

## FURTHER OBSERVATIONS ON CHROMOSOMES IN THE GENUS *INDIGOFERA* L.

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After publication of the first study on the cytology in the genus *Indigofera* (FRAHM-LELIVELD, 1960), we got a number of additional material, mainly pertaining to the East African and South-East African taxa of the genus. The said material reached us in the nature of seeds collected from herbarium sheets belonging to the Kew Herbarium. We could like to express our acknowledgement to Mr Gillett who placed both seeds and accompanying notes at our disposal. Out of twenty samples, collected between the years 1932-1960, seventeen germinated, the earliest one being from 1936. This proves that within the genus *Indigofera* and that even under herbarium conditions, germination capacity may be retained up to fifteen years at least.

As a subsequent addition to our knowledge of *Indigofera* cytology, two samples of Asiatic species, imported as ornamentals, were studied.

Table I contains the particulars on the material, the origin, the diploid chromosome number counted in root tips and the total length of the chromosome complement. The latter data were obtained by the same methods as have been described in our former publication on *Indigofera* (FRAHM-LELIVELD, 1960).

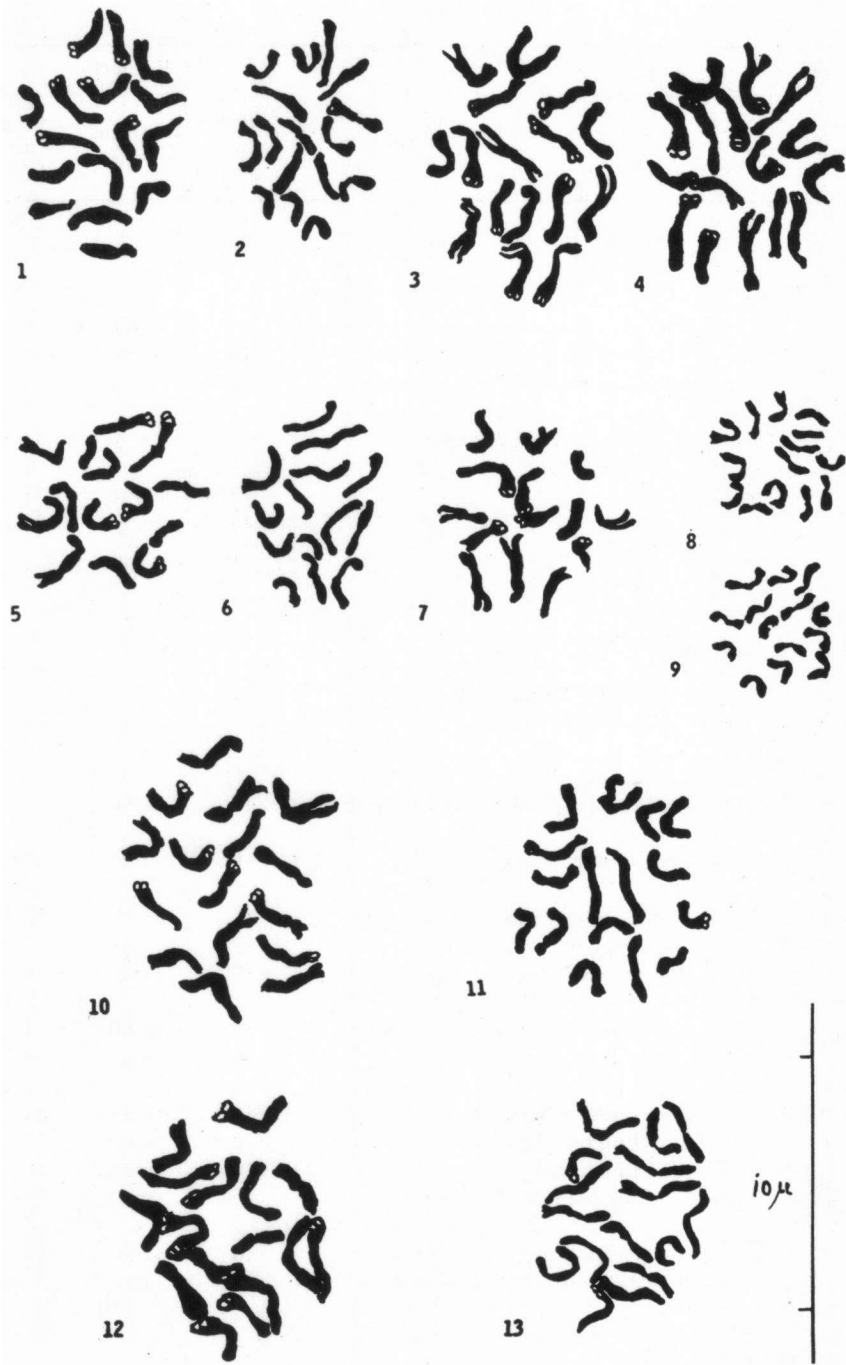
### RESULTS

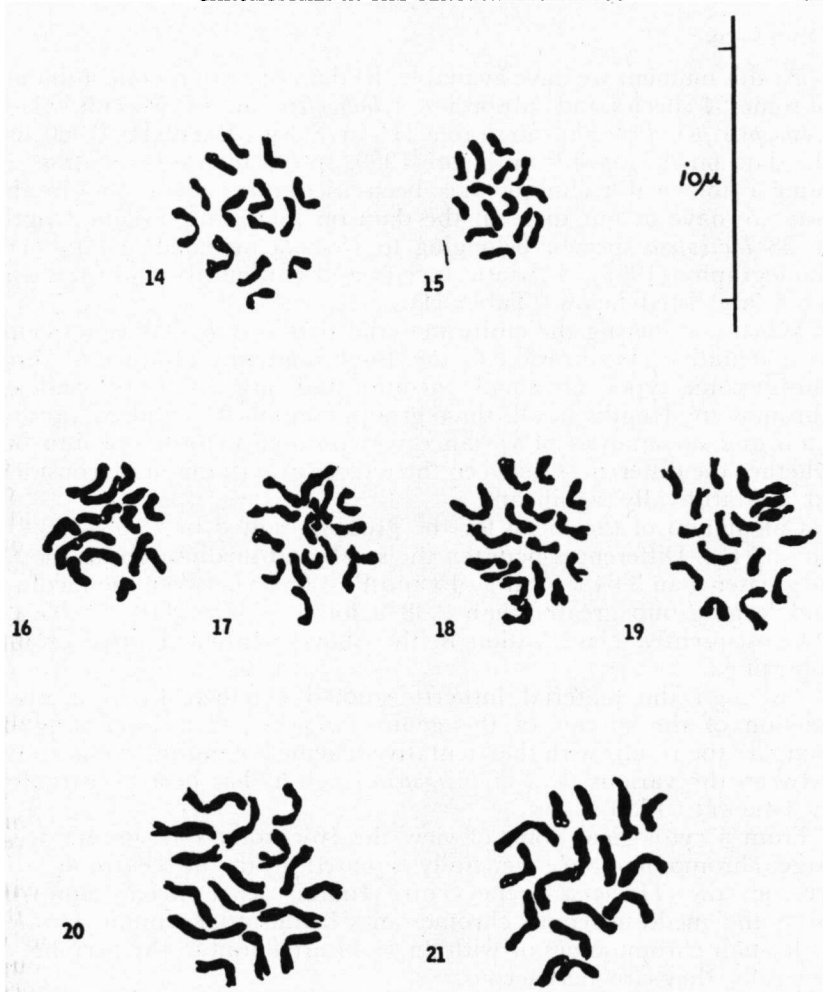
With respect to the results obtained in this study, it is of interest that Hagerup's count of  $2n = 14$  for *I. parviflora* Heyne could be confirmed. Moreover, the same number of  $2n = 14$  was observed in the two species studied from section *Latestipulatae* and from one more species belonging to subgenus *Indigastrum* but of these 14 chromosome species, *I. ischnoclada* decidedly has larger chromosomes than the other ones: total chromosome length for the former adds up to  $27.3 \mu$  whereas in the others this value varies from  $18.4-24.1 \mu$ .

In order to get an idea as to what extent these chromosome values could yield a clue to the supposed phylogenetic connection between the genera *Cyamopsis* and *Indigofera* the same procedure as to the total chromosomal length has been applied to two cultivars of *Cyamopsis psoralioides* in which formerly the chromosome number had been established as  $2n = 14$  (FRAHM-LELIVELD, 1953). Figs. 5 and 6 show that there is an agreement between these sets and that of *I. ischnoclada*, and also their total lengths ( $31.4, 31.7 \mu$  resp.) come within the same range.

Species	Collection No.
Genus <i>Indigofera</i> L.	
Subgenus B. <i>Amecarpus</i> Benth. ex Harvey	
Section 1. <i>Amecarpus</i> Benth. ex Harvey	
1 <i>Indigofera Hochstetteri</i> Bak. . . . .	61008
2 <i>Indigofera praticola</i> Bak. f. . . . .	61010
3 <i>Indigofera Charlieriana</i> Schinz. . . . .	61027
Section 2. <i>Demissae</i> Gillett	
4 <i>Indigofera demissa</i> Taub. . . . .	61009
Genus <i>Cyamopsis</i> DC.	
5 <i>Cyamopsis psoraloides</i> DC. Stbk. no. 34 . . . . .	
6 id. Stbk. no. 35 . . . . .	
Genus <i>Indigofera</i> L.	
Subgenus C. <i>Indigofera</i> Gillett	
Section 1. <i>Latestipulatae</i> (Bak. f.) Gillett	
7 <i>Indigofera ischnoclada</i> Harms . . . . .	61011
8 <i>Indigofera strobilifera</i> (Hochst.) Hochst. ex Bak. ssp. <i>lanuginosa</i> (Taub. ex Bak. f.) Gillett . . . . .	61012
9 id. id. . . . .	61026
Section 3. <i>Indigofera</i> L.	
Subsection a. <i>Juncifoliae</i> Harvey	
10 <i>Indigofera podophylla</i> Benth. ex Harvey . . . . .	61013
Subsection d. <i>Dissitiflorae</i> (Bak.) Gillett	
11 <i>Indigofera vohemarensis</i> Baill. . . . .	61014
Subsection c. <i>Spinosa</i> (Bak.) Gillett	
12 <i>Indigofera basiflora</i> Gillett . . . . .	61015
Subsection j. <i>Atratae</i> Gillett	
13 <i>Indigofera atriceps</i> Hook. f. ssp. <i>setosissima</i> (Harms) Gillett . . . . .	61016
Subgenus D. <i>Indigastrum</i> (Jaub. et Spach) Gillett	
14 <i>Indigofera costata</i> G. et P. ssp. <i>macra</i> (E. Mey.) Gillett. . . . .	61017
15 <i>Indigofera parviflora</i> Heyne ex. W. et A. . . . .	61019
Subgenus E. <i>Microcharis</i> (Benth.) Gillett	
16 <i>Indigofera lobata</i> Gillett . . . . .	61020
17 <i>Indigofera asparagoides</i> Taub. ssp. <i>asparagoides</i> . . . . .	61023
18 id. id. . . . .	61024
19 <i>Indigofera asparagoides</i> Taub. ssp. <i>ephemera</i> Gillett. . . . .	61025
Asiatic species	
20 <i>Indigofera amblyantha</i> Craib. . . . .	61030
21 <i>Indigofera potaninii</i> Craib. . . . .	61031

Origin			Remarks		
Kew Herb. No.	Date	Source	Chrom. No. 2 n	Chrom. type	Total length in $\mu$
Richards s.n.	12-6-1957	N. Rhodesia-Tanganyika border	16	large	35.5
Robinson 858	11-6-1954	Fort Jameson N. Rhodesia	16	large	44.1
Fanshawe 5702	29-5-1960	Livingstone N. Rhodesia	16	large	45.5
Fanshawe 2334	14-6-1955	Ndota N. Rhodesia	16	large	32.5
			14	large	31.4
			14	large	31.7
Banda 86	23-4-1955	Zomba Nyasaland	14	large	27.3
Bogdan 2572	12-8-1948	Saira Tanganyika	14	small	21.1
Mrs. Faulkner 2195	10-10-'58	Malindi Kenya	14	small	21.1
Balsinhas 146	30-3-1960	Lourenço Marques Moçambique	16	large	42.9
Mrs. Faulkner 760	21-12-'50	Bushiri Tanganyika	16	large	40.0
R. M. Davies 1197	23-8-1936	Engare Nairobi Tanganyika	16	large	48.6
Harker 593	17-7-1956	Ankole Rushori Uganda	16	large	45.0
Lamas & Balsinhas 65	16-6-1960	Chibate Port. East Africa	14	small	24.1
Thomas 4145	24-6-1945	Katwe Uganda	14	small	18.4
Mrs. Faulkner 1262	6-11-1953	Lushito Tanganyika	16	small	24.0
Harker 562	26-6-1956	Entebbe Uganda	16	small	23.5
Norman 15	8-7-1951	Entebbe Uganda	16	small	26.0
Mrs. Richards 4919/B	May 1955	Abenom N. Rhodesia	16	small	25.8
	1961	Arboretum Wageningen	16	large	39.3
	1961	Arboretum Wageningen	16	large	35.4





Legend to the Figures. 1. *Indigofera Hochstetteri*; 2. *I. demissa*; 3. *I. praticola*; 4. *I. Charlieriana*; 5. *Cyamopsis psoralioides* Stb. no. 34; 6. *C. psoralioides* Stb. no. 35; 7. *Indigofera ischnoclada*; 8. *I. strobilifera* ssp. *lanuginosa*; 9. *I. strobilifera* ssp. *lanuginosa*; 10. *I. podophylla*; 11. *I. vohemarensis*; 12. *I. basiflora*; 13. *I. atriceps* ssp. *setosissima*; 14. *I. costata* ssp. *macra*; 15. *I. parviflora*; 16. *I. lobata*; 17. *I. asparagoides* ssp. *asparagoides*; 18. *I. asparagoides* ssp. *asparagoides*; 19. *I. asparagoides* ssp. *ephemera*; 20. *I. amblyantha*; 21. *I. potaninii*.

The other species studied all have  $2n = 16$ . But in subgenus *Microcharis* we meet with the same small chromosome type that was encountered earlier in the *Acanthonotus*- and *Hirsutae* material. In these cases the range of total length runs between the values 18.8–25.8  $\mu$ . All of the remaining species belong to the so-called “large chromosome types”.

## DISCUSSION

At this moment we have available the data on chromosome numbers of some 54 species and subspecies of *Indigofera* and of two cultivars in *Cyamopsis psoralioides* in all: table III in FRAHM-LELIVELD, 1960 lists the data on *Indigofera* from before 1960. In our own investigation the same cytological technique has been used throughout and in this way we have at our disposal the data on total chromosome lengths in 38 *Indigofera* species, belonging to 15 taxa included in GILLETT's monography (1958), 5 Asiatic species and two cultivars of *Cyamopsis*. They are listed below (Table II).

When considering the entire material that was available, we came to a tentative classification of the 16-chromosome group into three chromosome types, i.e. small, medium and large. With 40 data on chromosome lengths in all, these groups contain 8, 7 and 25 variates each and an analysis of variance was possible in order to find out whether the differences between these three groups might be considered as statistically significant.

Calculation of the mean for the groups resulted in 23.5  $\mu$ , 28.4  $\mu$  and 37.1  $\mu$ . Differences between the small and medium group should be greater than 3.64  $\mu$  for  $n = 15$  and  $P = 0.05$ ; between the medium and large group greater than 2.38  $\mu$  for  $n = 32$  and  $P = 0.05$ .

Consequently, classification in the above-mentioned three groups is justified.

Although the material hitherto studied cytologically is a mere fraction of the species in the genus *Indigofera*, it is interesting to compare the results with the "tentative scheme" of mutual connections between the various taxa of *Indigofera*, such as has been constructed by GILLETT (1958).

From a cytological point of view the 16-chromosome groups with large chromosomes are generally situated near the centre of the scheme; the *Tinctoriae* (gene centre India?) as a mixed group of large and medium length chromosomes being an exception. Groups with small chromosomes or with  $2n = 14$  are found in the periphery: generally they are herbaceous.

When accepting this constellation, we also should be constrained to accept an evolution where a loss of chromosome material has taken place. According to LEDINGHAM (1958, 1960) a such-like phenomenon has taken place in another genus of the *Galegeae*, viz. in *Astragalus*.

It is possible, however, to draw an other line of thought, viz. that the genus *Indigofera* originated in a polyphyletic way and in separate gene centres e.g. in Asia, South-east Africa and West Africa, each of these centres supplying the types which became ecologically suited to their environment.

But only much more cytological investigations in the African, Asiatic and American groups could make it possible to reach an idea of the evolution in *Indigofera* and the adjacent genera.

TABLE II  
Number of chromosomes.

2 n = 14		2 n = 16		2 n = 32		2 n = 48	
small 18.4-24.1	large 27.3-31.7	small 18.8-25.8	medium 26.2-35.3	large 28.5-48.6	small 45.1-53.0	small 76.0	medium 87.4-88.0
I. strobilifera ----- costata ----- parviflora -----	C. psoralioides ----- I. ischnoclada -----	I. nummularii- folia ----- ----- ----- hirsuta astragalina ----- ----- lobata asparagoides -----	I. simplici- folia ----- ----- secundi- flora ----- ----- macro- phylla tinctoria	I. hochstetteri praticola charlieriana ----- demissa ----- ----- paniculata paracapitata congesta pulchra ----- ----- podophylla ----- ----- dendroides Heudelotii vohemarensis ----- ----- basiflora ----- ----- atriceps ----- ----- trita arrecta suffruticosa ----- ----- schimperii ----- amblyantha potaninii -----	I. spicata	I. heteranthera	I. cytisoides dosua

## SUMMARY

Root tip counts in a number of East- and South East African species of *Indigofera*, the seeds of which were made available by Kew Herbarium and of two more Asiatic species resulted in  $2n = 14$  for 2 species in the *Latestipulatae* section of the subgenus *Indigofera* and for 2 species in the subgenus *Indigastrum*. The latter report is in accordance with the previous record of Hagerup for *I. parviflora*. All the other ones investigated have  $2n = 16$ .

A considerable difference in chromosome shape and magnitude is present. Two cultivars of *Cyamopsis psoralioides* ( $2n = 14$ ) have been inserted; only the total chromosome length and shape of *Indigofera ischnoclada* (section *Indigastrum*) enters within the same order of *Cyamopsis*.

A tentative division of the 16 chromosome species hitherto studied in three groups with small, medium and large chromosomes was made and the actual differences between the three mean total chromosome lengths of these groups could be proved to be statistically significant.

A few implications as to the meaning of these differences in respect of the evolution and geographic distribution are worked out, but it is pointed out that these need be very preliminary and that further study of the *Indigofera* cytology is necessary.

## REFERENCES

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