CHAPTER 1

INTRODUCTION
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Cytology is an important field in biology which deals with cell structure, function and chemistry with main focus on chromosomes. Chromosomes are the packaged structures of DNA and proteins that carry the genetic information and pass it from parents to offspring through sexual reproduction involving meiosis. Hence, meiosis is an important aspect of cell cycle and maintains a balanced chromosome number over generations, besides creating variations via random assortment of homologous chromosomes and crossing over. It is a dynamic process involving a number of complex molecular and cellular events, such as DNA and chromosome replication, chromosome pairing and recombination, chromosome segregation and cytokinesis, and hence maintains genome stability and integrity over sexual life cycles. Normal meiotic course involving reductional and equational division leads to four healthy and haploid gametes each with half the chromosome number than the parent cell. Anomalous meiotic recombination, because of specific genome structures, induces structural aberrations in chromosomes and therefore a major driving force for gene and genome evolution. Outstanding progress in the field of botany has been permitted after the development of the electron microscope in the 20th century. Plant cytologists have been able to investigate features and processes that were unknown years ago. Plant species especially inhabiting harsh climates are exposed to various environmental stresses, which affects metabolism including cell structure, chromosome behavior and hence reproductive potential. On the other hand this may lead to chromosomal evolution through aneuploidy and chromosome doubling, and ultimately to speciation. Behaviour of the chromosomes in reduction divisions (meiosis-I) provides an explanation of Mendelian segregation and also of the irregularities of crosses between species, differing in chromosome number. Such study is therefore an interesting field of biology which provide an insight into genetic and environmental interactions and their possible effect on chromosomal variability in structure and number, on the morphology and reproduction of the organisms and hence evolution and speciation.

Kashmir often called ‘the paradise on earth’ is famous worldwide for its enchanting picturesque beauty of its lofted snow capped mountains, lush green meadows and supernatural lakes. It is a diverse phytogeographic zone located in the extreme north of India. The region shares international boundaries with Pakistan in
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the west, Chinese autonomous region of Xinjiang in the north and Tibet in the north-east. It is separated from the plains of India by the Pir Panjal range. It forms northwestern zone of Himalayan biodiversity hotspot, situated at geographical coordinates of 32° 20' to 34° 50' North latitude and 73° 55' to 75° 35' East longitude. Himalayas spreading over an area of 7,50,000 km² harbor about 10,000 flowering plants. Interestingly, the Kashmir Himalaya alone contributes nearly 2,000 (20 per cent) species within just 2.15 per cent (15,948 km²) of the total land area of entire Himalaya (Dar et al. 2002) with about 8 percent being endemic. It is predominantly a high mountainous area (64 percent mountainous) with an altitude from 1700 m in the temperate planes to 5500 m in the alpine range (Khuroo et al. 2007). On a daily average, the temperature of the area ranges from a minimum of 15°C and a maximum of 31°C during summer to a minimum of -4°C and a maximum of 4°C during winter. Most of the precipitation is received in the form of snow during the winter. Due to the diverse physiography, soil and climate, the region is rich in habitats like meadows, temperate, subalpine and alpine ranges, marshes, plateaus, rivers, lakes and glaciers, etc. thus supporting rich biodiversity including a large number of medicinal and aromatic plants. Over 100 plant species growing naturally here are considered as high potential medicines (Iqbal & Siddique 2004). The well known medicinal plants of the area include *Aconitum heterophyllum*, *Arnebia benthamii*, *Atropa acuminata*, *Codonopsis ovata*, *Picrorhiza kurroa*, *Podophyllum hexandrum*, *Prunella vulgaris*, *Rheum emodi*, *Saussurea costus*, *Valeriana jatamansii*, etc. The diverse phyto and zoogeography, scenic beauty and ethnic heterogeneity have attracted tourists and botanists besides other researchers from all over the world. Some of the important spots for such people have been Aharbal, Aphaswat, Dal Lake, Gulmarg, Gurez Valley, Lolab Valley, Mughal Gardens, Razdaan Pass, Sonmarg, Pahalgam, Wullar Lake, etc., to mention some. The anthropogenic activities have adversely affected the flora due to overexploitation and contributed to accelerated extinction and rarity of important species.

The present study deals with cytomorphology of subclass Gamopetalae. As per Bentham & Hooker (1862-1883), Gamopetalae includes dicots with partially or completely fused petals. It comprises of 3 series-

(i) **Inferae:** Flowers epigynous with inferior ovary; stamens as many as number of petals. The well represented family in Kashmir is Asteraceae.
(ii) **Heteromerae**: Flowers hypogynous with superior ovary; carpels more than two. Well represented family from Kashmir is Primulaceae.

(iii) **Bicarpellatae**: Flowers hypogynous with superior ovary; carpels two. Well represented families from Kashmir include Gentianaceae, Scrophulariaceae and Lamiaceae.

From Kashmir Himalaya subclass Gamopetalae as per Dhar and Kachroo (1983), is represented by 22 families and 137 genera, the largest being Asteraceae (50 genera, 334 species), followed by Lamiaceae (16 genera, 81 species) and Scrophulariaceae (11 genera, 85 species). Of the presently studies 134 species, around 75 percent fall under these 3 families.

In Asteraceae a number of economically important species are known from the Kashmir e.g. *Saussurea costus* against arthritis and inflammation (Damre *et al*. 2003), *S. involucrata* as anti-fatigue and antitumor (Wu *et al*., 2009), *Taraxacum officinale* has hepatoprotective, anti breast cancer and pancreatic lipase inhibitory activities (Sigstedt *et al*. 2008), etc. Some plants in the family are famous for horticulturalists such as species of *Tagetes* (marigolds), *Chrysanthemum, Dahlia, Zinnia*, etc., and are cultivated well in India. It is nowadays considered as the largest family with 1600 genera and 23000 species (Gao *et al*. 2010). There have been many genera in the family viz. *Artemisia, Chrysanthemum, Hieracium, Taraxacum*, etc. in which polyploidization, evolution and speciation remained hot topics in the field of cytological and genomic studies. Chromosomal evolution through euploidy or aneuploidy has lead to morphological variations, adaptabilities, changes in modes of reproduction and speciation in many such cases.

Under family Lamiaceae, Harley *et al*. (2004) recognizes 236 genera and 7200 species and Heywood *et al*. (2007) assigns 6900 species. The family is taxonomically much complex and confusing because the relationships between tribes, subtribes and genera within some subfamilies are poorly understood, as complex and possibly homoplasious morphological characters make taxa difficult to delimit. Although there is a great chromosomal variability in some genera, still some cytotaxonomic approaches by Love and Love (1942), Morales (1986) proved beneficial. The family is commercially very important, mainly due to essential oils, medicinal properties, aroma chemicals, perfume products, pot herbs, etc. The essential oils like menthol,
thymol are used in flavouring, perfumery, besides antiseptic. Some specific reports on medicinal properties of Labiates include antitumor and anti-inflammatory activity (Lee et al. 2004), antioxidant and antibacterial activity (Hussain 2009), anticancer activity (Ozkan & Erdogan 2011), besides as a source of podophyllotoxin (Konuklugil 1996).

A large variability in the base numbers is a cytological characteristic feature for the family Lamiaceae. This variability could possibly be the result of aneuploidy at generic level (Fernandes & Leitao, 1984). There is also a high percentage of polyploidy in Lamiaceae although it differs from 29.21 percent (Saggoo 1983) to 62 percent (Thoppil 1993) and meiotic aberrations have played a major role in evolution and diversification of the family. Molecular studies have revealed a lot of genetic diversity in various members of the family (Gobert et al. 2002).

Scrophulariaceae from Kashmir is as important as Lamiaceae in terms of species diversity. Phylogenetic studies have transferred many species to Plantaginaceae and Orobanchaceae, besides several newly created families (Olmstead, 2002). There are economically important species e.g. Digitalis purpurea an ideal source of digotoxin, Euphrasia officinalis called eyebright, useful in eye diseases (Lans et al. 2007). Owing to the presence of iridoid, phenyl and flavonoid compounds, the various species of the genus Pedicularis are potential antioxidants (Jiang et al. 2003; Khodaie et al. 2012).

Other families of Gamopetalae like Gentianaceae is well represented in Kashmir with 6 genera and 55 species mainly inhabiting subalpine/alpine range and thus less explored cytologically. Many of these species have high medicinal value due to possession of compounds like xanthenes, iridoides, etc. (Negi et al. 2011). There is a great chromosomal diversity of base numbers in the family, particularly in Gentiana. Cytology has time to time contributed in classifying the genus and there are some examples of effective intrageneric cytotaxonomical treatments in the genus (Love 1953; Yuan & Kupfer 1993).

Solanaceae is not common in Kashmir but some economically important species like Atropa acuminata, Datura stramonium, Hyoscyamus niger, Solanum nigrum, etc. grow well in the temperate to subalpine range and are commercially exploited. The alkaloids like atropine, hyoscyamine etc. extracted from some of these
species act as stimulant to the sympathetic nervous system and are employed as antidote to opium (Wani et al. 2007). Dipsacaceae with 3 genera and 6 species from Kashmir includes Dipsacus inermis locally called ‘wopalhakh’ which is ethnomedicinally used as a vegetable as general health improving, carminative and stomachic, etc. Primulaceae is another large family in Kashmir with 7 genera and 43 species. Some species in Primula and Androsace are cultivated because of their ornamental value.

The cytological exploration of Kashmir Himalaya is not comprehensive. There has been previous work in this field for different species or genera but it is lacking for a taxonomic group above genus level. Although some contributions in the field of cytology are praiseworthy like Khoshoo and Sobti (1958), Koul and Gohil (1973), Jee et al. (1983), etc. but mainly temperate to subalpine regions have been previously explored. The perusal of literature reveals that most of the alpine peaks are unexplored. There remains a large number of species with no cytogenetic information available. The reasons being climatic conditions where snow covers these areas for most part of the year, steep topography and far flung inaccessible areas, besides the political atmosphere of the valley that further aggravates the condition.

Knowledge of various meiosis-driven genome variations provide insight into genome evolution and genetic variability in plants and facilitates plant genome research (Cai & Xu, 2007). Such studies have led to the production of new forms by artificial disturbance of the chromosome mechanism. It has also offered a plausible explanation of the origin of new forms in nature e.g. in mountainous regions subject to violent temperature changes, besides, providing possible methods for producing artificial variants of economic importance.

Keeping in view the rich floristic diversity with restricted and endemic species, threatened medicinal and other economically important plants, and incomprehensive cytological exploration of this flora, present attempt has been made to contribute chromosomal database cataloguing, understanding the nature of intraspecific variable meiotic behavior and chromosomal evolution in these important Himalayan plant species. It will make a platform for further applied researches in order to mark out novel cytotypes in commercially important species.
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Aims and Objectives

Specific objectives of the study are:

- To carry, extensive and intensive plant surveys of gamopetalous species on population basis covering different climatic and altitudinal zones of Kashmir.
- To study the meiotic course, microsporogenisis, flowering and fruiting period for each species.
- To carry out the detailed cytological analysis of the species with intraspecific morphological / chromosomal diversity to know the nature of variation.
- To collect ethnobotanical information about the use of various species from the local people and Hakeems.