiograms were drawn from temporary preparations and were verified from several metaphase plates. Variant metaphase plates were drawn wherever encountered.

Observations

The somatic chromosome numbers of the different species and varieties of the tribe Scirpeae, so far investigated, vary considerably. In the genus *Eleocharis* the somatic chromosome number of the different species has been found to range from $2n=10$ to $2n=54$. The somatic numbers of most of the species of the genus *Fimbristylis* are multiples of their basic number which is held to be 5, excepting in two cases where it has been found to be $2n=22$ and $2n=24$. *Lipocarpha argentea* reveals $2n=26$ chromosomes. The range of somatic number of the species of the genus *Scirpus* worked out here is from $2n=28$ to $2n=80$.

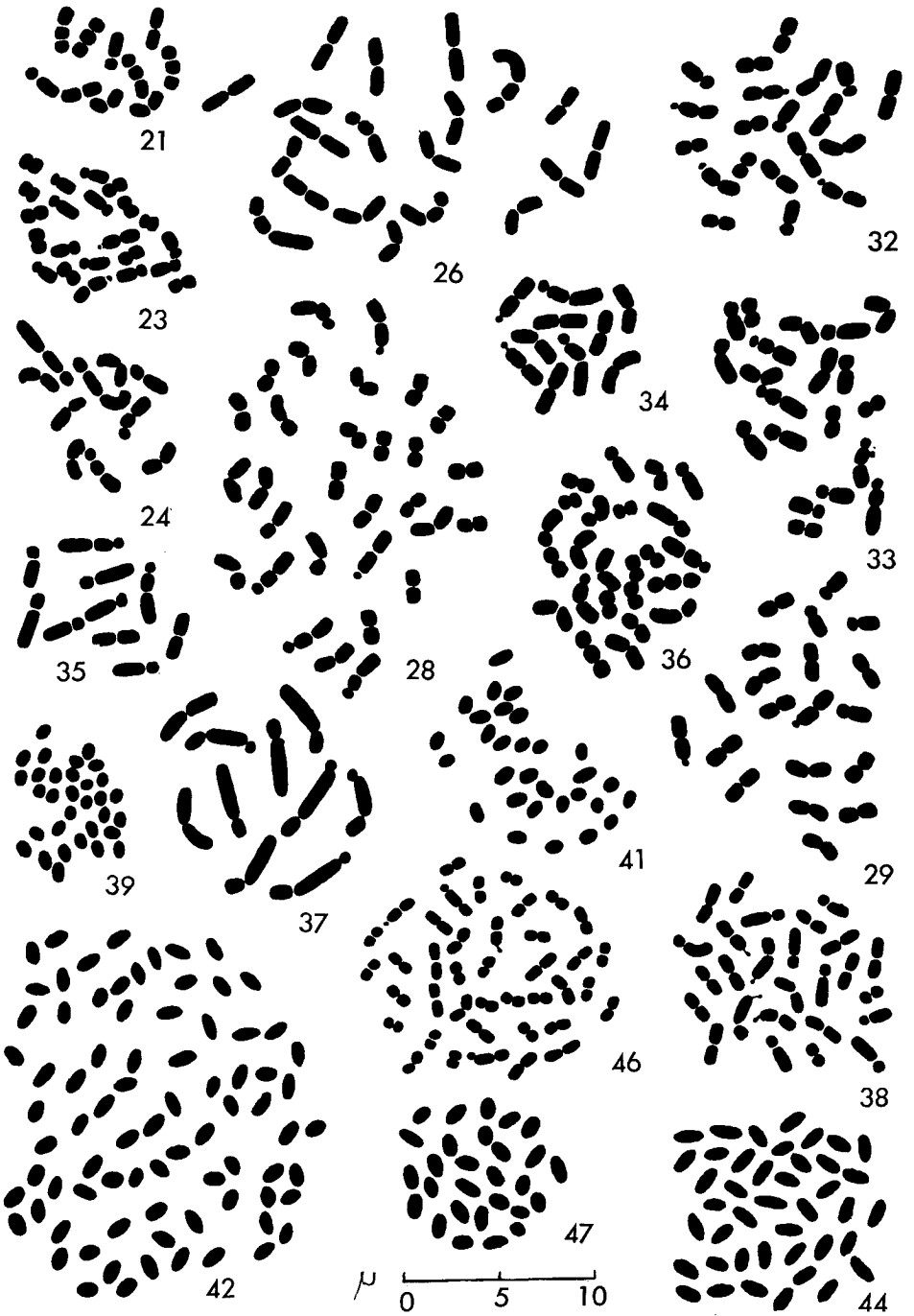
A detailed karyotype analysis reveals a gross morphological similarity in the chromosome complements of the entire family. The chromosomes, on an average, are very short in length, in comparison to the cells. Size difference is not marked with a gradual gradation. On the basis of their relative length they can be divided into three broad groups, viz.—comparatively long, medium and short. From a study of the general morphological features a number of chromosome types is seen to be common to all of them. A critical analysis, however, shows that minor alterations in the representatives of the types are met with in different species which may be considered as criteria for the identification of these species.

The following different types depending on the locations of primary and secondary constriction regions and size of the chromosome have been recorded (Fig. 1).

Type A—Comparatively long chromosome, longest in the set with both primary and secondary constrictions. One of the constrictions is submedian to nearly submedian in position and the other one is subterminal to nearly terminal at the distal end of the long arm. The middle segment is much longer than the terminal ones.

Type A_1—Comparatively long chromosome with a primary constriction ranging from nearly median to nearly submedian in position and a satellite at the distal end of the long arm. It differs from A in that the smaller end segment is a satellite.

Type B—Comparatively long chromosome with both primary and secondary constrictions. One of the constrictions is median to nearly submedian



Indian Cyperaceae I: explanation of figures in the text.

in position. The other one is subterminal in position situated on the distal end of the comparatively shorter arm. The middle segment is nearly two-third the length of the other arm and nearly double the length of the distal segment.

Type B_1—Comparatively long chromosome with two constrictions. One of the constrictions is situated at the median to nearly median position and the other one at the submedian to nearly subterminal position on the comparatively shorter arm of the chromosome. The lengths of the middle and the shorter terminal segments are almost equal.

Type B_2—Comparatively long chromosome with median to nearly median primary constriction and a satellite at the distal end of one arm.

Type C—Comparatively long chromosome with a primary constriction located in subterminal to nearly submedian positions. The shorter arm is almost one third to one fourth of the length of longer arm.

Type D—Comparatively long chromosome with primary constriction median to nearly median in position.

Type E—Medium sized chromosome with two constrictions, primary and secondary. One of the constrictions is median to nearly median in position. The other one is subterminal at the distal end of the comparatively shorter arm. The distal segment is almost one third the length of the middle segment.

Type E_1—Medium sized chromosome with a median primary constriction and a satellite at the terminal end of one of the arms.

Type E_2—Medium sized chromosome with two constrictions, primary and secondary. One of them is median to nearly median in position and the other one is submedian in position on one side of the chromosome. The middle segment is almost equal in length to the shorter segment beyond the submedian constriction.

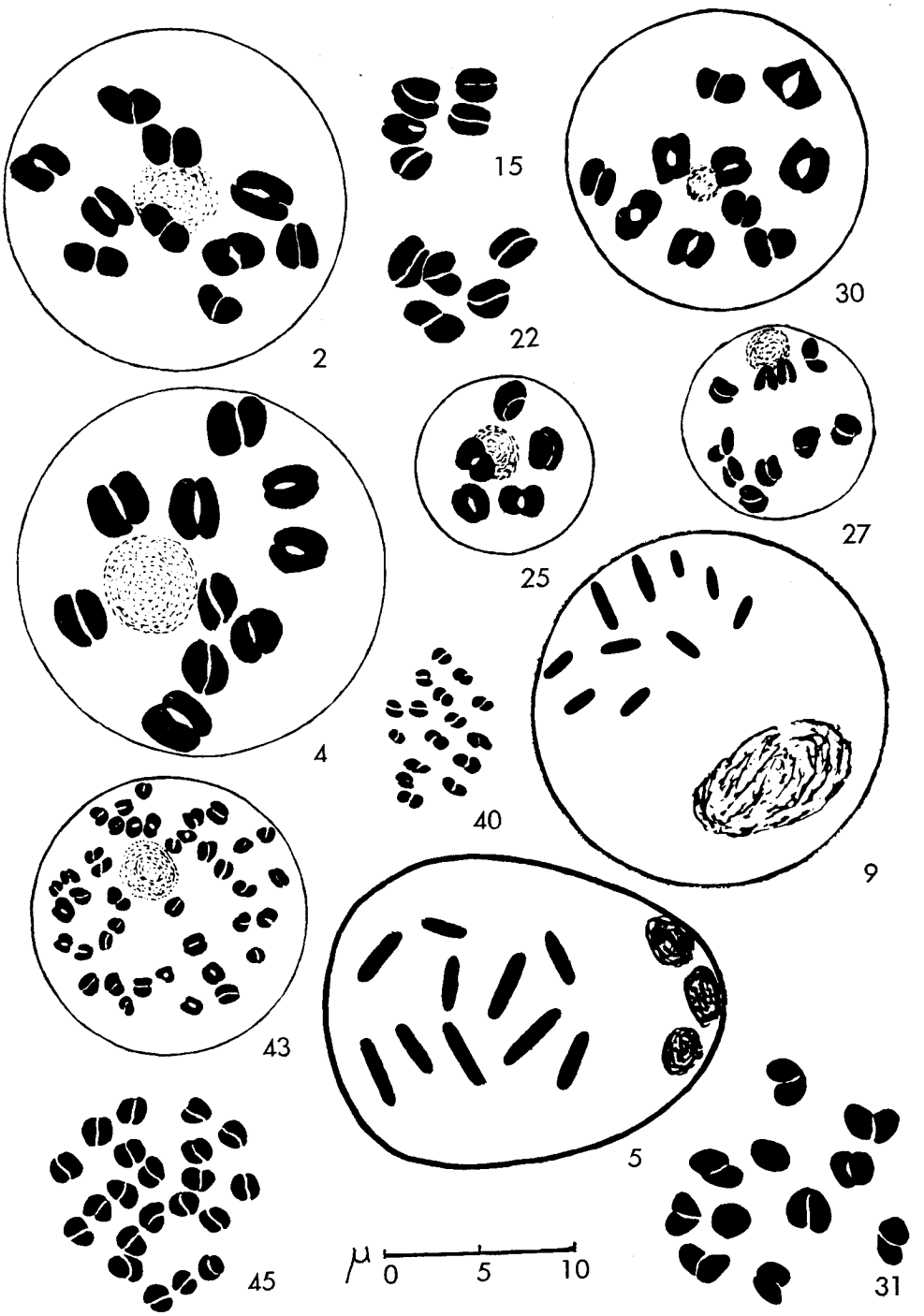
Type E_3—Medium sized chromosome with both primary and secondary constrictions. The two constrictions are submedian in position at the two opposite ends of the chromosome. The constrictions divide the chromosome into three almost equal parts.

Type F—Medium sized chromosome with submedian to nearly submedian primary constriction and a satellite at the distal end of the long arm.

Type F_1—Medium sized chromosome with both primary and secondary constrictions. The two constrictions are situated in nearly submedian positions at the two opposite ends of the chromosome. The end segments are equal in length. The middle segment is double the length of one of the end segments.

Type G—Small chromosome with a primary constriction median to nearly median in position grading from medium sized to short.

Type H—Small chromosome with a primary constriction lying in nearly subterminal to nearly submedian positions grading from medium sized to short.



Indian Cyperaceae I: explanation of figures in the text.

Genus—*Eleocharis*

Seven species and two cytotypes have been worked out in this genus.

E. afflata Steud. Type I $2n=20=4E+12G+4H=3.7-2\mu$ (Figs. 1 and 1a). $n=10_{II}$ (Fig. 2).

E. afflata Steud. Type II $2n=20=4E+2E_1+12G+2H=3.4-1.8\mu$ (Figs. 3, 3a, 4, 5). $n=10_{II}$.

The division of the PMC nucleus continues beyond the metaphase II. The metaphase presents ten chromosomes at its broader end and three organising nuclei at its narrower end suggesting the origin of polysporous condition in the pollen grain.

E. atropurpurea Kunth Type I $2n=20=2E+2B_1+10G+6H=2.6-1.4\mu$ (Figs. 6 and 6a).

E. atropurpurea Kunth Type II $2n=10=2A_1+8G=3.3-2.2\mu$ (Figs. 7, 7a).

E. capitata R. Br. $2n=20=4E+8G+8H=3.3-1.3\mu$ (Figs. 8, 8a, 9). $n=10_{II}$.

E. congesta Don. $2n=20=2B+4F+10G+4H=3.5-1.5\mu$ (Figs. 10, 10a).

E. fistulosa Schult. $2n=54=2E+2E_1+2F+46G+2H=2.3-1.0\mu$ (Figs. 11, 11a).

E. ovata R. Br. $2n=10=4B_2+6D=3.5-2.8\mu$ (Figs. 12, 12a).

E. palustris R. Br. $2n=16=2B+2E_1+6G+6H=3.6-1.9\mu$ (Figs. 13, 13a).

Genus—*Fimbristylis*

Fourteen species with three varieties and one cytotype have been worked out in this genus.

F. aestivalis Vahl. $2n=10=4E_3+2G+4H=3.1-2.5\mu$ (Figs. 14, 14a, 15). $n=5_{II}$.

F. dichotoma Vahl. $2n=20=2E_1+2F+14G+2H=2.9-1.5\mu$ (Figs. 16, 16a).

F. diphylla Vahl. $2n=20=4E_1+4G+12H=2.2-1.5\mu$ (Figs. 17, 17a).

F. diphylla var. *annua* R. and S. $2n=20=4E_1+6G+10H=3.0-2.1\mu$ (Figs. 18, 18a).

F. diphylla var. *pluristriata* Clarke $2n=20=2E+2E_1+16G=2.6-1.6\mu$ (Figs. 19, 19a).

F. dipsacea Benth. $2n=10=2F+8G=2.1-1.3\mu$ (Figs. 20, 20a).

F. ferruginea Vahl. $2n=10=2E_2+2E_3+4G+2H=2.3-1.8\mu$ (Figs. 21, 21a, 22). $n=5_{II}$.

F. junciformis Kunth $2n=22=2E_1+10G+10H=2.1-1.2\mu$ (Figs. 23, 23a).

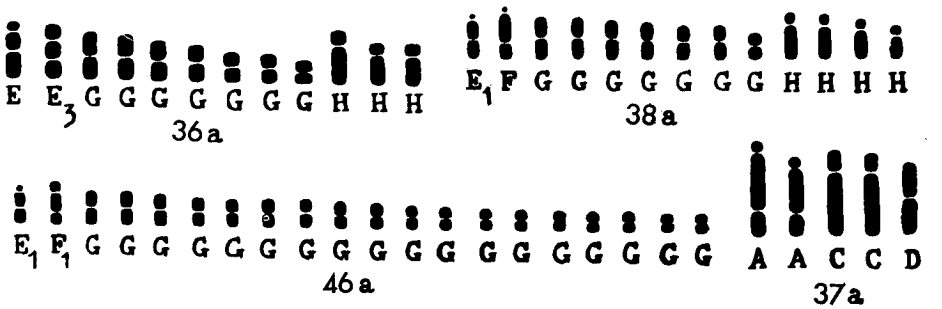
F. miliacea Vahl. $2n=10=2B+2E+4G+2H=4.2-2.0\mu$ (Figs. 24, 24a, 25). $n=5_{II}$.

F. monostachya Hassk. $2n=20=2B_1+2D+2E_2+14G=4.3-2.2\mu$ (Figs. 26, 26a, 27). $n=10_{II}$.

F. podocarpa Nees. $2n=30=4E+2E_1+20G+4H=2.6-1.3\mu$ (Figs. 28, 28a).

F. polytrichoides Vahl. $2n=20=2E_1+14G+4H=2.7-1.8\mu$ (Figs. 29, 29a, 30, 31). $n=10_{II}$.

About 30% of the PMC division contains two univalent chromosomes



Indian Cyperaceae I: explanation of figures in the text.

at the meiotic metaphase I. The metaphase I of this abnormal plate shows $9_{II}+2_{I}$ (Fig. 31).

F. polytrichoides var. *halophilia* Kurz. $2n=20=4E_1+12G+4H=2.7-1.6\mu$ Figs. 32, 32a).

F. quinquangularis Kunth $2n=20=4E+8G+8H=2.6-1.4\mu$ (Figs. 33, 33a).

F. schoenoides Vahl. Type I $2n=10=2E+2E_1+6G=3.4-2.5\mu$ (Figs. 34, 34a).

F. schoenoides Vahl. Type II $2n=10=2E+2G+6H=3.2-2.3\mu$ (Figs. 35, 35a).

F. squarrosa Vahl. $2n=24=2E+2E_3+14G+6H=2.8-1.3\mu$ (Figs. 36, 362).

F. tetragona R. Br. $2n=10=4A+4C+2D=4.7-3.6\mu$ (Figs. 37, 37a).

Genus—*Lipocarpha*

L. argentea R. Br. $2n=26=2E_1+2F+14G+8H=2.6-1.4\mu$ (Figs. 38, 38a).

Genus—*Scirpus*

Six species of the genus have been worked out. Except in one species, primary constrictions were not observed.

S. articulatus L. $2n=32=1.1-0.7\mu$ (Figs. 39, 40), $n=16_{II}$.

S. isolepis Boeck. $2n=30=1.5-1.0\mu$ (Fig. 41).

S. lacustris L. $2n=80=1.6-1.2\mu$ (Figs. 42, 43), $n=40_{II}$.

S. mucronatus L. $2n=42=1.9-1.3\mu$ (Figs. 44, 45), $n=21_{II}$.

S. squarrosus L. $2n=40=2E_1+2F_1+36G=2.2-1.0\mu$ (Figs. 46, 46a).

S. suspinus L. $2n=28=1.7-1.0\mu$ (Fig. 47).

Discussion

The different genera included within the present work fall under the tribe Scirpeae of Pax as adopted by Rendle (l.c.) and Engler and Prantl (l.c.). The genera *Eleocharis*, *Fimbristylis*, *Lipocarpha* and *Scirpus* are included within Scirpeae *sensu stricto* of Hutchinson (1959). In the former classification, the family Cyperaceae starts with Scirpeae being the most primitive one, whereas in the latter, Cypereae is the first tribe followed by Scirpeae.

Evolution and interrelationship within Scirpeae

In *Eleocharis* nine species and varieties have been studied during the present investigation and varying chromosome numbers have been reported. Though majority of the species is characterized by $n=5$ chromosomes yet there are others, such as *E. palustris* and *E. fistulosa*, showing multiples of 8 and 9 chromosomes respectively. In both *E. afflata* and *E. atropurpurea*, diploidy and polyploidy have been reported. External morphological differences are associated with polyploidy, but no ecological correlation with chromosome number could be brought out in them. Both the cytotypes of *E. afflata* were collected from temperate regions at Shillong, whereas those of *E. atropurpurea* were obtained from saline areas. Whether there is any physio-

logical adaptation involved in this difference is not yet known.

Extensive cytological investigation has been carried out in different centres of the world (Avdulov 1931, Baksay 1957, 1958, Davies 1956, Doxey 1938, Håkansson 1928, 1929, 1954, Harms 1964, Hedberg and Hedberg, 1964, Hicks 1929, Knaben 1950, Levitsky 1948, Lewis, K. R. and John 1961, Lewis 1962, Löve 1954, Löve and Löve 1956, 1961, Saunte 1958, Sorsa 1962, Tanaka 1937a, 1942, Tarnavschi 1948), but not in India, on the genus *Eleocharis*, which is often referred to as its synonym *Heleocharis*. Though $n=5$ in the most predominant number reported in the genus, yet extensive aneuploidy and polyploidy have been observed in different taxa. *E. palustris* and *E. uniglumis* are very good examples of intraspecific variation in chromosome number. A large number of aneuploid and polyploid cytotypes has been reported by Strandhede (1958) in both. In addition to these species, intraspecific variations though not so prevalent, have been reported in other species as well.

One of the principal reasons for which *Eleocharis* has been subjected to such extensive cytological investigation is the nature of its centromere, which has been supposed to be either diffuse or polycentric (Håkansson 1958, Strandhede 1958, 1961). The evidences put forward in support of the diffuse nature of the centromere involve parallel movement of the chromatids on the spindle, behaviour in meiosis, as well as survival of the fragments following irradiation. Moreover structural alterations have been regarded as one of the important features in the evolution of its species as exemplified by the heteromorphicity of the chromosome.

In the present work, on the other hand, where suitable pretreatment chemicals after standardization have been applied for the clarification of chromosome structure, no evidence of the diffuse nature could be deduced. The idiograms show localised centromeres in all the chromosomes even in the species with a chromosome number of $2n=10$. Evidences of the existence of localised centromere could be obtained from anaphase cells as well where the chromosomes show typical bends. Such anaphase configuration of course could be obtained only in preparations made without any pretreatment as otherwise spindle formation would be inhibited.

That structural changes play a very effective role in the evolution of species of *Eleocharis* is also seen from the karyotype difference between different species. Though following a common pattern in the gross morphology yet the positions of primary and secondary constrictions vary. Meiosis is mostly regular excepting the occurrence of polyspory in certain cases, as for example in *E. afflata*. The evidence of structural alteration, coupled with regular meiotic behaviour, suggests that the species has attained homozygosity with respect to these alterations.

Considerable discussions have been held with regard to the two species *E. palustris* and *E. uniglumis*. Individuals of these species so far collected from Europe have shown diffuse centromere in their chromosomes (Walters

1949, 1950, 1953). Saunte (1958) regarded the two species as a *palustris-uniglumis* complex and suggested their relationship with each other. He postulated that the 16 chromosomed *E. palustris* is an isolated entity, whereas there are gradations between 38 chromosomed *palustris* and 48 chromosomed *uniglumis*. Further work on morphological, cytological and genetical lines was suggested by him to assess the proper specific status of *E. palustris* and *E. uniglumis*. He visualized introgressive hybridization between *E. palustris* and *E. uniglumis* and also held that the 10 chromosomed Russian (Levitsky 1931) representative may be a different one. On the other hand, Lewis and John (1961) have shown that in populations growing at Oxford, a number of intermediaries and hybrids of *E. palustris* variety *microcarpa* ($2n = 16$) and *E. palustris* variety *vulgaris* ($2n=38$) occurs in nature. The viability of the different aneuploid numbers has been suggested to be due to hybridization. They further claimed that in these species, constrictions could often be located, but their positions were not constant.

In the present work on *E. palustris*, only a $2n=16$ form was collected in populations growing at Ranchi in tropical India. The most interesting feature, however, is the occurrence of constriction in this species, the position of which has been found to be constant as in other species too. Secondary constrictions also have been located, in addition to the primary constriction having the centromere. Further work on this particular species is needed on collections from different parts of India to explore the possibility, if any, of the occurrence of hybrids between 16 and 38 chromosomed forms as noted by Lewis and John (l.c.) and also between *E. palustris* and *E. uniglumis* as observed by Saunte (l.c.).

All species of *Eleocharis* investigated here show localised centromere as against diffuse centromere demonstrated by previous authors. In the present investigation, as pointed out before, special techniques were employed for the study of chromosomes of *Eleocharis* in which diffuse centromere has so far been reported. In all populations growing in India, and investigated so far, localised centromere has been found to be universal.

In view of the previous findings where diffuse centromeres have been demonstrated in clear preparations, supplemented by photomicrographs from individuals collected at Europe, as against the localised centromere found in the Indian species, it is likely that the diffuse nature of the centromere, though a primitive character, has undergone further evolution within the genus itself. Possibly such evolution, leading to their localised nature, may be related to their adaptation under different environmental conditions. This correlation though yet unexplored may quite likely exist in view of such fundamental differences between representatives growing in different parts of the world. One can visualize that species and populations showing diffuse centromere undoubtedly represent a primitive level as compared to those having centromeres localised. It is also likely that the former should be obtained in a

very high frequency in areas of their origin or more precisely where the gene centre is located. Genus *Eleocharis* provides, therefore, an interesting material for the study of different stages of chromosome differentiation associated with their adaptability. It is specially necessary to study such behaviour in *E. palustris* in view of the overwhelming evidence of the diffuse and localized nature of centromere in the same taxon.

From a survey of the different chromosome numbers in species of *Eleocharis* both in Indian and other taxa, n=5 is apparently the lowest chromosome number reported for the genus and may indicate possibly the basic one. That in the Indian representatives of the species of *Eleocharis*, duplication of chromosomes instead of fragmentation, has played an effective role in the evolution of species is also borne out from the histogram (vide histogram). In *E. atropurpurea* there is a considerable increase in chromatin length in polyploid form as compared to its diploid counterpart. In addition to this intraspecific variation, such evidences are also available at the interspecific level. Species with higher chromosome numbers showed corresponding increase in chromatin matter as compared to those with lower chromosome numbers. Interspecific differences however may not be considered as an important clue in this respect, but the intraspecific difference noted in *E. atropurpurea* is very significant. In the polyploid form of *E. atropurpurea* the chromatin length, though increased, is not double the amount of that noted in the diploids. This behaviour, however, is not uncommon in flowering plants, where a slight decrease in chromosome size associated with polyploidy has been noted (vide Sharma and Sharma 1959) in a number of cases. The exact cause of this decrease is not fully known, though, compact spiralization of chromosome as well as elimination of heterochromatin have been suggested as the explanations for this behaviour.

The other interesting genus within the tribe Scirpeae of Hutchinson (l.c.) is *Scirpus*, having a completely aquatic or marshy habit. Different chromosome numbers (2n=26, 42, 56, 58, 62, 104, 110) have been reported in this genus and it is very difficult to work out the exact basic number from these records (Beetle 1941, Ehrenberg 1945, Håkansson 1928, Heilborn 1927, 1938, 1939, Hicks 1928, Jörgensen *et al.* 1958, Kostriukova 1930, Löve 1950, Moore 1960, Otzen 1962, Piech, 1924, 1927, Rodrigues 1953, Schuyler 1964, Sharma and Bal 1956, Sköttsberg 1955, Sorsa 1963, Tanaka 1937b, 1948). On the other hand, the six species or *Scirpus* investigated during the present work also show varying chromosome series namely n=14, 15, 16, 20, 21 and 40. In general, as compared to other genera, *Scirpus* is characterized by very high chromosome numbers and extensive aneuploidy. Diffuse centromeres were reported by previous authors in this genus (Otzen 1962, Sharma and Bal 1956). In the present work too, excepting in one species of *Scirpus*, no evidence of localised centromere has been found in any other species. Only in *S. squarrosus* clearly localised centromere has been detected. There-

fore, similar to *Eleocharis*, it may be suggested that in *Scirpus* as well, diffuse centromere should not be considered as a universal characteristic and evolution toward localised centromere has been achieved and adapted under certain conditions.

The extensive aneuploidy in this genus can easily be accounted for on the basis of fragmentation of chromosomes and the survival of the fragments as distinct chromosomes, due to the diffuse nature of the centromere. In view of the extensive fragmentation of chromosome and subsequent evolution of species it is difficult to ascertain the basic number of the particular genus. However, of the different numbers so far reported, $2n=28$, 30 and 32 are the lowest, of which multiples of 7 and 8 chromosomes occur in a very high frequency. From these data, it may reasonably be claimed that 7 and 8 chromosomes became stabilized at an early stage of evolution of this genus and subsequent hybridization and duplication from the basic sets resulted in further diversification. Diffuse nature of the centromere, chromosome fragmentation, coupled with extensive vegetative reproduction, characteristics of Cyperaceae, have contributed greatly to the evolution of different species.

Saunte (1958) observed conspicuous difference in morphology specially in size between chromosomes of *Scirpus* and *Eleocharis*, which he considered as one of the evidences against merger of the two as suggested by certain taxonomists. However in the present investigation, no conspicuous difference in chromosome size could be noticed between species with high chromosome numbers of *Scirpus* and *Eleocharis*, so far as Indian representatives are concerned. But this negative evidence need not be taken as a criterion for merger of the two which, as far as other evidences show, is certainly not desirable. As within the family Cyperaceae as a whole, even between different genera chromosome size has been found to be identical, there seems to be no reason to merge the two genera which have been kept separate by modern taxonomists on the basis of their external morphology.

The genus *Fimbristylis* of which eighteen species have been investigated during the present work shows a constant chromosome number of $n=5$ or 10 excepting *F. junciformis* and *F. squarrosa* with $2n=22$ and 24 chromosomes respectively. In previous reports too ($2n=10$, 16, 20, 24, 28, 44, 38, Chuang *et al.* 1963, Dnyansagar and Tiwari 1956, Gadella and Kliphuis 1963, Sharma and Bal 1956, Sharma, B. R. 1962, Sköttsberg 1955, Tanaka 1937a) excepting in a few species such as *F. complanata*, *F. cymosa*, *F. makinoana* and *F. serisea*, the chromosome numbers are all found to be multiples of 5. Such constancy in chromosome number is rather unusual for the family Cyperaceae where most of the genera show wide numerical variations.

In this genus, the diploid species with $n=5$ chromosomes show differences in their karyotypes indicating the importance of structural alteration of chromosomes in their evolution. Moreover in all species so far studied no identical karyotype between two species has been observed which is a further

proof of the significance of structural alterations in speciation. Further as in *Eleocharis*, here also the polyploids show an increase in chromatin content but it is not double the total amount of that found in the diploids, thus indicating decrease in chromatin length to be associated with polyploidy during evolution. Lastly of the tribe Scirpeae, another genus *Lipocarpha* has also been investigated showing a chromosome number $2n=26$. This is no doubt an advanced species as indicated both by chromosome number and chromosome size.

If the tribe Scirpeae of Hutchinson (l.c.) as a whole is considered, the four genera studied so far, though showing differences in chromosome number, have enough similarities in their morphology to account for their inclusion in the tribe Scirpeae. As such its homogeneity cannot be doubted.

In this tribe, *Fimbristylis*, as pointed out above, is remarkable for its constancy in chromosome series unlike any other genus of Cyperaceae. This fact, taken in conjunction with its low chromosome number $n=5$, suggests its primitive status. Stability in chromosome number is often regarded as an indication of primitiveness as compared to instability which is often noted in advanced species. It may be presumed that in the former natural selection has operated through a long antecedent period of evolution resulting in the stabilization of its chromosome complements. In species showing variation in chromosome complements, evidently the period through which natural selection has been operative is not sufficient for its stabilization.

This fact, taken in conjunction with the very low chromosome number as well as the long size of chromosomes of *Fimbristylis*, suggests undoubtedly that it is a very primitive genus. On the other hand, it lacks the diffuse centromere, an accepted characteristic of primitiveness. That a primitive characteristic such as diffuse centromere can be maintained even in certain taxa of established advanced status is best exemplified in the genus *Carex*. Most of the Indian species of *Scirpus* as well as *Eleocharis* are endowed with this characteristic. But it has already been shown that even within the same genus diffuse and localized centromeres have been found in the same species, indicating thereby that the latter characteristic, though advanced, has evolved from the former within a very short period of evolution. In that case, the localized centromere of *Fimbristylis* may not be considered as an evidence against its primitiveness. Possibly the ancestors of *Fimbristylis* were endowed with diffuse centromeres which have undergone complete extinction or are yet to be explored. But the localization of the centromere has been achieved by the genus at a very early stage and since then it has been maintaining a number of other primitive characteristics. The present day species of *Eleocharis* and *Scirpus*, on the other hand, though retaining the primitive centromere in certain taxa derived from their ancestors, are very recent in their origin as specially noted in their chromosome number, morphology and large number of cytotypes. Extensive vegetative reproduction

is common for all the genera. As such, the innumerable cytotypes in *Fimbristylis* and *Scirpus* can not merely be attributed to their vegetative reproduction but also possibly indicate their advanced level of evolution.

In view of these facts, it may be presumed that the tribe Scirpeae represents a very primitive level in which the present day species of *Fimbristylis* have retained much more primitive characteristics as compared to the other constituents. All the taxa must have evolved from a common stock.

Summary

Cytotaxonomical studies have been carried out on 30 species and varieties under 4 genera belonging to the tribe Scirpeae, as part of a programme of investigation of Indian representatives of the family Cyperaceae with the aid of suitable schedules. Detailed karyotype analysis shows a general resemblance of the chromosome morphology, testifying to the homogeneity of the group as a whole. The genus *Fimbristylis* has been found to represent a very primitive level of evolution as compared to the genus *Eleocharis*. On the basis of evidences, it has been pointed out that possibly the evolution from diffuse to localised centromere has been achieved in a short step, since both types of centromere have been recorded in the species of *Scirpus* and *Eleocharis*.

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