Cyto-taxonomic Studies of the Genus *Coix* L.
I. Cyto-morphological studies of *C. gigantea*
Koenig ex Roxb.

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*Coix* L. is the most widely distributed genus among the Oriental genera of the tribe Maydeae. It consists of four species (Bor 1960) whose chromosome numbers range from $2n = 10$ to $40$ on the base number $x = 5$ (Darlington and Wylie 1995, Fedorov 1974, Goldblatt 1984, 1985, 1988). Now-a-days it is introduced into all warmer parts of the world since the different varieties of *C. lacryma-jobi* are useful as cereals, medicinals and ornamentals.

The taxonomy of this genus has been very vague and confusing because of the wide variation met within the various taxa and the presence of many intergrades between them. According to Mangelsdorf and Reeves (1939), *Coix* appears to be an assemblage of a few species with many intergrading forms. Various criteria like general morphology, habit, glandular hairs, morphology of the spikelets, nature of the fruit-case (involucre), cytology etc. have been used for the classification of the genus.

The taxonomy of *Coix* has been studied by many, including Hooker (1896), Watt (1904), Gamble (1934), Mangelsdorf and Reeves (1939), Mimeur (1951), Bor (1960), and Arora (1977). According to these classifications the number of species of *Coix* ranges from one to four with many varieties. However, Bor (1960) in his outstanding treatise on “The grasses of Burma, Ceylon, India and Pakistan” has recognised four species. His classification is mainly based on two criteria, the annual or perennial habit and the size of the wings of the lower glume of the male spikelets. He has classified the four species of *Coix* into two grops, based on the size of the wings of the lower glume of the male spikelets. He has made a distinction between narrow-winged or hardly-winged lower glume of the male spikelets, which according to him is found in *C. lacryma-jobi* and *C. puellarum* and the broadly-winged lower glume, as found in *C. aquatica* and *C. gigantea*. Further *C. gigantea*, according to Bor (1960) are erect plants which invade the paddy fields and render them unfit for the cultivation of paddy. The upper surface of the leaves is without numerous conspicuous glands and the involucre not abruptly constricted at the neck into a beak.

*C. gigantea* was collected from Calicut (Kerala) and Gopichettipalayam (Tamil Nadu) for the present study. This species is found to have only restricted distribution, in the paddy fields of certain areas of South India. Of special interest among the species of *Coix* are the long and narrow leaves resembling paddy leaves (mimicry) which is mainly responsible for its survival in the paddy fields and escaping from total eradication at the juvenile stages. Some of the morphological characters of taxonomic interest of this species, such as the size of the wings of the lower glume of the male spikelets and the length and breadth of leaves, have been compared with those of the cosmopolitan species, *C. lacryma-jobi*, var. *lacryma-jobi* (Trivandrum collection) in the present investigation. The aim of the present work is to understand the taxonomic status of *C. gigantea* collected from South India, based on evidences obtained from morphological and cytological studies.
Materials and methods

Natural populations of *C. gigantea* Koenig ex Roxb. were collected from the paddy fields of Calicut (Kerala) and Gopichettipalayam (Tamil Nadu) and maintained in the Botanical Garden, Department of Botany, University of Kerala. For mitotic study, actively growing root-tips were fixed in Carnoy's fluid after pre-treatment with 0.002 M 8-hydroxyquinoline for a period of about 3 hr at 4°C (Tjio and Levan 1950). For meiotic study, young inflorescences at the appropriate stage of development were fixed in Carnoy's fluid without any pre-treatment. Standard aceto-carmine squash technique was followed for the cytological analysis. The karyotype category was determined according to the karyotype asymmetry class of Stebbins (1971). Voucher specimens were deposited at the Herbarium of the Department of Botany.

Observations

*C. gigantea* Koenig ex Roxb. is a tall, robust, semi-aquatic annual grass, 2–3 m in height. The leaves are long and narrow, 70–100 cm in length and 1.00–1.5 cm in breadth (Fig. 1a). The involucres are usually spheroid elongated, hard-shelled, brownish and about 4–5 mm wide and 7–10 mm long (Fig. 1b). At the early stages, the involucre is constricted at the neck into a 'beak', but as growth proceeds, the 'beak' disappears. Spikelets are produced in threes, two

Fig. 1. Leaf and seeds of *C. gigantea*. a. leaf; b. seeds; c. leaf of *C. lacryma-jobi* var. *lacryma-jobi* for comparison.
sessile and the central pedicelled. The wings of the lower glume of the male spikelets of *C. gigantea* collected from both Calicut and Gopichettipalayam were studied and detailed explanatory figures have been prepared (Fig. 2a). As shown in the figures these wings are narrow in *C. gigantea*. For comparison, the wings of the lower glume of the cosmopolitan species *C. lacryma-jobi* var. *lacryma-jobi* commonly known as “Job’s tears” (Trivandrum collection) have also been studied and the wings in this species are found to be very broad (Fig. 2b).

Somatic chromosome study of root tip cells in the present material consistently showed 2n = 12 chromosomes which are comparatively large ranging in length from 3.79 to 6.51 μm (Fig. 3a). The karyotype consisted of four pairs of m-type and two pairs of sm-type chromosomes and of 1A category. Two pairs of chromosomes (I and IV) were provided with secondary constrictions in the short arms distal to the centromere (Table 1, Fig. 4).

The meiosis was found to be normal with six bivalents at diakinesis and metaphase I (Fig. 3b).

![Fig. 2. Floral morphology. a. C. gigantea; b. C. lacryma-jobi var. lacryma-jobi; 1. male spikelets, 2. winged lower glume, 3. upper glume, 4, 5. lemmas, 6, 7. paleas, 8, 9. lodicules, 10, 11. stamens.](image1)

![Fig. 3. Chromosomes of C. gigantea (×1500). a. Root-tip mitosis, 2n=12; b. Diakinesis in PMC, 6 bivalents, one attaching to nucleolus.](image2)
Two bivalents were often found associated with the nucleolus. Anaphase I segregation was also normal and the plants showed about 90% pollen fertility and normal seed set.

Discussion

*C. gigantea* is found to be unique in its cytological and morphological features. The genus *Coix* is characterised by the basic number *x* = 5 as the diploid species with 2n = 10 is reported in all the four species (Darlington and Wylie 1955, Venkateswarlu and Chaganti 1973, Goldblatt 1984, 1985, 1988). The cytotype now studied with 2n = 12 is a stabilized aneuploid population, but its origin is obscure. This species showed the presence of 12 distinctly large somatic chromosomes, in contrast to the usual condition in *Coix* species, which have smaller chromosomes, ranging in length from about 2.0 to 4.0 µm (Venkateswarlu and Chaganti 1973, Christopher and Mini 1988). It is interesting to mention here that the length and breadth of the leaves of this species which are distinctly linear resembling paddy leaves (mimicry), are mainly responsible for its survival and escaping from total eradication from the paddy fields, at juvenile stages, though it is an obnoxious weed. This is a sexually reproducing annual species, which completes its lifecycle within 4–5 months along with paddy plants, disseminating the seeds in the paddy fields for the next generation.

In this context, the leaves of the cosmopolitan species, *C. lacryma-jobi* var. *lacryma-jobi* which have also been studied for comparison, are much broader, about 4–6 cm in breadth and 50–70 cm in length (Fig. 1c).

It was found worthwhile to examine the morphological characters which have taxonomic relevance along with the cytological features. As mentioned in the introduction, the size of the wings of the lower glume of the male spikelet provide a valuable marker in the species determination of *Coix* (Bor 1960). The wings of the lower glume of male spikelets of *C. gigantea* collected from both Calicut and Gopichettipalayam, when compared with those of the cosmopolitan species *C. lacryma-jobi* var. *lacryma-jobi* revealed, that the wings are the broadest

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Table 1. Morphometric data on the somatic chromosomes of *C. gigantea* Koenig ex Roxb. (2n = 12)

<table>
<thead>
<tr>
<th>Chromosome number</th>
<th>Chromosome length (µm)</th>
<th>Relative length (%)</th>
<th>Arm ratio (L/S)</th>
<th>Chromosome type</th>
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<tr>
<td></td>
<td>Long arm</td>
<td>Short arm</td>
<td>Total</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>3.62</td>
<td>2.89</td>
<td>6.51</td>
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<td>2.50</td>
<td>1.29</td>
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</tbody>
</table>

Karyotype category-1A.

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Fig. 4. Idiogram of somatic chromosomes of *C. gigantea* (2n = 12).
in *C. lacryma-jobi* and much narrower in both the collections of *C. gigantea*. Obviously this is quite contrary to the classification of Bor (1960), in which the wings of the lower glume of the male spikelets are very broad in *C. gigantea* and *C. aquatica*, while in the two other species, *C. lacryma-jobi* and *C. puellarum*, the lower glumes are narrowly winged or hardly winged. Therefore it is evident that the classification of the four species of *Coix* (Bor 1960) into two groups, based on the size of the wings of the lower glume of the male spikelets appears to be invalid, even though *C. gigantea* agrees with his classification in the other details. As suggested by Mangelsdorf and Reeves (1939), most of the criteria used for classifying this genus are rather confusing, as specific and varietal delimitations and identifications have become a difficult proposition in this complex genus in view of intraspecific variations and overlapping boundaries that exist between the different taxa. It is of great interest that *C. gigantea* presently studied with 2n = 12 chromosomes could be collected only from South India and probably these populations represent relicts of a much wider distribution for this species. Undoubtedly most of the natural populations in the paddy fields must have been eliminated by human intervention. Bor (1960) has specifically associated this species with the marshy habitat of paddy fields. Detailed cytological and morphological studies on other populations from different regions of India might help us in determining the geographical distribution, taxonomic status and phylogenetic affinities of this species.

**Summary**

*C. gigantea* collected from South India is found to be markedly distinct on both morphological and cytological characters. This species is outstanding in its cytology as it showed the presence of the aneuploid number of 12 distinctly large chromosomes which are rather unspecialized. This is an annual sexual species with normal meiosis and good seed setting. The size of the wings of the lower glume of the male spikelets of *C. gigantea* collected from Calicut (Kerala) and Gopichettipalayam (Tamil Nadu) are narrower when compared with those of *C. lacryma-jobi* var. *lacryma-jobi* (local collection) which has very broad wings. The leaves are long and narrow when compared with those of *C. lacryma-jobi*. The present study has shown that the classification of the four species of *Coix* by Bor (1960) into two groups based on the size of the wings of the lower glume of the male spikelets appears to be invalid, even though *C. gigantea* agrees with this classification in the other morphological features and the ecological habitat.

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**References**


