*Froc. Indian natn. Sci. Acad.* **B48** No. 3 pp. 397-404 (1982)

# Karyotypic Studies in *Cassia* Linn. from India

S S BIR and SANTOSH KUMARI
*Department of Botany, Punjabi University, Patiala 147 002*

(Received 8 September 1981; after Revision 9 August 1982) .

Karyotypes of 17 taxa of *Cassia* from North Indian plains and Central Indian Hills have been worked out. The chromosomes are small sized but reflect great differences in size within the related species. There is no correlation between habit and karyotype symmetry of various species. However, the ploidy level and the total haploid chromatin length show some relationship. *Cassia angustifolia* and *C. artemisioides* are karyotypically most highly evolved species. As compared to trees and herbs, the shrubby species seem to have more evolved karyotypes.

**Key Words: Karyotypes, Evolution, Polyploidy, Chromosome numbers,** *Cassia*

## Introduction

*Cassia* Linn. is the type genus of Cassiaceae. Cumulative world-wide data* on this genus indicate that chromosome numbers are known for one fifth of a total of 500–600 species (cf. Airy Shaw 1973). To date, meiotic or somatic counts have been published for a majority of the Indian species, nevertheless information on karyotype morphology is available for only eight species (Tandon and Bhat 1971, Datta and Datta 1975). Therefore, the present studies on 16 species (17 taxa) of *Cassia* from North Indian plains and Central Indian Hills were taken up with the main objective to provide information on chromosome morphology and to know if there is any correlation between the karyotypic evolution and habit.

## Material and Methods

For details of localities/areas from which materials were collected, reference is made to table 1. Root and leaf tip squashes were made in usual manner after pretreatment with 0.003N solution of 8-hydroxy-quinoline for about 4 hours. For attaining chromosome size and karyotype standardization, the figures and formulae as given here are based on observations on at least 10 cells. For karyotype formulae, the classification of White (1945) is followed. To distinguish

* Information based on 'Chromosome Atlas of Flowering Plants', 'Index to Plant Chromosome Numbers', 'IOPB chromosome number reports I-LXVII,' Fedorov (1969), Löve and Löve (1961) and significant references included in Biological Abstracts from 1971–1980

chromosomes further, 9 basic types were recognised as long* (A, B, C), medium† (D, E, F) and short‡ (G, H, I) chromosomes with the position of centromere in relation to chromosome length taken as A, D, G—metacentric, B, E, H—sub-metacentric, and C, F, I—acrocentric. Such symbols as ' ′ ' or ' ″ ', and 'l' or 's' placed in superior and inferior positions indicate secondary constrictions or satellited chromosomes and long or short arms respectively. For example, $B_l^{\prime \text{ or } s}$ means long sub-metacentric chromosomes with secondary constriction on long or short arms, and A″ indicates long metacentric chromosome with terminal satellite. Chromosome arm symmetry index (SI) and chromosome gradient index (GI) were calculated according to Pritchard (1967). For the critical analysis of nature of karyotype, the index value 50 for SI and GI has arbitrarily been taken at a threshhold between symmetry and asymmetry.

## Observations

The somatic chromosome numbers of presently worked out species were found to vary from 2n=16 to 2n=56 (cf. table 1). Within the cells of the same root or leaf tip numerical variations in chromosome numbers have not been observed at all. A detailed karyotype analysis of different species (table 1) reveals wide differences between their complements. Further, the identity of various species is recognised by minute differences in the finer details such as chromosome size, position of the primary constrictions and the presence/absence of secondary constrictions or satellites. Within the genomes of each taxon, the chromosome size exhibits gradual gradation and nowhere abrupt change has been noticed. The size range of the presently studied chromosomes is as mentioned below :

Large : A—1.48–2.40 μm;
B—1.48–2.59 μm;
C—1.48–1.85 μm;
Medium : D—1.11–1.38 μm;
E—1.11–1.40 μm;
F—1.11–1.29 μm;
Short : G—0.74–1.10 μm;
H—0.92–1.10 μm;
I—1.01 μm.

All this indicates that for 17 worked out taxa the chromosomes on the whole are small sized.

A feature common to all the species (see figure 1–17) is the prevalence of meta- and sub-metacentric chromosomes. Wherever present, the chromosomes with SATs are always long meta- or submetacentrics with distinct satellited stalks. Details of differences in the karyotypes of various species are given in table 1.

On the basis of size, various species could be categorized as follows :

Type A : Long, medium and short chromosomes present in the complement—*C. absus*, *C. angustifolia*, *C. artemisioides*, *C. didymobotrya*, *C. fistula*, *C. javanica*, *C. mimosoides* var. *wallichiana*, *C. occidentalis*, *C. pumila*, *C. renigera*, *C. sialmea*, *C. sophera*, *C. surattensis* and *C. tora*.

Type B : Long and medium chromosomes—*C. excelsa*.

* Double or more than double the length of the shortest chromosomes within species worked out here

† From one and a half times to double the length of the shortest chromosome

‡ Less than one and a half times of the shortest chromosome

**Table 1** *Data about the karyotypes of members of* Cassia *from India*

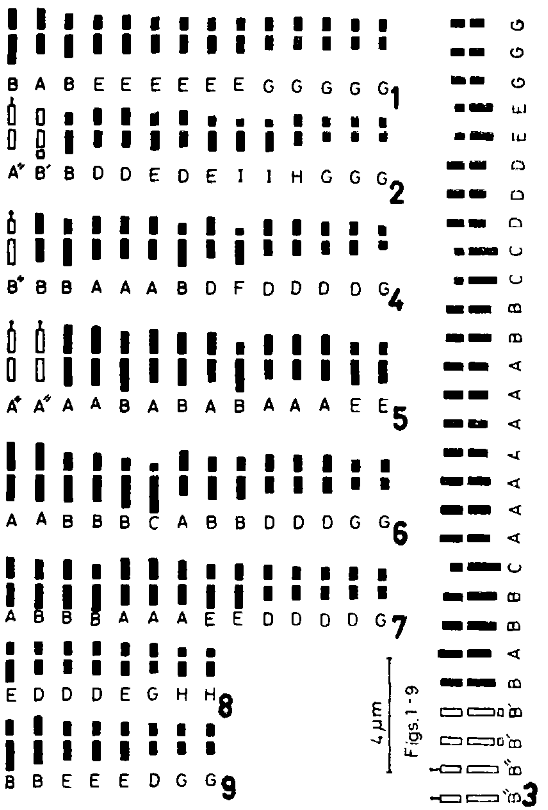
| Sl. No. | Name of the taxon | Locality* | Chromosome number | Chromosome size range (in $\mu$m) | Karyotype formula** | Karyotype analysis |
|---|---|---|---|---|---|---|
| | HERBS: | | | | | |
| 1. | *Cassia mimosoides* Linn. var. *demidiata* Roxb+ | 11 | 2n=16 | 0.92–1.20 | $V_8+L_8$ | $D_6+E_4+G_2+H_4$ |
| 2. | *C. mimosoides* Linn. var. *wallichiana* Baker+ | 12 | 2n=16 | 0.92–1.75 | $V_6+L_{10}$ | $B_4+D_2+E_6+G_4$ |
| 3. | *C. pumila* Lam.† | 9 | 2n=28 | 0.92–2.59 | $V_{14}+L_{12}+L^s{}_2$ | $A_{10}+B_{12}+B'_{28}+D_2+G_2$ |
| | SHRUBS: | | | | | |
| 4. | *C. absus* Linn.† | 7 | 2n=28 | 0.92–1.85 | $V_{12}+L_{16}$ | $A_2+B_4+E_{12}+G_{10}$ |
| 5. | *C. angustifolia* Vahl.† | 8 | 2n=28 | 0.83–1.66 | $V_{12}+V_2SAT+L_8+L^s_2+J_4$ | $A_2''+B_2+B'_{21}+D_6+E_4+G_6+H_2+I_4$ |
| 6. | *C. artemisioides* Gaudich†† | 1 | 2n=56 | 1.10–2.59 | $V_{28}+L_{14}+L^s_4+L_4SAT+J_6$ | $A_{16}+B_{10}+B'_{41}+B''_4+C_6+D_6+E_4+G_6$ |
| 7. | *C. occidentalis* Linn.† | 3,5,9 | 2n=28 | 0.74–1.48 | $V_{22}+L_6$ | $B_2+D_{14}+E_4+G_8$ |
| 8. | *C. sophera* Linn.† | 13 | 2n=28 | 0.92–2.31 | $V_{14}+L_{10}+L^s_2+J_2$ | $A_2+B_6+B'_{21}+C_2+D_6+E_2+G_6+H_2$ |
| 9. | *C. tora* Linn.† | 9 | 2n=26 | 0.74–1.85 | $V_{16}+L_6+J_2+J^s_2$ | $A_2+C'_{21}+D_6+E_4+F_2+G_8+H_2$ |
| | TREES | | | | | |
| 10. | *C. didymobotrya* Fresen† | 2 | 2n=28 | 0.80–2.03 | $V_{18}+L_6+L_2SAT+J_2$ | $A_6+B_8+B_2''+D_{10}+F_2+G_2$ |
| 11. | *C. excelsa* Schrad.† | 9 | 2n=28 | 1.38–2.40 | $V_{14}+V_4SAT+L_{10}$ | $A_{14}+A_4''+B_6+E_4$ |
| 12. | *C. fistula* Linn.† | 3,10 | 2n=28 | 1.01–2.22 | $V_{16}+L_{10}+J_2$ | $A_6+B_{10}+C_2+D_6+G_4$ |
| 13. | *C. javanica* Linn.† | 3 | 2n=28 | 1.01–1.75 | $V_{18}+L_{10}$ | $A_8+B_6+D_8+E_4+G_2$ |
| 14. | *C. nodosa* Buch.—Ham.† | 4,6 | 2n=28 | 0.80–1.10 | $V_{18}+L_{10}$ | $G_{18}+H_{10}$ |
| 15. | *C. renigera* Wall. ex Benth.† | 3 | 2n=28 | 1.01–1.48 | $V_{12}+L_{16}$ | $A_4+B_2+D_2+E_{12}+G_6+H_2$ |
| 16. | *C. siamea* Lamk.† | 12 | 2n=28 | 0.80–1.48 | $V_{20}+L_8$ | $B_4+D_8+E_4+G_{12}$ |
| 17. | *C. surattensis* Burm. f.† | 3 | 2n=28 | 1.01–1.48 | $V_{22}+L_6$ | $B_2+D_8+E_4+G_{14}$ |

* **North Indian Plains:** *1*, Delhi: Budha Gardens, 250 m; *2*, Punjab: Govt. College Ropar, 350 m; *3*, Patiala: University Campus, 251 m; *4*, Chandigarh: Sector 22, 340 m; *5*, Chandigarh: Sector 17, 340 m; *6*, Dehradun: Forest Research Institute, 600 m;

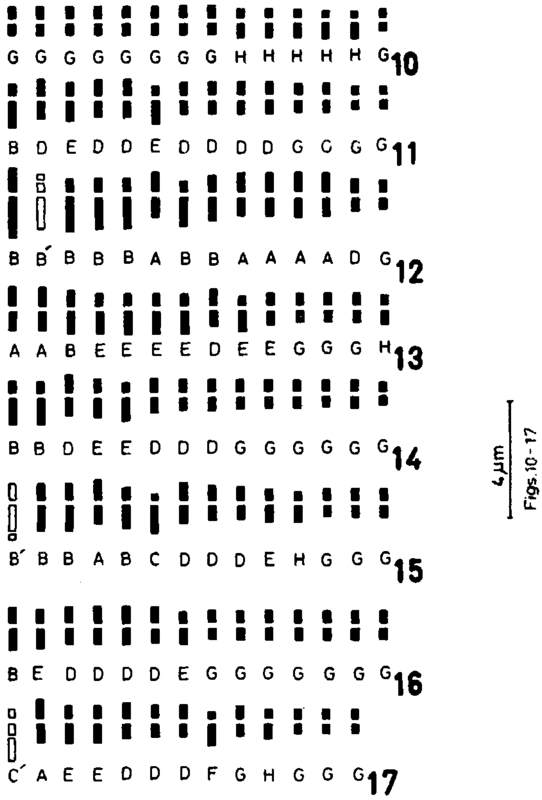
**Central India (Pachmarhi Hills):** *7*, Fairy Pool, 990 m; *8*, Govt. Garden, 1,000 m; *9*, Holiday Home, 1,000 m; *10*, Dhupgarh, 1,100 m; *11*, Old piparya Road, 300 m; *12*, Chushul Coy/Amba Mai, 1,000 m; *13*, Dokrakheri, 185 m.

** sat : Satellited chromosomes; *s*, chromosomes with secondary constrictions

\+ Diploids; † Tetraploids; †† Octoploids




**Figures 1–9** Idiograms drawn for karyotypes. *1, Cassia absus*; *2, C. angustifolia*; *3, C. artemisioides*; *4, C. didymobotrya*; *5, C. excelsa*; *6, C. fistula*; *7, C. javanica*; *8, C. mimosoides* var. *demidiata*; *9, C. mimosoides* var. *wallichiana*




**Figures 10–17** Idiograms drawn for karyotypes. *10, Cassia nodosa*; *11, C. occidentalis*; *12, C. pumila*; *13, C. renigera*; *14, C. siamea*; *15, C. sophera*; *16, C. surattensis*; *17, C. tora*

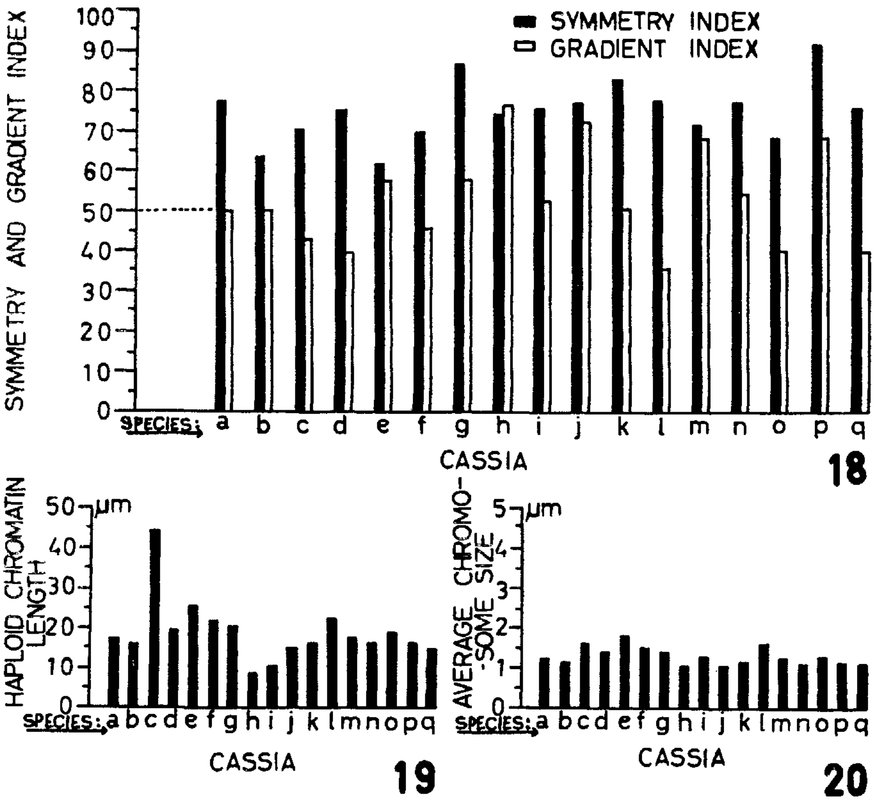
Type C : Medium and short chromosomes—*C. mimosoides* var. *demidiata*.

Type D : Short chromosomes—*C. nodosa*.

Comparative values for SI, GI, total haploid chromatin length and average chromosome size for various species of *Cassia* are represented in figures 18–20. Evaluating SI values independently of GI, it is clear that the karyotypes are moderately to highly symmetrical. But GI values would indicate something contrary to it. Nearly 9 taxa have asymmetrical karyotypes and the rest slightly to highly symmetrical (figure 18). In octoploid *C. artemisioides* ($2n=56$), the total haploid chromatin length (44.36 $\mu$m) is nearly double of the tetraploid species as *C. pumila* (22.32 $\mu$m) and *C. fistula* (21.41 $\mu$m). The other $4\times$ species as *C. didymobotrya* (19.50 $\mu$m) and *C. javanica* (19.70 $\mu$m) closely come to this generalization. Further, the diploid taxa *C. mimosoides* var. *demidiata* (8.49 $\mu$m) and var. *wallichiana* (10.23 $\mu$m) have almost half the chromatin length of the tetraploid species (cf. figure 19). Average chromosome size (figure 20) is the largest in tetraploid *C. excelsa* (1.79 $\mu$m), whereas the octoploid *C. artemisioides* has only 1.58 $\mu$m. The smallest size is shown by tetraploid *C. nodosa* (1.04 $\mu$m) or diploid *C. mimosoides* var. *demidiata* (1.06 $\mu$m).

## Discussion

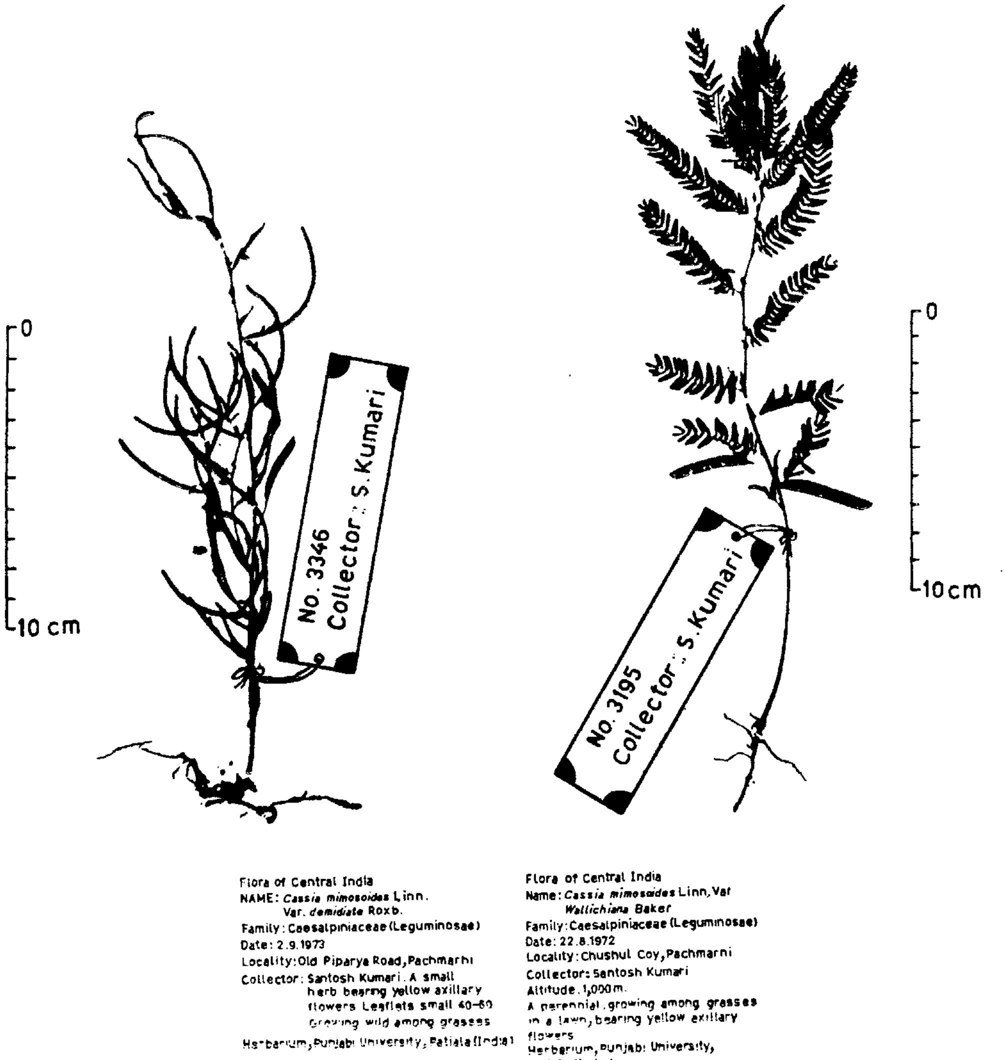
The absence of numerical variations in chromosomes within the cells of the same root/leaf tip tissue in different *Cassia* species is in strong contrast to the observations of Sharma and Raju (1968) for some species of *Bauhinia* where they recorded the frequent presence of varying numbers of chromosomes. Present studies reveal some differences as compared to the earlier observations of Datta and Datta (1975) for *C. occidentalis*, *C. sophera* and *C. tora*. We have not observed the secondary constrictions in *C. occidentalis* and SAT-pairs in *C. sophera* although earlier Datta and Datta (loc. cit.) had reported their presence and further 2n=26 for *C. tora* presently reported is also at variance from Datta and Datta's record of 2n=28. Our results for these species are in accordance with Tandon & Bhat (1971)




**Figures 18–20** Showing SI, GI values; total haploid chromatin length and average chromosome size. *a*, *C. absus*; *b*, *C. angustifolia*; *c*, *C. artemisioides*; *d*, *C. didymobotrya*; *e*, *C. excelsa*; *f*, *C. fistula*; *g*, *C. javanica*; *h*, *C. mimosoides*; var. *demidiata*; *i*, *C. mimosoides* var. *wallichiana*; *j*, *C. nodosa*; *k*, *C. occidentalis*; *l*, *C. pumila*; *m*, *C. renigera*; *n*, *C. siamea*; *o*, *C. sophera*; *p*, *C. surrattensis*; *q*, *C. tora*

but for *C. siamea* and *C. surattensis* there are some differences in meta- & submetacentric chromosomes ratio, which bring to light the fact that karyotypic variations exist in various populations of the same species and this emphasises the fact that microevolution is taking place presently. The mechanisms involved are structural changes and gene mutations.

On the basis of major differences in karyotypes, chromosome size and total haploid chromatin length (cf. table 1), the two varieties *wallichiana* and *demidiata* of *C. mimosoides*, are good taxonomic units and could be recognised as species*. This is supported by well marked out morphological characteristics of the two taxa (figures 21–22).




Acc. No. 9498 Acc. No. 6739

**Figures 21–22** Photographs of *Cassia mimosoides* var. *demidiata* and var. *wallichiana* specimens

**Cassia wallichiana* D C. in *Mem. Soc. Phys. Hist. Nat. Geneve 2* (2): 133, 1824; *C. demidiata* Roxb.; *Hort. Beng.* 32, 1814

Data for 17 worked out taxa indicate that there is a definite correlation between level of ploidy and total haploid chromatin length. Variations in total haploid chromatin length or karyotype morphology within different diploid or tetraploid taxa may possibly be attributed to chromosomal rearrangements involving loss or gain of segments, paracentric inversions and translocations. It is interesting to note that average chromosome size does not show any bearing on the chromosome numbers.

A perusal of data on karyotype formulae/analysis reveals that SAT-chromosomes are primarily present in the karyotypes of certain woody shrubs or trees as *C. angustifolia*, *C. artemisioides*, *C. excelsa* and *C. didymobotrya*. Further, it is clear that secondary constrictions are most common on the chromosomes of shrubs (*C. angustifolia*, *C. artemisioides*, *C. sophera* and *C. tora*). In contrast, these are absent in the chromosomes of trees. Karyotypically *C. angustifolia* and *C. artemisioides* seem to be the most highly evolved species of *Cassia* since some of their chromosomes show the presence of both, the satellites and secondary constrictions.

Analysis of karyotypes according to Stebbins (1958) is presented in table 2. As many as 8 taxa fall in category 2B, followed by 5 taxa in 2A and then 3 taxa in 1A and 1 taxon in 1B. No species conforms to the categories 3, 4A; 3, 4B or 1–4C. All this indicates that *Cassia* species have moderately to highly symmetrical karyotypes. Habit of the various members does not have any correlation with the karyotype symmetry (cf. tables 1, 2). Information on karyotype analysis as per table 1 clearly indicates that the shrubby members have the most highly evolved karyotypes as compared with trees or herbs. As earlier noted, by and large, the presence of small sized chromosomes in the woody taxa (shrubs and trees) of *Cassia* supports the contention of Stebbins (1971) that woody angiosperms mostly possess small chromosomes.

**Table 2** *Classification of karyotypes of various species of* Cassia *following Stebbins (1958)*

| Ratio Largest/ smallest | Proportion of chromosomes with arm ratio > 2:1 | | | |
|---|---|---|---|---|
| | 0.0 | 0.01—0.5 | 0.51—0.99 | 1.0 |
| < 2 : 1 | 1A<br>*C. javanica*<br>*C. mimosoides* var. *wallichiana*<br>*C. surattensis* | 2A<br>*C. excelsa*<br>*C. mimosoides* var. *demidiata*<br>*C. nodosa*<br>*C. renigera*<br>*C. siamea* | 3A | 4A |
| 2 : 1 — 4 : 1 | 1B<br>*C. absus* | 2B<br>*C. angustifolia*<br>*C. artemisioides*<br>*C. didymobotrya*<br>*C. fistula*<br>*C. occidentalis*<br>*C. pumila*<br>*C. sophera*<br>*C. tora* | 3B | 4B |
| > 4 : 1 | 1C | 2C | 3C | 4C |

However, contrary to his generalization, various species of *Cassia* show fairly large differences in size of chromosomes.

**Acknowledgements**

We are grateful to Professor G L Stebbins (Davis, California, USA) for stimulating discussions with SSB and valuable suggestions. One of us (SK) is thankful to the Council of Scientific & Industrial Research, New Delhi for the award of Fellowship during the course of present studies (1972–1975).

## References

Airy Shaw H K 1973 Willis, A *Dictionary of Flowering Plants and Ferns* 8th Ed. (London : Cambridge Univ. Press)

Datta S and Datta K B 1975 Biosystematics of *Cassia*. I. Cytological observations on some commonly growing *Cassias* of Bengal; *Jour. Cytol. & Genet.* Congr. Suppl. (Proc. First All India Congr. Cytol. & Genet. 1971) pp 55–59

Fedorov An A (Ed.) 1969 *Chromosome Numbers of Flowering Plants* (Leningrad : Academy of Sci. of the USSR Komarov Bot. Inst.)

Löve A and Löve D 1961 *Chromosome Numbers of Central and North-West European Plant Species, Opera Botanica* (Stockholm: Almquist and Wiksell)

Pritchard A J 1967 The somatic chromosomes of *Trifolium cherleri* L., *T. hirtum* All., *T. ligusticum* Balb. and *T. scabrum* L. *Caryologia* **20** 323–331

Sharma A K and Raju D T 1968 Structure and behaviour of chromosomes in *Bauhinia* and allied genera; *Cytologia* **33** 411–426

Stebbins G L 1958 Longevity, habitat and release of genetic variability in higher plants; *Cold spring Harbor Symp. on quantitative Biol.* **23** Exchange of genetie material : Mechanisms and consequences 365–378

—— 1971 *Chromosomal Evolution in Higher Pls.* (California: Addison-Wesley Publishing Co.)

Tandon S L and Bhat R N 1971 Cytogenetical evolution in the genus *Cassia* Linn.; *Jour. Indian Bot. Soc. (Gold. Jub. Vol.)* **50A** 430–436

White M J D 1945 *Animal Cytology and Evolution* (Cambridge : Cambridge Univ. Press)