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ADDITION TO THE CYTOLOGY OF MONOCOTS FROM DISTRICT KANGRA (H.P.) OF WESTERN HIMALAYAS, INDIA

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ABSTRACT

At present, the meiotic/varied chromosome numbers are reported for 27 species (33 cytotypes) belonging to 24 genera of 5 families of Monocots from district Kangra of Himachal Pradesh in the Western Himalayas. On the basis of the world-wide data, the chromosome counts for the two taxa as Lolium remotum var. aristatum (n=7) and Cymbopogon clandestinus (n=10) have been cytologically worked out for the first time. Seventeen species as Commelina hasskarlii (n=11, 30), C. kurzii (n=30), Murdannia nudiflora (n=12), Cyperus flavidus (n=32), Acrachne racemosa (n=6), Andropogon tristris (n=20), Brachiaria remota (n=16), Chrysopogon serrulatus (n=20), Digitaria granularis (n=36), Isachne albens (n=5), Microstegium vagans (n=20), Panicum antidotale (n=16), Pennisetum lanatum (n=21), P. purpureum (n=21), Pogonatherum crinitum (n=14), Setaria barbata (n=16) and S. homonyma (n=16) make new chromosome counts in the form of additional cytotypes on the world-wide basis. Also, the presence of B-chromosomes in the hexaploid cytotype (n=21+1B) of Avena fatua var. fatua are shown for the first time. To supplement the Indian data, chromosome counts for the ten species as Canna discolor (n=9), Briza minor (n=5), Bromus catharticus (n=21), Echinochloa crus-pavonis (n=27), Paspalum distichum (2n=50), Pennisetum lanatum (n=18), P. purpureum (n=18), Phalaris minor (n=21), Setaria barbata (n=18) and Monochoria vaginalis (n=12) are reported for the first time at India level.

Keywords: Chromosome number, cytotypes, district Kangra, Monocots.

I. INTRODUCTION

As a part of project to explore and evaluate cytomorphological diversity of Angiosperms of Western Himalayas, at present its smaller unit area as district Kangra of Himachal Pradesh has been selected to work out the detailed meiotic studies pertaining to Monocots only. District Kangra is one of the most picturesque valleys in the Himachal Pradesh, a hilly state of Western Himalayas in India. It lies between the range of N latitude 31° 45′ 0″ to 32° 28′ 05″ and E longitude 75° 35′ 34″ to 77° 04′ 46″ and shares its northern boundary with Chamba, north-east with Lahul and Spiti, east with Kullu, south-east with Mandi and south with Una and Hamirpur, other districts of H.P., as well as with other states as south-west with Punjab and north-west with Jammu and Kashmir. Vegetation of this phytogeographical area varies greatly with change in altitude from 500 to 5,500m in the form of scrub, chir, ban-oak and deodar forests. A perusal of literature brings to light that species level taxonomic descriptions of the Monocots of the area are available in different floras but there is hardly any previous

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cytological report of Monocots of this area. To study the genetic intraspecific variability, at present population based meiotic chromosome number studies have been carried out on 450 populations representing 152 species belonging to 52 genera and 11 families of monocotylednous group of Angiosperms. Some of the interesting results of these plants have already been published [1, 2, 3] including new cytological reports on eleven species. In this publication, 27 species are reported to have new /varied chromosome number reports on world-wide basis and India basis, respectively, thereby contributing significantly to the chromosomal database of flowering plants from India in general and the Western Himalayas in particular. All the species have been meiotically investigated for the first time from the studied area i.e. district Kangra (H.P.) to collect the information about their chromosome numbers, course of meiosis, pollen fertility as well as intraspecific variability (reported in 6 species) based on various morphological and /or cytological features. Among all the studied cytotypes, many of them exhibit significant morphological differences. Thus, the new chromosomal data as well as cytomorphological variations studied at present could be definitely of use by the other scientists in the time to come for need based exploitation for various purposes.

II. MATERIALS AND METHODS

For meiotic studies, young spikes were collected on population basis from various localities of district Kangra of Himachal Pradesh. Meiotic studies were carried out through standard smearing technique from young spikes fixed in Carnoy's fixative. Pollen fertility was estimated by mounting mature pollen grains in glycerol-acetocarmine (1:1) mixture. Well-filled pollen grains with stained nuclei were taken as apparently fertile while shrivelled and unstained pollen grains were counted as sterile. Pollen grain size was measured using occulomicrometer. Photomicrographs of pollen mother cells were made from freshly prepared slides using Nikon 80i eclipse Digital Imaging System. Voucher specimens are deposited in the Herbarium, Department of Botany, Punjabi University, Patiala (PUN).

III. RESULTS AND DISCUSSION

Information regarding specific locality with altitude, accession number, habit, present meiotic chromosome number, ploidy level, nature of meiotic course, pollen fertility and pollen size of these species is given in Table 1. The earlier chromosome reports have been compiled from [4], [5], Index to Plant Chromosome Numbers from 1968 onwards, various Journals, Proceeding volumes and internet.

3.1. Family: Cannaceae

3.1.1. *Canna discolor* Lindl.

The single accession of the species has been worked out with n=9 which makes a new chromosomal count on the India basis in conformity with the previous single report [6] from outside India.

3.2. Family: Commelinaceae

3.2.1. *Commelina hasskarlii* C.B.Clarke

Out of the three populations, two are found to have n=11 and the remaining population depicts n=30. Both the cytotypes make new chromosome records on the world-wide basis. The species is previously known to exhibit

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2n=30 [7] from Bangladesh; *2n*=90 [8] from India based on *x*=10 alongwith *2n*=84 [9] from India based on different number as *x*=12.

3.2.2. *C. kurzii* C.B.Clarke

The presently worked out accession of the species from Dharamsala (1,600m) shows meiotic count of *n*=30 which is a new chromosomal record for the species against the earlier reports of *2n*=90, 120 [10] from India.

3.2.3. *Murdannia nudiflora* (L.) Brenan

The chromosome report of *n*=12 makes an additional record for the species on world-wide basis as the species is previously known to exhibit *2n*=20 at diploid level based on *x*=10 [11, 12] from India and outside India, respectively.

3.3. Family: Cyperaceae

3.3.1. *Cyperus flavidus* Vahl

The present cytological work for the species reveals *n*=32 which is reported as a new chromosomal record on the world-wide basis. The species is also known to have other cytotypes from India as *2n*=16 from Western Himalayas [13] and eastern part of India [14]; *2n*=20 from different parts of eastern India [15, 16] and *2n*=72 from Punjab plains [17].

3.4. Family: Poaceae

3.4.1. *Acrachne racemosa* B. Heyne ex Roth Ohwi

This grass species depicts *n*=6 as the first time reported cytotype on world-wide basis. However, the species is already known to have other cytotypes as *2n*=18 [18] and *2n*=36 [19] from north India.

3.4.2. *Andropogon tristris* Nees ex Hack. (= *A. munroi* C.B. Clarke)

Both the accessions of the species with *n*=20 is being reported as a new tetraploid cytotype on world-wide basis. The species is already known to have *2n*=20 from Central and Eastern Himalayas [20].

3.4.3. *Avena fatua* L. var. *fatua* L.

The meiotic studies in this variety with *n*=21 conforms to the previous reports of *2n*=42 from north India [18]; Texas [21] and Libyan [22] but the presence of 1B-chromosome is first report on the world-wide basis. Earlier, the variety is known to have two other cytotypes as *2n*=14 and *2n*=18 also from the Western Himalayas [23].

3.4.4. *Brachiaria remota* Haines

The single accession of the species with *n*=16 is being reported as a new tetraploid cytotype on world-wide basis. Previously, the species exhibits *2n*=64 [24] based on *x*=8 and *2n*=36 [25] on *x*=9 from India.

3.4.5. *Briza minor* L.

The presently worked out accession of the species shows *n*=5 at diploid level which makes the first chromosomal count on the India basis and is in conformity with the previous reports of *2n*=10 from Extremadura [26] and South Africa [27]. Another diploid cytotype with *2n*=14 based on *x*=7 is also known from U.S.S.R. [28] and south-western United States & Mexico [29].

3.4.6. *Bromus catharticus* Vahl

All the four populations of the species from different localities reveal *n*=21 at hexaploid level which is reported as a new chromosomal count from India and conforms earlier reports from China [30] and Africa [31]. The species is also known to have two other cytotypes as *2n*=28 from India [32] and *2n*=30 from outside India [33].

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3.4.7. *Chrysopogon serrulatus* Trin.

Two populations of the species have been cytologically worked out at present. The first population from Dehra (650m) reveals *n*=10 at diploid level conforming to the previous reports of *2n*=20 from India [34] as well as from Pakistan [35]. The second population from Dyot (2,800m) exhibits *n*=20 making a new chromosomal record for the species on the world-wide basis. The species also exhibit *2n*=20 and *2n*=80 from Pakistan [36]. Thus, species show intraspecific polyploidy in the form of *2x*, *4x*, *8x* races based on *x*=10.

3.4.8. *Cymbopogon clandestinus* Stapf

The species has been cytologically studied for the first time on the world-wide basis which is distributed in India & Indo-china and it exhibits the chromosome count of *n*=10 at diploid level.

3.4.9. *Digitaria granularis* Trin. Henrard

The meiotic studies of all the five populations show *n*=36 making an additional chromosomal report for the species on the world-wide basis. The species is already known to have many reports of *2n*=36 from India [37] as well as single report from Thailand [38].

3.4.10. *Echinochloa crus-pavonis* (Kunth) Schult.

Both the populations of the species exhibit *n*=27 which makes new chromosomal count on India basis and is in conformity with the earlier single report [39] from east Africa. The species also has *2n*=18 [40] from Nigeria and *2n*=36 by various researchers from China [41] and Sudamericanas [42].

3.4.11. *Isachne albens* Trin.

The present report of cytological studies of the species show meiotic chromosome number *n*=5 for the first time on the world-wide basis. However, the previous reports exhibit *2n*=20 from Thailand [38]; *2n*=40 [20, 43] from Himalayan regions and Punjab plains respectively; *2n*=60 from north-eastern India [44], eastern India [45] and Taiwan [46]. The report of *x*=5 seems to be derived from *x*=10 through reduction or if we take *x*=5 is basic diploid then the cytotypes with *2n*=20, 40 & 60 will become *4x*, *8x*, *12x*.

3.4.12. *Lolium remotum* Schrank var. *aristatum* Döll Asch.

The variety of the species is cytologically worked out for the first time showing *n*=7 at diploid level. The meiotic studies of the species show *n*=7 which conforms to the previous reports of *2n*=14 from India [47] as well as from Poland [48] and Bulgaria [49]. However, at the variety level not even single cytological report is available.

3.4.13. *Microstegium vagans* (Nees ex Steud.) Hand.-Mazz.

The species exhibit *n*=20 for the first time. Previously, the species is known to have different cytotypes from India only, as *2n*=20 from western part of India [50]; *2n*=60+2-4B [51]; *2n*=60 [45, 52] from eastern India and *2n*=80 again from eastern India [53].

3.4.14. *Panicum antidotale* Retz.

The meiotic studies depict *n*=16 at tetraploid level based on *x*=8 which makes a new chromosomal count for the species. Previously, it is also known to have different cytotypes based on different base numbers as *2n*=28 on *x*=7 [54] from Punjab plains; *2n*=18 on *x*=9 from eastern India [55] and from Western Himalays in India [56] as well as outside India [35, 57] and *2n*=36 [58] from India.

3.4.15. *Paspalum distichum* L.

Both the populations of the species reported to have *2n*=50 in conformity with the previous single report [59] but makes a new chromosomal report on India basis. Previously, the species is also known to have *2n*=20 [60]

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from outside India; *2n*=40 from India [61] as well as outside India [59, 62]; *2n*=52, 54, 57, 58 [59] from outside India; *2n*=61 [63] from India and *2n*=120 [64] from outside India.

3.4.16. *Pennisetum lanatum* Klotzsch

At present, four populations of the species have been cytologically worked out. Two populations exhibit *n*=18 based on *x*=9 whereas other two depict *n*=21 based on *x*=7. The chromosome count of *n*=18 conforms to the earlier single report of *2n*=36 [35] from Pakistan. The report of *n*=18 is new report from India whereas the one with *n*=21 is new chromosome report at world level. The species also exhibits lower number *2n*=18 from Western Himalaya [23].

3.4.17. *P. purpureum* Schumach.

The meiotic studies have been made on four populations of the species. One population is found to have *n*=21 which is a new chromosomal report for the species on world-wide basis. However, other three populations show *n*=18 which is reported for the first time from India and is in conformity with the *2n*=36 [65] from Nigeria. The species is previously reported to have other cytotypes mostly from different parts of India as *2n*=14 [18]; *2n*=21 [66]; *2n*=27 [67]; *2n*=28 [55, 68]; *2n*=54 [69] and *2n*=56 [69, 70]. Thus, the species shows the intraspecific polyploid races on *x*=7 (*2n*=*2x*, *3x*, *4x*, *6x*, *8x*) and *x*=9 (*3x*, *6x*).

3.4.18. *Phalaris minor* Retz.

The present chromosome count of *n*=21 representing a new cytotype for this species from India is in agreement with earlier report [71] from Africa. The species is also known to exhibit *2n*=14 from South Africa [72, 73]; *2n*=28 from India with [74] or without [55] B-chromosomes and also from outside India [73, 75] as well as *2n*=56 [76] from outside India.

3.4.19. *Pogonatherum crinitum* Kunth

For this species, meiotic studies have been made on the three populations, out of which two are found to have *n*=10 conforming to the common reports of *2n*=20 from India [45, 77] and outside India [60]. The remaining one population shows *n*=14 based on *x*=7 making a new report of tetraploid cytotype on the world-wide basis.

3.4.20. *Setaria barbata* Lam. Kunth

Out of the three populations, the first one exhibits, *n*=16 which make a first record of tetraploid cytotype for the species. Another two populations show chromosome count of *n*=18 that is reported for the first time from India confirming the earlier report [40] from Nigeria. The species also has *2n*=54 commonly found from outside India [78] and single report from India [79] along with another report of *2n*=56 from India only [80].

3.4.21. *S. homonyma* Chiov.

The present chromosome count of *n*=16 based on *x*=8 is the first ever record of tetraploid cytotype for the species. Earlier it is known to have other cytotypes with *2n*=18 [81] and *2n*=36 [20] based on *x*=9 and *2n*=20 [81] based on *x*=10.

3.5. Family: Pontederiaceae

3.5.1. *Monochoria vaginalis* Kunth

The presently worked out populations for the species show *n*=12 for the first time on India basis and conforms to the previous single report [82] from Bangladesh**.** The species is already known to have *2n*=26 from Kashmir [83]; *2n*=28 from Taiwan [84]; *2n*=52 from outside India [85]; *2n*=72, 74 [86] and *2n*=80 from eastern Himalaya [87].

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Table 1: Information on taxa with accession number, habit, locality with altitude, present meiotic chromosome number (figure number), ploidy level, meiotic course, pollen fertility and average pollen grain size of the investigated members of Monocots from district Kangra of Himachal Pradesh.

Sr. No.	Taxon* (Accession number --PUN**)	Habit	Locality with Altitude (m)	Meiotic Chromosome Number [Figure Number]	Ploidy Level/ Meiotic course	Pollen Fertility (%)	Pollen grain size (µm)
I	II	III	IV	V	VI	VII	VIII
	FAMILY: CANNACEAE						
1.	***Canna discolor* Lindl.**						
	56402	Herb	Multhan, 2,400m	*n*=9 [Fig. 1A]	*2x*/N	94.32	69.13 × 67.76
	FAMILY: COMMELINACEAE						
2.	***Commelina hasskarlii* C.B.Clarke**						
	P-1 55354	Herb	Chhota Bhangal, 2,000m	*n*=11 [Fig. 1B]	*2x*/N	97.25	26.27 × 19.98
	P-2 55356		Suliali, 500m	*n*=11	*2x*/N	99.40	27.49 × 19.65
	P-3 55355		Bada Gran, 3,500m	*n*=30 [Fig. 1C]	*6x*/N	100.0	26.68 × 21.40
3.	***C. kurzii* C.B.Clarke**						
	56398	Herb	Dharamsala, 1,600m	*n*=30 [Fig. 1D]	*6x*/N	92.8	46.87 × 28.08
4.	***Murdannia nudiflora* (L.) Brenan**						
	P-1 53570	Herb	Chhota Bhangal, 2,000m	*n*=12 [Fig. 1E]	*2x*/N	83.80	48.92 × 35.73
	P-2 53571		Ranehar, 850m	*n*=12	*2x*/N	84.99	47.11 × 32.63
	FAMILY: CYPERACEAE						
5.	***Cyperus flavidus* Vahl**						
	56397	Herb	Multhan, 2,400m	*n*=32 [Fig. 1F]	*4x*/N	73.80	95.72 × 96.39
	FAMILY: POACEAE						
6.	***Acrachne racemosa* B. Heyne ex Roth Ohwi**						
	54750	Herb	Dharamsala, 1,600m	*n*=6 [Fig. 1G]	*2x*/N	98.60	22.89 × 20.15
7.	***Andropogon tristris* Nees ex Hack. = *A. munroi* C.B. Clarke**						
	56395	Herb	Multhan, 2,400m	*n*=20 [Fig. 1H]	*4x*/N	96.44	32.05 × 27.18
	56396		Bada Gran, 3,500m	*n*=20	*4x*/N	98.28	35.91 × 31.37

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8.	***Avena fatua* L. var. *fatua* L.**							
	P-1	52624	Herb	Rehlu, 950m	*n*=21+1B [Fig. 1I]	*6x*/A	37.40	42.21 ± 51.63 × 35.63 ± 44.29
	P-2	55279		Andretta, 1,250m	*n*=21+1B	*6x*/A	43.12	44.16 ± 49.31 × 43.81 ± 47.28
9.	***Brachiaria remota* Haines**							
	53576		Herb	Sakri, 530m	*n*=16 [Fig. 1J]	*4x*/N	95.50	28.56 × 26.84
10.	***Briza minor* L.**							
	54749		Herb	Palampur, 1,563m	*n*=5 [Fig. 1K]	*2x*/N	89.90	26.00 × 22.46
11.	***Bromus catharticus* Vahl**							
	P-1	54742	Herb	Andretta, 1,250m	*n*=21 [Fig. 1L]	*6x*/N	99.40	31.21 × 28.60
	P-2	54767		Palampur, 1,563m	*n*=21	*6x*/N	92.67	31.48 × 29.03
	P-3	54768		Bada Gran, 3,500m	*n*=21	*6x*/N	96.04	33.60 × 28.31
	P-4	54769		Bandla, 1,266m	*n*=21	*6x*/N	85.90	30.61 × 27.72
12.	***Chrysopogon serrulatus* Trin.**							
	P-1	53526	Herb	Dehra, 650m	*n*=10 [Fig. 1M]	*2x*/N	78.65	24.57 × 24.44
	P-2	52580		Dyot, 2,800m	*n*=20 [Fig. 1N]	*4x*/A	34.00	32.99 ± 38.86 × 28.53 ± 33.92
13.	***Cymbopogon clandestinus* Stapf**							
	55372		Herb	Suliali, 500m	*n*=10 [Fig. 1O]	*2x*/N	100.0	24.69 × 23.09
14.	***Digitaria granularis* Trin. Henrard**							
	P-1	55701	Herb	Plachek, 2,688m	*n*=36 [Fig. 1P]	*8x*/N	98.40	43.03 × 41.58
	P-2	55708		Jwala Ji, 600m	*n*=36	*8x*/N	99.07	38.89 × 37.42
	P-3	55713		Majhera, 1,550m	*n*=36	*8x*/N	96.66	43.25 × 42.80
	P-4	55714		Paprola, 1,400m	*n*=36	*8x*/N	100.0	41.77 × 40.88
	P-5	55715		Samloti, 600m	*n*=36	*8x*/N	99.00	39.57 × 38.52
15.	***Echinochloa crus-pavonis* (Kunth) Schult.**							
	P-1	55272	Herb	Bhanala, 800m	*n*=27 [Fig. 1Q]	*6x*/N	100.0	33.91 × 31.36
	P-2	55732		Rehlu, 950m	*n*=27	*6x*/N	96.00	33.68 × 29.67
16.	***Isachne albens* Trin.**							
	54740		Herb	Andretta, 1,250m	*n*=5 [Fig. 1R]	*2x*/N	97.33	22.08 × 17.01
17.	***Lolium remotum* Schrank var. *aristatum* Döll Asch.**							
	53554		Herb	Bada Gran, 3,500m	*n*=7 [Fig. 1S]	*2x*/A	55.17	30.00 × 28.10
18.	***Microstegium vagans* (Nees ex Steud.) Hand.-Mazz.**							
	56399		Herb	Dharamsala, 1,600m	*n*=20 [Fig. 1T]	*4x*/N	100.0	26.80 × 24.81
19.	***Panicum antidotale* Retz.**							
	56401		Herb	Paragpur, 610m	*n*=16 [Fig. 1U]	*4x*/N	100.0	26.14 × 20.97
20.	***Paspalum distichum* L.**							
	P-1	52630	Herb	Dharamsala, 1,600m	*2n*=50 [Fig. 1V]	*5x*/A	28.00	26.81 ± 32.09 × 25.72 ± 27.32
	P-2	53540		Bhagsunaag, 1,650m	*2n*=50	*5x*/A	35.24	26.30 ± 30.62 × 24.64 ± 27.32
21.	***Pennisetum lanatum* Klotzsch**							
	P-1	55584		Anantnag, 1,700m	*n*=18[(Fig. 1W]	*4x*/A	54.88	24.80 ± 32.50 × 22.48 ± 27.64
	P-2	55585		Ratnipora, 1,700m	*n*=18	*4x*/A	62.00	31.90 ± 35.98 × 27.72 ± 28.98
	P-3	52595		Dharamsala, 1,600m	*n*=21 [Fig. 1X]	*6x*/A	64.00	24.75 ± 28.23 × 23.12 ± 24.34
	P-4	55577		Majhera, 1,550m	*n*=21	*6x*/A	56.98	25.60 ± 33.50 × 23.58 ±

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								28.22
2	***P. purpureum* Schumach.**							
2.	P-1	53556	Herb	Chhota Bhangal, 2,000m	*n*=18 [Fig. 2A]	*4x*/A	72.08	28.56 ± 36.71 × 24.35 ± 32.81
	P-2	55370		Loharari, 2,500m	*n*=18	*4x*/A	65.47	29.71 ± 36.61 × 26.81 ± 31.51
	P-3	55379		Dyot, 2,800m	*n*=18	*4x*/A	68.80	33.01 ± 34.64 × 31.41 ± 34.03
	P-4	55369		Bada Gran, 3,500m	*n*=21 [Fig. 2B]	*6x*/A	64.00	31.20 ± 36.03 × 29.80 ± 33.12
2	***Phalaris minor* Retz.**							
3.	56394		Herb	Paragpur, 610m	*n*=21 [Fig. 2C]	*6x*/A	42.40	41.61 ± 46.04 × 35.90 ± 42.33
2	***Pogonatherum crinitum* Kunth**							
4.	P-1	55333	Herb	Bandla, 1,266m	*n*=10 [Fig. 2D]	*2x*/A	47.76	23.17 ± 28.56 × 22.06 ± 25.22
	P-2	55334		Tal-Mata, 1,103m	*n*=10	*2x*/N	100.0	26.34 × 23.64
	P-3	56393		Chandpur, 1,676m	*n*=14 [Fig. 2E]	*4x*/N	93.90	31.16 × 29.03
2	***Setaria barbata* Lam. Kunth**							
5.	P-1	52596	Herb	Ranehar, 850m	*n*=16 [Fig. 2F]	*4x*/N	90.00	36.91 × 36.32
	P-2	52597		Dharamsala, 1,600m	*n*=18 [Fig. 2G]	*4x*/A	68.80	34.23 ± 41.15 × 34.12 ± 40.96
	P-3	52598		Dehra, 650m	*n*=18	*4x*/N	100.0	37.34 × 37.17
2	***S. homonyma* Chiov.**							
6.	56400		Herb	Jwala Ji, 600m	*n*=16 [Fig. 2H]	*4x*/N	100.0	30.85 × 27.38
	FAMILY: PONTEDERIACEAE							
	***Monochoria vaginalis* Kunth**							
27.	P-1	56404	Herb	Rajgundha, 2,440m	*n*=12 [Fig. 2I]	*2x*/N	97.76	39.47 × 28.61
	P-2	56405		Multhan, 2,400m	*n*=12	*2x*/N	98.26	39.54 × 31.88
	P-3	56406		Bada Gran, 3,500m	*n*=12	*2x*/N	95.68	37.57 × 30.49

* Families, Genera and species, all are arranged alphabetically for convenient sake.

** Herbarium code of Botany Department, Punjabi University, Patiala as per "Index Herbarium" by HOLMGREN and HOLMGREN (1998).

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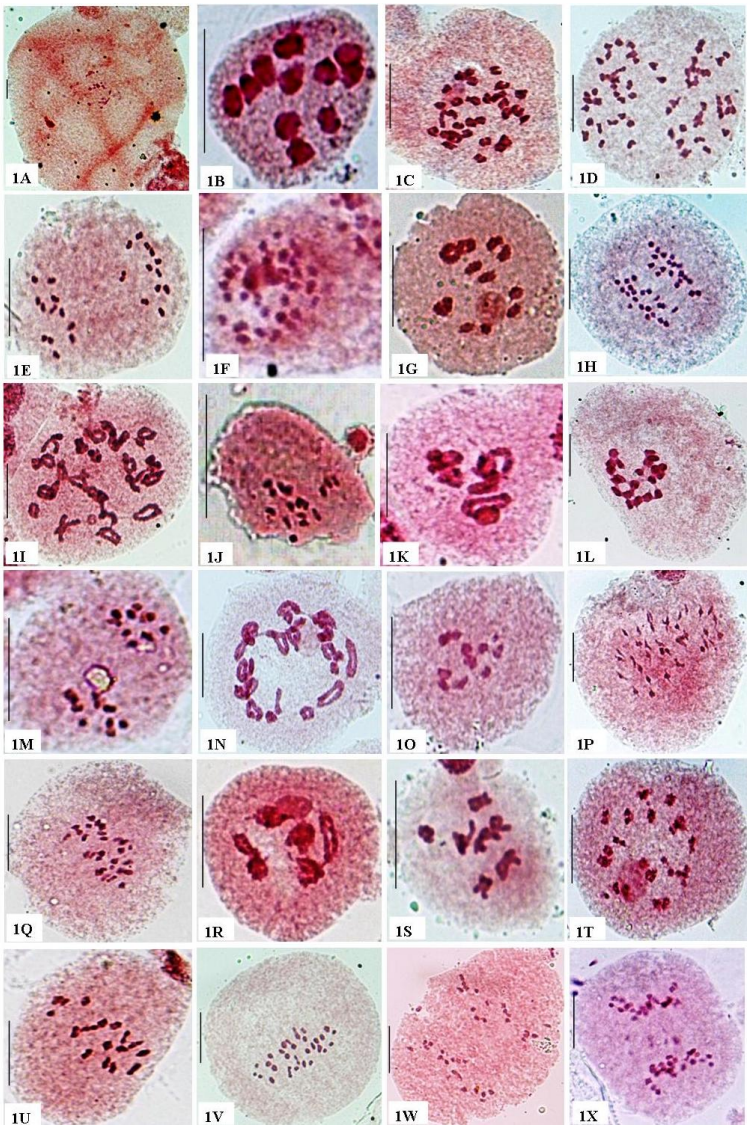

Abbreviations: PMC= Pollen mother cells; M-I= Metaphase-I; A-I= Anaphase-I

Figure Plate 1: 1A *Canna discolor*- PMC at M-I showing 9_{II}. **1B** *Commelina hasskarlii*- PMC at M-I showing 11_{II}. **1C** *C. hasskarlii*- PMC at diakinesis showing 30_{II}. **1D** *C. kurzii*- PMC at A-I with 30: 30 distribution of chromosomes at poles. **1E** *Murdannia nudiflora*- PMC at A-I with 12:12 distribution of chromosomes. **1F** *Cyperus flavidus*- PMC at diakinesis showing 32_{II}. **1G** *Acrachne racemosa*- PMC at diakinesis showing 6_{II}. **1H** *Andropogon tristris*- PMC at A-I with 20: 20 distribution of chromosomes at poles. **1I** *Avena fatua var. fatua*- PMC at diakinesis showing 21_{II}+1B. **1J** *Brachiaria remota*- PMC at M-I showing 16_{II}. **1K** *Briza minor*- PMC at diakinesis showing 5_{II}. **1L** *Bromus catharticus*- PMC at M-I showing 21_{II}. **1M** *Chrysopogon serrulatus*- PMC at A-I with 10: 10 distribution of chromosomes. **1N** *C. serrulatus*- PMC at diakinesis showing 20_{II}. **1O** *Cymbopogon clandestinus*- PMC at M-I showing 10_{II}. **1P** *Digitaria granularis*- PMC at M-I showing 36_{II}. **1Q** *Echinochloa crus-pavonis*- PMC at M-I showing 27_{II}. **1R** *Isachne albens*- PMC at diakinesis showing 5_{II}. **1S** *Lolium remotum* var. *aristatum*- PMC at M-I showing 7_{II}. **1T** *Microstegium vagans*- PMC at diakinesis showing 20_{II}. **1U** *Panicum antidotale*- PMC at M-I showing 16_{II}. **1V** *Paspalum distichum*- PMC at M-I showing $21_{II}+8_{I}$. **1W** *Pennisetum lanatum*- PMC at A-I with 18: 18 distribution of chromosomes at poles. **1X** *P. lanatum* PMC at A-I with 21: 21 distribution of chromosomes. Scale=10µm

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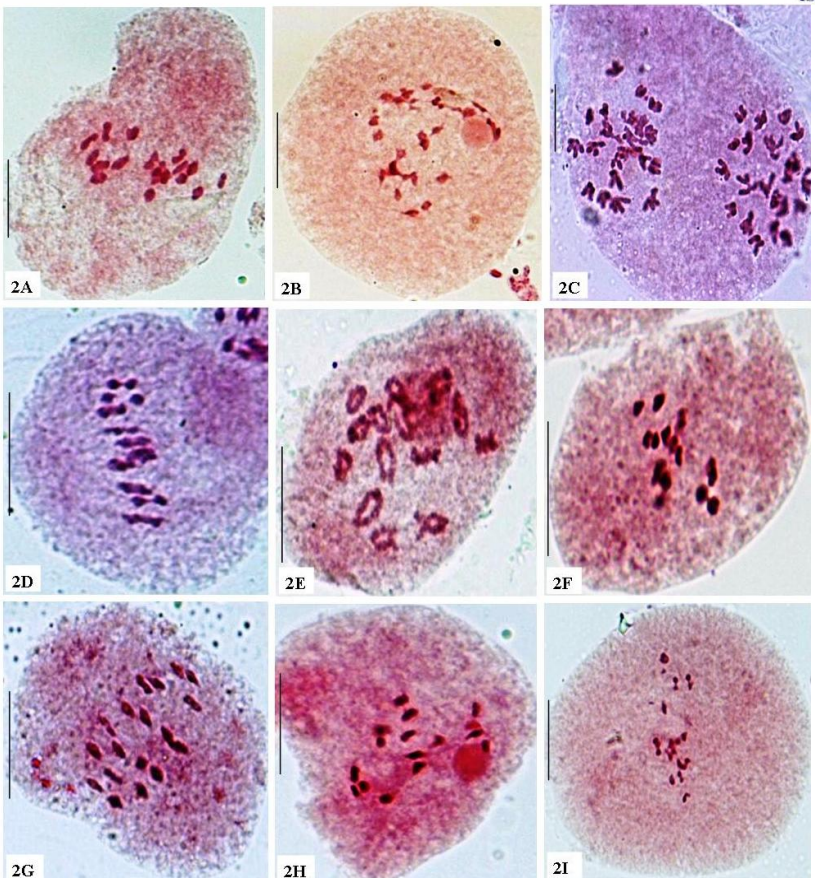

Figure Plate 2: **2A** *P. purpureum*- PMC at M-I showing 18_{II}. **2B** *P. purpureum*- PMC at diakinesis showing 21_{II}. **2C** *Phalaris minor*- PMC at M-II showing 21: 21 chromosomes. **2D** *Pogonatherum crinitum*- PMC at M-I showing 10_{II}. **2E** *P. crinitum*- PMC at diakinesis showing 14_{II}. **2F** *Setaria barbata*- PMC at M-I showing 16_{II}. **2G** *S. barbata*- PMC at M-I showing 18_{II}. **2H** *S. homonyma*- PMC at diakinesis showing 16_{II}. **2I** *Monochoria vaginalis*- PMC at M-I showing 12_{II}. Scale=10µm