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CHROMOSOME NUMBERS AND BASIC CHROMOSOME NUMBERS IN MONOCOTYLEDONOUS GENERA OF THE WESTERN HIMALAYAS (INDIA)

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Worldwide chromosome number information has been compiled from the literature for monocotyledonous genera whose members have been cytologically studied in the last three years from Kangra District (Himachal Pradesh) and Kashmir (Jammu & Kashmir) in the Western Himalayas, comprising 143 species of 86 genera in 12 families, many in the family Poaceae. Chromosome number information from the literature is supplemented with new and varied reports for 54 species/56 taxa from the present study. Overall, the chromosome numbers range from 2n=10 to 2n=120. Some species in all genera show a large number of cytotypes, clearly highlighting the role of inter- and intraspecific genetic diversity as well as polyploidy and dysploidy. The basic chromosome numbers in all 86 genera are reconsidered. Monobasic genera are more common in Poaceae, and polybasic genera are more common in the other 11 families. Polyploidy in the different genera ranges from 3x to 40x, and is quite high in certain genera (18x in *Avena*, *Bothriochloa*, *Isachne*, *Helictotrichon* and *Panicum*; 19x in *Saccharum*; 24x in *Tradescantia*; 28x in *Eleocharis*; 32x in *Cyperus*; 36x in *Andropogon*; 38x in *Poa*; 40x in *Dioscorea*). An updated checklist of chromosome number variability in these genera is given for India and worldwide.

Key words: Basic chromosome number, monocots, genetic diversity, polyploidy, Kangra, Kashmir.

INTRODUCTION

The present work is part of the Department of Botany's programme to evaluate the genetic diversity of all the groups of angiosperms from different parts of India, with a special focus on the Western Himalayas. It is largely based on our first attempt to cytologically study the genetic diversity of monocots from an unexplored pocket of the Western Himalayas – Kangra District in Himachal Pradesh – as well as some high-altitude localities of Kashmir in Jammu & Kashmir, and to assess it in light of worldwide cytological data. A similar paper covering dicots has been published (Rani et al., 2014). We studied populations of 146 species (457 populations) belonging to 86 genera in 12 families of an important group of flowering plants, the monocots. For 38.35% of these species our cytological investigations yielded chromosome numbers that were varied or new for world data or for India, some of which have been published (Kaur et al., 2010a,b, 2011a,b,c,d,e), supplementing the existing chromosome number database with our chromosome number reports. We also compiled the world and Indian chromosome number information at inter- and intraspecific level for these 86 Western Himalayan monocotyledonous genera, organizing the data according to parameters such as the number of species cytologically studied versus the number of taxonomically known species in the genera, the number of diploids, the frequency and level of polyploids, updated numbers for chromosomal races, reports for species for each genus, and the number of species per genus characterized by inter- and intraspecific euploid and dysploid variability. We note that not a single genus is devoid of intrageneric variability; hence it seems to be a general phenomenon of the genetic system in monocots, irrespective of family level. The large genera of different regions of the world, especially those with many cytologically known species, show more genetic variability, for example the genus *Carex* (Cyperaceae) with 1412

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cytotypes, and *Poa* (Poaceae) having 688 cytotypes. Other genera with fewer species have fewer cytotypes as well (see Tab. S1). We revisited the basic chromosome number data for these 86 genera, authenticated earlier in the Chromosome Atlas of Flowering Plants (Darlington and Wylie, 1955) as well as many research papers. This review revealed that the 13 types of basic chromosome numbers recorded here are predominated by x=10, followed by x=9, x=7, x=5, x=12, x=6, x=8, x=11, x=14, x=15, x=16, x=17 and x=19. We suggest new basic numbers for two Poaceae genera: *Isachne* (x=5) and *Acrachne* (x=6). Polyploidy is assessed in four broad categories: up to 25% (in only 7 genera), 26–50% (in 14 genera), 51–75% (in 34 genera) and 76–100% (in 31 genera). We also scored the frequency and prevalence of aneuploidy in all the genera, highlighting the phenomenon better called aneu-polyploidy.

MATERIALS AND METHODS

For meiotic studies, young spikes were collected from populations at different localities in Kangra District (Himachal Pradesh) and Kashmir (Jammu & Kashmir) in the Western Himalayas. Meiotic studies of young spikes fixed in Carnoy's fixative employed standard smearing technique. Voucher specimens are deposited in the Herbarium of the Department of Botany, Punjabi University, Patiala (PUN). Taxonomic records of the species are taken from different floras and recent research papers for India and worldwide. Published chromosome numbers are taken from chromosome number atlases (Darlington and Wylie, 1955; Fedorov, 1974; Kumar and Subramaniam, 1986; Khatoon and Ali, 1993), chromosome number indexes (Ornduff, 1966, 1967; Moore, 1967–1974; Goldblatt, 1975–1985; Goldblatt and Johnson, 1986–2006), IAPT/IOPB chromosome number data as published in Taxon, SOCGI as published in the *Journal of Cytology and Genetics*, the Internet (http://www.tropicos.org/ Project/IPCN) and recent published research papers.

The world data on the number of species per genus (Tab. S1) were compiled from Watson and Dallwitz (1992) for genera of Poaceae, and for the 11 other families from Dahlgren et al. (1985), Haynes et al. (1998), Johnson (2001) Kirschner et al. (2002), Govaerts et al. (2007), Goldblatt et al. (2008), Mabberley (2008) and Tanaka (2008). For Indian data, Bor (1960) was followed for the grass family, and for other genera the data were taken from Santapau and Henry (1973), Kumar and Subramaniam (1986), Karthikeyan et al. (1989) and Murti (2001).

RESULTS AND DISCUSSION

FREQUENCY OF CYTOLOGICALLY KNOWN TAXA

To place the investigated 86 monocot genera in context, the chromosome number details for each genus have been compiled for the world and for India; also given are the latest available taxonomic records (Tab. S1). At world level there are 25 large genera, containing more than 500 species (5 genera), 400 species (1 genus), 300 species (6 genera), 200 species (4 genera) and 100 species (9 genera), but for India there are only 2 such genera with more than 100 species per genus: *Carex* and *Cyperus* of Cyperaceae.

Cytomorphological studies on monocots at family and genus level have concentrated on the Poaceae family at the expense of the others. Cytologists have examined grasses from different parts of India: eastern (Sharma and Sharma, 1961; Sharma and Chatterjee, 1967; Sanyal and Sharma, 1972a,b; Mehra and Sachdeva, 1975; Mehra, 1982), northeastern (Mehra and Chaudhary, 1981; Kalia and Mehra, 1986; Christopher and Jacob, 1990), central (Koul and Paliwal, 1964; Gill et al., 1980), southern (Venkateswarlu and Pantulu, 1970; Christopher and Abraham, 1971; Christopher et al., 1987; Nijalingappa and Bai, 1990; Rao et al., 1993; Nair et al., 1999; Kameshwari and Muniyamma, 2001) and northern (Mehra and Kohli, 1966; Sharma and Kaur, 1980; Sharma and Kumar, 1985; Bir et al., 1987; Gupta et al., 2008; Gupta and Gupta, 2008). For northwest India – Punjab along with part of Haryana covered in the last decade – Bir et al. (1986, 1990), Cheema and Bir (1995), Gupta and Gupta (2008), Gupta et al. (2008), Gupta (2009) and Kaur and Gupta (2008–2009) have made significant studies of members of the Cyperaceae and Poaceae families. For the Western Himalayas a large number of cytological reports are available for monocots from Kashmir (Mehra and Remanandan, 1973; Mehra and Sharma, 1977; Mehra and Pandita, 1984; Pandita and Mehra, 1984; Pandita, 1986; Gohil and Koul, 1988; Koul and Gohil, 1989, 1990, 1991). There are a few scattered reports from Uttarkhand (Mehra and Remanandan, 1973; Mehra and Sachdeva, 1976b,c,d,e,f) and other parts of Himachal Pradesh (Mehra and Sachdeva 1976b,c,d,e,f) but not from the areas covered by this study.

The number and frequency of cytologically known species are shown in Table S1. In a few genera the number of cytologically known species is higher than the number of taxonomically recorded species, perhaps due to taxonomic revisions of hybrids, exotics and cultivars now considered to be species. A closer look at these 86 genera shows that overall, in 8 genera ≤ 25%, in 17 genera 26–50%, in

23 genera 51–75% and in 38 genera 76–100% of the species have been cytologically studied. High inter- and intraspecific variability is reflected in the relatively high number of cytotypes/chromosomal races as compared with the number of species cytologically studied. We split the cytological data by genus in order to analyze their ranges and frequencies of 2n chromosome numbers, and the number of cytotypes having particular chromosome numbers.

CHROMOSOME NUMBER VARIABILITY

Chromosome numbers vary considerably in the angiosperms, ranging from as low as 2n=4 in four monocots (*Zingeria biebersteiniana* and *Colpodium versicolor*, tribe Pooideae, Poaceae; *Rhynchospora tenuis*, Cyperaceae; *Ornitogalum tenuifolium*, Hyacinthaceae) and two dicots (*Haplopappus gracilis* and *Brachycome dichromosomatica*, family Compositae) (Ruffini Castiglione and Cremonini, 2012) to as high as 2n=640 in the dicot *Sedum suaveolens* (Crassulaceae) and 2n=606±3 in the monocot *Voanioala gerardii* (Arecaceae) (Stace, 2000). In eleven of the 86 genera studied, the lowermost 2n chromosome numbers were single exceptions and not confirmed again for any species of those genera: 2n=6, 8 for *Eleocharis*; 2n=8 for *Disporum*; 2n=10 for *Alisma*, *Cyperus* and *Setaria*; 2n=12 for *Alisma*, *Brachiaria*, *Koeleria*, *Leptochloa*, *Oplismenus*, *Panicum* and *Paspalum*. Those numbers cannot be used in determining the basic numbers of those genera. They may have originated by aneuploidy or may be the result of other factors such as experimental conditions, hence should be considered doubtful or to be taken with caution. In general, the lowermost 2n chromosome numbers in these 86 genera established as common diploid numbers for calculating the basic numbers are 2n=10 (8 genera), 2n=12 (10 genera), 2n=14 (34 genera), 2n=16 (26 genera), 2n=18 (45 genera), 2n=20 (44 genera), 2n=22 (16 genera), 2n=24 (13 genera), 2n=26 (12 genera), 2n=28 (7 genera), 2n=30 (9 genera), 2n=32 (4 genera), 2n=34 (12 genera), 2n=36 (3 genera) and 2n=38 (7 genera), indicating the wide variation of 2n chromosome numbers at the very basic level of evolution in these genera. Chromosome numbers as high as 2n=100 or more are known in some species at world level in *Commelina, Tradescantia, Carex, Cyperus, Eleocharis, Dioscorea, Belamcanda, Juncus, Gagea, Bromus, Avena, Festuca, Helictotrichon, Poa, Alopecurus, Glyceria, Eragrostis, Sporobolus, Alloteropsis, Cenchrus, Digitaria, Echinochloa, Panicum, Paspalidium, Paspalum, Setaria, Andropogon, Apluda, Bothriochloa, Miscanthus, Saccharum* and *Themeda* (Tab. S1). These higher numbers can be explained mainly by their polyploid status (either natural or artificial).

BASIC NUMBERS OF GENERA

Basic number is the lowest detectable haploid number within a group of related taxa (Stuessy, 2009) or the haploid number present in the initial population of a monophyletic clade (Guerra, 2008). On the whole the basic chromosome numbers in angiosperms vary from x=2 in *Haplopappus* of Asteraceae to x=43 in Winteraceae (c.f. Kumari and Bir, 1987). According to Stebbins (1950), numbers of x=10 or less are primary basic numbers and all others are secondarily derivative ones. However, Ehrendorfer et al. (1968) proposed x=7 as the ancestral basic number of angiosperms and all others as of secondary origin. Grant (1982) suggested x=8 as an ancestral basic number because of the high frequency of its occurrence. Ancestral basic numbers between x=6 and x=10 have also been proposed for many monocot families (Goldblatt, 1980). Grant (1982) calculated the frequency of haploid numbers in over 5,000 monocots and found the most important polyploid series based on n=7 and n=10, suggesting basic numbers in the range of x=7 to x=9 as very probable for monocots; basic numbers higher than x=11 (Goldblatt, 1980) or x=13 (Grant, 1982) would be expected to be of polyploid origin (Soltis and Soltis, 1990). Generally, basic numbers are derived from the gametic numbers of species showing the lowest 2n chromosome numbers in a given genus. Sometimes additional criteria are used to infer the basic numbers, such as the number of nucleolar chromosomes in a complement (Gates, 1942), the number of chromosomes with secondary constrictions per complement, or secondary associations of chromosomes during meiosis I (Moffett, 1931; Lawrence, 1931), but these methods are not supported well enough to be generalized. The large amount of chromosome number data shows a wide range of 2n chromosome numbers in each of the 86 genera. Traditionally, basic chromosome numbers showing low variability within genera and particularly those forming a euploid series are taken as the established numbers. There are also diploids and/or polyploids carrying chromosome numbers that can be called dysploid variations. In such cases, it is preferable to infer basic chromosome numbers from analyses of the interrelationships and level of sharing of different cytotypes within species; thus the need for population studies covering a large range of altitudes and habitats, as in the present study.

THE GENERA GROUPS BASED ON SHARED FEATURES

Strictly monobasic

Eighteen genera are strictly monobasic. That is, they are genera with species at diploid level only, or at both diploid and polyploid level, but based on a sin-

gle basic number. The monobasic status of most of them was noted earlier in the literature, confirmed again here: *Alloteropsis* (x=9), *Apluda* (x=10), *Bromus* (x=7), *Canna* (x=9), *Capillipedium* (x=10), *Chloris* (x=10), *Chrysopogon* (x=10), *Dactylis* (x=7), *Dichanthium* (x=10), *Imperata* (x=10), *Lolium* (x=7), *Paspalidium* (x=9), *Poa* (x=7), *Saccharum* (x=10), *Vetiveria* (x=10) and *Vulpia* (x=7). Two monobasic genera (*Acrachne*, x=6; *Isachne*, x=5) are proposed with new basic numbers. *Acrachne* is a small genus containing 3 species, only one of which (*A. racemosa*) was earlier cytologically investigated, with two different chromosome numbers: 2n=18, 36 based on x=9. We report 2n=12 at diploid level for that species, *A. racemosa*, and propose a new basic chromosome number, x=6, for the genus. Sixteen of the 100 *Isachne* species have been investigated cytologically (Tab. S1). Previous records show the genus to be monobasic with x=10 (Darlington and Wylie, 1955); we found a diploid count of 2n=10, and propose the basic number x=5 to replace x=10.

Monobasic but with some doubtful basic numbers

Twelve genera are monobasic but show other basic numbers which seem doubtful in view of the occurrence of many aneuploid variations through intermediate numbers and euploid series. Single reports of chromosome numbers were never confirmed again for any of the species. In 8 genera – *Alopecurus* (x=7), *Cymbopogon* (x=10), *Helictotrichon* (x=7), *Mnesithea* (x=9), *Oplismenus* (x=9), *Phacelurus* (x=10), *Sorghum* (x=5) and *Themeda* (x=10) – single basic numbers form an intraspecific euploid series, but the other debatable basic numbers (Tab. S1) do not exist independently and thus are doubtful.

Belamcanda (x=16) – the genus is monobasic with x=16 making a euploid series; other basic numbers such as x=14, 15 are doubtful because the cytotypes based on these are present only in conjunction with cytotypes having 2n=32 based on x=16. Regarding studies suggesting x=8 (Darlington and Wylie, 1955), there is no report of 2n=16 in the literature; thus, x=16 is supported as the valid primary basic number.

Festuca (x=7) – this genus shows high chromosome number variation from 2n=14 to 2n=170, and is found to be monobasic with x=7, on the basis of which 76 species show intraspecific euploidy. Other basic numbers such as x=8, 10, 12, 13 and 15 are to be taken with caution because they all seem to be secondary derivatives of the ancestral basic number x=7.

Microstegium (x=10) – the genus is reported to be monobasic with x=10; the other basic number x=18 is doubtful because the single report of 2n=36 (in *M. nudum*) appears among many other reports based on x=10 and has never been reconfirmed for any of the species, suggesting that 2n=36 may be dysploid at 4x level.

Dibasic

Twelve genera show two different established basic numbers: *Bothriochloa* (x=9, 10), *Briza* (x=5, 7), *Echinochloa* (x=9, 12), *Glyceria* (x=7, 10), *Hedychium* (x=9, 17), *Hemarthria* (x=9, 10), *Ischaemum* (x=9, 10), *Phalaris* (x=6, 7), *Phleum* (x=5, 7), *Pogonatherum* (x=7, 10), *Polypogon* (x=7, 10) and *Rottboellia* (x=9, 10). Certain genera (*Andropogon*, x=5, 9; *Cynodon*, x=9, 10; *Leptochloa*, x=10, 18) appear to be dibasic but show other basic numbers which are questioned. More examples of this are discussed below.

The genus *Avena* is dibasic (x=7, 11) but also shows very low frequency of x=8, associated with other regular numbers (Tab. S1). The number of cytologically studied species is higher than the number of reported taxa, confirming its variation of chromosome number; chromosome dysploidy may be attributable to apomixis in several species of the genus (Watson and Dallwitz, 1992).

Koeleria (x=7, 13) – other basic numbers such as x=6 and 9 seem debatable because they were shown only once in *K. pubescens* and *K. glauca*, associated with regular cytotypes.

The genus *Eragrostis* (x=9, 10) shows high chromosomal variation from 2n=16 (*E. viscosa*) to 2n=120 (*E. intermedia*), including 15 species showing intraspecific aneuploidy. Intraspecific euploidy is seen in 3 species based on x=9, and in 44 species based on x=10. The genus is dibasic, having x=9 and more commonly x=10; x=8 is a doubtful basic number.

Monochoria (x=14, 15) – other ascending and descending basic numbers such as x=12, 13, 17 and 20 are to be taken with caution because these are found only in conjunction with the primary basic numbers (x=14, 15) in certain species.

Tribasic

These are 5 genera based on three different basic numbers: *Gagea* (x=8, 9, 12), *Melica* (x=7, 9, 10), *Setaria* (x=7, 8, 9), *Sporobolus* (x=6, 9, 10) and *Tradescantia* (x=6, 7, 8). Some genera such as *Brachiaria* (x=7, 8, 9), *Muhlenbergia* (x=8, 9, 10) and *Piptatherum* (x=11, 12, 17) are tribasic and form a euploid series but have other basic numbers as well. These dysploid chromosome number reports are found in conjunction with regular cytotypes and have never been confirmed again for any of the species, so they need to be reconsidered.

The genus *Alisma* (x=7, 8, 13) is tribasic with x=7, 8 and 13 (x=7 being common). Other basic numbers such as x=5, 6 and 17 are doubtful because there are only single reports of 2n=10, 12 and 34 in different species, associated with 2n=14.

Cenchrus (x=9, 16, 17) – x=14 is considered the least possible basic number for the genus, and the occurrence of a large array of chromosome numbers including the disjunct dysploid series 2n=18, 28, 30, 32, 34, 35, 36, 37, 38, 40, 42, 44, 45, 46, 48, 52, 54, 56, 64, 66, 68, 70, 72 and 102 in this genus demonstrates its cytological complexity.

Digitaria (x=9, 12, 17) – Mulay and Leelamma (1956) and Gould (1960) suggested x=10 as the basic number of the genus. Later, Mary and Malik (1971) suggested x=7 and x=8 as the basic numbers. Chromosome numbers in the genus range from 2n=16 in *D. foliosa* to 2n=108 in *D. setifolia*. The most frequent chromosome numbers in the genus have been shown to be 2n=18, 36, 54 and 72, supporting x=9; a few independent species are based on x=12 and others on x=17, along with variants. Intraspecific variability of chromosome numbers was also reported by Fedorov (1974) and Goldblatt and Johnson (2000). This variation clearly suggests that dysploid changes in chromosome numbers have played a significant role in the evolution of this genus.

Polybasic

There are many genera based on more than three basic numbers. Most of them belong to Com-melinaceae, Cyperaceae, Juncaceae, Orchidaceae and Poaceae. The wide chromosomal variation, intraspecific variability and formation of dysploid series might be associated with apomictic or vegetative modes of reproduction in various genera, as well as aneuploid variation. These genera include *Asparagus* (x=8, 9, 10, 12, 15), *Sagittaria* (x=8, 9, 10, 11), *Commelina* (x=8, 9, 10, 11, 12, 13, 14, 15), *Murdannia* (x=6, 7, 9, 10, 11), *Carex* (x=6, 7, 8, 9, 10, 11, 13, 17, 19), *Fimbristylis* (x=3, 5, 8, 11, 13, 14), *Juncus* (x=9, 10, 13, 14, 15, 16, 17, 19), *Polygonatum* (x=7, 8, 9, 10, 11, 12, 13), *Epipactis* (x=8, 9, 10, 12, 19), *Brachypodium* (x=5, 7, 8, 9, 10, 17, 19), *Agrostis* (x=4, 7, 8, 9, 11, 15, 17), *Arundinella* (x=7, 8, 9, 10, 17), *Pennisetum* (x=5, 7, 8, 9), *Urochloa* (x=7, 9, 13, 15), *Arthraxon* (x=8, 9, 10, 13, 15), *Coix* (x=5, 6, 8, 9, 11) and *Miscanthus* (x=10, 14, 18, 19).

Polybasic but with questioned basic numbers

Following are several genera forming dysploid series based on ascending and descending basic numbers of established numbers.

The genus *Cyanotis* (x=8, 10, 11, 12, 13) is polybasic with x=8, 10, 11, 12 and 13 (x=12 being common); x=14, 15 and 17 are to be taken with caution as these numbers do not exist independently.

Cyperus (x=7, 8, 9, 10, 11, 12, 13, 17, 19) – this genus was assigned basic chromosome numbers of x=8 and x=9 (Darlington and Wylie, 1955), later confirmed by Rath and Patnaik (1974) and Mehra and Sachdeva (1976a). Rath and Patnaik (1974) also reported the new basic number x=13 for the genus. Recently, Kaur and Gupta (2008–2009) suggested that the genus *Cyperus* is polybasic, exhibiting x=8, 9, 10, 11, 12 and 13.

Only 93 of the 550 floristically known species have been cytologically studied, assigned x=7, 8, 9, 10, 11, 12, 13, 17 and 19, of which x=8 is the most common basic number followed by x=7 and x=9 (see data on cytotypes in Tab. 1). The basic chromosome number x=5 is doubtful because the single chromosomal report of 2n=10 for *C. inundates* has never been confirmed again in any other species. Of the cytologically studied *Cyperus* species, 90.32% are polyploid, reaching up to 32x, and 45 species show intraspecific dysploidy. Intraspecific euploid series occur in 24 species (Tab. S1). The high level of polyploidy and intraspecific dysploidy may be due to apomixis.

Eleocharis (x=5, 6, 7, 8, 9, 11, 17, 19) – in this genus, x=3 and 4 seem doubtful because the reports of 2n=6 in *E. subarticulata* and 2n=8 in *E. parvula* have never been reconfirmed.

Dioscorea (x=10, 12, 14, 15, 18) – the ancestral basic number for this genus is x=10 according to Essad (1984) but recent molecular studies suggest that its double, x=20, is the basic number (Bousalem et al., 2006).

The chromosomal data compiled for the genus (Tab. S1) indicate that the chromosome numbers in 93 species (173 cytotypes) range from 2n=20 to 2n=400, most of them based on x=10. The genus is polybasic, with x=10, 12, 14, 15 and 18 (x=10 being more common). The basic numbers x=17 and 19 are to be taken with caution because x=34 and x=38 are reported in only one species each and have never been reconfirmed.

Disporum (x=6, 7, 8, 9, 11, 15) – the genus is polybasic, with x=6, 7, 8, 9, 11 and 15 (x=8 being more common). Earlier, Darlington and Wylie (1955) characterized the genus as polybasic but with x=6, 8, 9 and 11 only. The lower basic number x=4 is doubtful because x=8 is the predominant basic number in the genus, and the single chromosomal report of 2n=8 in *D. serotinum* is in association with 2n=32 (x=8).

Stipa (x=9, 11, 12, 13, 14, 16, 17) – the genus is polybasic, with x=9, 11, 12, 13, 14, 16 and 17 (x=11 being common). Twenty-six of the species in this genus show intraspecific dysploidy. Thus it

TABLE 1. Information on 86 monocot genera studied, with details of polyploidy

Family	Number of genera studied	Frequency of polyploid genera (habit*)				Level of polyploidy	
		≤25%	26–50%	51–75%	76–100%	Most common	Highest
Alismataceae	02	1B	1B	–	–	4x	8x
Cannaceae	01	1B	–	–	–	3x	4x
Commelinaceae	04	1C	–	3 2C+1B	–	4x	24x
Cyperaceae	04	–	–	2C	2 1B+1C	4x	32x
Dioscoreaceae	01	–	–	–	1E	4x	40x
Iridaceae	01	–	1B	–	–	8x	8x
Juncaceae	01	–	–	–	1C	4x	17x
Liliaceae	04	1B	2 1B+1D	1B	–	4x	12x
Orchidaceae	01	–	–	–	1B	4x	8x
Poaceae	65	3B	10 5C+2A+3B	27 18C+1A+8B	25 18C+6B+1A	4x	38x
Pontederiaceae	01	–	–	–	1C	4x	7x
Zingiberaceae	01	–	–	1B	–	4x	6x
Total	86	07	14	34	31		

*Symbols for habit; A – annual herbs; B – perennial herbs; C – annual and perennial herbs; D – herbs and shrubs; E – shrubs

seems that other ascending and descending basic numbers might be due to higher chromosomal variation. Recently, Hilu (2004) suggested that the chromosomal diversity in *Stipa* represents speciation enhanced by various levels of euploidy and aneuploidy.

Dactyloctenium (x=9, 10, 11, 12) – only 3 species of this genus have been studied cytologically; they yielded 21 cytotypes with chromosome numbers 2n=18, 20, 22, 23, 24, 27, 34, 36, 38, 40, 42, 46, 48 and 52. All the species carry polyploid and aneuploid cytotypes but reach maximum 4x. The established basic numbers are x=10 followed by x=9, 11 and 12.

Eleusine (x=7, 8, 9, 10) – the genus is polybasic with x=8, 9 and 10 (Bisht and Mukai, 2002; Mallikharjun et al., 2005); x=9 is common, and x=7 is speculated for cytotypes with 2n=28 and 2n=42.

Panicum (x=7, 8, 9, 10) – the cumulative chromosome number data (Tab. S1) show 265 species yielding 396 cytotypes, including 140 polyploid species (reaching 18x). The chromosome numbers range from 2n=10 in *P. ramosum* to 2n=144 in *P. virgatum*. The genus is polybasic, with x=7, 8, 9 and 10 (x=9, 10 being common).

Paspalum (x=6, 8, 9, 10) – the chromosome numbers of this genus show high variation from 2n=10 in *P. orbiculatum* and *P. oteroi* to 2n=160 in *P. botteri* and *P. floridanum*. The genus is polybasic, with x=6, 8, 9 and 10 (x=10 being common), and shows intraspecific euploidy in 62 species, mainly based on x=10. Thus, the basic number x=5 does not find more support.

Among the different types, monobasic genera dominate, followed by polybasic, dibasic and tribasic (Fig. 1). More Poaceae genera (27) are monobasic; in the other 11 families more genera (14) are polybasic.

POLYPLOID FREQUENCY AND LEVELS

Polyploidy is one of the most important cytogenetic mechanisms in plant evolution (Levin, 2002; Bennett, 2004), as it is a prime facilitator of rapid speciation (Hiremath and Salimath, 1991). It is also one of the major processes in the evolutionary history of plants, profoundly affecting biodiversity dynamics and ecosystem functioning (Ainouche and Jenczewski, 2010). Polyploidy is believed to protect plants against the immediate deleterious effects of most gene mutations (Aase, 1935), permitting greater polymorphism and thereby greater adaptability (Stebbins, 1958). Several reviews of polyploidy in plants have addressed its impact on speciation, genome structure and gene expression (Soltis and Soltis, 2000; Wendel, 2000; Pikaard, 2001). There are different estimates of frequency of polyploidy in flowering plants, for example 50%

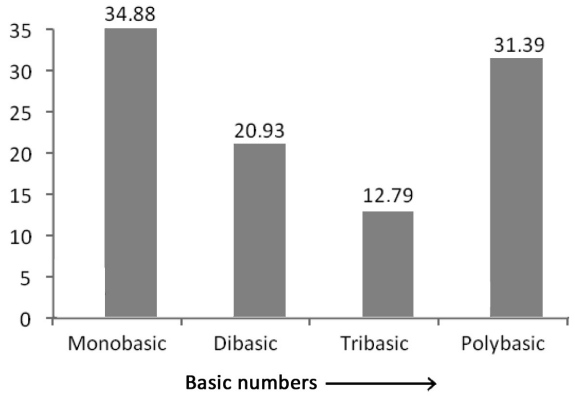

Fig. 1. Frequency of basic numbers in the 86 monocot genera studied.

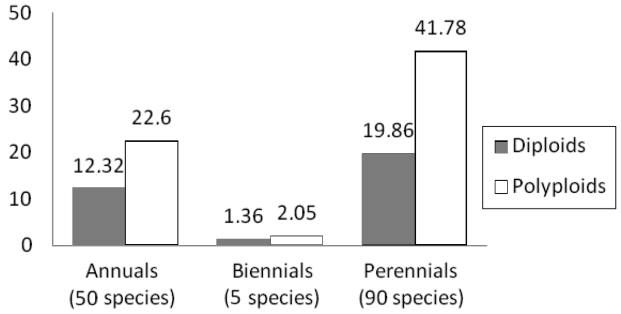

Fig. 2. Correlations between polyploidy and habit.

(Darlington, 1937), 40% (White, 1952), 30–35% (Stebbins, 1956), 47% (Grant, 1963), 70–80% (Lewis, 1980) and 60% (Grant, 1981). Goldblatt (1980) gave the incidence of polyploidy in monocots at 70%. Sharma (1985) estimated 63.41% polyploidy in the Himalayan grasses. Gupta (2009) recorded 63.3% polyploidy for grasses from Haryana and the adjoining Shiwalik Hills, and compiled the Indian chromosomal data showing 72.3% polyploidy. We considered the role of polyploidy in the 86 genera studied. Table S1 gives the number and frequency of polyploid species based on chromosomally reported species of each genus. Euploids are arranged in increasing order in the same Table. All 86 genera of these 12 families of monocots are polyploid. Polyploidy occurs in 25% of the species in 7 genera, 26–50% in 14 genera, 51–75% in 34 genera, and 76–100% in 31 genera; the majority of genera show more than 50% polyploidy (Tab. 1). Tetraploid is the most common ploidy level, shared by almost all the genera. The highest polyploidy level reached by genera varies widely; we noted 4x, 5x, 6x, 7x, 8x, 9x, 10x, 11x, 12x, 14x, 16x, 17x, 18x, 19x, 24x, 28x, 32x, 36x, 38x and 40x (Tab. S1). That level was lowest (4x) in 9 genera: *Canna*, *Disporum*, *Briza*, *Piptatherum*, *Dactyloctenium*, *Arthraxon*, *Mnesithea*, *Pogonatherum* and *Vetiveria*. It was highest (40x) in *Dioscorea* (Tabs. 1, S1).

CORRELATION BETWEEN POLYPLOIDY AND HABIT

Stebbins (1971) and de Wet (1980) suggested that the origin and success of polyploids depend upon their habit, habitat and breeding system, and noted that the frequency of polyploidy is higher in perennial herbs than in annuals. Others have made similar observations (Fernandes and Queiros, 1978; Kumari and Bir, 1987; Gupta, 2009). Another suggestion from de Wet (1980) is that high polyploidy in perennials will, over time, multiply their chances of achieving a combination of traits (i.e., a habit) enabling the newly formed polyploids to compete better in a given habitat. Wright (1976) rejected the notion of a correlation between polyploidy and habit. Figure 2 shows the growth habits and ploidy levels in the 86 genera. The annual herbs show 12.32% diploids and 22.6% polyploids, the biennial herbs show 1.36% diploids and 2.05% polyploids, and the perennial herbs show 19.86% diploids and 41.78% polyploids. Overall, the perennials have a higher level of polyploidy.

EUPLOIDY

Euploids are very common in monocotyledonous genera; on the world level, 1,185 species belonging to 84 genera in 11 families show diploids and polyploids or only polyploid complexes; the corresponding figures for India are 348 species belonging to 75 genera in 10 families (Tab. S1). Table 1 also shows the number of species in each genus having more than one intraspecific euploid series, each based on different basic numbers; it reveals the successful basic numbers against which the cytotypes forming an aneuploid series can be recognized in species belonging to those genera.

ANEUPLOIDY

Aneuploidy is thought to be the result of a series of unequal translocations (Stebbins, 1971, 1974) and is even attributed to centric fusions (Jones, 1978). Levin (2002) discussed the role of aneuploidy in relation to shifts in life history and the asexual mode of reproduction. According to de la Casa-Esperon and Sapienza (2003) and Bean et al. (2004), aneuploidy might be ameliorated by epigenetic silencing of unpaired chromosomes. Meiotic irregularities and a high rate of non-disjunction may also lead to the production of aneuploids. The

data compiled for 86 monocot genera show the magnitude of aneuploidy in various genera (Tab. S1). On the world level we note 928 species from 86 genera showing irregular chromosome numbers, and for India 218 species of 28 genera. The India reports may be at diploid level or polyploid level, or both diploid and polyploid levels. The data on the number of intraspecific aneuploid variants in a given number of species within genera supplement the picture of genetic diversity revealed by euploid variability.

CONCLUSION

We made the first study of the chromosome numbers of monocots from an unexplored area, Kangra District (Himachal Pradesh) and some high-altitude localities of Kashmir (Jammu & Kashmir) in the Western Himalayas. We compiled and analyzed these chromosome number reports from population-based meiotic studies together with previously known reports. The analysis focused on inter- and intraspecific chromosome number variability, determining genetic diversity in each genus in India and worldwide. We reconsidered the basic numbers for all the genera in light of the updated chromosome data. This study of polyploidy and aneuploidy was aimed at establishing a basis for assessing their role in the evolution of the species of these genera. The data on total chromosome number diversity in the studied 86 monocot genera should prove useful in cytotaxonomic research on this important group of plants.

AUTHORS' CONTRIBUTION

All authors contributed equally. HK investigation of plants from Kangra District, Himachal Pradesh; MN investigation of plants from Kashmir; SK and RCG supervision of research. The authors declare that they have no conflicts of interest.

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SUPPLEMENTARY MATERIAL

Supplementary material (Tab. S1) for this article can be found in the online version at doi: 10.2478/abcsb-2014-0015

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TABLE S1. Cytological overview of the investigated monocotyledonous genera, based on previous and present chromosome number reports

Genus (habit)	Number of species				Various euploid levels	Number of cytotypes (chromosomal races) = known 2n* chromosome numbers; number of species/cytotypes given in parentheses	Number of species with more than one cytotype		Basic numbers** (common ones underlined)
	Taxonomically known	Cytologically known					Intraspecific euploids; respective base numbers given in parentheses	Intraspecific dysploids	
	+World	Total (%)	Diploids	Polyploids (%)					
	++India								
Family: Alismataceae Vent. (x=7, 11)									
***Alisma* L.** (Perennial herbs)	+9 (13)	13 (100)	8	5 (38.46)	2x, 4x, 6x, 8x	**28=**10(1), 12(1), 14(10), 16(3), 24(2), 26(3), 28(5), 34(1), 40(1), 42(1)	5(7), 1(6)	5	(5), (6), 7, 8, 13, (17)
	++1 (3)	3 (100)	3	–	2x, 4x	**5=** 14(2), 16(1), 26(1), 28(1)	1(7)	1	7, 8, 13
***Sagittaria* L.** (Perennial herbs)	+40	34 (85.00)	33	1 (2.94)	2x, 4x, 6x	**40=** 16(1), 18(1), 20(2), 22(34), 36(1), 54(1)	1(9)	2	8, 9, 10, 11
	++2	2 (100)	1	1 (50.00)	2x, 4x, 6x	**5=** 18(1), 22(2), 36(1), 54(1)	1(9)	–	9, 11
Family: Cannaceae Juss. (x=9)									
***Canna* L.** (Perennial herbs)	+20 (25)	25 (100)	20	5 (20.00)	2x, 3x, 4x	**32=** 18(25), 24(1), 27(5), 36(1)	5(9)	–	9
	++60	9 (15.00)	6	3 (33.33)	2x, 3x	**12=** 18(9), 27(3)	3(9)	–	9
Family: Commelinaceae Mirb. (x=6, 10, 12, 14, 15)									
***Commelina* L.** (Annual or perennial herbs)	+170	85 (50.00)	33	52 (61.17)	2x, 3x, 4x, 5x, 6x, 8x, 10x, 12x, 13x, 14x	**174=** 16(1), 18(1), 20(3), 22(5), 24(5), 26(5), 28(16), 30(26), 32(1), 35(1), 36(1), 40(1), 42(5), 44(4), 45(2), 46(1), 48(4), 52(5), 53(1), 56(12), 58(3), 60(25), 61(1), 62(2), 64(1), 66(1), 68(1), 72(2), 75(2), 84(2), 86(2), 88(2), 90(17), 104(2), 110(1), 112(1), 120(6), 150(2), 180(1)	1(8), 1(9), 3(11), 1(12), 1(13), 5(14), 14(15)	24	8, 9, 10, 11, 12, 13, 14, 15
	++24(35)	35 (100)	13	22 (62.85)	2x, 3x, 4x, 5x, 6x, 8x, 10x, 13x, 14x	**63=** 20(2), 22(2), 24(5), 28(3), 30(9), 35(1), 42(1), 44(1), 45(1), 48(2), 56(2), 60(11), 62(1), 64(1), 72(1), 75(1), 90(10), 104(1), 110(1), 112(1), 120(4), 150(2)	1(12), 1(14), 9(15)	7	10, 11, 12, 14, 15
***Cyanotis* D.Don** (Annual or perennial herbs)	+50	34 (68.00)	27	7 (20.58)	2x, 4x, 6x	**51=** 16(2), 20(3), 22(4), 24(25), 26(6), 28(1), 30(1), 34(1), 48(4), 52(1), 72(3)	3(12)	9	8, 10, 11, 12, 13, (14), (15), (17)
	++16(25)	25 (100)	20	5 (20.00)	2x, 6x	**32=** 16(1), 20(2), 22(1), 24(20), 26(2), 48(3), 72(3)	2(12)	3	8, 10, 11, 12, 13
***Murdannia* Royle** (Annual or perennial herbs)	+50	28 (56.00)	11	17 (60.71)	2x, 4x, 6x, 8x	**47=** 12(1), 14(1), 18(5), 20(9), 22(1), 24(5), 36(1), 39(1), 40(12), 42(3), 44(1), 60(3), 64(2), 80(2)	4(10), 1(11)	8	6, 7, 9, 10, 11
	++24	23 (95.83)	8	15 (65.21)	2x, 4x, 6x, 8x	**40=** 12(1), 14(1), 18(5), 20(9), 22(1), 24(4), 36(1), 40(9), 42(1), 44(1), 60(3), 64(2), 80(2)	4(10), 1(11)	6	6, 7, 9, 10, 11

***Tradescantia* L.** (Perennial herbs)	+60	59 (98.33)	19	40 (67.79)	2x, 3x, 4x, 5x, 6x, 8x, 10x, 12x, 15x, 18x, 19x, 20x, 22x, 24x	**115=**12(28), 14(3), 15(1), 16(7), 18(5), 22(1), 23(1), 24(30), 26(2), 28(1), 30(2), 32(3), 36(2), 38(1), 40(1), 42(1), 48(2), 50(2), 60(2), 64(2), 67(1), 70(2), 72(3), 74(1), 76(2), 90(1), 92(1), 108(1), 109(1), 110(1), 114(1), 132(1), 140(1), 144(1)	20(6), 1(7), 1(8)	7	6, 7, 8
	++50	6 (12.00)	1	5 (83.33)	2x, 4x, 10x	**7=**12(1), 24(5), 60(1)	1(6)	–	6
Family: Cyperaceae Juss. (x=5, 7, 8, 9, 10)									
***Carex* L.** (Perennial herbs)	+2000	645 (32.25)	22	623 (96.58)	2x, 3x, 4x, 5x, 6x, 7x, 8x, 9x, 10x, 12x, 13x, 14x, 16x	**1412=** 12(4), 14(1), 16(2), 17(1), 18(8), 19(1), 20(4), 21(3), 22(4), 23(3), 24(5), 25(2), 26(14), 27(3), 28(8), 29(3), 30(21), 31(3), 32(24), 33(6), 34(24), 35(4), 36(30), 37(3), 38(28), 39(7), 40(30), 41(5), 42(21), 43(5), 44(26), 45(2), 46(24), 47(4), 48(35), 49(2), 50(38), 51(6), 52(52), 53(4), 54(52), 55(6), 56(63), 57(6), 58(63), 59(5), 60(83), 61(9), 62(55), 63(7), 64(65), 65(6), 66(41), 67(9), 68(66), 69(12), 70(61), 71(9), 72(39), 73(10), 74(40), 75(9), 76(38), 77(7), 78(34), 79(7), 80(42), 81(6), 82(23), 83(4), 84(24), 85(4), 86(6), 88(5), 90(5), 92(2), 94(1), 98(2), 100(1), 104(3), 106(2), 108(1), 110(2), 112(1), 113(1), 114(3), 146(1), 148(1)	1(6), 12(7), 7(8), 4(9), 22(10), 3(13), 7(17), 3(19)	273	6, 7, 8, 9, 10, 11, 13, 17, 19
	++140	14 (10.00)	–	14 (100)	4x, 6x, 12x, 13x	**18=** 42(1), 44(3), 46(2), 48(3), 52(1), 58(1), 60(1), 62(1), 76(1), 84(1), 94(1), 104(2)	–	4	7, 8, 10, 11, 13, 19
***Cyperus* L.** (Annual or perennial herbs)	+550	93 (16.90)	9	84 (90.32)	2x, 3x, 4x, 5x, 6x, 8x, 9x, 10x, 11x, 12x, 14x, 16x, 18x, 20x, 32x	**216=** 10(1), 14(1), 16(6), 18(4), 20(1), 22(2), 24(3), 26(5), 28(1), 30(2), 32(6), 34(2), 36(7), 38(4), 40(3), 42(7), 43(1), 44(1), 46(2), 48(4), 50(5), 52(1), 54(2), 56(3), 58(3), 60(1), 63(1), 64(3), 68(2), 70(1), 72(10), 74(2), 76(1), 78(1), 80(7), 81(1), 82(3), 83(1), 84(6), 86(4), 88(5), 90(2), 92(1), 94(1), 96(9), 98(5), 100(5), 102(1), 104(6), 106(1), 108(8), 109(1), 110(2), 112(8), 113(2), 114(4), 116(3), 118(1), 120(4), 124(3), 128(4), 132(2), 134(1), 136(1), 138(1), 146(1), 152(3), 160(1), 174(1), 186(1), 196(1), 200(1), 208(3), 220(1), 224(1)	4(7), 6(9), 8(8), 3(10), 2(11), 1(13)	45	(5), 7, 8, 9, 10, 11, 12, 13, 17, 19
	++100	67 (67.00)	5	62 (92.53)	2x, 3x, 4x, 5x, 6x, 8x, 9x, 10x, 11x, 12x, 14x, 16x, 18x, 20x	**158=** 10(1), 16(5), 18(2), 20(1), 22(2), 24(2), 26(5), 28(1), 30(1), 32(5), 34(1), 36(6), 38(3), 40(2), 42(5), 46(1), 48(4), 50(4), 52(1), 54(2), 56(3), 58(2), 60(1), 64(3), 68(2), 70(1), 72(7), 74(1), 76(1), 78(1), 80(4), 84(5), 86(2), 88(4), 90(2), 92(1), 94(1), 96(6), 98(5), 100(4), 104(6), 108(8), 109(1), 110(2), 112(7), 114(2), 116(3), 118(1), 120(3), 124(3), 128(4), 132(2), 138(1), 152(1), 160(1), 196(1), 208(2)	4(7), 8(8), 2(9), 2(10), 1(11)	36	(5), 7, 8, 9, 10, 11, 12, 13, 17, 19

***Eleocharis* R.Br.** (Annual or perennial herbs)	+200	72 (36.00)	19	53 (73.61)	2x, 3x, 4x, 5x, 6x, 7x, 8x, 9x, 10x, 12x, 13x, 14x, 15x, 16x, 17x, 18x, 19x, 20x, 22x, 23x, 24x, 26x, 28x	**193=**6(1), 8(1), 10(12), 12(1), 14(1), 15(2), 16(9), 17(1), 18(8), 19(2), 20(25), 22(1), 24(2), 25(1), 28(1), 30(5), 32(3), 34(1), 36(3), 37(1), 38(6), 39(3), 40(8), 41(1), 42(4), 43(1), 44(1), 45(1), 46(5), 47(2), 48(2), 49(1), 50(3), 51(1), 52(1), 54(4), 55(1), 56(3), 58(1), 60(1), 64(1), 69(1), 72(1), 74(1), 75(1), 76(3), 77(1), 78(1), 79(1), 80(4), 81(2), 82(2), 83(1), 84(2), 85(1), 86(2), 87(1), 88(2), 89(1), 90(1), 91(1), 92(2), 93(1), 94(2), 95(2), 96(2), 97(2), 98(2), 99(2), 100(2), 136(2), 172(1), 176(1), 177(1), 178(1), 179(1), 180(1), 181(1), 182(1), 183(1), 184(1), 196(1), 216(1)	9(5), 4(7), 5(8), 3(9), 1(11)	20	(3), (4), 5, 6, 7, 8, 9, 11, 17, 19
	++15	9 (60.00)	–	9 (100)	2x, 4x, 6x, 8x, 16x, 24x	**18=**10(2), 14(1), 16(1), 20(3), 28(1), 30(1), 32(1), 36(1), 40(1), 54(2), 76(2), 80(1), 216(1)	3(5), 1(7)	3	5, 7, 8, 9, 19
***Fimbristylis* Vahl** (Annual or perennial herbs)	+300	49 (16.33)	20	29 (59.18)	2x, 4x, 6x, 8x, 14x	**73=**6(3), 10(29), 12(1), 16(3), 20(17), 22(2), 24(2), 26(1), 28(1), 30(3), 32(2), 40(3), 42(1), 44(3), 48(1), 52(1)	13(5), 1(8), 1(11)	7	3, 5, 8, 11, 13, 14
	++50	38 (76.00)	16	22 (57.89)	2x, 4x, 6x, 8x	**55=**6(3), 10(25), 16(2), 20(14), 22(2), 26(1), 30(2), 32(2), 40(2), 44(2)	11(5), 1(11)	6	(3), 5, 8, 11, 13
Family: Dioscoreaceae R.Br. (x=10)									
***Dioscorea* L.** (Annual or perennial herbs, shrubs or climbers)	+600	93 (15.50)	16	77 (82.79)	2x, 3x, 4x, 5x, 6x, 7x, 8x, 10x, 12x, 14x, 40x	**173=** 20(24), 24(3), 28(2), 30(5), 34(1), 36(13), 38(1), 40(45), 45(3), 48(1), 50(1), 52(2), 54(7), 55(1), 56(1), 60(13), 61(2), 62(1), 63(1), 64(2), 66(2), 70(3), 72(1), 80(16), 81(1), 90(2), 98(1), 100(4), 104(1), 120(4), 138(1), 140(3), 142(1), 144(3), 400(1)	1(8), 5(9), 3(9, 10), 18(10), 1(9, 10, 11)	14	10, 12, 14, 15, (17), 18, (19)
	++50	23 (46.00)	2	21 (91.30)	2x, 3x, 4x, 5x, 6x, 7x, 8x, 10x	**54=** 20(5), 30(4), 36(4), 38(1), 40(13), 45(2), 50(1), 52(1), 55(1), 60(4), 66(1), 70(3), 80(9), 90(2), 98(1), 100(2)	8(10), 1(9, 10) 1(10, 11)	4	10, 15, 18, (19)
Family: Iridaceae Juss. (x=16)									
***Belamcanda* Adans.** (Perennial herbs)	+1(2)	2 (100)	1	1 (50.00)	2x, 8x	**5=** 28(1), 30(1), 32(2), 128(1)	1(16)	1	(14), (15), 16
	++1(2)	2 (100)	2	–	2x	**4=** 28(1), 30(1), 32(2)	–	1	(14), (15), 16
Family: Juncaceae Juss. (x=10)									
***Juncus* L.** (Annual or perennial herbs)	+300	123 (41.00)	19	104 (84.55)	2x, 3x, 4x, 5x, 6x, 7x, 8x, 9x, 10x, 11x, 12x, 13x, 14x, 17x	**194=** 5(1), 8(1), 18(1), 20(2), 26(1), 27(1), 28(1), 30(8), 32(4), 34(7), 35(1), 36(3), 37(1), 38(6), 40(58), 42(8), 44(5), 46(2), 48(4), 50(1), 52(1), 54(1), 58(1), 60(9), 64(1), 68(1), 70(2), 74(2), 76(1), 78(1), 80(29), 81(1), 84(5), 90(1), 100(3), 106(1), 108(1), 110(1), 112(2), 115(1), 120(6), 126(1), 130(2), 132(1)134(2), 170(1)	1(9, 10), 20(10)	25	9, 10, 13, 14, 15, 16, 17, 19
	++28	7 (25.00)	–	7 (100)	2x, 4x, 6x, 8x, 12x	**12=** 5(1), 20(1), 40(2), 44(1), 60(2), 76(1), 80(3), 120(1)	1(10)	1	10

Family: Liliaceae Juss. (x=8, 10, 12)									
***Asparagus* L.** (Perennial herbs or subshrubs)	+300	69 (23.00)	35	34 (49.27)	2x, 4x, 6x, 8x	**96=** 16(2), 18(2), 20(48), 22(1), 24(2), 30(2), 40(28), 48(1), 60(9), 80(1)	16(10)	6	8, 9, 10, (11), 12, 15
	++20	15 (75.00)	8	7 (46.66)	2x, 4x, 6x	**21=** 20(11), 22(1), 30(1), 40(5), 48(1), 60(2)	3(10)	2	10, (11), 12, 15
***Disporum* Salisb.** (Perennial herbs)	+20 (26)	26 (100)	22	4 (15.38)	2x, 4x	**40=** 8(1), 12(2), 14(6), 16(19), 18(5), 22(1), 24(1), 28(1), 30(2), 32(2)	1(7), 1(8)	7	(4), 6, 7, 8, 9, 11, 15
	++3 (4)	4 (100)	4	–	2x	**9=** 12(1), 14(3), 16(4), 30(1)	–	3	6, 7, 8, 15
***Gagea* Salisb.** (Perennial herbs)	+250	89 (35.6)	42	47 (52.80)	2x, 4x, 5x, 6x, 8x, 11x	**119=** 16(1), 18(5), 24(50), 25(1), 32(1), 36(15), 48(26), 60(7), 72(7), 80(1), 96(2), 102(1), 106(1), 132(1)	17(12)	4	8, 9, 12
	++8	7 (87.5)	2	5 (71.42)	2x, 4x, 5x, 6x, 8x	**9=** 24(2), 48(3), 60(1), 72(1), 96(2)	2(12)	–	12
***Polygonatum* Adans.** (Perennial herbs)	+57 (67)	67 (100)	36	31 (46.26)	2x, 3x, 4x, 6x, 8x, 10x, 12x	**166=**14(1), 16(2), 18(20), 19(2), 20(28), 21(1), 22(15), 24(7), 26(7), 27(2), 28(15), 29(4), 30(19), 31(3), 32(3), 36(4), 38(2), 40(6), 44(1), 46(1), 52(1), 54(1), 56(3), 58(1), 59(1), 60(5), 62(1), 64(2), 66(1), 78(1), 84(1), 86(1), 88(1), 90(2), 91(1)	3(7), 1(8), 3(9), 10(10), 2(11), 1(13)	27	7, 8, 9, 10, 11, 12, 13
	++24	11 (45.83)	1	10 (90.90)	2x, 3x, 4x, 6x, 8x	**41=**18(2), 22(1), 24(1), 26(3), 27(1), 28(6), 29(2), 30(9), 31(2), 36(2), 38(1), 40(1), 56(1), 58(1), 59(1), 60(3), 62(1), 64(1), 66(1), 88(1)	1(7), 3(10), 1(11)	7	7, 8, 9, 10, 11, 12, 13
Family: Orchidaceae Juss. (x=10)									
***Epipactis* Pers.** (Perennial herbs)	+25 (34)	34 (100)	3	31 (91.17)	2x, 3x, 4x, 6x, 8x	**68=** 16(1), 18(1), 20(4), 24(3), 30(1), 32(3), 34(1), 36(5), 38(9), 40(28), 44(2), 46(1), 48(1), 52(1), 60(5), 80(2)	10(10)	10	8, 9, 10, 12, 19
	++4 (6)	6 (100)	–	6 (100)	2x, 4x, 6x, 8x	**14=** 20(2), 36(1), 38(2), 40(6), 44(1), 60(1), 80(1)	4(10)	2	9, 10, 19
Family: Poaceae Barnhart									
Subfamily: Pooideae (x=7, 9)									
Tribe: Brachypodieae (x=7, 9)									
***Brachypodium* P.Beauv.** (Annual or perennial herbs)	+16	14 (87.50)	5	9 (64.28)	2x, 3x, 4x, 5x, 6x, 8x	**41=** 10(1), 14(4), 16(2), 18(6), 20(2), 28(7), 30(2), 31(1), 32(1), 34(1), 35(1), 36(4), 38(1), 40(2), 42(3), 44(1), 46(1), 56(1)	3(7), 2(9)	8	5, 7, 8, 9, 10, 17, 19
	++3	1 (33.33)	–	1 (100)	2x, 4x, 6x	**4=** 14(1), 18(1), 28(1), 42(1)	1(7)	1	7, 9
Tribe: Bromeae (x=7)									
***Bromus* L.** (Annual or perennial herbs)	+160	129 (80.62)	29	100 (77.51)	2x, 3x, 4x, 6x, 8x, 10x, 12x, 16x	**203=** 14(53), 21(1), 24(1), 28(61), 30(1), 42(35), 54(2), 56(34), 70(11), 84(2), 112(2)	46(7)	2	7
	++14	6 (42.85)	2	4 (66.66)	2x, 4x, 6x, 8x	**8=** 14(3), 28(2), 42(2), 56(1)	1(7)	–	7

Tribe: Poeae (x=7)									
***Agrostis* L.** (Annual or perennial herbs)	+220	126 (57.27)	19	107 (84.92)	2x, 3x, 4x, 5x, 6x, 7x, 8x, 12x	**187=** 8(1), 14(30), 16(1), 17(1), 18(1), 21(1), 22(1), 24(1), 28(59), 30(2), 32(2), 33(1), 34(2), 35(6), 36(1), 41(2), 42(51), 44(2), 46(1), 49(1), 50(1), 55(1), 56(15), 58(1), 72(1), 84(1)	28(7)	8	4, 7, 8, 9, 11, 15, 17
	++28	21 (75.00)	2	19 (90.47)	2x, 4x, 6x	**33=** 14(4), 28(15), 36(1), 42(11), 44(1), 58(1)	7(7)	2	7, 9, 11
***Avena* L.** (Annual herbs)	+27 (56)	56 (100)	23	33 (58.92)	2x, 4x, 6x, 9x, 12x, 18x	**86=** 14(31), 15(1), 16(1), 19(1), 20(1), 22(1), 23(1), 28(20), 32(1), 40(2), 41(1), 42(14), 43(1), 44(4), 48(2), 63(1), 120(1), 124(1), 126(1)	9(7), 1(11)	8	7, (8), 11
	++9	4 (44.44)	–	4 (100)	2x, 4x, 6x	**7=** 14(1), 28(2), 41(1), 42(3)	1(7)	1	7
***Briza* L.** (Annual or perennial herbs)	+16 (29)	29 (100)	8	21 (72.41)	2x, 4x	**32=** 10(1), 14(10), 28(21)	2(7)	1	5, 7
	++3	2 (66.66)	2	–	2x	**2=** 10(1), 14(1)	–	–	5, 7
***Dactylis* L.** (Perennial herbs)	+5 (11)	11 (100)	3	8 (72.72)	2x, 3x, 4x, 5x, 6x	**20=** 14(6), 21(2), 27(1), 28(6), 29(1), 31(1), 35(1), 40(1), 42(1)	3(7)	2	7
	++1	1 (100)	–	1 (100)	2x, 4x, 6x	**3=** 14(1), 28(1), 42(1)	1(7)	–	7
***Festuca* L.** (Perennial herbs)	+500	345 (69.00)	87	258 (74.78)	2x, 3x, 4x, 5x, 6x, 7x, 8x, 9x, 10x, 17x	**490=** 14(129), 15(1), 16(1), 20(1), 21(4), 24(2), 26(1), 27(1), 28(153), 29(1), 30(1), 31(1), 35(1), 36(1), 40(1), 41(1), 42(121), 43(2), 44(3), 46(1), 47(1), 48(1), 49(4), 50(1), 52(1), 53(1), 55(1), 56(32), 60(2), 63(3), 64(1), 68(1), 70(13), 170(1)	76(7)	10	7, (8), (10), (12), (13), (15)
	++12(25)	25 (100)	8	17 (68.00)	2x, 4x, 6x, 7x, 8x, 9x, 10x	**37=** 14(9), 26(1), 28(9), 30(1), 42(8), 49(1), 56(6), 63(1), 70(1)	12(7)	–	7, 13, 15
***Helictotrichon* Besser** (Perennial herbs)	+90	45 (50.00)	14	31 (68.88)	2x, 4x, 6x, 8x, 12x, 14x, 16x, 18x	**71=** 14(22), 16(1), 28(22), 42(9), 56(3), 60(1), 62(1), 70(2), 84(1), 98(1), 100(1), 112(2), 120(2), 121(1), 126(2)	13(7)	4	7, (8)
	++7	3 (42.85)	–	3 (100)	4x, 6x, 8x	**6=** 28(3), 42(2), 56(1)	2(7)	–	7
***Koeleria* Pers.** (Perennial herbs)	+60	54 (90.00)	16	38 (70.37)	2x, 3x, 4x, 6x, 7x, 8x, 9x, 10x, 12x	**85=** 12(1), 14(26), 15(1), 18(1), 26(2), 28(23), 30(1), 41(1), 42(10), 43(1), 45(1), 49(1), 56(7), 70(7), 84(2)	14(7)	5	(6), 7, (9), 13
	++2	2 (100)	2	–	2x	**1=** 14(2)	–	–	7
***Lolium* L.** (Annual or perennial herbs)	+8 (15)	15 (100)	10	5 (33.33)	2x, 4x, 8x, 10x	**29=** 14(14), 15(1), 16(1), 22(1), 24(1), 25(1), 26(1), 28(5), 30(1), 56(2), 70(1)	4(7)	1	7
	++6 (7)	7 (100)	4	3 (42.85)	2x, 4x	**15=** 14(7), 16(1), 22(1), 24(1), 25(1), 26(1), 28(2), 30(1)	2(7)	1	7

***Poa* L.** (Annual or perennial herbs)	+500	269 (53.8)	29	240 (89.21)	2x, 3x, 4x, 5x, 6x, 7x, 8x, 9x, 10x, 11x, 12x, 13x, 14x, 15x, 16x, 21x, 38x	**688=**14(50), 15(1), 16(1), 21(7), 22(1), 23(1), 24(2), 25(1), 26(2), 28(129), 29(3), 30(2), 31(1), 32(4), 33(4), 34(2), 35(12), 36(2), 37(3), 38(5), 39(6), 40(2), 41(3), 42(84), 43(8), 44(6), 45(4), 46(4), 47(2), 48(6), 49(12), 50(6), 51(2), 52(3), 53(1), 54(4), 55(1), 56(51), 57(1), 58(7), 59(4), 60(5), 61(3), 62(13), 63(20), 64(15), 65(3), 66(6), 67(4), 68(7), 70(27), 71(4), 72(14), 73(1), 74(8), 75(3), 76(6), 77(3), 78(4), 79(1), 80(7), 81(4), 82(6), 83(1), 84(21), 85(2), 86(3), 87(1), 88(1), 90(4), 91(4), 92(4), 93(1), 94(3), 95(2), 96(1), 97(2), 98(2), 100(3), 101(1), 103(1), 104(1), 105(3), 106(2), 112(3), 117(1), 124(1), 127(2), 147(1), 263(1), 265(1), 266(1)	79(7)	60	7
	++52	27 (51.92)	4	23 (85.18)	2x, 4x, 5x, 6x, 8x, 9x, 10x	**50=**14(9), 28(16), 32(1), 33(1), 34(1), 35(1), 42(6), 50(1), 51(1), 52(1), 56(4), 63(1), 64(2), 66(1), 70(2), 72(1), 80(1)	8(7)	6	7
***Polypogon* Desf.** (Annual or perennial herbs)	+18	12 (66.66)	–	12 (100)	2x, 4x, 5x, 6x, 8x	**22=** 14(2), 26(1), 28(8), 35(1), 40(1), 42(6), 50(1), 56(1), 60(1)	6(7)	1	7, 10
	++2 (3)	3 (100)	–	3 (100)	4x, 6x	**5=** 28(3), 42(2)	2(7)	–	7
***Vulpia* C.C.Gmel.** (Annual herbs)	+23 (29)	29 (100)	16	13 (44.82)	2x, 4x, 6x, 9x	**41=** 14(23), 28(8), 42(9), 63(1)	7(7)	–	7
	++4	2 (50.00)	1	1 (50.00)	2x, 4x, 6x	**3=** 14(1), 28(1), 42(1)	1(7)	–	7
Tribe: Phleeae (x=7)									
***Alopecurus* L.** (Annual or perennial herbs)	+36 (45)	45 (100)	14	31 (68.88)	2x, 3x, 4x, 6x, 7x, 8x, 10x, 12x, 13x, 14x, 15x, 16x, 17x	**78=** 14(21), 20(1), 21(1), 26(1), 28(16), 30(1), 32(1), 42(3), 45(1), 56(8), 70(1), 80(1), 98(2), 100(3), 105(3), 112(4), 114(1), 116(1), 117(1), 119(1), 120(2), 122(1), 130(2), 150(1)	3(10), 14(7)	6	7, (10)
	++6 (7)	7 (100)	2	5 (71.42)	2x, 3x, 4x, 6x	**13=** 14(4), 20(1), 26(1), 28(4), 30(1), 42(1), 45(1)	3(7)	1	7, (10)
***Phalaris* L.** (Annual or perennial herbs)	+22	16 (72.72)	5	11 (68.75)	2x, 4x, 5x, 6x, 8x	**37=** 12(3), 14(10), 15(2), 27(1), 28(9), 35(1), 42(4), 48(1), 56(4), 66(2)	7(7)	3	6, 7
	++5	3 (60.00)	–	3 (100)	2x, 4x, 6x	**5=** 12(1), 14(1), 28(2), 42(1)	1(7)	–	6, 7
***Phleum* L.** (Annual or perennial herbs)	+15 (22)	22 (100)	9	13 (59.09)	2x, 3x, 4x, 5x, 6x, 8x, 9x, 10x, 12x	**42=** 10(1), 14(15), 21(3), 28(11), 35(1), 36(1), 40(1), 42(3), 56(3), 63(1), 70(1), 84(1)	8(7)	1	5, 7
	++4	4 (100)	–	4 (100)	2x, 4x, 6x, 8x	**8=** 14(2), 28(4), 42(1), 56(1)	3(7)	–	7

Tribe: Meliceae (x=9, 10)									
***Glyceria* R.Br.** (Perennial herbs)	+40 (43)	43 (100)	20	23 (53.48)	2x, 4x, 5x, 6x, 8x, 12x	**57=** 14(5), 20(23), 28(7), 35(1), 40(14), 56(3), 60(3), 120(1)	2(7), 6(10)	5	7, 10
	++3	1 (33.33)	–	1 (100)	2x, 4x	**2=** 20(1), 40(1)	1(10)	–	10
***Melica* L.** (Perennial herbs)	+80	56 (70.00)	45	11 (19.64)	2x, 3x, 4x, 6x	**65=** 14(2), 18(49), 19(1), 20(1), 27(1), 30(1), 36(9), 54(1)	5(9), 1(10)	2	7, 9, 10
	++9	5 (55.55)	4	1 (20.00)	2x, 4x	**5=** 18(4), 36(1)	–	–	9
Tribe: Stipeae (x=11, 12)									
***Piptatherum* P.Beauv.** (Perennial herbs)	+26	24 (92.30)	20	4 (16.66)	2x, 3x, 4x	**32=**20(1), 22(5), 24(17), 34(2), 36(1), 46(2), 48(4)	2(12)	6	(10), 11, 12, 17
	++13	4 (30.76)	4	–	2x	**5=**22(1), 24(4)	–	1	11, 12
***Stipa* L.** (Perennial herbs)	+300	103 (34.33)	17	86 (83.49)	2x, 3x, 4x, 6x, 7x, 8x	**142=** 18(1), 19(1), 20(1), 22(3), 23(1), 24(6), 26(1), 28(5), 32(5), 34(6), 36(10), 40(9), 42(4), 44(56), 46(7), 48(3), 60(2), 64(3), 66(8), 68(3), 70(2), 72(1), 74(1), 82(1), 88(1), 96(1)	2(11)	26	9, (10), 11, 12, 13, 14, 16, 17
	++22	2 (9.09)	1	1 (50.00)	2x	**2=** 24(1), 46(1)	–	1	12
Tribe: Cynodonteae (x=9, 10)									
***Acrachne* Chiov.** (Annual herbs)	+3	1 (33.33)	–	1 (100)	2x, 3x, 6x	**3=** 12(1), 18(1), 36(1)	1(6)	1	6
	++1	1 (100)	–	1 (100)	2x, 3x, 6x	**3=** 12(1), 18(1), 36(1)	1(6)	–	6
C*hloris* Sw. (Annual or perennial herbs)	+55	34 (61.81)	3	31 (91.17)	2x, 4x, 5x, 6x, 8x, 9x, 10x, 12x	**63=** 14(1), 20(7), 26(1), 30(5), 36(2), 40(28), 50(2), 56(3), 60(2), 62(1), 63(2), 64(1), 65(1), 66(1), 72(2), 80(2), 84(1), 100(1)	6(10)	9	10
	++10(14)	14 (100)	3	11 (78.57)	2x, 4x, 5x, 6x, 8x	**23=** 20(6), 30(2), 36(1), 40(9), 50(1), 56(1), 60(2), 65(1)	4(10)	1	10
***Cynodon* Rich.** (Perennial herbs)	+10	10 (100)	6	4 (40.00)	2x, 3x, 4x, 6x	**16=** 18(6), 20(1), 27(1), 28(1), 30(1), 36(2), 40(1), 42(1), 54(2)	3(9)	1	9, 10, (14)
	++4	3 (75.00)	1	2 (66.66)	2x, 3x, 4x, 6x	**7=** 18(3), 27(1), 36(2), 54(1)	2(9)	–	9
***Dactyloctenium* Willd.** (Annual or perennial herbs)	+13	3 (23.07)	–	3 (100)	2x, 3x, 4x	**21=** 18(2), 20(3), 22(1), 23(1), 24(1), 27(1), 40(3), 34(1), 36(1), 38(1), 42(1), 44(1), 46(1), 48(2), 52(1)	1(9), 3(10), 1(11), 1(12)	2	9, 10, 11, 12, (17), (19)
	++5	3 (60.00)	–	3 (100)	2x, 3x, 4x,	**21=** 18(2), 20(3), 22(1), 23(1), 24(1), 27(1), 34(1), 36(1), 38(1), 40(3), 42(1), 44(1), 46(1), 48(2), 52(1)	1(9), 3(10), 1(11), 1(12)	2	9, 10, 11, 12, (17), (19)
***Eleusine* Gaertn.** (Annual or perennial herbs)	+9 (18)	18 (100)	6	12 (66.66)	2x, 4x, 5x, 6x	**35=**16(2), 18(9), 20(1), 28(1), 34(1), 36(9), 37(1), 38(2), 39(2), 40(1), 42(1), 43(1), 45(3), 54(1)	6(9)	7	7, 8, 9, 10, (17), (19)
	++3 (15)	15 (100)	4	11 (73.33)	2x, 4x, 5x, 6x	**26=**16(1), 18(6), 28(1), 34(1), 36(7), 37(1), 38(1), 39(2), 42(1), 43(1), 45(3), 54(1)	4(9)	3	7, 8, 9, (17), (19)

***Eragrostis* Wolf** (Annual or perennial herbs)	+350	136 (38.85)	24	112 (82.35)	2x, 4x, 5x, 6x, 7x, 8x, 10x, 12x	**226=** 16(1), 18(2), 20(47), 28(1), 30(8), 35(1), 36(3), 40(79), 41(2), 42(3), 44(2), 50(5), 54(2), 56(1), 60(39), 62(1), 63(1), 70(2), 72(3), 80(15), 84(1), 90(1), 100(3), 108(2), 120(1)	3(9), 44(10)	15	(8), 9, 10
	++42	21 (50.00)	2	19 (90.47)	2x, 4x, 5x, 6x, 7x	**47=**16(1), 18(2), 20(9), 28(1), 30(2), 36(1), 40(15), 42(1), 50(1), 54(2), 60(11), 70(1)	1(9), 12(10)	7	(8), 9, 10
***Leptochloa* P.Beauv.** (Annual or perennial herbs)	+27	19 (70.37)	9	10 (52.63)	2x, 4x, 6x, 8x	**30=** 12(1), 20(13), 36(3), 40(8), 54(1), 60(2), 72(1), 80(1)	5(10), 2(18)	2	(6), 10, 18
	++5 (6)	6 (100)	4	2 (33.33)	2x, 4x, 6x	**11=** 12(1), 20(6), 36(1), 40(2), 54(1)	1(9), 2(10)	1	(6), 10, 18
***Muhlenbergia* Schreb.** (Perennial herbs)	+160	85 (53.12)	38	47 (55.29)	2x, 4x, 6x, 7x, 8x	**112=** 16(2), 18(4), 20(39), 21(1), 22(2), 24(4), 30(2), 40(37), 42(5), 46(1), 60(8), 64(1), 68(1), 70(1), 72(1), 80(2), 82(1)	14(10)	12	8, 9, 10, (11)
	++4	2 (50.00)	–	2 (100)	2x, 4x	**3=** 20(1), 40(2)	1(10)	–	10
***Sporobolus* R.Br.** (Annual or perennial herbs)	+160	65 (40.62)	15	50 (76.92)	2x, 4x, 5x, 6x, 8x, 10x, 12x, 14x, 16x	**135=** 12(3), 16(1), 18(11), 20(11), 24(16), 28(1), 30(3), 31(1), 32(1), 36(30), 38(3), 40(13), 42(1), 44(2), 45(1), 46(2), 48(8), 50(1), 52(1), 54(9), 56(1), 60(3), 72(3), 80(2), 88(1), 90(2), 108(2), 126(1), 144(1)	4(6), 12(9), 4(10)	21	6, 9, 10
	++22	12 (54.54)	3	9 (75.00)	2x, 4x, 6x	**29=** 12(1), 16(1), 18(3), 20(3), 24(4), 28(1), 32(1), 36(8), 40(2), 48(3), 54(2)	1(6), 4(9), 1(10)	6	6, 9, 10
Tribe: Arundinelleae (x=10)									
***Arundinella* Raddi** (Annual or perennial herbs)	+55	21 (38.18)	12	9 (42.85)	2x, 4x, 5x6x, 8x, 10x	**45=** 14(2), 16(2), 18(2), 20(13), 24(2), 28(2), 32(2), 34(2), 36(3), 40(2), 48(1), 50(1), 54(3), 56(1), 60(3), 70(1), 72(1), 80(2)	2(7), 2(8), 1(9), 3(10)	7	7, 8, 9, 10, 17
	++23	12 (52.17)	6	6 (50.00)	2x, 4x, 5x, 6x, 8x, 10x	**30=** 14(1), 16(2), 18(2), 20(6), 24(1), 28(1), 32(2), 34(1), 36(1), 40(2), 48(1), 50(1), 54(3), 60(2), 70(1), 72(1), 80(2)	1(8), 1(9), 3(10)	5	7, 8, 9, 10, 17
Tribe: Isachneae (x=5)									
***Isachne* R.Br.** (Annual or perennial herbs)	+100	16 (16.00)	–	16 (100)	2x, 4x, 8x, 10x, 12x, 18x	**24=** 10(1), 20(9), 40(9), 50(1), 60(3), 90(1)	6(5)	–	5
	++25	6 (24.00)	–	6 (100)	2x, 4x, 8x, 10x, 12x	**9=** 10(1), 20(3), 40(3), 50(1), 60(1)	2(5)	–	5
Tribe: Paniceae (x=7, 9, 10, 17)									
***Alloteropsis* C. Presl** (Annual or perennial herbs)	+8	3 (37.5)	1	2 (66.66)	2x, 4x, 6x, 8x, 12x	**7=** 18(2), 30(1), 36(1), 54(1), 72(1), 108(1)	1(9)	1	9
	++2	1 (50.00)	–	1 (100)	4x	**1=** 36(1)	–	–	9
***Brachiaria* (Trin.) Griseb.** (Annual or perennial herbs)	+100	43 (43.00)	8	35 (81.39)	2x, 3x, 4x, 6x, 8x, 10x, 12x	**97=** 12(1), 14(3), 18(18), 20(2), 28(5), 30(1), 32(4), 34(2), 36(27), 40(1), 42(5), 45(1), 46(1), 48(2), 52(1), 54(7), 55(1), 56(1), 64(3), 72(8), 80(1), 84(1), 90(1)	3(7), 1(8), 16(9)	11	(6), 7, 8, 9, (10), (17)
	++21	17 (80.95)	1	16 (94.11)	2x, 4x, 6x, 8x, 12x	**37=** 12(1), 14(2), 18(3), 20(1), 28(1), 30(1), 32(3), 34(1), 36(11), 40(1), 42(1), 48(2), 52(1), 54(4), 72(3), 84(1)	1(7), 5(9)	5	(6), 7, 8, 9, (10), (17)

***Cenchrus* L.** (Annual or perennial herbs)	+22 (23)	23 (100)	13	10 (43.47)	2x, 3x, 4x, 5x, 6x, 8x	**61=**18(1), 28(1), 30(1), 32(3), 34(20), 35(1), 36(7), 37(1), 38(1), 40(1), 42(2), 44(1), 45(2), 46(1), 48(1), 52(1), 54(4), 56(1), 64(1), 66(1), 68(4), 70(1), 72(3), 102	5(9), 2(16), 3(17)	9	9, (14), 16, 17
	++7	6 (85.71)	1	5 (83.33)	2x, 3x, 4x, 6x, 8x	**30=** 18(1), 30(1), 32(2), 34(4), 35(1), 36(5), 37(1), 38(1), 40(1), 42(1), 44(1), 45(2), 48(1), 52(1), 54(3), 56(1), 64(1), 72(2)	4(9), 2(16)	5	9, 16, 17
***Digitaria* Haller** (Annual or perennial herbs)	+220	79 (35.90)	17	62 (78.48)	2x, 3x, 4x, 5x, 6x, 8x, 12x	**159=** 16(1), 18(39), 24(1), 27(2), 28(1), 30(4), 34(5), 35(1), 36(47), 37(1), 40(1), 45(4), 48(2), 54(22), 60(1), 68(2), 70(1), 72(22), 76(1), 108(1)	33(9)	14	(8), 9, 12, (14), 17
	++29	28 (96.55)	3	25 (89.28)	2x, 3x, 4x, 5x, 6x, 8x	**58=** 18(10), 27(1), 28(1), 36(16), 40(1), 48(1), 54(11), 68(1), 70(1), 72(14), 76(1)	13(9)	5	9, 12, (14), 17
***Echinochloa* P.Beauv.** (Annual or perennial herbs)	+40	23 (57.50)	1	22 (95.65)	2x, 4x, 6x, 8x, 10x, 12x, 14x	**62=** 18(7), 24(1), 32(1), 36(14), 38(1), 42(1), 48(4), 50(1), 52(1), 54(15), 56(3), 72(5), 90(2), 96(1), 100(1), 108(3), 126(1)	10(9), 1(12)	4	9, 12
	++7	7 (100)	–	7 (100)	2x, 4x, 6x, 8x, 12x	**21=** 24(1), 36(5), 48(3), 52(1), 54(6), 56(1), 72(1), 96(1), 108(2)	5(9), 1(12)	3	9, 12
***Oplismenus* P.Beauv.** (Annual or perennial herbs)	+7	6 (85.71)	–	6 (100)	2x, 3x, 4x, 5x, 6x, 8x, 10x	**22=** 12(1), 18(2), 20(1), 24(1), 27(1), 36(1), 40(2), 44(1), 45(1), 54(4), 60(1), 72(5), 90(1)	4(9), 1(10)	4	(6), 9, (10)
	++4	2 (50.00)	–	2 (100)	2x, 4x	**5=** 18(2), 20(1), 36(1), 40(1)	1(9)	2	9, (10)
***Panicum* L.** (Annual or perennial herbs)	+450	265 (58.88)	125	140 (52.83)	2x, 3x, 4x, 5x, 6x, 7x, 8x, 9x, 10x, 12x, 13x, 14x, 16x, 18x	**396=**10(1), 14(2), 16(2), 18(134), 20(22), 21(1), 25(1), 27(1), 28(3), 30(4), 32(6), 34(2), 36(99), 38(1), 40(25), 41(1), 42(3), 44(1), 45(2), 48(2), 49(2), 50(2), 52(2), 54(39), 55(2), 56(1), 58(1), 60(4), 63(1), 64(2), 65(1), 70(3), 72(11), 82(1), 84(1), 90(1), 98(1), 100(2), 108(2), 112(1), 130(1), 132(1), 144(1)	3(7), 1(8), 42(9), 5(10)	31	(5), 7, 8, 9, 10
	++29(50)	50 (100)	11	39 (78.00)	2x, 4x, 6x, 8x, 10x, 13x, 16x	**100=** 10(1), 14(1), 16(1), 18(18), 20(3), 28(2), 30(1), 32(4), 34(1), 36(26), 40(7), 42(3), 45(1), 48(1), 52(1), 54(10), 56(1), 58(1), 60(3), 64(1), 70(3), 72(6), 100(2), 112(1), 130(1)	1(8), 16(9), 3(10)	13	(5), 7, 8, 9, 10
***Paspalidium* Stapf** (Perennial herbs)	+27	7 (25.92)	–	7 (100)	2x, 4x, 6x, 8x	**15=**18(1), 36(5), 44(1), 54(3), 56(1), 60(1), 72(1), 112(1), 224(1)	3(9)	1	9
	++3	3 (100)	–	3 (100)	2x, 4x, 6x	**6=** 18(1), 36(2), 54(1), 56(1), 112(1)	2(9)	1	9
***Paspalum* L.** (Annual or perennial herbs)	+350	184 (52.57)	52	132 (71.73)	2x, 3x, 4x, 5x, 6x, 7x, 8x, 12x, 16x	**280=** 10(2), 12(2), 16(1), 18(3), 20(83), 21(1), 23(1), 24(1), 25(1), 30(5), 32(2), 40(94), 41(1), 42(1), 43(1), 45(1), 48(1), 50(7), 52(2), 54(2), 55(1), 56(1), 57(1), 58(1), 60(35), 61(2), 62(1), 63(3), 64(1), 70(1), 72(2), 80(11), 76(1), 108(2), 120(3), 160(2)	1(6), 4(9), 57(10)	14	(5), 6, 8, 9, 10
	++14(22)	22 (100)	1	21 (95.45)	2x, 4x, 5x, 6x, 8x, 12x	**45=**18(2), 20(3), 25(1), 30(1), 40(16), 42(1), 48(1), 50(4), 54(2), 55(1), 60(8), 61(1), 72(1), 80(1), 108(1), 120(1)	1(9), 8(10)	6	8, 9, 10

***Pennisetum* Pers.** (Annual or perennial herbs)	+80	62 (77.50)	19	43 (69.35)	2x, 3x, 4x, 5x, 6x, 8x, 9x, 10x, 12x	**154=** 7(2), 10(1), 13(1), 14(17), 15(2), 16(3), 18(18), 19(1), 20(2), 21(2), 22(2), 24(2), 26(1), 27(8), 28(5), 29(1), 30(1), 32(5), 34(2), 35(2), 36(27), 40(1), 42(3), 43(1), 45(7), 48(3), 52(1), 53(1), 54(18), 56(2), 63(3), 66(1), 68(1), 70(1), 72(4), 84(1), 90(1)	6(7), 4(8), 22(9)	14	5, 7, 8, 9
	++16(39)	39 (100)	13	26 (66.66)	2x, 3x, 4x, 5x, 6x, 8x, 10x	**91=** 7(1), 10(1), 14(14), 15(2), 16(2), 18(9), 19(1), 20(1), 21(2), 22(1), 24(2), 26(1), 27(5), 28(5), 29(1), 30(1), 32(3), 34(2), 35(2), 36(11), 42(3), 45(3), 48(1), 54(13), 56(2), 68(1), 70(1)	5(7), 1(8), 10(9)	9	5, 7, 8, 9
***Setaria* P.Beauv.** (Annual or perennial herbs)	+110	78 (70.90)	10	68 (87.17)	2x, 3x, 4x, 5x, 6x, 8x, 9x, 12x	**143=** 10(1), 14(1), 18(25), 20(1), 22(1), 27(1), 28(1), 32(5), 34(1), 35(2), 36(56), 38(4), 40(1), 44(1), 54(23), 56(1), 63(2), 68(1), 72(13), 108(2)	1(7), 30(9)	14	7, 8, 9
	++17(31)	31 (100)	7	24 (77.41)	2x, 4x, 5x, 6x, 8x, 12x	**65=** 14(1), 18(14), 20(1), 28(1), 32(2), 35(1), 36(21), 38(3), 44(1), 54(12), 56(1), 72(6), 108(1)	11(9)	5	7, 8, 9
***Urochloa* P.Beauv.** (Annual or perennial herbs)	+120	14 (11.66)	4	10 (71.42)	2x, 3x, 4x, 6x	**28=** 14(2), 18(2), 26(2), 28(3), 30(4), 32(1), 36(7), 42(2), 46(1), 48(1), 54(2), 60(1)	2(7), 2(9), 1(15)	3	7, 9, 13, 15
	++5 (8)	8 (100)	1	7 (87.50)	2x, 3x, 4x, 6x	**14=** 14(1), 28(3), 32(1), 36(4), 46(1), 48(1), 54(2), 60(1)	1(9)	2	7, 9, 15
Tribe: Andropogoneae (x=5, 9, 10, 19)									
***Andropogon* L.** (Annual or perennial herbs)	+100	98 (98.00)	–	98 (100)	2x, 4x, 6x, 7x, 8x, 9x, 10x, 12x, 14x, 16x, 20x, 24x, 36x	**142=** 10(2), 18(1), 20(44), 21(1), 30(1), 32(1), 35(1), 36(1), 40(31), 42(2), 43(1), 44(1), 45(2), 50(2), 60(25), 68(1), 70(6), 78(1), 80(5), 90(1), 100(3), 120(7), 180(2)	26(5)	5	5, 9, (16)
	++9 (14)	14 (100)	–	14 (100)	4x, 8x, 9x, 10x	**17=** 20(7), 40(6), 45(2), 50(2)	1(5)	1	5
***Apluda* L.** (Perennial herbs)	+1 (3)	3 (100)	2	1 (33.33)	2x, 4x, 6x, 7x, 14x	**7=** 20(3), 40(1), 60(1), 70(1), 140(1)	1(10)	–	10
	++1 (2)	2 (100)	1	1 (50.00)	2x, 4x, 6x	**4=** 20(2), 40(1), 60(1)	1(10)	–	10
***Arthraxon* P. Beauv.** (Annual or perennial herbs)	+7 (19)	19 (100)	6	13 (68.42)	2x, 4x	**33=** 16(4), 18(8), 20(3), 26(1), 30(1), 36(12), 38(1), 40(3)	3(9), 1(10)	7	8, 9, 10, 13, 15
	++21	16 (76.19)	6	10 (62.5)	2x, 4x	**24=** 16(4), 18(7), 20(1), 26(1), 30(1), 36(8), 38(1), 40(1)	2(9), 1(10)	3	8, 9, 10, 13, 15
***Bothriochloa* Kuntze** (Perennial herbs)	+40 (37)	37 (100)	4	33 (89.18)	2x, 3x, 4x, 5x, 6x, 8x, 12x, 18x	**61=** 20(7), 30(2), 36(2), 40(17), 44(1), 50(5), 60(16), 80(3), 120(6), 180(2)	11(10)	3	9, 10
	++17	15 (88.23)	3	12 (80.00)	2x, 3x, 4x, 5x, 6x, 8x	**27=** 20(4), 30(1), 36(1), 40(10), 44(1), 50(3), 60(6), 80(1)	4(10)	2	9, 10

***Capillipedium* Stapf** (Annual or perennial herbs)	+14	8 (57.14)	–	8 (100)	2x, 4x, 5x	**11=** 20(3), 40(7), 50(1)	3(10)	–	10
	++7	5 (71.42)	–	5 (100)	2x, 4x	**8=** 20(3), 40(5)	3(10)	–	10
***Chrysopogon* Trin.** (Perennial herbs)	+25	15 (60.00)	8	7 (46.66)	2x, 4x, 8x	**24=** 20(14), 40(7), 80(3)	6(10)	–	10
	++16	14 (87.50)	7	7 (50.00)	2x, 4x, 8x	**21=** 20(13), 40(6), 80(2)	5(10)	–	10
***Coix* L.** (Annual or perennial herbs)	+5	5 (100)	1	4 (80.00)	2x, 3x, 4x, 5x, 6x, 8x	**34=** 10(4), 11(2), 12(1), 15(1), 16(1), 18(1), 19(1), 20(4), 21(3), 22(2), 23(1), 24(1), 25(1), 27(2), 29(1), 30(2), 31(1), 39(1), 40(3), 41(1)	3(5), 1(6)	3	5, 6, 8, 9, 11
	++4	4 (100)	1	3 (75.00)	2x, 3x, 4x, 6x, 8x	**19=** 10(4), 11(1), 12(1), 16(1), 20(2), 21(1), 22(1), 27(1), 29(1), 30(1), 31(1), 39(1), 40(2), 41(1)	3(5)	3	5, 6, 8, 9, 11
***Cymbopogon* Spreng.** (Perennial, rarely Annual herbs)	+40	34 (85.00)	9	25 (73.52)	2x, 3x, 4x, 6x, 8x	**67=** 20(28), 22(1), 24(1), 30(5), 40(21), 60(10), 80(1)	21(10)	1	10, (12)
	++26	25 (96.15)	6	19 (76.00)	2x, 3x, 4x, 6x	**50=** 20(21), 24(1), 30(4), 40(16), 60(8)	17(10)	–	10, (12)
***Dichanthium* Willemet** (Perennial, rarely Annual herbs)	+16 (18)	18 (100)	6	12 (66.66)	2x, 3x, 4x, 5x, 6x, 8x	**32=** 20(11), 30(1), 32(1), 40(11), 50(2), 60(5), 80(1)	6(10)	1	10
	++9 (18)	18 (100)	6	12 (66.66)	2x, 3x, 4x, 5x, 6x, 8x	**31=** 20(11), 30(1), 32(1), 40(10), 50(2), 60(5), 80(1)	5(10)	1	10
***Hemarthria* R.Br.** (Perennial, rarely Annual herbs)	+12	8 (66.66)	3	5 (62.5)	2x, 4x, 6x	**16=**16(1), 18(5), 20(4), 36(3), 54(3)	3(9)	3	9, 10
	++5	3 (60.00)	–	3 (100)	2x, 4x, 6x	**7=**18(2), 20(2), 36(1), 54(2)	2(9)	2	9, 10
***Imperata* Cirillo** (Perennial herbs)	+8	4 (50.00)	3	1 (25.00)	2x, 4x, 6x	**7=** 20(4), 40(1), 52(1), 60(1)	1(10)	1	10
	++2	1 (50.00)	–	1 (100)	2x, 4x	**2=** 20(1), 40(1)	1(10)	–	10
***Ischaemum* L.** (Perennial, sometimes Annual herbs)	+60	35 (58.33)	13	22 (62.85)	2x, 3x, 4x, 5x, 6x, 8x	**63=** 18(2), 20(23), 24(1), 30(2), 34(1), 36(4), 38(1), 40(15), 44(1), 50(1), 52(1), 54(2), 56(1), 58(1), 60(4), 68(1), 72(2)	2(9), 11(10)	9	9, 10
	++56	26 (46.42)	13	13 (50.00)	2x, 3x, 4x, 6x	**35=** 18(1), 20(17), 24(1), 30(1), 36(2), 38(1), 40(8), 60(4)	6(10)	2	9, 10
***Microstegium* Nees** (Annual or perennial herbs)	+15	7 (46.66)	1	6 (85.71)	2x, 4x, 6x, 7x, 8x	**19=** 20(5), 36(1), 40(5), 42(1), 60(2), 70(1), 72(1), 80(3)	4(10)	2	10, (18)
	++8	5 (62.50)	–	5 (100)	2x, 4x, 6x, 7x, 8x	**17=** 20(4), 36(1), 40(4), 42(1), 60(2), 70(1), 72(1), 80(3)	4(10)	2	10, (18)
***Miscanthus* Andersson** (Perennial herbs)	+20	17 (85.00)	5	12 (70.58)	2x, 3x, 4x, 5x, 6x	**37=** 20(1), 28(1), 35(1), 36(2), 38(11), 40(5), 41(1), 42(2), 46(1), 57(5), 64(1), 76(3), 95(1), 114(2)	1(10), 1(14), 4(19)	5	10, 14, 18, 19
	++4	2 (50.00)	–	2 (100)	2x, 4x	**3=** 20(1), 40(2)	1(10)	–	10

***Mnesithea* Kunth** (Perennial, rarely Annual herbs)	+5	3 (60.00)	2	1 (33.33)	2x, 4x	**4=** 14(1), 18(2), 36(1)	–	1	(7), 9
	++2	2 (100)	2	–	2x	**3=** 14(1), 18(2)	–	1	(7), 9
***Phacelurus* Griseb.** (Perennial herbs)	+7	2 (28.57)	–	2 (100)	2x, 4x, 6x, 7x, 8x	**6=** 20(1), 22(1), 40(1), 60(1), 70(1), 80(1)	1(10)	1	10, (11)
	++1	1 (100)	–	1 (100)	2x, 6x, 7x, 8x	**5=** 20(1), 22(1), 60(1), 70(1), 80(1)	1(10)	1	10, (11)
***Pogonatherum* P.Beauv.** (Perennial herbs)	+3	3 (100)	–	3 (100)	2x, 4x	**6=** 14(1), 20(2), 28(1), 40(2)	1(7), 1(10)	1	7, 10
	++3	3 (100)	–	3 (100)	2x, 4x	**6=** 14(1), 20(2), 28(1), 40(2)	1(7), 1(10)	1	7, 10
***Rottboellia* L.f.** (Annual herbs)	+4 (6)	6 (100)	4	2 (33.33)	2x, 4x, 5x, 6x	**10=** 18(3), 20(2), 36(1), 40(1), 50(1), 54(1), 60(1)	1(10)	1	9, 10
	++2	2 (100)	1	1 (50.00)	2x, 4x, 6x	**5=** 20(2), 36(1), 40(1), 60(1)	1(10)	1	9, 10
***Saccharum* L.** (Perennial herbs)	+5 (11)	11 (100)	–	11 (100)	2x, 3x, 4x, 5x, 6x, 7x, 8x, 9x, 10x, 11x, 12x, 14x, 16x, 17x, 19x	**160=** 20(3), 22(1), 24(1), 30(6), 32(1), 34(1), 36(1), 38(1), 40(9), 48(5), 50(1), 52(2), 54(3), 55(1), 56(1), 58(1), 60(15), 62(2), 63(1), 64(6), 66(1), 68(4), 70(2), 72(3), 77(1), 78(1), 79(1), 80(8), 81(2), 82(2), 83(2), 84(3), 88(4), 90(4), 91(1), 92(3), 93(1), 94(1), 96(4), 99(1), 100(3), 102(1), 104(4), 105(1), 106(1), 107(1), 108(2), 110(1), 112 (4), 114(2), 116(2), 118(1), 119(1), 120(8), 121(1), 124(5), 126(3), 128(3), 168(1), 170(1), 172(1), 176(1), 194(1)	11(10)	10	10
	++15	8 (53.33)	–	8 (100)	2x, 3x, 4x, 6x, 7x, 8x, 9x, 10x, 12x, 17x	**57=** 20(2), 22(1), 24(1), 30(1), 32(1), 34(1), 36(1), 38(1), 40(4), 48(3), 52(1), 54(1), 56(1), 58(1), 60(4), 62(1), 64(3), 68(2), 70(1), 72(1), 80(3), 82(1), 84(1), 88(2), 90(2), 92(1), 96(1), 100(1), 104(1), 112(1), 116(1), 120(4), 124(2), 126(1), 128(2), 170(1)	5(10)	4	10
***Sorghum* Moench** (Annual or perennial herbs)	+30 (73)	73 (100)	46	27 (36.98)	2x, 4x, 6x, 8x, 12x	**99=** 10(20), 18(1), 20(53), 21(3), 22(1), 30(4), 40(15), 60(2)	15(5)	5	5, (9)
	++25(42)	42 (100)	26	16 (38.09)	2x, 4x, 8x, 12x	**51=** 10(7), 18(1), 20(36), 40(6), 60(1)	7(5)	1	5, (9)
***Themeda* Forssk.** (Annual or perennial herbs)	+18 (22)	22 (100)	7	15 (68.18)	2x, 3x, 4x, 5x, 6x, 8x, 10x	**47=**18(1), 20(11), 21(1), 22(3), 23(1), 24(1), 30(1), 32(1), 40(9), 42(1), 50(2), 54(1), 59(1), 60(6), 80(4), 90(1), 100(1), 110(1)	6(10)	6	(9), 10, (11), (12), (16)
	++18	17 (94.44)	6	11 (64.70)	2x, 3x, 4x, 5x, 6x, 8x, 10x	**33=** 18(1), 20(9), 22(2), 30(1), 40(7), 50(2), 54(1), 60(5), 80(3), 90(1), 110(1)	5(10)	4	(9), 10, (11)
***Vetiveria* Bory** (Perennial herbs)	+10	3 (30.00)	1	2 (66.66)	2x, 4x	**4=** 20(2), 36(1), 40(1)	–	1	10
	++2 (3)	3 (100)	1	2 (66.66)	2x, 4x	**3=** 20(2), 40(1)	–	–	10

Family: Pontederiaceae Kunth (x=14)									
Monochoria **C.Presl** (Annual or perennial herbs)	+8	6 (75.00)	1	5 (83.33)	2x, 4x, 5x, 6x, 7x	**25=** 24(1), 26(1), 28(4), 30(1), 34(1), 40(1), 48(1), 52(2), 53(1), 54(1), 55(1), 56(1), 70(1), 72(1), 74(1), 76(1), 80(3), 82(1), 84(1)	1(10), 1(12, 13)	4	(12), (13), 14, 15, (17), (20)
	++2	2 (100)	–	2 (100)	2x, 4x	**5=** 24(1), 26(1), 28(1), 52(1), 80(1)	1(13)	1	(12), (13), 14, (20)
Family: Zingiberaceae Martinov (x=17)									
Hedychium **J.Koenig** (Perennial herbs)	+80	16 (20.00)	6	10 (62.5)	2x, 3x, 4x, 6x	**28=**18(1), 24(1), 34(13), 36(1), 51(2), 52(5), 54(2), 66(2), 68(1)	1(9), 3(17)	7	9, 17
	++24	14 (58.33)	5	9 (64.28)	2x, 4x, 6x	**26=**18(1), 24(1), 34(12), 36(1), 51(2), 52(5), 54(2), 66(1), 68(1)	1(9), 3(17)	7	9, 17

+ World data for grasses are compiled mainly from Watson & Dallwitz (1992), and for other genera from publications cited for each genus in Results.
Numbers of cytologically known species higher than the corresponding numbers of taxonomically recorded species are given in parenthesis. Disparities may be due to taxonomic revision of hybrids, exotics and cultivars previously assigned species rank.

++ Indian data for grasses are based mainly on Bor (1960), and for other genera are based on publications cited for each genus in Results.

***** Compiled from Darlington & Wylie (1955), Fedorov (1974) and Kumar & Subramaniam Vol. II. (1986), *Index to Plant Chromosome Number Reports* from 1968 onwards, journals, proceedings and the Internet. The chromosome numbers are recorded as mitotic numbers or converted from meiotic numbers.

** Common basic numbers are underlined. Basic numbers that are doubtful, under consideration or to be taken with caution are given in parentheses.