PART II

MORPHOLOGICAL AND CYTOLOGICAL CONSIDERATIONS

MORPHOLOGICAL AND CYTOLOGICAL CONSIDERATIONS

Morphological description based on different populations for each species is given. This is done with a view to compare them, to know the intra- and interspecific variations.

The commonly observed somatic chromosome numbers are 2n = 16 in Indigofera and Alysicarpus and 2n = 22 in Desmodium and Dendrolobium. The detailed karyomorphological study of different populations of the species of the above mentioned genera has been made. The measurements of somatic chromosomes are presented in separate tables.

In the present investigation, the chromosomes are classified based on their length and position of centromere. This is done with a view to describe the karyotype and to represent the same by karyotypic formulae. This would also help in better understanding of karyotypes of the taxa analysed and their relationships at intraspecific, interspecific as well as at intergeneric levels. The uniform categorization adopted in the present work is as follows :

	Types
1. Long chromosomes - 4 μ to 6 μ in length	
1.1 with nearly median centromere	A
1.2 with nearly submedian centromere	B
2. Medium chromosomes - 2 μ to less than 4 μ in length	
2.1 with median centromere	C
2.2 with nearly median centromere	D
2.3 with submedian centromere	E
2.4 with nearly submedian centromere	F
3. Short chromosomes 1 μ to less than 2 μ in length	
3.1 with nearly median centromere	G
3.2 with nearly submedian centromere	H

Superscript

S - denotes satellites.

$S^{'}$ - denotes secondary constrictions on long arms.

$S^{''}$ - denotes secondary constriction on short arms.

Indigofera Linn.

The genus Indigofera belonging to the tribe Indigoferae,

with about 800 species is widely distributed in tropics of the new and old worlds (Hutchinson, 1967). However, disjunct areas of distribution in north and south of the equator are reported by Gillett (1958).

The genus includes certain species, which contain indigo, from which it had obtained its name. The indigo has been known from very ancient times, since it is proved have to been used for staining mummy clothes found in Egyptian tombs. There are several other economic uses of the genus such as medicine, poison, fodder, cover crops, green manures and also as food. (Gillett, 1958).

The genus Indigofera was established by Linnaeus in 1837. Subsequently Baker (1876), Craib (1903), Gillett (1958), Ali (1958) and others have studied the genus in greater details.

Baker (1876) in 'Flora of British India' has divided the genus into 4 subgenera viz. Acanthonotus, Sphaeridiophora, Euindigofera and Amecarpus. The subgenus Euindigofera is subdivided into 6 groups viz. Simplicifoliae, Sessiliflorae, Digitate, Disstiflorae, Tinctoriae and Paniculatae. Totally 40 species are included in the above mentioned groupings. Gillett (1958) based on extensive survey (278 species) of the

Table 2a. Changes of the systems of the genus Indigofera Linn.

BAKER (1876)	GILLETT (1958)
INDIGOFERA	INDIGOFERA
Subgen. Acanthonotus	Subgen. Acanthonotus
Subgen. Sphaeridiophora	Subgen. Amecarpus
Subgen. Euindigofera	Sect. Amecarpus
Group Simplicifoliae	Sect. Demissae
Group Sessiliflorae	Subgen. Indigofera
Group Digitatae	Sect. Latestipulatae
Group Dissitiflorae	Sect. Paniculatae
Group Tinctoriae	Subsect. Paniculatae
?I. Leaflets 3-5	Subsect. Trichopodae
?II. Leaflets many, opposite flowers small	Sect. Indigofera
?III. Leaflets many, opposite flowers large	Subsect. Juncifoliae
Group Paniculatae	Subsect. Brevi-erectae
Subgen. Amecarpus	Subsect. Anomalae
	Subsect. Dissitiflorae
	Subsect. Spinosae
	Subsect. Brevi-patentes
	Subsect. Pilosae
	Subsect. Viscosae
	Subsect. Centrae
	Subsect. Atratae
	Subsect. Psiloceratiae
	Subsect. Geanthae
	Subsect. Tinctoriae
	Subsect. Hirsutae
	Subsect. Microcarpae
	Subsect. Alternifoliae
	Subsect. Simplices-reflexae
	Subgen. Indigastrum
	Subgen. Microcharis

genus from Tropical Africa, has classified it into 5 subgenera viz. Acanthonotus, Amecarpus, Indigofera, Indigastrum and Microcharis. The subgenera Amecarpus and Indigofera are subdivided into 2 and 3 sections respectively. The last section i.e. Indigofera is further subdivided into 19 subsections. The changes in the treatment of the genus are summarised in the table **2a.**

The genus is characterised by herbs, shrubs or subshrubs, more or less clothed with adpressed medifixed hairs, sometimes mixed with other indumentum. Leaves imparipinnate or pinnately or digitately trifoliate, sometimes 1-foliolate or simple; stipules often small and setaceous, very shortly adnate to petiole; leaflets entire, sometimes stipellate. Inflorescence axillary or terminal raceme. Flowers pedicellate or sessile in the axil of a caducous bract. Calyx minute, lobes subequal or the lowest longer. Corolla rose or purple; vexillum ovate or orbicular, sessile or clawed, often persisting for long time; wings oblong, slightly covering with the keel, keel erect, obtuse or acuminate, often spurred near the base. Stamens diadelphous, anthers uniform, apiculate. Ovary sessile or nearly so, ovules numerous to 1 or 2; style glabrous; stigma capitate, often penicillate. Pod linear to globose, rarely terate, 4-3 sided or flattened, septate within and

between seeds. Seeds globose to cylindric and truncate, compressed or quadrate, estrophiolate.

Different species investigated presently are arranged following the classification of Gillett (1958).

Genus : Indigofera Linn.

Subgenus : Acanthonotus (Benth.) Benth. & Hook. f.

Subgenus : Amecarpus Benth. ex Harvey

Section : Amecarpus

I. hochstetteri Bak.

Section : Demissae Gillett -

Subgenus : Indigofera

Section : Latestipulatae (Bak. f.) Gillett -

Section : Paniculatae (Bak.) Gillett -

Section : Indigofera Gillett -

Subsection : Juncifoliae Harvery -

Subsection : Brevi-erectae Gillett

I. linifolia Linn. f.

I. linifolia Linn. f. var.campbelli Wight

I. cordifolia Heyne. ex Roth.

I. linnaei Ali.

Subsection : Anomalae Gillett -

Subsection : Dissitiflorae (Bak.) Gillett

Subsection : Spinosae (Bak.) Gillett -

Subsection : Pilosae Gillett -

Subsection : Viscosae Rydberg

I. colutea (Burm., f.) Merrill

Subsection : Centrae Gillett

I. vicioides Jaub. & Spach.

Subsection : Atratae Gillett -

Subsection : Psiloceratae Gillett -

Subsection : Geanthae Gillett -

Subsection : Tinctoriae (Bak.) Gillett

I. subulata Vahl ex Poir.

I. trita Linn. f.

I. arrecta Hochst. ex A. Rich.

I. tinctoria Linn.

I. heterantha Wall. ex Brandis

I. amblyantha Craib.

I. angulosa Bak.

Subsection : Hirsutae Rydberg

I. hirsuta Linn.

I. astragalina DC.

Subsection : Microcarpae Rydberg

I. glandulosa Willd.

I. trifoliata Linn.

I. duthei Drum. ex Naik

Subsection : Alternifoliae (Harvey) Gillett

I. oblongifolia Forsk.

I. spicata Forsk.

Subsection : Simplices-reflexae Gillett -

Subgenus : Indigastrum (Jaub. ex Spach) Gillett -

Subgenus : Microcharis (Benth.) Gillett ----

Indigofera hochstetteri Baker, F. T. A. 2 : 101, 1871;

Gillett, loc. cit. 13; Ali, Bot. Notis. 3 : 552, 1958.

I. anabaptista Steud. (nom. nud.); FBI. 2 : 102, 1876;

Cooke, 1 : 334, 1902.

A diffuse or prostrate herb. Branches numerous, grooved,

glabrous or nearly so. Leaves imparipinnate, leaflets 5, opposite, oblanceolate, apiculate, clothed with appressed hairs. Flowers red, in short peduncled axillary racemes. Pods linear, flat papery with longitudinal ridges on flattened faces and a transverse ridge between each of the seeds (Fl. Fr. August - September) S. 28.

Very rare, observed in the open places in forests.

Earlier reports are 2n = 16 (Frahm-leliveld, 1960; Cave, 1961; Singh and Roy, 1970) and 2n = 32 (Bhatt, 1974) for the species. The present study confirms the latter report of 2n = 32 and is therefore a tetraploid taxon.

Coll. No. 28.

Karyotype formulae : 2n = 32 = $D_{10}+D_2^S+D_2^{S'}+F_{12}+F_4^{S'}+G_2$=85.06 μ (Fig.1).

There are equal number of chromosomes with nearly median (D and G - types) and nearly submedian (F-type) centromeres in the complement. Secondary constrictions are, present on a pair of nearly median ($D^{S'}$-type) and a nearly submedian ($F^{S'}$-type) types of chromosomes and another pair of nearly median chromosomes are with satellites (D^S-type). The chromosomes are medium sized except for a pair of short sized chromosomes (G-type). The chromosome length ranges from 3.44 μ to 1.74 μ, with a mean

Table 3. Measurements of somatic chromosomes of *I. hochstetteri* Bak. (Coll. No. 28).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	2.38+1.06=3.44	100.00	0.44	2.24	nsm	F
3, 4	2.55+0.89=3.44	100.00	0.34	2.86	nsm	F
5, 6	0.68+1.36+1.27=3.31	96.22	0.62	1.60	nm	$D^{S'}$
7, 8	2.12+0.93=3.05	88.66	0.43	2.27	nsm	F
9, 10	0.68+1.27+0.93=2.88	83.72	0.47	2.09	nsm	$F^{S'}$
11, 12	1.78+1.10=2.88	83.72	0.61	1.61	nm	D
13, 14	0.76+1.02+0.93=2.71	78.77	0.52	1.91	nsm	$F^{S'}$
15, 16	1.74+0.93=2.67	77.61	0.53	1.87	nsm	F
17, 18	1.78+0.76=2.54	73.83	0.42	2.34	nsm	F
19, 20	1.61+0.89=2.50	72.67	0.55	1.80	nsm	F
21, 22	1.40+0.97=2.37	68.89	0.69	1.44	nm	D
23, 24	1.36+0.93=2.29	65.56	0.68	1.46	nm	D
25, 26	1.53+0.76=2.29	65.56	0.49	2.01	nsm	F
27, 28	1.36+0.85=2.21	64.24	0.62	1.60	nm	D^{S}
29, 30	1.36+0.85=2.21	64.24	0.62	1.60	nm	D
31, 32	1.02+0.72=1.74	50.58	0.70	1.41	nm	G

Indigofera hochstetteri

Fig. 1. Camera lucida drawing of somatic metaphase and idiogram.

Figs. 2 and 3. PMCs showing 16 bivalents at metaphase (polar and side views).

I. linifolia

Fig. 4. Camera lucida drawing of somatic metaphase and idiogram.

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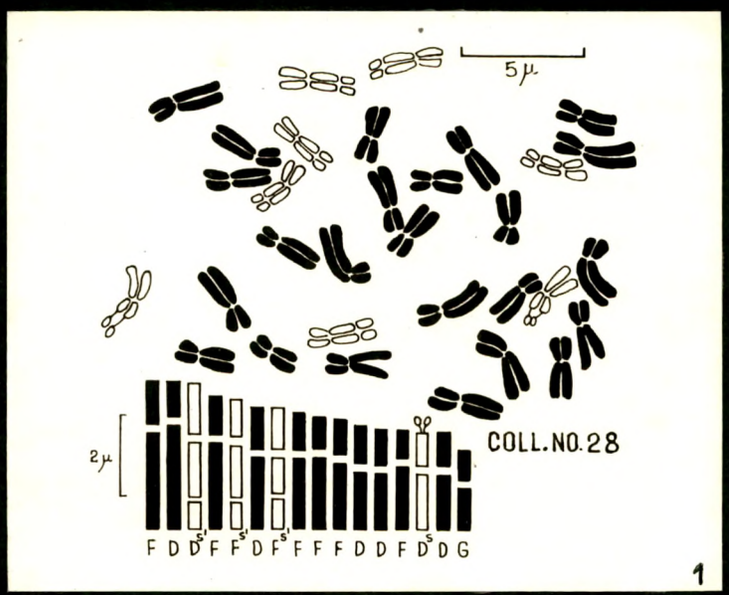
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2μ
COLL.NO.28
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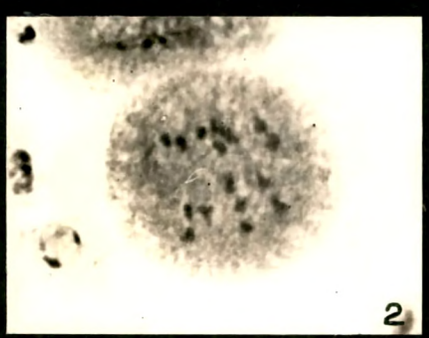
1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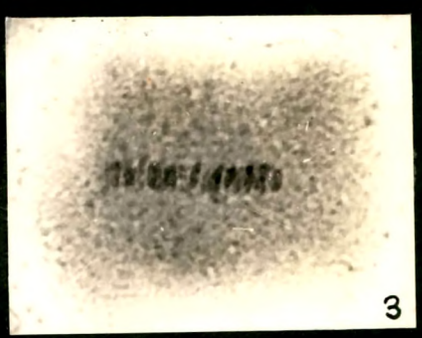
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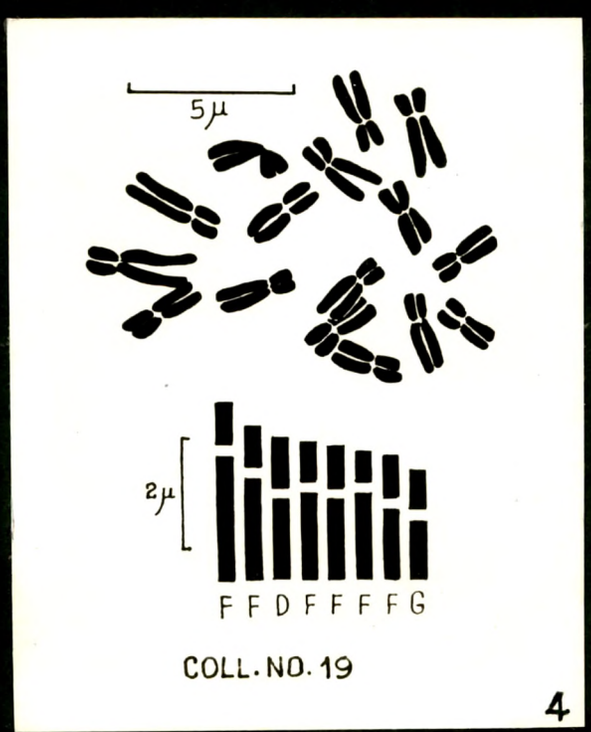

5μ
2μ
F F D F F F F G
COLL. NO. 19
4

length of 2.66 μ. The karyotype is asymmetrical and graded as the TF% and L/S are 34.72 and 1.95 respectively.

Bhatt (1974) reports 2 pairs of median, 8 pairs of submedian and 6 pairs of subterminal chromosomes in the taxon analysed by him. In the present karyotype analysis only nearly median and nearly submedian chromosomes are observed. In contrast to the earlier report (Bhatt, 1974) of 2 pairs of chromosomes with satellites, in the present work 2 pairs of chromosomes with secondary constrictions and one pair with satellites are observed.

Meiosis is regular showing 16 bivalents at metaphase I (Figs. 2 and 3). The pollen fertility determined for the species is 87.61%.

Indigofera linifolia (Linn. f.) Retz., obs. Bot. 4 : 29, 1786; FBI. 2 : 92, 1876; Cooke, 1 : 330, 1902; Gillett, loc. cit. 35; Ali, loc. cit. 546.

Hedysarum linifolium Linn. f., Suppl. Pl. 331, 1781.

A prostrate, suberect or at times erect herb. Branches wiry, spreading, covered with silvery white hairs, more or less angular. Leaves simple, linear, acute. Flowers bright

red in dense sessile or subsessile axillary racemes. Pods globose, silvery white, 1-seeded (Fl. Fr. August - October) S. 19, 20, and 21.

Fairly common on plains among grasses and also observed in sandy river beds.

The chromosome numbers n = 8 and 2n = 16 determined presently confirm the earlier reports of Bir and Sidhu (1966 and 1967); Singh and Roy (1970) and Bhatt (1974) for the species. Three collections are investigated cytologically.

Coll. Nos. 19 and 20.

Karyotype formulae : 2n = 16 = $D_2+F_{12}+G_2$=36.78 μ (Fig. 4).

The karyotype shows 2 pairs of chromosomes with nearly median centromeres (D and G - types) and 6 pairs with nearly submedian centromeres (F-type). The chromosomes in the complement are medium sized, except for a pair of short sized chromosomes (G-type). The length of chromosomes ranges from 2.97 μ to 1.78 μ, with a mean length of 2.29 μ. The karyotype is asymmetrical and graded, as TF% and L/S are 33.93 and 1.60 respectively.

Table 4. Measurements of somatic chromosomes of *I. linifolia* (Linn. f.) Retz. (Coll. No. 19).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	2.21+0.76=2.97	100.00	0.34	2.90	nsm	F
3, 4	1.82+0.76=2.58	86.86	0.41	2.39	nsm	F
5, 6	1.44+0.94=2.38	79.79	0.64	1.54	nm	D
7, 8	1.53+0.76=2.29	77.10	0.49	2.01	nsm	F
9, 10	1.44+0.76=2.20	74.07	0.52	1.89	nsm	F
11, 12	1.53+0.63=2.16	72.72	0.41	2.42	nsm	F
13, 14	1.27+0.76=2.03	68.35	0.59	1.67	nsm	F
15, 16	1.02+0.76=1.78	59.93	0.74	1.34	nm	G

Coll. No. 21.

Karyotype formulae : $2n = 16 = D_4+F_6+H_4+H_2^S = 35.02\ \mu$ (Figs. 5 & 6).

The karyotype of this collection differs from the earlier ones in having more number of short chromosomes and a pair of chromosomes with satellites (H^S-type).

The morphological similarities and karyotypic differences (Table 6) of the populations studied indicate the presence of cytotypes in the species.

In contrast to the earlier reports (Singh and Roy, 1970 and Bhatt, 1974) of 3 pairs of median and 5 pairs of submedian chromosomes in the karyotype, the present analysis shows 2 pairs of nearly median and 6 pairs of nearly submedian chromosomes. Satellites on a pair of chromosomes observed presently were not recorded in the earlier works.

During meiosis formation of 8 distinct bivalents at metaphase I and their equal distribution at anaphase I (Figs. 7 and 9) are observed. Some PMCs showed association of bivalents at metaphase I and early disjunction of chromosomes at metaphase II (Figs. 8 and 10). The pollen fertility determined for the species is 88%.

Table 5. Measurements of somatic chromosomes of *I. linifolia* (Linn. f.) Retz. (Coll. No. 21).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.62+1.06=2.68	100.00	0.65	1.52	nm	D
3, 4	1.70+0.94=2.64	98.51	0.55	1.81	nsm	F
5, 6	1.66+0.94=2.60	97.01	0.57	1.76	nsm	F
7, 8	1.19+0.94=2.13	79.48	0.79	1.27	nm	D
9, 10	1.32+0.68=2.00	74.63	0.52	1.94	nsm	F
11, 12	1.45+0.51=1.96	73.13	0.35	2.84	nsm	H^S
13, 14	1.28+0.60=1.88	70.14	0.47	2.13	nsm	H
15, 16	1.02+0.60=1.62	60.45	0.59	1.70	nsm	H

I. linifolia Contd.

Fig. 5. Camera lucida drawing somatic metaphase and idiogram.

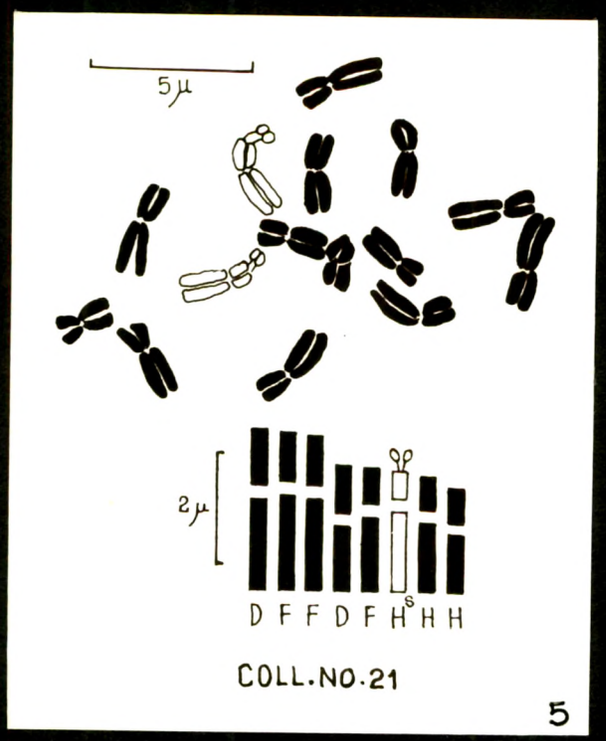
Fig. 6. Photomicrograph of somatic metaphase.

Fig. 7. PMC showing 8 distinct bivalents at metaphase I. (Coll. No. 19).

Fig. 8. " " association of bivalents. (Coll. No. 19).

Fig. 9. " " equal distribution at anaphase I. (Coll. No. 20).

Fig.10. " " early disjunction of chromosomes at metaphase II (Coll. No. 21).



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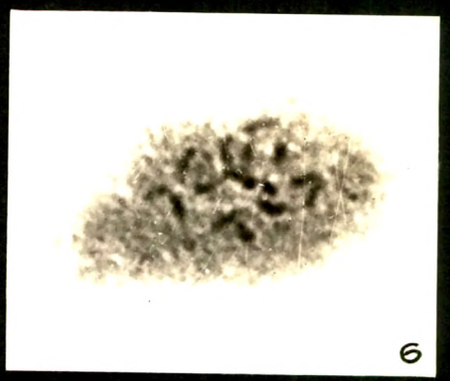

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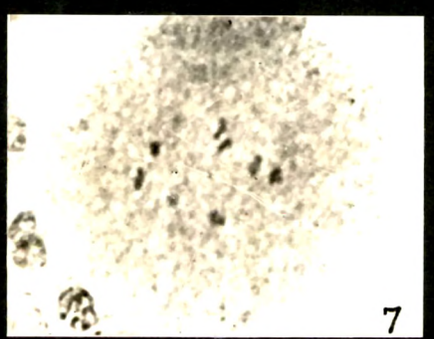

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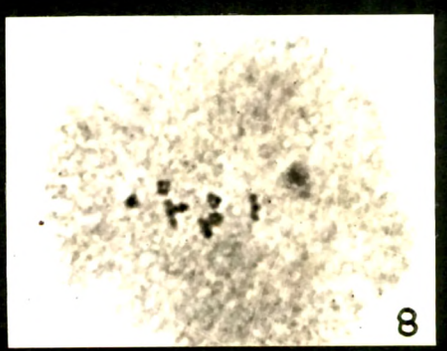

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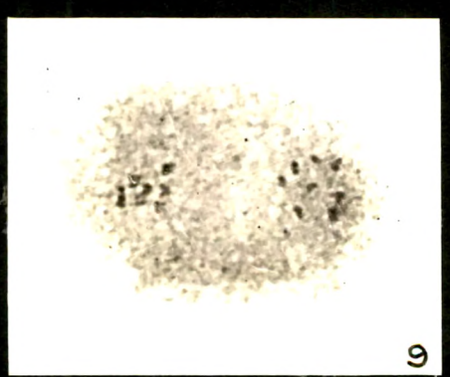

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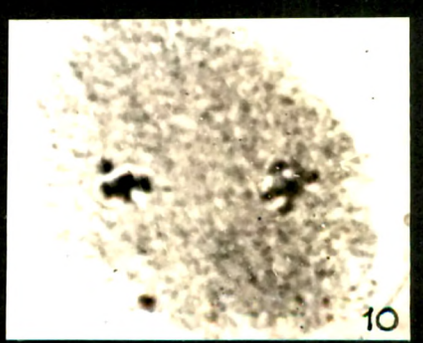

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Table 6.

Comparision of somatic chromosomes of different populations of I. linifolia Retz.

Populations	Somatic number (2n)	nm		nsm		Chromosomes with SATs	Absolute length (in μ)	Mean length (in μ)	L/S
		Types		Types		Type			
		D	G	F	H	H^S			
Coll. Nos. 19 and 20	16	2	2	12	-	-	36.78	2.29	1.60
Coll. No. 21	16	4	-	6	6	2	35.02	2.19	1.65

Indigofera linifolia (Linn. f.) Retz. var. campbelli Wight

Cooke, 1 : 331, 1902; Gamble, 1 : 218, 1935.

A prostrate, annual herb, branching from the ground or at times erect among grasses. Stem and branches 2-edged. Leaves obovate, or ovate-elliptic, subacute. Flowers red in many flowered, short, axillary racemes. This resembles the type species in many characters except, the nature of stem, the size and shape of the leaf (Fl. Fr. August - October) S. 18, 62.

Rare, noted along with the type species in open lands and among grasses.

No data regarding the cytological work for the taxon is available. In the present study n = 8 and 2n = 16 are the chromosome numbers determined for the taxon.

Coll. Nos. 18, 62.

Karyotype formulae : 2n = 16 = $D_2+F_{10}+F^{S'}_2+G_2=38.32\ \mu$ (Figs. 11 & 12)

The karyotype includes 2 pairs of chromosomes with nearly median centromeres and 6 pairs with nearly submedian centromeres. One pair of chromosomes with nearly submedian centromeres ($F^{S'}$-type) are with secondary constrictions on long arms. The chromosomes are medium sized except for a pair of short sized

Table 7. Measurements of somatic chromosomes of

I. linifolia (Linn.f.) Retz.var. campbellii Wight (Coll.No.62)

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	0.60+1.36+1.02=2.98	100.00	0.52	1.92	nsm	F^S
3, 4	1.70+0.98=2.68	89.93	0.58	1.73	nsm	F
5, 6	1.70+0.94=2.64	88.59	0.55	1.80	nsm	F
7, 8	1.70+0.85=2.55	85.57	0.50	2.00	nsm	F
9, 10	1.45+0.81=2.26	75.83	0.56	1.79	nsm	F
11, 12	1.36+0.85=2.21	74.16	0.63	1.60	nm	D
13, 14	1.28+0.77=2.05	68.79	0.60	1.66	nsm	F
15, 16	0.94+0.85=1.79	60.06	0.90	1.11	nm	G

I. linifolia var. campbelli

Fig. 11. Camera lucida drawing somatic metaphase and idiogram.

Fig. 12. Photomicrograph of somatic metaphase.

Fig. 13. PMC showing 8 bivalents at metaphase I.(Coll. No.18).

Fig. 14. " " metaphase II (Coll. No. 62).

Fig. 15.

I. cordifolia

Fig. 15. Camera lucida drawing of somatic metaphase and idiogram.

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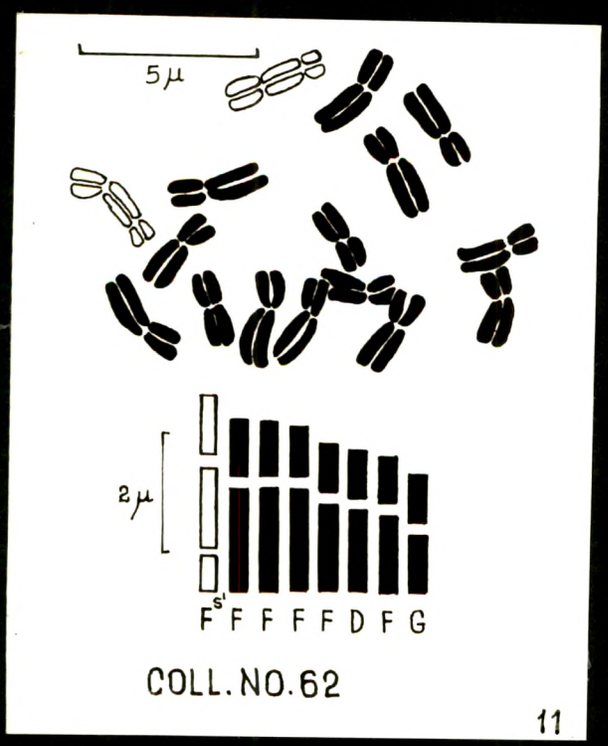
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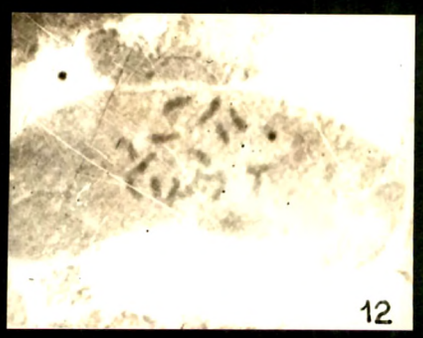
COLL. NO. 62
11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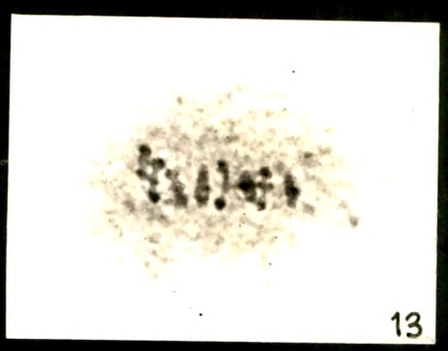
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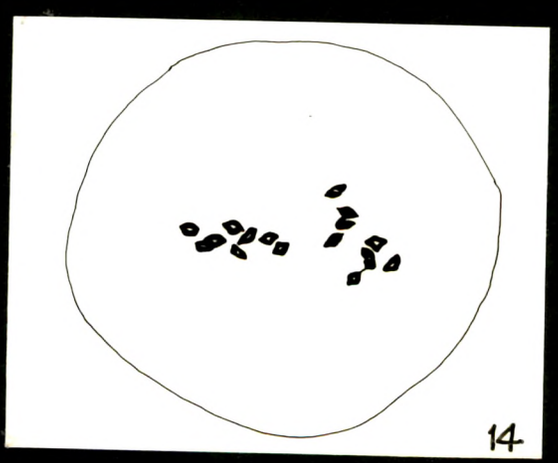
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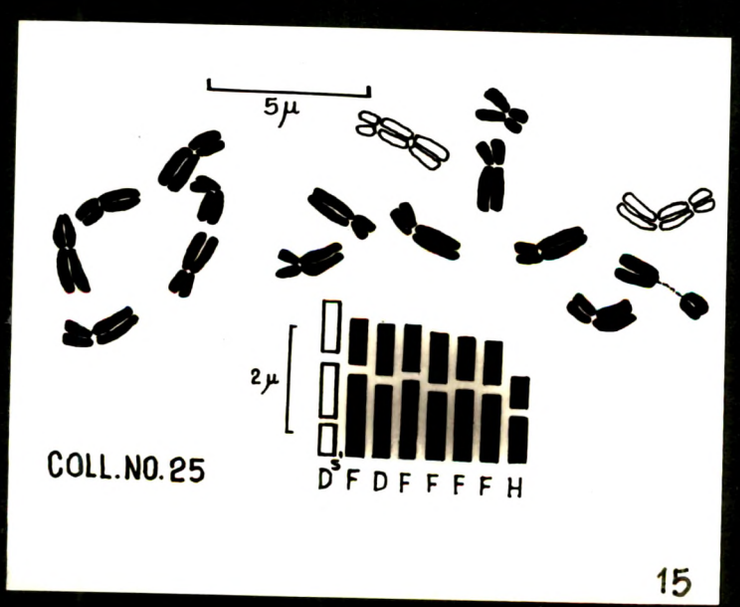
5μ
2μ
D F D F F F F H
COLL. NO. 25
15

chromosomes (G-type). The length of chromosomes varies from 2.98 μ to 1.79 μ, with an average length of 2.40 μ. The karyotype is asymmetrical and graded as the TF% and L/S are 36.90 and 1.66 respectively.

Meiosis is normal showing formation of 8 bivalents at metaphase I (Fig. 13). However, some PMCs showed grouping of chromosomes at metaphase II (Fig. 14). The pollen fertility determined for the taxon is 86%.

Indigofera cordifolia Heyne. ex Roth., Nov. Pl. Sp. 357, 1821; FBI. 2:93, 1876; Cooke, 1:311, 1902; Gillett, loc.cit. 35.

A prostrate or diffuse annual herb, covered with white pubescence all over. Leaves simple, broadly ovate-cordate, sessile, hairy on both the sides (more densely beneath). Flowers bright red in dense, axillary heads. Calyx hairy outside. Pods cylindric, densely hairy, 1-2-seeded (Fl. Fr. August - November) S. 25, 26 and 60.

Fairly common; observed on escarpments, along roadsides and on plains along with grasses.

The chromosome number 2n = 16 reported earlier (Ramanathan, 1955; Frahm-leliveld, 1966; Singh and Roy, 1970 and Bhatt, 1974)

is confirmed in the present investigation. However, Bir and Sidhu (1967) have reported n = 14 for the species. All the 3 collections (25, 26, 60) investigated showed similarity in their karyotypes.

Karyotype formulae:2n = 16 = $D_2+D_2^{S'}+F_{10}+H_2$=34.42 μ (Fig. 15).

The somatic complement shows 2 pairs of chromosomes with nearly median (D-type) and 6 pairs with nearly submedian (F and H - types) centromeres. A pair of nearly median chromosomes ($D^{S'}$-type) are with secondary constrictions on long arms. The chromosomes are medium sized except for a pair of short sized chromosomes (H-type). The length of chromosomes ranges from 2.64 μ to 1.36 μ, with a mean length of 2.15 μ. The TF% (37.88) and L/S (1.94) show that, the karyotype is asymmetrical and graded.

The present report of 2 pairs of nearly median and 6 pairs of nearly submedian chromosomes in the karyotype of the species, differs from the earlier reports (Singh and Roy, 1970 and Bhatt, 1974) of equal number of median and submedian chromosomes. A pair of chromosomes with secondary constrictions or satellites observed in the present work as well as in the work of Bhatt (1974) were not recorded by Singh and Roy (1970).

Table 8. Measurements of somatic chromosomes of *I. cordifolia* Heyne ex Roth (Coll. No. 25)

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	0.60+1.02+1.02=2.64	100.00	0.63	1.59	nm	$D^{S'}$
3, 4	1.53+0.81=2.34	88.64	0.53	1.89	nsm	F
5, 6	1.36+0.94=2.30	87.12	0.69	1.45	nm	D
7, 8	1.45+0.85=2.30	87.12	0.59	1.71	nsm	F
9, 10	1.28+0.85=2.13	79.17	0.66	1.51	nm	D
11, 12	1.32+0.77=2.09	80.68	0.58	1.71	nsm	F
13, 14	1.28+0.77=2.05	77.65	0.60	1.66	nsm	F
15, 16	0.85+0.51=1.36	51.52	0.60	1.66	nsm	H

Meiosis is regular showing 8 bivalents at metaphase I (Fig. 16). However, cytomixis at telophase I and association of chromosomes at metaphase II (Figs. 17 and 18) are recorded in few PMCs. 85.5% is the pollen fertility determined for the species.

Indigofera linnaei Ali, Bot. Notis. 3 : 549, 1958.

I. ennaephylla Linn., Mant. 2 : 272, 1771, append. 571, 1771(nom. illegit.); FBI. 2 : 94, 1876; Cooke, 1 : 332, 1902; Gillett, loc. cit. 35.

A prostrate, annual herb. Branches appressedly silvery white hairy. Leaves pinnate, leaflets 7-9, alternate, obovate, rounded or emarginate at the apex, densely covered with white appressed hairs on both the sides. Flowers red, in short, axillary heads or racemes. Pods cylindric, silvery white, hairy, 2-seeded, with a slight depression between the seeds (Fl. Fr. August - September) S. 22, 23 and 24.

Very common; observed among grasses in lawns and as a weed in cultivated fields.

Earlier reports n = 8 (Bir and Sidhu, 1966, 1967) and 2n = 16 (Ramanathan, 1955; Singh and Roy, 1970 and Bhatt, 1974) for the species are confirmed in the present study.

I. cordifolia Contd...

Fig. 16. PMC showing 7 bivalents at metaphase I (side view) (Coll. No. 25).

Fig. 17. PMCs showing cytomixis at telophase I (Coll.No.26).

Fig. 18. PMC showing grouping of chromosomes at metaphase II (Coll. No. 25).

Fig. 19. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 20. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 21. Photomicrograph of somatic metaphase.

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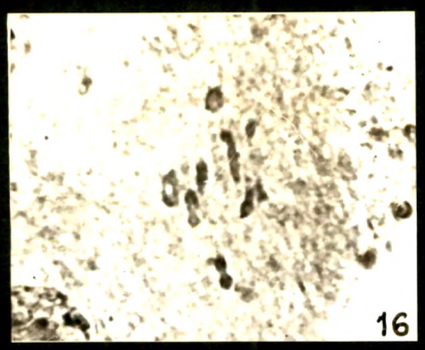

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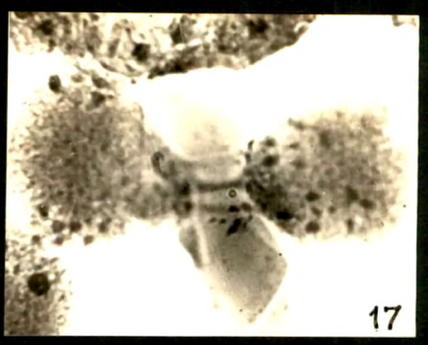

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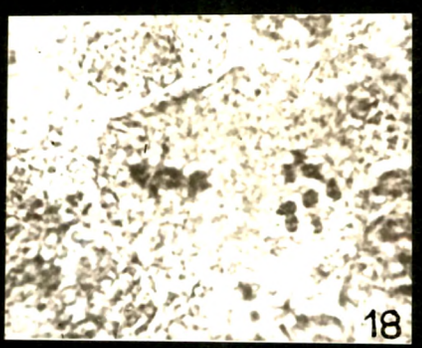

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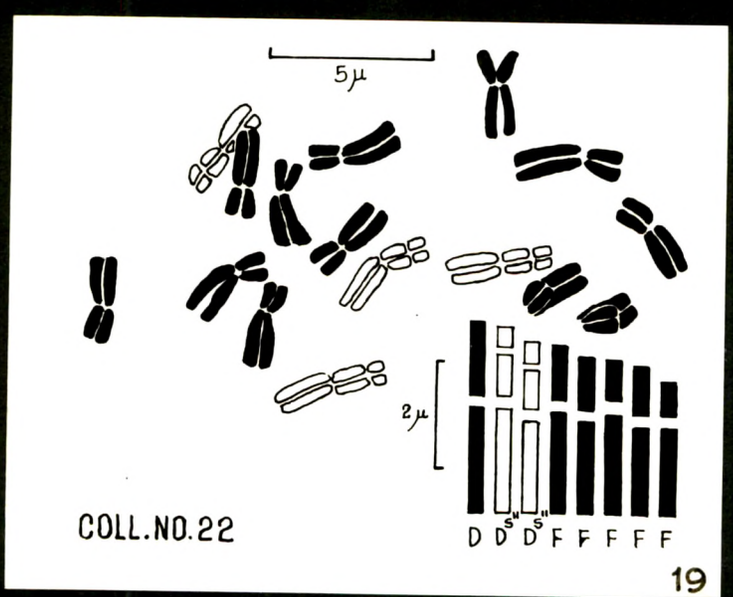

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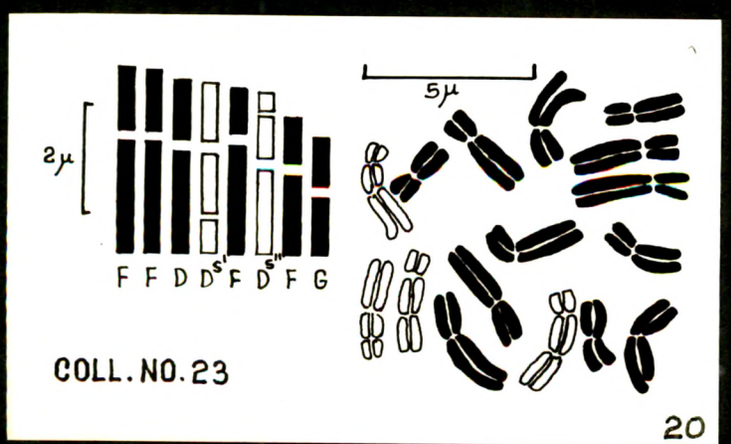

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21

Coll. Nos. 22 and 24.

Karyotype formulae : $2n = 16 = D_2+D^{S''}_4+F_{10}= 44.76\ \mu$ (Fig. 19).

The somatic complement consists of 3 pairs of chromosomes with nearly median (D-type) and 5 pairs with nearly submedian (F-type) centromeres. 2 pairs of nearly median chromosomes are with secondary constrictions ($D^{S''}$-type) on short arms. The chromosomes are medium sized, the length ranges from 3.31 μ to 2.37 μ, with a mean length of 2.79 μ. As the TF% and L/S are 37.26 and 1.39 respectively, the karyotype is asymmetrical and graded.

Coll. No. 23.

Karyotype formulae: $2n=16=D_2+D^{S'}_2+D^{S''}_2+F_8+G_2=44.14\ \mu$ (Figs. 20 & 21).

The karyotype of this collection is similar to the above one, except for the presence of one additional pair of nearly median chromosomes.

It is evident from the morphological and cytological study (Table 11) that, 2 cytotypes are present in the species.

The karyotypes are comparable with the earlier analysed ones (Singh and Roy, 1970 and Bhatt, 1974), in having less pairs of nearly median and more of nearly submedian chromosomes.

Table 9. Measurements of somatic chromosomes of *I. linnaei* Ali (Coll. No. 22).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.95+1.36=3.31	100.00	0.69	1.44	nm	D
3, 4	1.91+0.80+0.42=3.13	94.56	0.63	1.56	nm	$D^{S"}$
5, 6	1.70+0.76+0.42=2.88	87.00	0.69	1.44	nm	$D^{S"}$
7, 8	1.78+1.02=2.80	84.59	0.57	1.74	nsm	F
9, 10	1.70+1.02=2.72	82.17	0.60	1.66	nsm	F
11, 12	1.78+0.85=2.63	79.45	0.47	2.09	nsm	F
13, 14	1.61+0.93=2.54	76.73	0.57	1.73	nsm	F
15, 16	1.61+0.76=2.34	71.60	0.47	2.11	nsm	F

Table 10. Measurements of somatic chromosomes of *I. linnaei* Ali (Coll. No. 23).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	2.04+1.19=3.23	100.00	0.58	1.71	nsm	F
3, 4	2.21+0.98=3.19	98.76	0.44	2.55	nsm	F
5, 6	1.87+1.19=3.06	94.73	0.64	1.57	nm	D
7, 8	0.60+1.11+1.19=2.90	89.78	0.70	1.44	nm	$D^{S'}$
9, 10	1.99+0.85=2.84	87.92	0.43	2.34	nsm	F
11, 12	1.53+0.77+0.34=2.64	81.73	0.93	1.38	nm	$D^{S''}$
13, 14	1.45+0.85=2.30	71.20	0.59	1.71	nsm	F
15, 16	1.06+0.85=1.91	59.13	0.80	1.25	nm	G

Table 11.

Comparision of somatic chromosomes of different populations of I. linnaei Ali

Populations	Somatic number (2n)	nm		nsm	Chromosomes with Sec. const.		Absolute length (in μ)	Mean length (in μ)	L/S
		Types		Type	Types				
		D	G	F	$D^{S'}$	$D^{S''}$			
Coll. Nos. 22, 24	16	6	-	10	-	4	44.76	2.79	1.39
Coll. No. 23	16	6	2	8	2	2	44.14	2.76	1.69

I. linnaei Contd...

Fig. 22. PMC showing 8 distinct bivalents at metaphase I. (Coll. No. 22).

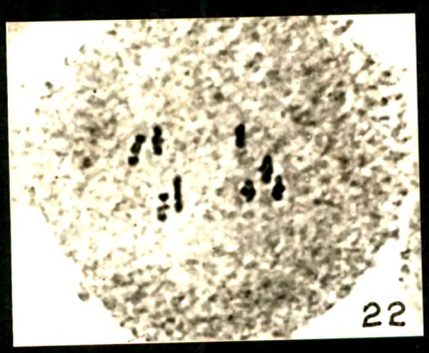
Fig. 23. " " equal distribution at anaphase I. (Coll. No. 22).

Fig. 24. " " grouping of chromosomes at metaphase II. (Coll. No. 23).

I. colutea

Fig. 25. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 26. Photomicrograph of somatic metaphase.



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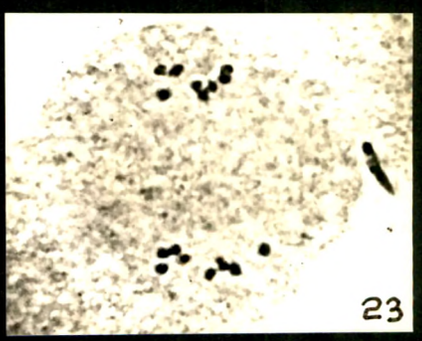

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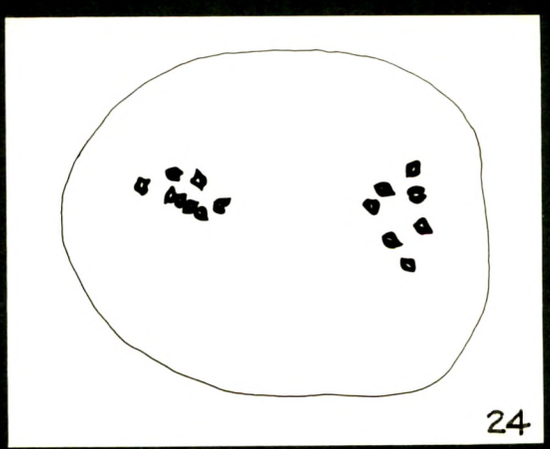

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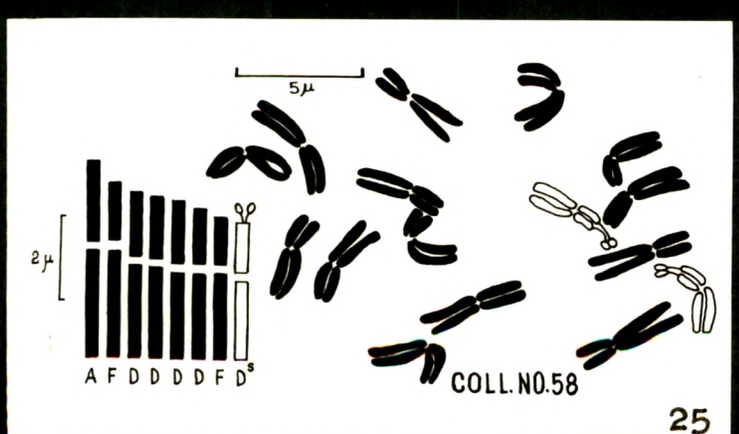

25

26

The occurrence of 2 pairs of chromosomes with secondary constrictions reported in the present work were not recorded earlier.

Meiosis is regular in showing the formation of 8 distinct bivalents at metaphase I and their equal distribution at Anaphase I (Figs. 22 and 23). However, tendency of association of the chromosomes at metaphase II (Fig. 24) is recorded in some PMCs. The pollen fertility determined for the species is 89%.

Indigofera colutea (Burm. f.) Merr., Phil. J. Sci. 19: 335, 1925; Gillett, loc. cit. 65; Ali, loc. cit. 548; Raizada, Ind. For. 92(5): 312, 1966.

Galega colutea Burm. f., Fl. Ind. 172, 1768; non sensu Willd. Sp. Pl. 3 : 1246, 1803.

Indigofera viscosa Lamk., Encycl. 3 : 247, 1789; FBI. 2:95, 1876; Cooke, 1 : 337, 1902.

An erect, annual herb or undershrub. Stems and branches densely covered with gland-tipped hairs. Leaves imparipinnate; leaflets obovate, obtuse, apiculate, hairy on both the sides. Flowers pink, in 6-12 flowered racemes, inflorescence axis glandular hairy. Pods slender, cylindric, torulose, clothed

Table 12. Measurements of somatic chromosomes of *I. colutea* (Burm. f.) Merrill (Coll.No.58).

Chromosome pair	Length in u	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	2.55+1.87=4.42	100.00	0.73	1.37	nm	A
3, 4	2.55+1.36=3.91	88.86	0.53	1.88	nsm	F
5, 6	2.21+1.53=3.74	84.62	0.69	1.44	nm	D
7, 8	2.17+1.45=3.62	81.90	0.67	1.50	nm	D
9, 10	2.08+1.45=3.53	79.86	0.69	1.43	nm	D
11, 12	2.04+1.32=3.36	76.02	0.65	1.55	nm	D
13, 14	2.04+1.11=3.15	71.27	0.54	1.84	nsm	F
15, 16	1.87+1.19=3.06	69.23	0.64	1.57	nm	D^S

with simple and glandular hairs. Seeds small, about 12 per pod (Fl. Fr. September - November) S. 58.

Source : Botanical Surveyo of India, Coimbatore, Tamil Nadu.

n = 8 (Hagerup, 1932) and 2n = 16 (Frahm-leliveld, 1960 and Singh and Roy, 1970) are the chromosome numbers reported for the species. The present study confirms the earlier report of 2n = 16.

Coll. No. 58.

Karyotype formulae: $2n=16=A_2+D_8+D_2^S+F_4=57.58\ \mu$ (Figs. 25 and 26).

The chromosomes in the complement are having nearly median centromeres (A and D - types) on 6 pairs and nearly submedian centromeres (F-type) on 2 pairs. One pair of nearly median chromosomes (D^S-type) are with satellites. The chromosomes are medium sized except for a pair of long chromosomes (A-type). The length of chromosomes ranges from 4.42 μ to 3.06 μ, the mean length being 3.60 μ. The karyotype is apparently asymmetrical and graded as the TF% and L/S are 40.42 and 1.44 respectively.

Indigofera vicioides Jaub. & Spach, Ill. Pl. Or. t. 481, 1876; Gillett, loc. cit. 73.

The present report of 2n = 16 for the species, confirms

Table 13. Measurements of somatic chromosomes of *I. vicioides* Jaub. & Spach (Coll. No. 103).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.70+1.57=3.27	100.00	0.92	1.08	nm	D
3, 4	2.21+1.02=3.23	98.78	0.46	2.17	nsm	F
5, 6	0.60+1.02+1.45=3.07	93.88	0.90	1.12	nm	$D^{S'}$
7, 8	1.99+1.02=3.01	92.05	0.51	1.95	nsm	F
9, 10	1.62+1.02=2.64	80.73	0.63	1.59	nm	D
11, 12	1.36+0.72=2.08	63.61	0.53	1.89	nsm	F
13, 14	1.02+0.47=1.49	45.57	0.46	2.17	nsm	H
15, 16	0.77+0.38=1.15	35.17	0.49	2.03	nsm	H

the earlier report of Frahm-leliveld (1966). The karyotype analysis is worked out for the first time.

Coll. No. 103.

Karyotype formulae:$2n=16=D_4+D_2^{S'}+F_6+H_4=39.88\ \mu$ (Figs. 27 and 28).

The somatic complement includes 3 pairs of chromosomes with nearly median (D-type) and 5 pairs with nearly submedian centromeres (F and H - types). One pair of nearly median chromosomes ($D^{S'}$-type) are with secondary constrictions on long arms. The chromosomes are medium to short sized, the length ranges from 3.27 μ to 1.15 μ, with a mean length of 2.49 μ. The karyotype is asymmetrical as the TF% and L/S are 36.37 and 2.84 respectively. The graded nature of the karyotype is shown in idiogram (Fig. 27).

Indigofera subulata Vahl ex Poir., Lam. Encycl. Suppl. 3 : 150, 1813; FBI. 2 : 96, 1876; Meikle, Kew Bull. 352, 1950; Gillett, loc. cit. 100.

A prostrate, suffruticose herb. Branches slender, hairy. Leaves imparipinnate; leaflets 5, obovate, glabrescent above and with few appressed grey hairs below. Flowers white, in 20-40 flowered axillary racemes. Pods straight or slightly

I. vicioides

Fig. 27. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 28. Photomicrograph of somatic metaphase.

I. subulata

Fig. 29. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 30. PMC showing 8 bivalents at metaphase I(side view).

Fig. 31. " " equal distribution at anaphase I.

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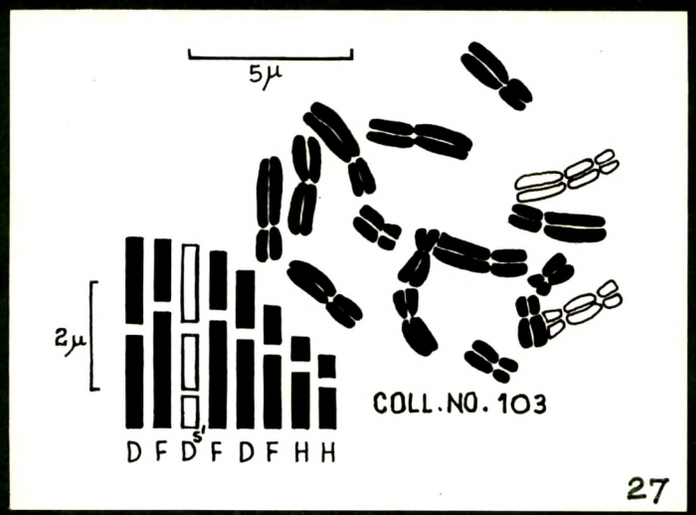
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2μ
D F D' F D F H H
COLL. NO. 103
27


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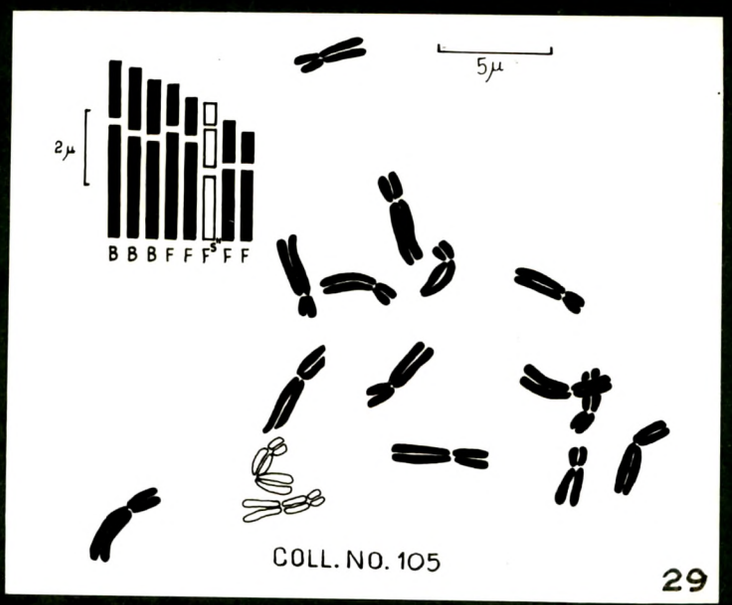
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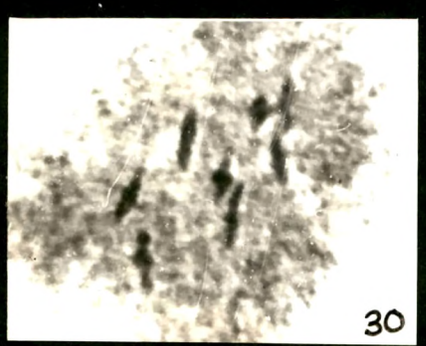
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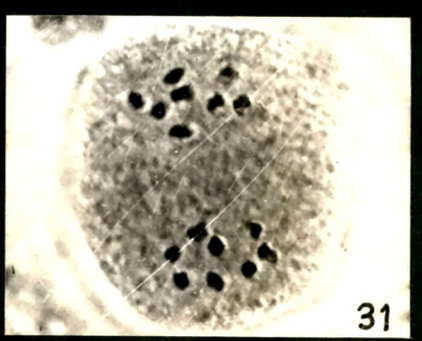
31

curved, sub-tetragonal, 10-15 seeded, not torulose (Fl. Fr. August - October) S. 105.

Source : National Agricultural Research Station, Kenya.

Ramanathan (1955) and Singh and Roy (1970) reports 2n = 16, while Frahm-leliveld (1966) reports 2n = 16 and 32 for the species. The present observation is in confirmity with the early reports of 2n = 16.

Coll. No. 105.

Karyotype formulae : 2n = 16 = $B_6+F_8+F_2^{S''}$=48.28 μ (Fig. 29).

The karyotype shows that, the chromosomes are with only nearly submedian centromeres. One pair of $F^{S''}$ -type of chromosomes are with secondary constrictions on short arms. The chromosomes are longer to medium sized, the length ranges from 4.43 μ to 2.64 μ, with a mean length of 3.64 μ. The asymmetrical and graded nature of the karyotype can be ascertained from TF% (34.80) and relative length (Table 14).

The present analysis of the karyotype is in confirmity with earlier analysis of Singh and Roy (1970) in having similar types of chromosomes. However, the complement analysed presently showed longer chromosomes and one pair of chromosomes with secondary constrictions.

Table 14. Measurements of somatic chromosomes of *I. subulata* Vahl ex Poir. (Coll. No. 105).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	2.98+1.45=4.43	100.00	0.49	2.06	nsm	B
3, 4	2.68+1.57=4.25	95.94	0.59	1.71	nsm	B
5, 6	2.55+1.45=4.00	90.29	0.57	1.76	nsm	B
7, 8	2.80+1.11=3.91	88.26	0.40	2.52	nsm	F
9, 10	2.55+0.98=3.53	79.68	0.38	2.60	nsm	F
11, 12	1.87+1.02+0.51=3.40	76.75	0.80	1.22	nsm	$F^{S"}$
13, 14	1.87+1.11=2.98	67.27	0.59	1.68	nsm	F
15, 16	1.87+0.77=2.64	59.59	0.41	2.43	nsm	F

I. subulata Contd....

Fig. 32. PMC showing association of chromosomes at metaphase II.

Fig. 33. " " irregular distribution at anaphase II.

Fig. 34. " " non-synchronised movement at anaphase II.

Fig. 35. " " telophase II.

I. trita

Fig. 37. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 38. Photomicrograph of somatic metaphase.

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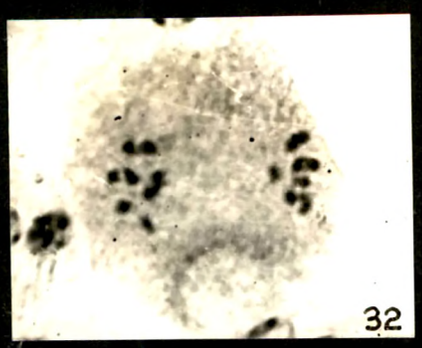

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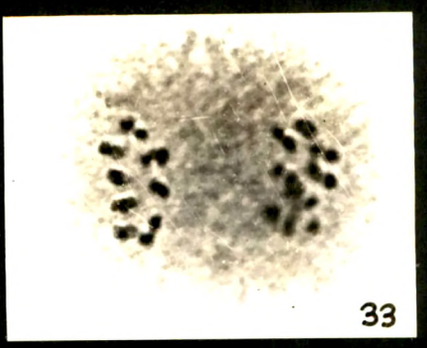

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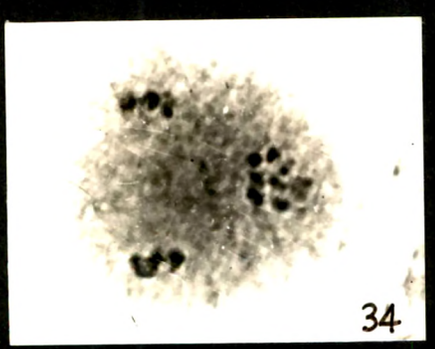

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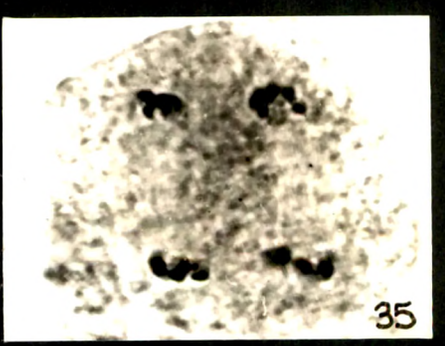

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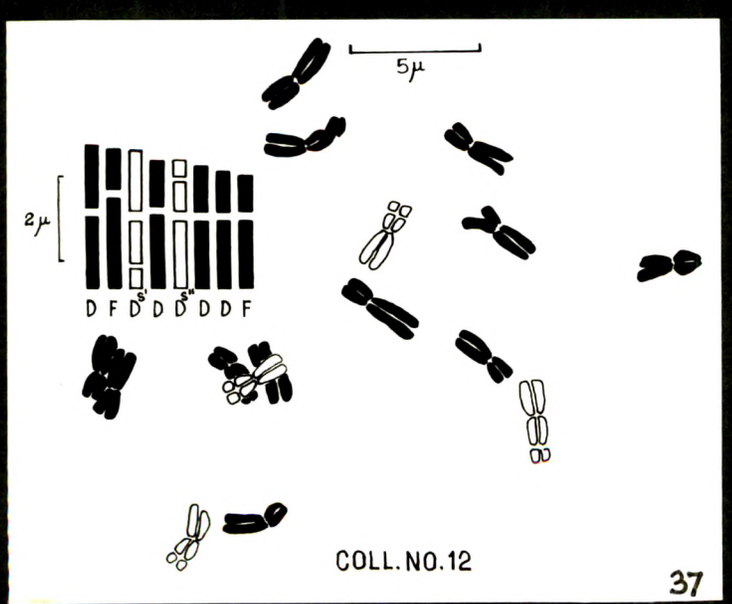

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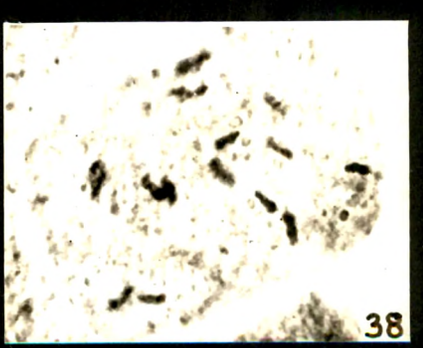


38

During meiosis, formation of 8 distinct bivalents is observed at metaphase I and their equal distribution at anaphase I (Figs. 30 and 31). However, some PMCs showed association of chromosomes at metaphase II (Fig. 32), irregular distribution and non-synchronised movement at anaphase II (Figs. 33 and 34). The pollen fertility scored for the species is 86.90%.

Indigofera trita Linn. f., Suppl. 335, 1781; FBI. 2 : 96, 1876; Cooke, 1 : 335, 1902; Gillett, loc. cit. 101; Ali, loc. cit. 553.

An erect, shrub. Stems and branches covered with greyish tomentum. Leaves 3-foliolate; lateral leaflets opposite, nearly sessile, ovate to suborbicular; terminal leaflet large, stalked, broadly ovate, all obtuse, more or less hairy on both the sides. Flowers pinkish-red in short axillary racemes, shorter than leaves. Corolla twice as long as the calyx, standard hairy on the back. Pods tetragonous, appressedly hairy, divaricate, hard pointed (Fl. Fr. August - January) S. 12, 13, 14 and 97.

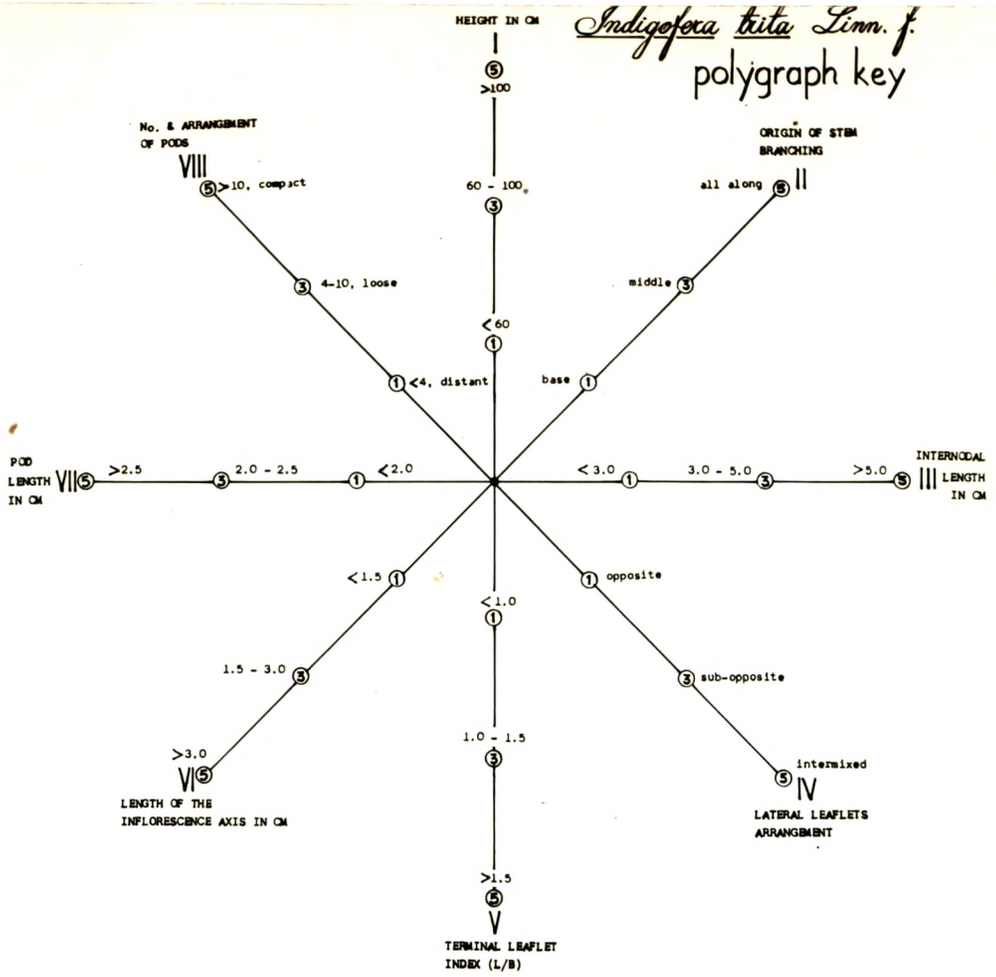
Commonly observed along roadsides and on open waste lands.

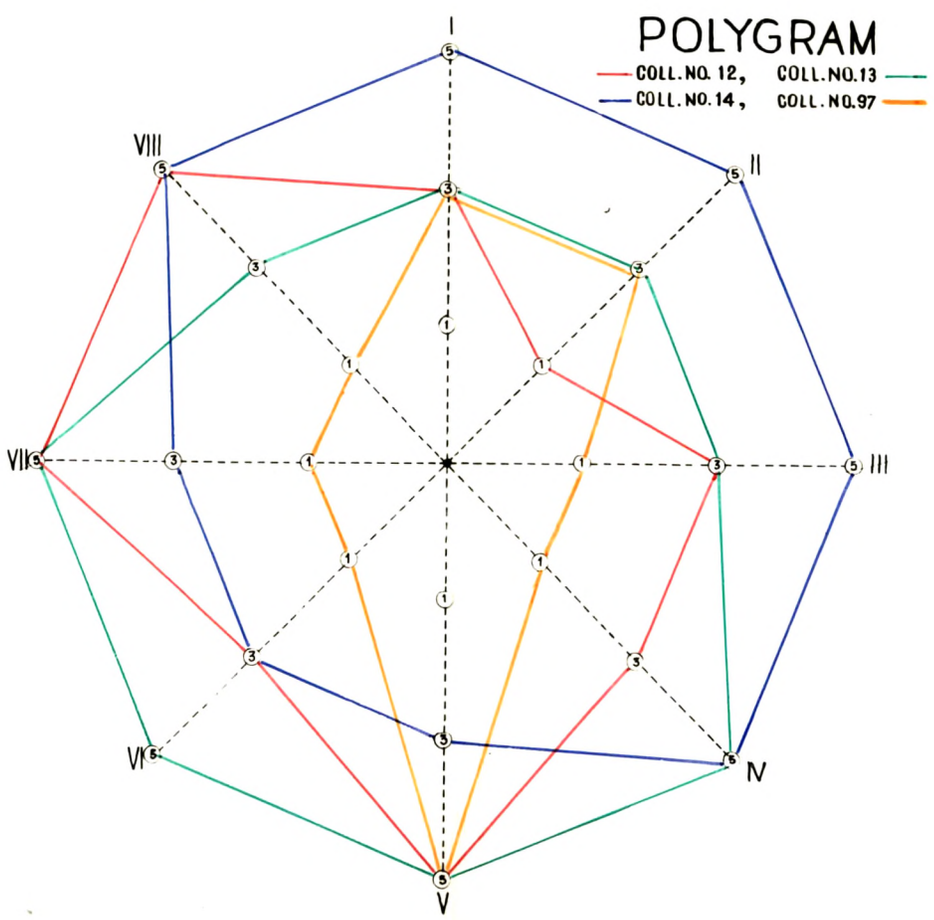
All the 4 collections investigated cytologically showed

Fig. 36. Polygraph key and polygram of different populations of *I. trita*

Indigofera tinta Linn. f.

polygraph key





2n = 16 in their somatic complements. This is in confirmity with the earlier reports of Frahm-leliveld (1960), Bhatt (1974), Sareen and Singh (1975).

Coll. Nos. 12 and 13.

Karyotype formulae: $2n=16=D_8+D_2^{S'}+D_2^{S''}+F_4=42.98\ \mu$ (Figs. 37 and 38).

The somatic complement contains 6 pairs of chromosomes (D-type) with nearly median and 2 pairs (F-type) with nearly submedian centromeres. 2 pairs of nearly median chromosomes are with secondary constrictions on long arms ($D^{S'}$-type) and short arms ($D^{S''}$-type). The karyotype shows medium sized chromosomes, the length ranges from 3.02 μ to 2.34 μ, with a mean length of 2.68 μ. The karyotype is apparently asymmetrical and graded as the TF% and L/S are 39.97 and 1.29 respectively.

Coll. No. 14.

Karyotype formulae : $2n=16=A_2^{S''}+D_4+D_2^{S'}+F_6+F_2^{S}=57.96\ \mu$ (Fig. 39).

The karyotype shows equal number of chromosomes with nearly median (A and D - types) and nearly submedian (F-type) centromeres. 2 pairs of nearly median chromosomes are with secondary constrictions on long arms ($D^{S'}$-type) and short arms ($A^{S''}$-type) and one pair of nearly submedian type of chromosomes (F^{S}-type) are with satellites. The chromosomes are medium sized except

Table 15.Measurements of somatic chromosomes of *I. trita* Linn. f. (Coll. No. 13).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.62+1.40=3.02	100.00	0.86	1.15	nm	D
3, 4	2.08+0.89=2.97	98.34	0.42	2.33	nsm	F
5, 6	0.48+0.94+1.36=2.78	92.05	0.95	1.04	nm	$D^{S'}$
7, 8	1.66+1.02=2.68	88.74	0.61	1.62	nm	D
9, 10	1.53+0.68+0.43=2.64	87.41	0.72	1.37	nm	$D^{S''}$
11, 12	1.53+1.06=2.59	85.76	0.69	1.44	nm	D
13, 14	1.53+0.94=2.47	81.78	0.61	1.62	nm	D
15, 16	1.53+0.81=2.34	77.48	0.52	1.88	nsm	F

Table 16. Measurements of somatic chromosomes of *I. trita* Linn. f. (Coll. No. 14)

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	2.38+1.02+0.63=4.03	100.00	0.70	1.41	nm	$A^{S''}$
3, 4	2.38+1.44=3.82	94.78	0.69	1.44	nsm	F
5, 6	2.38+1.40=3.78	93.79	0.60	1.65	nsm	F
7, 8	2.25+1.44=3.69	91.56	0.58	1.71	nm	D
9, 10	2.04+1.61=3.65	90.57	0.64	1.56	nm	D
11, 12	2.42+1.19=3.61	89.57	0.78	1.26	nsm	F
13, 14	0.61+1.19+1.57=3.56	85.35	0.49	2.03	nm	$D^{S'}$
15, 16	2.04+0.80=2.84	70.47	0.83	1.19	nsm	F

I. trita Contd....

Fig. 39. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 40. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 41. Photomicrograph of somatic metaphase.

Fig. 42. PMC showing 8 bivalents at metaphase I. (Coll. No. 14).

Fig. 43. " " association of bivalents at metaphase I (Coll. No. 13).

Fig. 44. " " early disjunction of bivalent at metaphase I (Coll. No. 12).

Fig. 45. " " precocious movement at anaphase I (Coll. No. 12).

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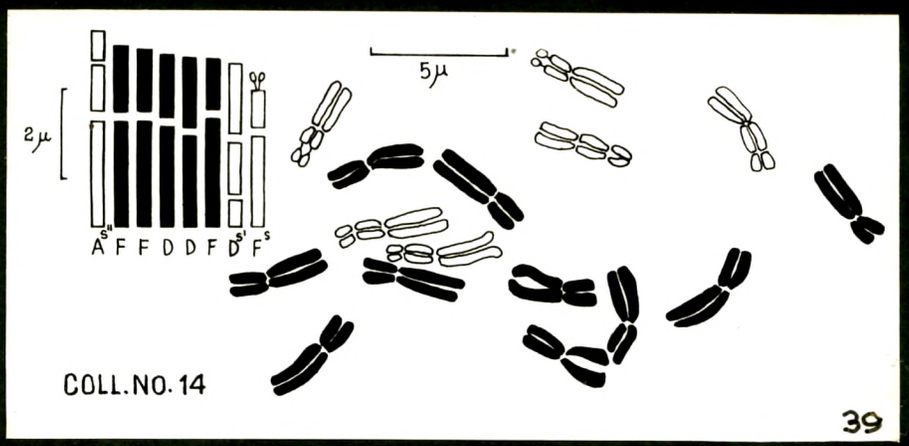

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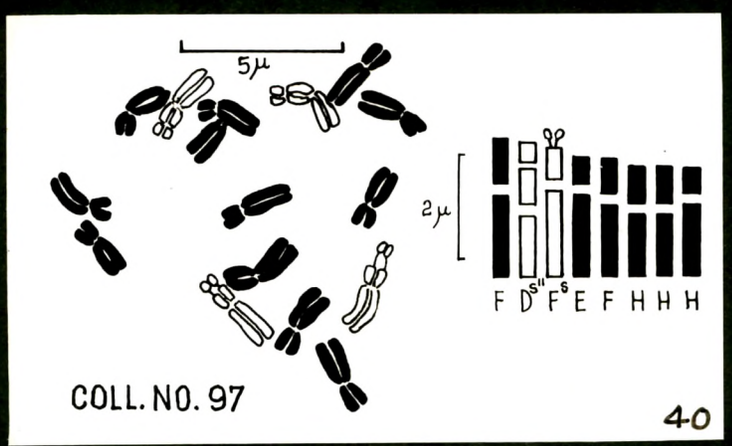

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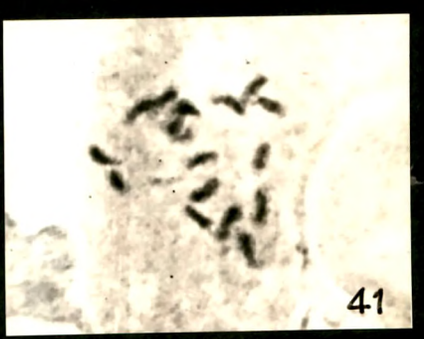

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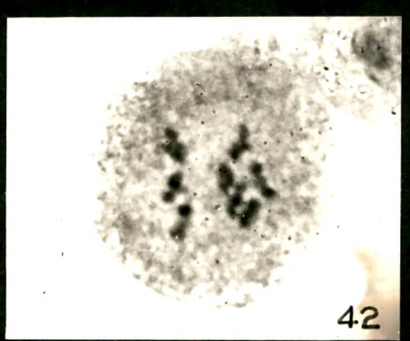

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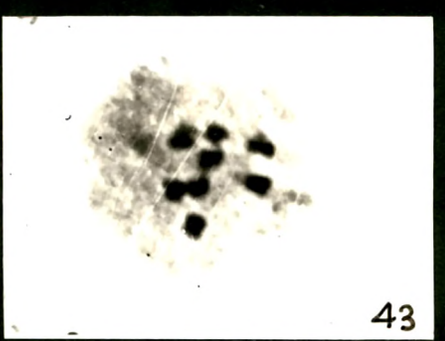

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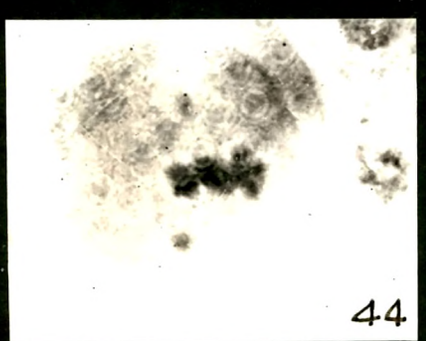

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for one pair of long chromosomes (A-type) in the complement. The length of chromosomes ranges from 4.03 μ to 2.84 μ, with their mean length being 3.62 μ. The karyotype is asymmetrical and graded as the TF% and L/S are 38.45 and 1.41 respectively.

Coll. No. 97.

Karyotype formulae: $2n=16=D_2^{S''}+E_2+F_4+F_2^{S}+H_6=33.18\ \mu$ (Figs. 40 and 41).

The karyotype includes 1 pair of chromosomes with nearly median (D-type), 1 pair with submedian (E-type) and 6 pairs with nearly submedian centromeres (F and H - types). Secondary constrictions and satellites are present on a pair of nearly median ($D^{S''}$-type) and a pair of nearly submedian chromosomes (F^{S}-type) respectively. The chromosomes are medium to short sized, the length ranges from 2.38 μ to 1.87 μ, the mean length being 2.07 μ. The karyotype is asymmetrical as the TF% is 33.87.

Populations collected from different localities showed variations in morphological characters (Fig. 35). While the karyotypes of these populations showed gross similarities as well as differences (Table 18). This indicates that 3 ecotypes are present in the species.

Bhatt (1974) observed 3 pairs of median, 4 pairs of submedian and a pair of subterminal chromosomes in the

Table 17. Measurements of somatic chromosomes of *I. trita* Linn. f. (Coll. No. 97).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.53+0.85=2.38	100.00	0.55	1.80	nsm	F
3, 4	1.19+0.68+0.43=2.30	96.63	0.93	1.07	nm	$D^{S''}$
5, 6	1.62+0.60=2.22	93.27	0.37	2.70	nsm	F^{S}
7, 8	1.53+0.51=2.04	85.71	0.33	3.00	SM	E
9, 10	1.36+0.68=2.04	85.71	0.50	2.00	nsm	F
11, 12	1.19+0.68=1.87	78.57	0.57	1.75	nsm	H
13, 14	1.19+0.68=1.87	78.57	0.57	1.75	nsm	H
15, 16	1.36+0.51=1.87	78.57	0.37	2.66	nsm	H

Table 18.

Comparision of somatic chromosomes of different populations of I. trita Linn. f.

Populations	Somatic number (2n)	nm Types A	nm Types D	nm Types G	SM Type E	nsm Types F	nsm Types H	Chromosomes with Sec. Const. Types $A^{S''}$	Chromosomes with Sec. Const. Types $D^{S'}$	Chromosomes with Sec. Const. Types $D^{S''}$	Chromosomes with SATs Type F^{S}	Absolute length (in μ)	Mean length (in μ)	L/S
Coll. Nos. 12 and 13	16	-	12	-	-	4	-	-	2	2	-	42.98	2.68	1.29
Coll. No. 14	16	2	6	-	-	8	-	2	2	-	2	57.96	3.62	1.41
Coll. No. 97	16	-	2	-	2	6	6	-	-	2	2	33.18	2.07	1.27

I. trita Contd....

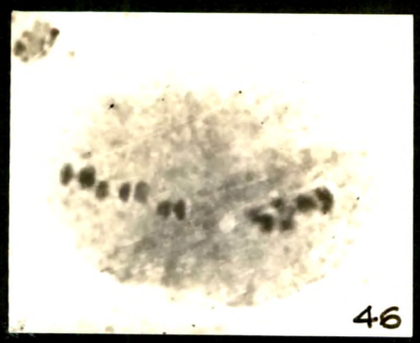
Fig. 46. PMC showing grouping of chromosomes at metaphase II (Coll. No. 13).

Fig. 47. " " abnormal orientation of chromosome at metaphase II (Coll. No. 13).

Fig. 48. " " non-synchronised movement at anaphase II *I. arrecta* (Coll.No.14).

Fig. 49. Camera lucida drawing of somatic metaphase and idiogram(→ β-chromosomes).

Fig. 50. Photomicrograph of somatic metaphase.



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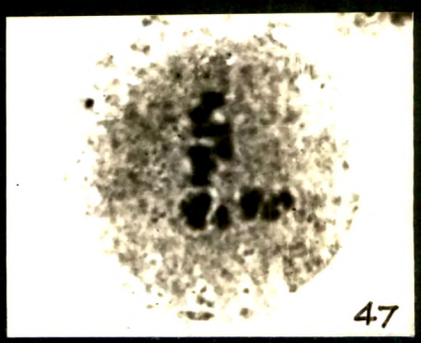

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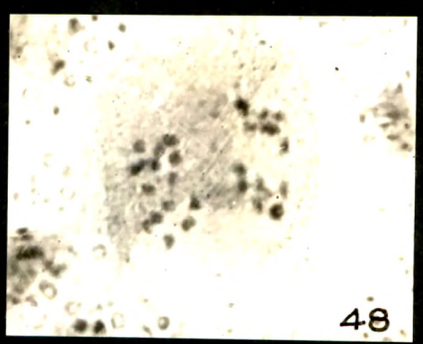

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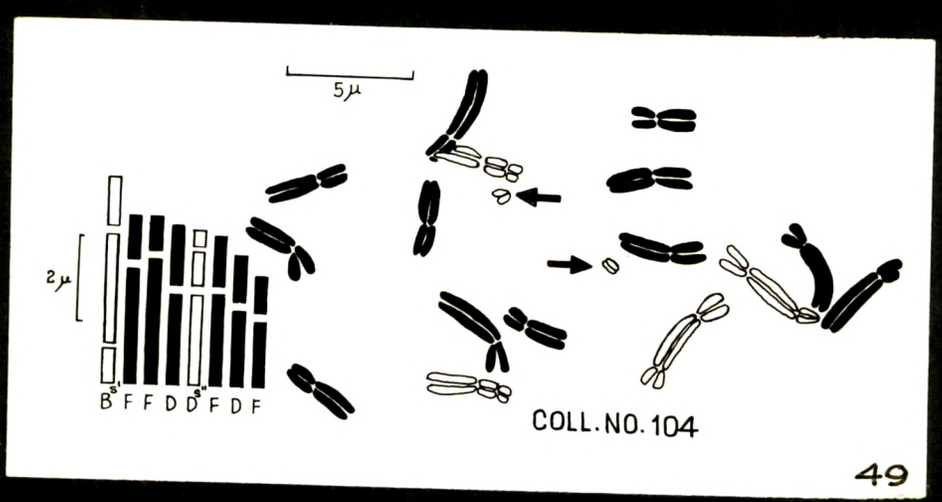
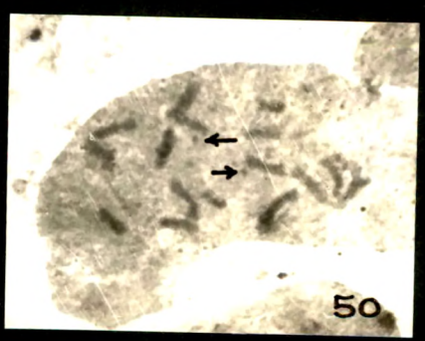


COLL. NO. 104

49



50

complement analysed by him. The present analysis differs from it, in having only nearly median and nearly submedian chromosomes except for a pair of submedian chromosomes in Coll. No. 97. In contrast to the earlier report of (Bhatt, 1974) 1 pair of chromosomes with satellites, in the present work, the majority of the populations studied showed 1 or 2 pairs of chromosomes with secondary constrictions and a pair with satellites.

During meiosis, 8 distinct bivalents at metaphase I (Fig. 42) are observed. This confirms the earlier report of n = 8 (Sareen and Singh, 1975) for the species. Some of the abnormalities like, early disjunction and association of bivalents at metaphase I (Figs. 43 and 44), precocious movement at anaphase I (Fig. 45), grouping of chromosomes and abnormal orientation at metaphase II (Figs. 46 and 47) and irregular distribution at anaphase II (Fig. 48) are observed. These abnormalities are observed in very low percent of PMCs, with the result that, the pollen fertility determined for the species is as high as 94%.

Indigofera arrecta Hochst. ex A. Rich., Tent. Fl. Ab. 1 : 184, 1874; Gillett, loc. cit. 105.

The present report of 2n = 16 for the species is in confirmity with earlier reports of Frahm-leliveld (1957, 1960).

Coll. No. 1C4.

Karyotype formulae: $2n=16=B_2^{S'}+D_4+D_2^{S''}+F_8=55.74\ \mu$ (Figs. 49 and 50).

The karyotype consists of 3 pairs of chromosomes with nearly median centromeres (D-type), 5 pairs with nearly submedian centromeres (B and F - types) and a pair of β-chromosomes. Within the complement one pair of chromosomes are with secondary constriction on long arms ($B^{S'}$-type) and another pair with secondary constrictions on short arms ($D^{S''}$-type) are observed. The chromosomes are medium sized, except for one pair of longer chromosomes (B-type). The chromosome length ranges from 4.59 μ to 2.38 μ, with a mean length of 3.48 μ. The TF% (32.69) and L/S (1.93) show that the karyotype is asymmetrical. The karyotype is graded except for one pair of long chromosomes (Fig. 49).

Indigofera tinctoria Linn., Sp. Pl. 751, 1753; FBI. 2: 99, 1876; Cooke, 1 :339, 1902; Gillett, loc. cit. 106; Ali, loc. cit. 567.

An erect, extensively branched shrub. Branches tetrate or angular, covered with appressed hairs. Leaves imparipinnate,

Table 19. Measurements of somatic chromosomes of I. arrecta Hochst. ex A. Rich. (Coll. No. 104)

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	0.85+2.55+1.19=4.59	100.00	0.35	2.86	nsm	$B^{S'}$
3, 4	2.72+1.11=3.83	83.44	0.41	2.45	nsm	F
5, 6	2.98+0.85=3.83	83.44	0.29	3.51	nsm	F
7, 8	2.13+1.45=3.58	77.99	0.68	1.47	nm	D
9, 10	2.13+0.85+0.51=3.49	76.03	0.64	1.57	nm	$D^{S''}$
11, 12	2.17+1.19=3.36	73.20	0.55	1.82	nsm	F
13, 14	1.70+1.11=2.81	61.22	0.65	1.53	nm	D
15, 16	1.53+0.85=2.38	51.85	0.56	1.80	nsm	F

leaflets 9-13, opposite, oblong, rounded, apiculate, membranous, glabrous above and hairy beneath. Flowers red, in axillary racemes. Calyx hairy outside. Corolla about twice as long as the calyx or longer, standard pubescent on the back. Pods linear, long, slightly curved, apiculate, 8-12 seeded (Fl. Fr. August - October). S. 1, 2, 3, 4 and 5.

Fairly common; noted along roadsides and on open grounds in forests.

The present report of 2n = 16 for the species confirms the earlier reports of Ramanathan (1950); Frahm-leliveld (1960, 1962); Cave (1961); Miege (1962); Singh and Roy (1970) and Bhatt (1974). 5 collections have been cytologically investigated.

Coll. Nos. 1 and 2.

Karyotype formulae: $2n=16=D_8+D_2^{S'}+F_6=41.20\ \mu$ (Fig. 51).

The karyotype consists of 5 pairs of chromosomes with nearly median (D-type) and 3 pairs with nearly submedian centromeres. Among the nearly median types of chromosomes, 1 pair is with secondary constrictions on long arms ($D^{S'}$-type). The chromosomes in the complement are medium sized and range in length from 2.81 μ to 2.08 μ, with their mean length being 2.57 μ. The TF% (41.20) and relative length (Table 20) indicate that the karyotype is apparently asymmetrical and graded.

Table 20. Measurements of somatic chromosomes of *I. tinctoria* Linn. (Coll. No. 1).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.49+1.32=2.81	100.00	0.88	1.12	nm	D
3, 4	1.57+1.19=2.76	98.22	0.75	1.31	nm	D
5, 6	0.51+1.11+1.11=2.73	97.15	0.68	1.45	nm	$D^{S'}$
7, 8	1.62+1.06=2.68	95.37	0.65	1.52	nm	D
9, 10	1.70+0.94=2.64	93.95	0.55	1.80	nsm	F
11, 12	1.62+0.98=2.60	92.52	0.60	1.65	nsm	F
13, 14	1.36+0.94=2.30	81.85	0.69	1.44	nm	D
15, 16	1.36+0.72=2.08	74.02	0.52	1.88	nsm	F

I. tinctoria

Fig. 51. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 52. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 53. Photomicrograph of somatic metaphase.

Fig. 54. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 55. Photomicrograph of somatic metaphase.

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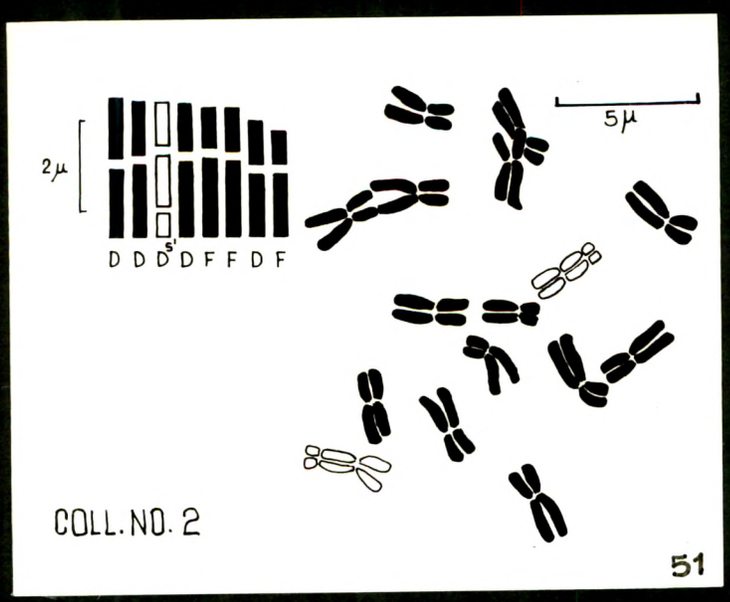
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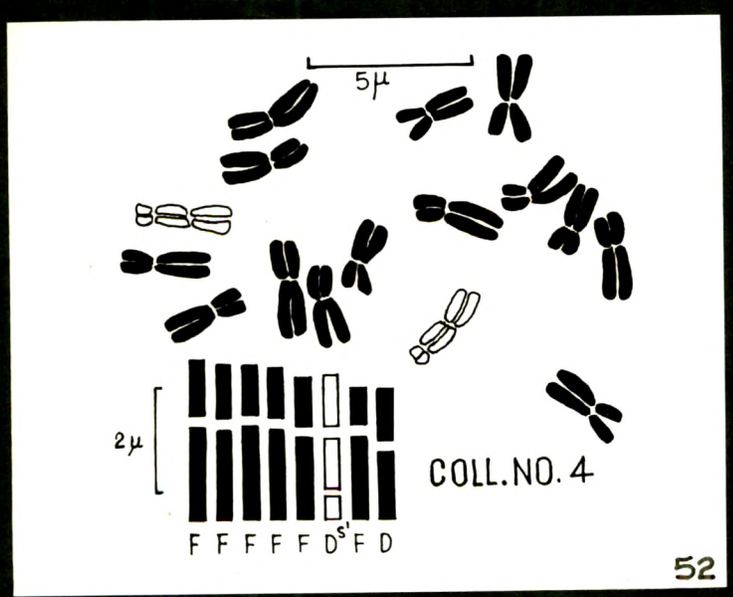
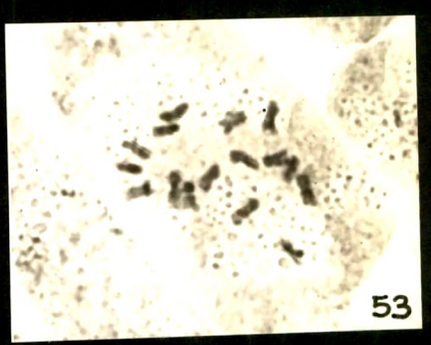
D D D$^{s'}$ D F F D F
5μ
COLL. NO. 2

51


5μ
2μ
F F F F F D$^{s'}$ F D
COLL. NO. 4

52



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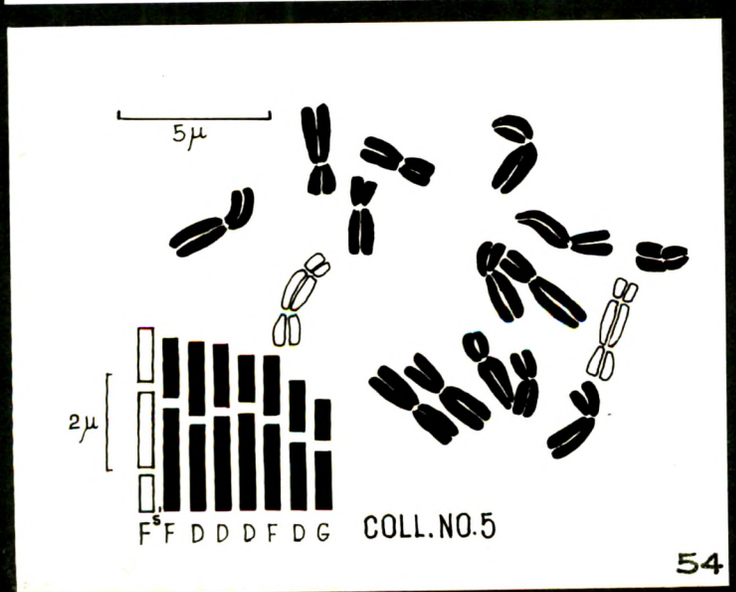
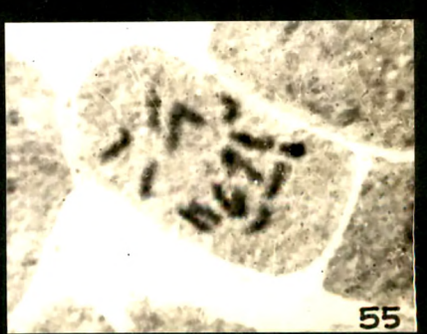

5μ
2μ
F$^{s'}$ F D D D F D G
COLL. NO. 5

54



55

Coll. Nos. 3 and 4.

Karyotype formulae: $2n=16=D_2+D_2^{S'}+F_{12}=40.60\ \mu$ (Figs. 52 and 53).

The karyotype of these collections differ from the preceeding ones in having more number of nearly submedian types of chromosomes (6 pairs i.e. F-type).

Coll. No. 5.

Karyotype formulae : $2n=16=D_8+F_4+F_2^{S'}+G_2=46.08\ \mu$ (Figs. 54 and 55).

The karyotype of this collections differs from all others in having a pair of short chromosomes with nearly median centromere (G-type) and a pair of nearly submedian chromosomes ($F^{S'}$-type) with secondary constrictions on long arms. TF% (38.75) and relative length (Table 22) are indicative of asymmetrical and graded nature of the karyotype.

The 5 populations collected from different localities resemble among themselves in gross morphology. However, the karyotypic differences (Table 23) metwith in these populations indicate the presence of 3 cytotypes in the species.

Comparison of presently and previously analysed karyotypes (Singh and Roy, 1970 and Bhatt, 1974) showed similarity in

Table 21. Measurements of somatic chromosomes of *I. tinctoria* Linn. (Coll. No. 4).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.78+1.02=2.80	100.00	0.57	1.74	nsm	F
3, 4	1.70+1.02=2.72	97.14	0.60	1.66	nsm	F
5, 6	1.78+0.93=2.71	96.78	0.52	1.91	nsm	F
7, 8	1.70+0.97=2.67	95.35	0.57	1.75	nsm	F
9, 10	1.53+0.93=2.46	87.85	0.60	1.64	nsm	F
11, 12	0.46+0.93+1.02=2.41	86.07	0.73	1.36	nm	D^S
13, 14	1.53+0.76=2.29	81.78	0.49	2.01	nsm	F
15, 16	1.27+0.97=2.24	80.00	0.76	1.30	nm	D

Table 22. Measurements of somatic chromosomes of *I. tinctoria* Linn. (Coll. No. 5).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	0.76+1.53+1.02=3.31	100.00	0.44	2.24	nsm	$F^{S'}$
3, 4	2.04+1.19=3.23	97.58	0.58	1.71	nsm	F
5, 6	1.70+1.49=3.19	96.37	0.87	1.14	nm	D
7, 8	1.87+1.28=3.15	95.17	0.68	1.46	nm	D
9, 10	1.70+1.19=2.89	87.31	0.70	1.42	nm	D
11, 12	1.96+0.93=2.89	87.31	0.47	2.08	nsm	F
13, 14	1.36+1.02=2.38	71.90	0.75	1.33	nm	D
15, 16	1.19+0.80=1.99	60.12	0.67	1.48	nm	G

Table 23.

Comparision of somatic chromosomes of different populations of I. tinctoria Linn.

Populations	C Somatic Number (2n)	nm Types D	nm Types G	nsm Types F	Chromosomes with Sec. Const. Types D^S'	Chromosomes with Sec. Const. Types F^S'	Absolute length (in μ)	Mean length (in μ)	L/S
Coll. Nos. 1 and 2	16	10	-	6	2	-	41.20	2.57	1.35
Coll. Nos. 3 and 4	16	4	-	12	2	-	40.60	2.53	1.25
Coll. No. 5	16	8	2	6	-	2	46.08	2.88	1.66

I. tinctoria Contd....

Fig. 56. PMC showing 8 bivalents at metaphase I.(Coll.No.4).

Fig. 57. " " association of bivalents at metaphase I (Coll. No. 4).

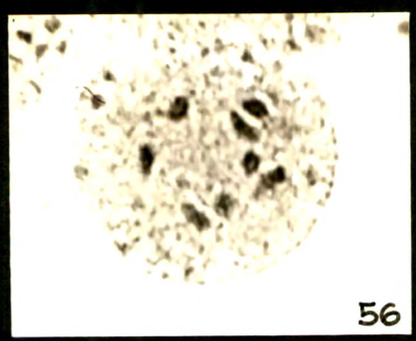
Fig. 58. " " equal distribution at anaphase I. (Coll. No. 5).

Fig. 59. " " grouping of chromosomes at metaphase II (Coll. No. 4).

I. heterantha

Fig. 60. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 61. Photomicrograph of somatic metaphase.



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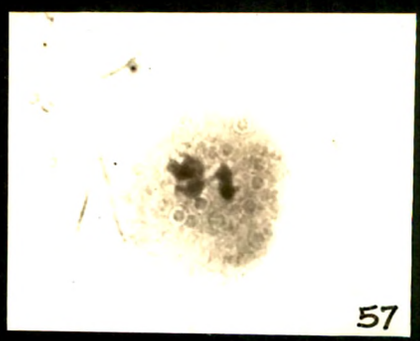

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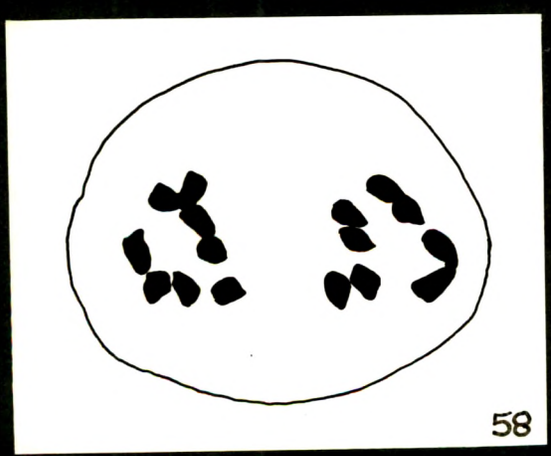

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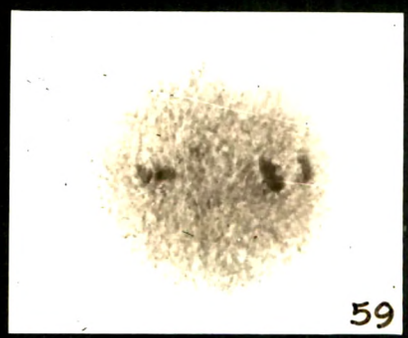
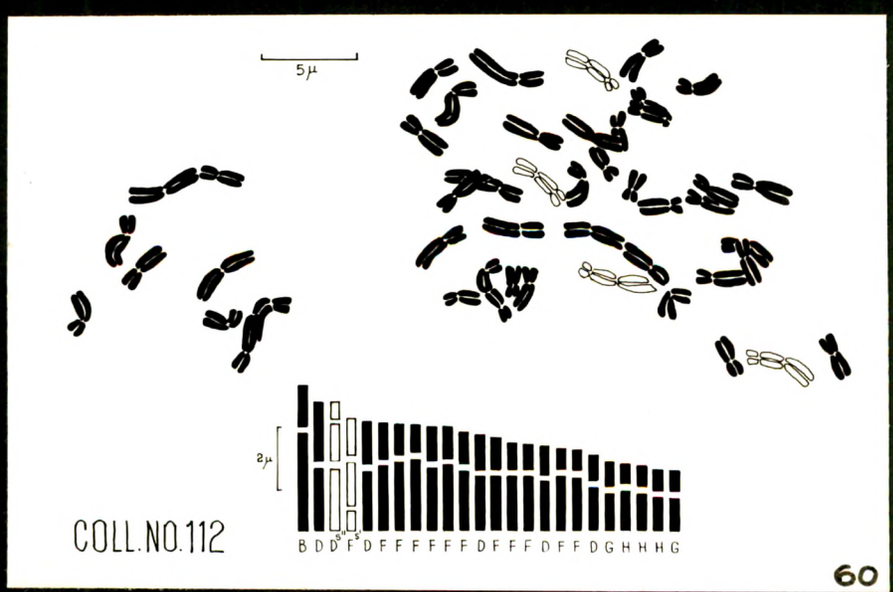


59



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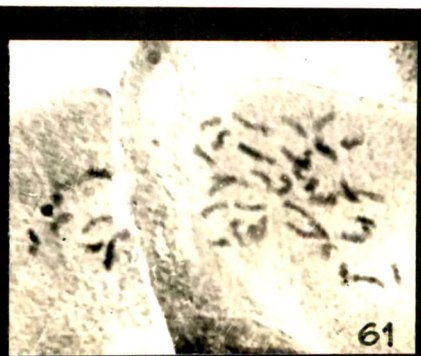


61

types of chromosomes. But a pair of chromosomes with secondary constrictions on long arms observed in the present study, are not encountered in the earlier works.

Meiosis is mostly normal showing 8 distinct bivalents at metaphase I (Fig. 56) and their equal distribution at anaphase I (Fig. 58). However, association of bivalents at metaphase I (Fig. 57) and grouping of chromosomes at metaphase II (Fig. 59) are also noticed. The pollen fertility determined for the species is 94%.

Indigofera heterantha Wall. ex Brandis, For. Fl. N. W. and C. Ind. 135, 1874; Ali, loc. cit. 566.

I. gerardiana Wall. ex Bak., FBI. 2 : 100, 1876.

I. gerardiana Wall. ex Bak. var. heterantha (Wall. ex Brandis) Bak., FBI. 2 : 100, 1876.

A low, copiously branched shrub. The branches distinctly argentio-canascent. Leaves compound; leaflets subcoriaceous, opposite, pale grey-green, thinly clothed with short white bristles above, glaucous and thinly argentio-canascent below, obtuse and apiculate. (Flowers red, in axillary 12-20 flowered racemes. Pods subcylindrical, glabrous, 6-10 seeded — adopted from FBI. 2 : 100, 1876). S. 112.

Source : Seeds obtained from Kew Gardens.

2n = 48 (Frahm-leliveld, 1957 and 1960) and n = 8 (Bir and Sidhu, 1967b and Hsu, 1968) are the chromosome numbers reported for the species. The present study confirms the earlier report of 2n = 48. Frahm-leliveld (1960) considered this as an octoploid taxon. The karyotype is worked out for the first time for the species.

Coll. No. 112.

Karyotype formulae: $2n=48=B_2+D_{10}+D^{S''}_2+F_{22}+F^{S'}_2+G_4+H_6=132.18\ \mu$ (Figs. 60 and 61).

There are 8 pairs of chromosomes with nearly median (D and G - types) and 16 pairs with nearly submedian (B, F and H -types) centromeres in the somatic complement. Among them one pair of nearly median ($D^{S''}$-type) and one pair of nearly submedian ($F^{S'}$-type) chromosomes are with secondary constrictions on short and long arms respectively. The chromosomes are long, medium and short sized, their length varies from 4.34 μ to 1.70 μ, the mean length being 2.75 μ. The karyotype is asymmetrical as the TF% and L/S are 36.61 and 2.55 respectively. The graded nature of the karyotype is indicated in the idiogram (Fig. 60).

Table 24. Measurements of somatic chromosomes of *I. heterantha* Wall. ex Brandis (Coll. No. 112).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	3.06+1.28=4.34	100.00	0.42	2.39	nsm	B
3, 4	1.96+1.87=3.83	88.25	0.95	1.05	nm	D
5, 6	1.96+1.19+0.60=3.75	86.41	0.91	1.09	nm	$D^{S''}$
7, 8	0.68+1.36+1.19=3.23	74.42	0.58	1.71	nsm	$F^{S'}$
9, 10	1.87+1.36=3.23	74.42	0.58	1.71	nsm	F
11, 12	2.04+1.19=3.23	74.42	0.48	2.10	nsm	F
13, 14	2.13+1.02=3.15	72.58	0.48	2.09	nsm	F
15, 16	2.21+0.94=3.15	72.58	0.43	2.35	nsm	F
17, 18	1.96+1.11=3.07	70.74	0.57	1.76	nsm	F
19, 20	2.04+1.02=3.06	70.51	0.50	2.00	nsm	F
21, 22	1.87+1.02=2.89	66.59	0.55	1.83	nsm	F
23, 24	1.70+1.11=2.81	64.75	0.65	1.53	nm	D
25, 26	1.70+1.02=2.72	62.67	0.60	1.67	nsm	F
27, 28	1.70+0.85=2.55	58.76	0.50	2.00	nsm	F
29, 30	1.70+0.81=2.51	57.83	0.48	2.10	nsm	F
31, 32	1.53+0.94=2.47	56.91	0.61	1.63	nm	D
33, 34	1.62+0.77=2.39	55.07	0.48	2.10	nsm	F
35, 36	1.70+0.68=2.38	54.84	0.40	2.50	nsm	F
37, 38	1.36+0.85=2.21	50.92	0.63	1.60	nm	D
39, 40	1.19+0.77=1.96	45.16	0.43	2.35	nm	G
41, 42	1.28+0.60=1.88	43.32	0.47	2.13	nsm	H
43, 44	1.19+0.64=1.83	42.17	0.54	1.86	nsm	H
45, 46	1.06+0.68=1.74	40.09	0.64	1.56	nm	H
47, 48	1.02+0.68=1.70	39.17	0.67	1.50	nm	G

Indigofera amblyantha Craib, Notes Bot. Gard. Edin. 8 : 47,1913.

The only report of chromosome number is 2n = 16 (Frahm-leliveld, 1962) for the species. However, the chromosome number observed in the present study is 2n = 48. This is the first analysis of karyotypic study for the species.

Coll. No. 111.

Karyotype formulae : 2n = 48 = $C_2+D_6+D^{S''}_6+F_{28}+F^{S}_2+G_4$=129.74 μ (Figs. 62 and 63).

The complement shows 1 pair of chromosomes with median (C-type), 8 pairs with nearly median (D and G - types) and 15 pairs with nearly submedian (F-type) centromeres. Among them, 3 pairs of nearly median chromosomes ($D^{S''}$-type) are with secondary constrictions on short arms and 1 pair of nearly submedian chromosomes (F-type) are with satellites. The chromosomes are medium to short sized, the length ranges from 3.60 μ to 1.70 μ, with a mean length of 2.70 μ. Both TF% (37.89) and L/S (2.12) indicate the asymmetrical nature of the karyotype. The diffuse gradation of the same is indicated in idiogram (Fig. 62).

Indigofera angulosa Edgew., FBI. 2 : 97, 1876; Chavan et al., Ind. For. 88(11) : 865, 1962.

Table 25. Measurements of somatic chromosomes of I. amblyantha Craib. (Coll. No. 111).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.87+0.85+0.68=3.60	100.00	0.93	1.08	nm	$D^{S"}$
3, 4	1.96+1.45=3.41	94.72	0.74	1.35	nm	D
5, 6	2.38+1.02=3.40	94.44	0.43	2.33	nsm	F
7, 8	2.08+1.02=3.10	86.11	0.49	2.04	nsm	F
9, 10	1.70+0.85+0.51=3.06	85.00	0.80	1.25	nm	$D^{S"}$
11, 12	1.53+1.53=3.06	85.00	1.00	1.00	M	C
13, 14	1.91+1.02=2.93	81.39	0.53	1.87	nsm	F
15, 16	1.91+0.94=2.85	79.17	0.49	2.03	nsm	F
17, 18	1.45+0.85+0.51=2.81	78.06	0.94	1.07	nm	$D^{S"}$
19, 20	1.87+0.94=2.81	78.06	0.50	1.99	nsm	F
21, 22	1.87+0.94=2.81	78.06	0.50	1.99	nsm	F
23, 24	1.70+1.02=2.72	75.56	0.60	1.67	nsm	F^{S}
25, 26	1.87+0.85=2.72	75.56	0.45	2.20	nsm	F
27, 28	1.70+1.02=2.72	75.56	0.60	1.67	nsm	F
29, 30	1.70+1.02=2.72	75.56	0.60	1.67	nsm	F
31, 32	1.70+1.02=2.72	75.56	0.60	1.67	nsm	F
33, 34	1.70+0.85=2.55	70.83	0.50	2.00	nsm	F
35, 36	1.53+0.94=2.47	68.61	0.61	1.63	nm	D
37, 38	1.53+0.85=2.38	66.11	0.56	1.80	nsm	F
39, 40	1.49+0.81=2.30	63.89	0.54	1.84	nsm	F
41, 42	1.36+0.85=2.21	61.39	0.63	1.60	nm	D
43, 44	1.40+0.68=2.08	57.78	0.49	2.06	nsm	F
45, 46	1.06+0.68=1.74	48.33	0.64	1.56	nm	G
47, 48	1.02+0.68=1.70	47.22	0.67	1.50	nm	G

I. amblyantha

Fig. 62. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 63. Photomicrograph of somatic metaphase.

I. angulosa

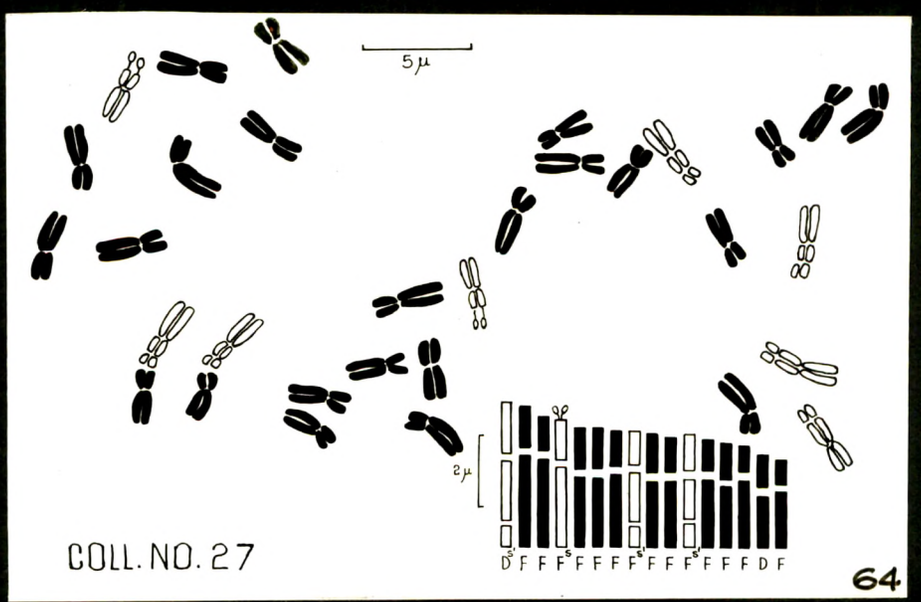
Fig. 64. Camera lucida drawing of somatic metaphase and idiogram.

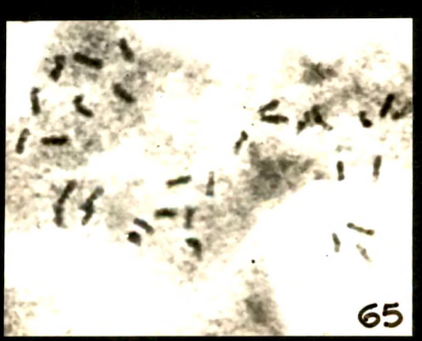
Fig. 65. Photomicrograph of somatic metaphase.

Contd.....


5μ
2μ
COLL.NO.111
62


63


5μ
2μ
COLL. NO. 27
64


65

An erect, undershrub. Branches and leaves, covered with grey, appressed hairs. Leaves pinnate; leaflets 5, opposite, oblong with mucronulate apex, hairy on both the sides. Flowers pink, small, in axillary racemes. Pods grey, moniliform, 1-3 seeded, gradually narrowed into the style (Fl. Fr. August - October) S. 27, 63.

Rare; observed growing on the escarpments of hillocks.

The cytology of this species has been worked out for the first time. n = 16 and 2n = 32 are the chromosome numbers determined for the species.

Coll. Nos. 27 and 63.

Karyotype formulae : 2n = 32 = $D_2+D_2^{S'}+F_{22}+F_2^S+F_4^{S'}=96.42\ \mu$ (Figs. 64 and 65).

The karyotype consists of 2 pairs of chromosomes with nearly median (D-type) and 14 pairs with nearly submedian centromeres (F-type). Among them, one pair of nearly median ($D^{S'}$-type) and 2 pairs of nearly submedian ($F^{S'}$-type) chromosomes are with secondary constriction on long arms and a pair of F-type is with satellites. The chromosomes are medium sized, range in length from 3.75 μ to 2.25 μ with a mean length of 2.25 μ. The karyotype is asymmetrical as the TF%

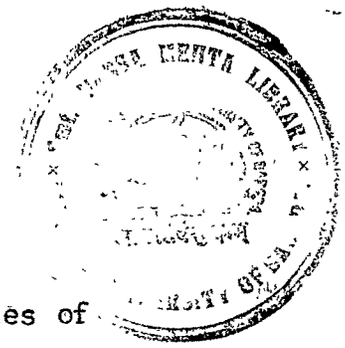


Table 26. Measurements of somatic chromosomes of I. angulosa Edgew. (Coll. No. 27).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	0.60+1.70+1.45=3.75	100.00	0.63	1.59	nm	$D^{S'}$
3, 4	2.55+1.19=3.74	99.73	0.47	2.14	nsm	F
5, 6	2.47+0.94=3.41	90.93	0.38	2.63	nsm	F
7, 8	2.21+1.19=3.40	90.67	0.54	1.86	nsm	F^{S}
9, 10	1.96+1.19=3.15	84.00	0.60	1.65	nsm	F
11, 12	1.96+1.19=3.15	84.00	0.60	1.65	nsm	F
13, 14	2.04+1.02=3.06	81.60	0.55	2.00	nsm	F
15, 16	0.60+1.36+1.02=2.98	79.47	0.48	1.92	nsm	$F^{S'}$
17, 18	1.83+1.11=2.94	78.40	0.61	1.67	nsm	F
19, 20	1.87+1.02=2.89	77.07	0.55	1.83	nsm	F
21, 22	0.68+1.19+1.02=2.89	77.07	0.55	1.83	nsm	$F^{S'}$
23, 24	1.91+0.94=2.85	76.00	0.49	2.03	nsm	F
25, 26	1.70+1.02=2.72	72.53	0.60	1.67	nsm	F
27, 28	1.87+0.77=2.64	70.40	0.41	2.43	nsm	F
29, 30	1.45+0.94=2.39	63.73	0.65	1.54	nm	D
31, 32	1.53+0.72=2.25	60.00	0.47	1.92	nsm	F

I. angulosa Contd.....

Fig. 66. PMC showing 16 bivalents at diakinesis (Coll. No. 27).

Fig. 67. " " 8 groups $1_{(4)}+1_{(3)}+3_{(2)}+3_{(1)}$ of 16 bivalents at metaphase I.

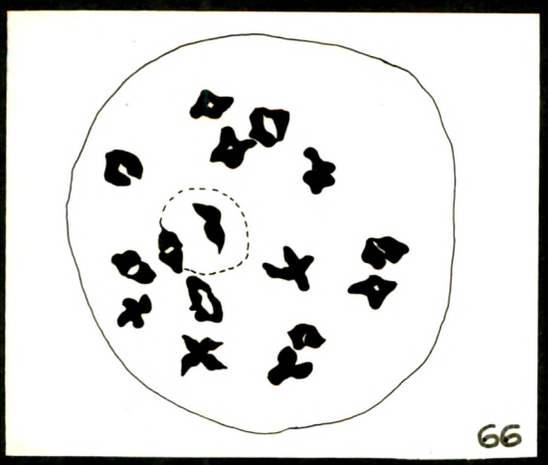
Fig. 68. " " photomicrograph of metaphase I.

Fig. 69. " " early division of bivalents at metaphase I.

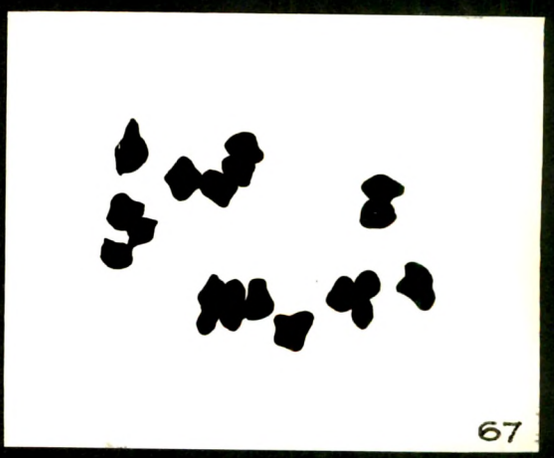
Fig. 70. " " irregular distribution at anaphase I.

Fig. 71. " " grouping of chromosomes at metaphase II.

Fig. 72. " " abnormal orientation at metaphase II.



66



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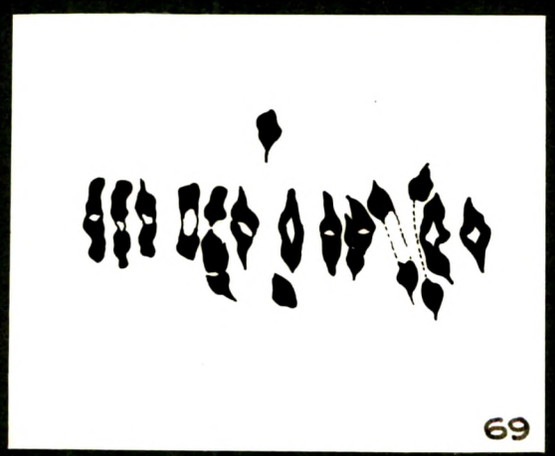

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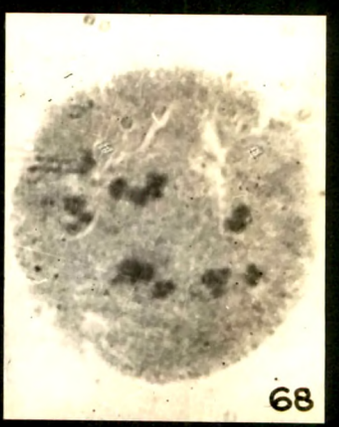

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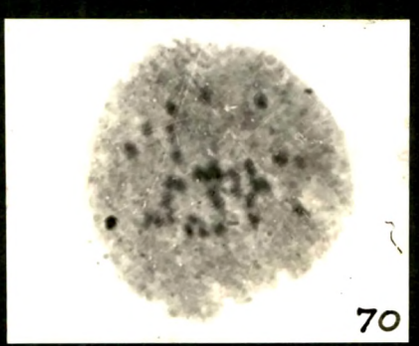

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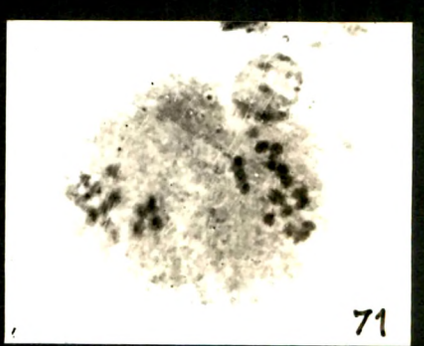

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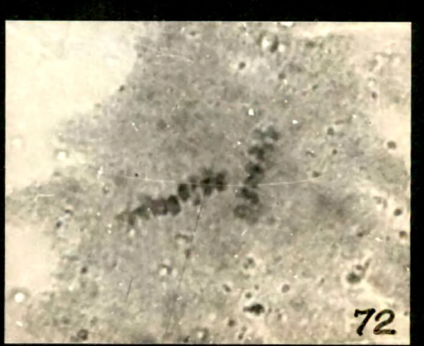

72

and L/S are 34.70 and 1.67 respectively. The graded nature of the karyotype is indicated in the idiogram (Fig. 64).

The meiosis is mostly regular showing 16 bivalents at diakinesis (Fig. 66). Several PMCs showed the formation of 8 groups of 16 bivalents at metaphase I (Fig. 67) indicating that, the species must have originated from a parent having n = 8. This also indicates that, the species is a tetraploid. Abnormalities like early disjunction of bivalents at metaphase I (Fig. 69), irregular distribution at anaphase I (Fig. 70), grouping of chromosomes and abnormal orientation at metaphase II (Figs. 71 and 72) are observed. The pollen fertility determined for the species is 89%.

Indigofera hirsuta Linn., Sp. Pl. 751, 1753; Gillett, loc. cit. 110, Kew Bull. 14(2): 290-295, 1960; Ali, loc. cit. 559.

An annual, erect, stout herb. Stems and branches covered with reddish brown hairs, deeply purplish or red when old. Leaves imparipinnate; leaflets usually 7, rarely 9, opposite, elliptic or obovate, obtuse and minutely apiculate at the apex, densely stiff hairy on both the sides. Flowers in axillary racemes, always more than 25 mm long, dense and much longer than leaves. Calyx densely hairy. Pods deflexed, stout, straight,

tetragonous, 6-9 seeded, densely brown hairy (Fl. Fr. October - December) S. 57, 102.

Source : Seeds obtained from I.A.R.I., New Delhi and National Agricultural Research Station, Kenya.

Frahm-leliveld (1953, 1960, 1962) and Singh and Roy (1970) reports 2n = 16 for the species. The present study confirms the above number. However, some seeds in Coll. No. 57 showed 2n = 18 chromosomes.

Coll. No. 102.

Karyotype formulae : 2n = 16 = $F_4+G_8+G_2^{S'}+H_2$=27.44 μ (Figs. 75 and 76).

The complement consists of 5 pairs of chromosomes with nearly median (G-type) and 3 pairs with nearly submedian centromeres (F and H - types). One pair of nearly median chromosomes ($G^{S'}$-type) are with secondary constrictions on long arms. The chromosomes are medium to short sized, the length ranges from 2.05 μ to 1.00 μ, with a mean length of 1.72 μ. The karyotype is apparently asymmetrical as the TF% and L/S are 38.85 and 2.09 respectively.

Coll. No. 57.

Karyotype formulae : 2n = 18 = $D_2+F_8+F_2^{S'}+H_6$=38.56 μ (Figs. 73 and 74).

I. hirsuta

Fig. 73. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 74. Photomicrograph of somatic metaphase.

Fig. 75. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 76. Photomicrograph of somatic metaphase.

I. astragalina

Fig. 77. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 78. Photomicrograph of somatic metaphase.

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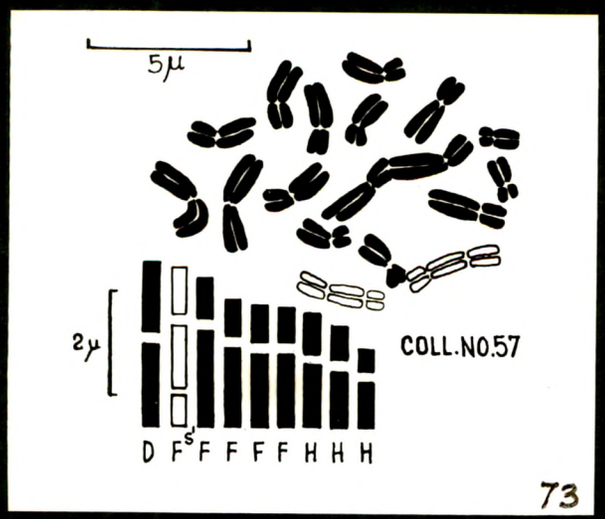
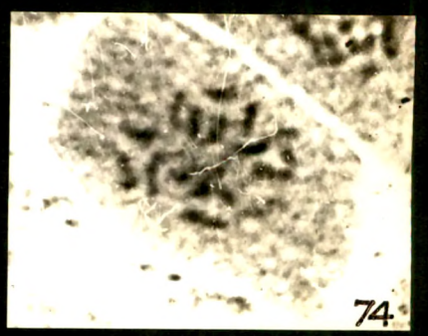


73



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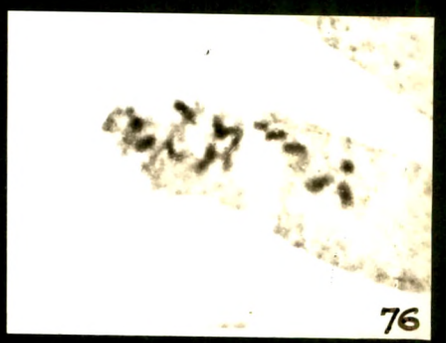

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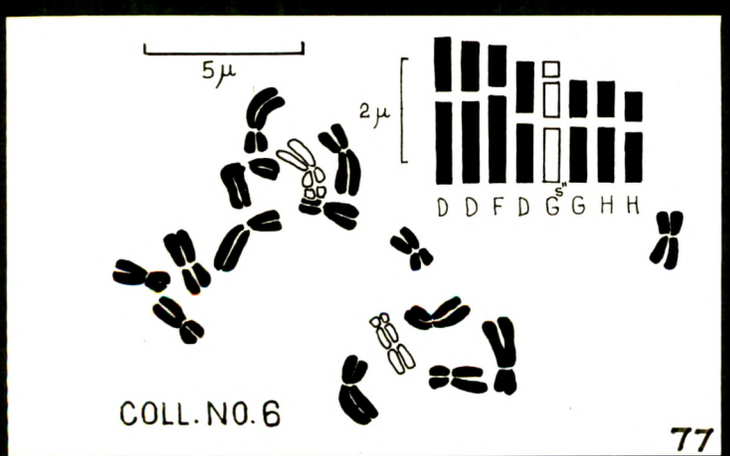

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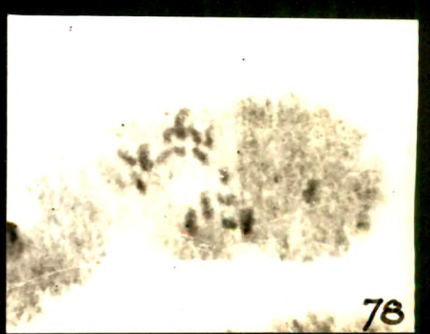

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Table 27. Measurements of somatic chromosomes of *I. hirsuta* Linn. (Coll. No. 102).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.28+0.77=2.05	100.00	0.60	1.66	nsm	F
3, 4	1.36+0.68=2.04	99.51	0.50	2.00	nsm	F
5, 6	1.02+0.85=1.87	91.22	0.83	1.20	nm	G
7, 8	0.38+0.68+0.77=1.83	89.27	0.73	1.38	nm	$G^{S'}$
9, 10	1.11+0.68=1.79	87.32	0.61	1.63	nm	G
11, 12	1.11+0.60=1.71	83.41	0.54	1.85	nsm	H
13, 14	0.85+0.60=1.45	70.73	0.71	1.42	nm	G
15, 16	0.60+0.40=1.00	47.80	0.66	1.50	nm	G

Table 28. Measurements of somatic chromosomes of *I. hirsuta* Linn. (Coll. No. 57).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.53+1.32=2.85	100.00	0.86	1.16	nm	D
3, 4	0.60+1.19+0.94=2.73	97.79	0.53	1.90	nsm	$F^{S'}$
5, 6	1.79+0.77=2.56	89.82	0.43	2.32	nsm	F
7, 8	1.49+0.77=2.26	79.30	0.52	1.94	nsm	F
9, 10	1.36+0.77=2.13	74.74	0.57	1.77	nsm	F
11, 12	1.36+0.68=2.04	71.58	0.50	2.00	nsm	F
13, 14	1.19+0.72=1.91	67.02	0.61	1.65	nsm	H
15, 16	1.02+0.60=1.62	56.84	0.59	1.70	nsm	H
17, 18	0.85+0.43=1.28	44.87	0.51	1.74	nsm	H

Table 29.

Comparision of somatic chromosomes of different populations of I. hirsuta Linn.

Population	Somatic number (2n)	nm Types D	nm Types G	nsm Types F	nsm Types H	Chromosomes with Sec. const. $F^{S'}$	Chromosomes with Sec. const. $G^{S'}$	Absolute length (in μ)	Mean length (in μ)	L/S
Coll. No. 102	16	-	10	4	2	-	2	27.44	1.72	2.09
Coll. No. 57	18	2	-	10	6	2	-	38.56	2.42	1.75

The karyotype shows chromosomes with nearly submedian centromeres (F and H - types), except for a pair with nearly median centromeres (D - type). One pair of nearly submedian chromosomes are with secondary constrictions on long arms. The chromosomes are medium to short sized, the length ranges from 2.85 u to 1.28 u, the mean length being 2.42 u. The karyotype is asymmetrical as the TF% and L/S are 36.11 and 1.75 respectively.

The two populations studied show differences in chromosome number and morphology (Table 29) indicating the presence of cytotypes in the species.

Indigofera astragalina DC., Prodr. 2 : 228, 1825; Gillett, loc. cit. 110; Kew Bull. 14(2) : 290-295, 1960.

I. hirsuta Linn. Sensu Baker, FBI. 2 : 98, 1876 pp (non Linn.) Cooke, 1 : 319, 1902.

An erect, stout annual herb. Stems and branches covered with brown pubescence. Leaves imparipinnate, leaflets 9-11. Flowers pink or rose in a long (25 mm long) axillary racemes. Pods 4-6 seeded, covered with white hairs, arranged closely on the peduncle often overlapping.

The present observation of 2n = 16 chromosomes in the

somatic complement, confirms the earlier reports of Frahm-leliveld (1960, 1962); Singh and Roy (1970) and Bhatt (1974). 3 populations are investigated cytologically. All the populations showed similarity in karyotypes.

Coll. Nos. 6, 7 and 8.

Karyotype formulae : $2n = 16 = D_6+F_2+G_2+G_2^{S''}+H_2=32.56\ \mu$ (Figs. 77 and 78).

The karyotype contains 5 pairs of chromosomes with nearly median (D and G - types) and 3 pairs with nearly submedian centromeres. One pair of nearly median chromosomes ($G^{S''}$-type) are with secondary constrictions on short arms. The chromosomes in the complement are medium to short sized, their length ranges from 2.64 μ to 1.45 μ, with a mean length of 2.03 μ. The karyotype is apparently asymmetrical as the TF% is 39.86. The graded nature of the karyotype is clearly indicated in idiogram (Fig. 77).

Singh and Roy (1970) reports that, the karyotype consists of equal number of median and submedian chromosomes, without secondary constrictions or satellites. While, Bhatt (1974) reports 3 pairs of median and 5 pairs of submedian chromosomes, with one of the submedian pair having satellites in the taxon

Table 30. Measurements of somatic chromosomes of *I. astragalina* DC. (Coll. No. 6).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.53+1.11=2.64	100.00	0.72	1.37	nm	D
3, 4	1.53+0.94=2.47	93.56	0.6=	1.62	nm	D
5, 6	1.62+0.77=2.39	79.54	0.47	2.10	nsm	F
7, 8	1.11+0.94=2.05	77.65	0.84	1.18	nm	D
9, 10	1.02+0.60+0.34=1.96	74.24	0.92	1.08	nm	$G^{S"}$
11, 12	1.02+0.68=1.70	64.39	0.66	1.50	nm	G
13, 14	1.02+0.60=1.62	61.36	0.58	1.70	nsm	H
15, 16	0.94+0.51=1.45	54.92	0.54	1.84	nsm	H

I. astragalina Contd....

Fig. 79. PMC showing 8 bivalents at diakinesis (Coll.No.6).

Fig. 80. " " " at metaphase I "

I. glandulosa

Fig. 81. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 82. Photomicrograph of somatic metaphase.

Fig. 83. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 84. Photomicrograph of somatic metaphase.

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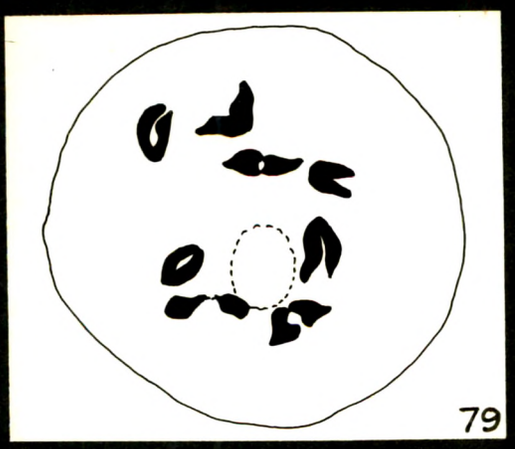

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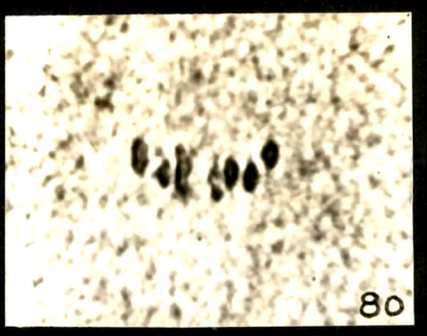

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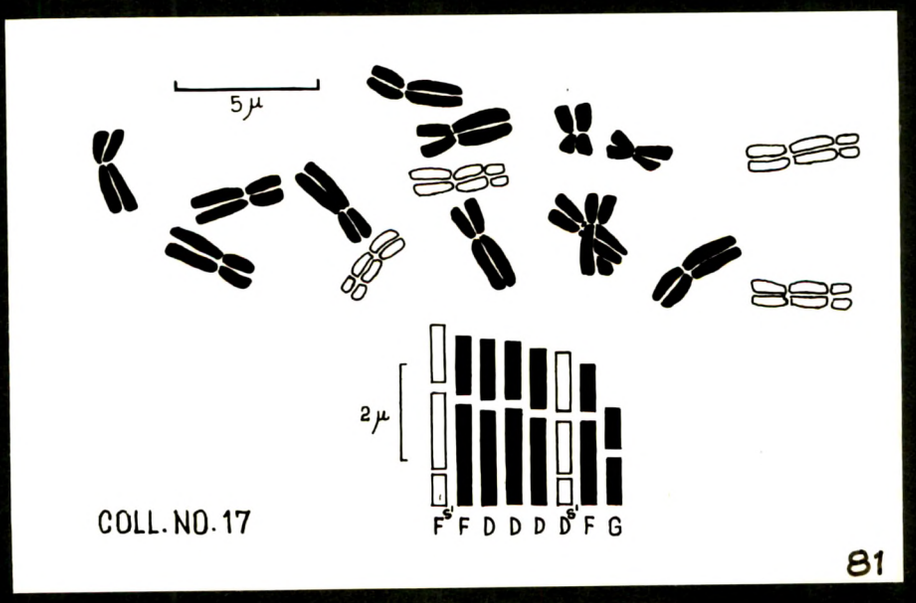

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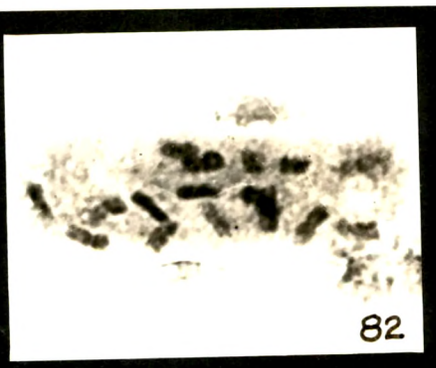

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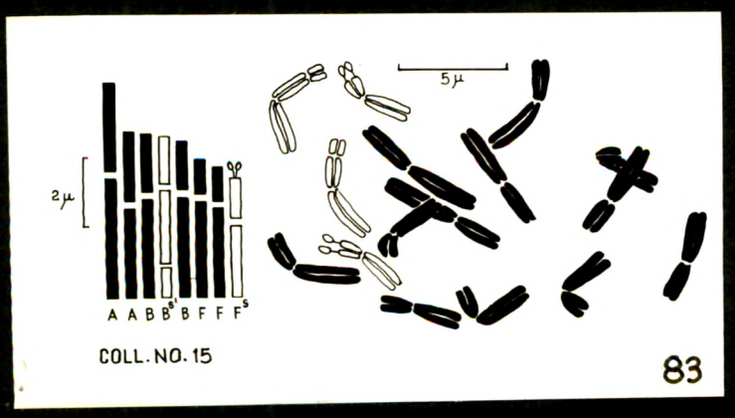

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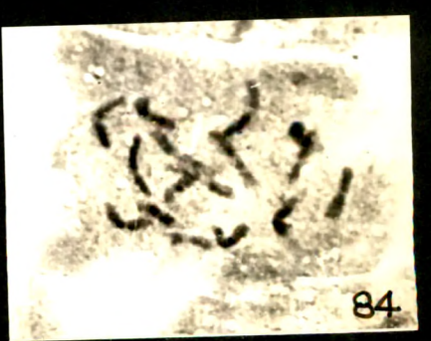

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analysed. The present observation differs from the earlier studies in having more number of chromosomes with nearly median centromeres, less with nearly submedian centromeres and a pair of nearly median chromosomes ($G^{S"}$-type) with secondary constrictions.

Meiosis is regular showing 8 bivalents at diakinesis and metaphase I (Figs. 79 and 80). This is the first report of haploid number (n = 8) for the species. The pollen fertility determined for the species is 89.50%.

Indigofera glandulosa Roxb. ex Willd., Sp. Pl. 3 : 1227, 1800; Fl. Ind. 3 : 372, 1832; FBI. 2 : 94, 1876; Cooke, 1 : 311, 1902.

An erect, much branched herb. Branches hairy when young. Leaves 3-foliolate; leaflets oblanceolate, obtuse, glabrous or nearly so above, glaucous and nigro-punctate beneath; stipules minute. Flowers red or pink in short condensed axillary racemes. Pods oblong, angled, the angles winged, wings toothed, 1-2 seeded (Fl. Fr. August - November) S. 15, 16, 17, 85.

Commonly observed along roadsides and along forest paths.

n = 8 (Bir and Kumari, 1973) and 2n = 16 (Bhatt, 1974) are

the chromosome numbers reported for the species. These numbers are confirmed in the present study. 4 collections are investigated cytologically.

Coll. No. 15.

Karyotype formulae : 2n = 16 = $A_4+B_4+B_2^{S'}+F_4+F_2^{S}$=68.16 μ (Figs. 83 and 84).

The complement consists of 2 pairs of chromosomes with nearly median (A-type) and 6 pairs with nearly submedian centromeres (B and F - types). Secondary constrictions and satellites are present on 2 pairs of nearly submedian chromosomes ($B^{S'}$- and F^{S} - types). The karyotype has 5 pairs of longer and 3 pairs of medium sized chromosomes. The length of chromosomes ranges from 5.95 μ to 3.23 μ, with a mean length of 4.26 μ. The karyotype is asymmetrical and graded as the TF% and L/S are 35.92 and 1.84 respectively.

Coll. Nos. 16, 17 and 85.

Karyotype formulae : 2n = 16 = $D_6+D_2^{S'}+F_4+F_2^{S'}+G_2$=47.96 μ (Figs. 81 and 82).

The karyotype of these collections show nearly median centromeres (D and G - types) on 5 pairs and nearly submedian

Table 31. Measurements of somatic chromosomes of *I. glandulosa* Roxb. ex Willd. (Coll. No. 15).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	3.40+2.55=5.95	100.00	0.75	1.33	nm	A
3, 4	2.55+2.04=4.59	77.14	0.80	1.25	nm	A
5, 6	2.80+1.70=4.50	75.63	0.60	1.65	nsm	B
7, 8	0.85+2.04+1.36=4.25	71.43	0.47	2.13	nsm	$B^{S'}$
9, 10	2.89+1.36=4.25	71.43	0.46	2.00	nsm	B
11, 12	2.72+1.02=3.74	62.80	0.38	2.67	nsm	F
13, 14	2.55+1.02=3.57	60.00	0.40	2.50	nsm	F
15, 16	2.04+1.19=3.23	54.28	0.58	1.71	nsm	F^{S}

Table 32. Measurements of somatic chromosomes of *I. glandulosa* Roxb. ex Willd. (Coll. No. 17).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	0.68+1.53+1.19=3.40	100.00	0.53	1.85	nsm	$F^{S'}$
3, 4	2.04+1.19=3.23	95.00	0.58	1.71	nsm	F
5, 6	1.91+1.27=3.18	93.52	0.66	1.50	nm	D
7, 8	1.95+1.19=3.14	92.35	0.61	1.63	nm	D
9, 10	1.78+1.19=2.97	87.35	0.66	1.49	nm	D
11, 12	0.32+1.06+1.23=2.92	85.88	0.72	1.37	nm	$D^{S'}$
13, 14	1.70+0.97=2.67	78.52	0.57	1.75	nsm	F
15, 16	0.97+0.80=1.77	52.05	0.82	1.21	nm	G

I. glandulosa Contd.....

Fig. 85. PMC showing 8 bivalents at diakinesis (Coll.No.15).

Fig. 86. " " " at metaphase I (Coll.No.17).

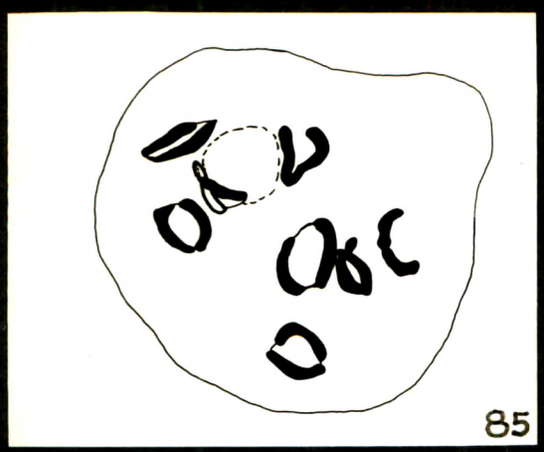
Fig. 87. " " association of bivalents at metaphase I (polar view)(Coll. No. 15).

Fig. 88. " " nucleolii at telophase I (Coll.No. 16).

Fig. 89. " " telophase I (Coll. No. 85).

Fig. 90. " " grouping of chromosomes at metaphase II (Coll. No. 85).

Fig. 91. " " 3 groups of chromosomes at metaphase II (Coll. No. 15).



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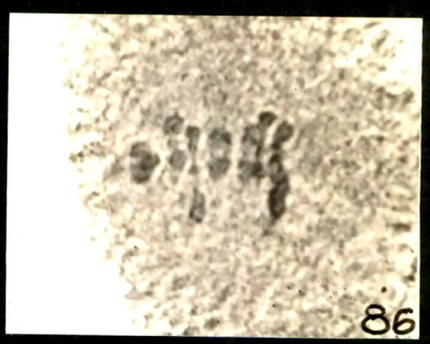

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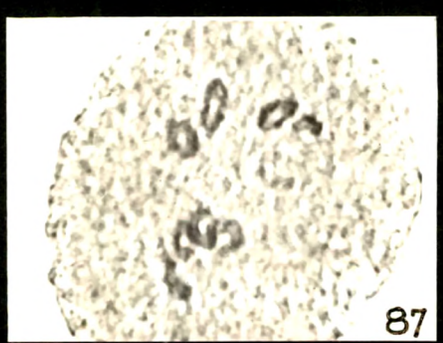

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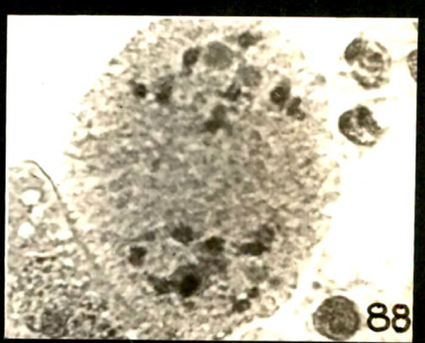

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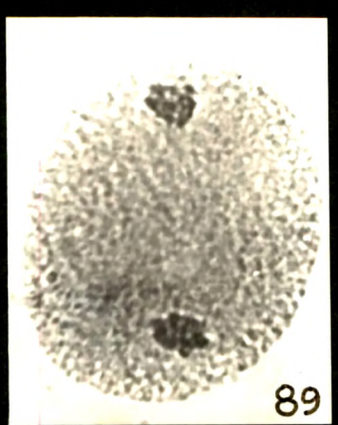

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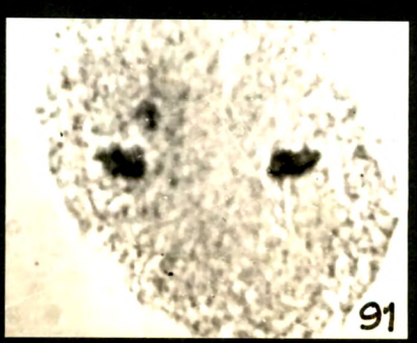

91

centromeres on 3 pairs of chromosomes. Among them 2 pairs of chromosomes (D^S-and F^S - types) are with secondary constrictions on long arms. The chromosomes in the complement are medium to short sized in contrast to the longer to medium sized observed in the preceeding collection. They range in length from 3.40 μ to 1.77 μ with a mean length of 2.99 μ. The asymmetrical and graded nature of the karyotype is indicated by TF% (38.78) and L/S (1.66).

The morphological similarities accompanied by karyotypic differences (Table 33) among the populations studied, indicate the presence of cytotypes in the species.

The present analysis of karyotype differs from the one analysed by Bhatt (1974) in having chromosomes with secondary constrictions, and satellites and in the absence of subterminal chromosomes.

During meiosis 8 distinct bivalents are noticed at diakinesis and metaphase I (Figs. 85 and 86). Some PMCs showed association of bivalents at metaphase I (Fig. 87), formation of nucleolii at telophase I (Fig. 88) and grouping of chromosomes at metaphase II (Figs. 89 and 90). The pollen fertility determined for the species is 92.38%.

Table 33.

Comparision of somatic chromosomes of different populations of I. glandulosa Roxb.ex Willd.

Populations	Somatic number (2n)	nm Types A	nm Types D	nm Types G	nsm Types B	nsm Types F	Chromosomes with Sec. Const. Types D^S	Chromosomes with Sec. Const. Types B^S	Chromosomes with Sec. Const. Types F^S	Chromosomes with SATs Type F^S	Absolute length (in μ)	Mean length (in μ)	L/S
Coll. Nos. 15	16	4	-	-	6	6	-	2	-	2	68.16	4.26	1.84
Coll. Nos. 16,17,85	16	-	8	2	-	6	2	-	2	-	47.96	2.99	1.92

Indigofera trifoliata Linn., Amoen. Acad. 4 : 327, 1759; FBI. 2 : 96, 1876; Cooke, 314, 1902; Ali, loc. cit. 552.

An erect, annual, much branched herb. Young branches covered with scattered, appressed hairs, soon glabrescent. Leaves subdigitately 3-foliolate; leaflets membranous, oblanceolate, rounded and minutely apiculate at the apex, hairy on both the surfaces, more densely hairy and nigro-punctate beneath; terminal leaflet sessile or nearly so. Flowers pink, in congested sessile, 6-12 flowered racemes, shorter than leaves. Calyx hairy, outside. Corolla longer than calyx; standard densely hairy beneath. Pods deflexed, straight, somewhat tetragonous, thinly hairy, with 4 narrow wings on each side of the suture, 6-8 seeded (Fl. Fr. August - October) S.29,30.

Observed in open waste lands.

The determination of somatic chromosome number (2n = 16) and karyotype analysis of the species are worked out for the first time.

Coll. No. 29.

Karyotype formulae : 2n = 16 = $A_4+B_2+D_6+F_2+F_2^{S''}$=57.06 μ (Figs. 92 and 93).

The complement shows nearly median centromeres (A and D -

Table 34. Measurements of somatic chromosomes of *I. trifoliata* Linn. (Coll. No. 29).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	2.72+1.70=4.42	100.00	0.63	1.60	nm	A
3, 4	2.55+1.70=4.25	96.15	0.67	1.50	nm	A
5, 6	2.72+1.36=4.08	92.31	0.50	2.00	nsm	B
7, 8	2.55+0.85+0.51=3.91	88.46	0.53	1.88	nsm	$F^{S"}$
9, 10	1.87+1.53=3.40	76.92	0.82	1.22	nm	D
11, 12	2.21+1.02=3.23	73.08	0.47	1.63	nsm	F
13, 14	1.79+1.28=3.07	69.07	0.72	1.40	nm	D
15, 16	1.32+0.85=2.17	49.10	0.64	1.55	nm	D

I. trifoliata

Fig. 92. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 93. Photomicrograph of somatic metaphase.

Fig. 94. Camera lucida drawing of somatic metaphase and idiogram.

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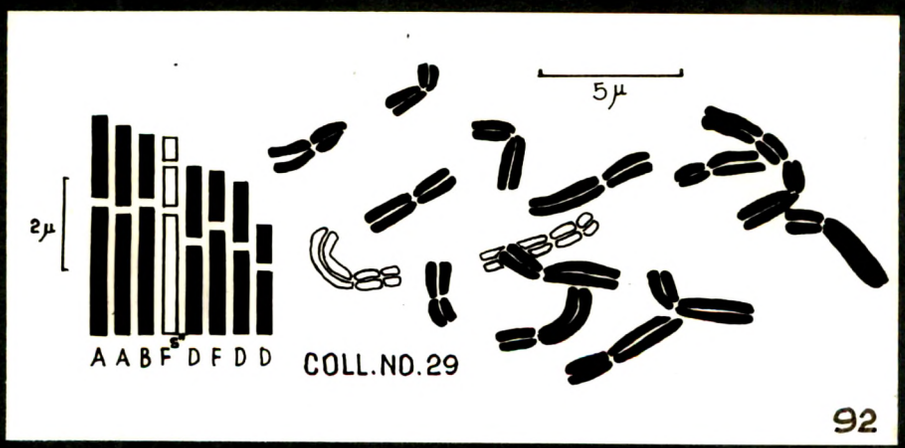
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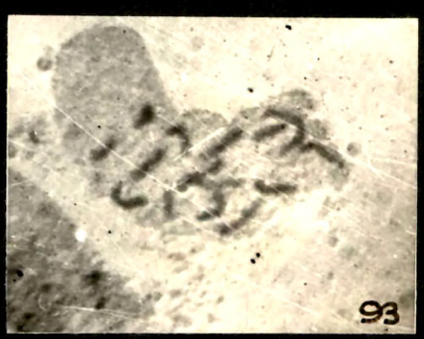
2μ
A A B F D F D D
COLL. NO. 29
92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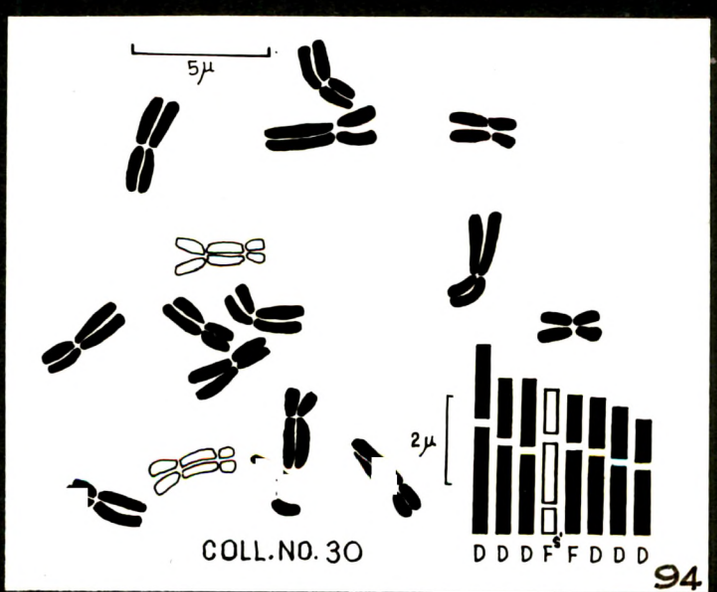
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2μ
COLL. NO. 30
D D D F D D D
94

types) on 5 pairs and nearly submedian (B and F - types) on 3 pairs of chromosomes. One pair of nearly submedian chromosomes ($F^{S''}$-type) are with secondary constrictions on short arms. The chromosomes in the complement are long to medium sized, range in length from 4.42 μ to 2.17 μ with a mean length of 3.57 μ. The TF% (37.85) and L/S (2.04) are indicative of asymmetrical and graded nature of the karyotype.

Coll. No. 30.

Karyotype formulae: $2n = 16 = D_{12}+F_2+F_2^{S'}=48.58\ \mu$ (Fig. 94).

The karyotype of this collection differs from the above one,in having shorter chromosomes, one additional pair of nearly median chromosomes and in the presence of secondary constrictions on long arms.

Populations collected from different localities showed morphological similarities. The karyotypic differences (Table 36) observed in these populations indicate the presence of cytotypes in the species.

Meiosis is normal showing the formation of 8 distinct bivalents at diakinesis and metaphase I (Figs. 95 and 96). This confirms the earlier report of n = 8 by Bir and Kumari (1973). Late separation of chromosomes at anaphase I are

Table 35. Measurements of somatic chromosomes of

I. trifoliata Linn. (Coll. No. 30).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	2.38+1.61=3.99	100.00	0.67	1.48	nm	D
3, 4	1.95+1.31=3.26	81.70	0.67	1.48	nm	D
5, 6	1.78+1.48=3.26	81.70	0.83	1.20	nm	D
7, 8	0.59+1.36+1.02=2.97	74.43	0.52	1.92	nsm	$F^{S'}$
9, 10	1.87+1.02=2.89	72.43	0.54	1.83	nsm	F
11, 12	1.78+1.10=2.88	72.18	0.61	1.62	nm	D
13, 14	1.53+1.14=2.67	66.91	0.74	1.34	nm	D
15, 16	1.44+0.93=2.37	53.39	0.64	1.54	nm	D

Table 36.

Comparision of somatic chromosomes of different populations of I. trifoliata Linn.

Populations	Somatic number (2n)	nm Types A	nm Types D	nsm Types B	nsm Types F	Chromosomes with Sec. Const. Types $F^{S'}$	Chromosomes with Sec. Const. Types $F^{S''}$	Absolute length (in μ)	Mean length (in μ)	L/S
Coll. No. 29	16	4	6	2	4	-	2	57.06	3.57	2.04
Coll. No. 30	16	-	12	-	4	2	-	48.58	3.03	1.68

I. trifoliata Contd.....

Fig. 95. PMC showing 8 bivalents at diakinesis (Coll.No.30).

Fig. 96. " " " at metaphase I(Coll.No.29).

Fig. 97. " " photomicrograph of metaphase I.

Fig. 98. " " late separation of chromosomes at anaphase I (Coll. No. 30).

Fig. 99. " " metaphase II (Coll. No. 29).

I. duthei

Fig. 100. Camera lucida drawing of somatic metaphase.

Fig. 101. Photomicrograph of somatic metaphase.

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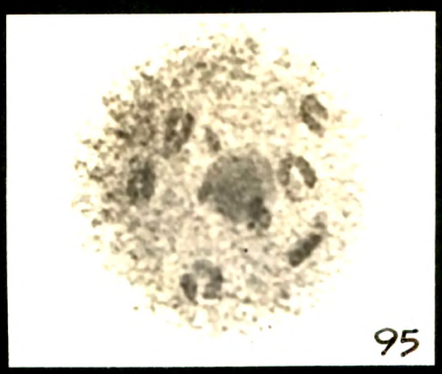

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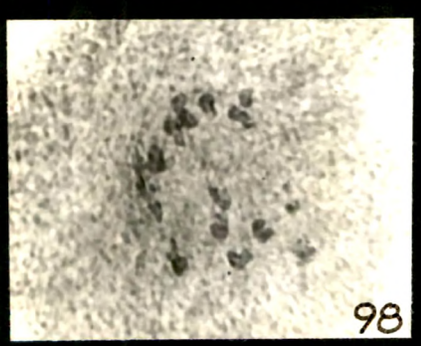

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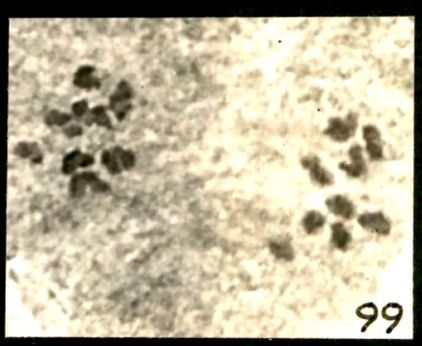

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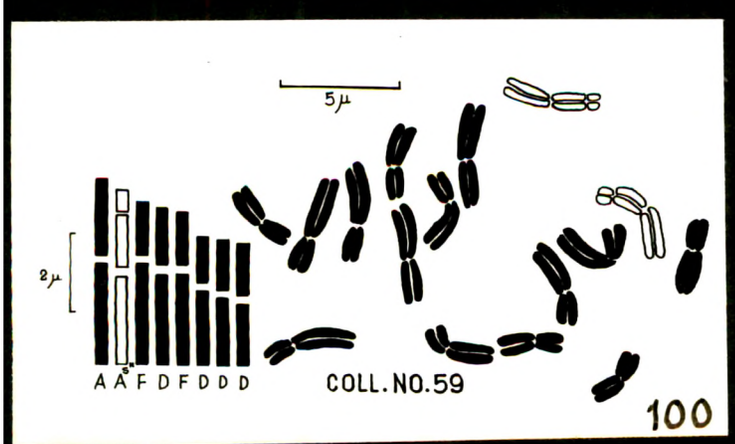

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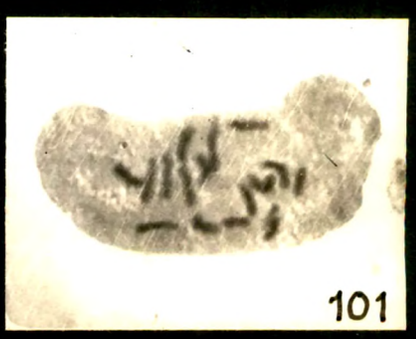


101

observed in some PMCs. The pollen fertility determined for the species is 93.25%.

Indigofera duthei Drum ex Naik, Proc. Indian Acad. Sci. 71(6), Sect. B : 226-229, 1970.

An erect, annual herb. Branches covered with scattered hairs. Leaves digitately 3-foliolate; leaflets membranous, lanceolate to oblanceolate, rounded, hairy on both the surfaces with punctate glands beneath; all leaflets have equal lengthed petiolules. Flowers pink in congested axillary racemes, pods slightly deflexed, straight, somewhat tetragonous, thinly hairy, wings absent on the sides of sutures, apiculate, 3-5 seeded. (Fl. Fr. September - November) S. 59.

Source : Seeds received from Dr. V. N. Naik, Aurangabad.

No data regarding cytological work of this species could be traced from the available literature. The chromosome numbers n = 8 and 2n = 16 are determined for the species.

Coll. No. 59.

Karyotype formulae : 2n = 16 = $A_2+A_2^{S''}+D_8+F_4$=57.42 μ (Figs. 100 and 101).

Table 37. Measurements of somatic chromosomes of *I. duthei* Drum. ex Naik (Coll. No. 59).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	2.55+1.87=4.42	100.00	0.73	1.36	nm	A
3, 4	2.21+1.36+0.51=4.08	92.31	0.85	1.18	nm	$A^{S"}$
5, 6	2.55+1.36=3.91	88.46	0.53	1.88	nsm	F
7, 8	2.30+1.45=3.75	84.84	0.63	1.59	nm	D
9, 10	2.30+1.36=3.66	82.81	0.59	1.69	nsm	F
11, 12	1.87+1.15=3.02	68.33	0.61	1.63	nm	D
13, 14	1.70+1.28=2.98	67.42	0.75	1.33	nm	D
15, 16	1.53+1.36=2.89	65.38	0.89	1.13	nm	D

The somatic complement includes 6 pairs of chromosomes with nearly median centromeres (A and D - types) and 2 pairs with nearly submedian (F-type). One pair of nearly median chromosomes ($A^{S"}$-type) are with secondary constrictions on short arms. The chromosomes in the complement are long to medium sized, their length ranges from 4.42 μ to 2.89 μ, with a mean length of 3.59 μ. The TF% and L/S are 40.75 and 1.53 respectively. Therefore, the karyotype is apparently asymmetrical and graded.

Meiosis is regular showing 8 bivalents at metaphase I (Fig. 102). However, grouping of chromosomes are observed at metaphase II (Fig. 103). The pollen fertility determined is 90.16%.

Indigofera oblongifolia Forsk., Pl. Aeg.-Arab. 137, 1775.

I. paucifolia Del., Fl. Aeg.-Arab 107, t. 37, f. 2, 2, 1813; FBI. 2 : 97, 1876; Cooke, 1 : 313, 1902; Gillett, loc. cit. 116; Ali, loc. cit. 546.

An erect, bushy shrub, very twiggy, ashy all over. Branches glabrous. Leaves compound; leaflets variable, alternate, hairy on both the surfaces, silvery hairy beneath. Flowers red, in axillary racemes. Pods numerous, densely

I. duthei Contd.....

Fig. 102. PMC showing 8 bivalents at metaphase I.

Fig. 103. " " grouping of chromosomes at metaphase II.

I. oblongifolia

Fig. 104. Camera lucida drawing of somatic metaphase and idiogram.

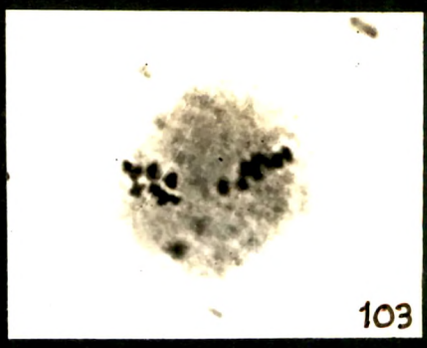
Fig. 105. Photomicrograph of somatic metaphase.

Fig. 106. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 107. Photomicrograph of somatic metaphase.

Contd.....

102



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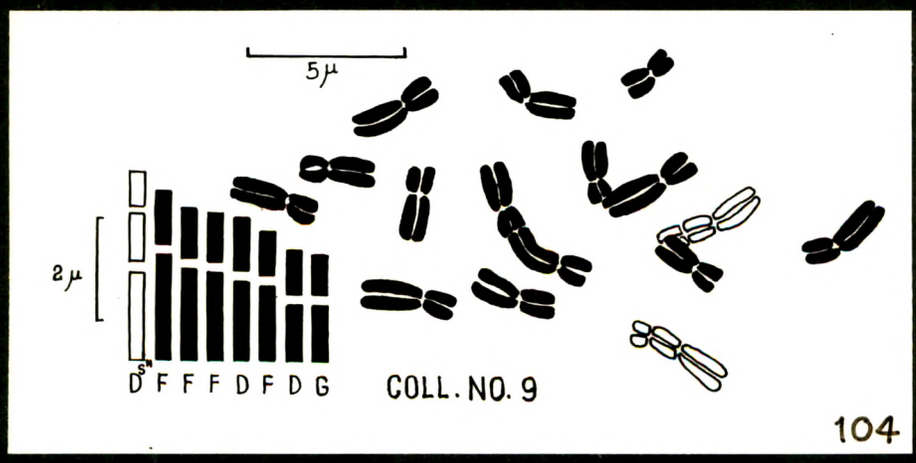
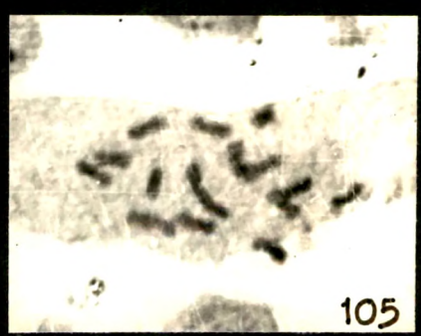


104



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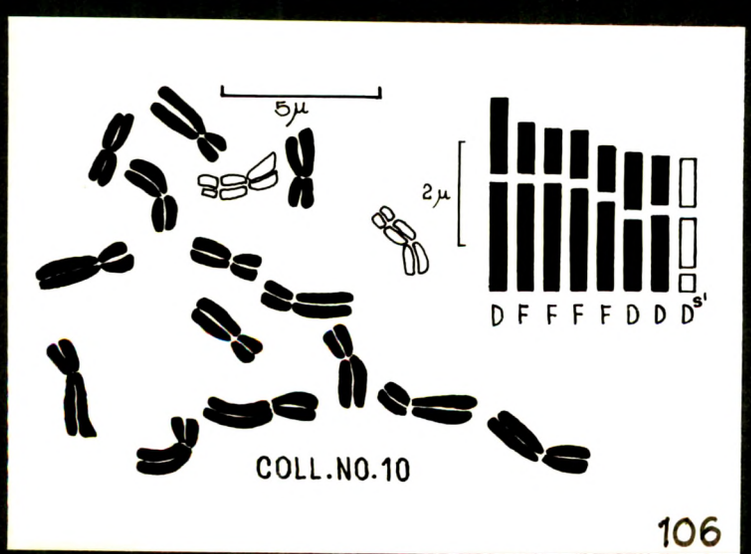
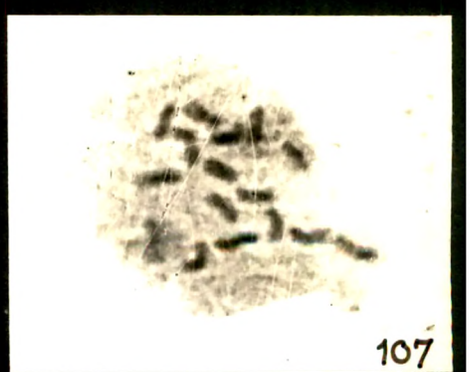


106



107

silvery when young, more or less deflexed, 6-8 seeded, torulose (Fl. Fr. September - January) S. 9, 10 and 11.

Observed in open waste lands and along forest paths.

Frahm-leliveld (1966); Singh and Roy (1970) and Bhatt (1974) have reported 2n = 16 chromosomes in the somatic complement for the species. This is confirmed in the present work. Three collections have been cytologically investigated.

Coll. No. 9.

Karyotype formulae : 2n = 16 = $D_4+D_2^{S''}+F_8+G_2$=41.20 μ (Figs. 104 and 105).

The karyotype shows equal number of chromosomes with nearly median (D and G - types) and nearly submedian (F-type) centromeres. One pair of nearly median chromosomes ($D^{S''}$-type) are with secondary constrictions on short arms. The chromosomes in the complement are medium sized, except for one pair of short sized chromosomes (G-type). The chromosomes vary in length from 3.32 μ to 1.96 μ, with their average length being 2.57 μ. The karyotype is asymmetrical as the TF% and L/S are 38.88 and 1.69 u respectively. The graded nature of the karyotype is indicated in idiogram (Fig. 104).

Table 38. Measurements of somatic chromosomes of *I. oblongifolia* Forsk. (Coll. No. 9).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.70+0.94+0.68=3.32	100.00	0.95	1.04	nm	$D^{S"}$
3, 4	2.04+1.02=3.06	92.16	0.50	2.00	nsm	F
5, 6	1.79+0.94=2.73	82.22	0.52	1.90	nsm	F
7, 8	1.70+0.94=2.64	79.51	0.55	1.80	nsm	F
9, 10	1.53+1.02=2.55	76.80	0.66	1.50	nm	D
11, 12	1.45+0.85=2.30	69.27	0.58	1.70	nsm	F
13, 14	1.19+0.85=2.04	61.44	0.71	1.40	nm	D
15, 16	1.19+0.77=1.96	59.03	0.64	1.54	nm	G

Coll. No. 10.

Karyotype formulae : 2n = 16 = $D_6+D_2^{S'}+F_8$=43.58 μ (Figs. 106 and 107).

The karyotype of this collection resembles the preceeding one (i.e. Coll. No. 9) in having equal number of chromosomes nearly median and nearly submedian centromeres, but differs from it in having secondary constrictions on long arms ($D^{S'}$-type) and absence of short chromosomes.

Coll. No. 11.

Karyotype formulae : 2n = 16 = $D_2+F_8+F_2^{S'}+G_2^{S}+H_2$=37.10 μ (Fig. 108).

The karyotype of this collection differs from the preceeding ones in having less number nearly median (2 pairs), more number of nearly submedian (6 pairs) and a pair of satellited (G^{S}-type) chromosomes.

Populations collected from different localities showed similarities in gross morphological characters. But the karyotypic differences (Table 41) observed among them indicate the presence of cytotypes within the species.

The meiosis is normal showing 8 distinct bivalents at metaphase I (Fig. 109) and equal distribution at anaphase I

Table 39. Measurements of somatic chromosomes of *I. oblongifolia* Forsk. (Coll. No. 10).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	2.04+1.45=3.49	100.00	0.71	1.40	nm	D
3, 4	2.04+0.94=2.98	85.38	0.46	2.17	nsm	F
5, 6	2.04+0.85=2.89	82.80	0.41	2.40	nsm	F
7, 8	1.96+0.89=2.85	81.66	0.45	2.20	nsm	F
9, 10	1.70+0.85=2.55	73.06	0.50	2.00	nsm	F
11, 12	1.36+1.06=2.42	69.34	0.77	1.28	nm	D
13, 14	1.45+0.94=2.39	68.48	0.64	1.54	nm	D
15, 16	0.34+0.94+0.94=2.22	63.61	0.73	1.36	nm	D^S

Table 40. Measurements of somatic chromosomes of *I. oblongifolia* Forsk. (Coll. No. 11).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.70+0.94=2.64	100.00	0.55	1.81	nsm	F
3, 4	0.64+1.11+0.85=2.60	98.48	0.49	2.05	nsm	$F^{S'}$
5, 6	1.70+0.89=2.59	98.10	0.52	1.91	nsm	F
7, 8	1.53+0.85=2.38	90.15	0.56	1.80	nsm	F
9, 10	1.45+0.85=2.30	87.12	0.56	1.71	nsm	F
11, 12	1.19+1.02=2.21	83.71	0.86	1.17	nm	D
13, 14	1.19+0.77=1.96	74.24	0.65	1.55	nm	G^{S}
15, 16	1.19+0.68=1.87	70.83	0.57	1.75	nsm	H

Table 41.

Comparision of somatic chromosomes of different populations of I. oblongifolia Forsk.

Populations	Somatic number (2n)	nm Types D	nm Types G	nsm Types F	nsm Types H	Chromosomes with Sec. Const. Types $D^{S'}$	Chromosomes with Sec. Const. Types $D^{S''}$	Chromosomes with Sec. Const. Types $F^{S''}$	Chromosomes with SATs Type G^{S}	Absolute length (in μ)	Mean length (in μ)	L/S
Coll. No. 9	16	6	2	8	-	-	2	-	-	41.20	2.57	1.69
Coll. No. 10	16	8	-	8	-	2	-	-	-	43.58	2.72	1.57
Coll. No. 11	16	12	2	12	2	-	-	2	2	37.10	2.32	1.41

I. oblongifolia Contd....

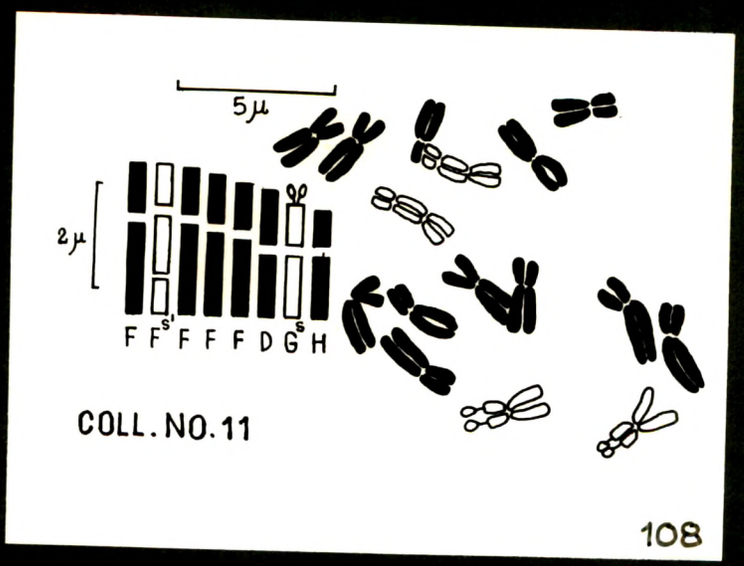
Fig. 108. Camera lucida drawing of somatic metaphase and idiogram.

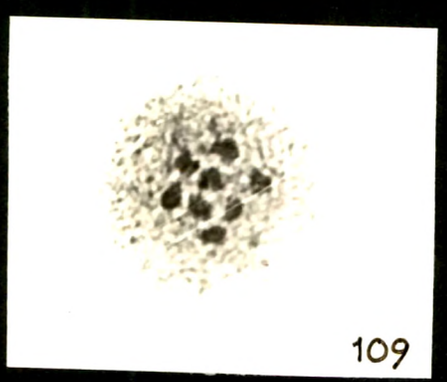
Fig. 109. PMC showing 8 bivalents at metaphase I (polar view) (Coll. No. 11).

Fig. 110. " " association of bivalents at metaphase I (Coll. No. 10).

Fig. 111. " " late separation of chromosomes at anaphase (Coll. No. 11).

Fig. 112. " " grouping of chromosomes at metaphase II (Coll. No. 112).


5μ
2μ
F F S' F F F D G S H
COLL. NO. 11
108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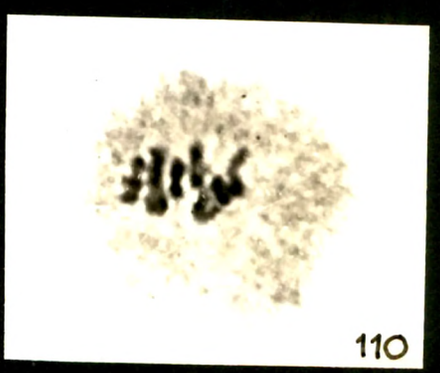
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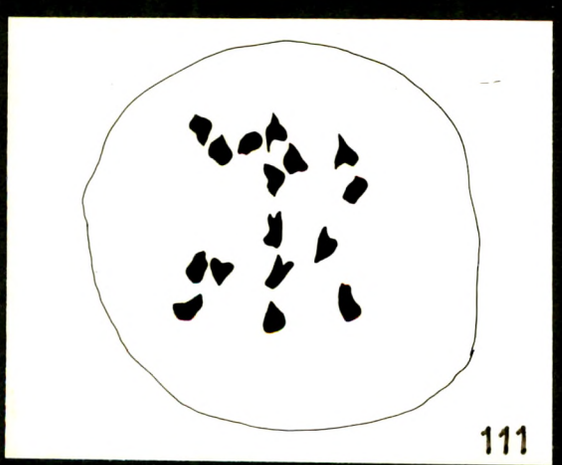
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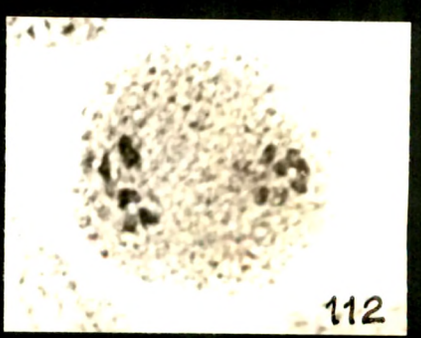

112

(Fig. 111). This is the first report of meiosis and haploid number (n = 8) for the species. Some of the PMCs showed association of bivalents at metaphase I (Fig. 110) and grouping of chromosomes at metaphase II (Fig. 112). The pollen fertility determined for the species is 91.08%.

Indigofera spicata Forsk., Fl. Aeg.-Arab. 138, 1775; Gillett, loc. cit. 119.

I. hendecapylla Jacq., Coll. Bot. 2 : 358, 1788.

"I. endecaphylla Jacq.", Lam. Encycl. Suppl. 3 : 147, 1813, per errore; FBI. 2 : 98, 1876.

An annual or biennial with trailing stems. Branches covered with only few hairs. Leaves compound, leaflets 5-9, membranous, alternate, oblanceolate, obtuse, appressedly grey hairy; stipules lanceolate, acuminate. Racemes close, usually peduncled. Calyx teeth setaceous, long. Corolla violet-purple, twice the calyx. Pods straight, deflexed, glabrescent, 6-10 seeded - adopted from FBI. 2 : 98, 1876. (Coll. No. 96).

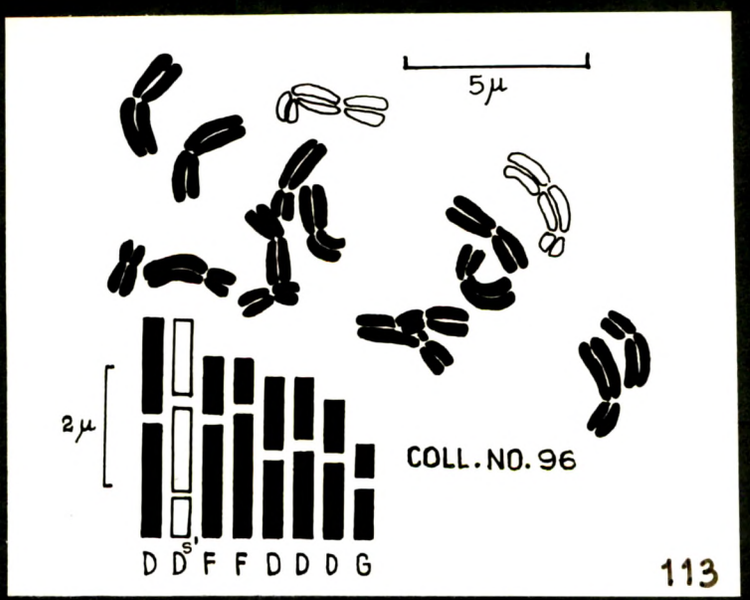
Source : Seeds obtained from Kew gardens, England.

Frahm-leliveld (1960) reports 2n = 16, while Pritchard and Gould (1964) reports 2n = 16 and 32 for the species. The

I. spicata

Fig. 113. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 114. Photomicrograph of somatic metaphase.


5μ
2μ
COLL. NO. 96
D D S' F F D D D G
113

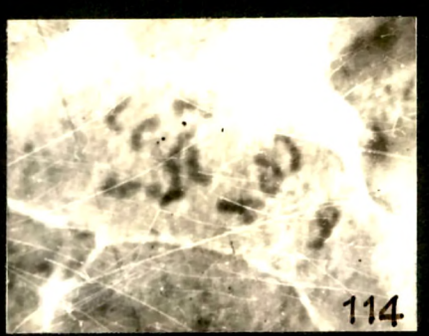

114

Table 42. Measurements of somatic chromosomes of *I. spicata* Frosk. (Coll. No. 96).

Chromosome pair	Length in u	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.87+1.53=3.40	100.00	0.83	1.22	nm	D
3, 4	0.68+1.36+1.28=3.32	97.65	0.63	1.59	nm	$D^{S'}$
5, 6	1.87+0.94=2.81	82.65	0.50	1.99	nsm	F
7, 8	2.04+0.77=2.81	82.65	0.38	2.65	nsm	F
9, 10	1.28+1.19=2.47	72.65	0.93	1.08	nm	D
11, 12	1.45+1.02=2.47	72.65	0.70	1.42	nm	D
13, 14	1.23+0.81=2.04	68.82	0.66	1.52	nm	D
15, 16	0.81+0.51=1.32	60.00	0.63	1.59	nm	G

haploid number n = 8 is reported by Turner (1956). The somatic number 2n = 16 is confirmed in the present study. The karyotype is worked out for the first time.

Coll. No. 96.

Karyotype formulae : 2n = 16 = $D_8+D_2^{S'}+F_4+G_2$=41.28 μ (Figs. 113 and 114).

The complement shows 6 pairs of chromosomes with nearly median (D and G - types) and 2 pairs with nearly submedian centromeres (F-type). One pair of nearly median chromosomes ($D^{S'}$-type) are with secondary constrictions on long arms. The chromosomes are medium to short sized, the length varies from 3.40 μ to 1.32 μ, with a mean length of 2.48 μ. The karyotype is apparently asymmetrical as the TF% is 39.06. The graded nature of the karyotype is indicated in the idiogram (Fig. 113).

Desmodium Desv.

The genus Desmodium belonging to the tribe Desmodiae, was first established by Desvaux in 1813. Prior to this most species of Desmodium and its closely related genera were referred to Hedysarum (Linnaeus, 1753). Meibomia (Fabricius, 1759), Edusaron (Medikus, 1787) and Pleurolobus (Saint-Hilaire, 1812). Kuntze (1819) transferred some 230 species of Desmodium sensu lato to Meibomia and it was accepted by Rochester and

American codes of nomenclature. But later botanical congress accepted the name Desmodium as one of the 'nomina conservanda' against the generic names Meibomia and Pleurolobus.

The genus has been studied in greater details by De Candolle (1825), Bentham (1852, 1865), Baker (1876), Schindler (1928), Hutchinson (1966) and Ohashi (1973). The comparison of the different treatments is summarised in the Table 43a.

The genus comprises 350-450 species widely distributed in the tropics and subtropics of the world. Southern Asia and Mexico are considered as the two centres of distribution and differentiation. However, Asiatic region is considered as the primary centre (Ohashi, 1973).

The genus Desmodium is characterised by shrubs, subshrubs or herbs; erect, prostrate, decumbent or subclimbing. Leaves unifoliolate or pinnately trifoliolate; terminal leaflet the larger, variously shaped; stipellate; stipules free, somewhat joined and striate. Inflorescence axillary or terminal, falsely racemose. The flowers pink or pale purple, solitary or fasciculated on the rachis; bracts dimerous striate, persistent or membranous and deciduous. Calyx usually broadly companulate, more or less 2-lipped, the upper lip composed of 2 lobes (joined together), the lower three, teeth acute or acuminate. Corolla mostly small, vexillum oblong to orbicular, rounded

or emarginate at the apex, shortly clawed; wings more or less adherent to the keels, oblong, rounded to obtuse at the apex, shortly clawed; keel longer or shorter than wings acute or obtuse at the apex. Stamens mostly diadelphous, vexillary filament free or partly joined; anthers uniform. Ovary sessile or stipitate, pubescent, many ovuled; style inflexed or incurved, glabrous; stigma terminal, capitate or minute. Pods exerted from the calyx, sessile or stipitate, compressed, jointed, dehiscent or indehiscent, joints 1-seeded. Seeds reniform or oblong, compressed estrophiolate,pollen grains tricolpate, colpi long and membrane granulated.

Taxa investigated in the present work, have been arranged following the classification of Ohashi (1973).

Genus DESMODIUM Desv.

Subgenus : Catenaria (Benth.) Bak.

Subgenus : Desmodium

Section : Angustistipulosa Ohashi

D. laxiflorum DC.

Section : Desmodium

D. salicifolium (Poir.) DC.

Subgenus : Dollinera (Endl.) Schindl.

Section : Dollinera

Subsection : Dollinera -

Subsection : Khasiana (Schindl.) Ohashi -

Subsection : Tilifolia (Schindl.) Ohashi -

D. elegans DC.

Section : Kingiana Ohashi -

Section : Sequax Ohashi -

Section : Siamensia Ohashi -

Subgenus : Hanslia (Schindl.) Ohashi -

Subgenus : Ougeinia (Benth.) Ohashi -

Subgenus : Podocarpium (Benth.) Ohashi -

Subgenus : Sagotia (Duchass et Walpers) Bak.

Section : Chalarioidea Benth.

D. dichotomum (Willd.) DC.

D. distortum (Aubl.) Mcbr.

Section : Heteroloma Benth.

D. gangeticum Linn.

D. velutinum (Willd.) DC.

Section : Nicolsonia (DC) Benth.

D. heterocarpon (Linn.) DC. var. strigosum Van Meeuwen

69

D. rotundifolium Bak.

D. intortum (Mill.) Urb.

D. sandwicense E. Mey.

D. uncinatum (Jacq.) DC.

Section : Oxytes (Schindl.) Ohashi –

Section : Renifolia Ohashi –

Section : Sagotia

D. triflorum (Linn.) DC.

Genus DENDROLOBIUM (Wt. & Arn.) Benth.

D. triangulare (Retz.) Schindl.

Desmodium laxiflorum DC., Prodr. 2 : 335, 1825; FBI. 2: 164, 1876; Cooke, 1 : 376, 1902; Ohashi, loc. cit. 101.

An erect, herb or undershrub. Stems angled more or less hairy. Leaves trifoliolate; leaflets membranous, ovate-lanceolate, acute or subacute, glabrous above, more or less hairy beneath. Flowers pink in axillary or terminal racemes, flowers usually in distant fascicles, the rachis slightly hairy. Pods scarcely constricted between the seeds, joints 6-10, longer than broad, covered with minute hooked hairs (Fl. Fr. September - December) S. 54.

Noted in hedges and as an undergrowth in the forests.

n = 11 (Mehra and Dhawan, 1971; Bir and Talwar, 1973) and 2n = 22 (Bhatt, 1974) are the previous reports of chromosomes numbers for the species and the same numbers are confirmed in the present investigation.

Coll. No. 54.

Karyotype formulae : $2n = 22 = D_4+D_2^{S''}+G_{12}+H_2+H_2^S=39.18\ \mu$ (Figs. 115 and 116).

The karyotype consists of 9 pairs of chromosomes with nearly median (D and G - types) and 2 pairs with nearly submedian centromeres. One pair of nearly median type ($D^{S''}$-type) is with secondary constrictions on short arms and another pair of nearly submedian (H^S-type) type is with satellites. The chromosomes are medium to short sized, the length varies from 2.51 μ to 1.19 μ, with an average length of 1.78 μ. The apparent asymmetry of the karyotype is evident from TF% of 40.02 and L/S of 2.11.

In contrast to the earlier analysis (Bhatt, 1974) of the karyotype showing 3 pairs of chromosomes with median and 8 pairs with submedian centromeres, in the present investigation 9 pairs of chromosomes with nearly median and 2 pairs with

Table 43. Measurements of somatic chromosomes of *D. laxiflorum* DC. (Coll. No. 54).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.53+0.98=2.51	100.00	0.64	1.56	nm	D
3, 4	1.19+0.77+0.34=2.30	91.63	0.93	1.07	nm	$D^{S"}$
5, 6	1.28+0.85=2.13	84.86	0.66	1.51	nm	D
7, 8	1.11+0.68=1.79	71.31	0.61	1.65	nm	G
9, 10	0.94+0.77=1.71	68.13	0.82	1.22	nm	G
11, 12	1.19+0.51=1.70	67.73	0.43	2.33	nsm	H
13, 14	1.02+0.68=1.70	67.73	0.67	1.50	nm	G
15, 16	1.06+0.51=1.57	62.55	0.48	2.08	nsm	H^S
17, 18	0.94+0.60=1.54	61.35	0.64	1.57	nm	G
19, 20	0.81+0.64=1.45	57.77	0.79	1.27	nm	G
21, 22	0.68+0.51=1.19	47.47	0.75	1.33	nm	G

Desmodium laxiflorum

Fig. 115. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 116. Photomicrograph of somatic metaphase.

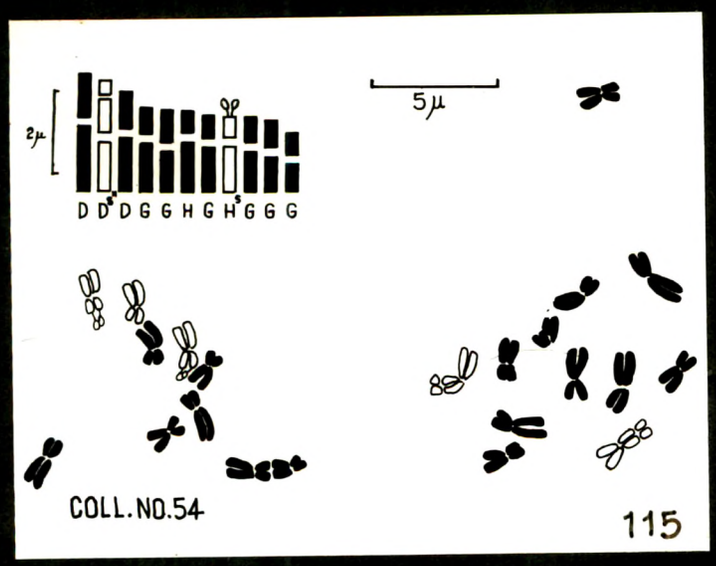
Fig. 117. PMC showing 11 bivalents at diakinesis.

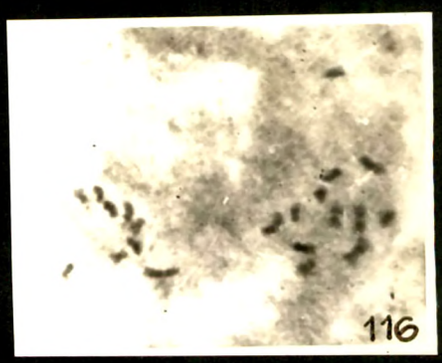
Fig. 118. " " association of bivalents at metaphase I.

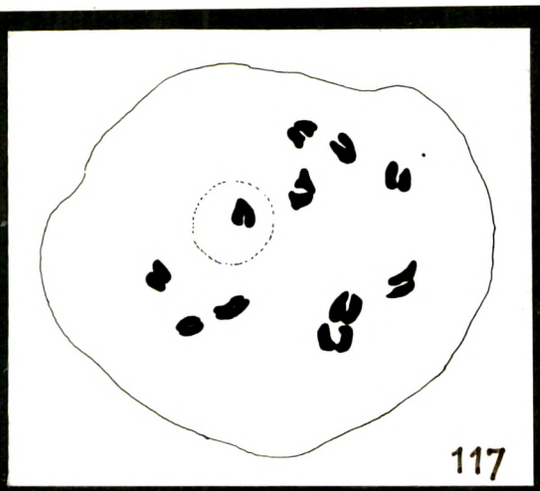
Fig. 119. " " association of bivalents at metaphase I.

Fig. 120. PMCs showing cytomixis at metaphase I.

Fig. 121. PMC showing late separation of chromosomes at anaphase I.


2μ
5μ
D D' D G G H G H' G G G
COLL. NO. 54
115


116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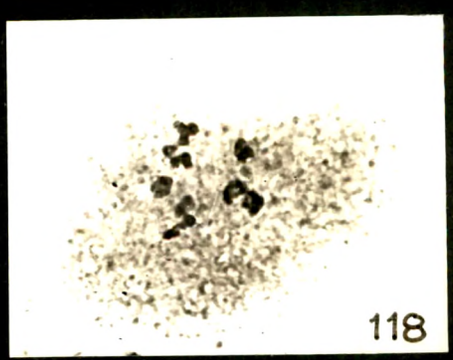
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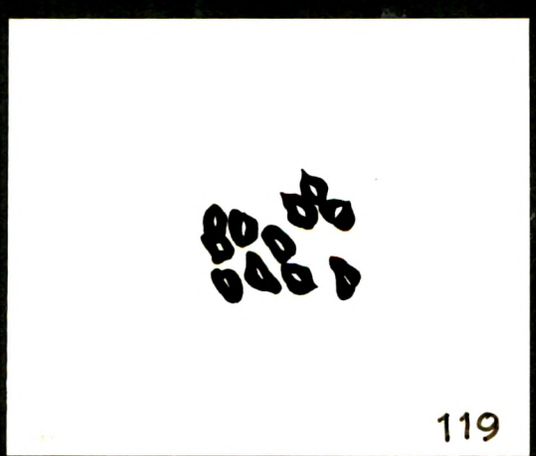
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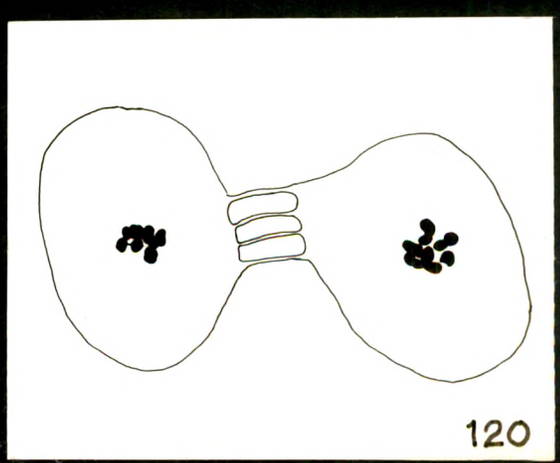
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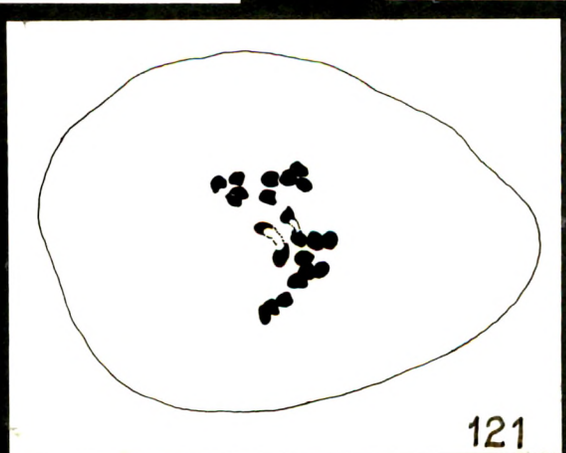

121

nearly submedian centromeres are observed. However, both the analyses resemble each other in having 2 pairs of chromosomes with satellites or secondary constriction.

Meiosis is normal showing the formation of 11 bivalents at diakinesis and metaphase I (Figs. 117 and 119). Association of bivalents at metaphase I (Figs. 118 and 119), cytomixis at metaphase I (Fig. 120) and late separation of chromosomes at anaphase I (Fig. 121) are some of the abnormalities recorded in few PMCs. The pollen fertility determined for the species is 91%.

Desmodium salicifolium (Poir.) DC. Prodr. 2 : 337, 1825; Verdec., Kirkia 9(2) : 522, 1974.

Hedysarum salicifolium Poir., Lam. encycl. Meth. Bot. 6 : 422, 1805.

An erect, woody subshrub. Branches striate covered with spreading hairs. Leaves trifoliolate; stipules ovate-lanceolate, striate, ciliate, persistent; leaflets oblong-elliptic to ovate-lanceolate, rounded to acute with mucronulate apex, hairy on both the surfaces (more on veins beneath). Flowers pink, in dense axillary and terminal racemes. Pods thickened on the margins, slightly indented on both the sutures, joints 3-7, hairy with raised reticulations. (Fl. Fr. October - November) S. 95.

Table 44. Measurements of somatic chromosomes of *D. salicifolium* (Poir.) DC. (Coll. No. 95).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.96+1.87=3.83	100.00	0.95	1.05	nm	D
3, 4	1.87+1.53=3.40	88.77	0.82	1.22	nm	D
5, 6	1.70+0.94+0.60=3.24	84.60	0.91	1.10	nm	$D^{S''}$
7, 8	1.53+1.28=2.81	73.37	0.84	1.20	nm	D
9, 10	1.53+1.02=2.55	66.58	0.67	1.50	nm	D
11, 12	1.53+0.85=2.38	62.14	0.56	1.80	nsm	F
13, 14	1.36+0.68=2.04	53.26	0.50	2.00	nsm	F
15, 16	1.36+0.60=1.96	51.17	0.44	2.27	nsm	H
17, 18	1.02+0.51=1.53	39.95	0.50	2.00	nsm	H
19, 20	1.02+0.43=1.45	37.86	0.42	2.37	nsm	H

72

Source : Seeds received from Kew gardens (origin Zambia).

The somatic chromosome number 2n = 20, determined for the species, is in confirmity with the earlier reports of Turner and Fearing (1959). However, Miege (1960) reports 2n = 22 for the species.

Coll. No. 95.

Karyotype formulae : 2n = 20 = $D_8+D_2^{S''}+F_4+H_6$=50.38 μ (Figs. 122 and 123).

The complement includes equal number of chromosomes with nearly median (D-type) and nearly submedian (F and H - types) centromeres. A pair of nearly median chromosomes are with secondary constrictions on short arms. The chromosomes are medium to short sized, the length ranges from 3.88 μ to 1.45 μ, with a mean length of 2.52 μ. Despite the fact that, the equal number of nearly median and nearly submedian chromosomes, an overall asymmetry is apparent in the karyotype owing to its high L/S ratio(2.64).

Desmodium elegans DC., Ann. Sci. Nat. 4 : 100, 1825; Ohashi, loc. cit. 110.

D. taliaefolium (D. Don) Wall., FBI. 2 : 168, 1876.

A large deciduous shrub. Branches striate, more or less

D. salicifolium

Fig. 122. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 123. Photomicrograph of somatic metaphase.

D. elegans

Fig. 124. Camera lucida drawing of somatic metaphase and idiogram.

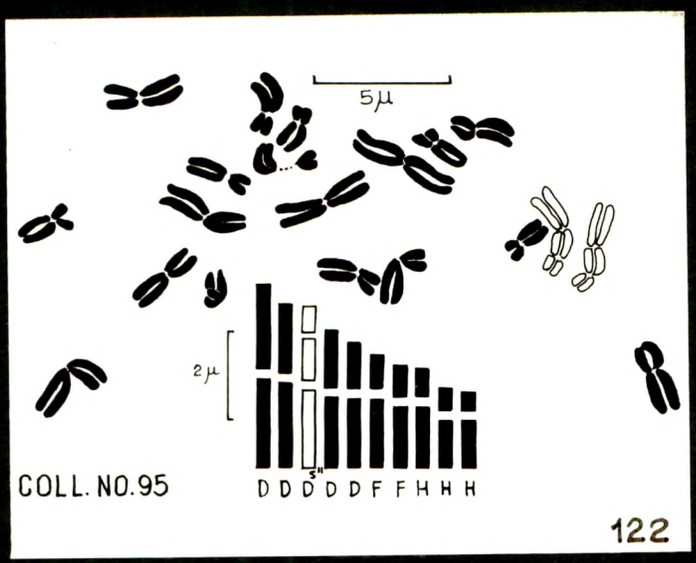
Fig. 125. Photomicrograph of somatic metaphase.

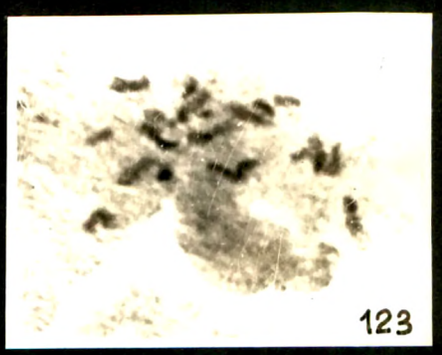
D. dichotomum

Fig. 126. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 127. Photomicrograph of somatic metaphase.

Contd.....


5μ
2μ
COLL. NO. 95
D D D D D F F H H H
122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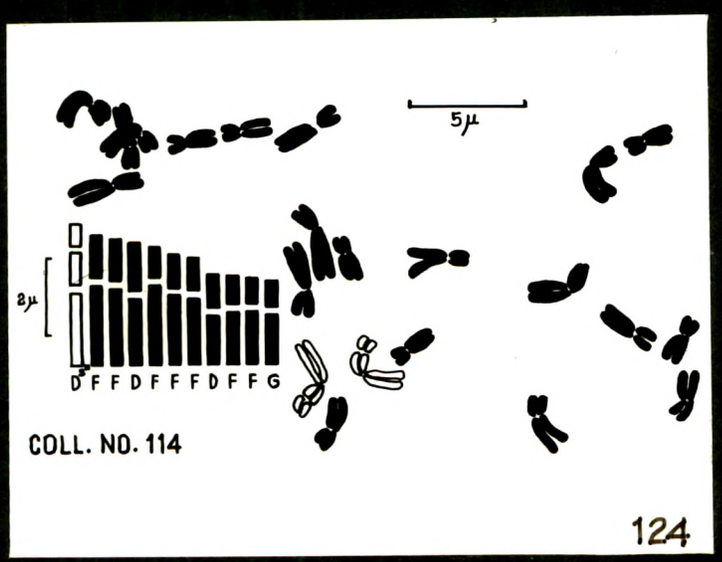
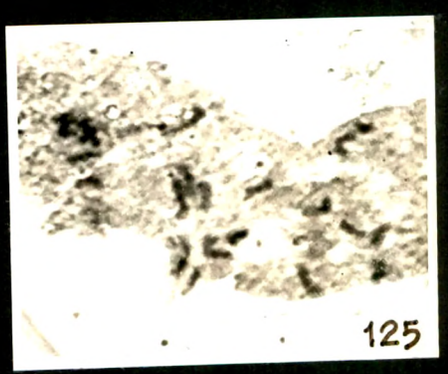

5μ
2μ
D F F D F F F D F F G
COLL. NO. 114
124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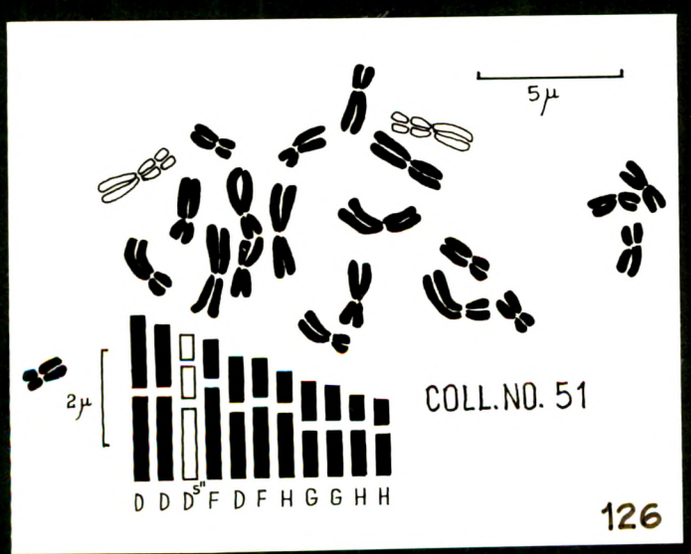
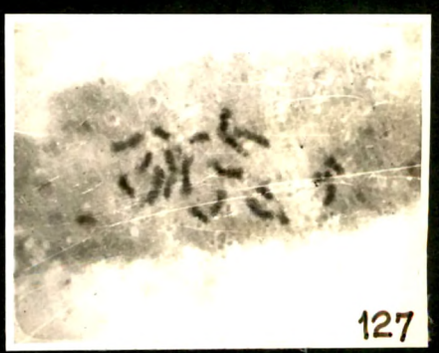

5μ
2μ
D D D F D F H G G H H
COLL. NO. 51
126


127

densely hairy. Leaves trifoliolate; stipules narrow, linear, caducous; leaflets variable, orbicular, ovate or obovate, obtuse or abruptly acuminate, glabrescent above and silky-white hairy beneath, lateral leaflets oblique. Flowers pale lilac, in large terminal, much branched panicles, flowers usually clustered. Pods sessile or distinctly stalked, indented on the lower suture, joints 6-9, covered with appressed hairs. Seeds black. - adopted from FBI. 2 : 168, 1876. Coll. No. 114.

Source : Seeds obtained from Kew gardens.

Many workers have reported n = 11 (Bir and Sidhu, 1967; Rao, 1967; Rotar and Urata, 1967) and 2n = 22 (Tixier, 1965; Kaul and Gohil, 1973) as the chromosome numbers for the species. 2n = 22 is confirmed in the present study. Detailed analysis of karyotype is attempted for the first time.

Coll. No. 114.

Karyotype formulae : 2n = 22 = $D_4+D_2^{S''}+F_{14}+G_2$=57.48 μ (Figs. 124 and 125).

There are 4 pairs of chromosomes with nearly median (D and G - types) and 7 pairs with nearly submedian (F-type) centromeres in the complement. A pair of nearly median chromosomes ($D^{S''}$-type) are with secondary constrictions on short arms. The chromosomes are medium to short sized, the length ranges

Table 45. Measurements of somatic chromosomes of *D. elegans* DC. (Coll. No. 114).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.87+0.85+0.60=3.32	100.00	0.78	1.29	nm	$D^{S"}$
3, 4	2.04+1.11=3.15	94.88	0.54	1.84	nsm	F
5, 6	1.96+1.11=3.07	92.47	0.57	1.77	nsm	F
7, 8	1.70+1.28=2.98	89.76	0.75	1.33	nm	D
9, 10	2.04+0.77=2.81	84.64	0.38	2.65	nsm	F
11, 12	1.79+0.85=2.64	79.52	0.47	2.11	nsm	F
13, 14	1.70+0.85=2.55	76.81	0.50	2.00	nsm	F
15, 16	1.28+0.85=2.13	64.16	0.66	1.51	nm	D
17, 18	1.32+0.77=2.09	62.95	0.58	1.71	nsm	F
19, 20	1.36+0.68=2.04	61.45	0.50	2.00	nsm	F
21, 22	1.06+0.85=1.91	59.04	0.80	1.25	nm	G

from 3.32 u to 1.96 u, with a mean length of 2.61 u. The karyotype is asymmetrical as the TF% is 36.20.

Desmodium dichotomum (Willd.) DC., Prodr.2 : 336, 1825; Van Meeuwen, Reinwardtia 6(3): 248, 1962; Ohashi, loc. cit. 173; Verdec., loc. cit. 523.

Hedysarum dichotomum Willd., Sp. Pl. 3 : 1180, 1802.

Desmodium diffusum (Willd.) DC., Prodr. 2 : 336, 1825; FBI. 2: 169, 1876; Cooke, 1 : 377, 1903.

An erect, annual herb or undershrub. Stem stout, deeply grooved, very sticky all over with short, recurved hairs. Leaves trifoliolate; stipules large, amplexicaul and auricled; leaflets stiff, ovate-oblong, more or less hairy on both the sides. Flowers in small fascicles, in large, axillary and terminal racemes. Pods indented on both the sutures, joints 3-6, rounded, covered with small hooked hairs (Fl. Fr. September-December) S. 50, 51 and 87.

Common; observed in open places and along roadsides in forests.

The present investigation confirms the earlier reports of chromosome numbers n = 11 (Bhaumik, 1975) and 2n = 22 (Rotar and Urata, 1967 and Bhatt, 1974) for the species.

D. dichotomum Contd....

Fig. 128. PMC showing 11 bivalents at diakinesis (Coll. No. 51).

Fig. 129. " " univalents at diakinesis (Coll.No.50).

Fig. 130. " " interbivalent connections ( ) at metaphase (polar view) (Coll. No. 51).

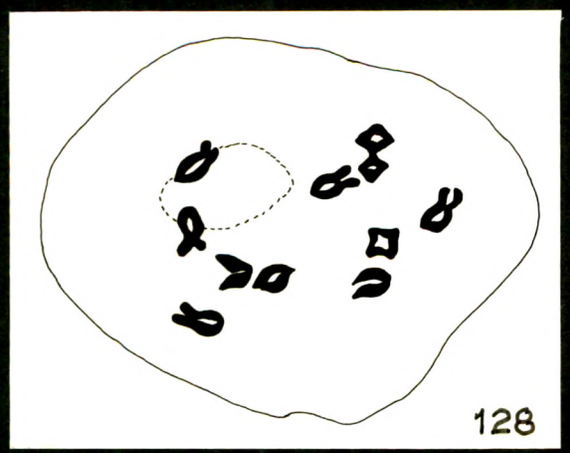
Fig. 131. " " association of bivalents at metaphase I (Coll. No. 87).

Fig. 132. " " association of bivalents at metaphase I (Coll. No. 51).

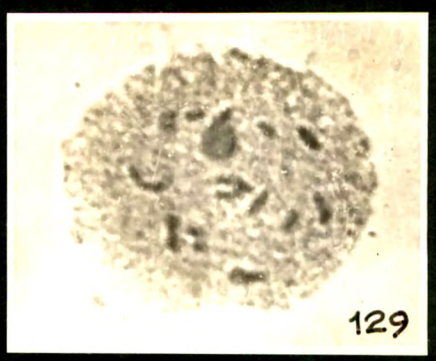
Fig. 133. PMCs showing cytomixis at metaphase I.

Fig. 134. PMC showing precocious movement at anaphase I (Coll. No. 51).

Fig. 135. " " grouping of chromosomes at metaphase II (Coll. No. 87).



128



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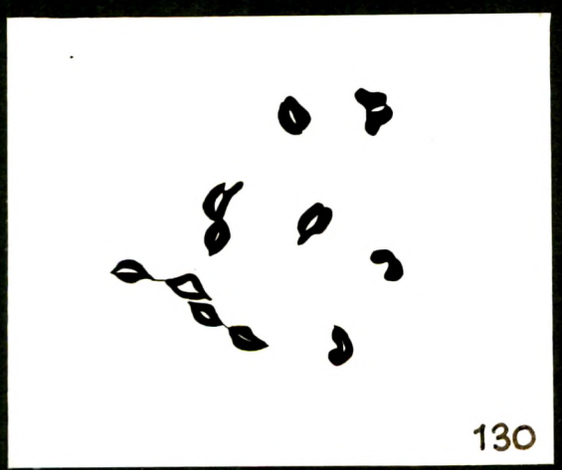

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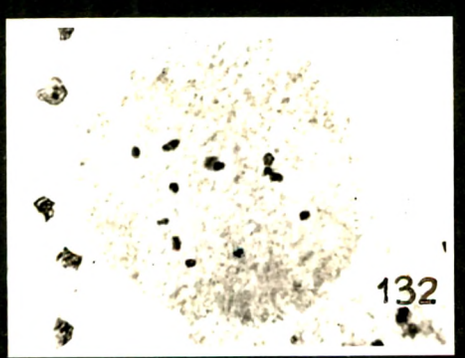
131



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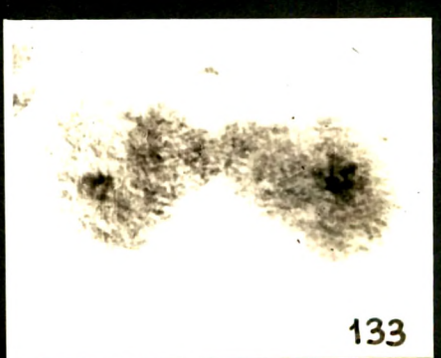

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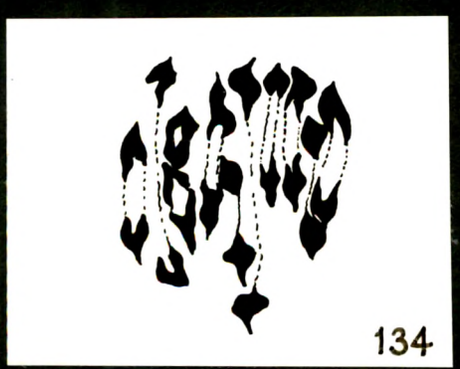
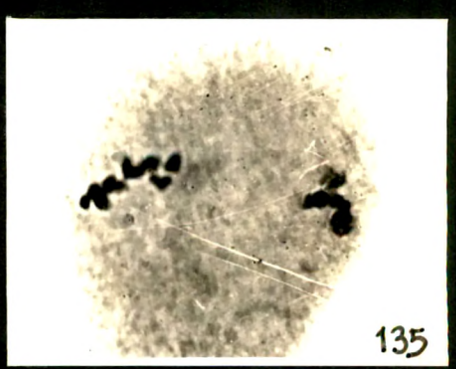


134



135

Coll. Nos. 50, 51, and 87.

Karyotype formulae : 2n = 22 = $D_6+D_2^{S''}+F_4+G_4+H_6$=48.30 μ (Figs. 126 and 127).

In the somatic complement the centromeres are nearly median (D and G - types) on 6 pairs and nearly submedian (F and H - types) on 5 pairs of chromosomes. One pair of nearly median ($D^{S''}$-type) chromosomes are with secondary constrictions on short arms.The chromosomes are medium to short sized, the length ranges from 3.15 μ to 1.36 μ, with a mean length of 2.20 μ. The karyotype is apparently asymmetrical as the TF% is 39.88.

The present and the previous (Bhatt, 1974) karyotypic studies resemble each other in types of chromosomes. However, secondary constrictions on a pair of chromosomes ($D^{S''}$-type) observed presently were not recorded earlier.

The meiosis is normal showing 11 bivalents at diakinesis and metaphase I (Figs. 128 and 130). Some PMCs showed univalents at diakinesis, interbivalent connections, association of bivalents and cytomixis at metaphase I (Figs. 129 - 133), precocious movement at anaphase I (Fig. 134), and grouping of chromosomes at metaphase II (Fig. 135). 94.26% is the pollen fertility determined for the species.

Table 46. Measurements of somatic chromosomes of *D. dichotomum* (Willd.) DC. (Coll. No. 50).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.70+1.45=3.15	100.00	0.85	1.17	nm	D
3, 4	1.70+1.28=2.98	94.60	0.75	1.33	nm	D
5, 6	1.45+0.68+0.51=2.64	83.81	0.82	1.22	nm	$D^{S"}$
7, 8	1.87+0.77=2.64	83.81	0.41	2.43	nsm	F
9, 10	1.36+0.94=2.30	73.02	0.69	1.45	nm	D
11, 12	1.45+0.81=2.26	71.75	0.56	1.79	nsm	F
13, 14	1.32+0.60=1.92	60.95	0.45	2.20	nsm	H
15, 16	0.94+0.85=1.79	56.83	0.90	1.11	nm	G
17, 18	0.94+0.72=1.66	52.70	0.77	1.31	nm	G
19, 20	0.94+0.51=1.45	46.03	0.54	1.84	nsm	H
21, 22	0.85+0.51=1.36	43.17	0.60	1.67	nsm	H

Desmodium distortum (Aubl.) Mcbr., Publ. field Mus. Nat. Hist. Chicago, Bot. Ser. 8 : 101, 1930.

A stout, erect, undershrub. Stems and branches striate, hairy. with red markings below nodes. Leaves trifoliolate; stipules large, semiamplexicaul, ovate, acuminate; leaflets ovate to ovate-lanceolate, obtuse with mucronulate apex, hairy on both the surfaces. Flowers bluish-purple, in terminal paniculate racemes, peduncles densely hairy. Pods straight or slightly curved, indented on both the sutures, joints 4-7, as long as broad, faintly reticulately veined, hairy (Fl. Fr. September - October) S. 99 and 109.

Rare; few plants are noticed near Baroda museum. Seeds were also obtained from National Agricultural Research Station, Kenya.

The chromosome numbers for the species are reported by Rotar and Urata (1967) and Pritchard and Gould (1964) as n = 11 and 2n = 22 respectively. The present study confirms the above reports. The karyotype is investigated for the first time.

Coll. No. 99.

Karyotype formulae : 2n = 22 = $D_4+D_2^{S''}+F_{14}+H_2$=55.82 μ (Figs. 136 and 137).

Table 47. Measurements of somatic chromosomes of *D. distortum* (Aubl.) Mcbr. (Coll. No. 99).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.53+0.85+0.60=2.98	100.00	0.95	1.06	nm	$D^{S"}$
3, 4	1.87+1.02=2.89	96.98	0.55	1.83	nsm	F
5, 6	1.87+1.02=2.89	96.98	0.55	1.83	nsm	F
7, 8	1.70+1.02=2.72	91.28	0.60	1.67	nsm	F
9, 10	1.79+0.85=2.64	88.59	0.47	2.11	nsm	F
11, 12	1.79+0.77=2.56	85.91	0.43	2.32	nsm	F
13, 14	1.53+0.94=2.47	82.89	0.61	1.63	nm	D
15, 16	1.70+0.68=2.38	79.87	0.57	2.50	nsm	F
17, 18	1.45+0.85=2.30	77.18	0.59	1.71	nsm	F
19, 20	1.36+0.85=2.21	74.16	0.63	1.60	nm	D
21, 22	1.19+0.68=1.87	62.75	0.57	1.75	nsm	H

D. distortum

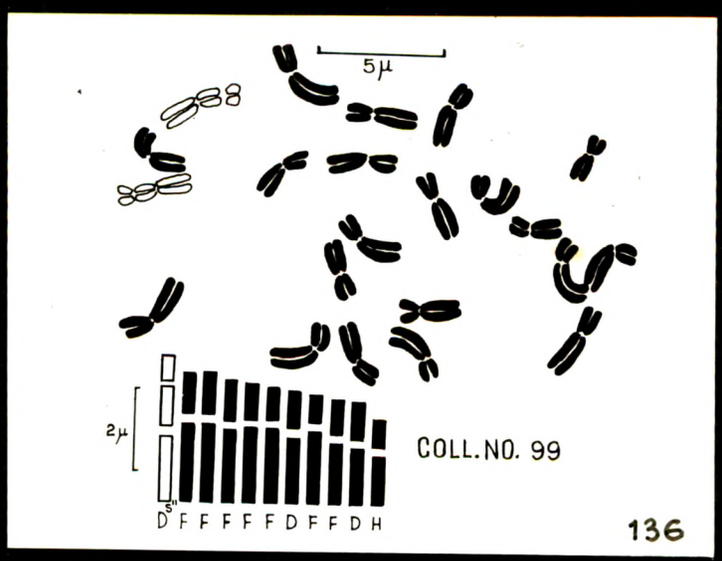
Fig. 136. Camera lucida drawing of somatic metaphase and idiogram.

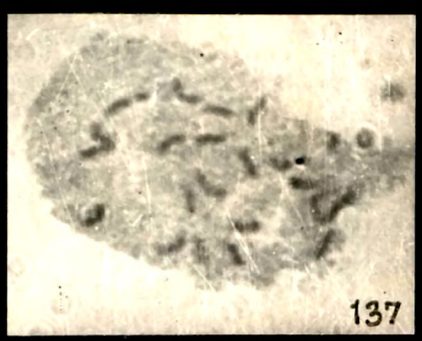
Fig. 137. Photomicrograph of somatic metaphase.

Fig. 138. PMC showing 11 bivalents at metaphase I (polar view) (Coll. No. 99).

Fig. 139. " " association of bivalents at metaphase I (side view) (Coll.No.99).

Fig. 140. " " telophase II.


5μ
8
2μ
COLL. NO. 99
D F F F F F D F F D H
136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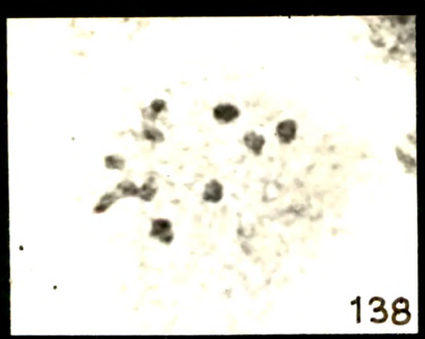
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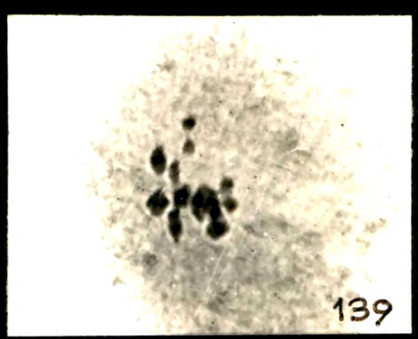
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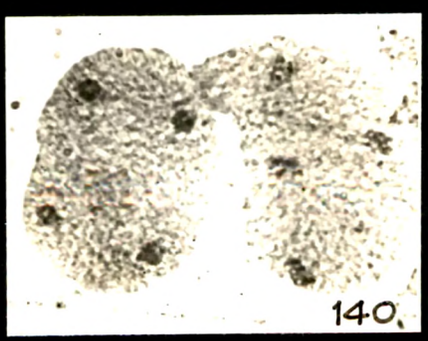

140

The karyotype shows 3 pairs of chromosomes with nearly median (D-type) and 8 pairs with nearly submedian (F and H - types) centromeres. One pair of nearly median chromosomes ($D^{S"}$-type) are having secondary constrictions on short arms. The chromosomes are medium to short sized, the length ranges from 2.98 μ to 1.87 μ, with a mean length of 2.54 μ. The karyotype is asymmetrical as the TF% is 36.30. The graded nature of the karyotype is evident from idiogram (Fig. 138) and relative length (Table 47).

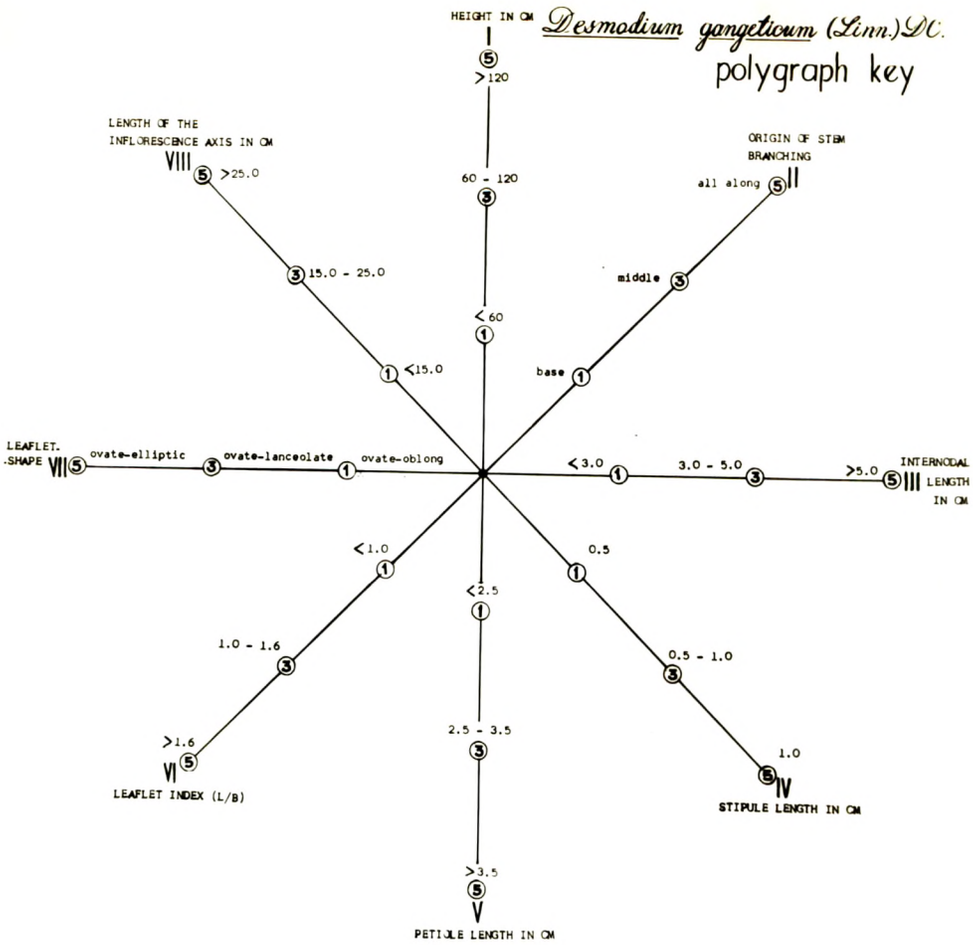
Meiosis is normal showing the formation of 11 bivalents at metaphase I (Fig. 138). However, association of bivalents at metaphase I (Fig. 139) are observed in some PMCs. The estimated pollen fertility for the species is 89.96%.

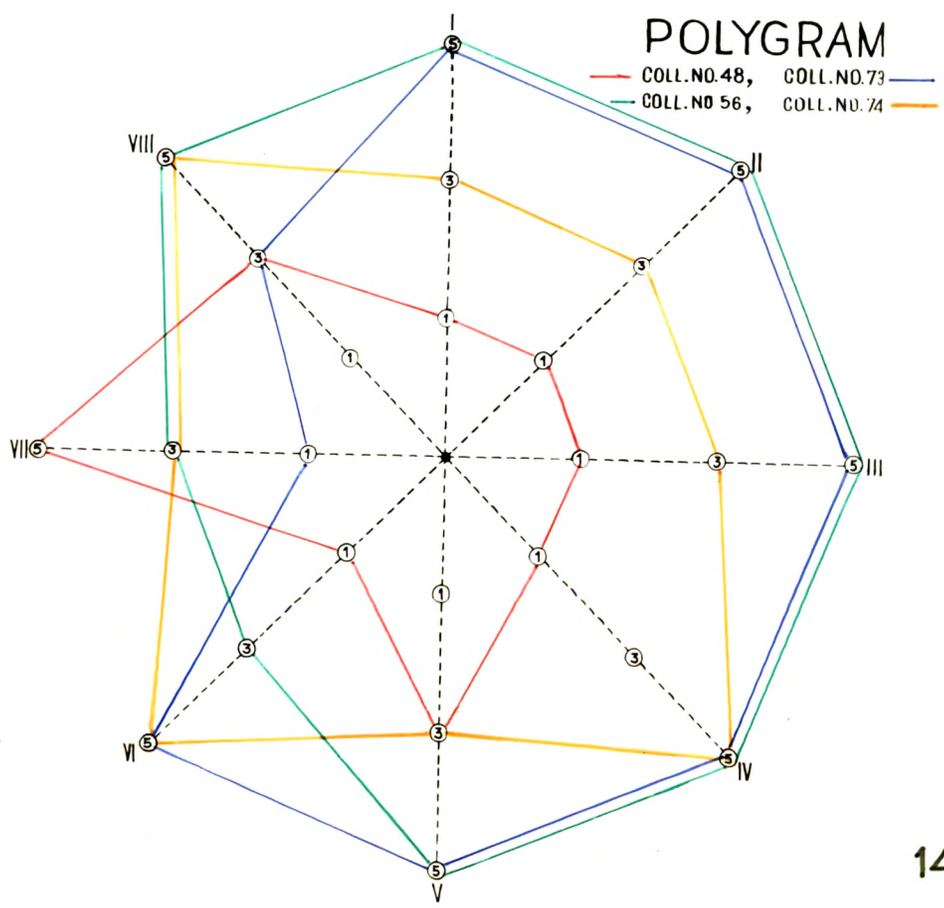
Desmodium gangeticum (Linn.) DC., Prodr. 2 : 327, 1825; FBI. 2: 168, 1876; Cooke, 1 : 379, 1902; Ohashi, loc. cit. 184; Verdec., loc. cit. 520.

Hedysarum gangeticum Linn. Sp. Pl. 746, 1753.

A stout, erect, herb or undershrub. Branches angled more or less hairy. Leaves unifoliolate; leaflets membranous, ovate-oblong or broadly ovate, acute, rounded at the base. Flowers violet or purple in large axillary and terminal

Fig. 141. Polygraph key and polygram of different populations of D. gangeticum.


Desmodium gangeticum (Linn.)DC.
polygraph key
HEIGHT IN CM
>120
60 - 120
<60
ORIGIN OF STEM BRANCHING
all along
middle
base
INTERNODAL LENGTH IN CM
>5.0
3.0 - 5.0
<3.0
STIPULE LENGTH IN CM
1.0
0.5 - 1.0
0.5
PETIOLE LENGTH IN CM
>3.5
2.5 - 3.5
<2.5
LEAFLET INDEX (L/B)
>1.6
1.0 - 1.6
<1.0
LEAFLET. SHAPE
ovate-oblong
ovate-lanceolate
ovate-elliptic
LENGTH OF THE INFLORESCENCE AXIS IN CM
>25.0
15.0 - 25.0
<15.0


POLYGRAM
COLL.NO.48,
COLL.NO.73
COLL.NO 56,
COLL.NO.74

racemes. Pods slightly falcate, deeply indented on lower suture, joints 6-8, longer than broad, hairy (Fl. Fr. September - December). S. 48, 49, 56 and 74.

Fairly common; observed in waste lands and as undergrowth in forests.

Different populations showed variations in several vegetative characters and they were subjected to polygraphic study (Fig. 141).

Bir and Sidhu (1967), Rotar and Urata (1967) and Bhaumik (1975) have reported n = 11, while Pantulu (1942), Miege (1960), Bhatt (1974) and Bhaumik (1975) have reported 2n = 22 as chromosome numbers for the species. Above mentioned numbers are confirmed in the present work.

Coll. No. 49.

Karyotype formulae : 2n = 22 = $F_8+G_4+H_8+H_2^S$=41.46 μ (Figs. 142 and 143).

The chromosomes in the complement are having nearly submedian centromeres (F and H - types), except for 2 pairs of chromosomes which have nearly median centromeres (G-type). One pair of nearly submedian chromosomes (H^S-type) are with satellites. The chromosomes are medium to short sized, the

D. gangeticum

Fig. 142. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 143. Photomicrograph of somatic metaphase.

Fig. 144. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 145. Photomicrograph of somatic metaphase.

Fig. 146. PMC showing 11 bivalents at diakinesis (Coll. No. 73).

Fig. 147. " " " at metaphase I (polar view) (Coll. No. 49).

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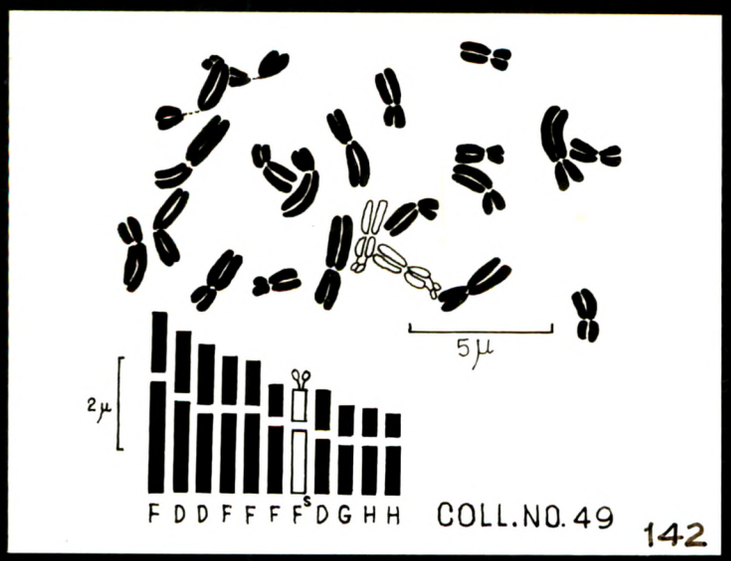
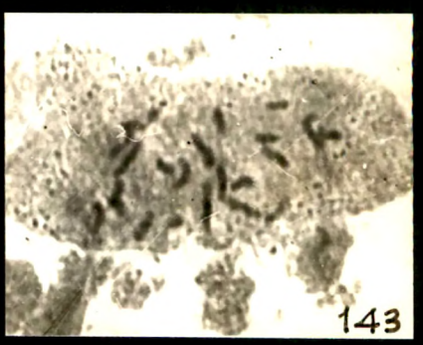

5μ
2μ
F D D F F F F S D G H H
COLL. NO. 49
142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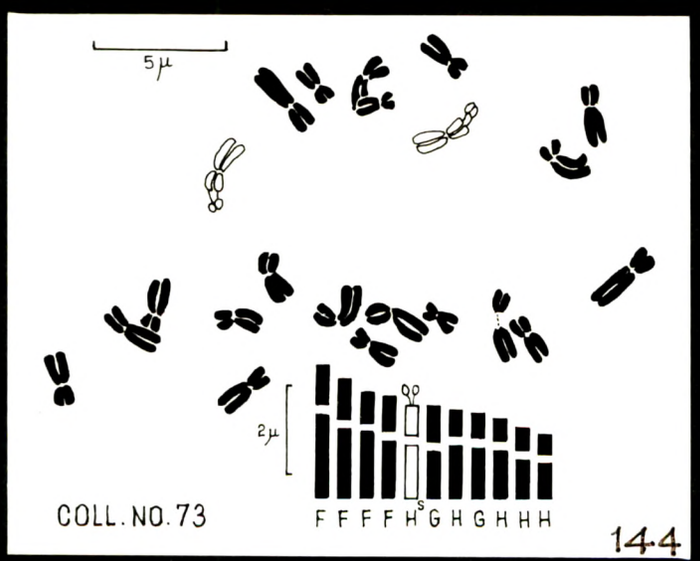
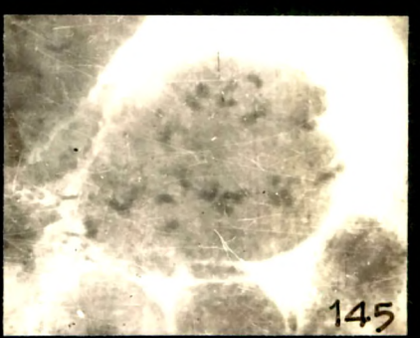

5μ
2μ
COLL. NO. 73
F F F F H S G H G H H H
144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146

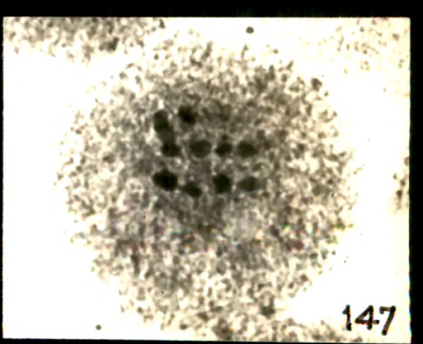
147

Table 48. Measurements of somatic chromosomes of *D. gangeticum* (Linn.) DC. (Coll. No. 49).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.87+0.85=2.72	100.00	0.45	2.20	nsm	F
3, 4	1.53+0.85=2.38	87.50	0.56	1.80	nsm	F
5, 6	1.45+0.68=2.13	78.31	0.47	2.13	nsm	F
7, 8	1.28+0.77=2.05	75.37	0.60	1.67	nsm	F
9, 10	1.19+0.68=1.87	68.75	0.57	1.75	nsm	H^S
11, 12	1.02+0.85=1.87	68.75	0.83	1.20	nm	G
13, 14	1.19+0.60=1.79	65.81	0.50	1.98	nsm	H
15, 16	1.11+0.68=1.79	65.81	0.61	1.63	nm	G
17, 18	1.06+0.51=1.57	57.72	0.48	2.08	nsm	H
19, 20	0.85+0.51=1.36	50.00	0.60	1.67	nsm	H
21, 22	0.77+0.43=1.20	44.12	0.56	1.79	nsm	H

length ranges from 2.72 μ to 1.20 μ, with an average length of 1.88 μ. The karyotype is asymmetrical as the TF% and L/S are 34.74 and 2.27 respectively.

Coll. Nos. 48, 56, 73, 74.

Karyotype formulae : 2n = 22 = $D_6+F_8+F^S_2+G_2+H_4$=52.60 μ (Figs. 144 and 145).

In all the four above mentioned collections, there are 4 pairs of chromosomes with nearly median centromeres (D and G - types), as against 2 pairs metwith in Coll. No. 49. The remaining 7 pairs are with nearly submedian centromeres (F and H - types), of which one pair is with satellites (F^S-type). The chromosomes in the complement are medium to short sized, the length varies from 3.66 μ to 1.53 μ, with an average length of 2.39 μ. The asymmetry of the karyotype is indicated by the TF% (37.26) and L/S (2.39).

The polygraphic (Fig. 141) and karyotypic observation (Table 50) show that, there are 2 ecotypes in the species.

In contrast to the previously analysed taxon (Bhatt,1974) having 4 pairs of median, 5 pairs of submedian and 2 pairs of subterminal chromosomes, the presently analysed one (Coll. No.49)

Table 49. Measurements of somatic chromosomes of *D. gangeticum* (Linn.) DC. (Coll. No. 73).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	2.38+1.28=3.66	100.00	0.54	1.86	nsm	F
3, 4	1.96+1.28=3.24	88.52	0.65	1.53	nm	D
5, 6	1.70+1.28=2.98	81.42	0.75	1.33	nm	D
7, 8	1.70+1.02=2.72	74.32	0.60	1.67	nsm	F
9, 10	1.70+0.94=2.64	72.13	0.55	1.81	nsm	F
11, 12	1.45+0.68=2.13	58.20	0.47	2.13	nsm	F
13, 14	1.36+0.68=2.04	55.74	0.50	2.00	nsm	F^S
15, 16	1.19+0.85=2.04	55.74	0.71	1.40	nm	D
17, 18	1.02+0.68=1.70	46.45	0.67	1.50	nm	G
19, 20	1.02+0.60=1.62	44.26	0.59	1.70	nsm	H
21, 22	1.02+0.51=1.53	41.80	0.50	2.00	nsm	H

Table 50.

Comparision of somatic chromosomes of different populations of D. gangeticum (Linn.) DC.

Populations	Somatic number (2n)	nm Types		nsm Types		Chromosomes with SATs Types		Absolute length (in μ)	Mean length (in μ)	L/S
		D	G	F	H	F^S	H^S			
Coll. No. 48	22	-	4	8	10	-	2	41.46	1.88	2.27
Coll. Nos. 49, 73, 56 and 74	22	6	2	10	4	2	-	52.60	2.39	2.03

D. gangeticum Contd.....

Fig. 148. PMC showing 1 non-congressional bivalent at metaphase I (Coll. No. 73).

Fig. 149. " " 4 non-congressional bivalents at metaphase II (Coll. No. 73).

Fig. 150. " " grouping of chromosomes at metaphase II (Coll. No. 73).

Fig. 151. " " telophase II (Coll. No. 49).

D. velutinum

Fig. 152. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 153. Photomicrograph of somatic metaphase.

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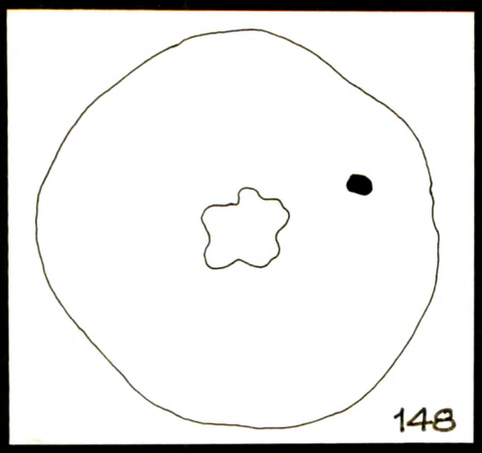

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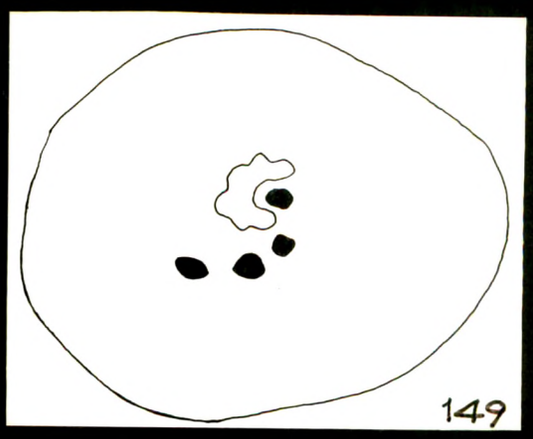

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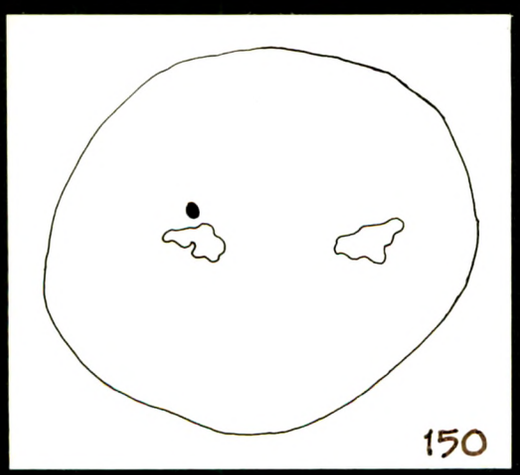

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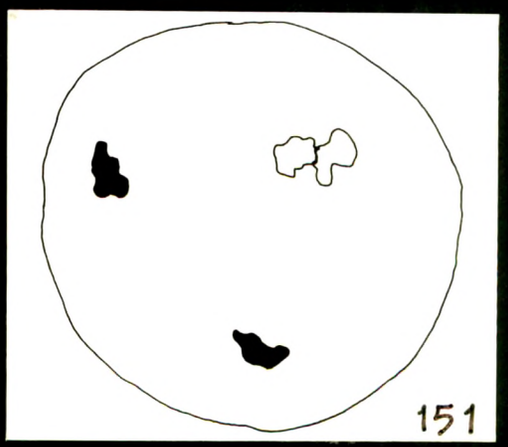

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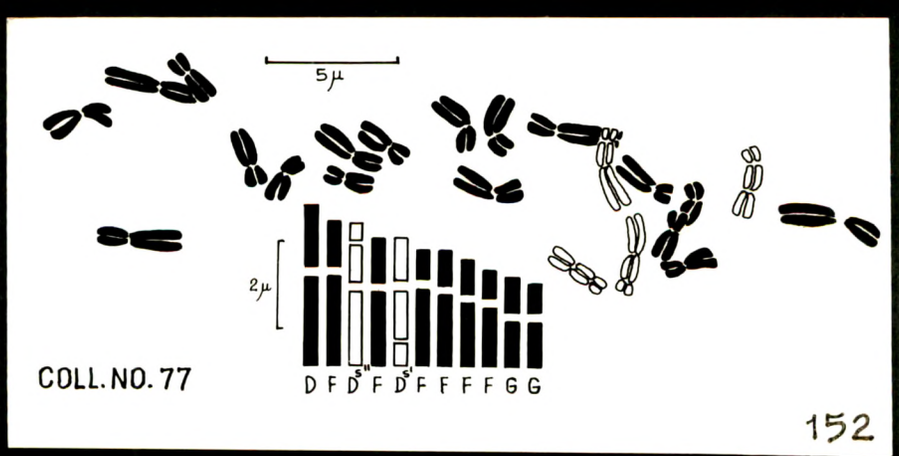

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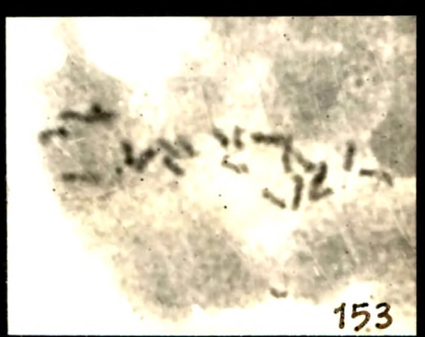


153

shows 2 pairs of nearly median and 9 pairs nearly submedian chromosomes in the complement.

During meiosis formation of 11 bivalents are observed at diakinesis and metaphase I (Figs. 146 and 147). However, non-congressional bivalents at metaphase I (Figs. 148 and 149), grouping of chromosomes at metaphase II (Fig. 150) are recorded in some PMCs. 89% is the pollen fertility determined for the species.

Desmodium velutinum (Willd.) DC., Prodr. 2 : 328, 1825; Ohashi, loc. cit. 192; Verdec., loc. cit. 518.

Hedysarum velutinum Willd., Sp. Pl. ed. 4, 3(2) : 1174, 1802.

Desmodium latifolium (Roxb. ex Ker.) DC. Prodr. 2 : 328, 1825; FBI. 2: 168, 1876; Cooke, 1 : 380, 1903.

An erect, herb or undershrub. Branches densely covered with short spreading ferruginous hairs. Leaves unifoliolate; leaflets broadly ovate or suborbicular, obtuse or subacute, adpressedly pubescent above and velvety beneath. Flowers purple in long axillary or terminal racemes. Pods straight, slightly indented on upper suture, joints 4-7, densely covered with hooked hairs (Fl. Fr. September - November). S. 75, 77.

Observed on the plains in shaded localities and as an undergrowth of forests.

The chromosome numbers n = 11 and 2n = 22 reported presently for the species confirms the earlier reports of n = 11 by Frahm-leliveld (1957), Rotar and Urata (1967); Mehra and Dhawan (1971), Bir and Kumari (1973), Bhaumik (1975) and 2n = 22 by Young (1940). The karyotype is studied for the first time.

Coll. No. 77.

Karyotype formulae : 2n = 22 = $D_2+D^{S'}_2+D^{S''}_2+F_{12}+G_4$=55.32 μ (Figs. 152 and 153).

The chromosomes in the complement have nearly median centromeres (D and G - types) on 5 pairs and nearly submedian (F-type) on 6 pairs. Two pairs of nearly median chromosomes ($D^{S'}$ and $D^{S''}$ - types) have secondary constrictions on long arms and short arms respectively. The chromosomes are mostly medium sized, except for 2 pairs of short sized chromosomes (G-type), the length ranges from 3.49 μ to 1.70 μ, with a mean length of 2.51 μ. The karyotype is asymmetrical as the TF% and L/S are 37.24 and 2.05 respectively.

Meiosis is mostly regular showing the formation of

Table 51. Measurements of somatic chromosomes of *D. velutinum* (Willd.) DC. (Coll. No. 77).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	2.04+1.45=3.49	100.00	0.71	1.41	nm	D
3, 4	2.08+1.02=3.10	88.83	0.49	2.04	nsm	F
5, 6	1.70+0.85+0.43=2.98	85.39	0.75	1.33	nm	$D^{S''}$
7, 8	1.70+1.02=2.72	77.94	0.60	1.67	nsm	F
9, 10	0.60+1.02+1.02=2.64	75.64	0.63	1.59	nm	$D^{S'}$
11, 12	1.79+0.68=2.47	70.77	0.38	2.63	nsm	F
13, 14	1.62+0.85=2.47	70.77	0.52	1.94	nsm	F
15, 16	1.45+0.77=2.22	63.61	0.53	1.88	nsm	F
17, 18	1.32+0.68=2.00	57.31	0.52	1.94	nsm	F
19, 20	1.02+0.85=1.87	53.58	0.83	1.20	nm	G
21, 22	1.02+0.68=1.70	48.71	0.67	1.50	nm	G

D. velutinum Contd.....

Fig. 154. PMC showing univalents at diakinesis (Coll. No. 75).

Fig. 155. " " association of bivalents at metaphase I (polar view) (Coll.No.77).

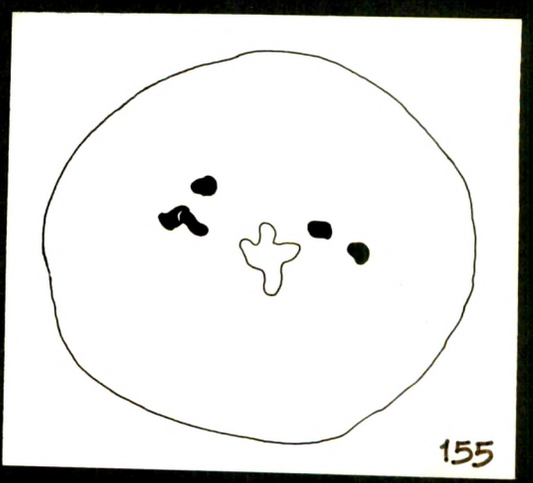
Fig. 156. " " non-congressional bivalent ( ) at metaphase I (Coll. No. 77).

Fig. 157. " " grouping of chromosomes at metaphase II (Coll. No. 75).

Fig. 158. " " 5 nucleii at telophase II (Coll.No.77).

Fig. 159. PMCs showing cytomixis at telophase I. (Coll. No. 77).


154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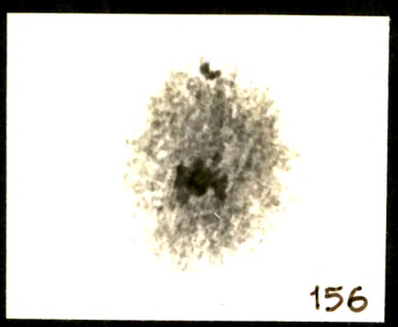
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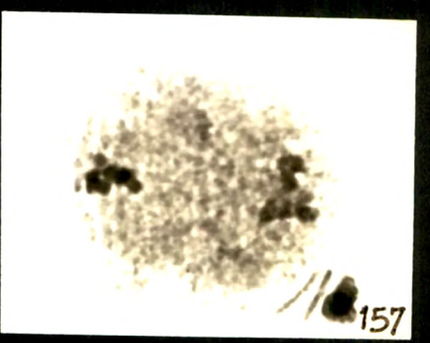
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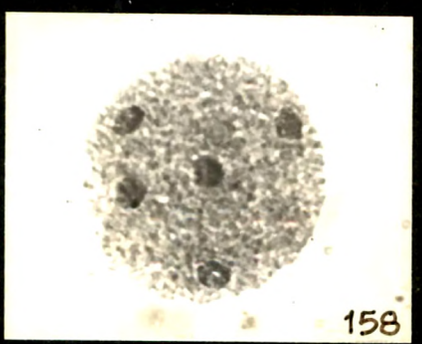
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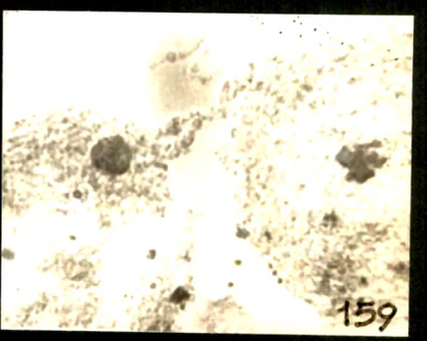

159

11 bivalents at metaphase I (Fig. 155).However, univalents at diakinesis, (Fig. 154), association of bivalents and non-congressional bivalents at metaphase I (Figs. 155 and 156), grouping of chromosomes at metaphase II (Fig. 157), formation of 5 nuclei at telophase II (Fig. 158) and cytomixis (Fig. 159) are recorded in some PMCs. The pollen fertility determined for the species is 90%.

Desmodium heterocarpon (Linn.) DC. var. strigosum Van Meeuwen, Reinwardtia 6 : 95, 1961 and 251, 1962; Ohashi, loc. cit. 210.

Hedysarum heterocarpon Linn., Sp. Pl. 747, 1753.

Desmodium polycarpum DC., Prodr. 2 : 334, 1825; FBI. 2 : 171, 1876; Cooke, 1 : 337, 1902.

An erect or suberect undershrub. Branches slender, slightly angular, clothed with short appressed, grey hairs. Leaves trifoliolate; leaflets obovate-cuneate, rounded at the apex, glabrous above, hairy beneath. Flowers purple, in dense axillary and terminal racemes, peduncles densely, straight hairy. Pods ciliate on both the sides,indented, dehiscing along the lower suture, joints 5-8, faintly reticulately veined and hooked hairy. (Fl. Fr. August - October). S. 98.

Noted in waste lands and forest paths.

The chromosome numbers n = 11 and 2n = 22 reported earlier (Mehra and Dhawan, 1971 under the name D. heterocarpum; Larsen, 1971 under the names D. heterocarpon and D.ovalifolium - see Ohashi, 1973) are confirmed in the present investigation. This is the first attempt to describe the karyotype of the species.

Coll. No. 98.

Karyotype formulae : 2n = 22 = $D_6+D_2^{S''}+F_{10}+H_4$ ± 56.84 μ (Fig.160).

The karyotype contains 4 pairs of chromosomes with nearly median (D-type) and 7 pairs with nearly submedian centromeres (F and H - types). One pair of nearly median chromosomes ($D^{S''}$-type) are with secondary constrictions on short arms. The chromosomes are medium to short sized, the length varies from 3.74 μ to 1.36 μ, with an average length of 2.58 μ. The karyotype is asymmetrical as the TF% and L/S are 38.07 and 2.70 respectively.

The meiotic study shows the formation of 11 bivalents at metaphase I and their normal disjunction at anaphase I (Figs. 161 and 162). 91% is the pollen fertility determined for the species.

Table 52. Measurements of somatic chromosomes of *D. heterocarpon* DC. var. *strigosum* Van Meeuwen (Coll. No.98.).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	2.04+1.70=3.74	100.00	0.83	1.20	nm	D
3, 4	1.87+0.85+0.68=3.40	90.91	0.82	1.22	nm	D^S"
5, 6	2.04+1.11=3.15	84.22	0.54	1.84	nsm	F
7, 8	2.13+0.94=3.07	82.09	0.44	2.27	nsm	F
9, 10	1.70+1.11=2.81	75.13	0.65	1.53	nm	D
11, 12	1.70+0.85=2.55	68.18	0.50	2.00	nsm	F
13, 14	1.36+1.02=2.38	63.64	0.75	1.33	nm	D
15, 16	1.36+0.77=2.13	56.95	0.57	1.77	nsm	F
17, 18	1.36+0.68=2.04	54.55	0.50	2.00	nsm	F
19, 20	1.19+0.60=1.79	47.86	0.50	2.00	nsm	H
21, 22	0.85+0.51=1.36	36.36	0.60	1.67	nsm	H

D. heterocarpon var. strigosum

Fig. 160. Camera lucida drawing of somatic metaphase and idiogram.

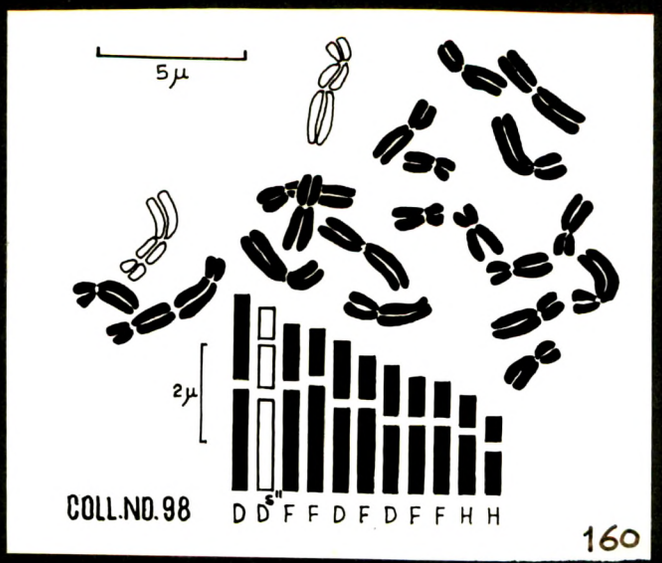
Fig. 161. PMC showing 11 bivalents at metaphase I (side view).

Fig. 162. " " equal distribution at anaphase I.

D. rotundifolium

Fig. 163. Camera lucida drawing of somatic metaphase and idiogram.

Contd....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2μ
COLL.NO.98
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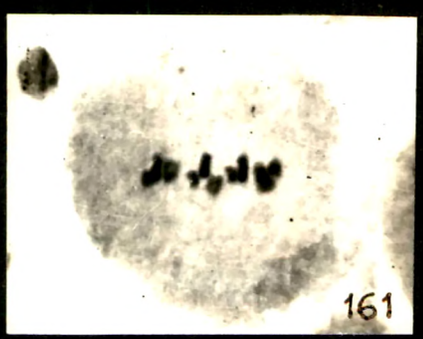
160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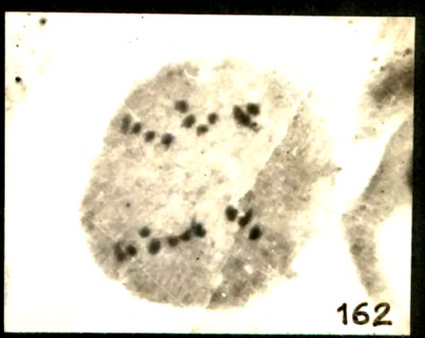
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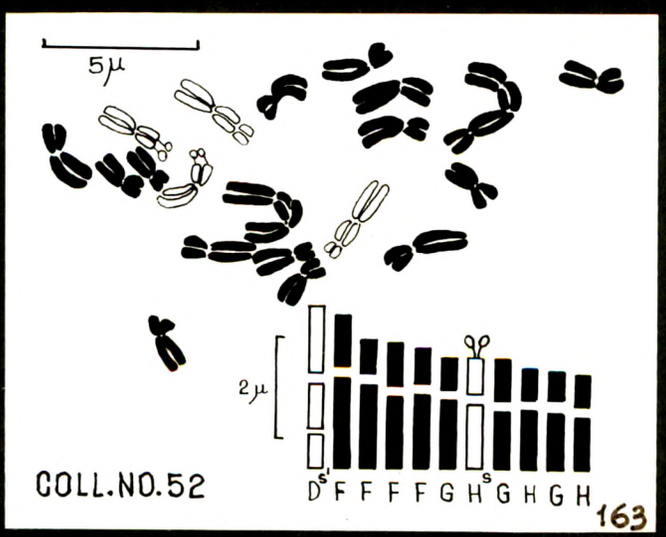

5μ
2μ
COLL.NO.52
D S' F F F F G H S G H G H
163

Desmodium rotundifolium Bak., FBI. 2 : 172, 1876 (non Wall.); Cooke, 1 : 381, 1902.

An ascending, much branched herb. Stems and branches striate, clothed with spreading fulvous hairs in the upper parts. Leaves unifoliolate; leaflets membranous, orbicular - suborbicular, obtuse or subacute, glabrous above appressedly hairy beneath. Flowers pink, in very lax, terminal racemes. Calyx almost divided to the base, teeth subulate and ciliate. Pods nearly straight or slightly curved, indented on both the sutures, the lower deeper, joints 4-6, covered with hooked hairs (Fl. Fr. November - January). S. 52.

Critical note : Dalzell (MS. in Herb. Kew) "Places this plant in the genus Alysicarpus, but the pods are somewhat turgid and resemble the pods of that genus, the calyx is not glumaceous and the corolla is considerably exerted".

Observed in open waste lands and at the base of the hillocks.

Young (1940) and Turner (1956) have preported n = 11 for the species. The somatic number 2n = 22 determined in the present study is the first report for the species.

Table 53. Measurements of somatic chromosomes of *D. rotundifolium* Bak. (Coll. No. 52).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	0.68+0.85+1.28=2.81	100.00	0.84	1.20	nm	$D^{S'}$
3, 4	1.79+0.94=2.73	93.81	0.51	1.90	nsm	F
5, 6	1.62+0.68=2.30	79.04	0.42	2.38	nsm	F
7, 8	1.40+0.85=2.25	77.32	0.60	1.65	nsm	F
9, 10	1.45+0.68=2.13	73.20	0.47	2.13	nsm	F
11, 12	1.32+0.64=1.97	67.70	0.48	1.55	nm	G
13, 14	1.28+0.68=1.96	67.35	0.53	1.88	nsm	H^{S}
15, 16	1.20+0.68=1.88	66.90	0.56	1.76	nsm	H
17, 18	1.15+0.64=1.79	61.51	0.56	1.80	nsm	H
19, 20	1.11+0.68=1.79	61.51	0.81	1.63	nm	G
21, 22	1.02+0.60=1.62	57.65	0.59	1.70	nsm	H

D. rotundifolium Contd....

Fig. 164. PMC showing 11 bivalents at diakinesis.

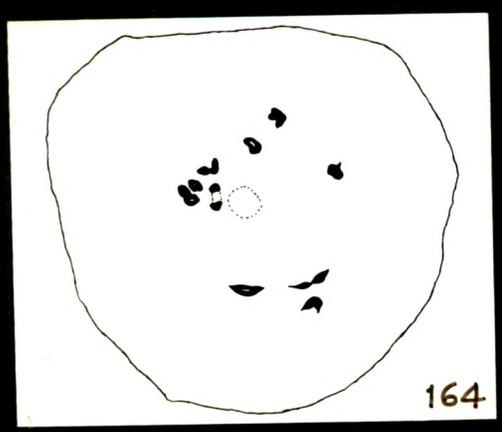
Fig. 165. " " " " metaphase I. (side view).

Fig. 166. " " late separation of chromosomes at anaphase I.

Fig. 167. " " grouping of chromosomes at metaphase II.

Fig. 168. " " telophase II.

Fig. 169. " " micronucleii at telophase I.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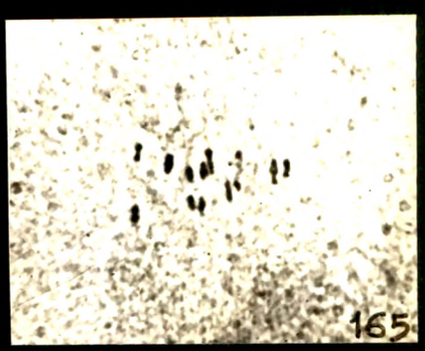
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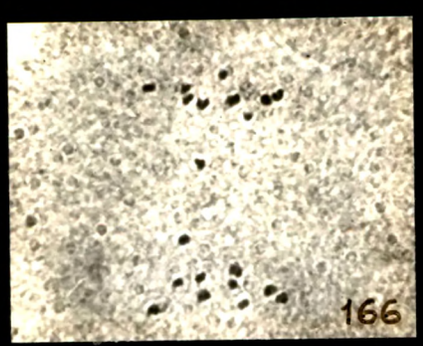
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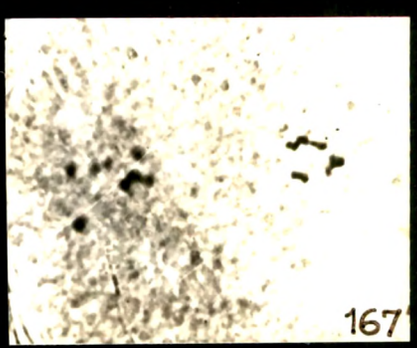
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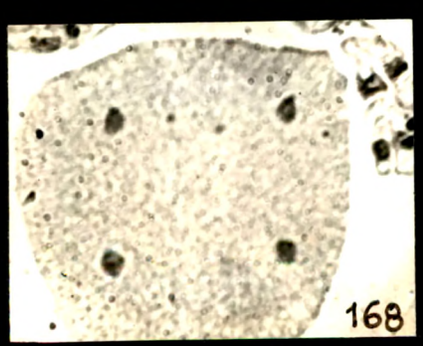
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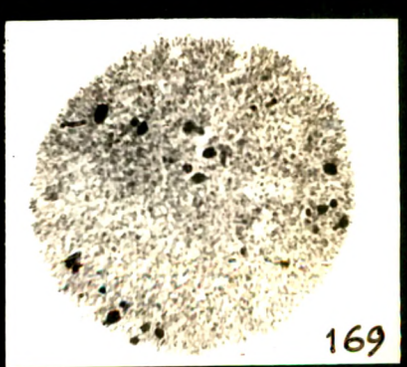

169

Coll. No. 52.

Karyotype formulae : 2n = 22 = $D_2^{S'}+F_8+G_6+H_4+H_2^{S}$=46.60 μ (Fig.163).

The karyotype shows 4 pairs of chromosomes with nearly median (D and G - types) and 7 pairs with nearly submedian (F and H - types) centromeres. A pair of nearly median chromosomes are with secondary constrictions on long arms ($D^{S'}$-type) and a pair of nearly submedian chromosomes (H^{S}-type) are with satellites. The chromosomes in the complement are medium to short sized, the length ranges from 2.81 μ to 1.62 μ, with a mean length of 2.12 μ. The karyotype is asymmetrical as the TF% and L/S are 36.57 and 1.73 respectively. The idiogram and relative length (Table 53) shows that the karyotype is of graded type.

Meiosis is mostly regular showing the formation of 11 bivalents at diakinesis and metaphase I (Figs. 164 and 165). Some of the abnormalities like, late separation at anaphase I (Fig. 166), grouping of chromosomes at metaphase II (Figs 167) and micronucleii at telophase II (Fig. 169) are observed. The pollen fertility determined for the species is 91.83%.

Desmodium intortum (Mill.) Urb., symb. Antill. 8 : 292,1920.

The present report 2n = 22 for the species, is in

Table 54. Measurements of somatic chromosomes of *D. intortum* (Mill.) Urb. (Coll. No. 106).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	2.21+1.15=3.36	100.00	0.52	1.92	nsm	F
3, 4	0.60+1.19+1.19=2.98	88.69	0.66	1.50	nm	$D^{S'}$
5, 6	1.96+1.02=2.98	88.69	0.52	1.92	nsm	F
7, 8	0.68+1.11+1.11=2.90	86.31	0.62	1.61	nm	$D^{S'}$
9, 10	1.87+0.85=2.72	80.95	0.45	2.20	nsm	F
11, 12	1.87+0.68=2.55	75.89	0.36	2.75	nsm	F
13, 14	1.70+0.85=2.55	75.89	0.50	2.00	nsm	F
15, 16	1.36+0.85=2.21	65.77	0.62	1.60	nm	D^{S}
17, 18	1.36+0.85=2.21	65.77	0.62	1.60	nm	D
19, 20	1.19+0.85=2.04	60.71	0.71	1.40	nm	D
21, 22	1.02+0.68=1.70	50.60	0.67	1.50	nm	G

confirmity with the earlier reports of Pritchard and Gould (1964), Rotar and Urata (1967) and Bhaumik (1975). The karyotype analysis is worked out for the first time.

Coll. No. 106.

Karyotype formulae : 2n = 22 = $D_4+D^S_2+D^{S'}_4+F_{10}+G_2$=56.40 μ (Figs. 170 and 171).

The complement includes 6 pairs of chromosomes having nearly median (D and G - types) and 5 pairs having nearly submedian centromeres. Two pairs of nearly median chromosomes are with satellites (D^S-type) and secondary constrictions on long arms ($D^{S'}$-type). The chromosomes are mostly medium sized except for a pair of short sized chromosomes (G-type). The length of the chromosomes ranges from 3.36 μ to 1.70 μ, with a mean length of 2.56 μ. The karyotype is asymmetrical as the TF% is 35.74.

Desmodium sandwicense E. Mey., Cat. Sem. Hort. Regiom (1850) - Linnaea 24 : 230, 1851.

The only report of chromosome number for the species is 2n = 22 by Pritchard andGould (1964). This number is confirmed in the present study. The karyotype analysis for the species is worked out for the first time.

D. intortum

Fig. 170. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 171. Photomicrograph of somatic metaphase.

D. sandwicense

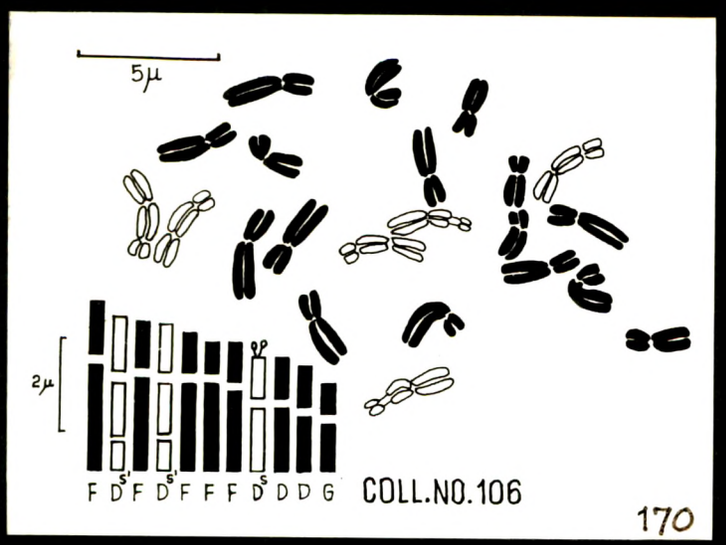
Fig. 172. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 173. Photomicrograph of somatic metaphase.

D. uncinatum

Fig. 174. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 175. Photomicrograph of somatic metaphase.



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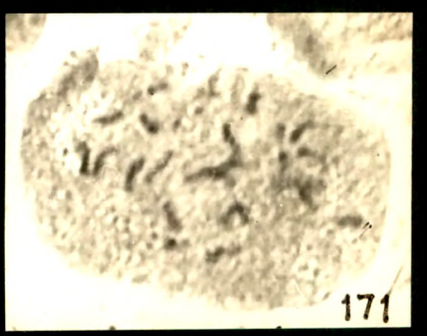
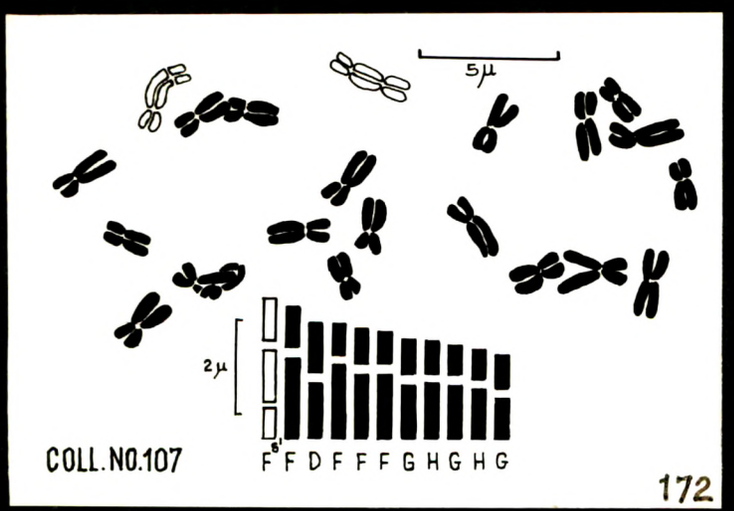


171



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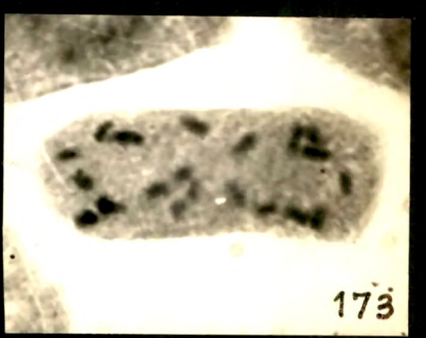

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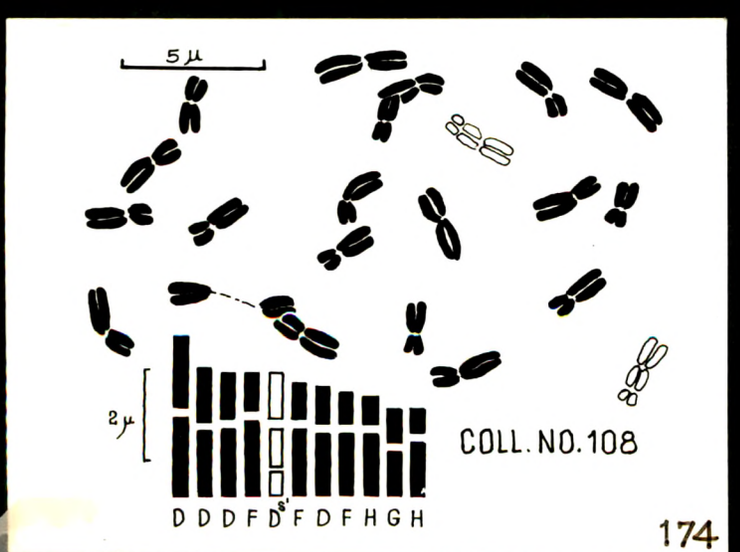

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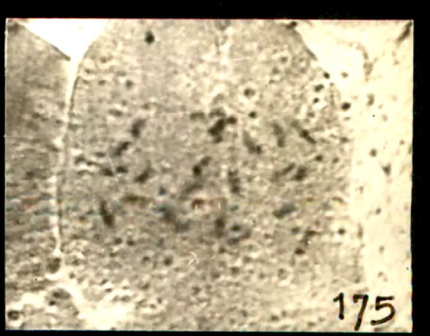


175

Table 55. Measurements of somatic chromosomes of *D. sandwicense* E. Mey (Coll. No. 107).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	0.68+1.11+0.89=2.68	100.00	0.50	2.00	nsm	$F^{S'}$
3, 4	1.70+0.85=2.55	95.15	0.50	2.00	nsm	F
5, 6	1.19+1.02=2.21	82.46	0.86	1.17	nm	D
7, 8	1.53+0.68=2.21	82.46	0.44	2.22	nsm	F
9, 10	1.36+0.77=2.13	79.48	0.57	1.77	nsm	F
11, 12	1.36+0.68=2.04	76.12	0.50	2.00	nsm	F
13, 14	1.11+0.77=1.88	70.15	0.69	1.44	nm	G
15, 16	1.19+0.68=1.87	69.78	0.57	1.75	nsm	H
17, 18	1.11+0.68=1.79	66.79	0.61	1.63	nm	G
19, 20	1.02+0.60=1.62	60.45	0.59	1.70	nsm	H
21, 22	0.85+0.68=1.53	57.09	0.80	1.25	nm	G

Coll. No. 107.

Karyotype formulae : 2n = 22 = $D_2+F_8+F^{S'}_2+G_6+H_4$=45.02 μ (Figs. 172 and 173).

In the somatic complement the centromeres are nearly median (D and G - types) on 4 pairs and nearly submedian (F and H - types) on 7 pairs. One pair of nearly submedian chromosomes ($F^{S'}$-type) are with secondary constrictions on long arms. The chromosomes are medium to short sized, the length ranges from 2.68 μ to 1.53 μ, the mean length being 2.05 μ. The karyotype is clearly asymmetrical as the TF% is 36.87 and L/S is 1.75. The idiogram (Fig. 172) and relative length (Table 55) are indicative of graded nature of the karyotype.

Desmodium uncinatum (Jacq.) DC., Prodr. 2 : 325, 1825.

n = 11 (Rotar and Urata, 1967) and 2n = 22 (Pritchard and Gould, 1964; Mitra, 1964) are the chromosome numbers reported for the species. The present investigation confirms the earlier report of 2n = 22. This is the first analysis of the karyotype.

Coll. No. 108.

Karyotype formulae : 2n = 22 = $D_8+D^{S'}_2+F_6+G_2+H_4$=50.02 μ (Figs. 174 and 175).

Table 56. Measurements of somatic chromosomes of *D. uncinatum* (Jacq.) DC. (Coll. No. 108).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.70+1.53=3.23	100.00	0.90	1.11	nm	D
3, 4	1.40+1.19=2.59	80.19	0.85	1.18	nm	D
5, 6	1.45+1.02=2.47	76.47	0.70	1.42	nm	D
7, 8	1.62+0.85=2.47	76.47	0.52	1.91	nsm	F
9, 10	0.51+0.85+1.02=2.38	73.68	0.75	1.33	nm	$D^{S'}$
11, 12	1.45+0.81=2.26	69.98	0.56	1.79	nsm	F
13, 14	1.36+0.85=2.21	68.42	0.63	1.60	nm	D
15, 16	1.36+0.68=2.04	63.16	0.50	2.00	nsm	F
17, 18	1.36+0.60=1.96	60.68	0.44	2.27	nsm	H
19, 20	0.98+0.72=1.70	52.63	0.73	1.15	nm	G
21, 22	1.19+0.51=1.70	52.63	0.43	2.33	nsm	H

The complement consists of 6 pairs of chromosomes (D and G - types) with nearly median and 5 pairs with nearly submedian centromeres (F and H - types). Secondary constrictions are present on a pair of nearly median chromosomes ($D^{S'}$-type). The chromosomes are medium to short sized, the length ranges from 3.23 μ to 1.70 μ, with a mean length of 2.27 μ. The TF% of 39.10 and L/S 1.90 are indicative of the apparent asymmetry of the karyotype.

Desmodium triflorum (Linn.) DC., Prodr. 2 : 334, 1825; FBI. 2: 173, 1876; Cooke, 1 : 378, 1902; Ohashi, loc. cit. 245; Verdec., loc. cit. 512.

Hedysarum triflorum Linn., Sp. Pl. 749, 1753.

A small, perennial, prostrate herb. Branches numerous, often rooting at the nodes. Leaves trifoliolate; leaflets obovate, cuneate or subcordate. Flowers purple, in small fascicles (2-4 in a fascicle) in the axil. Pods falcate, the upper suture straight, the lower deeply indented, joints 2-5, with a strong reticulation of raised nerves (Fl. Fr. August - November). S. 53, 55.

Very common; in lawns and waste lands, also observed as an undergrowth in forests.

The somatic number 2n = 22 determined presently is in confirmity with earlier reports of Frahm-leliveld (1957) and Pritchard andGould (1967). However, some of the somatic metaphase plates of Coll. No. 53 showed 2n = 18 chromosomes.

Coll. No. 55.

Karyotype formulae: 2n = 22 = $D_4+F_4+G_6+G_2^S+H_6$=41.76 μ (Figs. 178 and 179).

The karyotype study reveals that, there are 6 pairs of chromosomes having nearly median (D and G - types) and 5 pairs having nearly submedian centromeres (F and H - types). One pair of nearly median chromosomes (G^S-type) are with satellites. The chromosomes in the complement are medium to short sized, the length varies from 2.89 μ to 1.41 μ, with an average length of 1.90 μ. The TF% and L/S are 38.79 and 2.05 respectively, hence the karyotype is asymmetrical.

Coll. No. 53.

This collection showed 2n = 22 as well as 2n = 18 in the somatic complements. The complements with 2n = 22 showed similar morphology of chromosomes as in the Coll. No. 55. While, somatic complements with 2n = 18 chromosomes showed the following karyotype. Table 57

Table 57. Measurements of somatic chromosomes of *D. triflorum* (Linn.) DC. (Coll. No. 53).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.96+1.11=3.07	100.00	0.57	1.77	nsm	F
3, 4	1.53+1.19=2.72	88.60	0.78	1.29	nm	D
5, 6	1.28+1.02=2.30	74.92	0.80	1.25	nm	D
7, 8	1.49+0.81=2.30	74.92	0.54	1.84	nsm	F
9, 10	1.40+0.77=2.17	70.68	0.55	1.82	nsm	F
11, 12	1.49+0.68=2.17	70.68	0.46	2.19	nsm	F^S
13, 14	1.02+0.64=1.66	54.07	0.63	1.59	nm	G
15, 16	0.98+0.51=1.49	48.53	0.52	1.92	nsm	H
17, 18	0.68+0.51=1.19	38.76	0.75	1.33	nm	G

Table 58. Measurements of somatic chromosomes of *D. triflorum* (Linn.) DC. (Coll. No. 55).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.70+1.19=2.89	100.00	0.70	1.43	nm	D
3, 4	1.28+0.85=2.13	73.70	0.66	1.51	nm	D
5, 6	1.49+0.64=2.13	73.70	0.43	2.33	nsm	F
7, 8	1.28+0.77=2.05	70.93	0.60	1.66	nsm	F
9, 10	1.19+0.68=1.87	64.71	0.57	1.75	nsm	H
11, 12	1.28+0.64=1.92	66.44	0.50	2.00	nsm	H
13, 14	0.98+0.81=1.79	61.94	0.83	1.21	nm	G
15, 16	0.94+0.68=1.62	56.06	0.72	1.38	nm	G^S
17, 18	1.02+0.60=1.62	56.06	0.59	1.70	nsm	H
19, 20	0.85+0.60=1.45	50.17	0.71	1.42	nm	G
21, 22	0.77+0.64=1.41	48.79	0.83	1.20	nm	G

D. triflorum

Fig. 176. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 177. Photomicrograph of somatic metaphase.

Fig. 178. Camera lucida drawing of somatic metaphase and idiogram.

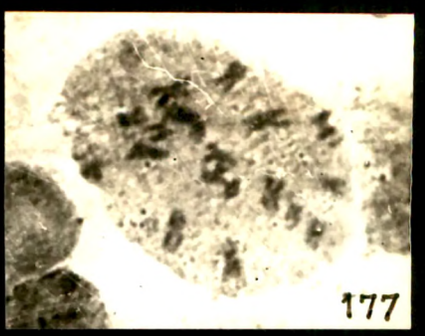
Fig. 179. Photomicrograph of somatic metaphase.

Fig. 180. PMC showing association of bivalents at metaphase I.

Fig. 181. " " equal distribution at anaphase I.

Contd.....


5μ
2μ
F D D F F F^S G H G
COLL. NO. 53
176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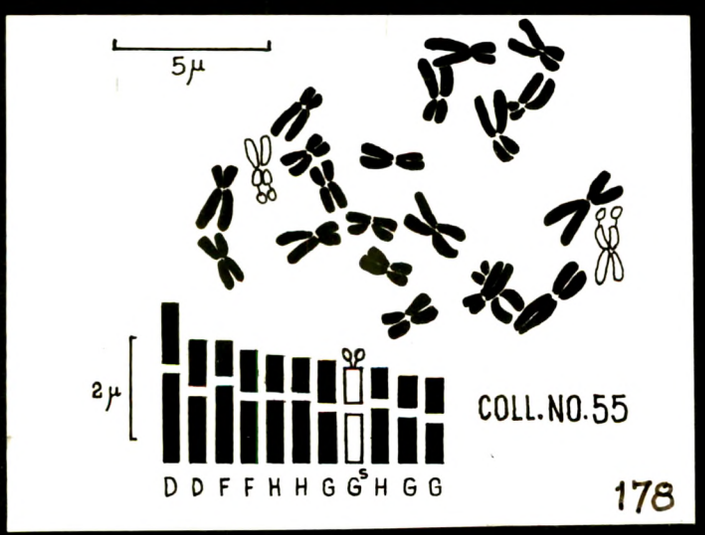
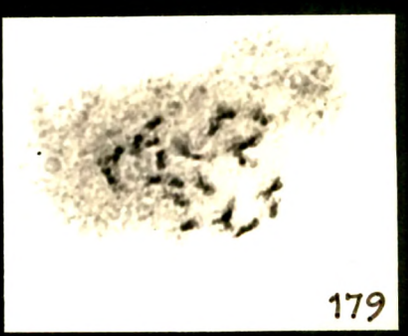

5μ
2μ
D D F F H H G G^S H G G
COLL. NO. 55
178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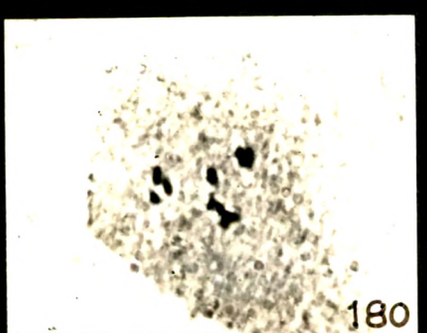
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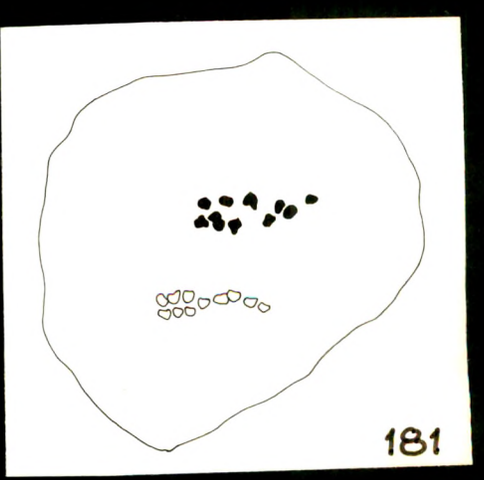

181

Karyotype formulae : 2n = 18 = $D_4+F_6+F^S_2+G_4+H_2$=38.14μ(Figs. 176 and 177).

The complement consists of 4 pairs of chromosomes with nearly median (D and G - types) and 5 pairs with nearly submedian (F and H - types) centromeres. One pair of nearly submedian chromosomes (F^S-type) are with satellites. The chromosomes are medium to short sized, the length ranges from 3.83 μ to 1.45 μ, with a mean length of 2.52 μ. The no apparent asymmetry of the karyotype is evident from TF% (40.93) and L/S (2.64).

The occurrence of 2 different chromosome numbers and morphology (Table 59) in Coll. No. 53 indicates the presence of cytotypes within the species.

Meiosis is normal showing 11 bivalents at metaphase I (Fig. 182). Some PMCs showed irregular distribution at anaphase I (Fig. 183). The pollen fertility determined for the species is 91.45%.

Meiosis of the individuals showing 2n = 18 in Coll. No. 53 could not be studied as the plants grown in garden were washed away during floods of 1976 in Baroda.

D. triflorum Contd....

Fig. 182. PMC showing irregular distribution at anaphase I.

Fig. 183. " " anaphase II.

Dendrolobium triangulare

Fig. 184. Camera lucida drawing of somatic metaphase and idiogram.

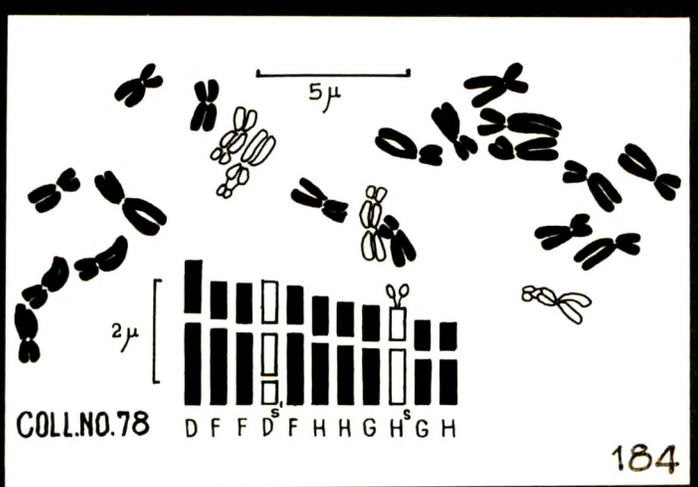
Fig. 185. Photomicrograph of somatic metaphase.

Table 59. Comparison of somatic chromosomes of different populations of D. triflorum (Linn.) DC.

Populations	Somatic number (2n)	nm		nsm		Chromosomes with SATs		Absolute length (in μ)	Mean length (in μ)	L/S
		Types		Types		Types				
		D	G	F	H	F^S	G^S			
Coll. No. 53.	18	4	4	8	2	2	-	38.14	2.52	2.64
Coll. No. 55	16	4	8	4	6	-	2	41.76	1.90	2.05

182

183



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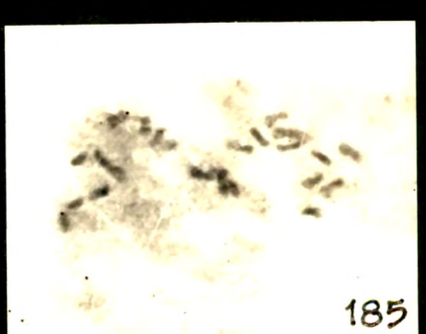

185

Dendrolobium triangulare (Retz.) Schindl., Fedde, Rep. 20 : 274, 1924; Ohashi, Ginkgoana 1 : 77, 1973.

Hedysarum triangulare Retz., Observ. Bot. 3 : 40, 1783.

Desmodium cephalotes (Roxb.) Wt. & Arn., Prodr. 1 : 224, 1834; FBI. 2 : 161, 1876.

D. cephalotes (Roxb.) Wt. & Arn. var. congestum (Wt. & Arn.) Prain, Jour. Asiatic Soc. Bengal 66(2) : 389, 1897; Cooke, 1 : 375, 1902.

An erect shrub. Branches appressedly silky, triquetrous. Leaves trifoliolate, leaflets elliptic-oblong, obovate-oblong or lanceolate, acute to acuminate, grey silky and finely reticulately veined beneath. Flowers red, in crowded, axillary, peduncled umbellate heads; bracts and bracteoles linear-subulate, ciliate, caducous. Pods slightly curved, indented on both sutures, deeply on the lower one, joints 3-6, as long as broad, slightly pubescent (Fl. Fr. August - October). S. 78.

Source : Seeds obtained from Botanical Survey of India, Southern Circle, Coimbatore (Tamil Nadu).

There is no earlier record of cytological study for this taxon. The chromosome number determined for the species is $2n = 22$.

Table 60. Measurements of somatic chromosomes of *Dendrolobium triangulare* (Retz.) Schindl. (Coll. No. 78).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.53+1.02=2.55	100.00	0.67	1.50	nm	D
3, 4	1.45+0.72=2.27	89.02	0.50	2.00	nsm	F
5, 6	1.36+0.77=2.13	83.53	0.57	1.77	nsm	F
7, 8	0.43+0.85+0.85=2.13	83.53	0.66	1.51	nm	$D^{S'}$
9, 10	1.36+0.72=2.08	81.57	0.53	1.89	nsm	F
11, 12	1.19+0.68=1.87	73.33	0.57	1.77	nsm	H
13, 14	1.11+0.60=1.71	67.06	0.54	1.86	nsm	H
15, 16	1.02+0.68=1.70	66.67	0.67	1.50	nm	G
17, 18	1.06+0.60=1.66	65.10	0.57	1.77	nsm	H^S
19, 20	0.85+0.55=1.40	54.90	0.65	1.55	nm	G
21, 22	0.85+0.51=1.36	53.33	0.60	1.67	nsm	H

Coll. No. 78.

Karyotype formulae : $2n = 22 = D_2+D_2^{S'}+F_6+G_4+H_6+H_2^S=41.72\ \mu$ (Figs. 184 and 185).

The somatic complement has 4 pairs of chromosomes with nearly median (D and G - types) and 7 pairs nearly submedian (F and H - types) centromeres. One pair of nearly median chromosomes ($D^{S'}$-type) are with secondary constrictions on long arms and one pair of nearly submedian chromosomes (H^S-type) are with satellites. The chromosomes in the complement are medium to short sized, the length varies from 2.55 μ to 1.36 μ, with a mean length of 1.90 μ. The asymmetry of the karyotype is evident, as the TF% and L/S are 36.91 and 1.88 respectively.

Alysicarpus Neck. ex Desv.

The genus Alysicarpus belonging to the tribe Desmodiae was first visualized by Neck. This was later established and validly published by Desvaux in 1813. Earlier to the establishment of the genus, all the species of Alysicarpus were referred to the genus Hedysarum (Linnaeus, 1753). The genus Alysicarpus with about 30 species is distributed in Africa, Asia, Australia, Polynesia and tropical America (Hutchinson, 1967). The genus shows remarkable uniformity in external morphology.

Some species of Alysicarpus show resemblance with the species of related genus Desmodium. Hence, there is a confusion regarding assignment of certain species to either genera.

Baker (1876), Sedgwick (1919), Ali (1966) and Verdcourt (1974) are the prominent workers, who have studied the genus taxonomically. Baker (1876) in "Flora of British India" has divided the genus into 2 groups viz.

1. Microcalycinae (Calyx not longer than the first joint of the pod).
2. Macrocalycinae (Calyx much longer than the first joint of the pod and its teeth imbricated in fruiting stage).

Moreover, the genus being one of the forage crops, an attempt is made on pollination of some species by Solomon and Rao (1955), to plan breeding work.

Alysicarpus Neck. ex Desv., Journ. de Bot. Ser. 2, 1:120,1813.

Erect or diffuse herbs. Leaves unifoliolate, petioles chanelled, 2 stipellate; stipules scarious, acuminate, free or connate. Inflorescence terminal, axillary or leaf opposed racemes. The flowers mostly pinkish or purplish, paired; bracts scarious and deciduous. Calyx deeply divided, the two

upper lobes often connate. Corolla small; vexillum ovate or obovate, narrowed into a claw; wings obliquely oblong, adhering to the keel; keel slightly incurved, obtuse often appendaged. Stamens diadelphous (9+1), anthers uniform. Ovary sessile or shortly stipitate, ovules many; style filiform, incurved at the apex; stigma capitate. Pods linear-oblong, terate or turgid, composed of several indehiscent, 1-seeded joints. Seeds suborbicular or subglobose; estrophiolate.

Different species investigated in the present work, are arranged following the classification of Baker (1876).

Microcalycine

A. monilifer (Linn.) DC.

A. procumbens (Roxb.) Schindl.

A. vaginalis (Linn.) DC.

A. ovalifolius (Schumach.) Leon.

Microcalycinae

A. bupleurifolius (Linn.) DC.

A. longifolius Wt. & Arn.

A. glumaceus (Vahl) DC.

A. rugosus (Willd.) DC.

A. tetragonolobus Edgew.

A. wallichii Complex

Alysicarpus monilifer (Linn.) DC., Prodr. 2 : 353, 1825; FBI. 2 : 157, 1876; Cooke, 1 : 368, 1902.

Hedysarum moniliferum Linn., Mant. 1 : 102, 1767.

A slender, prostrate, much branched herb. Branches glabrous. Leaflets oblong-elliptic to suborbicular, obtuse, mucronulate, glabrous above more or less hairy on the nerves beneath. Flowers small, in 4-10 flowered, axillary racemes. Calyx hairy, shorter than the first joint of the pod. Pods moniliform, joints 4-8, turgid, not reticulately veined (Fl. Fr. September - October). S. 37, 38, 39, 67.

Commonly observed along roadsides and on the river banks along with grasses.

The present reports are in agreement with the earlier reports of chromosome numbers n = 8 (Bir and Sidhu, 1966, 1967; Baquar and Washi, 1968) and 2n = 16 (Bhatt, 1974) for the species. 4 populations are cytologically investigated here.

Coll. Nos. 37, and 67.

Karyotype formulae : 2n = 16= $D_4+F_{10}+F_2^S$=44.64 μ (Fig. 186).

The chromosomes in the complement are having nearly median centromeres on 2 pairs (D-type) and nearly submedian on (F-type) 6 pairs. A pair of nearly submedian chromosomes (F^S-type) are having satellites. The chromosomes are medium sized, the length ranges from 2.46 μ to 3.82 μ, with a mean length of

Table 61. Measurements of somatic chromosomes of *A. monilifer* (Linn.) DC. (Coll. No. 37).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	2.46+1.19=3.65	100.00	0.48	2.07	nsm	F
3, 4	2.12+0.85=2.97	81.37	0.40	2.41	nsm	F^S
5, 6	2.04+0.85=2.89	79.18	0.42	2.40	nsm	F
7, 8	2.04+0.76=2.80	76.71	0.37	2.68	nsm	F
9, 10	1.87+0.85=2.72	74.52	0.45	2.20	nsm	F
11, 12	1.87+0.76=2.63	72.05	0.41	2.46	nsm	F
13, 14	1.44+0.93=2.37	64.93	0.65	1.53	nm	D
15, 16	1.44+0.85=2.29	62.74	0.59	1.69	nm	D

Alysicarpus monilifer

Fig. 186. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 187. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 188. Photomicrograph of somatic metaphase.

Fig. 189. PMC showing 8 bivalents at diakinesis (Coll. No. 38).

Fig. 190. " " early division of a bivalent at metaphase I (Coll. No. 39).

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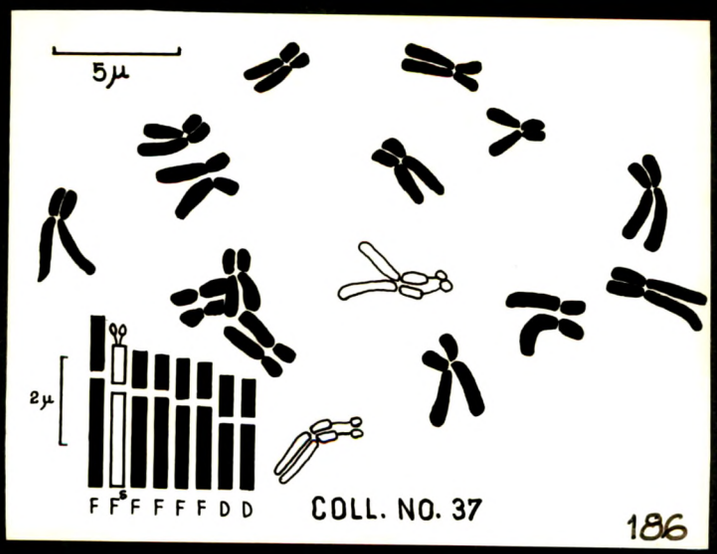
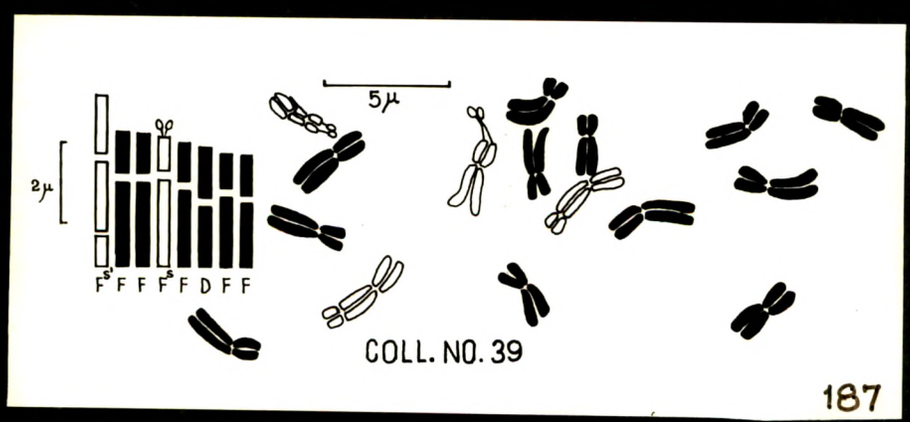

5μ
2μ
F F F F F F D D
COLL. NO. 37
186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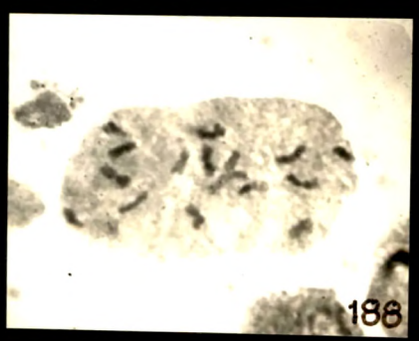
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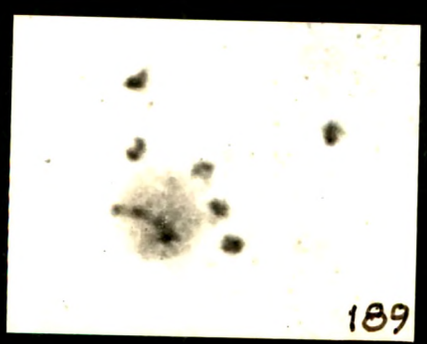
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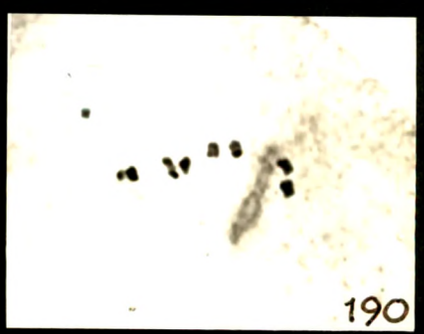

190

2.93 μ. The karyotype is asymmetrical as the TF% and L/S are 35.68 and 1.55 respectively.

Coll. Nos. 38 and 39.

Karyotype formulae : $2n = 16 = D_2+F_{10}+F_2^S+F_2^{S'}=46.96\ \mu$ (Figs. 187 and 188).

The karyotype of these collections are very similar to preceeding one, but differs from it, in having more number of chromosomes with nearly submedian centromeres and a pair of chromosomes with secondary constrictions on long arms.

Populations collected from different localities showed similarities in gross morphological characters. The karyotypes of these collections showed similarities as well as differences (Table 63), indicating presence of cytotypes in the species.

Comparison of the presently and previously analysed (Bhatt, 1974) karyotypes, showed similarity in types of chromosomes. However, a pair of chromosomes with secondary constrictions and/or with satellites observed presently were not reported earlier.

The meiosis is mostly regular showing 8 distinct bivalents at diakinesis and metaphase I (Figs. 189 and 190). Some of the abnormalities like, association of bivalents at metaphase I

Table 62. Measurements of somatic chromosomes of *A. monilifer* (Linn.) DC. (Coll. No. 39).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	0.76+1.62+1.42=3.80	100.00	0.60	1.65	nsm	$F^{S'}$
3, 4	2.04+1.10=3.14	82.19	0.53	1.85	nsm	F
5, 6	2.04+1.02=3.06	80.10	0.50	2.00	nsm	F
7, 8	2.12+0.85=2.97	77.74	0.40	2.49	nsm	F^{S}
9, 10	1.87+0.93=2.80	73.29	0.49	2.01	nsm	F
11, 12	1.44+1.27=2.71	70.94	0.88	1.13	nm	D
13, 14	1.70+0.85=2.55	66.75	0.50	2.00	nsm	F
15, 16	1.53+0.93=2.46	64.39	0.60	1.65	nsm	F

A. monilifer Contd.....

Fig. 191. PMC showing association of bivalents at metaphase I (Coll. No. 37).

Fig. 192. " " irregular distribution at anaphase I (Coll. No. 38).

Fig. 193. " " unequal distribution (7+9) at anaphase I (Coll. No. 39).

Fig. 194. " " grouping of chromosomes at metaphase II (Coll. No. 38).

Fig. 195. " " non-synchronised movement at anaphase II (Coll. No. 37).

Fig. 196. PMCs showing cytomixis (Coll. No. 37).

Fig. 197. PMC showing linearly arranged nucleii at telophase II (Coll. No. 39).

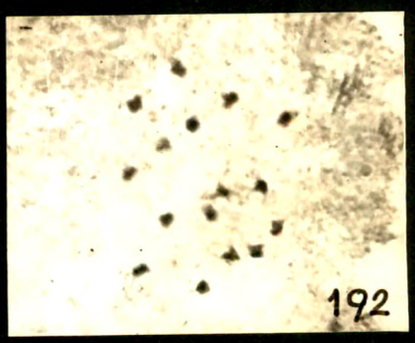
Fig. 198. " " 5 nucleii at telophase II. (Coll. No. 39).

Table 63.

Comparision of somatic chromosomes of different populations of A. monilifer (Linn.) DC.

Populations	Somatic number (2n)	nm / Type D	nsm / Type F	Chromosomes with Sec. Const. / Type F^S'	Chromosomes with SATs / Type F^S	Absolute length (in μ)	Mean length (in μ)	L/S
Coll. Nos. 37 and 67	16	4	12	-	2	44.64	2.79	1.59
Coll. Nos. 38 and 39	16	2	14	2	2	46.96	2.94	1.55


191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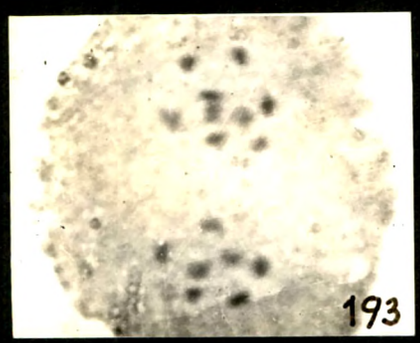
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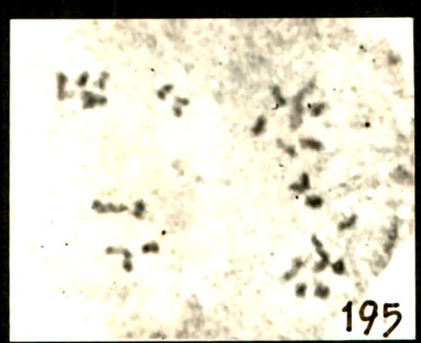
194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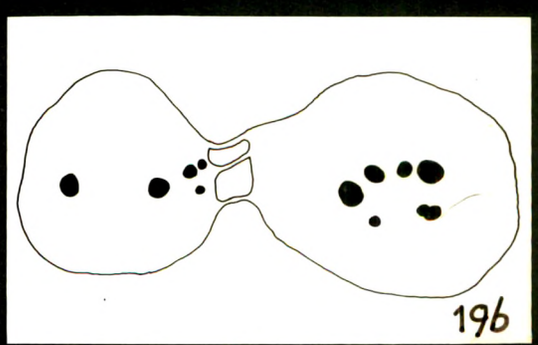
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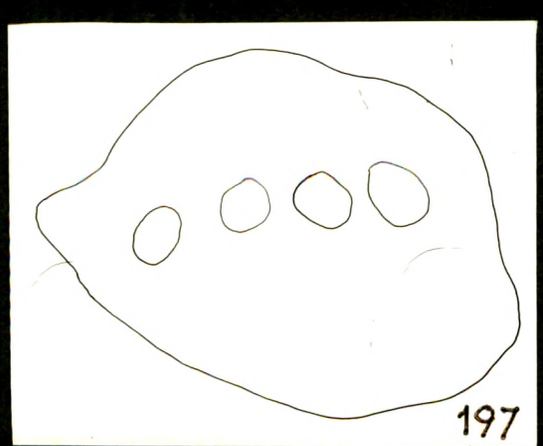
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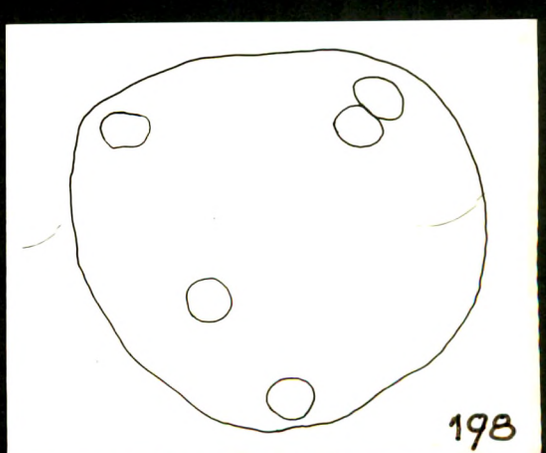
198

(Fig. 191), irregular movement and unequal distribution at anaphase I (Figs. 192 and 193), cytomixis at telophase I (Fig. 196), grouping of chromosomes at metaphase II (Fig. 194), non-synchronised movement at anaphase II (Fig. 195), linearly arranged nucleii and formation of 5 nucleii at telophase II (Figs. 197 and 198) are recorded. However, these abnormalities were found in very low percentage of PMCs. Hence, there was no effect on pollen fertility. The pollen fertility determined for the species is 89.15%.

Alysicarpus procumbens (Roxb.) Schindl., Fedde, Rep. 21 : 11, 1925; Saur. 1 : 147, 1966.

Hedysarum procumbens Roxb., Hort. Beng. 56, 1814.

Alysicarpus hamosus Edgew., Journ. Asiatic Soc. Bengal, 21 : 32 & 71, 1852; FBI. 2 : 157, 1876; Cooke, 1 : 368, 1902.

A suberect or prostrate herb. Branches clothed with spreading, greyish hairs. Leaflets ovate-suborbicular, mucronulate, slightly hairy on both the surfaces. Flowers purple or pinkish in axillary or terminal racemes. Calyx shorter than first joint of the pod. Pods straight, compressed, joints 3-8, as long as broad, covered with long (straight) and short (hooked) hairs.(Fl. Fr. September - October) S. 31, 32, 83.

Fairly common; observed in open grassy places, and as a weed in fallow fields.

98

The chromosome numbers n = 8 (Bir and Kumari, 1973; Sareen and Singh, 1975) and 2n = 16 (Bhatt, 1974) determined earlier for the species are confirmed in the present investigation.

Coll. Nos. 31 and 32.

Karyotype formulae : 2n = 16 = $D_6+D_2^{S'}+F_4+G_2+H_2$=33.08 μ (Figs. 199 and 200).

The chromosomes in the complement have nearly median centromeres (D and G - types) on 5 pairs and nearly submedian (F and H - types) on 3 pairs. One pair of nearly median chromosomes ($D^{S'}$-type) have secondary constrictions on long arms. The chromosomes are medium to short sized, the length ranges from 2.55 μ to 1.36 μ, the mean length being 2.07 μ. The karyotype is apparently asymmetrical as the TF% and L/S are 38.57 and 1.88 respectively.

Coll. No. 83.

Karyotype formulae : 2n = 16 = $D_4+F_6+F_2^{S'}+G_4$=39.18 μ (Figs. 201 and 202).

The karyotype of this collection differs from the above one, in havingequal number of chromosomes with nearly median and nearly submedian centromeres and also in having secondary constriction on nearly submedian chromosomes ($F^{S'}$-type).

A. procumbens

Fig. 199. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 200. Photomicrograph of somatic metaphase.

Fig. 201. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 202. Photomicrograph of somatic metaphase.

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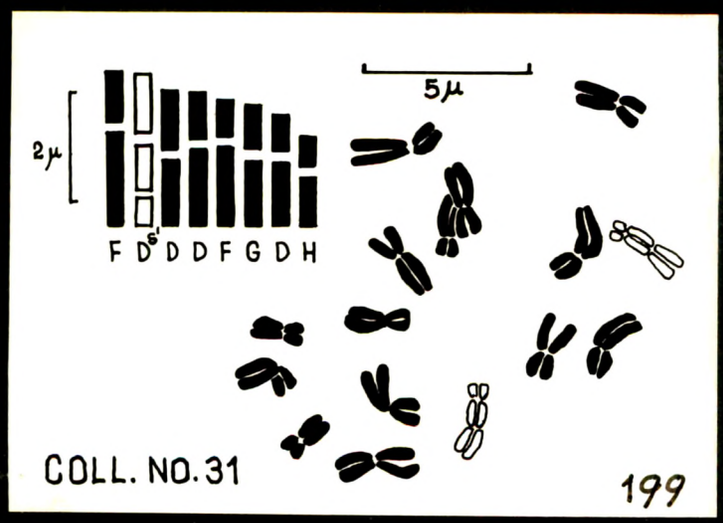
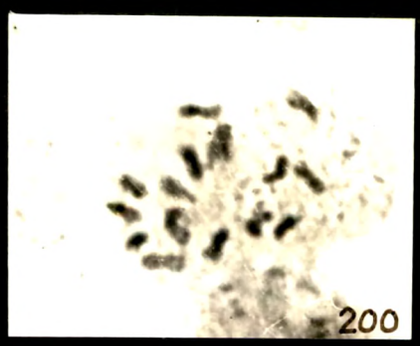

2μ
F D D D F G D H
5μ
COLL. NO. 31
199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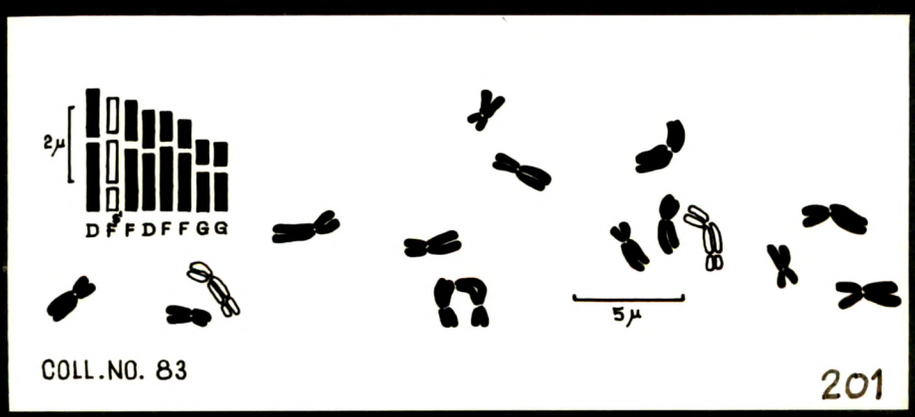

2μ
D F F D F F G G
5μ
COLL. NO. 83
201

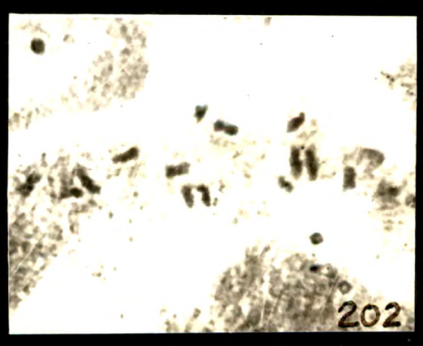

202

Table 64. Measurements of somatic chromosomes of *A. procumbens* (Roxb.) Schindler (Coll. No. 31).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.70+0.85=2.55	100.00	0.50	2.00	nsm	F
3, 4	0.51+0.85+1.02=2.38	93.33	0.75	1.33	nm	$D^{S'}$
5, 6	1.19+1.06=2.25	88.24	0.89	1.12	nm	D
7, 8	1.36+0.85=2.21	86.67	0.63	1.60	nm	D
9, 10	1.40+0.64=2.04	80.00	0.46	2.19	nsm	F
11, 12	1.19+0.77=1.96	76.86	0.65	1.55	nm	G
13, 14	1.11+0.68=1.79	70.20	0.61	1.63	nm	D
15, 16	0.85+0.51=1.36	53.33	0.60	1.67	nsm	H

Table 65. Measurements of somatic chromosomes of *A. procumbens* (Roxb.) Schindler (Coll. No. 83.).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.88+1.27=3.15	100.00	0.67	1.48	nm	D
3, 4	0.68+1.19+0.93=2.80	88.88	0.51	1.27	nsm	$F^{S'}$
5, 6	1.70+1.02=2.72	86.34	0.60	1.65	nsm	F
7, 8	1.53+1.02=2.55	80.95	0.66	1.50	nm	D
9, 10	1.76+0.76=2.52	80.00	0.43	2.31	nsm	F
11, 12	1.53+0.76=2.29	72.69	0.49	2.01	nsm	F
13, 14	1.10+0.68=1.78	56.50	0.74	1.34	nm	G
15, 16	1.02+0.76=1.78	56.50	0.61	1.61	nm	G

A. procumbens Contd.....

Fig. 203. PMC showing 8 bivalents at metaphase I (polar view) (Coll. No. 83).

Fig. 204. " " interbivalent connections (↑) at metaphase I (polar view) (Coll.No.83).

Fig. 205. " " precocious division of bivalents at metaphase I (Coll. No. 83).

Fig. 206. " " equal distribution at anaphase II (Coll. No. 83).

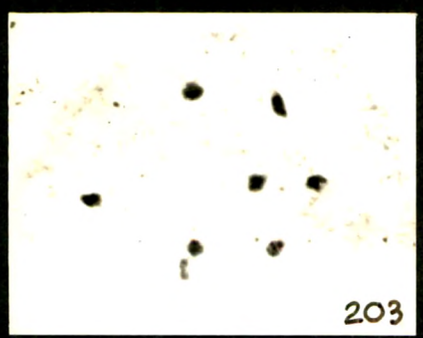
Fig. 207. " " grouping of chromosomes at metaphase II (Coll. No. 31).

Fig. 208. " " micronucleii at telophase II (Coll. No. 31).

Table 66.

Comparision of somatic chromosomes of different populations of A. procumbens (Roxb.)Schindler

Populations	Somatic number (2n)	nm Types D	nm Types G	nsm Types F	nsm Types H	Chromosomes with Sec. Const. Types $D^{S'}$	Chromosomes with Sec. Const. Types $F^{S'}$	Absolute length (in μ)	Mean length (in μ)	L/S
Coll. Nos. 31 and 32	16	8	2	4	2	2	-	33.08	2.07	1.88
Coll. No. 83	16	4	4	8	-	-	2	39.18	2.44	1.76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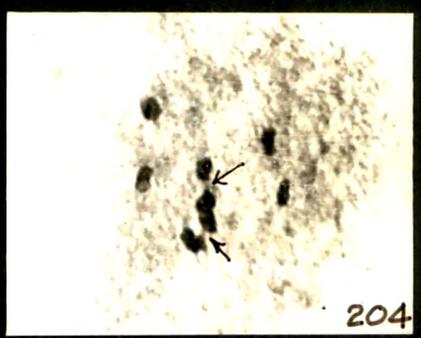
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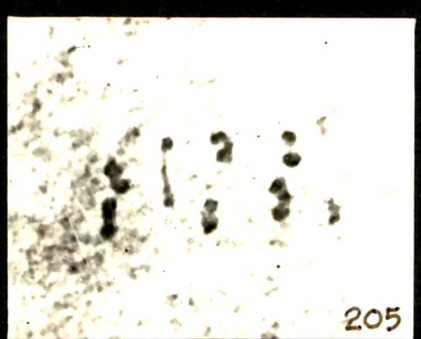
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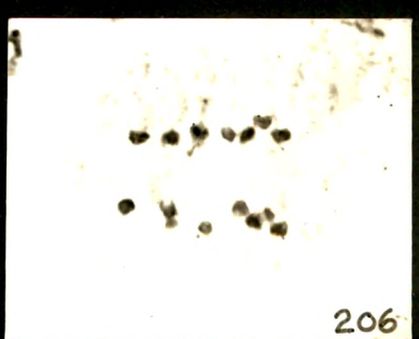
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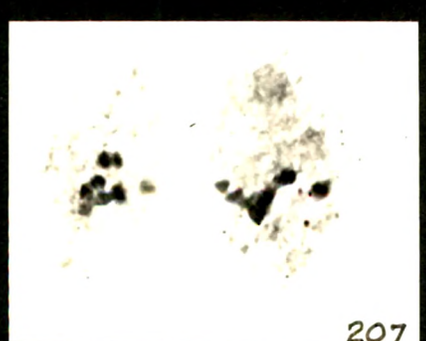
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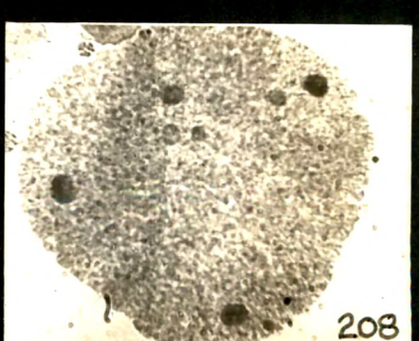

208

Different populations studied showed resemblance in morphological characters, but differ in their karyotypes (Table 66) indicating the presence of cytotypes in the species.

Bhatt (1974) reports 3 pairs with nearly median and 5 pair pairs with nearly submedian centromeres in the karyotype of the species. The present analysis of the karyotype differs from the earlier one in types of chromosomes and in having a pair of chromosomes with secondary constrictions.

The meiosis is regular showing 8 distinct bivalents at metaphase I and their normal distribution at anaphase I (Figs. 203 and 206). However, interbivalent connections at metaphase I (Fig. 204), precocious division at metaphase I (Fig. 205) grouping of bivalents at metaphase II (Fig. 207) and micronucleii at telophase II (Fig. 208) are recorded in a few PMCs. The pollen fertility determined for the species is 94%.

Alysicarpus vaginalis (Linn.) DC., Prodr. 2 : 353, 1825; FBI. 2 : 158, 1876; Cooke, 1 : 369, 1902.

Hedysarum vaginale Linn., Sp. Pl. 2 : 746, 1753.

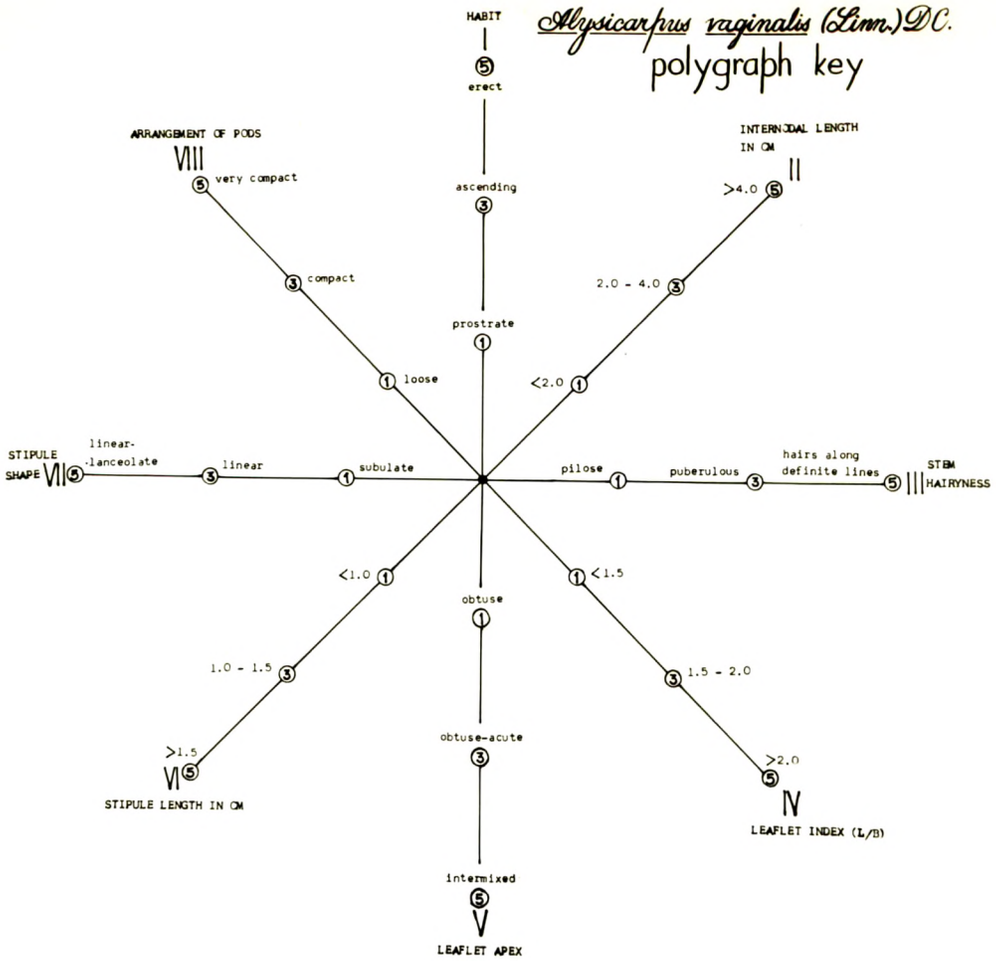
Alysicarpus vaginalis var. nummularifolius Baker, FBI. 2: 158, 1876; Cooke, 1 : 369, 1902.

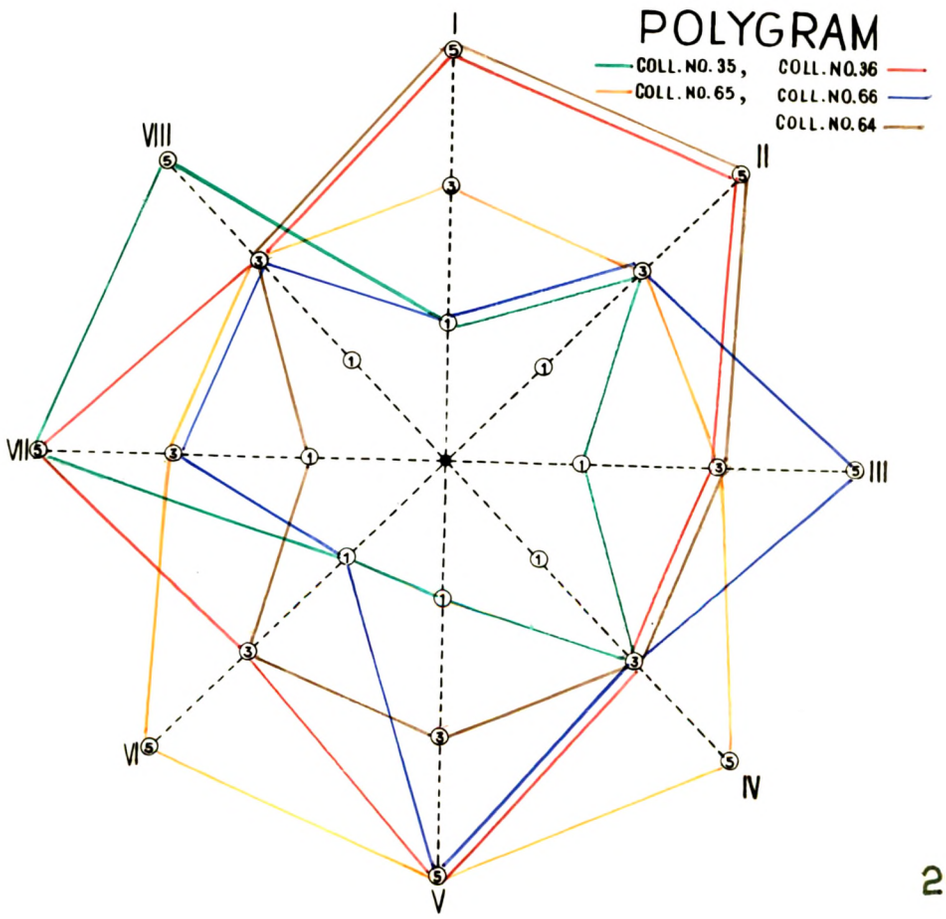
An erect, suberect or prostrate, much branched diffuse

Fig. 209. Polygraph key and polygram of different populations of A. vaginalis.

Alysicarpus vaginalis (Linn.) DC.

polygraph key





herb. Stems and branches glabrous. Leaflets variable on one and the same plant, oblong to broadly ovate, obtuse or rounded at the apex. Flowers purple, in elongated, 6-12 flowered racemes. Calyx as long as or little longer than the first joint of the pod. Pods thin, flattened, joints 4-8, longer than broad, covered with minute hooked hairs (Fl. Fr. September - October) S. 35, 36, 64, 65, 66.

Very common; observed in lawns, along roadsides, as a weed in fallow fields and on wet banks of rivers.

Different populations of the species studied show variations in several vegetative characters. Hence, they are subjected to polygraphic study (Fig. 209).

Earlier reports of n = 8 (Bir and Sidhu, 1966, 1967; Mitra and Datta, 1967) and 2n = 16 (Bhatt, 1974) are confirmed here for the species. However, Gadella and Kliphuis (1964) reports 2n = 20. In the present work 5 collections are investigated cytologically.

Coll. No. 35.

Karyotype formulae : $2n = 16 = D_4+F_2+G_4+H_4+H_2^S=34.42\ \mu$ (Fig.210).

The karyotype shows equal number of chromosomes with nearly median (D and G - types) and nearly submedian (F and H

Table 67. Measurements of somatic chromosomes of *A. vaginalis* (Linn.) DC. (Coll. No. 35).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.36+1.19=2.55	100.00	0.88	1.14	nm	D
3, 4	1.53+0.85=2.38	93.33	0.56	1.80	nsm	F
5, 6	1.36+0.89=2.25	88.24	0.65	1.55	nm	D
7, 8	1.19+0.77=1.96	76.86	0.65	1.55	nm	G
9, 10	1.28+0.68=1.96	76.86	0.53	1.85	nsm	H
11, 12	1.11+0.77=1.88	73.72	0.69	1.44	nm	G
13, 14	1.19+0.68=1.87	73.33	0.57	1.75	nsm	H^S
15, 16	0.85+0.51=1.36	53.33	0.60	1.67	nsm	H

A. vaginalis

Fig. 210. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 211. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 212. Photomicrograph of somatic metaphase.

Fig. 213. Camera lucida drawing of somatic metaphase and idiogram.

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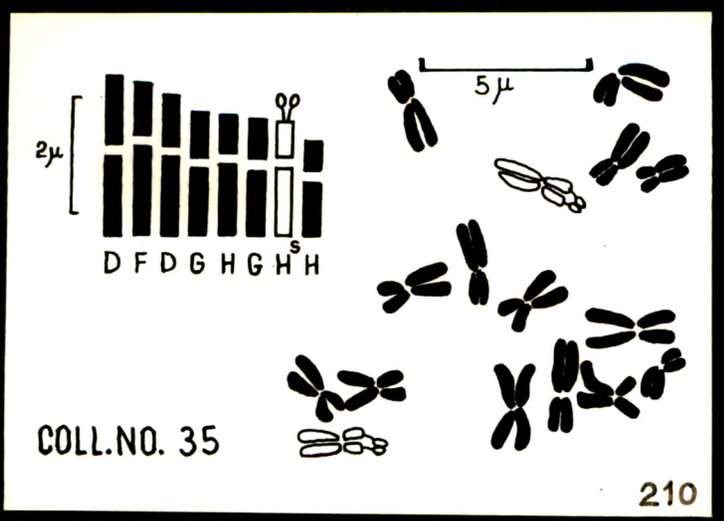
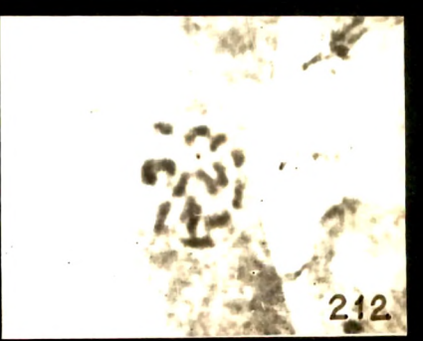

2μ
D F D G H G H H
s
5μ
COLL.NO. 35
210


2μ
F F F F H H G H
s'
s
5μ
COLL.NO. 36
211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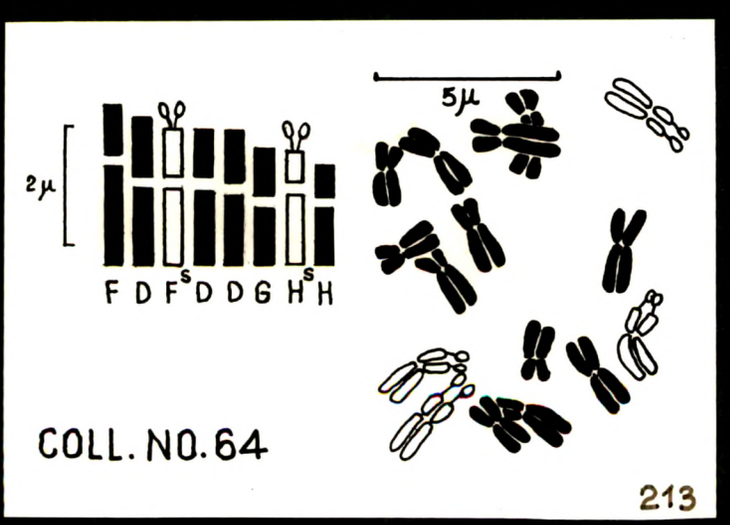

2μ
F D F D D G H H
s
s
5μ
COLL. NO. 64
213

types) centromeres. One pair of nearly median chromosomes (H^S-type) are with satellites. The chromosomes are medium to short sized, the length ranges from 2.55 μ to 1.36 μ, with a mean length of 2.03 μ. The karyotype is apparently asymmetrical and graded as the TF% and L/S are 39.11 and 1.88 respectively.

Coll. No. 36.

Karyotype formulae : $2n = 16 = F_6+F_2^{S'}+G_2^S+H_6=31.26\ \mu$ (Figs. 211 and 212).

The karyotype consists of 1 pair of chromosomes with nearly median (G-type) and 7 pairs with nearly submedian (F- and H - types) centromeres. One pair of nearly median chromosomes (G^S-type) are with satellites and one pair of nearly submedian chromosomes ($F^{S'}$-type) are with secondary constrictions on long arms. The chromosomes are medium to short sized, the length ranges from 2.38 μ to 1.44 μ, with a mean length of 1.94 μ. The karyotype is asymmetrical and graded as the TF% and L/S are 34.96 and 1.65 respectively.

Coll. No. 64.

Karyotype formulae : $2n = 16 = D_6+F_2+F_2^S+G_2+H_2+H_2^S=31.20\ \mu$ (Fig. 213).

The somatic complement includes equal number of chromosomes

Table 68. Measurements of somatic chromosomes of A. vaginalis (Linn.) DC. (Coll. No. 36).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	0.51+1.02+0.85=2.38	100.00	0.55	1.80	nsm	$F^{S'}$
3, 4	1.53+0.76=2.29	96.21	0.49	2.01	nsm	F
5, 6	1.53+0.68=2.21	92.85	0.44	2.25	nsm	F
7, 8	1.36+0.76=2.12	89.07	0.55	1.78	nsm	F
9, 10	1.36+0.59=1.95	81.93	0.43	2.30	nsm	H
11, 12	1.02+0.59=1.61	67.64	0.57	1.72	nsm	H
13, 14	0.85+0.68=1.53	64.29	0.80	1.25	nm	G^{S}
15, 16	0.93+0.51=1.44	60.50	0.54	1.82	nsm	H

Table 69. Measurements of somatic chromosomes of *A. vaginalis* (Linn.) DC. (Coll. No. 64).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.62+0.77=2.39	100.00	0.48	2.10	nsm	F
3, 4	1.28+0.94=2.22	92.89	0.73	1.36	nm	D
5, 6	1.28+0.77=2.05	85.77	0.60	1.66	nsm	F^S
7, 8	1.23+0.81=2.04	85.36	0.66	1.52	nm	D
9, 10	1.19+0.85=2.04	85.36	0.71	1.40	nm	D
11, 12	0.94+0.77=1.71	71.55	0.82	1.22	nm	G
13, 14	1.19+0.51=1.70	71.13	0.43	2.33	nsm	H^S
15, 16	0.94+0.51=1.45	60.67	0.54	1.84	nsm	H

with nearly median (D and G - types) and nearly submedian (F and H - types) centromeres. Two pairs of nearly submedian chromosomes (F^S and H^S - types) are with satellites. The chromosomes are medium to short sized, the length varies from 2.39 μ to 1.45 μ, with an average length of 1.95 μ. The karyotype is apparently asymmetrical in having TF% of 38.10 and L/S of 1.65.

Coll. No. 65.

Karyotype formulae : $2n = 16 = D_4+F_2+F_2^S+G_6+H_2=31.92\ \mu$ (Fig.214).

The somatic complement consists of 5 pairs of chromosomes with nearly median (D and G - types) and 3 pairs with nearly submedian (F and H - types) centromeres. One pair of nearly submedian chromosomes (F^S-type) are with satellites. The chromosomes are medium to short sized, the length ranges from 2.21 μ to 1.53 μ, the mean length being 1.93 μ.The karyotype is asymmetrical as the TF% is 34.80.

Coll. No. 66.

Karyotypic formulae : $2n = 16 = D_{10}+F_2+G_2+G_2^S=36.96\ \mu$ (Fig. 215).

The chromosomes in the complement are mostly with nearly median centromeres (D and G - types), except for a pair with nearly submedian centromeres (F-type). The chromosomes are

A. vaginalis Contd.....

Fig. 214. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 215. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 216. PMC showing 8 bivalents at diakinesis (Coll. No. 35).

Fig. 217. " " 8 bivalents at metaphase I (Coll. No. 35).

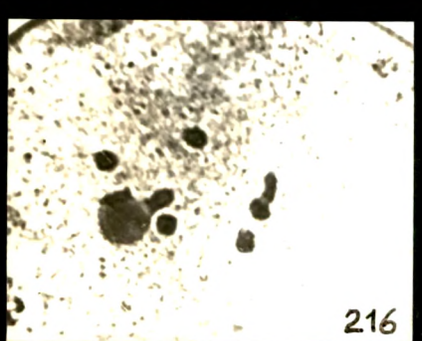
Fig. 218. " " interbivalent connections ( ) at metaphase I (Coll. No. 35).

Fig. 219. " " 2 nucleolii at telophase I (Coll. No. 64).

Contd.....


2μ
D D F F^s G G H G
5μ
COLL. NO. 65
214


5μ
2μ
D D D D D F G G^s
COLL. NO. 66
215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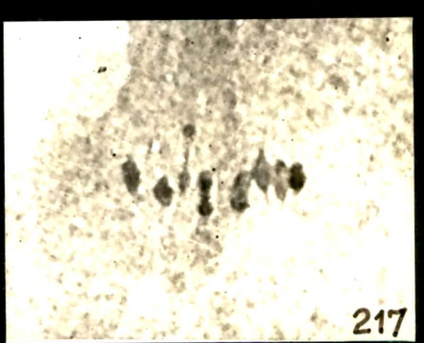
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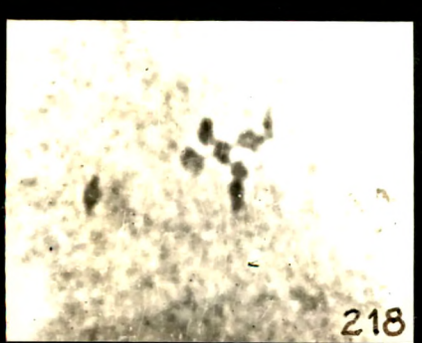
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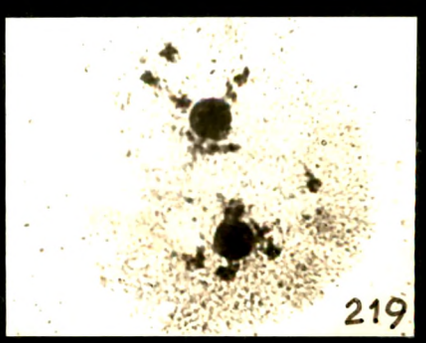
219

Table 70. Measurements of somatic chromosomes of *A. vaginalis* (Linn.) DC. (Coll. No. 65).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.36+0.85=2.21	100.00	0.63	1.60	nm	D
3, 4	1.19+1.02=2.21	100.00	0.86	1.17	nm	D
5, 6	1.36+0.85=2.13	96.38	0.57	1.77	nsm	F
7, 8	1.36+0.68=2.04	92.31	0.50	2.00	nsm	F^S
9, 10	1.11+0.81=1.92	86.88	0.73	1.37	nm	G
11, 12	0.94+0.77=1.71	77.38	0.82	1.22	nm	G
13, 14	1.11+0.60=1.71	77.38	0.54	1.85	nsm	H
15, 16	0.85+0.68=1.53	69.23	0.80	1.25	nm	G

Table 71. Measurements of somatic chromosomes of *A. vaginalis* (Linn.) DC. (Coll. No. 66).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.79+1.19=2.98	100.00	0.66	1.50	nm	D
3, 4	1.62+1.19=2.81	94.30	0.73	1.36	nm	D
5, 6	1.53+1.02=2.55	85.57	0.67	1.50	nm	D
7, 8	1.28+0.94=2.22	74.50	0.73	1.36	nm	D
9, 10	1.19+1.02=2.21	74.16	0.86	1.17	nm	D
11, 12	1.36+0.68=2.04	68.46	0.50	2.00	nsm	F
13, 14	1.11+0.77=1.88	63.09	0.69	1.44	nm	G
15, 16	1.11+0.68=1.79	60.07	0.61	1.63	nm	G^S

Table 72.

Comparision of somatic chromosomes of different populations of A. vaginalis (Linn.) DC.

Populations	Somatic number (2n)	nm Types D	nm Types G	nsm Types F	nsm Types H	Chromosomes with Sec.Const. Types $F^{S'}$	Chromosomes with SATs Types G^S	Chromosomes with SATs Types F^S	Chromosomes with SATs Types H^S	Absolute length (in μ)	Mean length (in μ)	L/S
Coll. No. 35	16	4	4	2	6	-	-	-	2	34.42	2.03	1.88
Coll. No. 36	16	-	2	8	6	2	2	-	-	31.26	1.95	1.65
Coll. No. 64	16	6	2	4	4	-	-	2	2	31.20	1.95	1.65
Coll. No. 65	16	4	6	4	2	-	-	2	-	31.92	1.93	1.44
Coll. No. 66	16	10	4	2	-	-	2	-	-	36.96	2.31	1.66

medium to short sized, the length ranges from 2.98 μ to 1.79 μ, with a mean length of 2.31 μ. The karyotype is apparently asymmetrical as the TF% and L/S are 40.53 and 1.66 respectively.

It is evident from the polygram (Fig. 209) that, there exists 5 distinct ecological forms among the populations investigated. As all these populations show karyotypic differences (Table 72), so it can be concluded that there are 5 ecotypes [redacted] in the species.

The presently analysed karyotypes resemble the earlier analysed one (Bhatt, 1974) in types of chromosomes. But differs from it in having a pair of chromosomes with secondary constrictions and another pair with satellites.

The PMCs showed regular meiotic behaviour, with the formation of 8 bivalents at diakinesis and metaphase I (Figs. 216 and 217). However, some of the abnormalities like inter-bivalent connections at metaphase I (Fig. 218), formation of nucleoli at telophase I (Fig. 219), grouping of chromosomes at metaphase II (Fig. 220) and irregular distribution at anaphase II (Fig. 221) are recorded in few PMCs. The pollen fertility determined for the species is 90.74%.

Alysicarpus ovalifolius (Schumach.) J. Leon., Bull. Bot. Braux. 24 : 88, fig. 11, 1954; Verdec., Kirkia 9(2):547, 1974.

Hedysarum ovalifolium Schumach., Beskr. Guin. Pl. :359,1827.

An erect or diffuse herb. Branches pubescent, later almost glabrous. Leaflets elliptic to oblong, acute or acuminate and mucronulate, finely puberulous on nerves beneath. Flowers pinkish, in terminal or leaf opposed lax racemes. Ovary pubescent, many ovuled; style bearded with long hairs; stigma capitate. Pods flattened, joints 5-7, longer than broad, puberulous with raised reticulate ridges (Fl. Fr. September - October) S. 93, 116.

Rare; observed in lawns along with A. vaginalis. Seeds were also obtained from Kew Gardens (origin Zambia).

No data regarding cytology of the species could be traced from the available literature. So this is the first report of chromosome number, karyotype analysis and meiosis for the species. The chromosome numbers determined for the species are n = 8 and 2n = 16. Of the two populations studied one is from Zambia (Coll. No. 93) and another from India (Coll. No. 116). Both the collections showed similarity in karyotypes.

Coll. Nos. 93 and 116.

Karyotype formulae: $2n=16=D_2+F_2^S+F_2^{S'}+G_2+H_8=31.36\ \mu$ (Figs. 222 and 223).

Table 73. Measurements of somatic chromosomes of *A. ovalifolius* (Schum.) J. Leon. (Coll. No. 93).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	0.51+1.02+0.93=2.46	100.00	0.59	1.68	nsm	$F^{S'}$
3, 4	1.44+0.93=2.37	96.34	0.64	1.54	nm	D
5, 6	1.44+0.59=2.03	82.52	0.40	2.44	nsm	F^{S}
7, 8	1.27+0.68=1.95	79.26	0.53	1.86	nsm	H
9, 10	1.36+0.59=1.94	79.26	0.43	2.30	nsm	H
11, 12	1.02+0.85=1.87	76.01	0.83	1.20	nm	G
13, 14	1.19+0.51=1.70	69.10	0.42	2.33	nsm	H
15, 16	0.85+0.51=1.36	55.28	0.61	1.67	nsm	H

A. vaginalis Contd.....

Fig. 220. PMC showing grouping of chromosomes at metaphase II (Coll. No. 66).

Fig. 221. " " non-synchronised movement at anaphase II (Coll. No. 64).

A. ovalifolius

Fig. 222. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 223. Photomicrograph of somatic metaphase.

Fig. 224. PMC showing 8 bivalents at diakinesis.

Fig. 225. " " " at metaphase I.

Fig. 226. " " association of bivalent at metaphase I.

Fig. 227. " " equal distribution at anaphase I.

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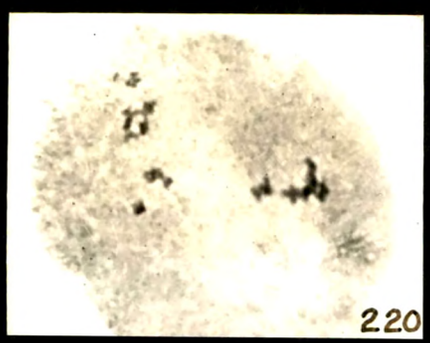

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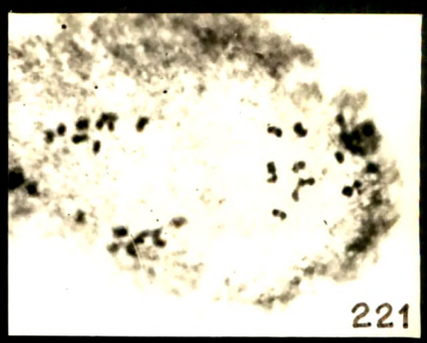

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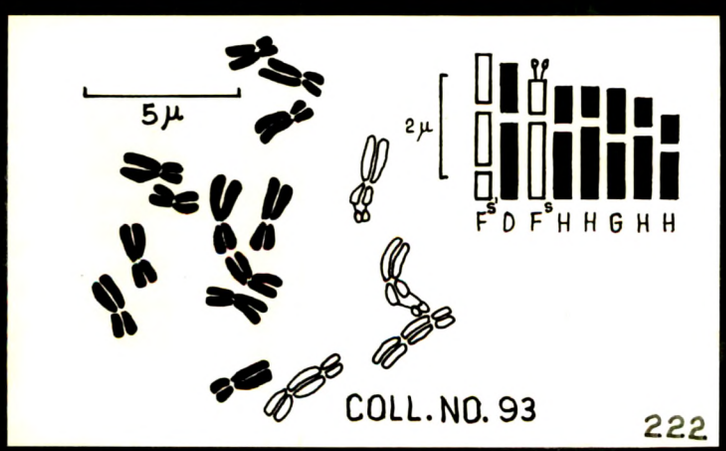

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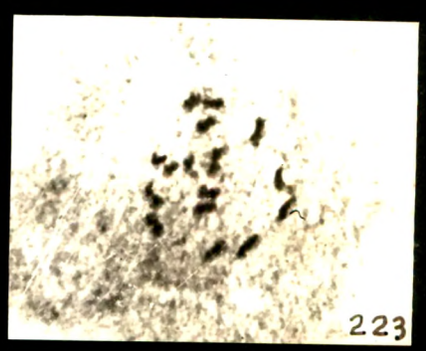

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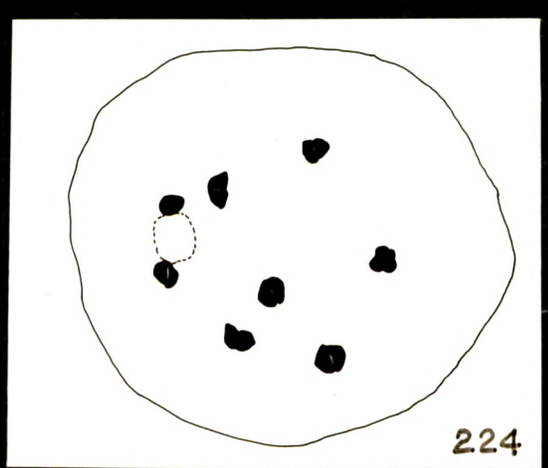

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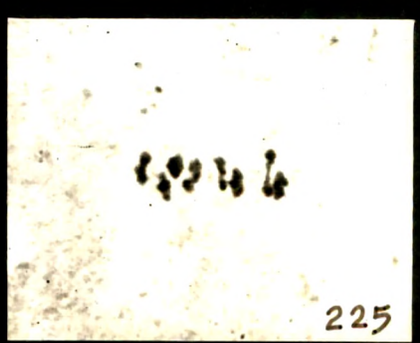

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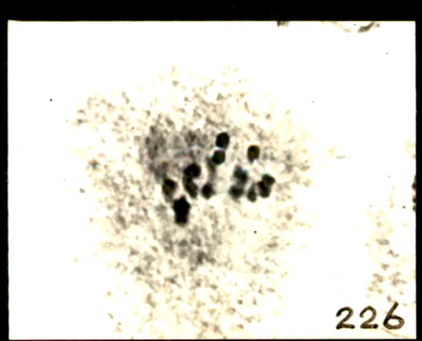

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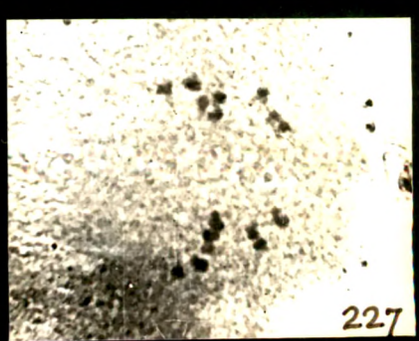

227

The somatic complement shows 2 pairs of chromosomes with nearly median (D and G - types) and 6 pairs with nearly submedian (F and H - types) centromeres. Two pairs of nearly submedian chromosomes are with secondary constrictions on long arms ($F^{S'}$-type) and satellites. The chromosomes are medium to short sized, the length ranges from 2.46 μ to 1.36 μ, the mean length being 1.96 μ. The karyotype is asymmetrical as the TF% and L/S are 35.62 and 1.80 respectively.

Meiosis is regular showing 8 bivalents at diakinesis, metaphase I and their normal disjunction at anaphase I (Figs. 224, 225 and 227). However, abnormalities like precocious division at metaphase I (Fig. 226), grouping of chromosomes at metaphase II (Fig. 228) and irregular distribution at anaphase II (Fig. 229) are recorded. The pollen fertility determined for the species is 88.67%.

Alysicarpus bupleurifolius (Linn.) DC., Prodr. 2 : 352, 1825; FBI. 2: 158, 1876; Cooke, 1 : 370, 1902.

Hedysarum bupleurifolium Linn. Sp. Pl. 745, 1753.

An erect or ascending herb, branches glabrous. Leaflets linear-lanceolate, acute, glabrous. Flowers purple, in 10-20 flowered, lax racemes. Calyx much longer than the first joint

of the pod, imbricate, glabrous on the back, ciliate along the margins. Pods cylindric, slightly moniliform, joints 4-8, not veined nor rugose, strongly apiculate (Fl. Fr. July - October) S. 101.

Commonly observed as a weed of waste lands and cultivated fields.

The chromosome numbers determined presently for the species are n = 8 and 2n = 16. This is in confirmity with the earlier reports of n = 8 (Bir and Sidhu, 1966, 1967; Mehra and Dhawan, 1971) and 2n = 16 (Bhatt, 1974).

Coll. No. 101.

Karyotype formulae : 2n = 16 = $D_6+D_2^{S''}+F_6+G_2$=43.48 μ (Figs. 230 and 231).

The karyotype consists of 5 pairs of chromosomes with nearly median (D and G - types) and 3 pairs with nearly submedian centromeres (F-type). One pair of nearly median chromosomes ($D^{S''}$-type) are with secondary constrictions on short arms. The chromosomes are medium sized, except for a pair of short sized chromosomes (G-type). The length of the chromosomes varies from 3.57 μ to 1.96 μ, with an average length of 2.72 μ. The karyotype is apparently asymmetrical as the TF% and L/S are 38.78 and 1.82 respectively.

A. ovalifolius Contd.....

Fig. 228. PMC showing grouping of chromosomes at metaphase II.

Fig. 229. " " irregular distribution at anaphase II.

A. bupleurifolius

Fig. 230. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 231. Photomicrograph of somatic metaphase.

Fig. 232. PMC showing 8 bivalents at metaphase I.

Fig. 233. " " association of bivalents at metaphase I.

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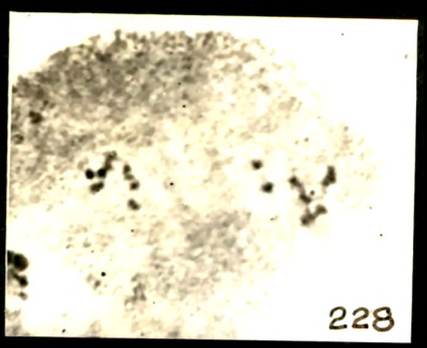

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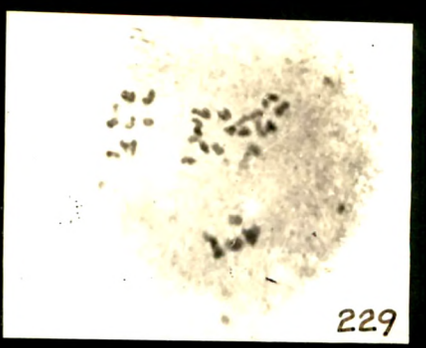

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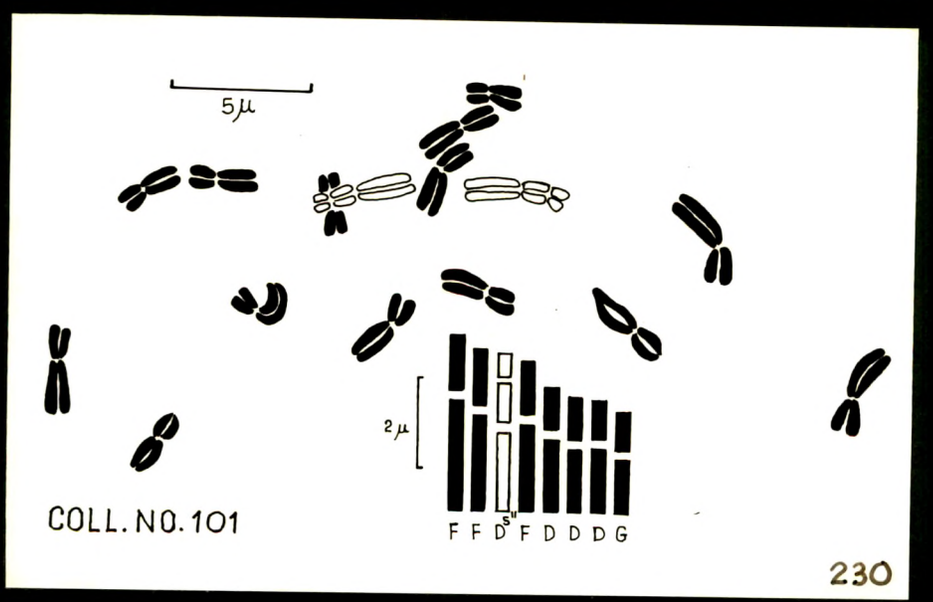

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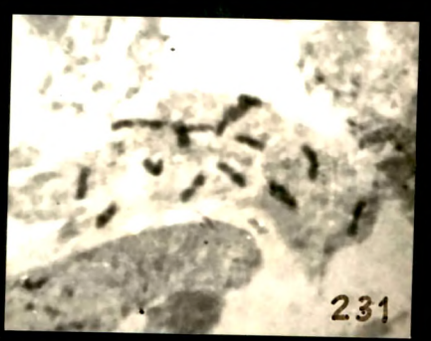

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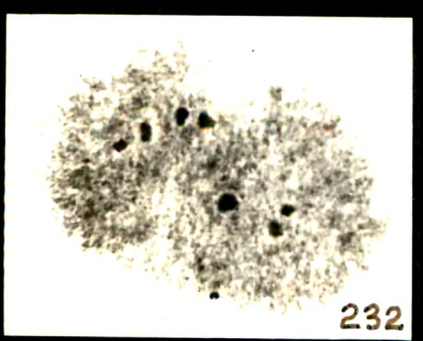

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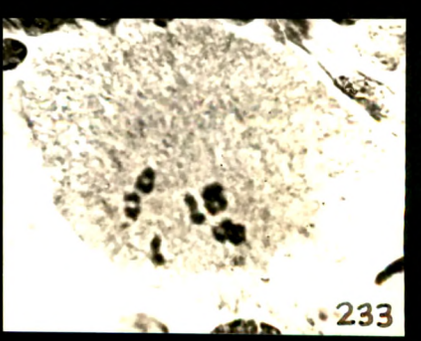


233

Table 74. Measurements of somatic chromosomes of A. bupleurifolius (Linn.) DC. (Coll. No. 101).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	2.38+1.19=3.57	100.00	0.50	2.00	nsm	F
3, 4	2.04+1.19=3.23	90.48	0.58	1.71	nsm	F
5, 6	1.70+0.85+0.51=3.06	85.71	0.80	1.25	nm	$D^{S''}$
7, 8	1.87+1.11=2.98	83.47	0.59	1.68	nsm	F
9, 10	1.53+0.94=2.47	69.19	0.61	1.63	nm	D
11, 12	1.32+0.94=2.26	63.31	0.71	1.40	nm	F
13, 14	1.36+0.85=2.21	61.90	0.63	1.60	nm	D
15, 16	1.11+0.85=1.96	54.90	0.77	1.31	nm	G

A. bupleurifolius Contd....

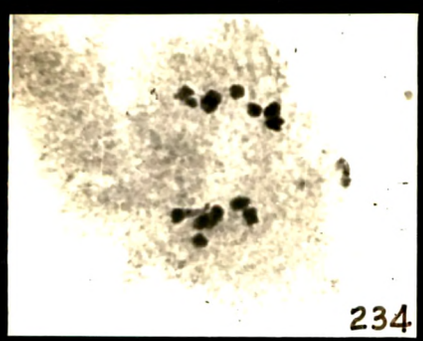
Fig. 234. PMC showing equal distribution at anaphase I.

Fig. 235. " " precocious movement at anaphase I.

Fig. 236. " " grouping of chromosomes at metaphase II.

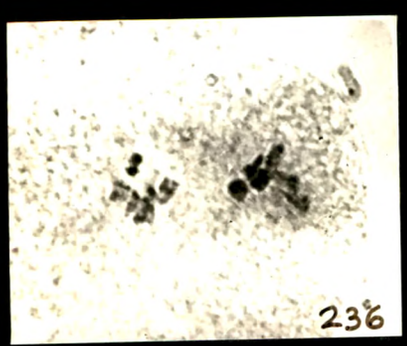
Fig. 237. PMCs showing cytomixis.

Fig. 238. PMC showing 6 nucleii at telophase II.



234

235



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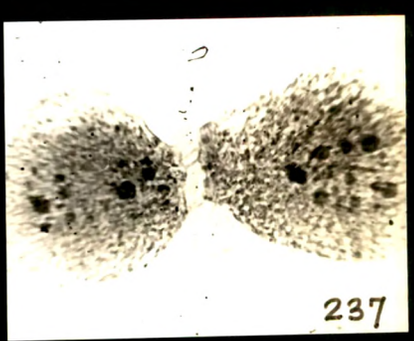

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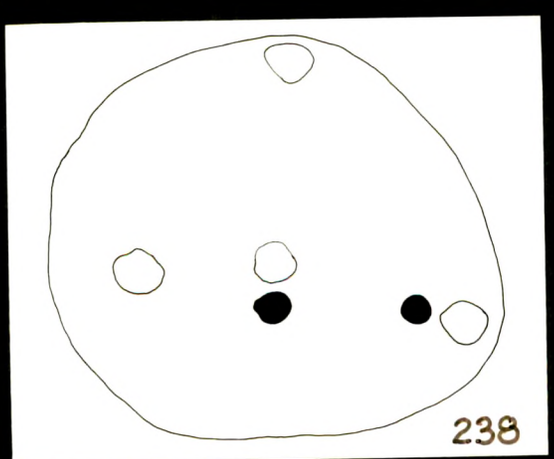


238

Meiosis is regular showing the formation of 8 bivalents at metaphase I (Fig. 232) and their equal distribution at anaphase I (Fig. 234). Some PMCs show precocious movement at anaphase I (Fig. 235), cytomixis at telophase I (Fig. 237), grouping of chromosomes at metaphase II (Fig. 236) and formation of 6 nucleii at telophase II (Fig. 238). The pollen fertility determined for the species is 85.98%.

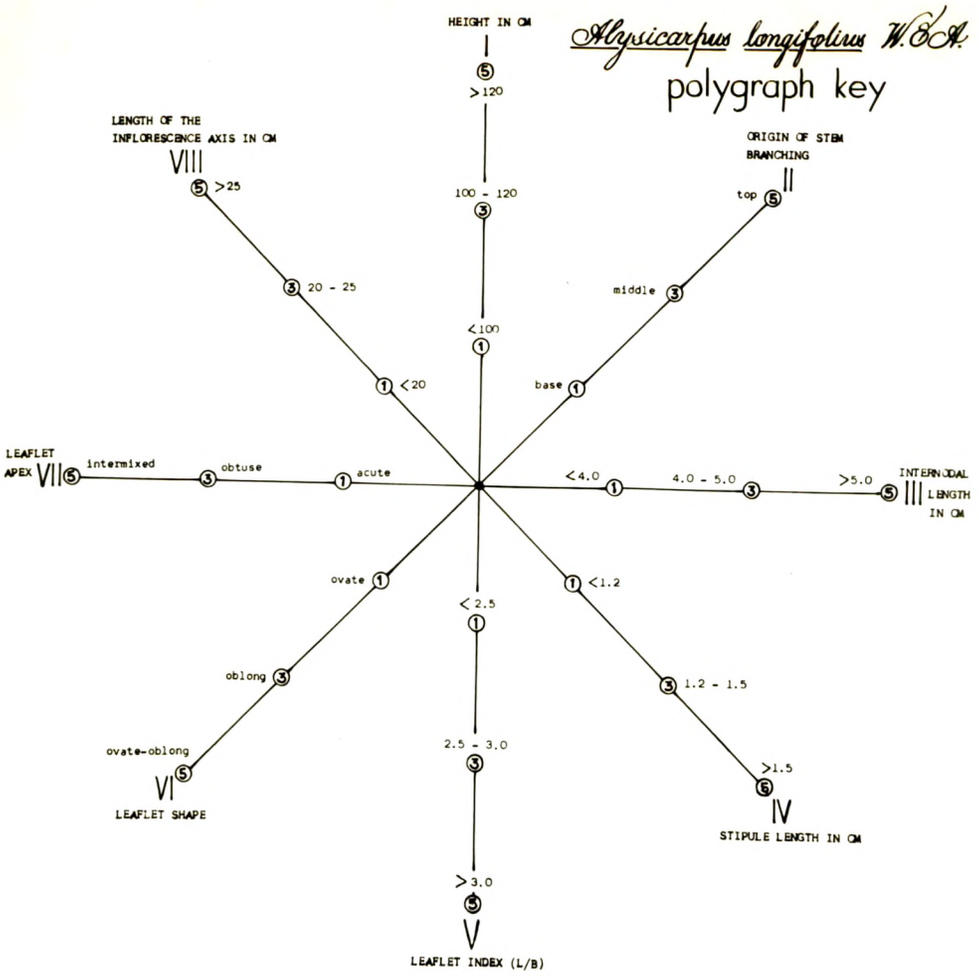
Alysicarpus longifolius Wt. & Arn. Prodr. 1 : 233, 1834; FBI. 2 : 159, 1876; Cooke, 1 : 370, 1902.

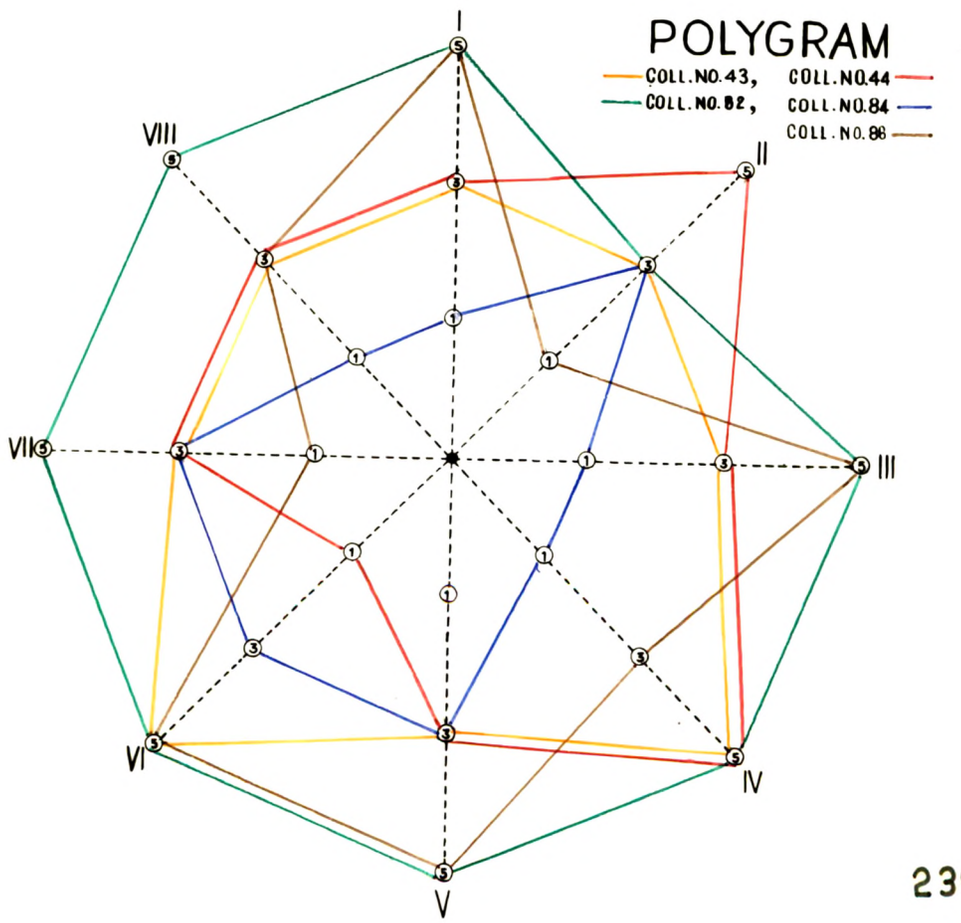
An erect stout herb. Stems and branches striate, glabrous. Leaflets ovate, oblong or linear-oblong, glabrous above, hairy on the nerves beneath. Stipules large, acute to acuminate, scarious. Flowers purple with a yellow dot, in long terminal racemes. Bracts large, lanceolate, acuminate, deciduous. Calyx pubescent, ciliate, striate. Pods shortly stalked, much exerted, 4-6 jointed, glabrous, reticulately veined, apiculate (Fl. Fr. September - January) S. 43, 44, 82, 84, 86.

Very common; observed as a weed in cultivated fields and in open places among grasses.

Different populations exhibited great variability in vegetative characters. Hence, they are subjected to polygraphic study (Fig. 239).

Fig. 239. Polygraph key and polygram of different populations of A. longifolius.


Alysicarpus longifolius W.&A.
polygraph key
HEIGHT IN CM
>120
100 - 120
<100
<20
20 - 25
>25
LENGTH OF THE INFLORESCENCE AXIS IN CM
VIII
ORIGIN OF STEM BRANCHING
II
top
middle
base
LEAFLET APEX
VII
intermixed
obtuse
acute
<4.0
4.0 - 5.0
>5.0
INTERNODAL LENGTH IN CM
III
ovate
oblong
ovate-oblong
VI
LEAFLET SHAPE
<2.5
2.5 - 3.0
>3.0
V
LEAFLET INDEX (L/B)
<1.2
1.2 - 1.5
>1.5
IV
STIPULE LENGTH IN CM


POLYGRAM
COLL.NO.43,
COLL.NO.82,
COLL.NO.44
COLL.NO.84
COLL.NO.88
VIII
II
VII
III
VI
IV
V

In the present investigation, chromosome numbers n = 8 (Bir and Kumari, 1973) and 2n = 16(Bhatt, 1974) reported earlier are confirmed. Five populations are investigated cytologically.

Coll. No. 43.

Karyotype formulae : 2n = 16 = $A_2^{S''}+B_4+D_2+F_8$=62.14 μ (Figs. 240 and 241).

There are 2 pairs of chromosomes with nearly median (A and D - types) and 6 pairs with nearly submedian (B and F - types) centromeres in the somatic complement. The longest pair in the complement ($A^{S''}$-type) is with secondary constrictions on long arms. The chromosomes are long to medium sized, the length ranges from 4.85 μ to. 2.72 μ, with a mean length of 3.88 μ. The karyotype is asymmetrical and graded as the TF% and L/S are 35.31 and 1.78 respectively.

Coll. No. 44.

Karyotype formulae : 2n = 16 = $D_4+D_2^{S'}+F_{10}$=51.30 μ (Figs. 242 and 243).

The karyotype consists of 5 pairs of chromosomes with nearly median centromeres (D and G - types) and 3 pairs with nearly submedian (F-type) centromeres. One pair of nearly

Table 75. Measurements of somatic chromosomes of *A. longifolius* Wt. & Arn. (Coll. No. 43).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	3.40+1.45=4.85	100.00	0.43	2.34	nsm	B
3, 4	3.06+1.36=4.42	91.13	0.44	2.25	nsm	B
5, 6	2.13+1.19+0.85=4.17	85.98	0.96	1.04	nm	$A^{S"}$
7, 8	2.72+1.19=3.91	80.62	0.44	2.29	nsm	F
9, 10	2.55+1.36=3.91	80.62	0.53	1.88	nsm	F
11, 12	2.55+1.19=3.74	77.11	0.47	2.14	nsm	F
13, 14	1.19+1.36=3.35	69.07	0.68	1.46	nm	D
15, 16	1.70+1.02=2.72	56.08	0.60	1.67	nsm	F

Table 76. Measurements of somatic chromosomes of *A. longifolius* Wt. & Arn. (Coll. No. 44).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	0.68+1.02+1.19=2.89	100.00	0.70	1.43	nm	$D^{S'}$
3, 4	1.87+0.85=2.72	94.12	0.45	2.20	nsm	F
5, 6	1.70+0.85=2.55	88.24	0.50	2.00	nsm	F
7, 8	1.53+0.94=2.47	85.47	0.61	1.63	nm	D
9, 10	1.36+1.02=2.38	82.35	0.75	1.33	nm	D
11, 12	1.53+0.85=2.38	82.35	0.56	1.80	nsm	F
13, 14	1.45+0.85=2.30	79.58	0.59	1.71	nsm	F
15, 16	1.36+0.77=2.13	73.70	0.57	1.77	nsm	F

A. longifolius

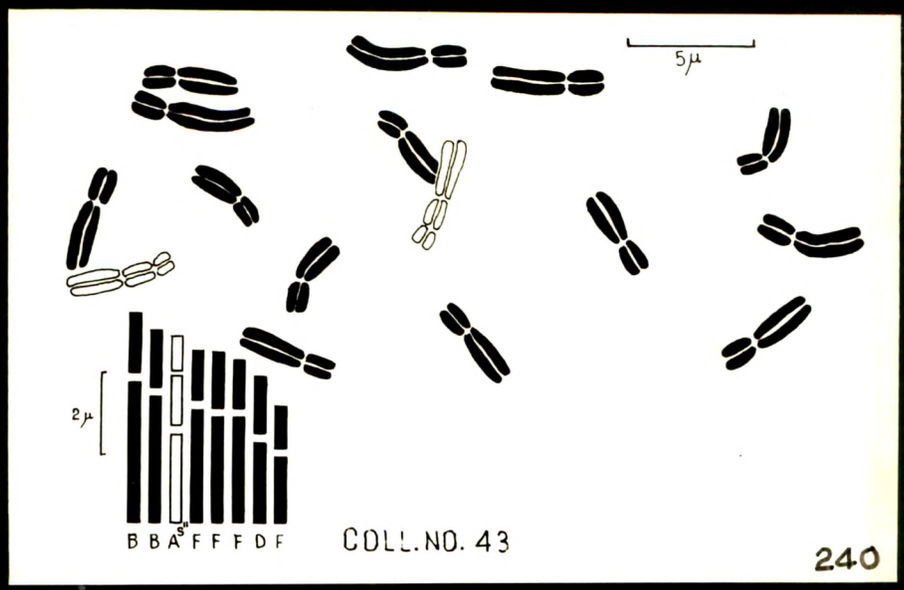
Fig. 240. Camera lucida drawing of somatic metaphase and idiogram.

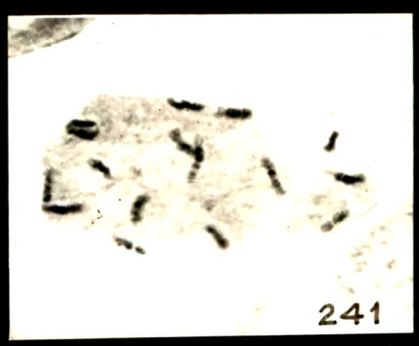
Fig. 241. Photomicrograph of somatic metaphase.

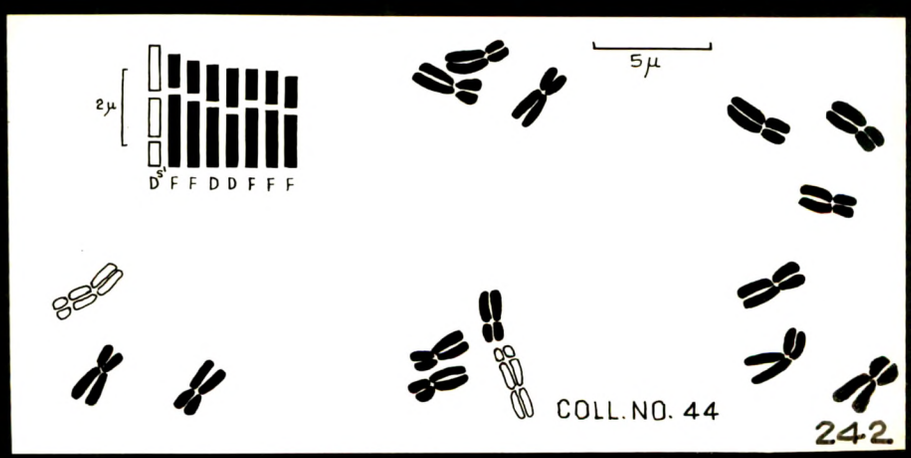
Fig. 242. Camera lucida drawing of somatic metaphase and idiogram.

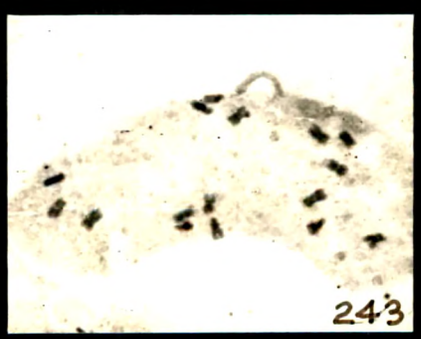
Fig. 243. Photomicrograph of somatic metaphase.

Contd.....


5μ
2μ
B B A S F F F D F
COLL. NO. 43
240


241


5μ
2μ
D S F F D D F F F
COLL. NO. 44
242


243

median type ($D^{S'}$-) is with secondary constrictions on short arms. The chromosomes in the complement are medium sized, except for a pair of short sized chromosomes (G-type). The length of the chromosomes ranges from 3.57 μ to 1.96 μ, with a mean length of 2.72 μ. The karyotype is apparently asymmetrical and graded as the TF% and L/S are 38.78 and 1.80 respectively.

Coll. No. 82.

Karyotype formulae : 2n = 16 = $D_8+F_6+F_2^{S'}$=40.24 μ (Figs. 244 and 245).

The complement shows equal number of nearly median (D-type) and nearly submedian (F-type) chromosomes. Secondary constrictions are present on one pair of nearly submedian chromosomes ($F^{S'}$-type). All the chromosomes are medium sized, the length ranges from 3.07 μ to 2.04 μ, with a mean length of 2.52 μ. The karyotype is apparently asymmetrical as the TF% is 38.02. The graded nature of the karyotype is indicated in the idiogram (Fig. 244).

Coll. No. 84.

Karyotype formulae : 2n = 16 = $D_4+F_2^{S}+F_{10}$=38.64 μ (Figs. 246 and 247).

The karyotype includes 2 pairs of chromosomes with nearly

Table 77. Measurements of somatic chromosomes of *A. longifolius* Wt. & Arn. (Coll. No. 82).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.88+1.19=3.07	100.00	0.63	1.57	nm	D
3, 4	0.51+1.36+1.02=2.89	94.13	0.54	1.83	nsm	$F^{S'}$
5, 6	1.76+1.02=2.78	90.55	0.57	1.72	nsm	F
7, 8	1.53+1.02=2.55	83.06	0.66	1.50	nm	D
9, 10	1.44+1.02=2.46	80.12	0.70	1.41	nm	D
11, 12	1.36+0.85=2.21	71.98	0.38	1.60	nsm	F
13, 14	1.27+0.85=2.12	69.05	0.66	1.49	nm	D
15, 16	1.36+0.68=2.04	66.44	0.50	2.00	nsm	F

Table 78. Measurements of somatic chromosomes of *A. longifolius* Wt. & Arn. (Coll. No. 84).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	2.55+1.28=3.83	100.00	0.50	1.99	nsm	F
3, 4	2.55+1.19=3.74	97.65	0.47	2.14	nsm	F
5, 6	2.34+1.36=3.70	96.61	0.58	1.72	nsm	F
7, 8	2.38+0.85=3.23	84.33	0.36	2.80	nsm	F
9, 10	2.13+1.02=3.15	82.25	0.48	2.09	nsm	$F^{S'}$
11, 12	2.13+1.02=3.15	82.25	0.48	2.09	nsm	F
13, 14	1.70+1.02=2.72	71.02	0.60	1.67	nm	D
15, 16	1.19+0.94=2.13	55.61	0.79	1.27	nm	D

A. longifolius Contd.....

Fig. 244. Camera lucida drawing of somatic metaphase and idiogram.

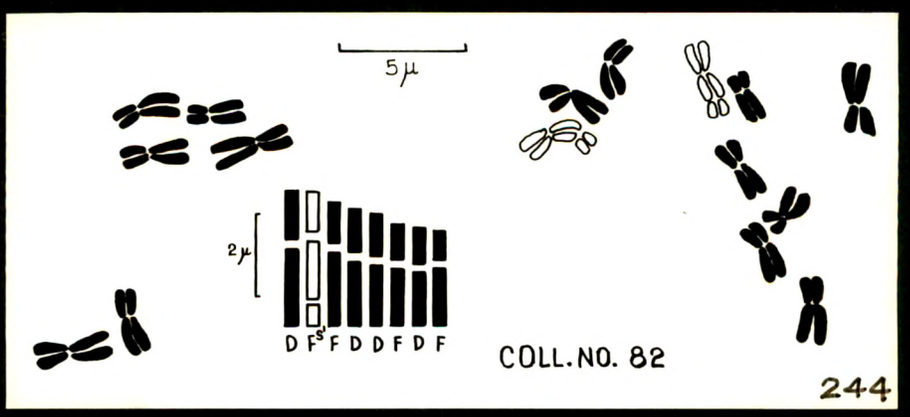
Fig. 245. Photomicrograph of somatic metaphase.

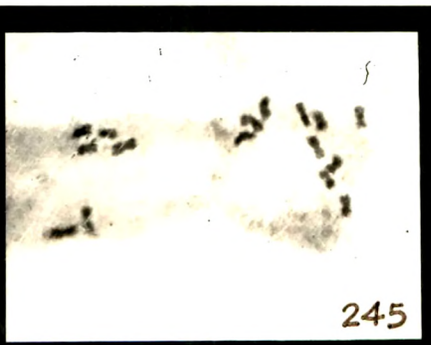
Fig. 246. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 247. Photomicrograph of somatic metaphase.

Fig. 248. Camera lucida drawing of somatic metaphase and idiogram.

Contd....


5μ
2μ
D F S F D D F D F
COLL. NO. 82
244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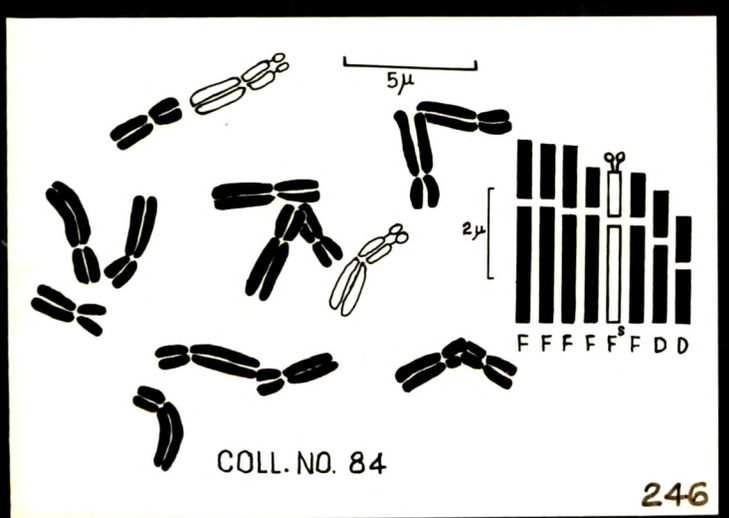
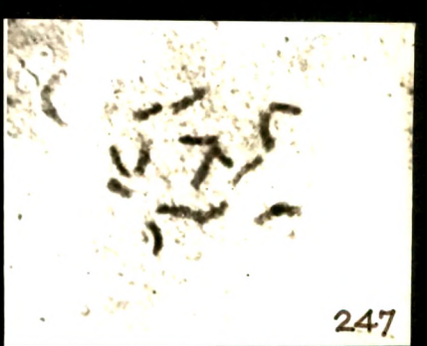

5μ
2μ
F F F F F S F D D
COLL. NO. 84
246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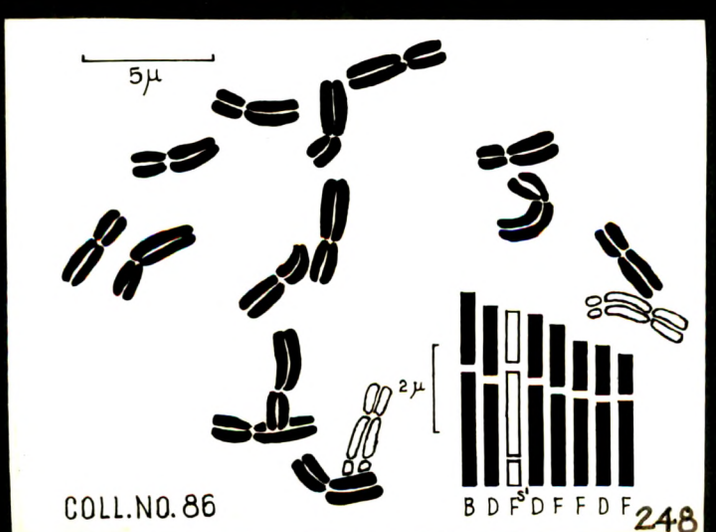

5μ
2μ
B D F S D F F D F
COLL. NO. 86
248

median (D-type) and 6 pairs with nearly submedian centromeres. One pair of nearly submedian chromosomes ($F^{S'}$-type) are with secondary constrictions on long arms. All the chromosomes in the complement are medium sized, the length ranges from 4.08 μ to 2.72 μ, with a mean length of 3.44 μ. The karyotype is asymmetrical and graded as the TF% and L/S are 36.93 and 1.36 respectively.

Coll. No. 86.

Karyotype formulae : $2n = 16 = B_2+D_6+F_6+F^{S'}_2=55.10\ \mu$ (Fig. 248).

The karyotype consists of 3 pairs of chromosomes with nearly median (D-type) and 5 pairs with nearly submedian (B and F - types) centromeres. The chromosomes in the complement are medium sized, except for a pair of long chromosomes (B-type). The length of the chromosomes ranges from 4.08 μ to 2.72 μ, with a mean length of 3.44 μ. The karyotype is apparently asymmetrical as the TF% is 37.02.

The polygraphic (Fig. 239) and karyotypic studies (Table 80) of different populations indicate the presence of 5 ecotypes in the species.

Bhatt (1974) reports 1 pair of median and 7 pairs of submedian chromosomes in the taxon analysed by him. In contrast to this, the present study all populations showed

Table 79. Measurements of somatic chromosomes of *A. longifolius* Wt. & Arn. (Coll. No. 86).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	2.55+1.53=4.08	100.00	0.60	1.67	nsm	B
3, 4	2.30+1.53=3.83	93.87	0.67	1.50	nm	D
5, 6	2.55+0.68+0.51=3.74	91.67	0.47	2.14	nsm	$F^{S'}$
7, 8	2.21+1.36=3.57	87.00	0.62	1.63	nm	D
9, 10	2.04+1.36=3.40	83.33	0.67	1.50	nm	D
11, 12	1.96+1.19=3.15	77.21	0.61	1.65	nsm	F
13, 14	1.87+1.19=3.06	75.00	0.64	1.57	nm	F
15, 16	1.87+0.85=2.72	66.67	0.45	2.20	nsm	F

Table 80.

Comparision of somatic chromosomes of different populations of A. longifolius Wt. & Arn.

Populations	Somatic number (2n)	nm Types A	nm Types D	nsm Types B	nsm Types F	Chromosomes with Sec.Const. Types $A^{S''}$	Chromosomes with Sec.Const. Types $D^{S'}$	Chromosomes with Sec.Const. Types $F^{S'}$	Chromosomes with SATs Type F^{S}	Absolute length (in μ)	Mean length (in μ)	L/S
Coll. No. 43	16	2	2	4	8	2	-	-	-	62.14	3.88	1.78
Coll. No. 44	16	-	6	-	10	-	2	-	-	51.30	3.21	1.80
Coll. No. 82	16	-	8	-	8	-	-	2	-	40.24	2.52	1.50
Coll. No. 84	16	-	6	-	10	-	-	-	2	38.64	2.48	1.36
Coll. No. 86	16	-	6	2	8	-	-	-	-	55.10	3.44	1.50

A. longifolius Contd.....

Fig. 249. PMC showing 8 bivalents at diakinesis (Coll.No.44).

Fig. 250. " " 2 univalents (↑) 7 bivalents at metaphase I (Coll. No. 85).

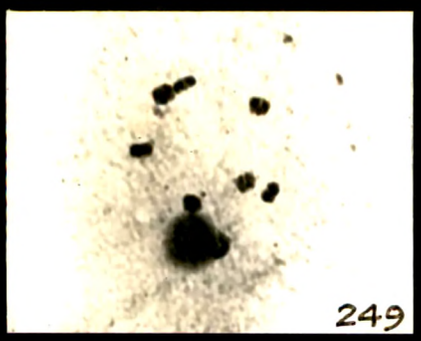
Fig. 251. and 252. PMC showing late separation and tarded division at anaphase I (Coll. No. 44).

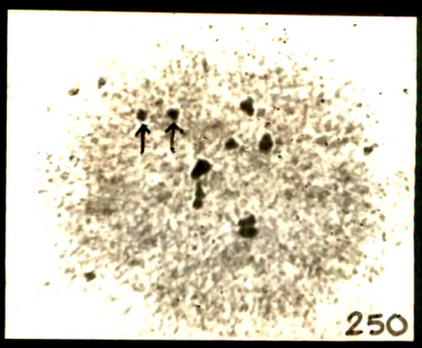
Fig. 253. PMCs showing cytomixis (Coll. No. 86).

Fig. 254. PMC showing grouping of bivalents at metaphase II (Coll. No. 84).

Fig. 255. " " non-synchronised movement at anaphase II (Coll. No. 44).

Fig. 256. " " 6 nucleii at telophase II (Coll. No. 86).


249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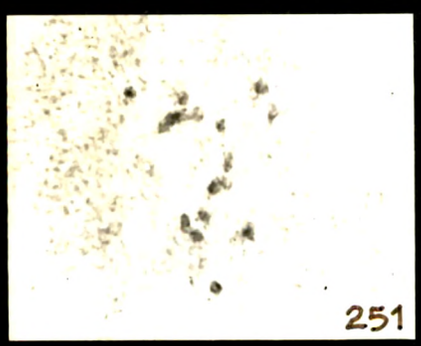
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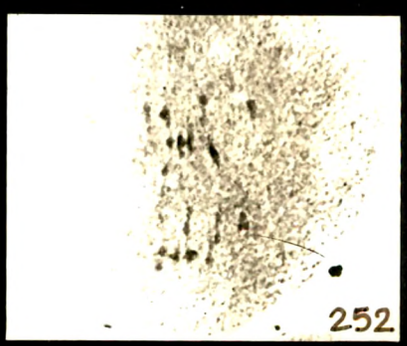
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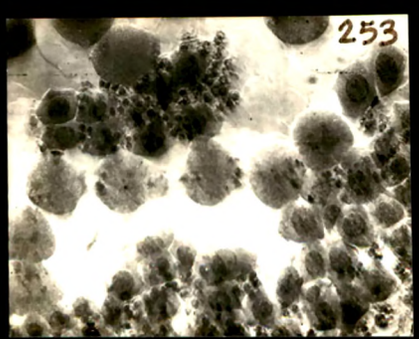
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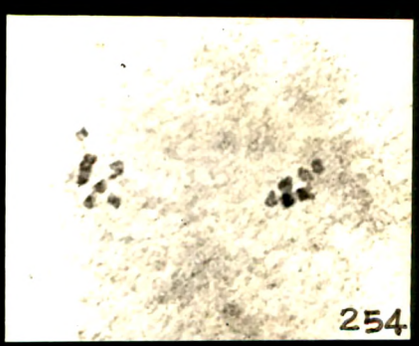
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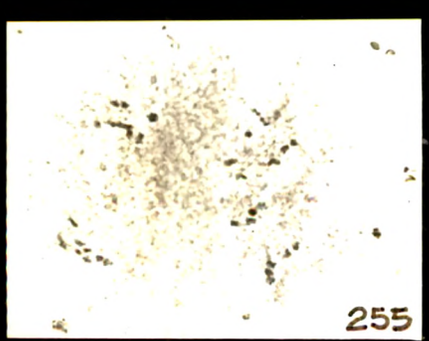
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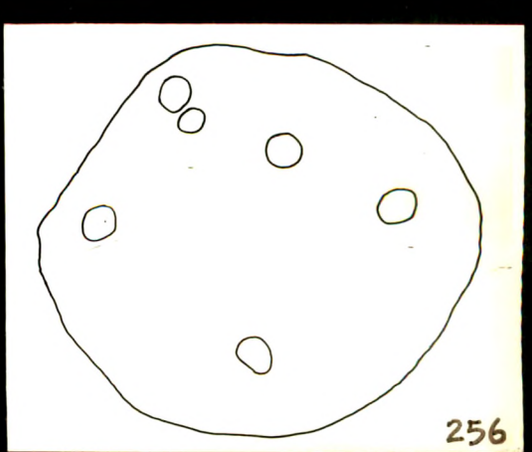

256

more or less equal number of nearly median and nearly sub-median types of chromosomes.

The meiosis is regular showing 8 distinct bivalents at diakinesis (Fig. 249). However, univalents at metaphase I (Fig. 250), late separation and tarded division of bivalent at anaphase I (Figs. 251 and 252), cytomixis at telophase I (Fig. 253), grouping of chromosomes at metaphase II (Fig. 254), non-synchronised movement at anaphase II (Fig. 255) and formation of 6 nucleii at telophase II (Fig. 256) are recorded in few PMCs. As these abnormalities occur in very low percentage of PMCs, there was no effect on pollen fertility. The pollen fertility determined for the species is 89%.

Alysicarpus glumaceus (Vahl) DC., Prodr. 2 : 353, 1825; Verdc., loc.cit. 553.

Hedysarum glumaceum Vahl, Symb. Bot. 2, Add. & Corrig. : 106, 1791.

An erect or procumbent, annual herb. Stems and branches are covered with spreading hairs. Leaflets oblong or linear, acute and mucronulate at the apex, finely puberulous. Flowers purple or reddish-purple in terminal and leaf opposed racemes. Calyx pubescent. Pods moniliform, joints 3-5, slightly exerted, pubescent. (Fl. Fr. November - December) S. 91, 110.

Source : Seeds received from Kew gardens (origin Zambia).

The present study confirms the earlier report (Bhatt, 1974) of 2n = 16 for the species.

Coll. No. 91.

Karyotype formulae : 2n = 16 = $D_2+F_6+F_2^{S'}+G_2+H_4$=38.52μ(Figs. 257 and 258).

The karyotype shows 2 pairs of chromosomes with nearly median (D and G - types) and 6 pairs with nearly submedian (F and H - types) centromeres. One pair of nearly submedian chromosomes ($F^{S'}$-type) are with secondary constrictions on long arms. The chromosomes in the complement are medium to short sized, the length ranges from 3.15 μ to 1.53 μ, with a mean length of 2.41 μ. The karyotype is asymmetrical as the TF% and L/S are 35.51 and 2.06 respectively.

Two populations of the taxon analysed earlier (Bhatt, 1974) differ from each other in their types and number of each type of chromosomes. One of the populations showed a pair of satellited chromosomes. The present analysis differs from the above in having 2 pairs of chromosomes with nearly median and 6 pairs with nearly submedian centromeres. In contrast to, one pair of chromosomes with satellites observed earlier, a pair

Table 81. Measurements of somatic chromosomes of *A. glumaceus* (Vahl) DC. (Coll. No. 91).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	2.13+1.02=3.15	100.00	0.48	2.09	nsm	F
3, 4	0.68+1.36+1.02=3.06	97.14	0.50	2.00	nsm	$F^{S'}$
5, 6	1.62+1.02=2.64	83.81	0.63	1.59	nm	D
7, 8	1.70+0.89=2.59	82.22	0.52	1.91	nsm	F
9, 10	1.70+0.85=2.55	80.95	0.50	2.00	nsm	F
11, 12	1.19+0.68=1.87	59.37	0.57	1.75	nsm	H
13, 14	1.02+0.85=1.87	59.37	0.83	1.20	nm	G
15, 16	1.02+0.51=1.53	48.57	0.50	2.00	nsm	H

A. glumaceus

Fig. 257. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 258. Photomicrograph of somatic metaphase.

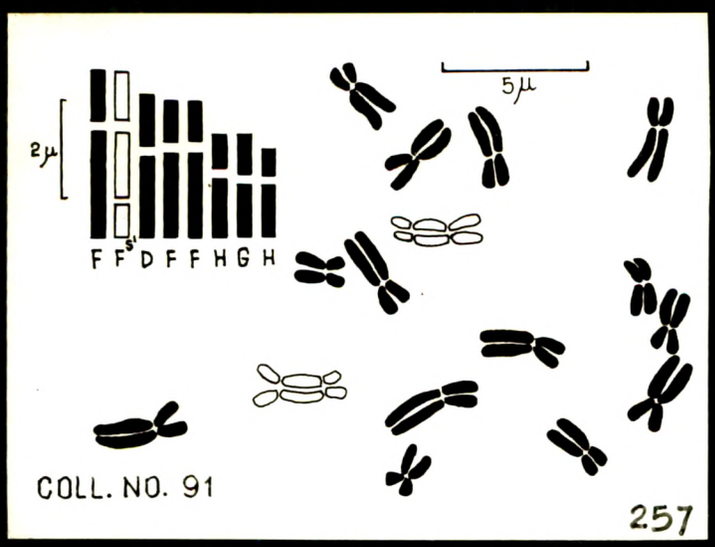
Fig. 259. PMC showing 8 bivalents at diakinesis.

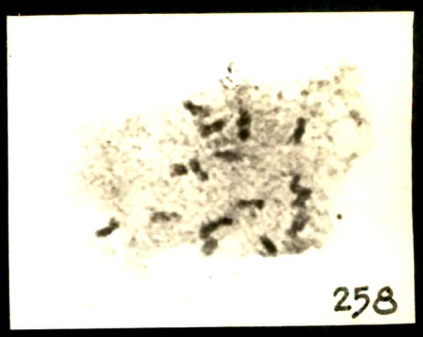
Fig. 260. " " " at metaphase I.

Fig. 261. " " univalents (→) at diakinesis.

Fig. 262. " " precocious division of bivalents at metaphase I.

Fig. 263. " " micronucleii at telophase II.


5μ
2μ
F F SAT D F F H G H
COLL. NO. 91
257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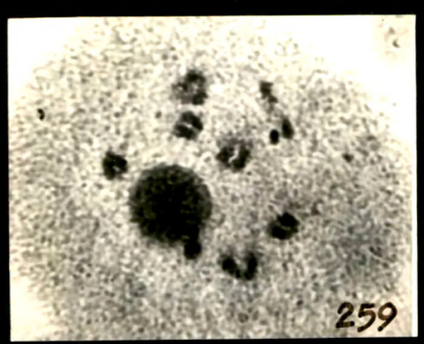
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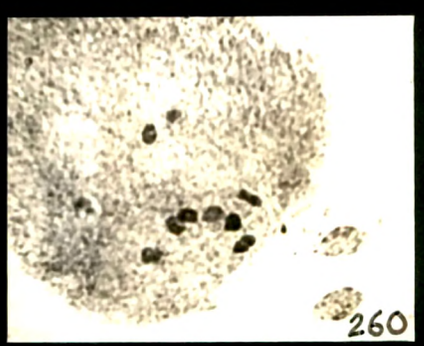
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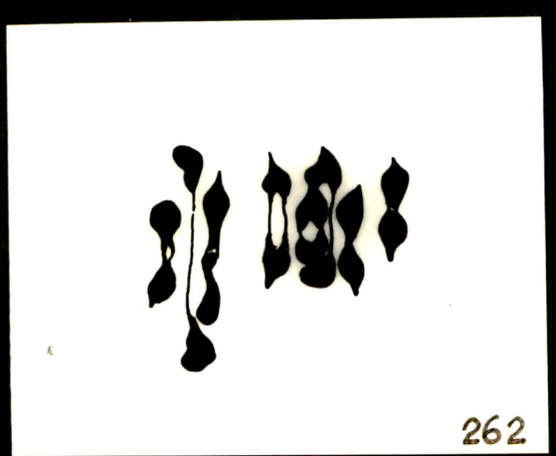
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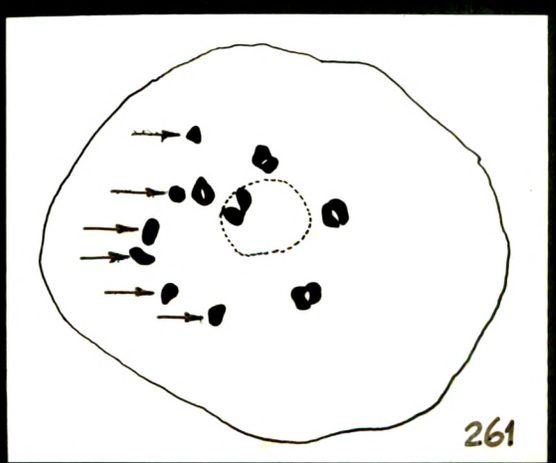
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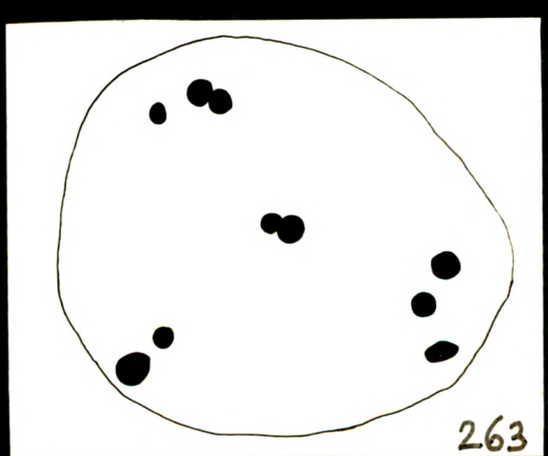

263

of chromosomes with secondary constriction are encountered in the present work.

Meiosis is regular showing 8 distinct bivalents at diakinesis and metaphase I (Figs. 259 and 260). However, univalents at diakinesis, precocious division of bivalents at metaphase I and micronucleii at telophase II (Figs. 261, 262 and 263), are recorded in a few PMCs. The pollen fertility determined for the species is 86.82%.

Alysicarpus rugosus (Willd.) DC., Prodr. 2 : 353, 1825; Verdc., loc. cit. 550.

Hedysarum rugosum Willd., Sp. Pl. ed. 4, 3(2): 1172, 1802.

An erect, prostrate or ascending, somewhat suffruticose herb. Stems pubescent or glabrous. Leaflets ovate-lanceolate, oblong or linear-lanceolate, acute and mucronulate at the apex, finely puberulous. Flowers pinkish or reddish-purple in axillary, terminal or leaf opposed racemes. Calyx densely pubescent. Pods scarcely exerted from the calyx, much constricted between the seeds, joints 3-6, with strong, close transverse ridges - adopted from Verdcourt, loc. cit. 550.

Source : Seeds obtained from Kew gardens (origin Zambia).

In contrast to the earlier reports of 2n = 20 (Miege, 1960)

Table 82. Measurements of somatic chromosomes of *A. rugosus* DC. (Coll. No. 92).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.78+0.93=2.71	100.00	0.52	1.91	nsm	F
3, 4	1.53+0.76=2.29	84.00	0.50	2.00	nsm	F
5, 6	1.36+0.85=2.21	81.55	0.62	1.60	nm	D
7, 8	1.36+0.76=2.12	78.23	0.56	1.79	nsm	F
9, 10	1.19+0.68=1.87	69.00	0.57	1.75	nsm	H
11, 12	1.02+0.68=1.70	62.73	0.67	1.50	nm	G
13, 14	1.02+0.59=1.61	59.41	0.58	1.73	nsm	H
15, 16	1.02+0.59=1.61	59.41	0.58	1.73	nsm	H

for the species, in the present investigation 2n = 16 chromosomes are observed in the somatic complement.

Coll. No. 92.

Karyotype formulae : $2n = 16 = D_4+F_4+H_6+H_2^S=32.24\ \mu$ (Fig. 264).

The chromosomes in the complement are having nearly median centromeres (D-type) on 2 pairs and nearly submedian (F and H - types) on 6 pairs. One of the nearly submedian pairs is with satellites (H^S-type). There are equal number of medium and short sized chromosomes. The length of the chromosomes ranges from 2.71 μ to 1.61 μ, with a mean length of 2.02 μ. The karyotype is asymmetrical as the TF% is 36.23.

Alysicarpus tetragonolobus Edgew., Journ. Asiatic Soc. Bengal 2 : 169, 1853; FBI. 2: 159, 1876; Cooke, 1 : 372, 1902.

An erect or suberect herb. Stems and branches are marked with lines of hairs. Leaflets elliptic-oblong to linear, obtuse or subacute, glabrous above, hairy on the veins beneath. Flowers pink, in lax axillary and terminal racemes. Calyx puberulous, strongly ciliate at the tips. Pods tetragonous, exerted, 2-6 jointed, transversely ribbed, marked with a long ridge along the middle of each face (Fl. Fr. August - October) S. 46, 47, 72, 88.

A. rugosus

Fig. 264. Camera lucida drawing of somatic metaphase and idiogram.

A. tetragonolobus

Fig. 265. Camera lucida drawing of somatic metaphase and idiogram.

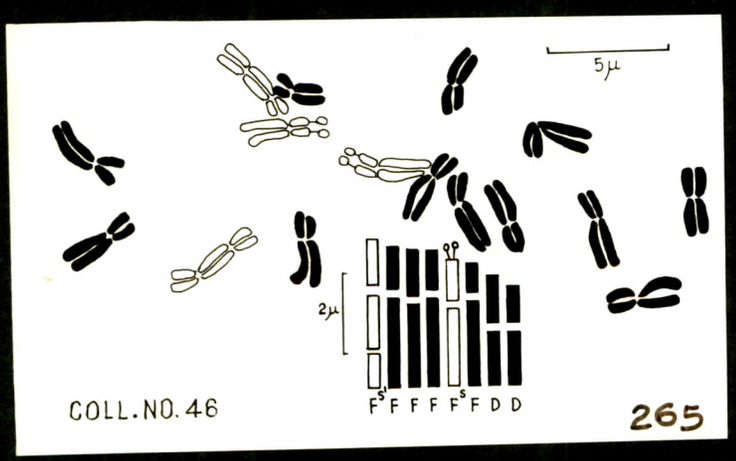
Fig. 266. Photomicrograph of somatic metaphase.

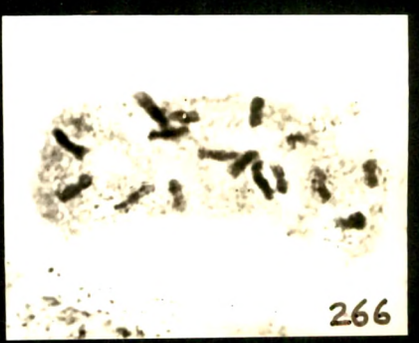
Fig. 267. PMC showing 8 bivalents at metaphase I (Coll. No. 46).

Fig. 268. " " equal distribution at anaphase I (Coll. No. 88).

Contd.....


5μ
2μ
F F D D H H H^S H
COLL. NO. 92
264


5μ
2μ
F^S F F F F^S F D D
COLL. NO. 46
265


266


267

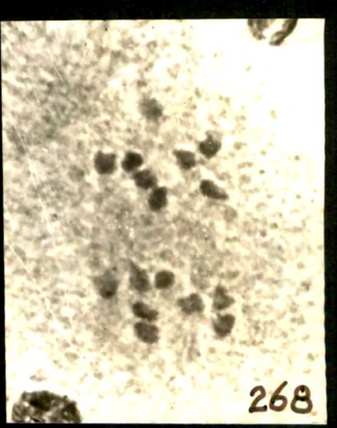

268

Table 83. Measurements of somatic chromosomes of *A. tetragonolobus* Edgew. (Coll. No. 46).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	0.85+1.36+1.19=3.40	100.00	0.54	1.86	nsm	$F^{S'}$
3, 4	2.21+1.10=3.31	97.35	0.50	2.00	nsm	F
5, 6	2.08+1.19=3.27	96.18	0.57	1.75	nsm	F
7, 8	2.21+1.02=3.23	95.00	0.46	2.70	nsm	F
9, 10	1.95+1.02=2.97	87.35	0.52	1.91	nsm	F
11, 12	2.12+0.76=2.88	84.71	0.36	2.79	nsm	F^{S}
13, 14	1.44+1.19=2.63	77.35	0.83	1.21	nm	D
15, 16	1.44+0.93=2.37	69.71	0.65	1.55	nm	D

A. tetragonolobus Contd.....

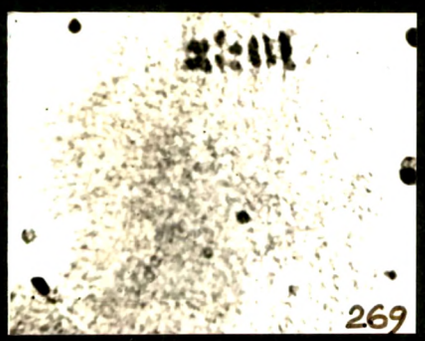
Fig. 269. PMC showing abnormal position of bivalents at metaphase I (Coll. No. 47).

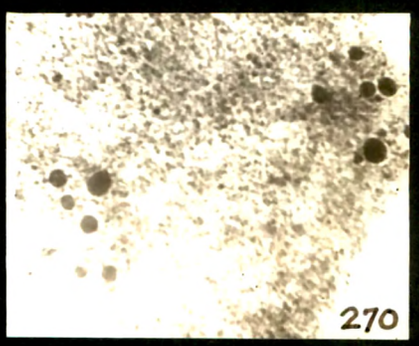
Fig. 270. " " micronucleii at telophase I (Coll. No. 46).

Fig. 271. " " grouping of chromosomes at metaphase II (Coll. No. 47).

Fig. 272. " " anaphase II (Coll. No. 47).

Fig. 273. " " 5 nucleii at telophase II (Coll. No. 47).


269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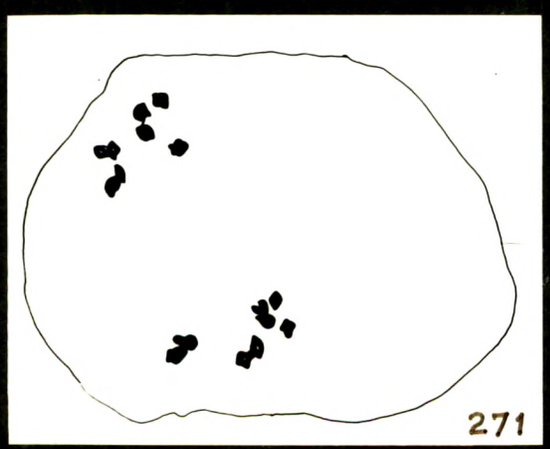
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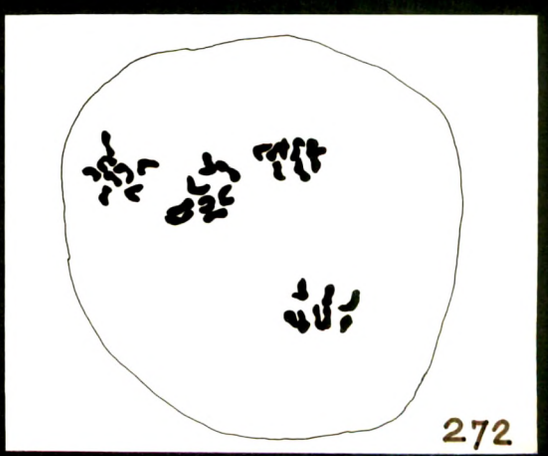
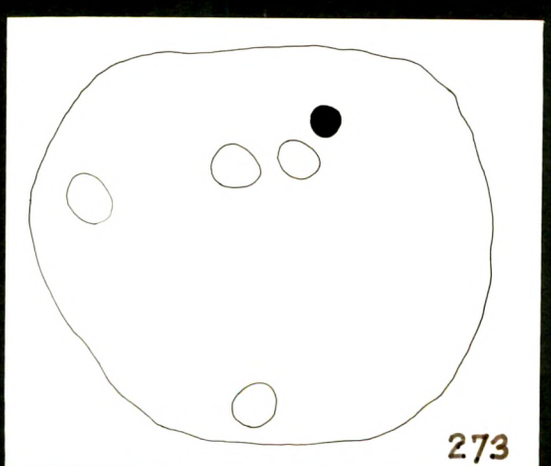

272


273

Observed as a weed in cultivated fields and also on open places in the forests.

Earlier reports of n = 8 (Sareen and Singh, 1975) and 2n = 16 (Bhatt, 1974) are confirmed in the present investigation.

Coll. Nos. 46, 47, 72 and 88.

Karyotype formulae : 2n = 16 = $D_4+F_8+F_2^S+F_2^{S'}$=48.12 μ (Figs. 265 and 266).

The complement consists of 2 pairs of chromosomes with nearly median (D-type) and 6 pairs are with nearly submedian (F-type) centromeres. Satellites (F^S-type) and secondary constrictions ($F^{S'}$-type) are observed on 2 pairs of nearly submedian types of chromosomes. The chromosomes are medium sized, the length ranges from 3.40 μ to 2.37 μ, with a mean length of 3.00 μ. The karyotype is asymmetrical as the TF% is 34.91.

During meiosis, 8 bivalents at metaphase I (Fig. 267) and their equal distribution at anaphase I (Fig. 268) are observed. However, abnormal orientation of bivalents at metaphase I (Fig. 269), micronucleii at telophase I (Fig. 270), grouping of chromosomes at metaphase II (Fig. 271) and formation of 5 nucleii at telophase II (Fig. 273) have been recorded in few PMCs. 86.53% is the pollen fertility determined for the species.

Alysicarpus wallichii Complex

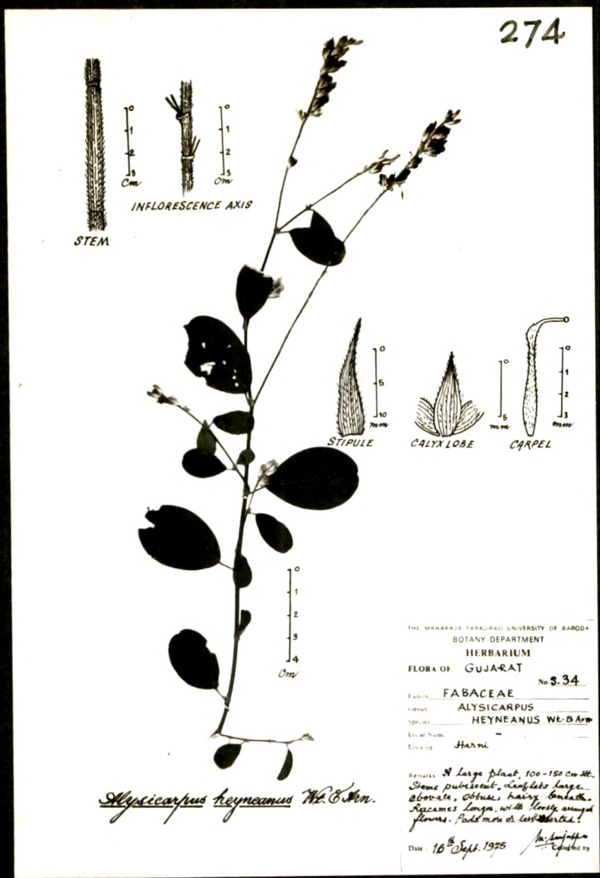
De Candolle (1828) described two species of Alysicarpus viz. A. styracifolius and A. rugosus having deeply jointed pods and joints closely transversely rugose. Wight and Arnott (1834) retained A. styracifolius of de Candolle and described A. wallichii and A. heyneanus having similar pod characters. Baker (1876) considered all these species as varieties of A. rugosus DC. Sedgwick (1919) retained A. rugosus DC. and raised all the varieties to the species level.

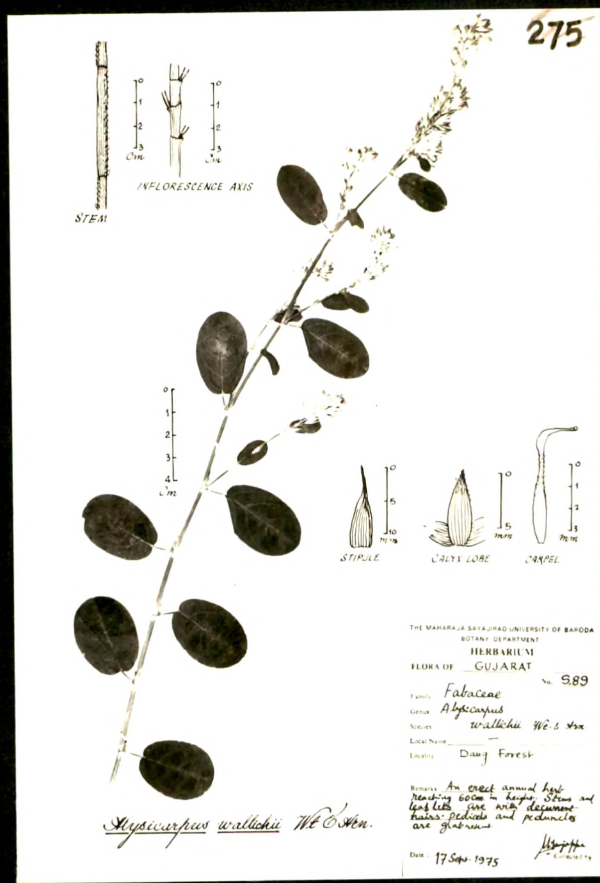
A. rugosus DC. and A. wallichii Wt. & Arn. are not conspecific and have clear geographical distribution. A. rugosus DC. is an African element and the Indian plants are referrable to A. wallichii and not to A. rugosus DC. (Sensu Cooke) (Polhill - personal communication dated 12th March, 1976). Further in his opinion, the different varieties of A. rugosus DC. (Sensu Cooke) represent variables within the limits of A. wallichii Wt. & Arn. The detailed morphological (Fig. 277) and cytological (Table 93) studies on various populations of these presented in the thesis, do not lend support to Polhill's contention. Sedgwick's treatment of the complex is, however, apparently more acceptable. The 3 recognized species within the complex are A. heyneanus, A. wallichii and A. styracifolius.

Fig. 274. Herbarium of *A. heyneanus*.

Fig. 275. Herbarium of *A. wallichii*.

Fig. 276. Herbarium of *A. styracifolius*.


274
STEM
INFLORESCENCE AXIS
STIPULE
CALYX LOBE
CARPEL
THE MAHARAJA SAYAJIRAO UNIVERSITY OF BARODA
BOTANY DEPARTMENT
HERBARIUM
FLORA OF GUJARAT
No. S.34
Family FABACEAE
Genus ALYSICARPUS
Species HEYNEANUS Wt. & Arn.
Local Name –
Locality Harni
Date 16th Sept. 1975
Collected by
Alysicarpus heyneanus Wt. & Arn.


275
STEM
INFLORESCENCE AXIS
STIPULE
CALYX LOBE
CARPEL
THE MAHARAJA SAYAJIRAO UNIVERSITY OF BARODA
BOTANY DEPARTMENT
HERBARIUM
FLORA OF GUJARAT
No. S.89
Family Fabaceae
Genus Alysicarpus
Species wallichii Wt. & Arn.
Local Name –
Locality Dang Forest
Remarks An erect annual herb reaching 60 cm in height. Stems and leaflets are with decurrent hairs. Pedicels and peduncles are glabrous
Date 17 Sept. 1975
Collected by
Alysicarpus wallichii Wt. & Arn.

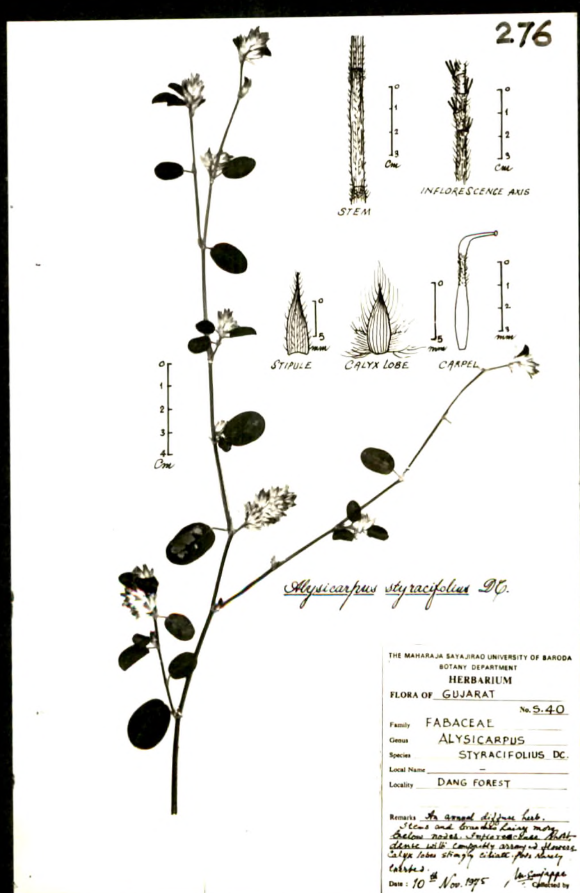
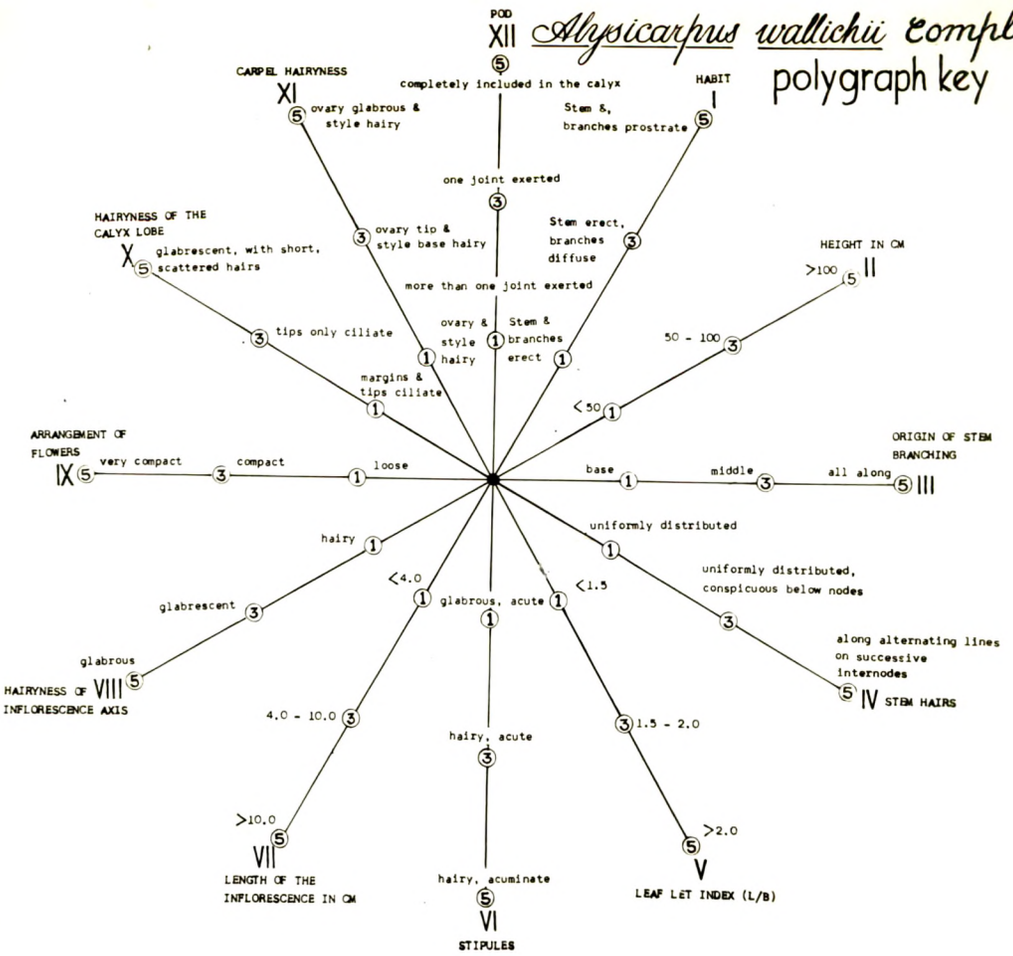
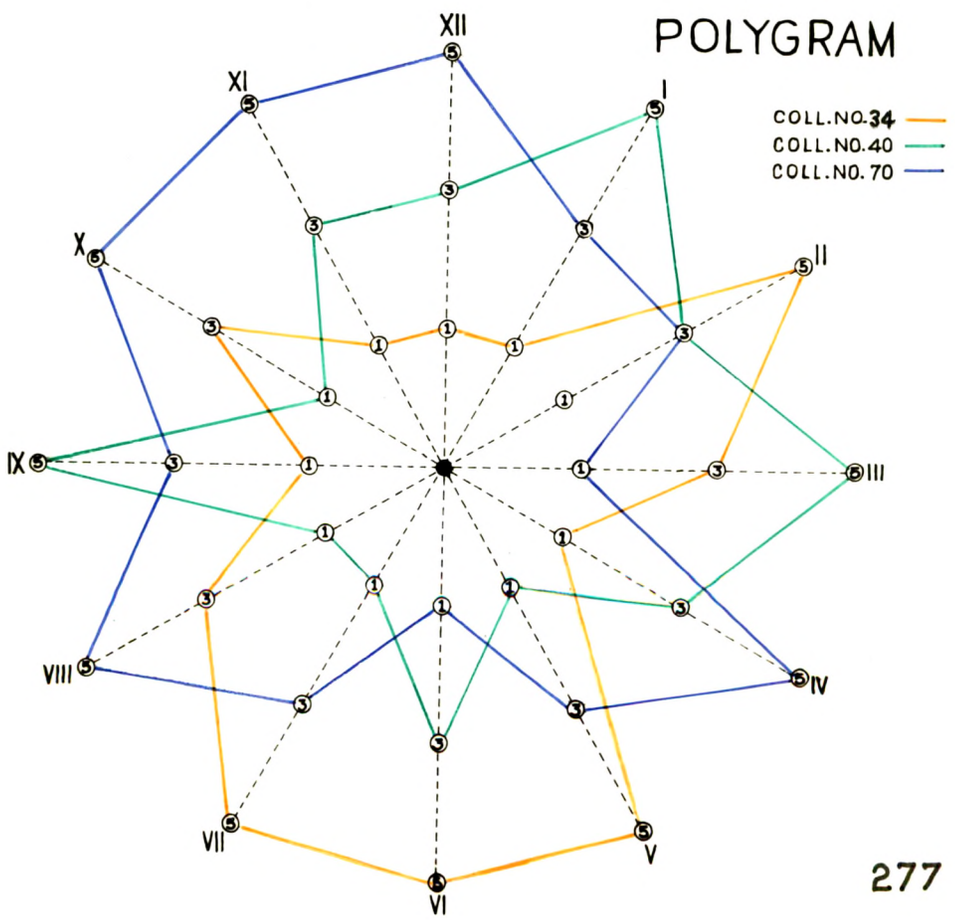

276
STEM
INFLORESCENCE AXIS
STIPULE
CALYX LOBE
CARPEL
Alysicarpus styracifolius DC.
THE MAHARAJA SAYAJIRAO UNIVERSITY OF BARODA
BOTANY DEPARTMENT
HERBARIUM
FLORA OF GUJARAT
No. S.40
Family FABACEAE
Genus ALYSICARPUS
Species STYRACIFOLIUS DC.
Local Name –
Locality DANG FOREST
Date : 10th Nov. 1975
Collected by

Fig. 277. Polygraph key and polygram of different populations of *A. wallichii* Complex.

Alysicarpus wallichii complex
polygraph key





Key to the species of *Alysicarpus wallichii* Complex

1. An erect herb, 150-200 cm high; branches uniformly hairy; racemes long with loosely arranged flowers; pod joints more or less exerted..*A. heyneanus*

1. An erect or procumbent herb, 50-80 cm high; branches uniformly hairy above; racemes dense with compactly arranged flowers, pod joints more or less included :

   2. Branches glabrous, except for alternating lines of appressed ascending hairs on successive internodes .....*A. wallichii*

   2. Branches uniformly hairy, conspicuous below nodes .....*A. styracifolius*

Alysicarpus heyneanus Wt. & Arn., Prodr. 1 : 234, 1834; Sedgwick, J. Indian Bot. Soc. 1 : 14-18, 1919.

A. rugosus var. *heyneanus* Bak., FBI. 2 : 159, 1876; Cooke, 1 : 371, 1902; Gamble, 1 : 239, 1935; Duthei, 1 : 256, 1960; Hains, 1 : 270, 1961; Prain, 1 : 307, 1963.

An erect herb. Stems and branches robust, pubescent. Leaflets large, ovate-oblong to obovate, obtuse to mucronulate,

thickly hairy beneath when young; stipules longer than petioles lanceolate, acuminate, hairy. Racemes terminal or leaf-opposed, long, rachis glabrescent with loosely arranged flowers. Calyx lobes long, striate, lanceolate, subacute, glabrous except for few long hairs at the tip. Ovary and style hairy. Pods 3-5, jointed, joints of the pod more or less exerted, joints black when ripe, broader than long. Seeds yellow to reddish brown in colour (Fl. Fr. September - October) S. 34, 68.

Common along the cultivated fields.

The haploid number n = 8 reported by Sareen and Singh (1975) is confirmed in the present study. The diploid number 2n = 16 determined for the species is the first report.

Coll. No. 34, 68

Karyotype formulae : 2n = 16 = $F_{10}+G_2+H_2+H_2^S$=36.20 μ (Figs. 278 and 279).

The karyotype shows nearly median centromeres (G-type) on 1 pair and nearly submedian (F and H - types) on 7 pairs of chromosomes. One pair of nearly submedian chromosomes (H^S-type) are with satellites. The chromosomes in the complement are medium to short sized. The length ranges from 3.01 μ to 1.72 μ,

Table 84. Measurements of somatic chromosomes of *A. heyneanus* Wt. & Arn. (Coll. No. 34).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	1.53+1.48=3.01	100.00	0.96	1.03	nm	D
3, 4	1.78+0.85=2.63	90.69	0.45	2.21	nsm	F
5, 6	1.61+0.93=2.54	84.38	0.57	1.73	nsm	F
7, 8	1.53+0.85=2.38	79.06	0.55	1.80	nsm	F
9, 10	1.36+0.76=2.12	70.43	0.55	1.80	nsm	F
11, 12	1.36+0.63=1.99	66.11	0.46	2.15	nsm	H
13, 14	1.06+0.68=1.74	57.80	0.64	1.55	nm	G
15, 16	1.13+0.59=1.72	56.14	0.55	1.78	nsm	H^S

A. heyneanus

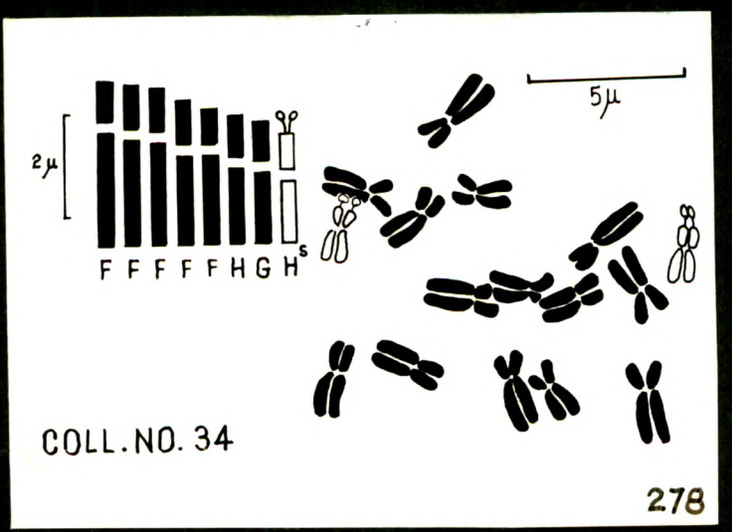
Fig. 278. Camera lucida drawing of somatic metaphase and idiogram.

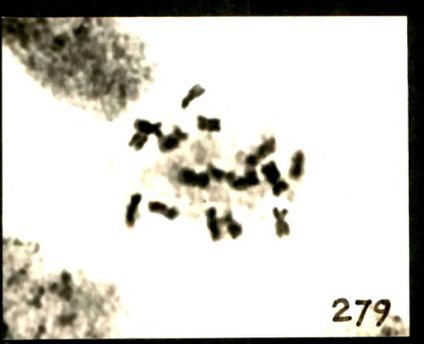
Fig. 279. Photomicrograph of somatic metaphase.

Fig. 280. PMC showing 8 bivalents at metaphase I (polar view) (Coll. No. 34).

Fig. 281. " " equal distribution at anaphase I (Coll. No. 68).

Fig. 282. " " univalents (↑) at diakinesis (Coll. No. 34).


2μ
F F F F F H G H s
5μ
COLL. NO. 34
278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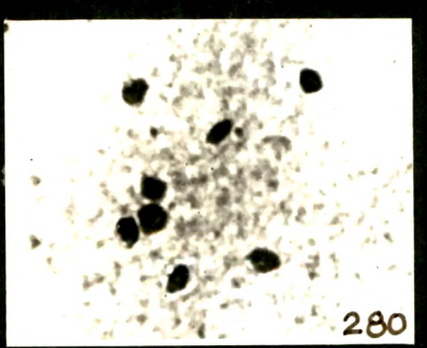
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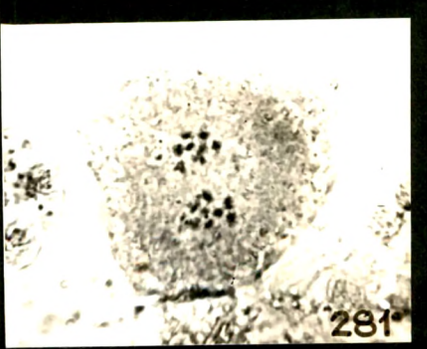
281


282

with a mean length of 2.26 μ. The karyotype is asymmetrical as the TF% and L/S are 37.41 and 1.78 respectively.

Meiosis is regular showing 8 bivalents at metaphase I (Fig. 280). However, some of the PMCs showed univalents at diakinesis (Fig. 282) and irregular distribution at anaphase I (Fig. 281). The pollen fertility determined for the species is 93%.

Alysicarpus wallichii Wt. & Arn., Prodr. 1 : 234, 1834; Sedgwick, J. Indian Bot. Soc. 1 : 14-18, 1919.

A. rugosus DC., Prodr. 2 : 353, 1825; FBI. 2 : 159, 1876; Cooke, 1 : 371, 1902, Gamble, 1 : 239, 1935; Duthei, 1 : 256, 1960; Hains, 1 : 275, 1961; Prain, 1 : 307, 1963.

An erect herb. Stem and branches glabrous except for alternating lines of appressed ascending hairs on successive internodes. Leaves 1-foliolate, leaflets ovate-oblong, subacute, base cordate, hairy on the veins beneath; stipules longer than petioles, lanceolate, acute, glabrous. Racemes terminal, dense in flowering, more or less elongating in fruit, rachis glabrous. Calyx lobes oblong-lanceolate, glabrescent with scattered hairs. Ovary glabrous and style hairy. Pods 4-5 jointed, broader than long, included in the calyx, blackish straw coloured when ripe. Seeds reddish brown in colour (Fl. Fr. September - December). S. 69, 70, 71, 81, 89, 90.

Commonly observed in open places in forest among grasses.

Coll. No. 69.

Karyotype formulae : 2n = 16 = $B_8+D_4+F_2^S+F_2^{S'}$=64.18 μ (Figs. 283 and 284).

The karyotype shows 2 pairs of chromosomes with nearly median (D-type) and 6 pairs with nearly submedian centromeres (B and F - types). Among the nearly submedian chromosomes one pair is with satellites (F^S-type) and another pair is with secondary constrictions ($F^{S'}$-type). The chromosomes are long, medium and short sized, the length varies from 5.18 μ to 3.14 μ, with a mean length of 4.00 μ. The karyotype is asymmetrical as the TF% is 33.31.

Coll. No. 70.

Karyotype formulae : 2n = 16 = $D_2^{S'}+F_{14}$=44.34 μ (Figs. 285 and 286).

The chromosomes in the complement show nearly median centromeres (D-type) on 1 pair and nearly submedian (F-type) on 7 pairs. One pair of nearly median chromosomes ($D^{S'}$-type) are with secondary constrictions on long arms. The chromosomes are medium sized, the length ranges from 3.23 μ to 2.25 μ, with a mean length of 2.77 μ. The karyotype is asymmetrical as the TF% is 34.73.

Table 85. Measurements of somatic chromosomes of *A. wallichii* Wt. & Arn. (Coll. No. 69).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	3.65+1.53=5.18	100.00	0.41	2.38	nsm	B
3, 4	3.57+1.10=4.67	90.15	0.30	3.24	nsm	B
5, 6	2.63+1.53=4.16	80.30	0.58	1.71	nsm	B
7, 8	2.63+1.44=4.07	78.57	0.54	1.82	nsm	B
9, 10	0.68+1.70+1.27=3.65	70.46	0.53	1.87	nsm	$F^{S'}$
11, 12	2.55+1.10=3.65	70.46	0.43	2.31	nsm	F^{S}
13, 14	2.04+1.53=3.57	68.91	0.75	1.33	nm	D
15, 16	1.95+1.19=3.14	60.61	0.61	1.63	nm	D

Table 86. Measurements of somatic chromosomes of *A. wallichii* Wt. & Arn. (Coll. No. 70).

Chromosome pair	Length in u	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	2.21+1.02=3.23	100.00	0.46	2.17	nsm	F
3, 4	1.96+1.02=2.98	92.26	0.52	1.92	nsm	F
5, 6	1.87+1.02=2.89	89.47	0.55	1.83	nsm	F
7, 8	0.60+0.94+1.28=2.82	87.31	0.83	1.20	nm	$D^{S'}$
9, 10	1.96+0.85=2.81	87.00	0.43	2.31	nsm	F
11, 12	1.87+0.94=2.81	87.00	0.50	2.00	nsm	F
13, 14	1.53+0.85=2.38	73.68	0.56	1.80	nsm	F
15, 16	1.53+0.72=2.25	69.66	0.47	2.13	nsm	F

A. wallichii

Fig. 283. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 284. Photomicrograph of somatic metaphase.

Fig. 285. Camera lucida drawing of somatic metaphase.

Fig. 286. Photomicrograph of somatic metaphase.

Fig. 287. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 288. Photomicrograph of somatic metaphase.

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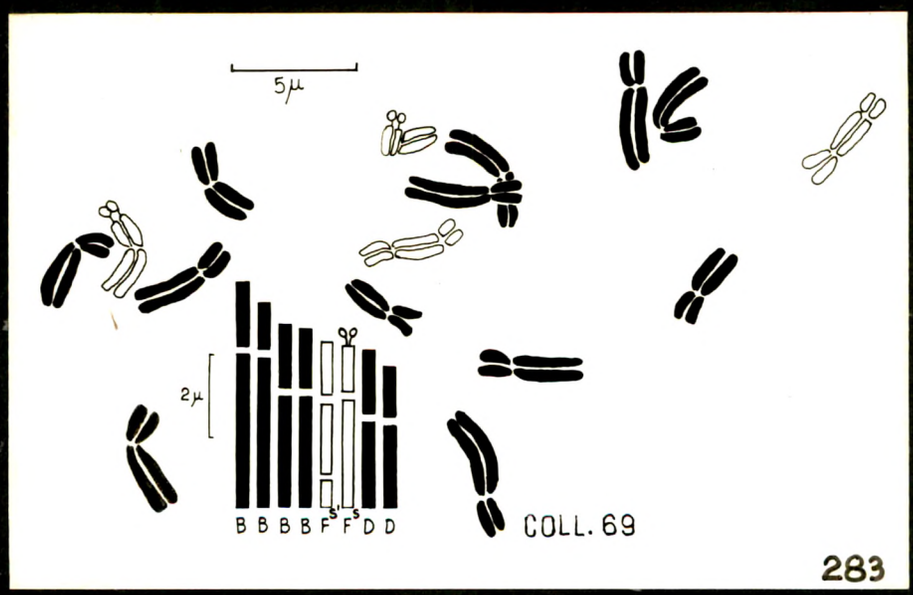
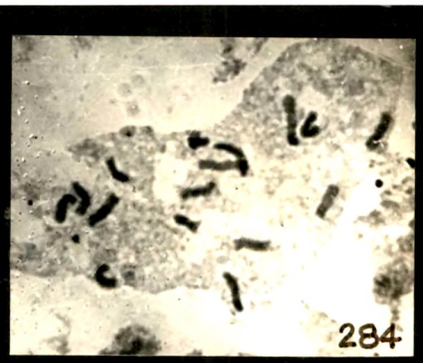

5μ
2μ
B B B B F S F S D D
COLL. 69
283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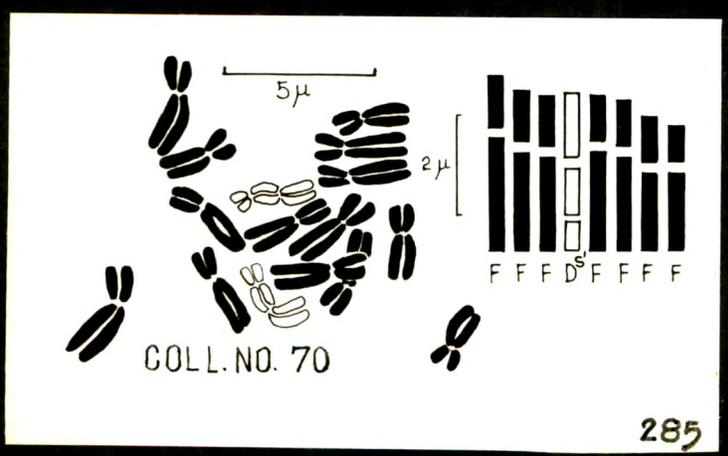
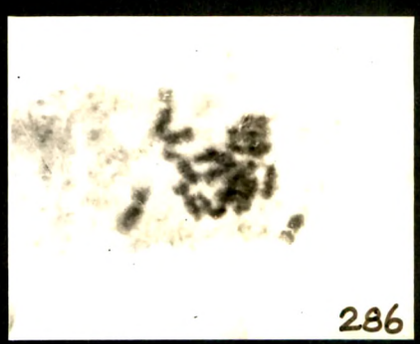

5μ
2μ
F F F D S F F F F
COLL. NO. 70
285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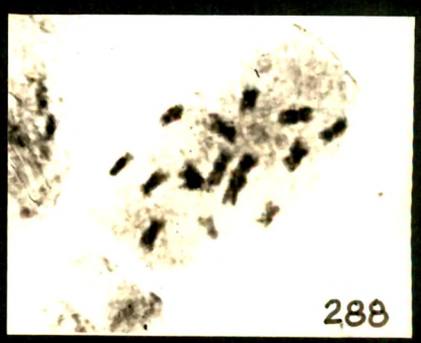
5μ
2μ
D S F F F F F G G
COLL. NO. 71
287


288

Coll. Nos. 71, 81.

Karyotype formulae : 2n = 16 = $D_2^{S'}+F_{10}+G_4$=36.46 μ (Figs. 287 and 288).

The karyotype consists of 3 pairs of chromosomes with nearly median ($D^{S'}$- and G - types) and 5 pairs with nearly submedian centromeres (F-type). One pair of nearly median chromosomes ($D^{S'}$-type) are with secondary constrictions on long arms. The chromosomes in the complement are medium to short sized, the length ranges from 2.90 μ to 1.79 μ, with a mean length of 2.28 μ. The karyotype is apparently asymmetrical as the TF% is 36.48.

Coll. Nos. 89 and 90.

Karyotype formulae : 2n = 16 = $D_8+F_6+F_2^S$=44.52 μ (Figs. 289 and 290).

The karyotype includes equal number of chromosomes with nearly median (D-type) and nearly submedian centromeres (F-type). One pair of nearly submedian chromosomes (F^S-type) are with satellites. The chromosomes in the complement are medium sized, the length ranges from 3.40 μ to 2.20 μ, with a mean length of 2.78 μ. The karyotype is asymmetrical as the TF% is 34.77.

Table 87. Measurements of somatic chromosomes of *A. wallichii* Wt. & Arn. (Coll. No. 71).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	0.60+0.94+1.36=2.90	100.00	0.88	1.13	nm	$D^{S'}$
3, 4	1.87+0.77=2.64	91.03	0.41	2.43	nsm	F
5, 6	1.53+0.85=2.38	82.07	0.56	1.80	nsm	F
7, 8	1.62+0.68=2.30	79.31	0.42	2.38	nsm	F
9, 10	1.36+0.77=2.13	73.45	0.57	1.77	nsm	F
11, 12	1.36+0.77=2.13	73.45	0.57	1.77	nsm	F
13, 14	1.19+0.77=1.96	67.59	0.65	1.55	nm	G
15, 16	1.11+0.68=1.79	61.72	0.61	1.63	nm	G

Table 88. Measurements of somatic chromosomes of *A. wallichii* Wt. & Arn. (Coll. No. 89).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	2.55+0.85=3.40	100.00	0.44	3.00	nsm	F
3, 4	2.04+1.02=3.06	90.00	0.44	3.00	nsm	F
5, 6	1.87+1.19=3.06	90.00	0.50	2.00	nsm	F
7, 8	1.78+1.12=2.90	85.29	0.63	1.57	nsm	F
9, 10	1.61+1.02=2.63	77.35	0.62	1.58	nm	D
11, 12	1.70+0.85=2.55	75.00	0.63	1.57	nsm	F^S
13, 14	1.70+0.76=2.46	72.35	0.50	2.00	nsm	F
15, 16	1.27+0.93=2.20	64.70	0.73	1.36	nsm	F

A. wallichii Contd.....

Fig. 289. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 290. Photomicrograph of somatic metaphase.

Fig. 291. PMC showing 8 bivalents at diakinesis (Coll. No. 69).

Fig. 292. " " 8 bivalents at metaphase I (Coll. No. 71).

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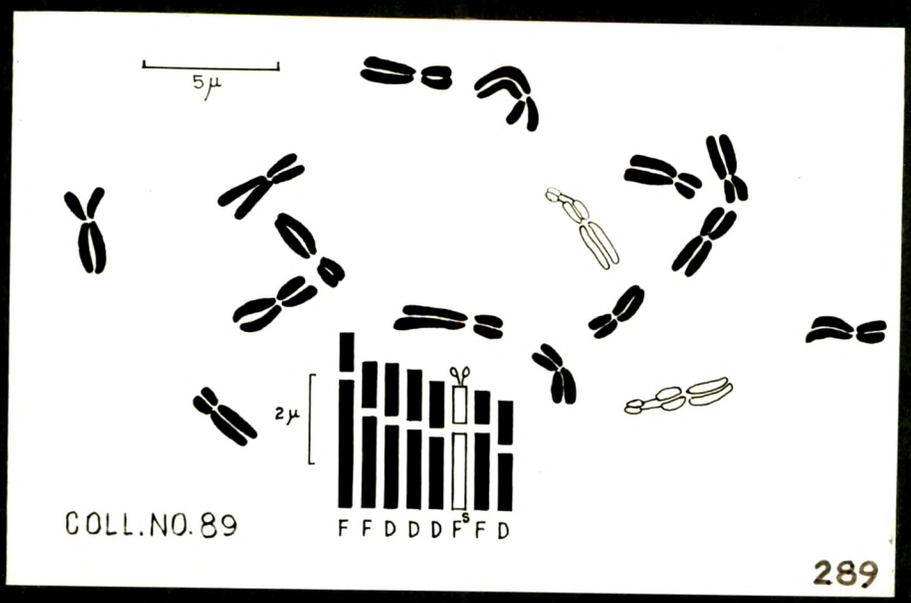
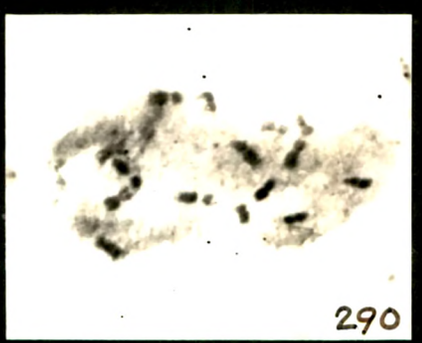

5μ
2μ
COLL. NO. 89
F F D D D F S F D
289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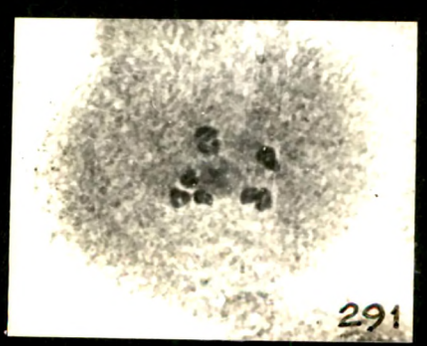
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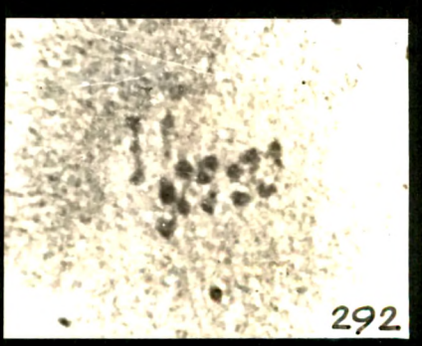

292

A. wallichii Contd.....

Fig. 293. PMC showing non-congressional bivalents metaphase I (Coll. No. 89).

Fig. 294. " " anaphase I (Coll. No. 81).

Fig. 295. PMCs showing cytomixis at telophase I.

Fig. 296. PMC showing abnormal orientation of chromosomes at metaphase II (Coll. No. 70).

Fig. 297. " " non-synchronised movement at anaphase II (Coll. No. 70).

Fig. 298. " " telophase II (Coll. No. 89).

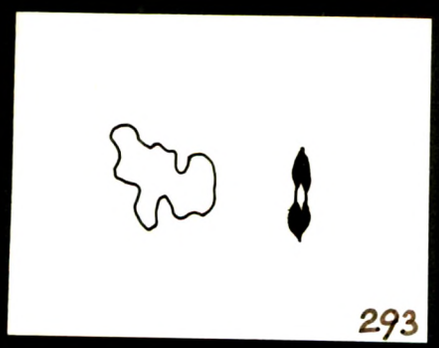
Fig. 299. " " micronucleii at telophase II (Coll. No. 89).

Fig. 300. " " 5 groups of chromosomes at telophase II (Coll. No. 89).

Table 89.

Comparision of somatic chromosomes of different populations of A. wallichii W. & A.

Populations	Somatic number (2n)	nm Types D	nm Types G	nsm Types B	nsm Types F	Chromosomes with SATs F^S	Chromosomes with sec. const. Types $D^{S'}$	Chromosomes with sec. const. Types $F^{S'}$	Absolute length (in μ)	Mean length (in μ)	L/S
Coll. No. 69	16	4	-	8	4	2	-	2	64.18	4.01	1.64
Coll. No. 70	16	2	-	-	14	-	2	-	44.34	2.77	1.44
Coll. No. 71 and 81	16	2	4	-	10	-	2	-	36.48	2.28	1.62
Coll. Nos. 89 and 90	16	8	-	-	8	2	-	-	44.52	2.78	1.54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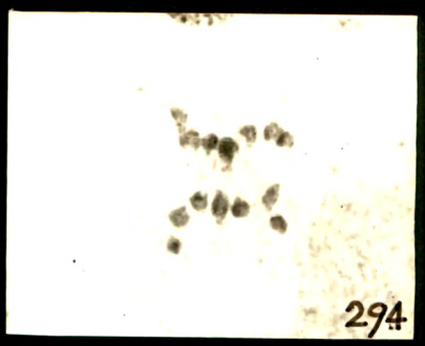
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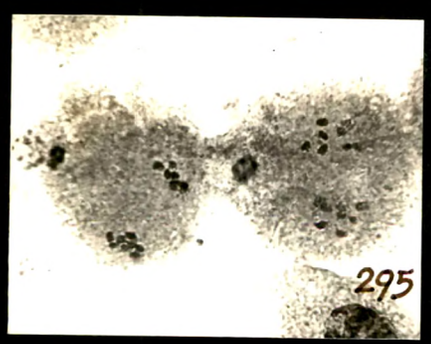
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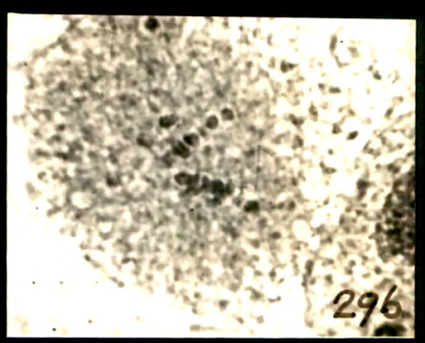
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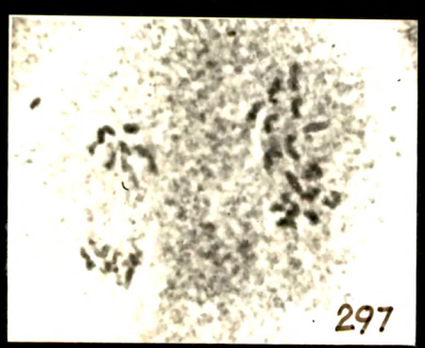
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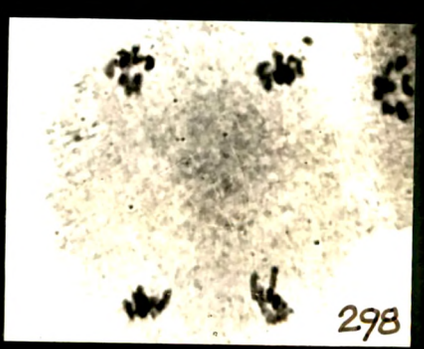
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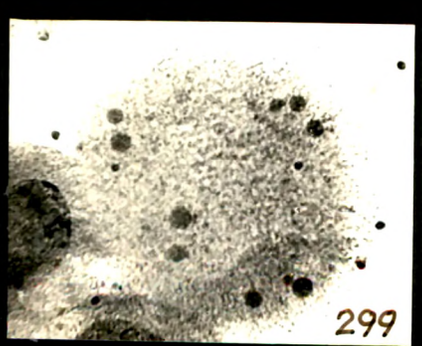
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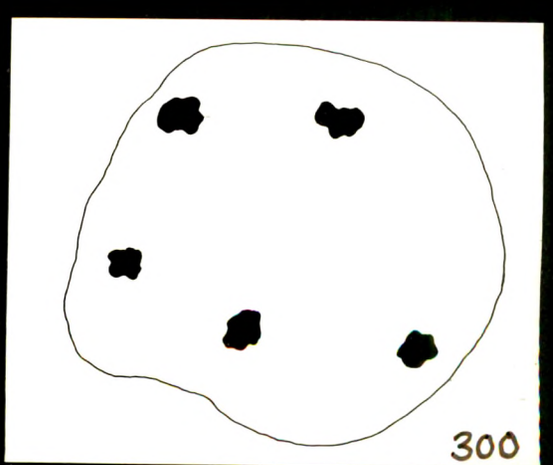

300

The populations collected from different localities showed morphological similarities and karyotypic differences (Table 90), indicating the presence of cytotypes in the species.

During meiosis 8 bivalents are observed at diakinesis, metaphase I and their equal distribution at anaphase I (Figs. 291, 292 and 294). Some of the abnormalities like non-congressional bivalent at metaphase I (Fig. 293), cytomixis at anaphase I (Fig. 295), abnormal orientation of chromosomes at metaphase II (Fig. 296), non-synchronised movement at anaphase II (Fig. 297), micronucleii and formation of 5 groups of chromosomes at telophase II (Figs. 299 and 300) are recorded. However, these abnormalities did not affect the pollen fertility, as they occur in low percentage. The pollen fertility determined for the species is 89%.

Alysicarpus styracifolius DC., Prodr. 2 : 353, 1825; Wt. & Arn. Prodr. 1 : 234, 1834; Sedgwick, J. Indian Bot. Soc. 1 : 14-18, 1919.

A. rugosus var. styracifolius Bak., FBI. 2 : 159, 1876; Cooke, 1 : 371, 1902; Gamble, 1 : 239, 1935; Duthei, 1 : 257, 1960; Hains, 1 : 275, 1961; Prain, 1 : 307, 1963.

A procumbent herb. Stem and branches pubescent, conspicuously more hairy below the nodes. Leaves 1-foliolate,

leaflets ovate-oblong, subacute to obtuse,mucronulate, base cordate, glabrous above and thickly hairy on the veins beneath; stipules longer, lanceolate, ciliate on the margins. Racemes terminal or leaf-opposed, short, very compact, rachis thickly covered with long white hairs. Calyx lobes lanceolate, glabrous on the back, plumose-ciliated along the margins. Ovary tip and style base hairy. Pods more or less included in the calyx except for one joint, joints blackish straw coloured when ripe. Seeds reddish brown in colour (Fl. Fr. November - December) S. 40, 41, 42.

Very common, in cultivated fields and among grasses in open places.

The chromosome numbers n = 8 and 2n = 16 determined for the species are the first reports. All the three collections studied showed similar karyotypes.

Coll. Nos. 40, 41, 42.

Karyotype formulae : 2n = 16 = $B_2+F_{10}+F^{S}_{2}+G_2$=48.46 μ (Figs. 301 and 302).

The karyotype consists of nearly median centromeres (G-type) on 1 pair and nearly submedian (B and F - types) on 7 pairs of chromosomes. One pair of nearly submedian chromosomes (F-type) are with satellites. The chromosomes in the complement

Table 90. Measurements of somatic chromosomes of *A. styracifolius* DC. (Coll. No. 40).

Chromosome pair	Length in μ	Relative length	Arm Ratios R_1	Arm Ratios R_2	Centromere	Type
1, 2	3.14+0.93=4.07	100.00	0.30	3.38	nsm	B
3, 4	2.55+1.36=3.91	96.07	0.53	1.88	nsm	F
5, 6	2.55+0.93=3.48	85.50	0.36	2.74	nsm	F
7, 8	2.21+1.02=3.23	79.36	0.46	2.17	nsm	F^S
9, 10	2.12+1.10=3.22	71.12	0.52	1.93	nsm	F
11, 12	1.44+0.85=2.29	56.27	0.59	1.69	nsm	F
13, 14	1.36+0.68=2.04	50.12	0.50	2.00	nsm	F
15, 16	1.19+0.80=1.99	48.89	0.67	1.49	nm	G

A. styracifolius

Fig. 301. Camera lucida drawing of somatic metaphase and idiogram.

Fig. 302. Photomicrograph of somatic metaphase.

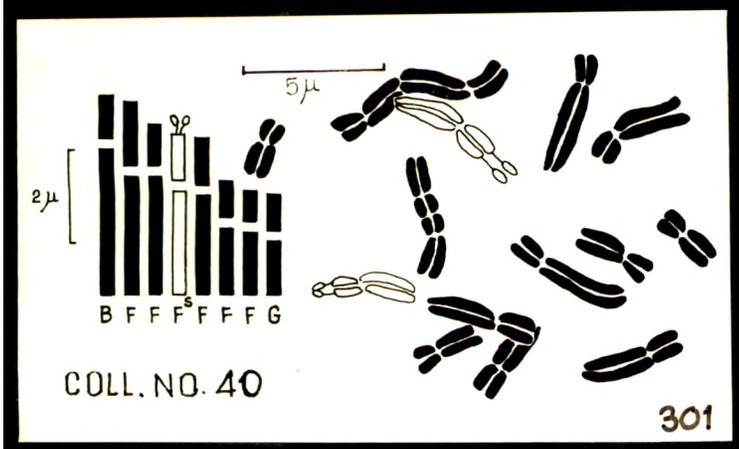
Fig. 303. PMC showing 8 bivalents at diakinesis (Coll. No. 40).

Fig. 304. " " association of bivalents at metaphase I (Coll. No. 41).

Fig. 305. " " equal distribution at anaphase I (Coll. No. 40).

Fig. 306. " " grouping of chromosomes at metaphase II (Coll. No. 42).

Fig. 307. " " laggard at anaphase II (Coll. No. 41).



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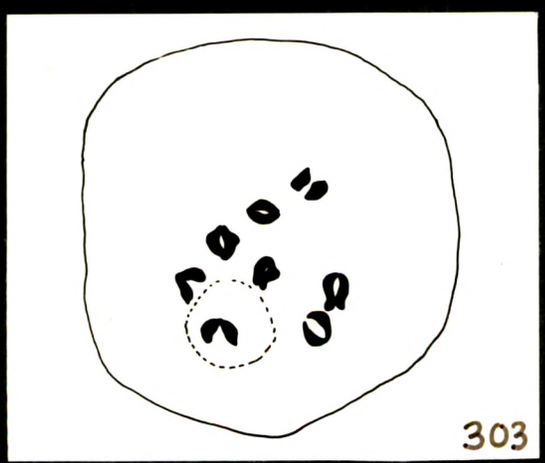
302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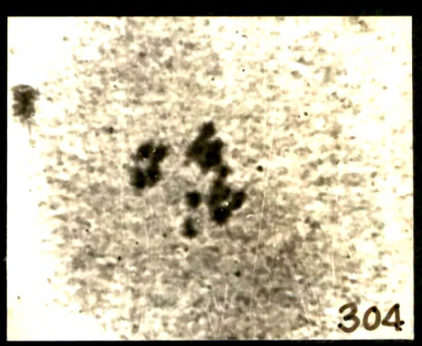
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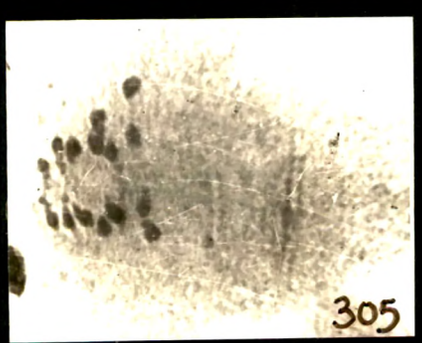
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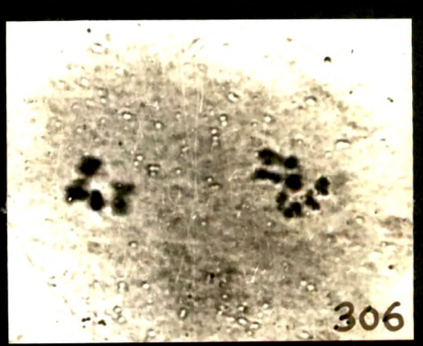
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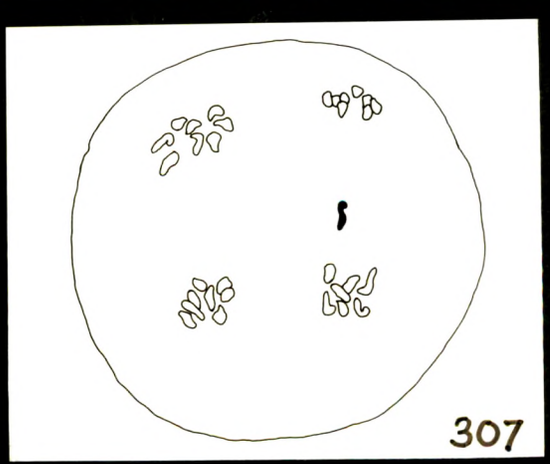
307

range in their length from 4.07 μ to 1.99 μ, with a mean length of 2.91 μ. The karyotype is asymmetrical as the TF% and L/S are 31.65 and 2.05 respectively.

Meiosis is normal showing 8 bivalents at diakinesis and metaphase I (Figs. 303 and 304). Some of the PMCs show precocious movement at anaphase I (Fig. 305), association of chromosomes at metaphase II (Fig. 306) and laggard at anaphase II (Fig. 307). The pollen fertility determined for the species is 89%.

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