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CYTOMORPHOLOGY OF SOME GRASSES (POACEAE) FROM LAHAUL-SPITI (HIMACHAL PRADESH), INDIA

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ABSTRACT

Meiotic study and pollen fertility was investigated in thirty five grass species belonging to twenty three genera from different localities of Lahaul-Spiti. This is the first cytological study in the grasses from this alpine Himalayas. *Bromus gracillimus* (n=7) and *Melica persica* (n=10), are cytologically worked out for the first time from world, whereas *Calamogrostis pseudophragmites* (n=7), *Helictotrichon pretense* (n=7), *Poa lahulensis* (n=14), *Stipa jacquemontii* (n=21, 22), *S. koelzii* (n=11), *S. splendens* (n=22), *Paspalum distichum* (n=28) and *P. longifolium* (n=30) show the varied chromosome reports at the world level.

Key Words: Cytomorphology, Grasses (Poaceae), Lahaul-Spiti, meiosis.

INTRODUCTION

Lahaul and Spiti are the two remote Himalayan valleys of Himachal Pradesh (India) lying on the Indo-Tibet border. It covers an area of 13,835 sq. kms. Lahaul-Spiti district can be divided into two main parts i.e. Lahaul valley and Spiti valley. Lahaul valley is situated towards the West whereas Spiti valley lies in the middle of Ladakh and Tibet, and on the Eastern side of the district with Kaza as its head-quarter. It is a mountaneous state and its altitude varies from 3000- 4,500 m. Due to harsh climatic conditions, the area is dominated with prostrate, thick, hairy and bushy type of vegetation. From the cold deserts of Lahaul-Spiti region, Aswal and Mehrotra (1994) reported 985 species of 353 genera belonging to 79 families of Dicots, Monocots and Gymnosperms. The district is inhabited by 'Swangla' and 'Gaddi' tribal communities. Due to difficult terain, the Lahaul-Spiti area had not attracted the attention of many cytogeneticists, except for recent reports from the department. As there is hardly any cytological work on grasses from the area, so the present exploration was done. The family Poaceae is one of the largest family with maximum economic importance. The family has documented evidence for the exploitation of most of the cytogenetical phenomena such as polyploidy, aneuploidy, apomixis with lot of cytological diversity. There are many studies on the cytology of the family from South Indian, Plains of North India and temperate Himalayas, but absolutely no report of chromosomal study from Lahaul-Spiti area.

MATERIALS AND METHODS

For the collection of materials, cytological survey of grasses had been carried out from the valleys of Lahaul-Spiti area. Young inflorescences were collected and fixed in Carnoy's fixative (Alcohol: Chloroform: Acetic acid in 6:3:1) for 24 hours and were transferred to 70% alcohol for preservation at 4˚ C. Meiotic studies were carried out by preparing smears of pollen mother cells (PMCs) in 1% acetocarmine. Photomicrographs of chromosome counts were made from freshly prepared slides using Leica Qwin and Nikon 80i Eclipse Microscope. Pollen fertility was estimated by their stainability in 1% glycerol-acetocarmine. Well stained pollen grains were considered as fertile and shriveled or unstained nuclei as sterile. Voucher specimens were submitted to Herbarium, Department of Botany, Punjabi University, Patiala (PUN).

RESULTS AND DISCUSSION

Presently, thirty five wildly growing grass species, falling under eleven tribes, belonging to twenty three genera from different localities of Lahaul-Spiti (H.P.) are cytomorphologically investigated. The information on name of the species, locality with altitude, accession number, chromosome number, ploidy level, habit and pollen fertility are presented in Table 1.

TRIBE: BRACHYPODIEAE

Brachypodium sylvaticum P. Beauv.
It shows the regular meiosis with n=9 at diakinesis and A-I (Figs. 1, 2). The chromosome number is in confirmation with the earlier reports from India and outside India (Mehra 1982).

Elymus semicostatus (Nees ex. Steud) Melderis
Cytologically, all the populations of the species show the chromosome count of n=14 with normal meiotic course (Fig. 3), and relatively low pollen fertility. The present meiotic course is in conformity with the previous reports by Mehra and Sharma (1972, 1977) from Gulmarg (Srinagar) and Ranikhet (Nainital).

TRIBE: BROMEAE

Bromus gracillimus Bunge
Cytological study of the species reveals the diploid chromosome count with n=7 at M-I (Fig. 4), which is the first chromosome report for the Indian population and confirms the previous reports from Russia (Podlech and Diaterle 1969). It shows normal meiosis with high pollen fertility.

B. tectorum L.
Extensive cytological studies on 7 populations from the high altitudinal range of Lahaul-Spiti area revealed the same chromosome number of n=7 at diakinesis (Fig. 5). All the populations show normal meiotic behavior with high pollen fertility (84-99%). The present report is in line with the previous report by Sharma and Sharma (1979).

B. unioloides Kunth.
Cytologically, the meiotic course reveals the presence of n=7 (Fig. 6) with normal meiosis and almost cent per cent pollen fertility. The present report of diploid cytotype confirms the previous reports by Sharma and Sharma (1979).

TRIBE: POEAE

Agrostis pilosula Trin.
The haxaploid (2n=42) chromosomal count has been confirmed with the presence of 21 bivalents at diakinesis. The species also shows inter-chromosomal connections at A-I (10-12% PMCs) and chromosomal bridges at A-I/T-I (11-13%PMCs) (Figs. 7-9) which leads to abnormal microsporogenesis, heterogenous sized pollen grains and low pollen fertility (62-78%). Mehra and Sharma (1975) recorded the same chromosome number from Tiffin Top, Nainital (2100m) and Toong-Soong Darjeeling (1800m).
Calamogrostis pseudophragmites (A. Haller) Koeler

Meiotic study on the single population from high altitudes of Spiti area showed 7 bivalents at early M-I. The further course of meiosis was abnormal with the presence of interbivalent connections at M-I (14%), late disjunction of bivalents at A-I (11.32%) (Figs. 10-12), although the pollen fertility was high (86.6%). The present chromosome report is a first ever diploid (n=7) cytotype for the species. Previously, tetraploid (n=14) cytotype was reported from Kashmir Himalayas (Koul and Gohil 1991).

Table 1: Locality with altitude, accession number, chromosome number, ploidy level, habit, and pollen fertility of the species studied

Species	Populations	Locality with altitude (m)	Accession no. (PUN)	Chromosome number (2n)	Ploidy level	Pollen fertility (%)	Remarks
TRIBE: BRACHYPODIEAE							
Brachypodium sylvaticum P. Beauv.	P1	Nako (H.P.), 3660 m	54664	18	2x	99.2	
	P2	Hansa (H.P.), 4075 m	54702	18	2x	98.6	
TRBE: TRITICEAE							
Elymus semicostatus (Nees ex. Steud) Melderis	P1	Nako (H.P.), 3660 m	54660	28	4x	62.4	
	P2	Mudh (H.P.), 4610 m	54669	28	4x	64.8	
	P3	Sichling (H.P.), 3809 m	54677	28	4x	63.2	
	P4	Kaza (H.P.), 3740 m	54685	28	4x	68.4	
	P5	Losar (H.P.), 4080 m	54723	28	4x	64.6	
TRIBE:BROMEAE							
Bromus gracillimus Bunge	P1	Hansa (H.P.), 4075 m	54701	14	2x	86.2	First report from India
	P2	Chhatru (H.P.), 3560 m	54542	14	2x	84.3	
B. tectorum L.	P1	Nako (H.P.), 3660 m	54653	14	2x	99.4	
	P2	Rangrik (H.P.), 4590 m	54689	14	2x	99.4	
	P3	Kibber (H.P.), 4205 m	54693	14	2x	86.4	
	P4	Pegmo (H.P.), 4060 m	54706	14	2x	86.2	
	P5	Losar (H.P.), 4080 m	54709	14	2x	84.2	
B. unioloides Kunth.	P1	Koksar (H.P.), 3160 m	54546	14	2x	98.4	
TRIBE:POEAE							
*Agrostis pilosula** Trin.	P1	Kibber (H.P.), 4205 m	54687	42	6x	78.2	
	P2	Losar (H.P.), 4080 m	54713	42	6x	76.4	
	P3	Sumling (H.P.), 3809 m	54668	42	6x	62.4	
	P4	Kaza (H.P.), 3740 m	54682	42	6x	66.6	
	P5	Chhota Darra (H.P.), 3690 m	54737	42	6x	68.4	
*Calamogrostis pseudophragmites** (A. Haller) Koeler	P1	Kee-Monestry (H.P.), 4166 m	54697	14	2x	86.6	First report from world

Table 1: continued…

Species	Populations	Locality with altitude (m)	Accession no. (PUN)	Chromosome number (2n)	Ploidy level	Pollen fertility (%)	Remarks
Dactylis glomerata* L.	P1	Sumling (H.P.), 3809 m	54681	14	2x	68.2	
	P2	Chhota Darra (H.P.), 3690 m	54547	14	2x	68.1	
	P3	Chhatru (H.P.), 2050 m	54709	14	2x	70.4	
	P4	Koksar (H.P.), 3160 m	54739	14	2x	65.0	
Festuca rubra L.	P1	Mudh (H.P.), 4610 m	54674	28	4x	82.4	
	P2	KIbber (H.P.), 4205 m	54686	28	4x	84.8	
	P3 P4	Losar (H.P.), 4080 m Kaza (H.P.), 3740 m	54708 54722	28 28	4x 4x	88.6 87.8	
Helictotrichon pretense (L.) Pilg.	P1	Koksar (H.P.), 3160 m	54541	14	2x	98.8	First report from world
Koeleria macrantha (Ladeb.) Schult.	P1	Chhatru (H.P.), 2050 m	54550	14	2x	100	
	P2	Koksar (H.P.), 3160 m	54552	14	2x	99.4	
Poa alpine L.	P1	Chhatru (H.P.), 2050 m	54543	28	4x	86.4	
	P2	Koksar (H.P.), 3160 m	54544	28	4x	88.2	
P. annua L.	P1	Chhatru (H.P.), 2050 m	54736	28	4x	82.6	
	P2	Chhota darra (H.P.), 3690 m	54721	28	4x	82.8	
P. bulbosa L.	P1	Chhatru (H.P.), 2050 m	54711	28	4x	88.2	
	P2	Koksar (H.P.), 3160 m	54739	28	4x	88.6	
P. lahulensis L.	P1	Nako (H.P.), 3660 m	54654	28	4x	68.8	First report from world
P. pratense L.	P1	Koksar (H.P.), 3160 m	54545	28	4x	88.2	
	P2	Rampur (H.P.), 924 m	54640	28	4x	88.4	

Table 1: continued…

Species	Populations	Locality with altitude (m)	Accession no. (PUN)	Chromosome number (2n)	Ploidy level	Pollen fertility (%)	Remarks
Trisetum spicatum (L.) K. Richt.	P1	Chhota darra (H.P.), 2150 m	54662	28	4x	78	
TRIBE: PHLEAE							
Alopecurus arundinaceous Poir.	P1	Nako (H.P.), 3660 m	54655	28	4x	78.6	
	P2	Chhatru (H.P.), 2050 m	54733	28	4x	74.2	
Phleum alpinum L.	Cyto type-A P1	Koksar (H.P.), 3160 m	54548	14	2x	83.0	
	Cyto type-B* P2	Chhatru (H.P.), 2050 m	54731	28	4x	66.2	
TRIBE: MELICEAE							
Melica persica Kunth.	Cyto type-A						
	P1	Pegmo (H.P.), 4060 m	54705	18	2x	99.0	
	Cyto type-B P2	Koksar (H.P.) 3160 m	54726	20	2x	78.6	
TRIBE: STIPEAE							
Oryzopsis lateralis (Regel) Stapf.	P1	Kibber (H.P.), 3691 m	54692	24	2x	64.6	
	P2	Pegmo (H.P.), 4060 m	54704	24	2x	62.2	
	P3	Hansa (H.P.), 4075 m	54540	24	2x	63.4	
Stipa jacquemontii* Jaub. & Spach.	Cyto type-A P1	Sumling (H.P.), 3809 m	54676	42	3x	62	First report from world
	P2	Moring (H.P.), 3900 m	54678	42	3x	59.5	
	Cyto type-B						

Table 1: continued…

Species	Populations	Locality with altitude (m)	Accession no. (PUN)	Chromosome number (2n)	Ploidy level	Pollen fertility (%)	Remarks
	P3	Rangrik (H.P.), 3900 m	54698	44	4x	91.2	First report from world
S. koelzii R.R.Stewart	P1	Kibber (H.P.), 3691 m	54698	44	2x	88.8	First report from world
S. splendens Trin.	P1	Kaza (H.P.), 3740 m	54684	44	4x	68.2	First report from world
	P2	Kibber (H.P.), 3691 m	54688	44	4x	67.4	
TRIBE: ARUNDINEAE							
Arundo donax L.	P1	Koksar (H.P.), 4110 m	54644	32	4x	78.3	
	P2	Nako (H.P.), 3660 m	54661	32	4x	76.4	
	P3	Chhota darra (H.P.), 3690 m	54717	32	4x	79.2	
	P4	Chhatru (H.P), 2050 m	54735	32	4x	77.4	
Neyraudia arundinacea* (L.) Henrard	P1	Nako (H.P.), 3660 m	54651	40	4x	78.4	
	P2	Mudh (H.P.), 4610 m	54670	40	4x	66.2	
	P3	Chhatru (H.P.), 2050 m	54730	40	4x	74.4	
TRIBE: CYNODONTEAE							
Muhlenbergia himalayensis Hack. ex Hook. f.	P1	Rampur, (H.P.), 924 m	54641	40	4x	67.4	
	P2	Mudh (H.P.), 4610m	54672	40	4x	64.2	
Sporobolus coromandelianus	P1	Chhatru (H.P.), 2050 m	54728	36	4x	76.2	
(Retz.) Kunth							
S. diander (Retz.) P. Beauv.	P1	Nako (H.P.) 3660 m	54657	36	4x	86.4	
S. tremulus	P1	Mudh (H.P)	54671	24	2x	68.8	First report

Table 1: continued…

Species	Populations	Locality with altitude (m)	Accession no. (PUN)	Chromosome number (2n)	Ploidy level	Pollen fertility (%)	Remarks
TRIBE: PANICEAE							
Paspalum distichum L.	P1	On way to Nako (H.P.), 3660 m	54648	56	8x	48.2	First report from world
P. longifolium Roxb.	P1	On way to Nako (H.P.), 3660 m	54649	60	6x	33.6	First report from world
Pennisetum flaccidum Griseb. ex Roscheb.	P1	Rampur (H.P.),924 m	54646	18	2x	76.4	
TRIBE: ANDROPOGONEAE							
Chrysopogon gryllus subsp.	P1	Nako (H.P.), 3660 m	54665	20	2x	100	
Echinulatus (Nees ex Steud.) Cope							
Lasiurus hirsutus (Nees ex Steud.) Cope	P1	Chhatru (H.P.), 2050 m	54710	20	2x	83.2	

***species with abnormal meiotic course**

Dactylis glomerata L.
Four populations of the species were studied from the Lahaul-Spiti area with diploid chromosome count (n=7). Besides this, the species shows irregular meiosis in the form of chromatin transfer (29% PMCs) and chromatin bridges at A-I/T-I/A-II/T-II (17.3% PMCs) (Figs. 13-15), which subsequently resulted in heterogenous sized pollen grains and low pollen fertility (68%). The present chromosome count confirms the previous reports (Koul and Gohil 1990).

Festuca rubra L.
The species studied cytologically from the high altitudinal regions of Spiti area showed the presence of n=14 at M-I (Fig. 16), with subsequent normal meiotic course. The same chromosome number has been reported by Mehra and Remanandan (1973) from Pehalgam area of Srinagar.

Helictotrichon pretense (L.) Pilg.
The species is found to be diploid with n=7 at diakinesis (n=7) (Fig. 17). The chromosomes are relatively large in size and meiotic course is normal with cent per cent pollen fertility. Cytologically, the species is first time worked out for an Indian accession and gives a new chromosome report at world level as earlier the species has been reported with n=21, 56 and 63 (Hubbard 1954; Lovkist and Hultgard 1999 and Röser 1997).

Koeleria macrantha (Ladeb.) Schult.
The species is collected from the bank of flowing water in Lahaul area. Meiotic studies on the species reveal the presence of 7:7

Plate-I

Figs. 1-19. 1,2. *Brachypodium sylvaticum.* (n=9) 1. PMC showing 9_{II} at Diakinesis 2. PMC with 9:9 chromosome distribution at A-I 3. *Elymus semicostatus.* (n=14) PMC showing 14_{II} at M-I 4. *Bromus gracillimus*. (n=7) PMC showing 7_{II} at M-I 5. *B. tectorum.* (n=7) PMC showing 7_{II} at Diakinesis 6. *B. unioloides* (n=7) PMC with 7_{II} at Diakinesis 7,8,9. *Agrostis pilosula* (n=21) 7. PMC with 21_{II} at Diakinesis 8. PMC at Anaphase-I with 21:21 chromosome distribution 9. Chromatin bridge at Anaphase-I. 10,11,12 *Calamogrostis pseudophragmites*. (n=7) 10. PMC showing 7_{II} at M-I 11. PMC at M-I with inter-bivalents connections 12. PMC at A-I showing late disjunction of bivalents 13,14,15. *Dactylis glomerata* (n=7) 13. PMC showing 7:7 chromosome distribution at A-I 14. PMCs involved in chromatin transfer 15. PMC at A-I showing chromatin bridge 16. *Festuca rubra* (n=14) PMC showing 14_{II} at M-I 17. *Helictotrichon pratense* (n=7) PMC showing 7_{II} at Diakinesis. 18. *Koeleria macrantha* (n=7) PMC showing 7:7 chromosomes at A-I 19. *Poa alpina.* (n=14) PMC with 14_{II} at Diakinesis

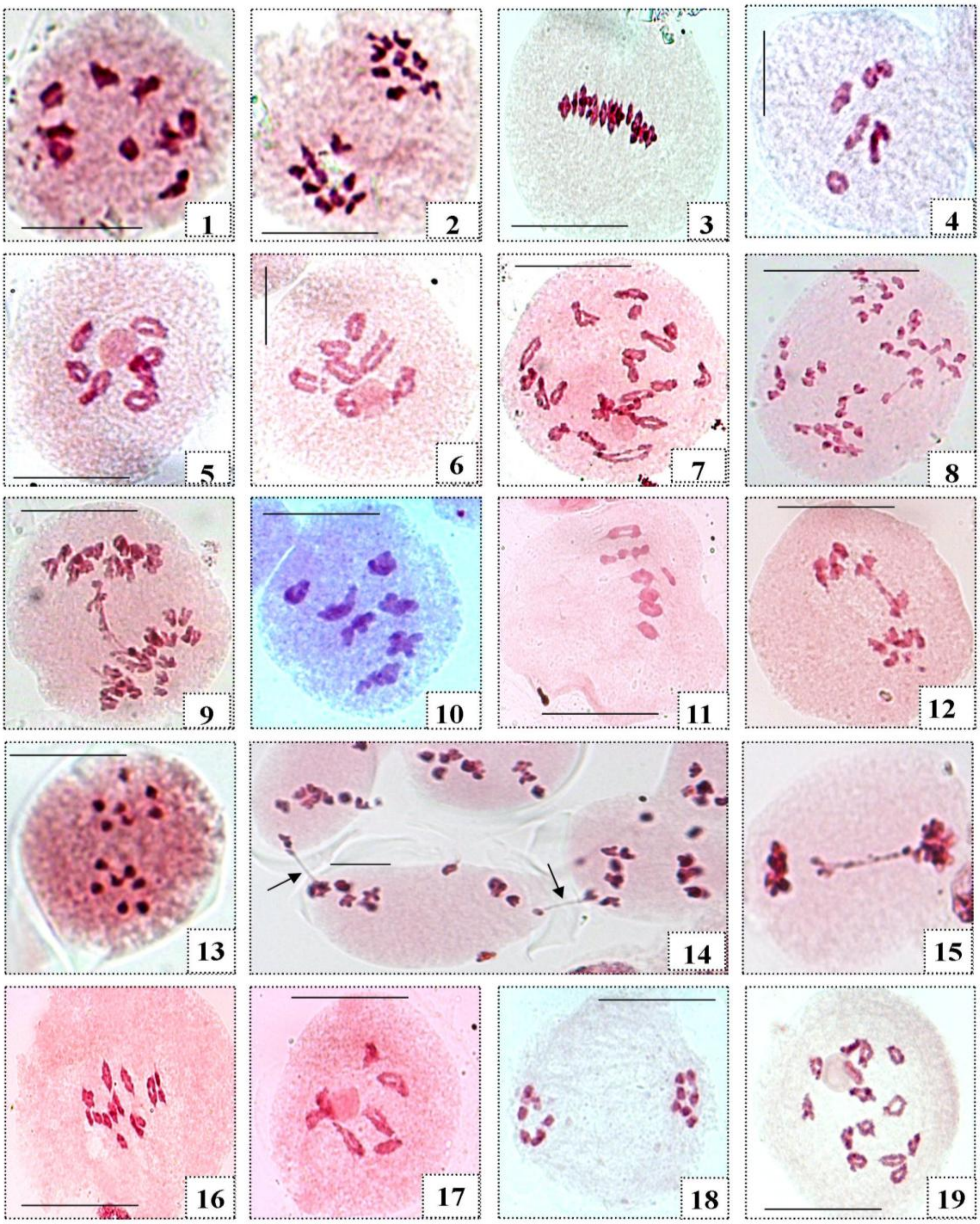


Plate-II

Figs. 13-26. 20. *P. annua*. (n=14). PMC showing 14_{II} at Diakinesis. 21. *P. bulbosa*. (n=14). PMC with 14_{II} at Diakinesis. 22. *P. lahaulensis* (n=14). PMC showing 14_{II} at Diakinesis. 23. *P. pretense* (n=14). PMC with 14_{II} at Diakinesis. 24. *Trisetum spicatum* (n=14). PMC showing 14_{II} at M-I. 25. *Alopecurus arundinaceous* (n=14). PMC with 14_{II} at M-I 26,27,28. *Phleum alpinum* (n=7, 14). 26. PMC showing 2n=14 at A-I with a laggard 27. PMC showing 14_{II} at M-I 28. Chromatin bridge at A-I 29,30. *Melica persica* 29.PMc showing 9_{II} at M-I 30. PMC showing 10_{II} at M-I 31. *Oryzopsis lateralis*. PMC with 12_{II} at M-I. 32,33,34,35. Stipa jacquemontii 32. PMC showing 21_{II} at M-I 33. PMC showing scattered chromatids at A-II 34. PMC showing spindle abnormalities 35. PMC at M-I showing $22_{II.}$ 36. S. koelzii PMC showing 11_{II} at M-I 37. S. splendens PMC showing 22_{II} at M-I 38. Arundo donax PMC with 16_{II} at M-I 39. *Neyraudia arundinacea* PMC with 20_{II} at M-I

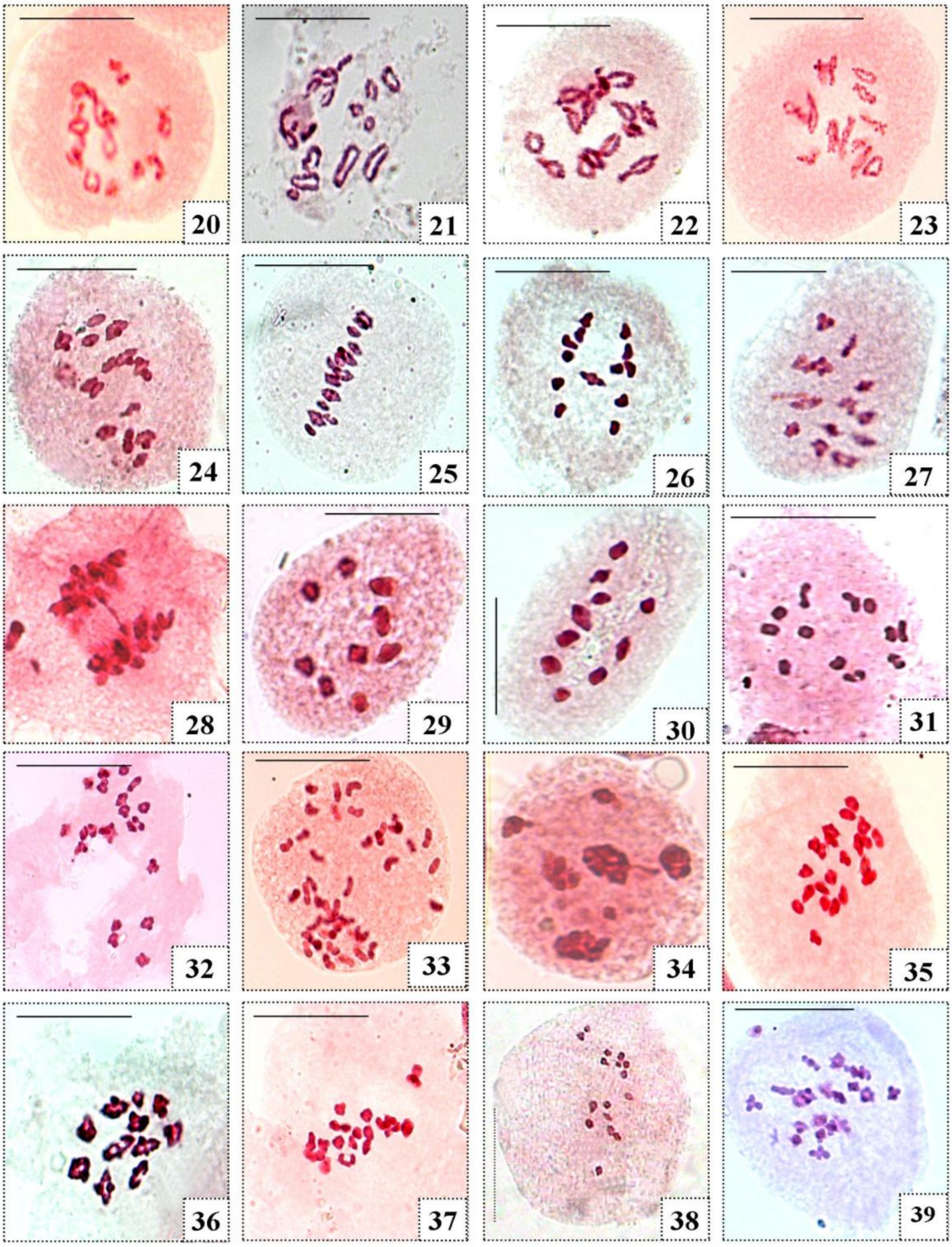
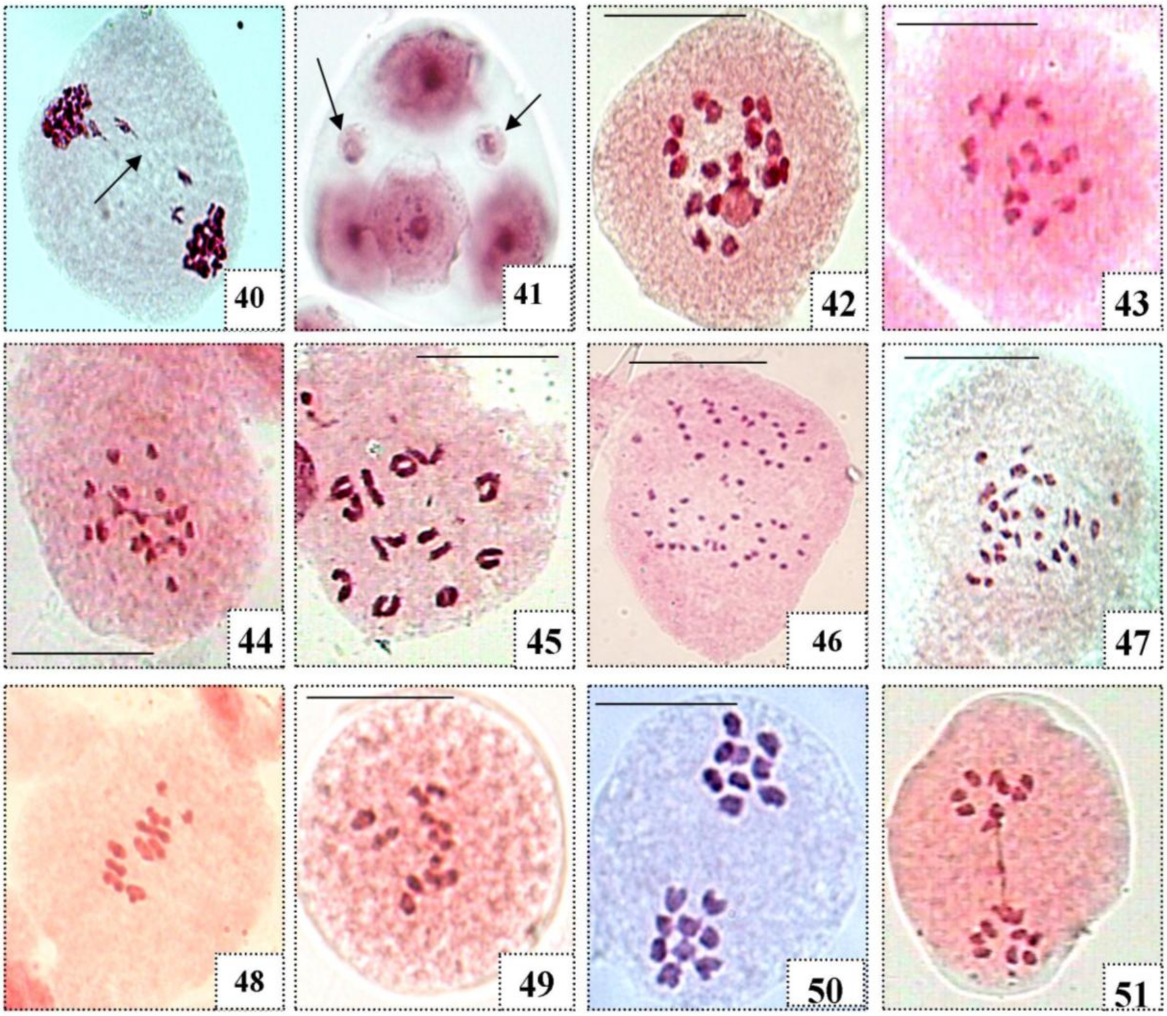


Plate-III

Figs. 26-35 40,41 *Neyraudia arundinacea* 40. PMC at T-I with laggards. 41. Tetrad with two micronuclei. 42. *Muhlenbergia himalayenis* PMC showing 20_{II} at Diakinesis. 43. *Sporobolus coromondelianus* PMC showing 18_{II} at M-I. 44. *S. diander* PMC with 18_{II} at M-I. 45. *S. tremulus* PMC showing 12_{II} at M-I. 46. *Paspalum distichum* PMC with 28: 28 at A-I. 47. *P. longifolium* PMC with 30_{II} at M-I. 48. *P. flaccidum.* PMC with 9_{II} at M-I. 49. *C. grylus* subsp. *echinulatus*. (n=10). PMC showing 10_{II} at M-I. 50,51. *Lasiurus hirsutus* PMC showing 9:9 chromosomes at A-I. 51. PMC showing late disjunction of 1 bivalent at A-I.



chromosomes at A-I with normal course of meiosis and high pollen fertility (Fig. 18). The present report is in conformity with the previous reports of Mehra and Sharma (1975).

Poa alpina L.

The species is distinguished from the other species with ovate to pyramidal inflorescence tinged with purple. Meiotic study of the species shows the presence of n=14 at diakinesis with normal course of meiosis (Fig. 19).

The present report is in conformity with the previous reports of Ghorai and Sharma (1981).

P. annua L.

Cytological investigation of the species reveals the presence of 14 bivalents (n=14) at diakinesis (Fig. 20). Meiosis is found to be normal. The present chromosome count is in conformity with the previous reports (Sharma and Khosla 1989).

P. bulbosa L.

The identifying key point of the species is that the leaf blades are abruptly contracted to a hooded tip often tinged with purple. Cytological investigation reveals the presence of n=14 (Fig. 21), and is in conformity with the previous report given by Koul and Gohil (1987).

P. lahulensis L.
Cytological investigation reveals the presence of 14 bivalents (n=14) (Fig. 22). Cytologically, worked out for the first time from world, with normal meiotic course but has low pollen fertility (68.8%).

P. pretense L.
Meiotically, the species is normal which showed 14 bivalents (n=14) at diakinesis (Fig. 23). The present report confirms the previous reports by Ghorai and Sharma (1981) from India, and Tischler (1934) from outside India.
Trisetum spicatum (L.) K. Richt.

Meiotic study showed the presence of 14 bivalents (n=14) at M-I (Fig. 24). The present report confirms the previous reports from North India (Mehra 1982).

TRIBE: PHLEAE
Alopecurus arundinaceous Poir.
Cytologically, the species shows the presence of 14 bivalents (n=14) at M-I (Fig. 25). Meiosis is found to be normal. The present chromosome count is in conformity with the previous reports (Mehra and Sunder 1970).

Phleum alpinum L.
The species shows great morphological variations. Two populations (P1 and P2) collected from the Lahaul-Spiti area are found to be diploid (n=7) and tetraploid (n=14), respectively (Figs. 26-28). Besides a little morphological disparity, the tetraploid cytotype shows abnormal meiotic course with the presence of chromatin bridges observed at A-I/T-I (9-11% PMCs), which results in heterogenous sized fertile and sterile pollen grains and reduced pollen fertility (66%). Population (P1) is normal with high pollen fertility. Both the cytotypes are common and are reported earlier from different parts of India Pashuk (1987) reported diploid cytotype, whereas Mehra and Remanandan (1973) reported tetraploid cytotype from India and outside India (Probatova and Sokolovskaya 1980). Petrova and Stoyanova (1998) reported B- chromosomes in the diploid cytotype.

TRIBE: MELICEAE
Melica persica Kunth.
The species shows morphological distinction between two cytotypes. Two populations were worked out, population P1 shows n=9 where as P2 with n=10 chromosome number (Figs. 29, 30). The population with n=10 is a new varied chromosome report from the world and the pollen fertility is slightly reduced (78.6%). The cytotype (n=9) confirms the previous reports from North India (Mehra and Sharma 1972; Gohil and Koul 1986).

TRIBE: STIPEAE
Oryzopsis lateralis (Regel) Stapf.
Meiotically, the species revealed the presence of 12 bivalents (n=12) at M-I (Fig. 31), which is in conformity with the previous reports from India (Mehra and Sharma 1975, 1977).

Stipa jacquemontii Jaub. & Spach.
During the present study, three populations were worked out from the different localities of Lahaul-Spiti. Two populations (P1 and P2) showed n=21 chromosome count. Meiotic analysis showed some sort of spindle abnormality that was reflected in the form of unequal distribution in chromosomes. Some of the PMCs shows scattered chromosomes at A-II (6-7% PMCs), few PMCs with chromatin bridges at T-II (7.6% PMCs) (Figs. 32-34), which leads to the abnormal microsporogenesis which (4-5% PMCs) lead to the formation of polyads, besides tetrads and heterogenous sized pollen grains. Further, it leads to reduced pollen fertility. The population (P3) reveals 22 bivalents (n=22) (Fig. 35). It shows normal meiotic behavior. Both the cytotypes are the new chromosome reports for the species, as the only earlier report is of 2n=24 (Mehra and Sharma 1975). Both the cytotypes show great morphological variations.

S. koelzii R. R. Stewart

Meiotic study on the species showed the presence of 11 bivalents (n=11) at M-I (Fig. 36). Meiotic course is normal. The present chromosome report for the species is a new chromosome report from world.

S. splendens Trin.
Meiotic study on the species exhibited the normal meiotic behavior with the presence of 22 bivalents (n=22) (Fig. 37). The presently reported chromosome count is a new varied chromosome report from world, as the earlier reported chromosome numbers are n=23 from Srinagar (Gohil and Koul 1986) and n=24 from outside India (Love 1948).

TRIBE: ARUNDINEAE
Arundo donax L.
Cytollogically, the species shows the presence of 16 bivalents (n=16) at M-I (Fig. 38) showing normal meiotic behavior and high pollen fertility. The present chromosome count is in conformity with the previous reports from India (Mehra 1982, Sinha et al. 1990). Larsen (1963); Devesa et al. (1991); Delay (1947) and Gorenflot et al. (1972) reported n=30, 50 55 and 56, respectively, from outside India.
Neyraudia arundinacea (L.) Henrard
Cytologically, the species revealed the presence of 20 bivalents at M-I. The meiotic behavior is observed to be abnormal with the presence of high frequency of laggards (33%) at A-I,II/T-I,II (Figs. 39-41), subsequently affecting microsporogenesis as micronuclei in tetrads and heterogenous sized pollen grains. The present chromosome number has been reported earlier from India (Mehra and Kalia 1976) as well as outside India (Larsen 1963) with low pollen fertility.
TRIBE: CYNODONTEAE
Muhlenbergia himalayensis Hack. ex Hook. f.
The cytological investigation of the species reveals the presence of 20 bivalents (n=20) at diakinesis (Fig. 42). This chromosome number is stable in the species as the same number is earlier reported from India (Mehra and Sharma 1972) and outside India (Teppner 2002).

Sporobolus coromondelianus (Retz.) Kunth
During the present studies, the material was collected from high altitudinal regions of Himachal Pradesh (Lahaul-Spiti). The meiotic couse is normal with the presence of 18 bivalents at M-I (Fig. 43). This confirms the various earlier reports from India (Bir et al. 1987, 1988) and outside India (Moinuddin et al. 1994).

S. diander (Retz.) P. Beauv.
Meiotic study on the species revealed the presence of 18 bivalents at M-I (Fig. 44). The meiotic course is normal which confirms the previous report from India (Bir and Sahni 1985).

S. tremulus (Willd.) Kunth
Meiotic studies on the species reveal the presence of 12 bivalents at M-I (Fig. 45) with low pollen fertility and normal meiotic course. The species is first time worked out cytologically from the world.

TRIBE: PANICEAE
Paspalum distichum L.
Cytological investigation on the species reveals the presence of 28 bivalents at M-I (Fig. 46), that is first ever octaploid cytotype for the species. Previously, n=10, 15, 20 and 24 are reported (Mehra 1982; Chatterjee 1975; Bir and Singh 1983).

P. longifolium Roxb.
Meioic analysis of the species collected from the high altitudes revealed the presence of 30 bivalents (n=30) at M-I (Fig. 47). The species shows the new cytological report for the species from world. The previous reports of n=20 and 25 were reported from India (Mehra 1982; Malik and Mary 1970), whereas, n=20 and 40 were reported from outside India.

Pennisetum flaccidum Griseb. ex Roscheb.
The present meiotic analysis reveals the chromosome count of n=9 at M-I (Fig. 48). This is in conformity with the previous reports from India (Koul and Gohil 1987, 1991).

TRIBE: ANDROPOGONEAE
Chrysopogon gryllus subsp. *Echinulatus* (Nees ex Steud.) Cope

During the meiotic analysis the species is found to be diploid with 10 bivalents at M-I (Fig. 49). Present study confirms the previous report by Sinha et al. (1990). Mehra (1982) reported 2B chromosomes in the diploid cytotyp*e.*

Lasiurus hirsutus (Forssk.) Boiss.
Meiotic study on the species revealed the presence 9 bivalents which are equally distributed at A-I (Figs. 50, 51). The presently reported chromosome count is in conformity with the previous reports from India (Bir and Sahni 1986) and outside India (Faruqi et al. 1979).

CONCLUSION

Presently, five species show new euploidy levels as were not reported earlier:Octaploidy in *Paspalum distichum* (2n=8x=56), hexaploidy in *P. longifolium* (2n=6x=60), tetraploidy in *Poa lahulensis* (2n=4x=28) and in case of *Stipa jacquemontii* both tetraploidy (2n=4x=44) and triploidy (2n=3x=42). Among the 35 species studied from the Lahaul-Spiti area19 species (54.2%) show various levels of polyploidy in comparison to diploid level (45.7%). Thus, it concludes and reveals that in case of grasses polyploidy is more frequent than diploids.

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