

CHAPTER 1

1. INTRODUCTION

1.1 Background

The family Asteraceae or Compositae (aster, daisy, or sunflower family) is the largest family of flowering plants, in terms of number of species. The family name 'Asteraceae' is derived from the type genus *Aster*, while the older name 'Compositae' is still valid name; compositae refers to the composite characteristic of inflorescence, a special type of pseudanthium found in only a few other angiosperm families. The study of this family is known as synantherology (Rahman *et al.*, 2008).

1.2 Morphological variations

Most of the members of Asteraceae are herbaceous, but a significant number are also shrubs, vines and trees. The family is distributed throughout the world except Antarctica. They are poorly represented only in tropical rain forests (Funk *et al.*, 2009).

Almost all the features generally occurring in plants can be found in this family. There are annual, biennial or perennial herbs, dwarf shrubs, shrubs, a few trees and some aquatics. Some are succulent, while others are spiny and some have milky sap. Many perennial species are adapted to survive the cold, dry winter season by underground storage organs producing annual stems in spring. The leaves may be arranged alternately, opposite or whorled along the stem; sometimes they are situated at the base of the stem radical and rosulate or in groups. Some have petiole while others are sessile. The leaves can be simple with smooth margins or the margins toothed, lobed or variously dissected to such an extent that the leaves appear to be compound with numerous leaf segments. All members of Asteraceae share a basic reproductive unit also termed as the head or capitulum. In this inflorescence the florets are arranged on the receptacle and they are referred to as Composites because it looks like a single large flower.

Asteraceae is considered to be the most highly evolved family of the angiosperms. The following characters seem to be indication of advanced family. The floral

characters occupy a more important place than the vegetative ones that are given below.

1. The condensed inflorescence, the capitulum, are protected by involucre of bracts.
2. Pollen mechanism, pollen protection and nectar placements etc. are preferable to cross-pollination by highly specialized insects.
3. The flowers are protandrous, thus self pollination is avoided.
4. In case of failure of cross pollinations, self pollination is possible because of curling back of stigmas to contact the pollen from their own anthers.
5. The floral parts are completely whorled and typically pentamerous = $K_{(5)(PAPPUS)} C_{(5)} \overset{\frown}{A_{(5)}} G_{-(2)}$.
 Sepal and petals are typically valvate. The sepals get reduced to pappus. Reduction in parts is a criterion of advancement.
6. The ovary in the entire family is completely inferior.
7. The floral buds are well protected by involucre bracts.
8. The corolla tube is usually short enough to enable the nectar secreted by a ring-like nectary at the base of the style to reach by all except the shortest tongued insects. Therefore, flowers are visited by large variety of insects.
9. The matured fruits are very light in majority of the plants due to the presence of a crown of hairy pappus. It is a very perfect mechanism for the dispersal of seeds by wind.

Nepal contains as large as over 7, 000 flowering plants (Shrestha *et al.*, 2000) though it occupies only 0.1 % of the total land of the earth (Joshi & Joshi 2001). Much of this diversity in flora is still unknown genetically. Kumar and Subramanian (1986) have suggested that the global flora is expecting in a condition of loss of 20-25 % of existing plant diversity due to global climate change and increasing habitat loss. The exploration of the genetic diversity of the Himalayan country, Nepal, has become utmost important to evaluate, maintain and manage it.

Stace (2000) has estimated that about 75% of the 2, 50,000 of flowering plants on earth are cytogenetically untouched. Research in the Himalayan flora still remains little touched field of investigation (Wakabayashi, 1988; Dhar, 2002).

There are different views regarding the number of genera and species of this family. According to Lawrence (1967) the family is with 950 genera and 2000 species where as according to Cronquist (1968) there are 19000 species in this family. Judd *et al.* (1999) regarded that the family comprises 1535 genera and 23000 species. Angiosperm Phylogeny Group II (2003) has recognized Asteraceae as second largest family of flowering plants containing approximately 1620 genera and 22750 species. Stevens (2010) considered it as the largest family on earth with over 24 000 described species, representing roughly 10% of all flowering plant species. One hundred forty genera and over 700 species of Asteraceae have been reported from India (Rajalaxmi, 2001). Polunin and Stainton (1997) reported 155 species of 46 genera of Asteraceae from himalaya regions.

In Nepal 111 genera and 417 species of Asteraceae has been reported from different regions (Press *et al.* 2000, Ohashi, 1975; Hara & Williams, 1979). They are mostly of temperate to tropical regions of Nepal.

The family is divided into two sub-families viz. Tubuliflorae and Liguliflorae. Twelve tribes included under the sub-family Tubuliflorae are Anthemideae, Arctitideae, Astereae, Calenduleae, Cynareae, Eupatorieae, Heliantheae, Helinieae, Inuleae, Mutisieae, Senecioneae, Vernonieae One tribe Cichorieae is included under the sub-family Liguliflorae (Bentham & Hooker, 1883).

The work followed in present investigation is on the basis of Bentham and Hooker system of classification. This system is based on form as well as the relationships of plants.

In the present investigation forty-five species of thirty-three genera of the family are cytogenetically researched. The taxa in Asteraceae included here fall into ten tribes. They are Astereae, Anthemideae, Calenduleae, Cichorieae, Cynareae, Eupatorieae, Helinieae, Heliantheae, Inuleae and Senecioneae.

Tribe Astereae

Plants within the tribe are distributed nearly worldwide and contains 170 genera and more than 2,800 species. In present study seven species are included from this tribe viz. *Aster barbellatus*, *A. ageratoides*, *A. peduncularis* subsp. *nepalensis*, *Conyza canadensis*, *Dichrocephala integrifolia*, *Erigeron annuus* and *Rhynchospermum verticillatum*.

Tribe Anthemideae

According to the most recent information (Oberprieler *et al.* 2006), tribe *Anthemideae* consists of 111 genera and c. 1,800 species found throughout the world. Four species from this tribe are included in the present study viz. *Artemisia abrotanum*, *A. indica*, *A. vulgaris* and *Chrysanthemum morifolium*.

Tribe Calenduleae

The tribe has been widely recognized since Alexandre in the early 19th century (Small 1911). There are eight genera and over 110 species in this tribe, mostly found in South Africa (Judd *et al.* 2008). Only one taxa *Calendula officinalis* is included from this tribe in the present investigation.

Tribe Cichorieae

This tribe comprises 98 genera and more than 1550 species and occurs predominantly in the Northern Hemisphere (Bremer, 1994). Five species from this tribe viz. *Crepis japonica*, *Ixeris polycephala*, *Sonchus asper*, *S. arvensis* and *Taraxacum officinale* are included in the present study.

Tribe Cynareae

Almost 80 genera with 2500 species are assigned to this tribe (Dittrich, 1977). Two species from this tribe are investigated in this study viz. *Centaurea cyanus* and *Cirsium arvense*.

Tribe Eupatorieae

This tribe comprises 190 genera and 2,000 species (Robinson & King, 1985). Most of the species are native to tropical and warm temperate areas. Four species from this tribe viz. *Ageratum conyzoides*, *A. houstonianum*, *Eupatorium adenophorum* and *Stevia rebaudiana* are included in the present study.

Tribe Heliantheae

Heliantheae is the third largest tribe of this family with some 190 genera and nearly 2500 species (Robinson, 1981). The name is derived from the genus *Helianthus*,

which is Greek word for sun flower. Eleven taxa from this tribe are investigated in this study viz. *Bidens pilosa*, *Coreopsis grandiflora*, *Eclipta prostrata*, *Galinsoga parviflora*, *Parthenium hysterophorus*, *Spilanthes acmella*, *S. calva*, *Tridax procumbens*, *Wedelia wallichii*, *Xanthium strumarium* and *Zinnia elegans*.

Tribe Helineae

The tribe consists of approximately 216 species divided among 28 genera. All are found in the New World, with a center of diversity in the Mexican highlands. The type genus is *Tagetes* (marigolds). One species investigated from this tribe is *Tagetes patula*.

Tribe Inuleae

This tribe includes about 66 genera and 687 species (Anderberg & Eldenas, 2007). Eight species from this tribe viz. *Anaphalis triplinervis* var. *triplinervis* *Blumea fistulosa* *B. lacera*, *B.lacera* var. *glandulosa*, *B.laciniata* and *B.mollis*, *Gnaphalium affine* and *G. purpureum* are investigated in the present study.

Tribe Senecioneae

Senecioneae is the largest tribe of the family comprising approximately 150 genera and 3,000 species. Almost one-third of the species in this tribe are placed in the genus *Senecio* (Pelser *et al.*, 2007). Two species from this tribe viz. *Crassocephalum crepidioides* and *Senecio laetus* are included in the present study.

1.3 Economic importance

Economically, members of this family are important for their food, medicinal and ornamental values. They also include important crops, rare and beautiful wildflowers, common allergens, costly invasive plants and rangeland weeds (Dempewolf *et al.*, 2008). Some uses of the presently investigated taxa are as follows.

Ageratum conyzoides is commonly known as goat weed and Nepali name is Boke ghaans or Ganhaaune ghaans. The plant is stimulant and tonic. Leaf and root is used in diarrhea, dysentery and fever. Flower bud of *Ageratum conyzoides* cures cancerous growth (Anonymous, 1997; Joshi 2000; Kirtikar & Basu, 1887). The species

Ageratum houstonianum commonly is called mist weed and Nilo gandhe or Gandhe jhar in Nepali. Its leaf juice is externally applied to stop bleeding and healing cut and wounds (Dongol and Gurung, 2000; Ghimire, 2000).

Anaphalis triplinervis is locally called Buke phul in Nepal. The flower paste is used as an antiseptic application in wounds for both human and cattle (Bhattarai, 1989, Pohle, 1990). *Artemisia abronatum* locally it is called tite paati in Nepal. The plant is used for spices. The common name of *Artemisia indica* is wormwood and Nepali name is tite paati. Leaf juice is taken to cure cough and also is used in treatment of ringworm (Baral & Kurmi 2006, Joshi & Joshi 2001, Manandhar 2002).

Artemisia vulgaris is commonly known as mugwort and is called tite paati in Nepal. The plant is used in fever and cough (Anonymous, 2007). The root paste of *Aster barbellatus* is applied to cuts and wounds (Manandhar, 2002). The root juice of *Aster peduncularis* is applied to fresh cuts and wounds. The *Bidens pilosa*, commonly called beggars stick, is known as Kalo kuro in Nepal. The leaf juice is applied in cuts and wounds. Powder of dried buds of this taxa mixed with alcohol is used to gargle to relief toothache (Rajbhandari, 2001).

Blumea lacera, commonly called Blumea, is known as Kurkure or Kukur ghaans in Nepal. The plant is used as liver tonic, expectorant and fish poison (Siwakoti & Siwakoti, 1998; Joshi 2000; Anonymous, 2001). Most of the species of *Blumea* are used in bodyache (Kirtikar & Basu, 1987). *Cirsium arvense*, commonly called thistle, is locally called Thaakal. The root powder reduces stomach pain, stem pith is chewed to relieve burning sensation while urinating (Pohle, 1990; Manandhar, 2002).

The Nepali name of *Crassocephalum crepidioides* is Anikaale Jhar. Plant juice is given to cure diarrhea (Manandhar, 2002). *Crepis japonica*, locally called chaullane in Nepal. The leaf juice of the plant is given in case of indigestion (Baral & Kurmi, 2006). In Nepal, local name for the *Dichrocephala integrifolia* is Haachhyun Jhaar.

Plant juice is given to treat fever. The juice of flower heads is snuffed to treat sinusitis and migraine (Anonymous, 1997; Manandhar, 2002).

Eupatorium adenophorum is commonly called crofton weed. In Nepal it is known as Banmaaraa. The paste of leaves is applied to boils. Bud paste and leaf juice is applied

to cut and wounds to prevent bleeding (Rajbhandari, 2001). The plant is also used in making bricket used for fuel in Nepal. *Eclipta prostrata* called Bhringraaj or Bhangeri Jhaar in Nepal. The plant paste rejuvenates hair and skin, expells intestinal worm, cures cough and asthma (Anonymous, 1997; Joshi 2000; Joshi & Joshi, 2001; Baral & Kurmi, 2006).

Galinsoga parviflora is known as Chitlaange Ghaans in Nepali. The plant juice is applied on wounds to check bleeding (Manandhar, 2002). Leaves of the plant, *Gnaphalium affine*, are astringent and vulneary (Anonymous, 2007). *Ixeris polycephala* is called Muli buti in Nepal. The plant juice is given in fever. Paste of the flower head is applied to treat scabies. (Manandhar, 2002).

Root decoction of the *Parthenium hysterophorus* is useful in dysentery (Singh *et al.*, 1996). The taxa *Senecio* are responsible for livestock poisonings (Pieter *et al.*, 2002).

Sonchus asper called Dudhe kaandaaas in Nepal. The plant produces latex. Plant paste is applied to wounds and boils (Manandhar, 2002). *Sonchus arvensis* is used as fodder, particularly for rabbits. The species *Spilanthes calva*, locally called Marethi in Nepal. Plant paste is applied on snake bite (Manandhar, 2002).

Spilanthes acmella is called Bhuin timur or Laato Ghaans in Nepal. The Plant paste is applied to snake bites. Their flower heads are pungent and chewed in case of toothache (Manandhar, 2002). *Stevia rebaudiana*, commonly known as sweet leaf, produces stevioside (a noncaloric sweetener) is considered to be 100-400 times as sweet as sucrose (Handro & Ferreira, 1989; Kinghorn & Soejarto, 1991). *Tagetes patula* is commonly called marigold. It is known as Baarahamaase sayapatri in Nepal. Roots and seeds of plants are purgative (Regmi,1991).

Taraxacum officinale is commonly called dandelion. It is called Tuki phul in Nepali. The plant is bitter and liver tonic. It has anthelmintic and anti-bacaterial properties (Bhattacharjee, 2001). *Tridax procumbens* is commonly called wild daisy. In Nepali it is called Hasura Jhaar. The plant paste is applied to treat boils and pimple (Dongol & Gurung, 2000). It is used as ornamental or fodder plant.

Wedelia wallichii is called Vringraaj in Nepal. Plant is used as anti- inflammatory. The plant is very specific in viral hepatitis (Anonymous, 2001; Baral & Kurmi, 2006).

Xanthium strumarium is called Bhende kuro in Nepal. Powder of gall is used in dysentery. Root is bitter tonic and useful in strumous diseases and cancer. (Joshi, 2000; Manandhar, 2002). The plant of *Xanthium* yields xanthinin which acts as a plant growth regulator (Oudhia & Tripathi, 1998; Sastry & Kavathekar, 1990). Young leaves of *Xanthium* (fresh or dried) are used as leaf vegetable, particularly in times of scarcity *Zinnia elegans* is grown in home garden for ornamental purposes. The leaves of *Crepis japonica* and *Taraxacum officinale* are edible (Anonymous, 2007). Many members of the family have ornamental values. Some of the well-known common plants include sunflowers, garden lettuce, artichokes, dandelions, thistles, daisies, ragweed, goldenrod and chicory. There are many varieties and cultivars available in the market in recent days. Familiar cutflowers are asters, dahlias, chrysanthemums, cornflowers and sunflowers. Some members in present study such as *Zinnia elegans*, *Coreopsis grandiflora*, *Chrysanthemum morifolium*, *Tagetes patula*, *Aster ageratoides*, *A. barbellatus*, *A. peduncularis*, *Calendula officinalis*, *Erigerom annuus*, *Rhynchospermum verticillatum* and *Centaurea cyanus* are used as ornamental purposes in home garden.

1.4 Cytogenetical works

Cytology is believed as a dependable tool for solving taxonomic problems and for elucidating systematic relationships, phylogeny and evolution of related plant groups. The information like chromosome number, structure, morphology and behavior during mitotic and meiotic divisions have been of considerable value in understanding inter- relationship and delimitation of taxa (Yoshikane & Naohiro 1991). Therefore, these factors are used as classification criteria in the same manner as the morphological characters since the chromosomes have direct relation to the genetic system of which they are an integral part.

Chromosome number, structure and behavior of chromosomes can also give important additional clues to know the interrelationship and evolutionary tendencies among the taxa (Stebbins, 1968, 1971). It is known that cytological studies have been carried out for more than hundred years (Rajalaxmi, 2001). However, most of the cytogenetic descriptions in the early stages consist of information only on the chromosome number only. More recently majority of chromosomal and cytogenetical studies have been based on visible characteristic of the chromosome. Karyotype

analysis is a well established method based on the morphological characteristic of chromosome and widely used in cytogenetical analysis. Cytogenetic studies such as determination of chromosome number and morphology of chromosome have been used in taxonomic determination in many species where phenotypic traits are insufficient to differentiate among species.

The pioneer cytological study was made by Tahara (1915) and Geisler (1931). However, cytological study by Turner *et al.* (1961, 1964, 1965) and Mehra *et al.* (1965) have given the sufficient information on the members of Asteraceae. Powell and Powell (1978) recorded chromosome number of 100 species of 54 genera of Asteraceae. Khamdamov and Noskova (1986), Jayaramu and Chatterji (1986), Ruas and Ruas (1987), Chui (1989), Watanabe *et al.* (1990), Qiao *et al.* (1990), Herickhoff *et al.* (1994), Branas and Xirau (1994), Dagne (1995), Xiong *et al.* (1995) and Arturo *et al.* (1996) are among the researchers of detailed karyotype analysis of Asteraceae members outside Nepal.

In Asteraceae, chromosome numbers have provided to be of great value in the determination of tribes (Naik, 1992). Karyotype analysis have been useful in classifying phylogenetic and evolutionary relationship between some related species and species groups, where differences in karyotypes between taxa are not distinct, The basic chromosome numbers were employed in formulating phylogenetic speculations and to find out the direction of evolution in the family.

The present study is remarkable work for Nepal in determining chromosome number, chromosome structure, basic number, as well as phyletic tree of various members of Asteraceae. With the realization of its importance, the present investigation has been undertaken for Nepalese Asteraceae.

1.5 Justification

1. The research on chromosome numbers and karyomorphology is very important but the study in this field is very few in Nepal.
2. The scope of the cytogenetical research in these plants is significantly more in the global context also because this family contains largest number of plants and many of them are yet to be studied cytogenetically.

1.6 Hypothesis

The cytogenetical investigations of the Nepalese members of Asteraceae are expected to show karyomorphological variations, the speciations processes and phylogenetic relationships among the taxa.

1.7 Objectives

1. To determine chromosome number including karyomorphology of all presently studied plants.
2. To find out co-relationship between chromosomes and the general morphology of investigated plants.
3. To study phylogenetic relationship among 45 taxa within 10 tribes of the family Asteraceae.

CHAPTER 2

2. LITERATURE REVIEW

The chromosome count made by previous authors were tabulated separately and given in appendix- I. In the table distribution of chromosome counts done by other authors outside Nepal are put in context to Nepal. The chromosome counts are from the different literatures (Darlington & Wylie, 1955, Taxon series-IOPB Chromosome number reports, Internet database [http:// mobot. mobot.org-Missouri Botanical Gardens Vast, W3 Tropicos](http://mobot.mobot.org-Missouri Botanical Gardens Vast, W3 Tropicos), 2010, 2011, 2012, 2013).

Kaul (1967) has reported $2n=40$ for *Ageratum conyzoides* from India. Gupta (1969) has made cytological investigations on 21 taxa belonging to 16 genera and 17 species of family Asteraceae from India. He determined two haploid numbers $n=10$ and 20 for *Ageratum conyzoides*.

Gupta *et al.* (1972) have made cytological investigations in 33 collections belonging to 28 species from ten different tribes of the family Asteraceae from India. They found $n=10$ for *Ageratum conyzoides*. Mathew and Mathew (1983, 1988) reported $2n=40$ for *Ageratum conyzoides*. Mathew and Mathew (1983), Jansen *et al.* (1984), Gupta and Gill (1989), Gill and Abubakar (1975) reported $n=20$ for *Ageratum conyzoides*. Keil *et al.* (1988) reported $n=20II$ for *Ageratum conyzoides*.

Husaini and Iwo (1990) have studied cytology of some weedy species of the family Compositae (Asteraceae) from Nigeria and found that haploid number $n=18$ for *Ageratum conyzoides*. Morton (1993) reported $2n=30$ for *Ageratum conyzoides*.

Razaq *et al.* (1994) have reported chromosome numbers of 82 taxa, belonging to 48 genera in ten tribes of the family Asteraceae from Pakistan. They found chromosome number $n=10$ for *Ageratum conyzoides*.

Rajalakshmi (2001) has made cytological studies in 47 species of 34 genera of Asteraceae from India. She reported chromosome number $2n=40$ for the taxa *Ageratum conyzoides* and *A. houstonianum*; $n=20$ for *A. houstonianum*; $2n=18$ for *Conyza Canadensis* and *Blumea mollis*; $2n=72$ for *Bidens pilosa*; $2n=22$ for *Eclipta prostrata*; $2n= 32$ for *Galinsoga parviflora*; $2n=36$ for *Parthenium hysterophorus*; $2n=78$ for *Spilanthes calva*; $2n=36$ for *Tridax procumbens*; $2n=50$ for *Wedelia*

chinensis; $2n=24$ for *Zinnia elegans* and *Tagetes patula*; $2n=40$ for *Crassocephalum crepidioides*. Zhen and Cheng (2003) also reported $2n=40$ for the taxa *Ageratum conyzoides*.

King *et al.* (1976) and Razaq *et al.* (1994) have found chromosome number $n=20$ for *Ageratum houstonianum*. Chromosome number $n=10$ was reported by Mathew and Mathew (1983) and King *et al.* (1976) for this species. The diploid chromosome number $2n=20$ was reported by Shukur *et al.* (1977) and $2n=40$ was reported by Nazeer *et al.* (1981) for this species.

Mehra and Remanandan (1975) have reported $n=14$ for the taxa *Anaphalis triplinervis*. Sharma (1970) reported $2n=28$ for this species. Peng and Hsu (1978) have made somatic chromosome counts of 76 taxa, representing 47 genera of Compositae from Taiwan. They found $2n=28$ for *Anaphalis margaritacea*.

Kaul (1965) has done cytology of polyploid *Artemisia maritima* from India and found $n=18$ bivalents and $n=36$ univalents for this species. Estes (1971) has reported $n=33$ for *Artemisia douglasiana* from U.S.A. Arohonka (1982) has made chromosome counts of vascular plants from Finland and found haploid chromosome number $n=8$ for *Artemisia vulgaris*.

Tanaka and Shimotomai (1961) have studied karyotype in four species of *Chrysanthemum* from Japan viz. *C. lineare*, *C. vulgare*, *C. rupestre* and *C. nipponicum* found all diploid with $2n=18$.

Gupta (1969) has made cytological investigations on 21 taxa belonging to 16 genera and 17 species of family Asteraceae from India. He determined $2n=11$ for *Blumea lacera*, $n=10$ for *B. laciniata*, $n=9$ for *Gnaphalium purpureum*, *Sonchus asper*, *Tridax procumbens* and $2n=16$ for *Calendula officinalis*.

Gupta *et al.* (1972) found $n=16$ for *Calendula officinalis* and for *Sonchus arvensis*; $n=9$ for *Blumea laciniata*, *Sonchus arvensis*, *Crepis japonica*, *Cirsium arvense*; $n=7$ for *Tagetes patula* and $n=11$ for *Coreopsis basalis*.

Mathew and Mathew (1975) have done cytological study of seven species of *Blumea* from South India and somatic chromosome number was found to be $2n=18$, $n=9$; $2n=16$ and $n=8$ in *B. barbata*; $2n=36$, $n=18$ in *B. lacera* var. *glandulosa*; $2n=18$ and

n=9 in *B. virens*; 2n=18 and n=9 in *B. jacquemontii*; n=9 in *B. oxyodonta*; n=18 showed in *B. membranacea*.

Peng and Hsu (1978) found 2n=28 for *Gnaphalium purpureum*; 2n=36 for *Artemisia capillaries*; 2n=36 for *Aster ageratoides*; 2n =72 for *Bidens bipinnata*; 2n=36 for *Blumea lacera*; 2n=34 for *Cirsium albescens*; 2n=16 for *Galinsoga parviflora* and *Ixeris chinensis*; 2n=24 for *Taraxacum officinale*; 2n=30 for *Wedelia prostrata*; 2n=18 for *Blumea laciniata*, *Conyza japonica*, *Chrysanthemum arisanense*, *Dichrocephala integrifolia*, *Erigeron annuus* *Rhynchospermum verticillatum* and *Sonchus arvensis* from Taiwan.

The chromosome number n=22 for *Bidens*; n=9 for *Conyza bonariensis*; n=10 for *Eupatorium hecatanthum*; n=18 for *Parthenium hysterophorus*; n=13 for *Spilanthes grisea*; n=20 for *Senecio deferens* and *S. nivalis*; n=30 for *Wedelia gluca*; n=12 for *Zinnia peruviana* were determined by Turner *et al.* (1979) from South America.

Robinson *et al.* (1981) have reported chromosome numbers of 145 taxa of Asteraceae from America. They found n=36 for *Bidens pilosa*; n=28 for *Coreopsis mutzca*; n=11 for *Eclipta alba*; n=16 for *Galinsoga quadriradiata*; n=18 for *Parthenium hysterophorus*; n=39 for *Spilanthes alba*; n=24 for *Tagetes terniyolia* and n=12 for *Wedelia grandiflora*.

Gopinathan and Babu (1982) have made cytogenetical investigations in two species of genus *Galinsoga*, viz. *Galinsoga parviflora* and *G. cilliata* from India and found that *G. parviflora* was diploid with chromosome number 2n=16, n=8 and *G. cilliata* was tetraploid with 2n=32 and n=16.

Razaq *et al.* (1988) reported chromosome number n=11 for *Eclipta prostrata* from Pakistan. Dutta and Shaha (1971), Nirmala and Rao (1986), Podlech (1986), Sidhu and Bir (1983) reported 2n=22 for this species. Renard *et al.* (1983), Silvestre (1980) reported 2n=18, Husaini and Iwo (1990) reported n=12 for this species.

Soegima and Peng (1998) have made cytological study in two species of *Aster ageratoides* complex from Taiwan viz. *A. ageratoides* with 2n=18 and *A. lasioclada* with 2n=36.

Keil *et al.* (1988) have made chromosome studies in Asteraceae from the United states, Mexico, The West Indies and South America in 196 taxa. They found chromosome number $n=9$ for *Conyza canadensis*; $n=9$ for *Bidens biternata*; $n=16$ for *Spilanthes urens* and $n=14$ for *Wedelia reticulata*.

Razaq *et al.* (1994) have reported chromosome numbers of 82 taxa belonging to 48 genera in ten tribes of the family Asteraceae from Pakistan. They found Chromosome number $n=9$ for *Conyza japonica* from tribe Astereae. From tribe Inuleae, $n=10$ for *Blumea lacera* and $n=7$ for *Gnaphalium affine* were reported. Haploid chromosome number $n=36$ for *Bidens biternata*; $n=10$ for *Coreopsis lanceolata*; $n=11$ for *Eclipta prostrata*; $n=8$ for *Galinsoga parviflora*; $n=18$ for *Tridax procumbens*; $n=18$ for *Xanthium strumarium* and $n=12$ for *Zinnia elegans* were reported from tribe Heliantheae. From tribe Tageteae (Helineae), they reported $n=24$ for *Tagetes minuta*. Chromosome number $n=20$ for *Senecio analogus* from tribe Senecione was recorded. From tribe Cynareae, $n=12$ was reported for *Centaurea cyanus*. Haploid chromosome number $n=5$ for *Crepis sancta*; $n=9$ for *Sonchus asper* and $n=16$ for *S. aleraceus* were determined from tribe Cichorieae (Lactuceae).

Daruwalla (1995) has done cytological investigations on the taxa *Blumea fistulosa* from Bombay (India) and reported $n=20$. The chromosome numbers with $2n=18$ (Gupta & Gill, 1979) and $2n=30$ (Gupta, 1983) were reported for the this species.

Anagnostopoulos (1997) have investigated karyotype variations in *Crepis fraasii* and *C. reuteriana* (Asteraceae) from Greece and found $2n=12$ for *Crepis fraasii* var. *fraasii* and karyotype consists of $2n=2x=8m+2m-SAT+2sm$; $2n=12$ for *Crepis fraasii* var. *mungieri* and karyotype consists of $2n=2x=8m+2m-SAT+2sm$. Diploid number $2n=8$ was reported by him for *Crepis reuteriana* with karyotype formula $2n=2x=2m+2st-SAT+2sm+2t-SAT$.

Carr *et al.* (1999) reported $2n=9_{11}$ for *Chrysanthemum coronarium*, $2n=27_{11}$ for *Conyza apurensis*, $2n=7_{11}$ for *Calendula officinalis* and $2n=24_{11}$ for *Bidens alba* from Africa.

Maria *et al.* (2008) have studied variations in chromosome number and meiotic behaviour in *Bidens pilosa* from Southern Brazil, found variable number of chromosome with $2n=36$, 48 and 54 for this species.

Razak *et al.* (1988, 1994) have reported haploid chromosome number $n=10$ for *Blumea lacera* whereas $n=11$ was reported by (Gupta & Gill 1989) for this species. Somatic chromosome numbers $2n=22$ (Daruwala 1995); $2n=36$ (Peng & Hsu 1977, 1978) and $2n=18$ (Nirmala & Rao 1984, 1990) were reported for *Blumea lacera*.

Verma and Vijayavalli (1998) have reported haploid chromosome number $n=18$ for *Blumea lacera* var. *glandulosa*. The two somatic numbers $2n=18, 22$ were reported by them for this species.

The somatic chromosome number $2n=18$ was reported by Sharma (1970), and Peng and Hsu (1977) for *Blumea laciniata*. The haploid chromosome number $n=9$ was reported (Sharma 1970; Bir & Sidhu 1979, 1980 and Gupta and Gill 1989) for this species.

The haploid chromosome number $n=11$ (Mehra & Remanandan, 1975; Daruwala, 1995 and Verma & Vijayavalli, 1998); $n=9$ (Gupta & Gill, 1989; Verma & Vijayavalli, 1998) and $n=10$ were reported (Daruwala, 1995) for *Blumea mollis*. The somatic chromosome number $2n=22$ was reported by Verma and Vijayavalli (1998) for this species.

Dekui (2001) has studied karyotypes of *Centaurea cyanus* and *Coreopsis grandiflora* from China. He reported chromosome number of *Centaurea cyanus* $2n=48$ and that of *Coreopsis grandiflora* $2n=26$. Romaschenko *et al.* (2004) reported $2n=16$ for *Centaurea cyanus* from Turkey. Arohonka (1982) reported. Gupta and Gill (1989) have reported $n=12$ for the species *Centaurea cyanus* and $2n=24$ for this species. Martin *et al.* (2009) studied karyomorphology of 8 species of *Centaurea* collected from various places of Turkey. The somatic chromosome number determined by them for these species are $2n=18$ in *C. cariensis*, *C. lycaonica*, *C. virgata* and *C. polyclada*; $2n=24$ in *C. cyanus*; $2n=36$ in *C. virgata* and *C. cariensis*; $2n=40$ in *C. urvillei*; $2n=54$ in *C. tuzgoluensis*. Koller (1935) reported $2n=10$ for *Crepis aura* and *C. rubra*.

Oliviera *et al.* (2004) have studied chromosome number and morphology of diploid and polyploidy cytotypes of *Stevia rebaudiana* from Brazil. They found all strains had $2n=22$ except two, which had $2n=33$ and $2n=44$. Meiosis was normal with $n=11$ and all strains had inviable pollen. Ghaffari and Kelich (2006) were reported $n=17$ for *Cirsium arvense* and $2n=5II$ for *Crepis sancta* from Iran.

Fazili *et al.* (2011) studied karyotype in apomictic *Taraxacum officinale*, a wild plant with high medicinal value, from India. They found that *Taraxacum officinale* of Kashmir (India) is a triploid ($2n=3x=24$) one, based on $x=8$. Karyotype of it is symmetrical, centromere is in six triplets and sub- metacentric in two triplets.

Mehra and Remanandan (1976), Mathew and Mathew (1988), and Gupta and Gill (1989) have reported $n=16$ for the species *Calendula officinalis*. The somatic chromosome number $2n=28$ (Vachova, 1978); $2n=32$ (Czapik, 1989, Baltisberger & Huber, 1987) were reported for this species.

Maria *et al.* (2008) studied chromosome number and meiotic behavior of *Bidens pilosa* from Brazil. They found different cytotypes with a variable number of chromosomes $2n=36$, $2n=48$ and $2n=54$ for this species.

Morton (1981), Parfitt (1981), Keil (1981), Ward and Spellenberg (1988), Keil *et al.* (1988), Nesom (1978) reported haploid number $n=9$ for the species *Conyza canadensis*. The diploid number $2n=18$ was reported by several authors (Nesom, 1978; Hollingsworth *et al.*, 1992; Kuzmanov *et al.*, 1986; Huber & Baltisberger, 1992; Javurková-Jarolímová, 1992; Lövkvist & Hultgård, 1999).

Gupta and Gill (1989) have reported $n=13$ for *Coreopsis grandiflora* and $2n=26$ was reported by Gupta and Gill (1981), and Mathew and Mathew (1988) for this species.

Henderson (1973), Gill and Omoigui (1987), Mathew and Mathew (1988) reported $n=20$ for *Crassocephalum crepidioides*. Baltisberger (1990), Morton (1993), Daniela (1997), Henderson (1973) and Mathew & Mathew (1988) reported $2n=40$ for this species.

Mathew and Mathew (1988) and Gupta and Gill (1989) reported $n=8$ for the taxa *crepis japonica*. Gupta and Gill (1988, 1989) and Gupta *et al.* (1989) have reported $n=9$ for *Dichrocephala integrifolia*. The chromosome number $2n=18$ was reported by Peng & Hsu (1978) and Morton (1993) for this species.

Razaq *et al.* (1988, 1994), Hunziker *et al.* (1989), Gill and Omoigui (1987, 1988), Jose and Mathew (1995), Sidhu (1979), Koul *et al.* (1976a) reported $n=11$ for *Eclipta prostrata*. The chromosome number $n=12$ was reported by Husaini and Iwo (1990) for this species. The somatic chromosome number $2n=18$ was reported by Renard *et*

al. (1983), Silvestre (1980), Dutta and Shaha (1971), Nirmala and Rao (1986), Sidhu and Bir (1983), Ge (1989), Ge and Wan (1990), Xu *et al.* (1992), Jose and Mathew (1995), Sidhu (1979), Tanaka and Tsuji (1978) for this species.

Melahat *et al.* (2011) have studied mitotic chromosome numbers of 37 accessions representing 24 taxa and 1 interspecific hybrid of the genus *Cirsium* from North-East Anatolia. They found the chromosome numbers for this genus were $2n=34$, $2n=36$ and $2n=68$. The chromosome number were $2n=34$ for *C. arvense* subsp. *vestitum*, *C. rigidum* and $2n=68$ for *C. vulgare*. The B-chromosomes were also reported in two taxa viz. *C. lappaceum* subsp. *lappaceum* and *C. pubigerum* var. *glomeratum* by them.

Guo *et al.* (2012) have investigated polyploid levels in the 405 species of large flowers of Chrysanthemum (*Chrysanthemum morifolium*) and found $2n=18$, $2n=28$, $2n=36$, $2n=44$ and $2n=53$ for this species from China.

Hong and Zhang (1990) have reported $n=9$ for *Erigeron annuus*. Different haploid numbers $n=13$ (Chojnacki *et al.*, 1982); $n=14$ (Nesom, 1978 and Carr *et al.*, 1999) were reported for this species. The diploid numbers $2n=26$ (Chojnacki *et al.*, 1980, 1982) and $2n=27$ (Nesom, 1978; Dmitrieva, 1987; Chojnacki *et al.*, 1982; Chojnacki *et al.*, 1980; Hill, 1995; Soliva, 1997; Morton, 1981; Peng & Hsu, 1978; Frey *et al.*, 2003; Peng & Hsu, 1977 and Dmitrieva, 2000) were reported for this species.

Khonglam and Singh (1980) reported $2n=51$ for *Eupatorium adenophorum*. Nishikawa (1984) reported $2n=14$ for *Gnaphalium affine*.) Haploid number $n=7$ by Mehra and Remanandan (1975) and $n=14$ by Mathew and Mathew (1988) were reported for *Gnaphalium purpureum*. The tetraploid number $2n=4x=28$ was reported by Sidhu and Bir (1979, 1983); Peng and Hsu (1977, 1978) for this taxa.

Pak and Kawano (1990) and Kim and Ko (1991) reported $2n=16$ for *Ixeris polycephala*. Sarkar *et al.* (1982), Gupta and Gill (1988, 1989), Gupta *et al.* (1989), Peng *et al.* (1988), Nirmala and Rao (1981), Hederson *et al.* (1977) reported the chromosome number $n=17$ for *Parthenium hysterophorus*. Haploid number $n=18$ was reported by Robinson *et al.* (1981), Mathew and Mathew (1988), Razaq *et al.* (1994), Turner *et al.* (1979) for this species. The diploid number $2n=34$ was reported by

Bakale and Srinivasu (1984), Nirmala and Rao (1984), Piazzano *et al.* (1998), Turner *et al.* (1979), Hederson *et al.* (1977), Zhen and Cheng (2003) for this species.

Peng and Hsu (1977, 1978) have reported the diploid number $2n=18$ for *Rhynchospermum verticillatum*. Prabha (1989), and Mathew and Mathew (1988) have reported $n=9$ for *Sonchus arvensis* whereas $n=27$ was reported by Mulligan (1984) for this species. The different somatic chromosome numbers viz. $2n=18$ (Prabha & Roy, 1986; Mathew & Mathew, 1988); $2n=34$ (Joshi, 1988); $2n=36$ Kuzmanov *et al.* 1986; Nazarova, 1984, 1989; Dmitrieva, 1987; Gorzko *et al.*, 1980) were reported for this taxa.

Joshi (1988) has made cytological studies on six oil-bearing plants of Nepal and found $2n=36$ in *Xanthium strumarium*; $2n=31$ in *Cirsium arvense* and $2n=36$ in *Sonchus arvensis*.

Jose *et al.* (2012) have made of chromosome morphology in prickly sow-thistle (*Sonchus asper*) from western Mediterranean region. The three populations showed to be same somatic number $2n = 18$ for the species.

Gupta and Gill (1989) reported $n=26$ for *Spilanthus acmella*. Diploid chromosome count $2n=46$ was reported by Nirmala and Rao (1981, 1984, 1989) for this species. Jose and Mathew (1995) reported $2n=72=12x$ for *Spilanthus calva*.

Sharma (1970) has reported $n=10, 12$ and 24 for *Tagetes patula*. Gupta and Gill (1989) reported $n=24$ for this species. Triploid $2n=24=3x$ (Nirmala & Rao, 1984, 1986), tetraploid $2n=48=4x$ (Probatova *et al.*, 1991. Serrato-Cruz *et al.*, 2000) were also recorded for this species.

The haploid chromosome numbers $n=13$ (Gill & Omoigui, 1988) and $n=18$ (Razaq *et al.*, 1988, 1994; Khatoon & Ali, 1993; Gill & Omoigui, 1988; Husaini & Iwo, 1990; Gill & Omoigui, 1987; Mathew & Mathew, 1988; Gupta & Gill, 1989; Jose & Mathew, 1995; Nirmala & Rao, 1981; Keil & Stuessy, 1975; Keil & Stuessy, 1977; Koul *et al.*, 1976) were reported for *Tridax procumbens*. The somatic chromosome number $2n=36$ was reported by Sidhu and Pelia (1987), Baltisberger (1990), Nirmala and Rao (1981, 1984, 1985), Xie and Zheng 2003) for this species.

The basic number $x=10, 15$ were determined for *Wedelia wallichii* by McVaugh (1984).

Sarkar *et al.* (1982), Mathew and Mathew (1988), Gupta and Gill (1989), Razaq *et al.* (1994), Jose and Mathew (1995), Sidhu (1979), Bir and Sidhu (1980), Pinkava and Keil (1977), Koul *et al.* (1976) reported $n=18$ for *Xanthium strumarium*. The diploid chromosome counts $2n=34$ was reported by Mohamed, (1997) and $2n=36$ (Love & Love, 1982; Bakale & Srinivasu, 1988; Mathew & Mathew, 1988; Jose & Mathew, 1995; Rostovtseva, 1979; Sidhu, 1979; Bir & Sidhu, 1980; Skalinska, 1978; Joshi, 1988) were reported for this species.

Gupta and Koak (1974), Powell and Powell (1978), Razaq *et al.* (1988, 1994), Banerjee (1971), Husaini and Iwo (1990), Gupta and Gill (1989) and Jose and Mathew (1995) reported $n=12$ for *Zinnia elegans*. The somatic chromosome counts $2n=24$ was reported by Banerjee (1971), Gupta and Koak (1974), Gupta *et al.* (1983), Mathew and Mathew (1988), Zhao *et al.* (1990), Nirmala and Rao (1984, 1990), Jose and Mathew (1995), Huang and Zhao (1995), Chen *et al.* (2003) for this species.

It has been stated from time to time that size, shape, variation in spine length and even the fertility can be used as an additional character for the identification and classification of the species of different families. These features are important in taxonomy and phylogenetic classification of the members of Asteraceae (Skvarla *et al.*, 1977; Mbagwu and Edeoga, 2006). In this concern, Wodehouse (1935) have reported that pollen grains of Asteraceae are unique and true to form and the author has outlined the principles of morphological evolution of spine form of the family, in which it is suggested that the reduction series from long to minute spines is important. Similarly, Meo *et al.* (1988) have stated that pollen size increases corresponding with ploidy levels.

Pinar and Donmez (2000) reported that spine cavities of pollen exine can be utilized as diagnostic characters in the genera of Asteraceae. Qureshi *et al.* (2002) have recognized tetrazonocolporate pollen grains with maximum spine length in *Sonchus uliginous*, *S. arvensis*, *S. asper*, *S. maritimus*, *S. oleraceous* and *S. palustris* from Pakistan. Dawer, *et al.* (2002) have grouped 22 taxa in *Inula* on the basis of pollen characters.

Meo and Khan (2004) have recognized 3 groups in *Scorzonera* (Cichorieae - Asteraceae) on the basis of exine thickness. The character of exine thickness in this

genus can be useful at specific level since almost all the species have different exine thickness. Meo and Khan (2006) have found that the pollen grains possess trizonocolporate structures in seven species of *Chrysanthemum* from Pakistan. Pollen shapes have been found to be spheroidal in polar view whereas sub-spheroidal in equatorial views (Meo & Khan, l.c.). Zafar *et al.* (2007) have pointed that the characteristics of pollen spine is significant in evolution at specific and generic levels in the classification of Asteraceae. Hayat *et al.* (2010) have pointed out that spinules in pollen structure is the excellent taxonomic marker for the genus *Artemisia* in tribe Anthemideae of the family Asteraceae. The authors (Hayat *et al.*, l. c.) have distinguished some genera of Asteraceae on the basis of pollen characters.

Kulkarni (2012) have reported medium sized, isopolar, spheroidal, tricolporate and echinate pollens for *Blumea lacera* and *B. laciniata*. Ahmad *et al.* (2012) have analysed the pollen morphology, with special reference to exine sculpture, of some species of the family Asteraceae from the Deosai Plateau of northern Pakistan and have found that the pollens are all tricolporate and echinate. Pollen fertility ranged from 82% to 94%, indicating the fact that selected plant species are well-established in the Alpine Zone of Pakistan (Ahmad *et al.*, l. c.).

Pollen fertility 97.9 % in *Zinnia elegans* have been reported by Ramalingan *et al.* (1971). Mathew and Mathew (1975) have found pollen fertility 92% in *B. wightiana*; over 90% in *B. lacera* var. *glandulosa*; 90% in *B. oxyodonta*. Gopinathan and Babu (1982) have recognized 100 % pollen viability in *Galinsoga parviflora* and *G. ciliata* from India. Zafer *et al.* (2007) have revealed that pollen fertility estimation ranged from 90-98.11% in *Ageratum conyzoides*, *Calendula arvensis*, *Eclipta alba*, *Parthenium hysterophorus* and *Taraxacum officinale* of Rawalpindi (Pakistan).

The behavior of the chromosomes at meiosis affects pollen viability. Irregular meiosis often leads to low pollen viability with the exception of a few (Sakya, 1991). However, if meiosis is regular, for example, chromosomes pair and segregate normally, sterility of the pollen grain is not expected to occur because of cytological reasons (Boff & Schifino-Wittmann, 2002).

Joshi (1968) has observed the disturbance of polarity of the grains resulting in different pollen shapes in the members of umbelliferae with the treatment of

chemicals. Hara (1969) suggested that diploid plants tend to have triporate pollen grains in general and number of aperture increases in higher polyploids. Singh and Roy (1986), while studying the inter-specific hybrid between *Solanum melongena* and *S. surattense*, have mentioned that pollen sterility may be observed in extensive meiotic irregularities. Tri-colpate and multicolpate pollen grains indicated the possibility of hybridization process in the genus due to possession of many deformed and sterile pollens and intraspecific variability of pollen grains. Tri-colpate and triporate pollens are considered to be most primitive pollen type and polyporate pollen grains are considered to be secondarily derived one (Hoot 1991).

Several authors (Singh & Chaudhary, 1992; Mishra & Chaudhary, 1992; Bijukshe & Chaudhary, 1992) have reported that aperture type, exine characters (exine thickness, structure and exine pattern), size of pollen grains provide valuable taxonomic characters suggesting possible lines of evolution of different taxa of flowering plants. Ranjitkar and Shrestha (2005), while studying pollens of the Nepalese plants, have indicated significant contributions of palynology in cytogenetics of plants.

Pollen fertility have been affected due to development of the abnormalities like laggards, non-orientation of chromosomes at T-II, tetrads with variable number of spores leading to the formation of deficient pollen grains resulting the sterility of pollens (Vaidya, 2005).

CHAPTER 3

3. MATERIALS AND METHODS

3.1 Plant collection

Living plants specimens belonging to family Asteraceae were collected from different parts of Nepal such as Central, Eastern as well as Western regions. Collected living specimens were brought to Kathmandu and planted in earthen pots at home garden for further cytogenetical investigation. Plants were identified with the help of different books, web sites, and identified herbaria (Central Dept. of Botany as well as Tri Chandra Multiple Campus, Botany Department). Identified plants were re-identified by comparing herbaria of herbarium section of National Botanical Garden, Godavari Kathmandu, Nepal.

In present investigation karyotypic analysis were conducted on forty five species of thirty three genera from ten tribes with squash technique. Voucher numbers were placed for each specimen.

3.2 Mitosis

Somatic chromosomes were observed in the meristamatic cells of root tips for karyotypic analysis. The root tips were obtained from plants transplanted in home garden that are collected from the field. For this, to ensure full turgidity, plants were sufficiently watered for two hours before the excision of the root tips for pretreatment. Healthy root tips were pretreated in aqueous solution of 0.002M 8-hydroxyquinoline for three hours. They were then fixed in a mixture of absolute ethanol and glacial acetic acid (3:1) for one day or more. For long time preservation the fixed materials were transferred to 70% ethyl alcohol solution for 24 hours at 4 degree centigrade. Chromosome preparations were made in Central Department of Botany of Tribhuvan University.

In the laboratory root tip materials were hydrolyzed and stained in a mixture of 2% aceto-orcein and 1N HCl (9:1) contained in watch glass and warmed for few seconds and left for 30 minutes to 1 hour. Squashes were made in 45% acetic acid.

Squashes were prepared by dissecting darkest stained part of material and macerating the tissue on a slide in 45% acetic acid with the help of a sharp blade. The cover glass was put over the macerated tissue warmed for a few seconds over flame and then

tapped gently with a rubber knob keeping the slide between folds of blotting paper. Too much pressure was avoided to prevent the rupture of cells and extrusion of chromosomes. The observations were done from this preparation to select the plates for photomicrography. The drawings were made at table level using opcolite-1366 Camera Lucida apparatus. Photomicrographs were taken with the help of digital camera of 12.1 megapixel using 10 x eye pieces and 100x objective of trinocular compound microscope. Later on photographs were enlarged to suitable sizes. Chromosomes were measured from the drawn figures. For karyotype studies at least three different preparations were made from root tips of each species. The divisions of root tips were found to be maximum between 9.30 to 11.0 am.

The permanent slides were prepared by using 3 dehydration grades of acetic acid and n-butyl alcohol series (Celarier's, 1958). In first case, slide placed upside down in Petri dish containing dehydration grade (A) made by one part n-butyl alcohol and one part acetic acid in ratio (1:1) till the cover slip falls down. In second case, slide and cover slip were transferred in dehydration grade (B) containing 3 part n-butyl alcohol and one part acetic acid in ratio (3:1) for 30 seconds. In third case, slide and cover slip were placed in Petri dish containing dehydration grade (C) of pure n-butyl alcohol for one minute.

The slide and the cover slip were mounted separately using euparal refractive index (1.5). The slides were observed after they were perfectly dried. Ideograms were drawn in decreasing order of length from left to right. The long arms were directed downward and short arm directed upward. The Karyotype formula is also given as devised by Levan *et al.* (1964-1965).

For karyomorphological measurements the Camera Lucida drawings were used. The chromosomes were measured in μm . The measurements of long arm and short arm were done separately. The mean values of all chromosomes, absolute length and relative length of each pair of chromosome were calculated. The centromeric position of chromosomes were obtained by calculating the arm ratio value ($r = \text{long arm} / \text{short arm}$). M is applied for the centromere at the median point ($r=1$), m for median region ($r= 1.01$ to 1.691), sm for sub median region ($r=1.7$ to 2.99), st for sub terminal region ($r=3.0$ to 6.99), t for terminal region ($r= 7.0$ to 38.99) and T for terminal point as devised by Levan *et al.* (1965) and accordingly karyotype formula was prepared.

The terminology of Sakya (1991) was used for chromosome size: small $< 1 \mu\text{m}$, medium 1 to $< 2.5 \mu\text{m}$. and large above $2.5 \mu\text{m}$. Measurements were first made in

millimeter (mm) and then converted into microns by comparing with the drawn scale of the stage micrometer under the same magnification.

Separate measurements were done for long arms, short arms and satellites. They were tabulated. All the measurements of chromosomes in a complement were also tabulated and homologous chromosomes were paired. The mean value of long arms, short arms and length of chromosomes was also tabulated. Then the chromosome pairs were arranged in a descending order based on their length. Ideogram of haploid complements were made by the input of the data (manually measured value in μm) in Microsoft Excel programme. Detail study of Karyomorphology has been done following the nomenclature of chromosomes proposed by Levan *et al.* (1964-65). Total Form Percentage was calculated by using the formula given below to determine the karyotype symmetry (Huziwara, 1962).

$$\text{Total Form Percentage (TF\%)} = \frac{\text{Total sum of short arms} \times 100}{\text{Total sum of all the chromosomes}}$$

3.3 Meiosis

The meiotic behavior of pollen mother cells was observed from appropriate anthers of fixed flower buds. For this study buds of suitable size are fixed in fixative prepared by one part acetic acid and three parts ethanol (1:3) for 24 hours. For long time preservation fixed bud were transferred in 70% alcohol. The buds were fixed between 9-11 a.m. Suitable anthers were dissected from the buds and teased with a needle in a thin film of 1-2 % aceto-carmin. After removing the debris the cover slip was placed over it. Excess stain was drained off with blotting paper and squashed with a gentle pressure. To prevent from drying, the slides were put in the moist chamber containing wet blotting papers. The desired stages of meiosis were photographed under the microscope with the same magnification as in the mitotic cells. In case of a prepared slide with less stained material, it was preserved in a moist chamber for a few to twenty four hours to get the maintained and better stained meiotic stages.

3.4 Pollen Stainability

Pollen fertility of all the investigated taxa was estimated on the basis of stainability test. It was determined by staining pollens in the solution of acetocarmine and glycerine mixed in 1:1 ratio (Muntzing, 1941). The estimation was based on examination of about 300 pollen grains. Shrivelled, unstained, empty and abnormally

small grains were considered as the sterile ones. On the other hand, well inflated, uniformly stained and healthy grains were considered as fertile ones. The pollen types were determined there-after. Pollen was photographed under the microscope with the same magnification as in the former cases.

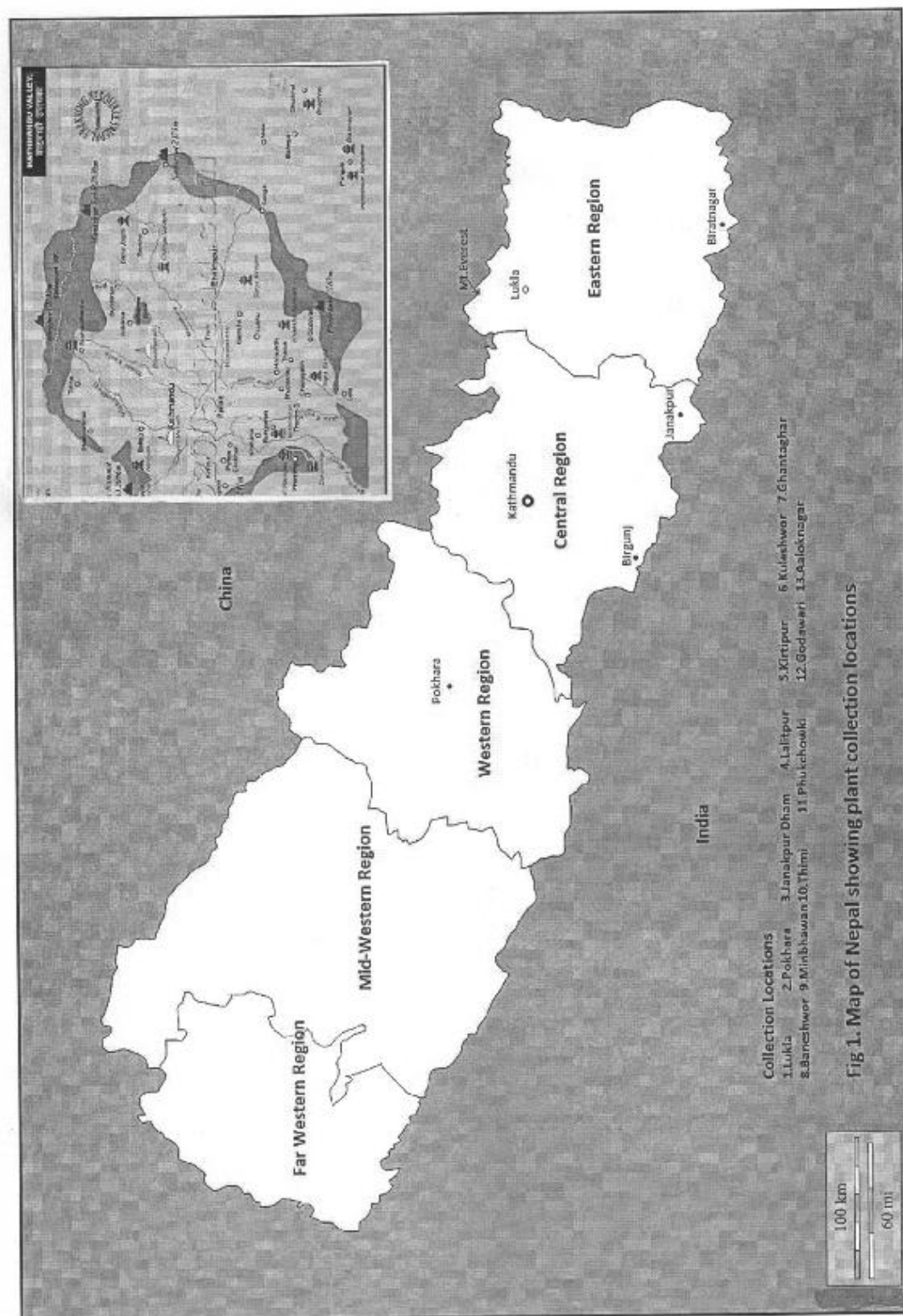


Fig. 1: Map of Nepal.

Table 1: Lists of the plants under study with their voucher numbers, place of collection and their altitudes in meter

V.N.	Taxa	Places of collection	Region/Altitude
101	<i>Ageratum conyzoides</i> L.	Minbhawan	C. Nepal 1280m
141	<i>Ageratum houstonianum</i> Mill.	Kirtipur	C. Nepal 1330m
102	<i>Anaphalis triplinervis</i> (Sims) C.B Clarke var. <i>triplinervis</i>	Phulchowki	C. Nepal 1900m
128	<i>Artemisia abronatum</i> L.	Lalitpur	C. Nepal 1250m
112	<i>Artemisia indica</i> L.	Ghantaghar	C. Nepal 1300m
129	<i>Artemisia vulgaris</i> L.	Lukla	E. Nepal 2800m
113	<i>Aster ageratoides</i> Kitam.	Ghantaghar	C. Nepal 1300m
142	<i>Aster barbellatus</i> Grierson	Godawari	C. Nepal 1515m
104	<i>Aster peduncularis</i> subsp. <i>nepalensis</i> Grierson	Baneshwor	C. Nepal 1280m
103	<i>Bidens pilosa</i> var. <i>minor</i> (Blume) Sherff	Ghantaghar	C. Nepal 1300m
118	<i>Blumea fistulosa</i> (Roxb.) Kurz	Janakpurdham	C. Nepal 600m
121	<i>Blumea lacera</i> (Burm.f.)DC.	Godawari	C. Nepal 1515m
124	<i>Blumea lacera</i> var. <i>glandulosa</i> (DC.) Hook.	Janakpurdham	C. Nepal 630m
125	<i>Blumea laciniata</i> DC.	Janakpurdham	C. Nepal 615m
126	<i>Blumea mollis</i> (D.Don) Merr.	Godawari	C. Nepal 1515m
114	<i>Calendula officinalis</i> L.	Ghantaghar	C. Nepal 1300m
143	<i>Centaurea cyanus</i> L.	Kirtipur	C. Nepal 1330m
117	<i>Chrysanthemum morifolium</i> Ramat.	Thimi	C. Nepal 1200m
115	<i>Cirsium arvense</i> Mill.	Kirtipur	C. Nepal 1340m
116	<i>Conyza canadensis</i> (L.) Cronquist	Minbhawan	C. Nepal 1280m
130	<i>Coreopsis grandiflora</i> Nutt. ex Chapm.	Pokhara	W. Nepal 700m
131	<i>Crepis japonica</i> (L.) Benth.	Baneshwor	C. Nepal 1220m
105	<i>Crassocephalum crepidioides</i> (Benth.) S. Moore	Aloknagar	C. Nepal 1220m
119	<i>Dichrocephala integrifolia</i> (L. f.) Kuntze	Godawari	C. Nepal 1515m
120	<i>Eclipta prostrata</i> (Linn.) Linn.	Janakpur	C. Nepal 620m
106	<i>Eupatorium adenophorum</i> Spreng.	Minbhawan	C. Nepal 1310m
144	<i>Erigeron annuus</i> (L.) Pers.	Godawari	C. Nepal 1515m
122	<i>Galinsoga parviflora</i> Cav.	Aloknagar	C. Nepal 1190m
123	<i>Gnaphalium affine</i> D.Don	Lukla	E. Nepal 2800m

133	<i>Gnaphalium purpureum</i> L.	Thimi	C. Nepal 1250m
134	<i>Ixeris polycephala</i> Cass.	Godawari	C. Nepal 1520m
124	<i>Parthenium hysterophorus</i> L.	Kirtipur	C. Nepal 1330m
138	<i>Rhynchospermum verticillatum</i> Reinw.	Godawari	C. Nepal 1515m
146	<i>Senecio laetus</i> Edgew.	Gdawari	C. Nepal 1530m
139	<i>Sonchus arvensis</i> L.	Baneshwor	C. Nepal 1280m
107	<i>Sonchus asper</i> (L.) Hill	Kirtipur	C. Nepal 1330m
140	<i>Spilanthes acmella</i> (L.) Murray.	Lalitpur	C. Nepal 1250m
108	<i>Spilanthes calva</i> DC.	Godawari	C. Nepal 1515m
132	<i>Stevia rebaudiana</i> (Bertoni) Bertoni.	Kuleshwor	C. Nepal 1285m
109	<i>Tagetes patula</i> L.	Minbhawan	C. Nepal 1310m
110	<i>Taraxacum officinale</i> F.H. Wigg.	Lukla	E. Nepal 2800m
136	<i>Tridax procumbens</i> L.	Pokhara	W. Nepal 700m
126	<i>Wedelia wallichii</i> Less.	Kuleshwor	C. Nepal 1210m
111	<i>Xanthium strumarium</i> L.	Kirtipur	C. Nepal 1330m
127	<i>Zinnia elegans</i> Jack.	Ghantaghar	C. Nepal 1300m

CHAPTER 4

4. RESULTS AND DISCUSSION

4.1 Results

In the present study forty five species with thirty three genera of the family Asteraceae from ten tribes are cytologically carried out. There is a great variation in chromosome numbers of different species in different genera of the family Asteraceae. The chromosome numbers $2n=14, 16, 18, 20, 22, 24, 26, 28, 30, 32, 34, 36, 40,$ and 50 have been encountered.

The results are given in tabulated form (Tables 2 to 46). In the table the first column represents for the chromosome pair, second for the length of long arm, third for the length of short arm, fourth for the total length of chromosome, fifth for the r-value, sixth for the relative length of chromosome and seventh for abbreviation of the chromosome type. All the measurements are in micron. During chromosome measurements, the gap of construction has not been considered. Ideograms based on computed data of chromosome measurements have been drawn. Meiotic behaviors at different stages have been studied in some of the taxa and chromosome configurations at metaphase-I have been recorded as far as possible.

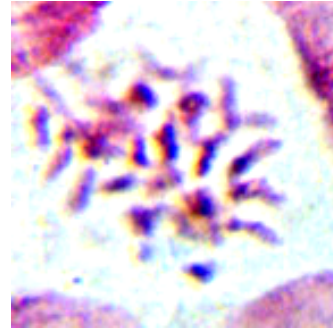
4.1.1 *Ageratum conyzoides* L. ($2n=20$, V.N. 101)

Locality : Minbhawan (C. Nepal), 1280 msl

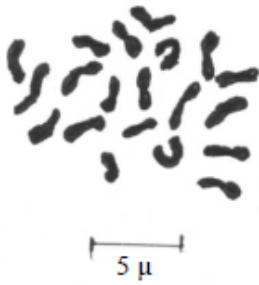
The plant is annual, erect, hairy herb, 0. 2-1m tall, strong, smelling. Leaves opposite, dentate with large glandular spots on lower surface. Capitula discoid, many-flowered, in dense corymbs. Involucre campanulate, bracts in 2 or 3 rows, free, ribbed, with membranous margins. Receptacle honey combed, conical, naked or paleate. Corolla white, tube cylindric below, campanulate above, lobes 5, much shorter than tube, glandular. Anthers obtuse at base, with oblong, apical appendage. Style terete, with short glandular branches. Cypsela 4- or 5-ribbed, glabrous. or short-setose on ribs; carpodium usually large and asymmetrical. Pappus coroniform, on 5 or 6 free scales or awns or 0.



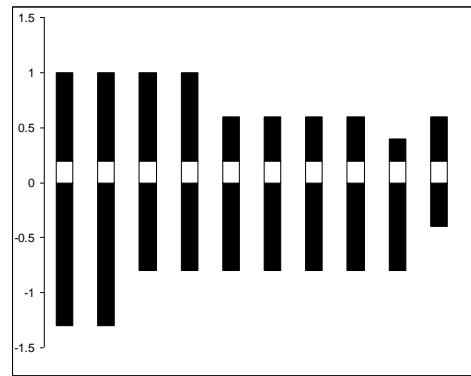
(2)



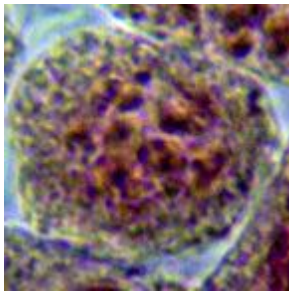
(3)



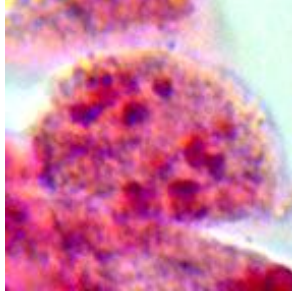
(4)



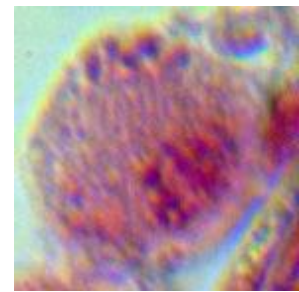
(5)



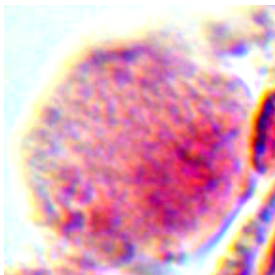
(6)



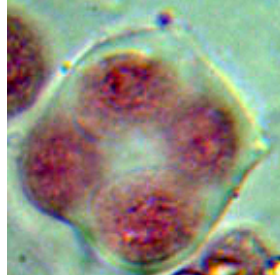
(7)



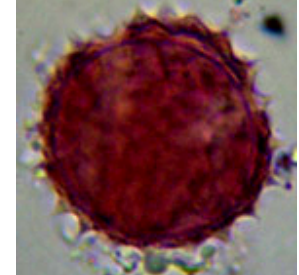
(8)



(9)



(10)



(11)

Figs. 2-11: *Ageratum conyzoides* L. (V. N. 101)

Fig. 2. Photograph of living plant. **Fig. 3.** Photomicrograph of somatic metaphase plate. **Fig. 4.** Camera lucida drawing of the same. **Fig. 5.** Ideogram of the above. **Fig. 6.** Diakinesis showing 10 bivalents. **Fig. 7.** M-II. **Fig. 8.** A-I. **Fig. 9.** T-II with non-synchronized division. **Fig. 10.** Pollen tetrad. **Fig. 11.** Pollen grain.

Chromosome number determined for this taxon is $2n=20$. The somatic chromosomes are shown in Fig. 3 and camera lucida drawing in Fig. 4. Its ideogram is represented in Fig. 5. The chromosome measurements are given in Table 2.

The karyotype consists of 4 different types of chromosome with centromere at median point, median region, sub-median region and sub-terminal region. The chromosome length ranged from 0.8 to 2.1 μm with mean length 1.4 μm . and absolute length 14 μm . TF % is 38.5. Karyotype formula is $M_6+m_4+sm_8+st_2$.

Meiosis is normal in this taxon. A cell with diakinesis showing 10 bivalents are shown in Fig.6. Normal metaphase-II (Fig.7), anaphase-I normal with precocious movement (Fig.8), telophase-II with non synchronized division (Fig.10), normal tetrad (Fig.11) and large pollen (Fig. 12) are observed. Pollen stainability is 91.0 percent.

Table 2: Chromosome measurement in *Ageratum conyzoides* L. (V.N. 101)

Chrom. Pairs	Long Arm (μm)	Short Arm (μm)	Total Length (μm)	r-value	Relative Length (μm)	Position of Centromere
I	1.3	0.8	2.1	1.6	15	m
II	1.3	0.8	2.1	1.6	15	m
III	0.8	0.8	1.6	1	11.4	M
IV	0.8	0.8	1.6	1	11.4	M
V	0.8	0.4	1.2	2	8.5	sm
VI	0.8	0.4	1.2	2	8.5	sm
VII	0.8	0.4	1.2	2	8.5	sm
VIII	0.8	0.4	1.2	2	8.5	sm
IX	0.8	0.2	1.0	4	7.1	st
X	0.4	0.4	0.8	1	11.4	M

4.1.2 *Ageratum houstonianum* Mill. ($2n=18$, V.N. 141)

Locality: Kirtipur (C. Nepal), 1330 msl

The plant is annual, erect or decumbent hairy herb, 3-12cm tall, strong smelling. Leaves 2-4cm, ovate, triangular, 3-nerved from the base, crenate-serrate, acute. Heads in dense terminal corymbs. Florets purple, achenes brown or black, glabrous or

sparse hairy. Five pappus scales. Flowering and fruiting throughout the year. It is a pantropical weed.

Chromosome number determined for this taxon is $2n=18$. The somatic chromosomes are shown in Fig. 12 and camera lucida drawing in Fig. 13. Its ideogram is represented in Fig. 14. The chromosome measurements are given in Table 3.

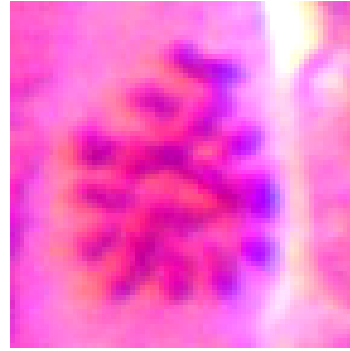
The karyotype consists of two different types of chromosomes with centromere at median point and sub-median region. The chromosome length ranged from 0.6 to 1.6 μm with mean length 1.1 μm and absolute length 10.2 μm . TF % is 45. Karyotype formula is $M_{12+} sm_6$. Meiosis could not be studied in this taxon due to the lack of suitable flower buds. Pollen stainability is 93.4 percent.

Table 3: Chromosome measurement in *Ageratum houstonianum* Mill. (V.N. 141)

Chrom. Pairs	Long Arm (μm)	Short Arm (μm)	Total Length (μm)	r-value	Relative Length (μm)	Position of Centromere
I	0.8	0.8	1.6	1	15.6	M
II	0.8	0.8	1.6	1	15.6	M
III	0.8	0.8	1.6	1	15.6	M
IV	0.8	0.4	1.2	2	11.7	sm
V	0.8	0.4	1.2	2	11.7	sm
VI	0.4	0.4	0.8	1	7.8	M
VII	0.4	0.4	0.8	1	7.8	M
VIII	0.4	0.4	0.8	1	7.8	M
IX	0.4	0.2	0.6	2	5.6	sm



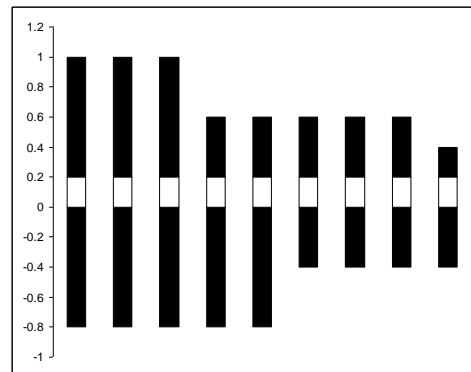
(12)



(13)



(14)



(15)

Figs. 12-15: *Ageratum houstonianum* Mill. (V.N. 141)

Fig. 12. Photograph of living plant. **Fig. 13.** Photomicrograph of somatic metaphase plate. **Fig. 14.** Camera lucida drawing of the same. **Fig. 15.** Ideogram of the above.

4.1.3 *Anaphalis triplinervis* (Sims.) C. B. Clarke var. *triplinervis* (2n=28, V.N. 102)

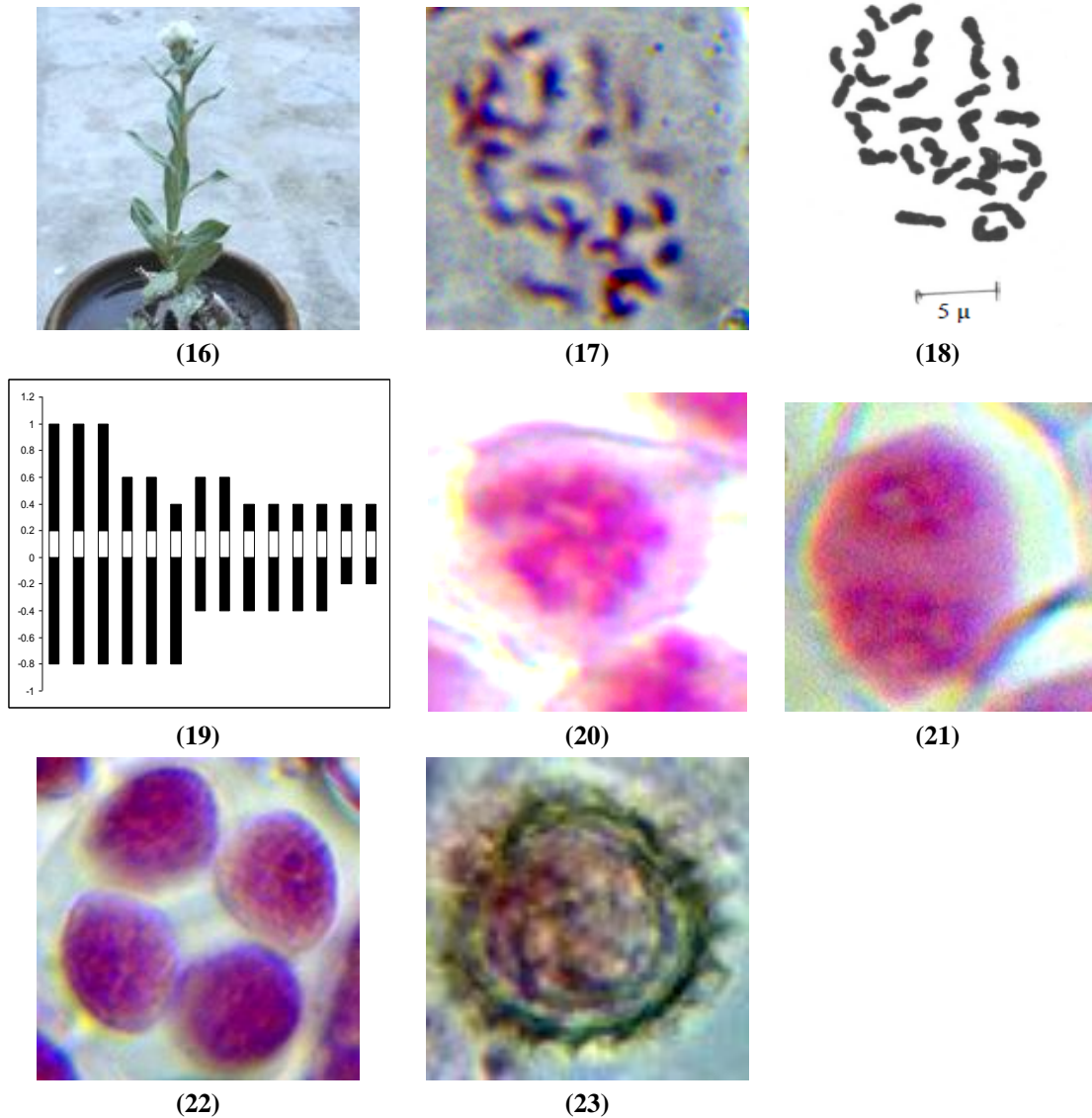
Locality : Phulchoki (C. Nepal), 1900 msl

The plant is herbaceous, perennial, erect rhizomatous 3-45cm. tall with white-woolly stems bearing narrowly elliptic, three nerved, greyish-green leaves, white-felted beneath, apex acute, tipped with black point base amplexicaul. Small, white everlasting flowers in loose terminal clusters. Heads white, up to 1.5cm in diameter, more in terminal corymbs. Involucral bracts ovate-lanceolate, white. Achenes oblong.

Chromosome number determined for this taxon is 2n=28. The somatic chromosomes are shown in Fig. 17 and camera lucida drawing in Fig. 18. Its ideogram is represented in Fig. 19. The chromosome measurements are given in Table 4.

Table 4: Chromosome measurement in *Anaphalis triplinervis* (Sims.) C. B. Clarke var. *triplinervis* (V.N. 102)

Chrom. Pairs	Long Arm (µm)	Short Arm (µm)	Total Length (µm)	r-value	Relative Length (µm)	Position of Centromere
I	0.8	0.8	0.8	1	12.3	M
II	0.8	0.8	1.2	1	12.3	M
III	0.8	0.8	0.6	1	12.3	M
IV	0.8	0.4	1.6	2	9.2	sm
V	0.8	0.4	1.2	2	9.2	sm
VI	0.8	0.2	1.6	4	7.6	st
VII	0.4	0.4	1.0	1	6.1	M
VIII	0.4	0.4	0.4	1	6.1	M
IX	0.4	0.2	1.6	2	4.6	sm
X	0.4	0.2	0.8	2	4.6	sm
XI	0.4	0.2	0.6	2	4.6	sm
XII	0.4	0.2	0.6	2	4.6	sm
XIII	0.2	0.2	0.6	1	3.0	M
XI V	0.2	0.2	0.4	1	3.0	M



Figs. 16-23: *Anaphalis triplinervis* (Sims.) C.B. Clarke var. *triplinervis* (V.N. 102)

Fig. 16. Photograph of living plant. **Fig. 17.** Photomicrograph of somatic metaphase plate. **Fig. 18.** Camera lucida drawing of the above. **Fig. 19.** Ideogram of the above. **Fig. 20.** M-I with 14 bivalents. **Fig. 21.** T-I. **Fig. 22** Tetrad . **Fig. 23.** Pollen grain.

The karyotype consists of three different types of chromosomes with centromere at median point, sub-median region and sub-terminal region. The chromosome length ranged from 0.4 to 1.6 μm with mean length 0.9 μm . and absolute length 13 μm . TF % is 41.5. Karyotype formula is $M_{14+} sm_{12}+st_2$.

Meiosis is irregular. At metaphase-I, 14 bivalents with sticky nature has been observed (Fig. 20). Telophase-I normal (Fig. 21). Pollen tetrads normal (Fig. 22). Circular, echinate pollen grains are observed (Fig. 23). Pollen stainability is 90.0 percent.

4.1.4 *Artemisia abronatum* L. (2n=36, V.N. 128)

Locality : Lalitpur (C. Nepal), 1250 msl

The plant is perennial, erect, undershrub which can reach a height up to 1m. Stems are herbacious. Leaves are grey-green with very finely divided, pleasantly aromatic. Small, nodding, dull yellow flower heads flowering at late summer.

Diploid chromosome number in present determination is $2n=36$. The somatic chromosomes are shown in Fig. 25 and camera lucida drawing in Fig. 26. Its ideogram is represented in Fig. 27. The chromosome measurements are given in Table 5. The karyotypes consist of 4 different types of chromosomes with centromere at median point, median region, sub-median region and subterminal region. The chromosome length ranged from 0.6 to 2.1 μm with mean length 1.4 μm and absolute length 26.7 μm . TF % is 41.9. Karyotype formula is $M_{18}+m_4+sm_{12}+st_2$.

Meiosis could not be studied in this taxon due to the lack of suitable flower buds. Pollen stainability is 80.0 percent.



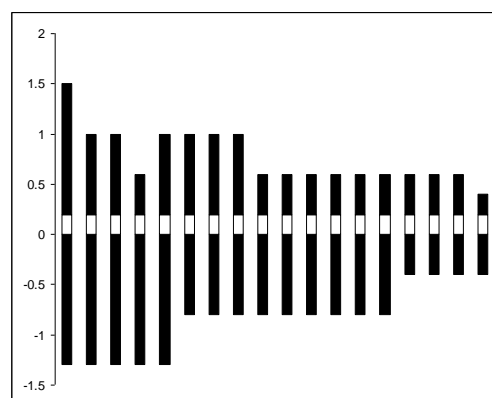
(24)



(25)



(26)



(27)

Figs. 24-27: *Artemisia abronatum* L. (V.N. 128)

Fig. 24. Photograph of living plant. **Fig. 25.** Photomicrograph of somatic metaphase plate. **Fig. 26.** Camera lucida drawing of the same. **Fig. 27.** Ideogram of the above.

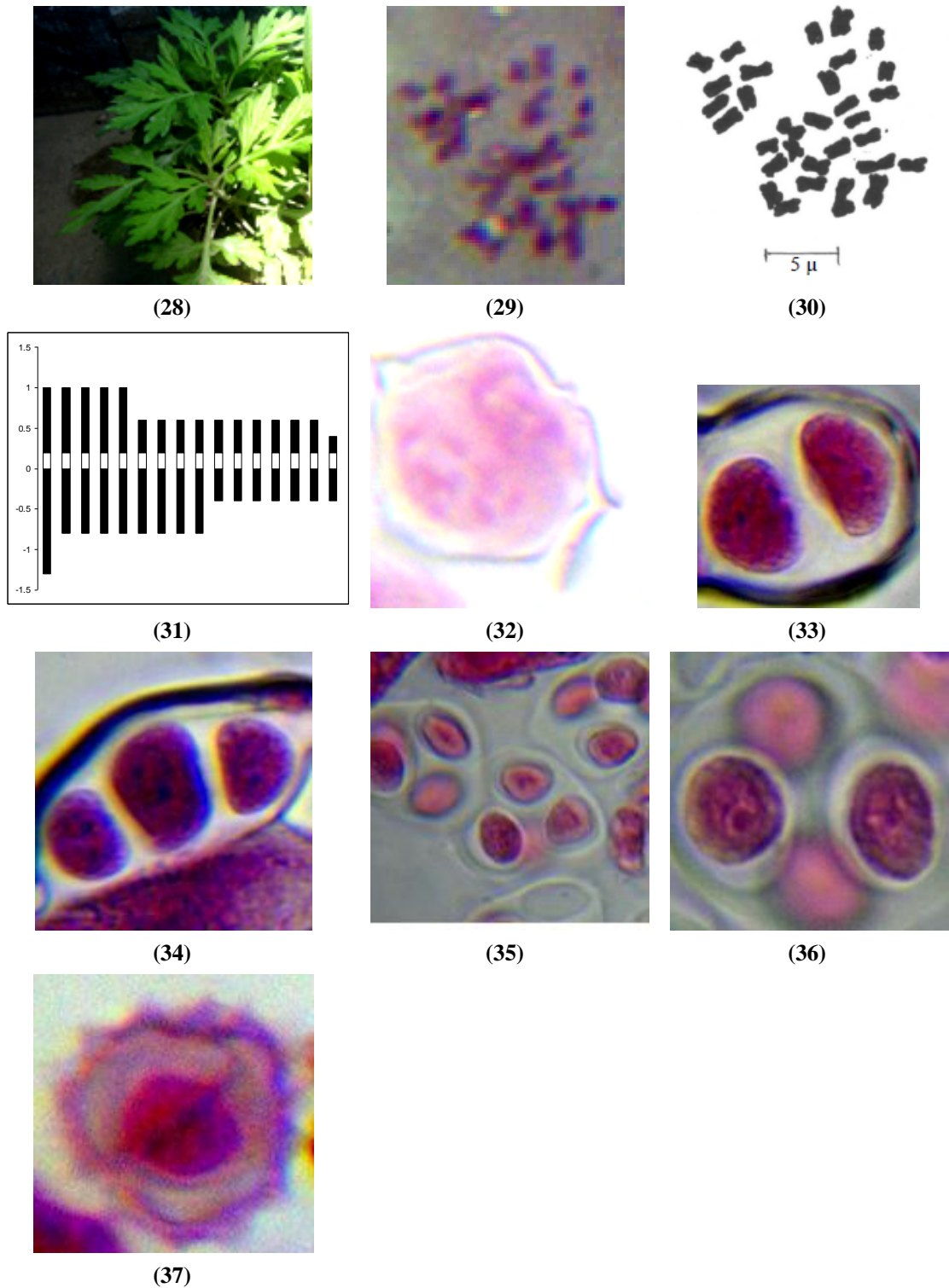
Table 5: Chromosome measurement in *Artemisia abronatum* L. (V.N. 128)

Chrom. Pairs	Long Arm (µm)	Short Arm (µm)	Total Length (µm)	r-value	Relative Length (µm)	Position of Centromere
I	1.3	1.3	2.6	1	9.7	M
II	1.3	1.3	2.6	1	9.7	M
III	1.3	0.8	2.1	1.6	7.8	m
IV	1.3	0.8	2.1	1.6	7.8	m
V	1.3	0.4	1.7	3.2	6.3	st
VI	0.8	0.8	1.6	1	5.9	M
VII	0.8	0.8	1.6	1	5.9	M
VIII	0.8	0.8	1.6	1	5.9	M
IX	0.8	0.8	1.6	1	5.9	M
X	0.8	0.4	1.2	2	4.4	sm
XI	0.8	0.4	1.2	2	4.4	sm
XII	0.8	0.4	1.2	2	4.4	sm
XIII	0.8	0.4	1.2	2	4.4	sm
XI V	0.8	0.4	1.2	2	4.4	sm
XV	0.4	0.4	0.8	1	2.9	M
XVI	0.4	0.4	0.8	1	2.9	M
XVII	0.4	0.4	0.8	1	2.9	M
XVII	0.4	0.2	0.6	2	2.2	sm

4.1.5 *Artemisia indica* Willd. (2n=32, V.N. 112)

Locality : Ghantaghar (C. Nepal), 1300 msl

The plant is perennial herbs or sub-shrubs, 80-150 cm tall, sparsely puberulous or glabrescent. Leaves short petiolate or sessile, upper surface of blade grey or yellowish, tomentose or glabrescent, lower surface densely grey arachnoid tomentose, lowermost blades ovate or oblong-ovate, pinnately parted, distal lobes larger, segments 3-4 pairs, winged along midrib, middle cauline leaves ovate or oblong-ovate or elliptic, 5-8×3-5 cm, pinnately parted, segments 3 (or 4) pairs, distal lobes larger, lobes elliptic-lanceolate, linear-lanceolate or linear, 10-20×3-5 mm, ultimate lobes deeply serrate, apex acute or acuminate, uppermost pinnately parted, leafy bracts 3-lobed or undivided. Inflorescences paniculate. Heads ovoid, oblong-ovoid or broadly ovoid, 1.5-2.5 mm in diam., involucral bracts puberulous or glabrescent. Outer florets 4-8. Central florets 8-12. Achenes oblong or obovoid. Flowering and fruiting from August to October.



Figs. 28-37: *Artemisia indica* Willd. (V.N. 112)

Fig. 28. Photograph of living plant. **Fig. 29.** Photomicrograph of somatic metaphase plate. **Fig. 30.** Camera lucida drawing of the same. **Fig. 31.** Ideogram of the above. **Fig. 32.** A-II. **Fig. 33.** Dyad formation. **Fig. 34.** Triad formation. **Fig. 35.** Tetrad. **Fig. 36.** Tetrad norma. **Fig. 37.** Pollen grain.

Diploid chromosome number in present investigation is $2n=32$. The somatic chromosomes are shown in Fig. 29 and camera lucida drawing in Fig. 30. Its ideogram is represented in Fig. 31. The chromosome measurements are given in Table 6.

Somatic chromosomes are of three types with centromere at median points, median regions and sub-medians regions. The chromosomes length ranged from 0.6 to 2.1 μm with mean length 1.2 μm and absolute length 20.4 μm . TF% is 43.1. Karyotype formulas are $M_{20+} m_2+ sm_{10}$.

Table 6: Chromosome measurement in *Artemisia indica* Willd. (V.N. 112)

Chrom. Pairs	Long Arm (μm)	Short Arm (μm)	Total Length (μm)	r-value	Relative Length (μm)	Position of Centromere
I	1.3	0.8	2.1	1.6	10.5	m
II	0.8	0.8	1.6	1	8.4	M
III	0.8	0.8	1.6	1	8.4	M
IV	0.8	0.8	1.6	1	8.4	M
V	0.8	0.8	1.6	1	8.4	M
VI	0.8	0.4	1.2	2	6.3	sm
VII	0.8	0.4	1.2	2	6.3	sm
VIII	0.8	0.4	1.2	2	6.3	sm
IX	0.8	0.4	1.2	2	6.3	sm
X	0.4	0.4	0.8	1	10.5	M
XI	0.4	0.4	0.8	1	8.4	M
XII	0.4	0.4	0.8	1	6.3	M
XIII	0.4	0.4	0.8	1	4.2	M
XIV	0.4	0.4	0.8	1	4.2	M
XV	0.4	0.4	1.2	1	6.3	M
XVI	0.4	0.2	0.6	2	3.1	sm

Regular meiosis has observed. Normal anaphase II (Fig. 32), normal tetrads (Fig.33), pollen tetrads with two abortive microspores (Fig. 34) dyad formation (Fig. 35) triad formation (Fig. 36) and tricolporate echinate pollen grains were observed (Fig.37). Pollen stainability is 89 percent.

4.1.6 *Artemisia vulgaris* L (2n=34, V. N. 129)

Locality : Lukla (E. Nepal), 2800 msl

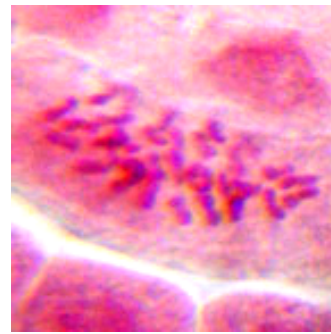
The taxa is a perennial erect herb, rhizomatous, aromatic, undershrub about 2ft. tall abundant on open fields. Stem reddish-brown in color and become woody with age paniculately branched (Fig. 39). Leaves simple, alternate, deeply lobed, petiolate, ovate and have a distinctive aroma. Florets brownish-red. Flower heads densely clustered in long narrow leafy panicle. Outer flower female inner hermaphrodite. Involucral bracts villous and with scarious margins. Achenes oblong, elliptoid, minute.

Table 7: Chromosome measurement in *Artemisia vulgaris* L. (V. N. 129)

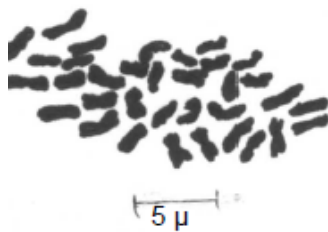
Chrom. Pairs	Long Arm (µm)	Short Arm (µm)	Total Length (µm)	r-value	Relative Length (µm)	Position of Centromere
I	0.8	0.4	1.2	2	10.3	Sm
II	0.8	0.4	1.2	2	10.3	Sm
III	0.8	0.4	1.2	2	10.3	Sm
IV	0.4	0.4	0.8	1	6.8	M
V	0.4	0.4	0.8	1	6.8	M
VI	0.4	0.4	0.8	1	6.8	M
VII	0.4	0.2	0.6	2	5.1	sm
VIII	0.4	0.2	0.6	2	5.1	sm
IX	0.4	0.2	0.6	2	5.1	sm
X	0.4	0.2	0.6	2	5.1	sm
XI	0.4	0.2	0.6	2	5.1	sm
XII	0.4	0.2	0.6	2	5.1	sm
XIII	0.2	0.2	0.4	1	3.4	M
XIV	0.2	0.2	0.4	1	3.4	M
XV	0.2	0.2	0.4	1	3.4	M
XVI	0.2	0.2	0.4	1	3.4	M
XVII	0.1	0.1	0.4	1	3.4	M



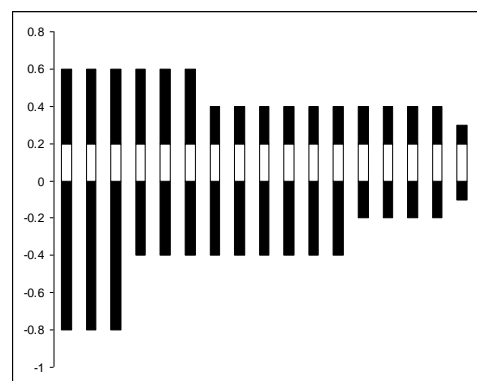
(38)



(39)



(40)



(41)

Figs. 38-41: *Artemisia vulgaris* L. (V. .N. 129)

Fig. 38. Photograph of living plant. **Fig. 39.** Photomicrograph of somatic metaphase plate. **Fig. 40.** Camera lucida drawing of the same. **Fig. 41.** Ideogram of the above.

Diploid chromosome number in present investigation is $2n=34$. The somatic chromosomes are shown in Fig. 39 and camera lucida drawing in Fig. 40. Its ideogram is represented in Fig. 41. The chromosome measurements are given in Table 7.

The karyotype consists of two different types of chromosomes with centromere at median point and sub-median region. The chromosome length ranged from 0.4 to 1.2 μm with mean length 0.68 μm and absolute length 11.6 μm . TF % is 39.6 Karyotype formula is $M_{16}+sm_{18}$.

Meiosis could not be studied in this taxon due to the lack of suitable flower buds. Pollen stainability is 98.6 percent.

4.1.7 *Aster ageratoids* Kitam. (2n=36, V.N. 113)

Locality : Ghantaghar (C. Nepal), 1300 msl

The plant is a late flowering herbaceous perennial, up to 1 m tall. It is native to eastern Asia (Nepal & China). The species *Aster ageratoides*, commonly known as the Japanese Aster. Leaves hairy, margin serrate. Flowers white capitulum ca. 1.5-2 cm across, involucre ca. 4mm long, 5-6mm wide, flowering in August to November. Fruits 2.5mm long. Head solitary. Ray florets white, disc florets yellow.

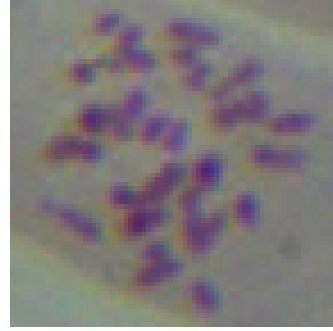
Diploid chromosome number determined is $2n=36$ for this taxon. The somatic chromosomes are shown in Fig. 43 and camera lucida drawing in Fig. 45. Its ideogram is represented in Fig. 46. The chromosome measurements are given in Table 8.

The mitotic divisions having 36 chromosomes are of four types viz. centromere at median point, median regions, sub-median regions and sub-terminal regions. The chromosome length ranged from 0.8 to 2.1 μm with mean length 1.5 μm and absolute length 27.5 μm . TF % is 43.1. Karyotype formula is $M_{14}+m_{10}+sm_{10}+st_2$.

Meiosis is normal. Metaphase-I with 18 bivalents is shown in Fig. 46. Dyad is observed (Fig. 47), tetrad (Fig. 48) and small pollen grain with triplicate, echinate, spheroidal shapes are observed (Fig. 49). Pollen stainability is 96.0%.



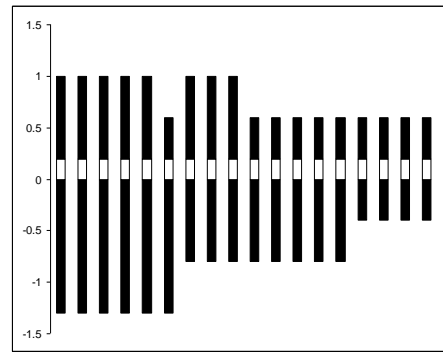
(42)



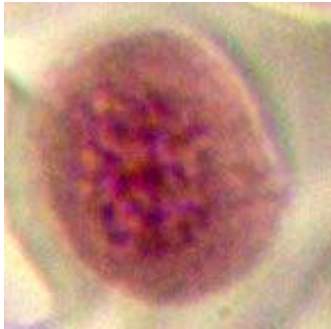
(43)



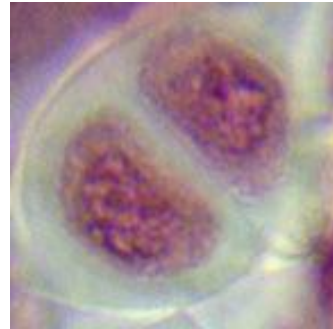
(44)



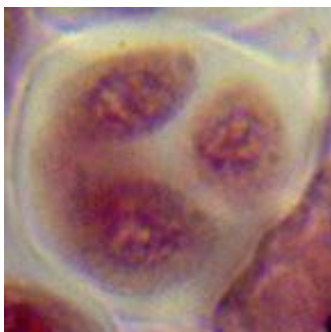
(45)



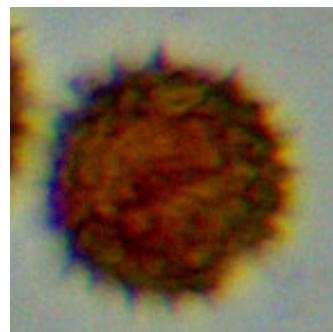
(46)



(47)



(48)



(49)

Figs. 42-49: *Aster ageratoides* Kitam. (V.N. 113)

Fig. 42. Photograph of living plant. **Fig. 43.** Photomicrograph of somatic metaphase plate. **Fig. 44.** Camera lucida drawing of the same. **Fig. 45.** Ideogram of the above. **Fig. 46.** M-I with 18 bivalents. **Fig. 47.** Dyad formation. **Fig. 48.** Tetrad (normal). **Fig. 49.** Pollen grain.

Table 8: Chromosome measurement in *Aster ageratoids* Kitam. (V. N. 113)

Chrom. Pairs	Long Arm (μm)	Short Arm (μm)	Total Length (μm)	r-value	Relative Length (μm)	Position of Centromere
I	1.3	0.8	2.1	1.6	8.8	m
II	1.3	0.8	2.1	1.6	8.8	m
III	1.3	0.8	2.1	1.6	8.8	m
IV	1.3	0.8	2.1	1.6	8.8	m
V	1.3	0.8	2.1	1.6	8.8	m
VI	1.3	0.4	1.7	3.2	6.0	st
VII	0.8	0.8	1.6	1	6.0	M
VIII	0.8	0.8	1.6	1	6.0	M
IX	0.8	0.8	1.6	1	6.0	M
X	0.8	0.4	1.2	2	5.0	sm
XI	0.8	0.4	1.2	2	5.0	sm
XII	0.8	0.4	1.2	2	5.0	sm
XIII	0.8	0.4	1.2	2	5.0	sm
XIV	0.8	0.4	1.2	2	5.0	sm
XV	0.4	0.4	0.8	1	3.0	M
XVI	0.4	0.4	0.8	1	3.0	M
XVII	0.4	0.4	0.8	1	3.0	M
XVIII	0.4	0.4	0.8	1	3.0	M

4.1.8 *Aster barbellatus* Grirson (2n=40, V.N. 142)

Locality : Godawari (C. Nepal), 1515 msl

The plant is herb, perennial, 20-40 cm tall, rhizomes stout, stoloniferous. Stems erect, simple, sparsely or moderately hirsute with sessile glands above. Leaves basal and cauline, cauline leaves reduced upward, densely to moderately strigose, sometimes upper leaves glandular, midvein abaxially somewhat prominent, triplinerved, veins inconspicuous, basal leaves usually persistent, broadly winged petiolate; blade spatulate to oblanceolate, ca. 2.5×0.6 -1 cm, base attenuate, margin entire or sparsely serrulate, densely strigose-ciliate, apex obtuse or rounded, middle leaves oblong to oblanceolate, 2 - 3.5×0.4 - 0.7 cm, base sub-clasping, upper leaves small, apex acute. Capitula terminal, solitary, 4-5 cm in diameter, purplish. Ray florets 30-40, blue or purplish, tube 2-2.2 mm, hairy, disk florets yellow, 3.5-5 mm, tube ca. 1.3 mm, distal tube and basal limb hairy, limb narrowly funnelform, lobes lanceolate, 1.2-1.5 mm, often purple. Achenes brown, obovoid, compressed, ca. 3 mm, densely strigose, sparsely glandular apically, 2-ribbed. Pappus reddish or buff, 3-seriate, bristles barbellate above, outermost bristles ca. 0.9 mm; inner bristles ca. 4.7 mm, acute.

Table 9: Chromosome measurement in *Aster barbellatus* Grirson (V.N. 142)

Chrom. Pairs	Long Arm (µm)	Short Arm (µm)	Total Length (µm)	r-value	Relative Length (µm)	Position of Centromere
I	0.8	0.8	1.6	1	8.8	M
II	0.8	0.8	1.6	1	8.8	M
III	0.8	0.8	1.6	1	8.8	M
IV	0.8	0.4	1.2	2	6.6	sm
V	0.8	0.4	1.2	2	6.6	sm
VI	0.8	0.4	1.2	2	6.6	sm
VII	0.4	0.4	0.8	1	4.4	M
VIII	0.4	0.4	0.8	1	4.4	M
IX	0.4	0.4	0.8	1	4.4	M
X	0.4	0.2	0.6	2	3.3	sm
XI	0.4	0.2	0.6	2	3.3	sm
XII	0.4	0.2	0.6	2	3.3	sm
XIII	0.4	0.2	0.6	2	3.3	sm
XIV	0.4	0.2	0.6	2	3.3	sm
XV	0.4	0.2	0.6	2	3.3	sm
XVI	0.4	0.2	0.6	2	3.3	sm
XVII	0.4	0.2	0.6	2	3.3	sm
XVIII	0.4	0.2	0.6	2	3.3	sm
XIX	0.4	0.2	0.6	2	3.3	sm
XX	0.2	0.2	0.4	1	2.2	M

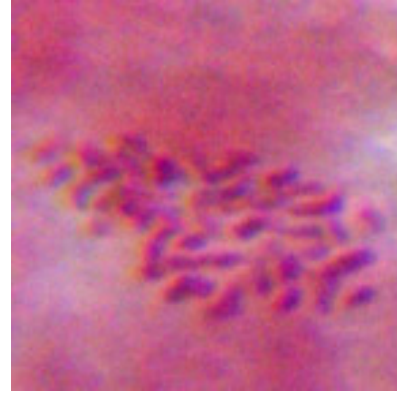
Diploid chromosome number presently determined is $2n=40$ for this taxon.. The somatic chromosomes are shown in Fig. 51 and camera lucida drawing in Fig. 52. Its ideogram is represented in Fig. 53. The chromosome measurements are given in Table 9.

The karyotype consists of two types of chromosome with centromere at median point and sub median region. The chromosome length ranged from 0.6 to 1.6 µm with mean length 0.9 µm and absolute length 13.0µm. TF % is 41.5. Karyotype formula is $M_{14+sm_{26}}$.

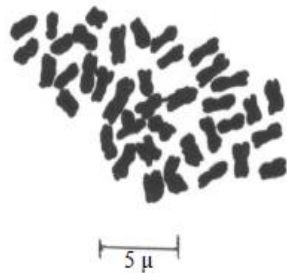
Meiosis could not be studied in this taxon due to the unavailability of suitable flower buds. Pollen stainability is 92.6 percent.



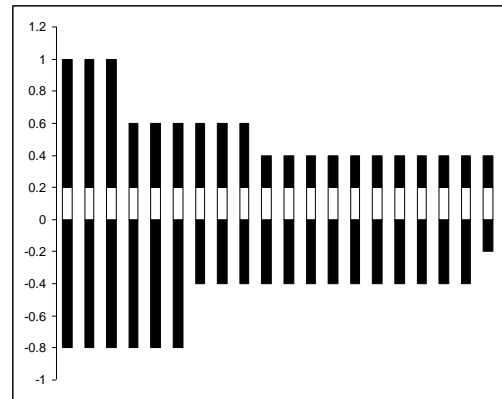
(50)



(51)



(52)



(53)

Figs. 50-53: *Aster barbellatus* Grirson (V.N. 142)

Fig. 50. Photograph of living plant. **Fig. 51.** Photomicrograph of somatic metaphase plate. **Fig. 52.** Camera lucida drawing of the same. **Fig. 53.** Ideogram above.

4.1.9 *Aster peduncularis* subsp. *nepalensis* Grirson (2n=40, V.N. 103)

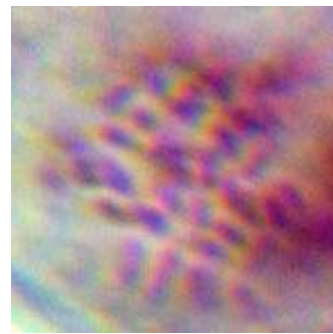
Locality: Baneshwor (C. Nepal), 1280 msl

The plant is perennial, rarely annual, herbs. Leaves alternate, sessile, entire, toothed or rarely incised, nerves often conspicuously raised, hairy or glabrous and sometimes glandular. Capitula radiate, large or medium-sized, occasionally small, solitary or in panicles or corymbs, pedunculate. Involucre campanulate or sub-hemispherical, bracts imbricate, in 3 or 4(5) rows. Receptacle flat or convex, epaleate. Ray florets female, fertile or rarely sterile, staminodes sometimes present, corolla blue, violet or white, in 1 or 2 rows, tubular below, mostly glandular-hairy, often hairy as well, produced into a strap-shaped, 3-toothed lamina in upper part. Disc-florets bisexual, fertile or rarely inner ones functionally male, corolla yellow, rarely purplish, tubular, expanded above, 5-toothed, always glandular-hairy. Anthers ecalcarate and ecaudate, apical appendage ovate-lanceolate, flat. Style branches narrowly oblong, apex triangular with conspicuous sweeping hairs outside. Cypsela elliptic to obovate, compressed, bright

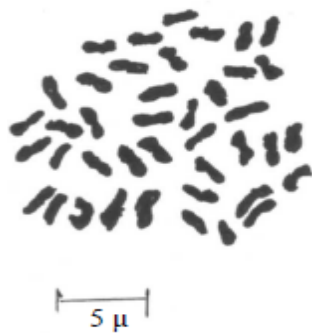
to dark brown to blackish, usually with thickened margins, hairy and with multicellular glands. Pappus in 2 rows.



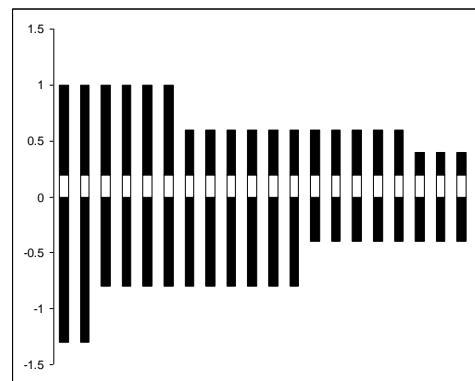
(54)



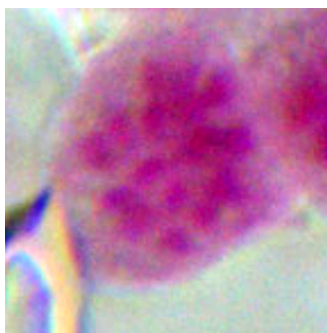
(55)



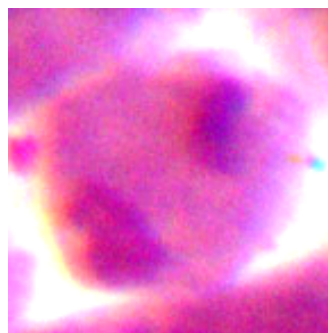
(56)



(57)



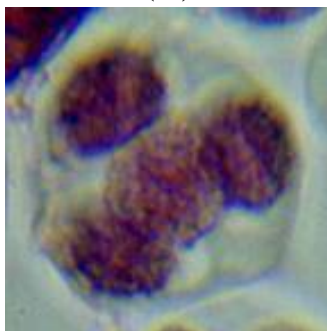
(58)



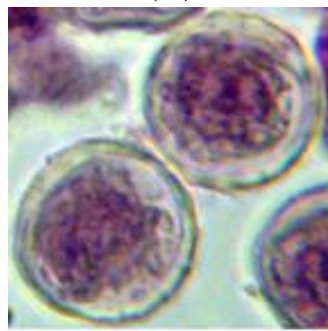
(59)



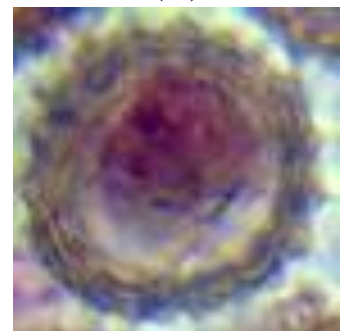
(60)



(61)



(62)



(63)

Figs. 54-63: *Aster peduncularis* subsp. *nepalensis* Grirson (V.N. 103)

Fig. 54. Photograph of living plant. **Fig. 55.** Photomicrograph of somatic metaphase plate. **Fig. 56.** Camera lucida drawing of the same. **Fig. 57.** Ideogram of the above. **Fig. 58.** M-I with 20 bivalents. **Fig. 59.** A-II with non-synchronized division. **Fig. 60.** T-I (normal). **Fig. 61.** Pollen tetrad. **Fig. 62.** pollen grain. **Fig. 63.** showing mature pollen grain.

Table 10: Chromosome measurement in *Aster peduncularis* subsp. *nepalensis* Grirson (V.N. 103)

Chrom. Pairs	Long Arm (µm)	Short Arm (µm)	Total Length (µm)	r value	Relative Length (µm)	Position of Centromere
I	1.3	0.8	2.1	1.6	6.7	m
II	1.3	0.8	2.1	1.6	3.3	m
III	0.8	0.8	1.6	1	6.3	M
IV	0.8	0.8	1.6	1	5.0	M
V	0.8	0.8	1.6	1	6.7	M
VI	0.8	0.8	1.6	1	5.0	M
II	0.8	0.4	1.2	2	3.3	sm
VIII	0.8	0.4	1.2	2	3.3	sm
IX	0.8	0.4	1.2	2	5.0	sm
X	0.8	0.4	1.2	2	6.7	sm
XI	0.8	0.4	1.2	2	3.3	sm
XI I	0.8	0.4	1.2	2	2.5	sm
XIII	0.4	0.4	0.8	1	2.5	M
XIV	0.4	0.4	0.8	1	3.3	M
XV	0.4	0.4	0.8	1	2.5	M
XVI	0.4	0.4	0.8	1	5.0	M
XVII	0.4	0.4	0.8	1	8.8	M
XVII	0.4	0.2	0.6	2	5.0	sm
XIX	0.4	0.2	0.6	2	5.0	sm
XX	0.4	0.2	0.6	2	6.7	sm

Diploid chromosome number in present determination for this taxon is $2n=40$. The somatic chromosome are shown in Fig. 55 and camera lucida drawing in Fig. 56. Its ideogram is represented in Fig. 57. The chromosome measurements are given in Table 10.

The karyotype consists of three different types of chromosome with centromere at median point, median region, and sub median region. The chromosome length ranged from 0.6 to 2.1 µm with mean length 1.1 µm and absolute length 23.6 µm. TF % is 41.5. Karyotype formula is $M_{18+m_4+sm_{18}}$. Pollen stainability is 92.0 %.

Meiosis is normal. Metaphase-I with twenty bivalents is shown in Fig. 58. Anaphase-II with non-synchronized division (Fig. 59), telophase-I (Fig-60), tetrads (Fig. 61), circular large pollen grains (Fig. 62) are observed. Fig. 63 shows mature pollen grain. Pollen stainability is 92.0%.

4.1.10 *Bidens pilosa* L. var. *minor* (Blume) Sherff (2n=36, V.N. 104)

Locality : Ghantaghar (C. Nepal), 1300 msl

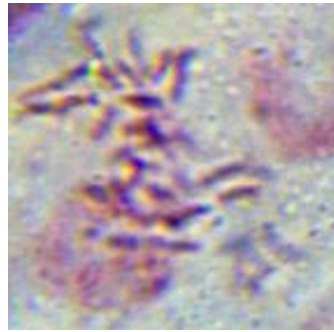
The plant is annual, erect, herb that grows up to 1 meter in height depending on the local conditions. It is commonly known as Cobbler's Pegs or Spanish Needle. Leaves 4-10 cm long opposite, imparipinnate, usually 3-foliate, segments ovate-lanceolate, serrate and acute. The petioles are slightly winged. Flowers are borne in small heads on relatively long peduncles. The heads bear about four or five broad white petals of ray florets, surrounding a disc of tubular yellow florets. The fruits are slightly curved, stiff, rough black rods about 1 cm long with typically two to three stiff, heavily barbed awns at their distal ends. Achenes quadrangular, black. Pappus setae 2-4, retrorsely bristly. Flowering time is May to November and fruiting time October to February.

Chromosome number determined for this taxon is $2n=36$. The somatic chromosome number determined from the root tip cell is shown in Fig. 66 and camera lucida drawing is in Fig. 67. Its ideogram is represented in Fig. 68. The chromosome measurements are given in Table 11.

The karyotype consists of four different types of chromosome with centromere at median point, median region, sub-median region and sub-terminal region. The chromosome length ranged from 0.4 to 2.1 μm with mean length 1.0 μm and absolute length 19.2 μm . TF % is 38.5. Karyotype formula is $M_{16}+m_2+sm_{14}+st_4$.



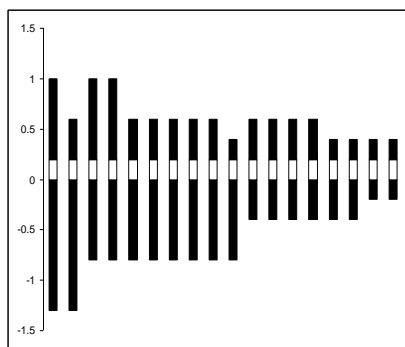
(64)



(65)



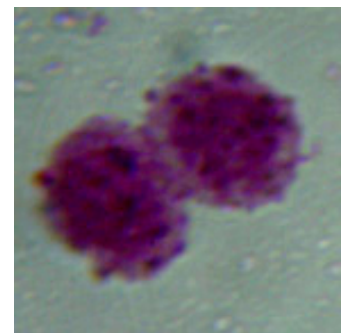
(66)



(67)



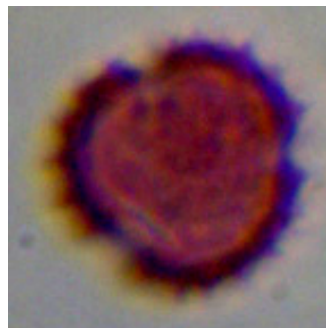
(68)



(69)



(70)



(71)

Figs. 64-71: *Bidens pilosa* L. var. *minor* (Blume) Sherff (V.N. 104)

Fig. 64. Photograph of living plant. **Fig. 65.** Photomicrograph of somatic metaphase plate. **Fig. 66.** Camera lucida drawing of the same. **Fig. 67.** Ideogram of the above. **Fig. 68.** Diakinesis showing 10 bivalents. **Fig. 69.** PMC. **Fig. 70** pollen tetrad. **Fig. 71.** Pollen grain.

Meiosis is normal in this taxon. Metaphase I with 18 bivalents is shown in Fig. 69. Pollen mother cells (Fig. 70), normal tetrads (Figs. 71, 72) and triplicate, echinate, spheroidal pollens (Fig. 73) are observed. Pollen stainability is 94.0 percent.

Table 11: Chromosome measurement in *Bidens pilosa* L. var. *minor* (Blume) Sherff (V.N. 104)

Chrom. Pairs	Long Arm (μm)	Short Arm (μm)	Total Length (μm)	r-value	Relative Length (μm)	Position of Centromere
I	1.3	0.8	2.1	1.6	10.9	m
II	1.3	0.4	1.7	3.2	8.8	st
III	0.8	0.8	1.6	1	8.3	M
IV	0.8	0.8	1.6	1	8.3	M
V	0.8	0.4	1.2	2	6.2	sm
VI	0.8	0.4	1.2	2	6.2	sm
VII	0.8	0.4	1.2	2	6.2	sm
VIII	0.8	0.4	1.2	2	6.2	sm
IX	0.8	0.4	1.2	2	6.2	sm
X	0.8	0.2	1.0	4	5.2	st
XI	0.4	0.4	0.8	1	4.1	M
XII	0.4	0.4	0.8	1	4.1	M
XII	0.4	0.4	0.8	1	4.1	M
XIV	0.4	0.4	0.8	1	4.1	M
XV	0.4	0.2	0.6	2	3.1	sm
XVI	0.4	0.2	0.6	2	3.1	sm
XVII	0.2	0.2	0.4	1	2.0	M
XVIII	0.2	0.2	0.4	1	2.0	M

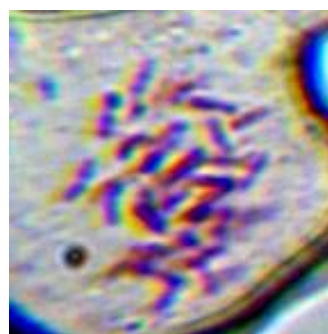
4.1.11 *Blumea fistulosa* (Roxb.) Kurz (2n=22, V.N. 118)

Locality : Janakpurdham (C. Nepal), 600 msl

The plant is herb, annual, erect, 15-100 cm tall, shaggily pubescent above. Leaves simple oblanceolate to obovate, 3-15 \times 0.5-5 cm, pubescent on both surfaces, base narrowly long attenuate, margin bidentate apex acute. Capitula in small sessile clusters arranged in interrupted spike like terminal racemes or sparsely branched panicles. Involucres 4- or 5- seriate, ca. 3.5 mm in diameter, phyllaries purplish adaxially, mostly recurved from middle by anthesis, 2.56 mm, pubescent, sparsely glandular, outer series lanceolate, remainder linear. Receptacle sparsely shortly pubescent. Corollas yellow, 4.2-5 mm, lobes of central florets with glandular and few glandular hairs. Pappus white. Flowering period October to April.



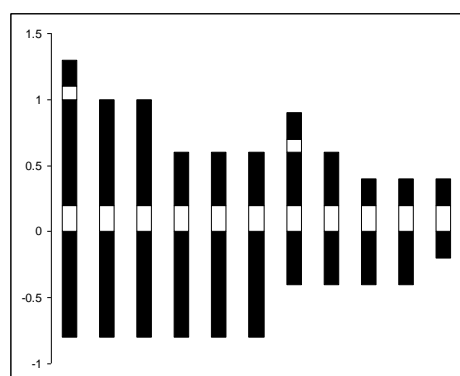
(72)



(73)



(74)



(75)

Figs. 72-75: *Blumea fistulosa* (Roxb.) Kurz (V.N. 118)

Fig. 72. Photograph of living plant. **Fig. 73.** Photomicrograph of somatic metaphase plate. **Fig. 74.** Camera lucida drawing of the same. **Fig. 75.** Ideogram of the above.

Chromosome number determined for this taxon is $2n=22$. The somatic chromosome number determined from the root tip cell is shown in Fig. 74 and camera lucida drawing in Fig. 75. Its ideogram is represented in Fig. 76. The chromosome measurements are given in Table 12.

The karyotype consists of two different types of chromosomes with centromere at median point and sub-median region. The chromosome length ranged from 0.6 to 1.6 μm with mean length 1.0 μm and absolute length 12.0 μmTF % is 45.0. Karyotype formula is $M_{12}+sm_{10}$.

Meiosis could not be studied in this taxon due to the lack of suitable flower buds. Pollen stainability is 97.4 percent.

Table 12: Chromosome measurement in *Blumea fistulosa* (Roxb.) Kurz (V.N. 118)

Chrom. Pairs	Long Arm (μm)	Short Arm (μm)	Total Length (μm)	r-value	Relative Length (μm)	Position of Centromere
I	0.8	0.8+0.2	1.6+0.2	1	8.8	M
II	0.8	0.8	1.6	1	8.8	M
III	0.8	0.8	1.6	1	8.8	M
IV	0.8	0.4	1.2	2	6.6	sm
V	0.8	0.4	1.2	2	6.6	sm
VI	0.8	0.4	1.2	2	6.6	sm
VII	0.4	0.4+0.2	0.8+0.2	1	4.4	M
VIII	0.4	0.4	0.8	1	4.2	M
IX	0.4	0.2	0.6	2	3.3	sm
X	0.4	0.2	0.6	2	3.3	sm
XI	0.2	0.2	0.4	1	2.2	M

4.1.12 *Blumea lacera* var. *glandulosa* (DC.) Hook (2n=32, V.N. 124)

Locality : Janakpurdham (C. Nepal), 1515 msl

The plant is an annual herb, slender, very variable weed with a strong turpentine or camphor odour, 45-60 cm high. Stem erect, simple or branched, covered with hairs and glands (Fig.78), often grey in more silky forms. Leaves alternate, petiolate, obovate, margin toothed; heads in short axillary cymes and collected into terminal panicles, 0.8 cm in diameter, involucre of bracts narrow, covered with hairs, florets female and bisexual, yellow, achenes nearly tetragonous and not ribbed.

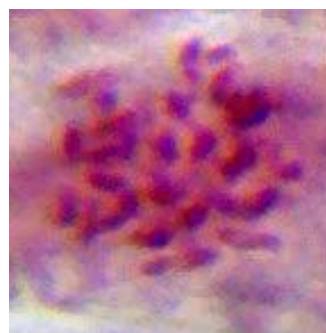
Table 13: Chromosome measurement in *Blumea lacera* var. *glandulosa* (DC.) Hook (V.N. 124)

Chrom. Pairs	Long Arm (μm)	Short Arm (μm)	Total Length (μm)	r-value	Relative Length (μm)	Position of Centromere
I	0.8	0.8	1.6	1	10.6	M
II	0.8	0.8	1.6	1	10.6	M
III	0.8	0.4	1.2	2	8.0	Sm
IV	0.8	0.4	1.2	2	8.0	Sm
V	0.8	0.4	1.2	2	8.0	Sm
VI	0.8	0.4	1.2	2	8.0	Sm
VII	0.8	0.2	1.0	4	6.6	St
VIII	0.8	0.2	1.0	4	6.6	St
IX	0.4	0.4	0.8	1	5.3	M
X	0.4	0.4	0.8	1	5.3	M
XI	0.4	0.4	0.8	1	5.3	M
XII	0.4	0.2	0.6	2	4.0	Sm
XIII	0.4	0.2	0.6	2	4.0	Sm
XIV	0.4	0.2	0.6	2	4.0	Sm
XV	0.2	0.2	0.8	1	5.3	M
XVI	0.2	0.2	0.8	1	5.3	M

Chromosome number presently determined for this taxon is $2n=32$. The somatic chromosome number determined from the root tip cell is shown in Fig. 79 and camera lucida drawing is in Fig. 80. Its ideogram is represented in Fig. 81. The chromosome measurements are given in Table 13.



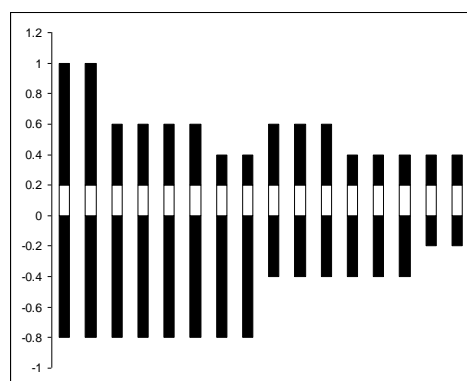
(76)



(77)



(78)



(79)

Figs. 76-79: *Blumea lacera* var. *glandulosa* (DC.) Hook.(V.N. 124)

Fig. 76. Photograph of living plant. **Fig. 77.** Photomicrograph of somatic metaphase plate. **Fig. 78.** Camera lucida drawing of the same. **Fig. 79.** Ideogram of the above.

The karyotype consists of three different types of chromosome with centromere at median point, sub-median region and sub-terminal region. The chromosome length ranged from 0.6 to 1.6 μm with mean length 0.9 μm and absolute length 8.4 μm. TF % is 39.2. Karyotype formula is $M_{14}+sm_{14}+st_4$.

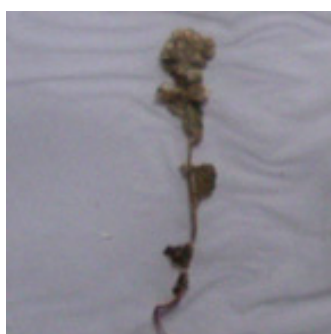
Meiosis could not be studied in this taxon due to the lack of suitable flower buds. Pollen stainability is 94.2 percent.

4.1.13 *Blumea lacera* (Buem f.) DC. (2n=18 V.N. 121)

Locality : Godawari (C. Nepal), 1515 msl

The plant is annual herb, with a strong odour of turpentine, stem erect, 30 cm tall, ash colored, densely glandular, pubescent. Leaves are often incised or lyrate 2.2-6.3 cm the lower leaves petioled, often incised or lyrate, the upper sub-sessile, elliptic oblong or ovovate, obtuse, finely silky on both sides, sharply serrate, dentate, base much tapered. Heads 6-8 mm diameter, many flowered, arranged in axillary cymes or terminal panicle, flower yellow. Corolla lobes of hermaphrodite flowers nearly glabrous. Involucral bracts densely silky-villous, the outer bracts somewhat herbaceous, linear-lanceolate the inner linear, scariosus with green midrib. Pappus white. Fruit an achene, oblong and not ribbed.

Chromosome number determined for this taxon is $2n=18$. The somatic chromosome number determined from the root tip cell is shown in Fig. 87 and camera lucida drawing is in Fig. 88. Its ideogram is represented in Fig. 89. The chromosome measurements are given in Table 14.



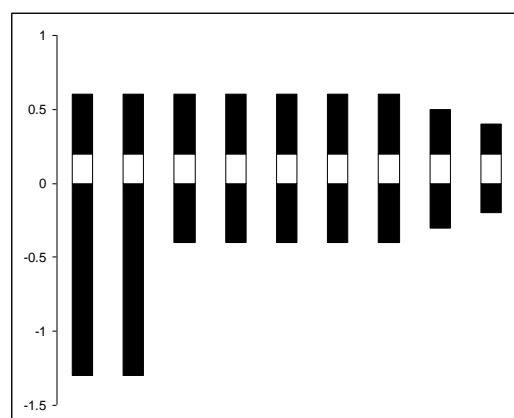
(80)



(81)



(82)



(83)

Figs. 80-83: *Blumea lacera* (Buem f.) DC. (V.N. 124)

Fig. 80. Photograph of herbarium plant. **Fig. 81.** Photomicrograph of somatic metaphase plate. **Fig. 82.** Camera lucida drawing of the same. **Fig. 83.** Ideogram of the above.

The karyotype consists of two different types of chromosomes with centromere at median point and sub-terminal region. The chromosome length ranged from 0.6 to 1.7 μm with mean length 0.9 μm . and absolute length 8.4 μm TF% was 39.2. Karyotype formula is $M_{14+} st_2$.

Meiosis could not be studied in this taxon due to the lack of suitable flower buds. Pollen stainability is 68.3 percent.

Table 14: Chromosome measurement in *Blumea lacera* (Buem f.) DC. (V.N. 121)

Chrom. Pairs	Long Arm (μm)	Short Arm (μm)	Total Length (μm)	r-value	Relative Length (μm)	Position of Centromere
I	1.3	0.4	1.7	3.2	20.2	st
II	1.3	0.4	1.7	3.2	20.2	st
III	0.4	0.4	0.8	1	9.5	M
IV	0.4	0.4	0.8	1	9.5	M
V	0.4	0.4	0.8	1	9.5	M
VI	0.4	0.4	0.8	1	9.5	M
VII	0.4	0.4	0.8	1	9.5	M
VIII	0.3	0.3	0.6	1	7.1	M
IX	0.2	0.2	0.4	1	4.7	M

4.1.14 *Blumea laciniata* DC. (2n=18, V.N. 134)

Locality : Janakpurdham (C. Nepal), 615 msl

The plant is annual, herb, erect, aromatic. Stems with many branches, arising from a woody base, short hairy with stalked gland. Lower leaves lyrate lobed, petioled, upper ones sessile obovate, base tapering, entire to coarsely dentate apiculate. Heads yellow combined into large, lax terminal panicle, glandular, pubescent. Outer bracts acicular, long glandular, hairy on dorsal surface.

Chromosome number determined here for this taxon is $2n=18$. The somatic chromosome number determined from the root tip cell is shown in Fig. 83 and camera lucida drawing in Fig. 84. Its ideogram is represented in Fig. 85. The chromosome measurements are given in Table 14.

The karyotype consists of two different types of chromosomes with centromere at median point and sub-median region. The chromosome length ranged from 0.8 to 1.6 μm with mean length 1.2 μm and absolute length 10.8 μm TF% was 44.4. Karyotype formula is $M_{12+} sm_6$.

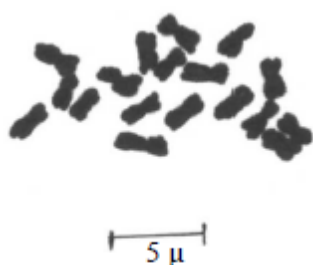
Meiosis could not be studied in this taxon due to the lack of suitable flower buds. Pollen stainability is 84.3 percent.



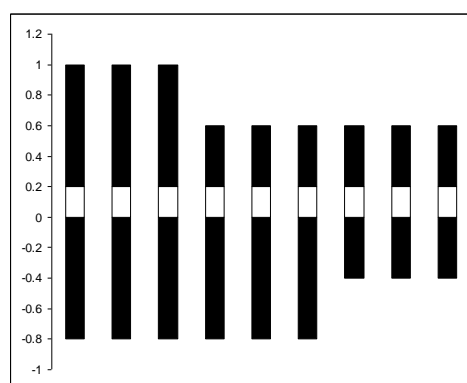
(84)



(85)



(86)



(87)

Figs. 84-87: *Blumea laciniata* DC.

Fig. 84. Photograph of living plant. **Fig. 85.** Photomicrograph of somatic metaphase plate. **Fig. 86.** Camera lucida drawing of the same. **Fig. 87.** Ideogram of the above.

Table 15: Chromosome measurement in *Blumea laciniata* DC. (V.N. 134)

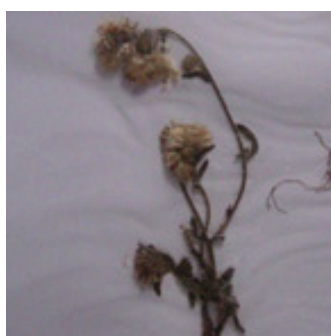
Chrom. Pairs	Long Arm (μm)	Short Arm (μm)	Total Length (μm)	r-value	Relative Length (μm)	Position of Centromere
I	0.8	0.8	1.6	1	14.8	M
II	0.8	0.8	1.6	1	14.8	M
III	0.8	0.8	1.6	1	14.8	M
IV	0.8	0.4	1.2	2	11.1	sm
V	0.8	0.4	1.2	2	11.1	sm
VI	0.8	0.4	1.2	2	11.1	sm
VII	0.4	0.4	0.8	1	7.4	M
VIII	0.4	0.4	0.8	1	7.4	M
IX	0.4	0.4	0.8	1	7.4	M

4.1.15 *Blumea mollis* (D. Don) Merr. (2n=22, V.N. 126)

Locality : Godawari (C. Nepal), 1515 msl

The plant is an perennial herb, usually pubescent, aromatic. Leaves alternate, simple, dentate or serrate, sessile or shortly petiolate. Capitula disciform, in loose or dense corymbs or panicles. Involucre campanulate or hemispherical, bracts in few to many rows, narrow, cartilaginous. Receptacle flat or slightly convex, epaleate with scale-like ridges. Outer florets female, in several rows, filiform, 2-4-toothed, yellow. Central florets bisexual, tubular, widening upwards with 5 short lobes, yellow, sometimes white or purplish. Anthers caudate and minutely calcarate. Style bifid with acute sweeping hairs, not reaching the furcation. Cypsela narrowly oblong, hairy. Pappus barbellate with capillary bristles in 1 row.

Chromosome number determined for this taxon is $2n=22$. The somatic chromosome number determined from the root tip cell is shown in Fig. 87 and camera lucida drawing in Fig. 88. Its ideogram is represented in Fig. 89. The chromosome measurements are given in Table 16.



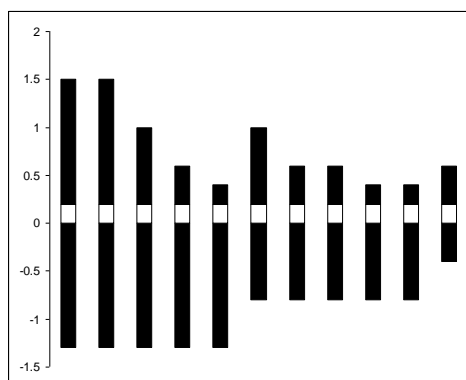
(88)



(89)



(90)



(91)

Figs. 88-91: *Blumea mollis* (D. Don) Merr. (V.N. 126)

Fig. 88. Photograph of herbarium plant **Fig. 89.** Photomicrograph of somatic metaphase plate. **Fig. 90.** Camera lucida drawing of the same. **Fig. 91.** Ideogram of the above.

The karyotype consists of four different types of chromosomes with centromere at median point, median region, sub-median region and sub-terminal region. The chromosome length ranged from 0.8 to 2.6 μm with mean length 1.5 μm and absolute length 17.3 μm . TF % is 36.9. Karyotype formula is $M_8+m_2 + sm_4+ st_8$.

Meiosis could not be studied in this taxon due to the lack of suitable flower buds.

Pollen stainability is 75.2 percent.

Table 16: Chromosome measurement in *Blumea mollis* (D. Don) Merr. (V.N. 126)

Chrom. Pairs	Long Arm (μm)	Short Arm (μm)	Total Length (μm)	r-value	Relative Length (μm)	Position of Centromere
I	1.3	1.3	2.6	1	15.0	M
II	1.3	1.3	2.6	1	15.0	M
III	1.3	0.8	2.1	1.6	12.1	m
IV	1.3	0.4	1.7	4.2	9.8	st
V	1.3	0.2	1.5	6.5	8.6	st
VI	0.8	0.8	1.6	1	6.9	M
VII	0.8	0.4	1.2	2	6.9	sm
VIII	0.8	0.4	1.2	2	6.9	sm
IX	0.8	0.2	1.0	4	5.7	st
X	0.8	0.2	1.0	4	5.7	st
XI	0.4	0.4	0.8	1	4.6	M

4.1.16 *Centaurea cyanus* L. (2n=24, V.N. 143)

Locality : Kirtipur (C. Nepal), 1330 msl

The plant is annual or biennial, erect, 15-75cm tall, branched. Lower leaves lanceolate, entire or lyrate-pinnatifid, acute, petiolate, upper linear- lanceolate entire. Heads ovoid. Involucral bracts oblong, obtuse, cottony, tip broad with brown scarious toothed margins. Outer florets blue, inner bluish. Achenes grey, silky. The flowers are hermaphrodite and are pollinated by bees, flies, lepidoptera and self. The plant is self-contratile. It flower from Jun to August and the seeds ripen from August to October. It is noted that the flower is attractive for insects. Pappus 4 mm long.

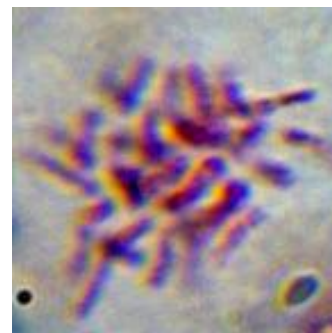
Chromosome number determined for this taxon is $2n=24$. The somatic chromosome number determined from the root tip cell is shown in Fig. 95 and camera lucida drawing in Fig. 96. Its ideogram is represented in Fig. 97. The chromosome measurements are given in Table 17.

Table 17: Chromosome measurement in *Centaurea cyanus* L. (V.N. 143)

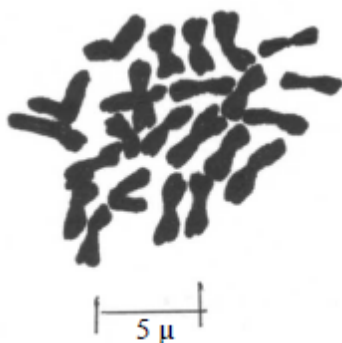
Chrom. Pairs	Long Arm (μm)	Short Arm (μm)	Total Length (μm)	r-value	Relative Length (μm)	Position of Centromere
I	1.3	1.3	2.6	1	13.0	M
II	1.3	0.8	2.1	1.6	10.5	m
III	1.3	0.8	2.1	1.6	10.5	m
IV	1.3	0.8	2.1	1.6	10.5	m
V	1.3	0.4	1.7	3.2	8.5	st
VI	1.3	0.4	1.7	3.2	8.5	st
VII	0.8	0.8	1.6	1	8.0	M
VIII	0.8	0.8	1.6	1	8.0	M
IX	0.8	0.8	1.6	1	8.0	M
X	0.8	0.4	1.2	2	6.0	sm
XI	0.4	0.4	0.8	1	4.0	M
XII	0.4	0.4	0.8	1	4.0	M



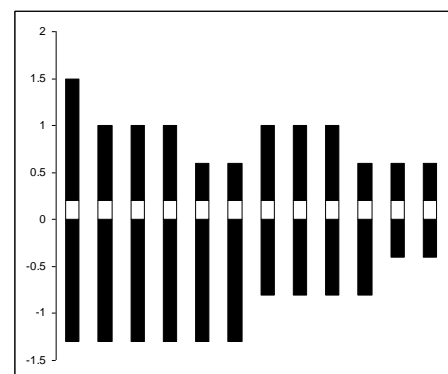
(92)



(93)



(94)



(95)

Figs. 92-95: *Centaurea cyanus* L. (V.N. 143)

Fig. 92. Photograph of living plant. **Fig. 93.** Photomicrograph of somatic metaphase plate. **Fig. 94.** Camera lucida drawing of the same. **Fig. 95.** Ideogram of the above.

The karyotype consists of four different types of chromosomes with centromere at median point, median region, sub-median region and sub-terminal region. The chromosome length ranged from 0.8 to 2.6 μm with mean length 1.6 μm and absolute length 19.9 μm . TF % is 40.7. Karyotype formula is $M_{12}+m_6+sm_2+st_4$.

Meiosis could not be studied in this taxon due to the lack of suitable flower buds.

Pollen stainability is 79.4 percent.

4.1.17 *Calendula officinalis* L. (2n=28, V.N. 114)

Locality: Ghantaghar (C. Nepal), 1300 msl

The plant is a short living, aromatic and erect annual herb, growing up to 80 cm tall with sparsely branched stem. It is commonly called pot marigold. The stem is angular, glandular and hairy. The leaves 2.5-7.5 cm, oblong, lanceolate and hairy on both sides, entire margins. The inflorescence is yellow comprising a thick capitulum. Heads terminal, 5 cm diameter with involucre bract 6 mm. Flowers bright orange yellow 3-toothed, tube hairy. In the wild form they have a single ring of ray florets surrounding the central disc florets. The disc florets are tubular and hermaphrodite, and generally of a more intense orange-yellow colour than the ray florets. Peripheral ray florets tridentate. The flowers may appear throughout year where conditions are suitable. The fruit is a thorny curved achene. Achenes longer than the involucre, curved boat-shaped dorsally muricate not beaked, outer longer ventrally crested, beaked.

Chromosome number determined for this taxon is $2n=28$. The somatic chromosome number determined from the root tip cell is shown in Fig. 98 and camera lucida drawing in Fig. 99. Its ideogram is represented in Fig.100. The chromosome measurements are given in Table 18.

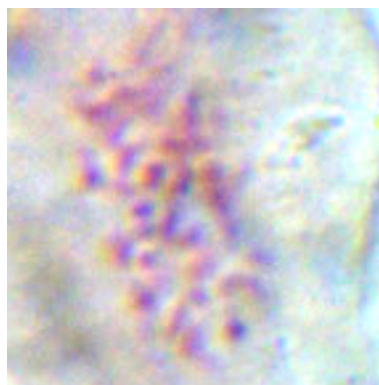
Chromosome of metaphase plate shows three types with centromere at median points, median regions and sub median regions. The chromosomes length ranged from 0.4 to 2.6 μm with mean length 1.5 μm and absolute length 21.9 μm . TF% is 44. Karyotype formula is $M_{16}+m_{4+}sm_8$.

Meiosis in this taxon exhibited both regular as well as irregular behaviour. Diakinesis shown in Figs. 101 and 102 . Metaphase-I is shown in Fig. 103-106. are noted. Telophase-I is in Fig. 107. Metaphase- II (Fig. 108-110), Anaphase-II with non-synchronous division (Fig. 111) and Anaphase-II with non-oriented chromosomes

(Fig. 112) have been observed. Telophase-II is shown in Fig. 113. Normal tetrads (Fig.114) and circular, round, echinate large pollens (Fig.115) are observed. Pollen stainability is 84.4 percent.



(96)

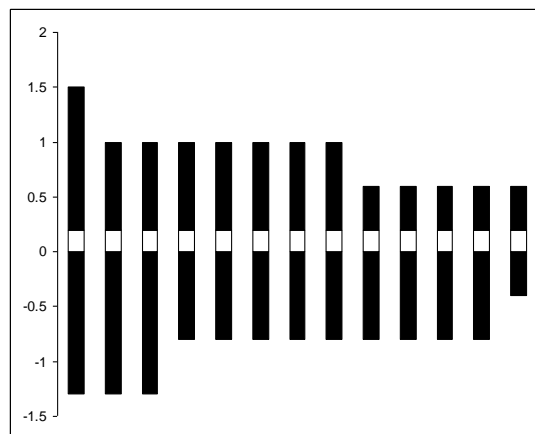


(97)

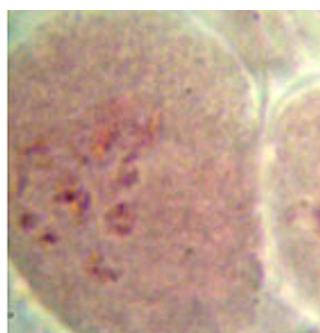


5 μ

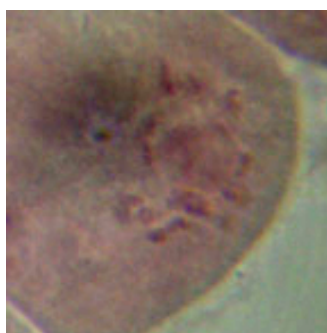
(98)



(99)



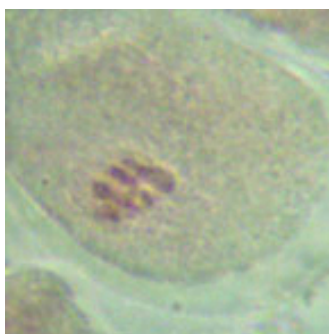
(100)



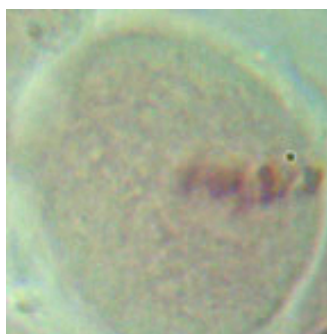
(101)



(102)



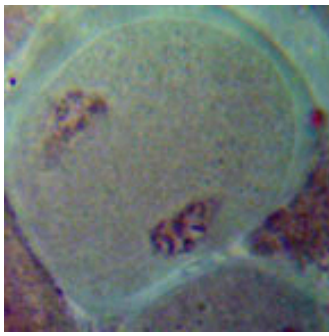
(103)



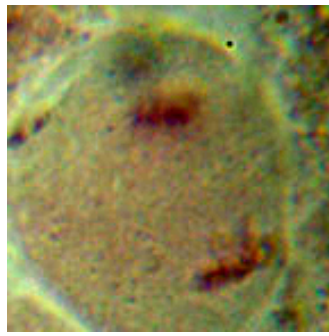
(104)



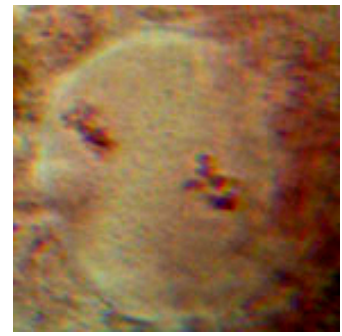
(105)



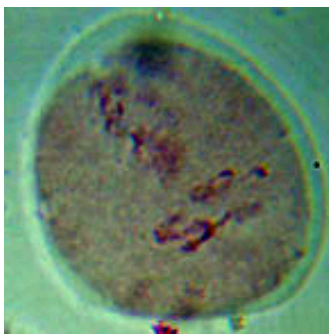
(106)



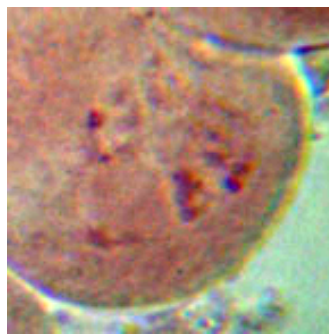
(107)



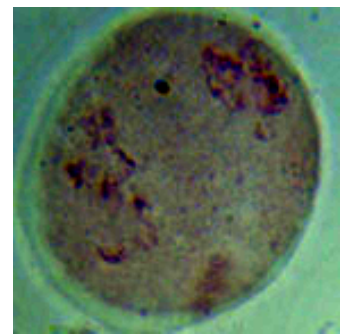
(108)



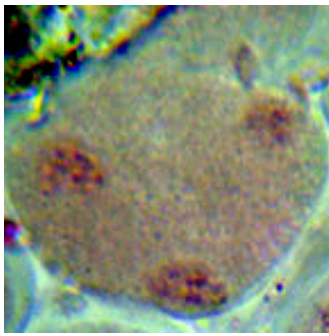
(109)



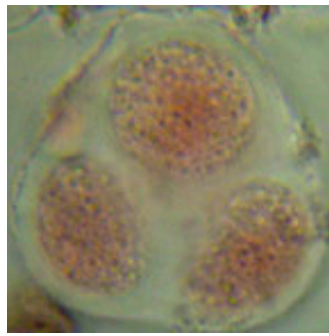
(110)



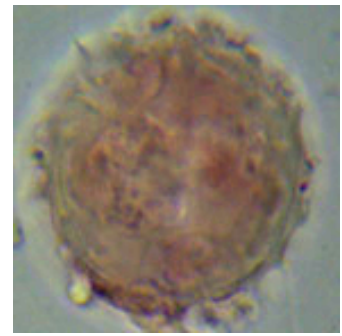
(111)



(112)



(113)



(114)

Figs. 96-114: *Calendula officinalis* L. (V.N. 114)

Fig. 96. Photograph of living plant. **Fig. 97.** Photomicrograph of somatic metaphase plate. **Fig. 98.** Camera lucida drawing of the same. **Fig. 99.** Ideogram of the above. **Fig. 100-101.** Diakinesis. **Fig. 102- 105.** M-I. **Fig. 106.** T-I. **Fig. 107- 109** M-II. **Fig. 110.** A-II with non synchronized division. **Fig. 111.** A-II with non-oriented chromosomes. **Fig. 112.** T-II. **Fig. 113.** Tetrad normal. **Fig.114.** Pollen grain.

Table 18: Chromosome measurement in *Calendula officinalis* L. (V.N. 114)

Chrom. Pairs	Long Arm (µm)	Short Arm (µm)	Total Length (µm)	r-value	Relative Length (µm)	Position of centromere
I	1.3	1.3	2.6	1	11.8	M
II	1.3	0.8	2.1	1.6	9.8	m
III	1.3	0.8	2.1	1.6	9.8	m
IV	0.8	0.8	1.6	1	7.8	M
V	0.8	0.8	1.6	1	7.8	M
VI	0.8	0.8	1.6	1	7.8	M
VII	0.8	0.8	1.6	1	7.8	M
VIII	0.8	0.8	1.6	1	7.8	M
IX	0.8	0.4	1.2	2	5.9	sm
X	0.8	0.4	1.2	2	5.9	sm
XI	0.8	0.4	1.2	2	5.9	sm
XII	0.8	0.4	1.2	2	5.9	sm
XIII	0.4	0.4	0.8	1	3.9	M
XIV	0.2	0.2	0.4	1	1.9	M

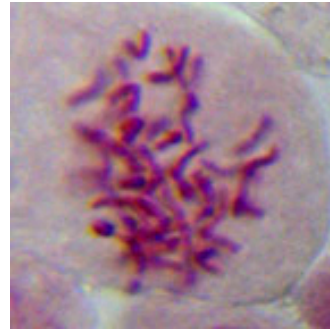
4.1.18 *Chrysanthemum morifolium* Ramat. (2n=36, V.N. 117)

Locality: Thimi (C. Nepal), 1200 msl

The plant is annual herb. Leaves alternate, serrate-dentate and pinnatifid, somewhat amplexicaul. Capitula radiate, pedunculate, solitary or laxly corymbose, many-flowered. Involucre campanulate, bracts in 2-4 rows, often with brown, scarious margin and sometimes membranous tip. Receptacle convex, ray florets unisexual, female, fertile, corolla usually white or yellow, tube usually short with entire or toothed lamina 3 times as long as tube. Ray cypsela triquetrous, laterally winged. Disc florets bisexual, fertile or sterile, corolla tube campanulate above, glandular, with 5 ovate lobes sometimes awned on back. Anthers ecalcarate and ecaudate with ovate, apical appendage. Style with swollen base and with oblong, truncate branches. Disc cypsela prismatic with narrow adaxial wing or terete with thick undulating wall thus apparently ribbed. Pappus 0 in both disc and ray florets.



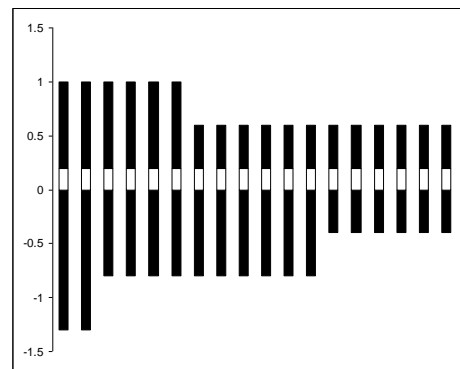
(115)



(116)



(117)



(118)

Figs. 115-118: *Chrysanthemum morifolium* Ramat. (V.N. 117)

Fig. 115. Photograph of living plant. **Fig. 116.** Photomicrograph of somatic metaphase plate. **Fig. 117.** Camera lucida drawing of the same. **Fig. 118.** Ideogram of the above.

Chromosome number determined for this taxon is $2n=36$. The somatic chromosome number determined from the root tip cell is shown in Fig. 119 and camera lucida drawing in Fig. 120. Its ideogram is represented in Fig. 121. The chromosome measurements are given in Table 19.

Countable metaphase at mitosis revealed 36 chromosomes. Somatic chromosomes are of three types with centromere at median points, median regions and sub-median regions. The chromosome length ranged from 0.8 to 2.1 μm with mean length 1.2 μm and absolute length 23.1 μm . TF % was 44.6. Karyotype formula is $M_{20}+m_4+sm_{12}$.

Table 19: Chromosome measurement in *Chrysanthemum morifolium* Ramat. (V.N. 117)

Chrom. Pairs	Long Arm (µm)	Short Arm (µm)	Total Length (µm)	r-value	Relative Length (µm)	Position of Centromere
I	1.3	0.8	2.1	1.6	9.0	m
II	1.3	0.8	2.1	1.6	9.0	m
III	0.8	0.8	1.6	1	7.1	M
IV	0.8	0.8	1.6	1	7.1	M
V	0.8	0.8	1.6	1	7.1	M
VI	0.8	0.8	1.6	1	7.1	M
VII	0.8	0.4	1.2	2	5.4	sm
VIII	0.8	0.4	1.2	2	5.4	sm
IX	0.8	0.4	1.2	2	5.4	sm
X	0.8	0.4	1.2	2	5.4	sm
XI	0.8	0.4	1.2	2	5.4	sm
XII	0.8	0.4	1.2	2	5.4	sm
XIII	0.4	0.4	0.8	1	3.6	M
XIV	0.4	0.4	0.8	1	3.6	M
XV	0.4	0.4	0.8	1	3.6	M
XVI	0.4	0.4	0.8	1	3.6	M
XVII	0.4	0.4	0.8	1	3.6	M
XVIII	0.4	0.4	0.8	1	3.6	M

Meiosis could not be studied in this taxon due to the lack of suitable flower buds.

Pollen stainability is 85.4 percent.

4.1.19 *Cirsium arvense* Mill. (2n=34, V.N. 115)

Locality: Kirtipur (C. Nepal), 1340 msl

The plant is perennial, erect herb, 1 m. tall. Stem grooved, branching at top, glabrous early but becoming pubescent with maturity. Leaves pinnatifid, margins spiny, glabrous above and cottony beneath. Upper surface of mature leaf is dark green and hairless while the lower surface is light green in color and may be with or without hairs. Capitula discoid, many-flowered, solitary, corymbose or variously clustered. Involucre ovoid or globose, bracts in many rows, spiny. Receptacle flat or convex, densely setose. Florets bisexual, corolla purple, tube narrowly cylindrical below, slightly widened above, deeply 5-lobed. Anthers linear, sagittate, adjacent auricles connate and prolonged into entire or lacerated tail. Style abruptly thickened below

branches, often with ring of hairs there, often partly connate, sometimes linear or filiform. Cypselas obovoid-oblong, glabrous with nearly central, horizontal, basal attachment scar. Pappus of feathery bristles in several rows, connate at base.

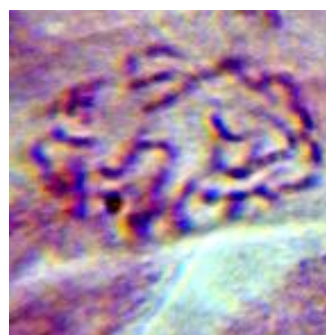
Chromosome number determined for this taxon is $2n=34$. The somatic chromosome number determined from the root tip cell is shown in Fig. 121 and camera lucida drawing in Fig. 122. Its ideogram is represented in Fig. 123. The chromosome measurements are given in Table 20.

Mitotic division consists of three types of chromosomes having centromere at median points, sub-median regions and sub-terminal regions. The chromosomes length ranged from 0.8 to 1.2 μm with mean length 1.1 μm and absolute length 19.1 μm . TF% was 39.5. Karyotype formula is $M_{16}+sm_{14}+st_4$.

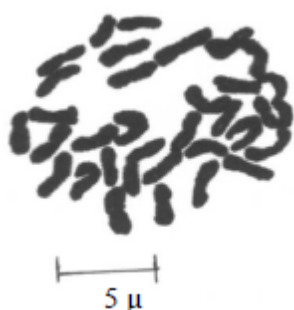
Meiosis could not be studied in this taxon due to the lack of suitable flower buds. Pollen stainability is 83.9 percent.



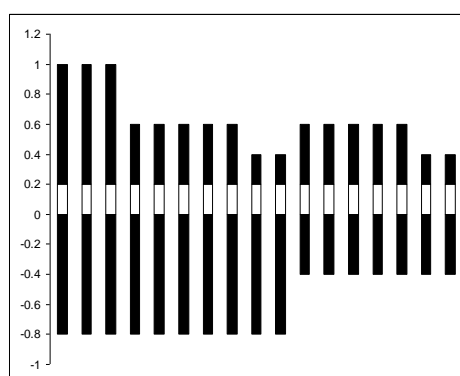
(119)



(120)



(121)



(122)

Figs. 119-122: *Cirsium arvense* Mill (V.N. 115)

Fig. 119. Photograph of living plant. **Fig. 120.** Photomicrograph of somatic metaphase plate. **Fig. 121.** Camera lucida drawing of the same. **Fig. 122.** Ideogram of the above.

Table 20: Chromosome measurement in *Cirsium arvense* Mill. (V.N. 115)

Chrom. Pairs	Long Arm (µm)	Short Arm (µm)	Total Length (µm)	r-value	Relative Length (µm)	Position of Centromere
I	0.8	0.8	1.6	1	8.9	M
II	0.8	0.8	1.6	1	8.9	M
III	0.8	0.8	1.6	1	8.9	M
IV	0.8	0.4	1.2	2	6.7	sm
V	0.8	0.4	1.2	2	6.7	sm
VI	0.8	0.4	1.2	2	6.7	sm
VII	0.8	0.4	1.2	2	6.7	sm
VIII	0.8	0.4	1.2	2	6.7	sm
IX	0.8	0.2	1.0	4.1	5.5	st
X	0.8	0.2	1.0	4.1	5.5	st
XI	0.4	0.4	0.8	1	4.4	M
XII	0.4	0.4	0.8	1	4.4	M
XIII	0.4	0.4	0.8	1	4.4	M
XIV	0.4	0.4	0.8	1	4.4	M
XV	0.4	0.4	0.8	1	4.4	M
XVI	0.4	0.2	0.6	2	3.3	sm
XVII	0.4	0.2	0.6	2	3.3	sm

4.1.20 *Conyza canadensis* (L.) Cronquist (2n=22, V.N. 116)

Locality: Minbhawan (C. Nepal), 1280 msl

The plant is annual, erect, herb, 15 to 200 cm in height. Root fusiform. Stalk straight, costate, covered with rigid simple hairs bent upward. Leaves green, erect, linear-lanceolate 0.1 to 11 cm in length and 0.2 to 18 mm in width. Lower leaves petiolate, serrate-dentate, sparsely covered along both sides with large rigid hairs bent upwards. Apical leaves gradually become smaller losing denticles whereas pubescence remains on leaf margins only. Lower leaves sessile. Inflorescence paniculate. Anthodia numerous, 3-5 mm in diameter, located more or less on long stems. Inner leaflets of involucre linear, pointed, bare, grassy, membranous at margins, outer ones two times shorter, grassy with posteriorly bent simple hairs.

Marginal flowers feminine, ligular, white, 2.5-3.5 mm in length, arranged in a few rows, covered with short hairs in upper part of tube. Inner flowers pale yellow, bisexual, tubular, cylindrical, four-dentate and covered with short hairs on upper part. Pappus dirty white, up to 3 mm in length, flattened. Blossoming occurs in July-November. It is spread by pappose seeds which are easily carried by wind at a great distance.

Chromosome number determined here for this taxon is $2n=22$. The somatic chromosome number determined from the root tip cell is shown in Fig. 127 and camera lucida drawing in Fig. 128. Its ideogram is represented in Fig. 129. The chromosome measurements are given in Table 21.

Somatic chromosomes are of four types having centromeres at median points median regions, sub-median regions and sub-terminal regions. The chromosomes length ranged from 1.2 to 3.4 μm with mean length 2.3 μm and absolute length 25.7 μm . TF % is 35. Karyotype formulas is $M_2+m_{10}+sm_6+st_4$.

Meiosis could not be studied in this taxon due to the lack of suitable flower buds.

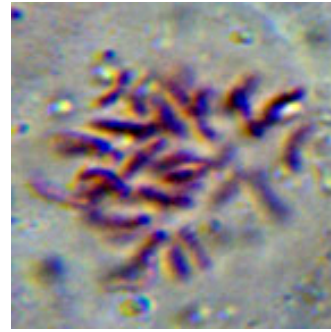
Pollen stainability is 93.9 percent.

Table 21: Chromosome measurement in *Conyza canadensis* (L.) Cronquist (V.N. 116).

Chrom. Pairs	Long Arm (μm)	Short Arm (μm)	Total Length (μm)	r-value	Relative Length (μm)	Position of Centromere
I	2.1	1.3	3.4	1.6	13.0	m
II	1.8	1.3	3.1	1.3	12.0	m
III	1.2	0.8	2.0	1.5	8.0	m
IV	2.1	0.8	2.9	2.6	11.0	sm
V	1.8	0.8	2.6	2.2	10.0	sm
VI	1.3	0.8	2.1	1.6	8.0	m
VII	1.3	0.4	1.7	3.2	7.0	st
VIII	1.3	0.4	1.7	3.2	7.0	st
IX	0.8	0.8	1.6	1	6.0	M
X	0.8	0.4	1.2	2	5.0	sm
XI	2.1	1.3	3.4	1.6	13.0	m



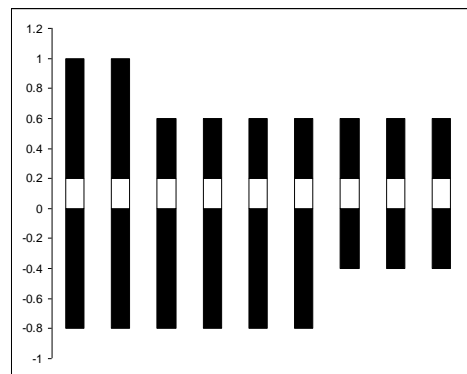
(123)



(124)



(125)



(126)

Figs. 123-126: *Conyza canadensis* (L.) Cronquist (V.N. 116)

Fig. 123. Photograph of living plant. **Fig. 124.** Photomicrograph of somatic metaphase plate. **Fig. 125.** Camera lucida drawing of the same. **Fig. 126.** Ideogram of the above.

4.1.21 *Coreopsis grandiflora* Nutt. ex Chapm. ($2n=26$, V.N. 130)

Locality: Pokhara (W. Nepal), 700 msl

The plant is a herbaceous perennial up to 30-70 cm tall. It is glabrous or sparsely hairy. The leaves are arranged oppositely or alternately at intervals along the stem. They are pinnatifid and deeply lobed. The leaf segments are linear and rather irregular, the terminal segment is usually the largest. A few leaves at the bottom or the top may be linear and lack lobes. These leaves are up to 3" long and 2" across, At the apex of the plant, is a rather long and naked flowering stem with a single composite flower about 2½" across. It consists of 6-12 yellow ray florets that surround numerous golden yellow disk florets. Each ray floret has 4-5 notches along the outer edge. This provides the composite flower with an attractive, somewhat ragged, appearance, little or no floral scent. The flower buds have a smooth, spherical appearance, and are olive

green. The achenes are flat and rather oblong, with two small scales at the apex. They are distributed to a limited extent by the wind. The blooming period occurs during early to mid-summer and lasts about a month.

Chromosome number determined for this taxon is $2n=26$. The somatic chromosome number determined from the root tip cell is shown in Fig. 131 and camera lucida drawing in Fig. 132. Its ideogram is represented in Fig. 133. The chromosome measurements are given in Table 22.

Chromosomes are of two types having centromere at median points and sub-median regions. The chromosomes length ranged from 0.6 to 1.6 μm with mean length 1.1 μm and absolute length 14.3 μm . TF% is 43. Karyotype formula is $M_{14}+sm_{12}$.

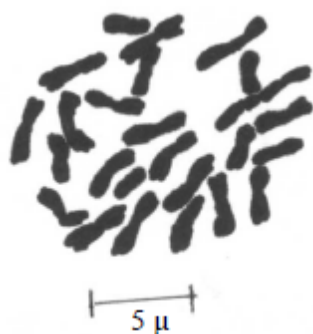
Meiosis could not be studied in this taxon due to the lack of suitable flower buds. Pollen stainability is 78.0 percent.



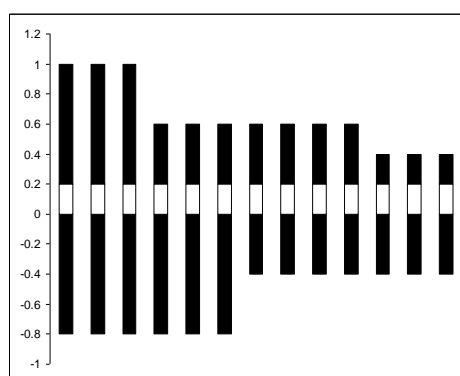
(127)



(128)



(129)



(130)

Figs. 127-130: *Coreopsis grandiflora* Nutt. ex Chapm. (V.N. 130)

Fig. 127. Photograph of living plant. **Fig. 128.** Photomicrograph of somatic metaphase plate. **Fig. 129.** Camera lucida drawing of the same. **Fig. 130.** Ideogram of the above.

Table 22: Chromosome measurement in *Coreopsis grandiflora* Nutt. ex Chapm. (V.N. 130)

Chrom. Pairs	Long Arm (µm)	Short Arm (µm)	Total Length (µm)	r-value	Relative Length (µm)	Position of centromere
I	0.8	0.8	1.6	1	8.9	M
II	0.8	0.8	1.6	1	8.9	M
III	0.8	0.8	1.6	1	8.9	M
IV	0.8	0.4	1.2	2	8.9	sm
V	0.8	0.4	1.2	2	8.9	sm
VI	0.8	0.4	1.2	2	8.9	sm
VII	0.4	0.4	0.8	1	5.9	M
VIII	0.4	0.4	0.8	1	5.9	M
IX	0.4	0.4	0.8	1	5.9	M
X	0.4	0.4	0.8	1	5.9	M
XI	0.4	0.2	0.6	2	4.4	sm
XII	0.4	0.2	0.6	2	4.4	sm
XIII	0.4	0.2	0.6	2	4.4	sm

4.1.22 *Crepis japonica* (L.) Benth. (2n=16, V.N. 131)

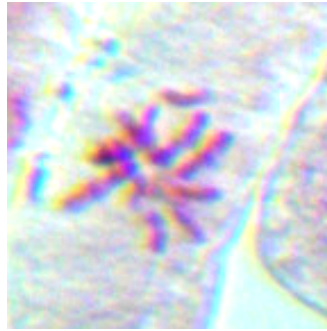
Locality: Baneshwor (C. Nepal), 1230 msl

The species is an perennial herbs, glabrous or pubescent with milky latex. Leaves mostly rosulate, glabrous. Capitula ligulate, many-flowered, solitary, terminal or in lax corymbs. Involucre cylindric-campanulate; bracts in 2 distinct unequal rows. Receptacle flat, epaleate, pitted, shortly fimbriiferous. Florets bisexual, fertile, corolla yellow, tube shorter than lamina, oblong, 5-toothed. Anthers sagittate with oblong, apical appendage. Style linear, becoming terete and pilose above with linear, obtuse glandular branches. Cypsela subterete or marginal ones compressed, many-ribbed, sometimes attenuate into apical beak. Pappus of scabrid-barbellate bristles.

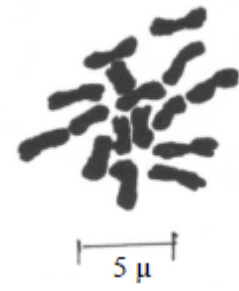
Chromosome number determined for this taxon is 2n=16. The somatic chromosome number determined from the root tip cell is shown in Fig. 135 and camera lucida drawing in Fig. 136. Its ideogram is represented in Fig. 137. The chromosome measurements are given in Table 23.



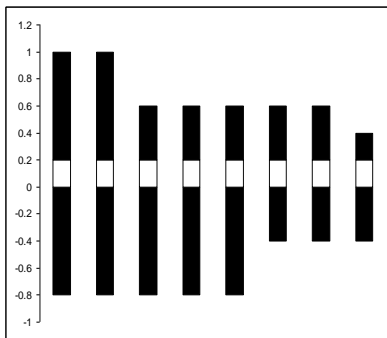
(131)



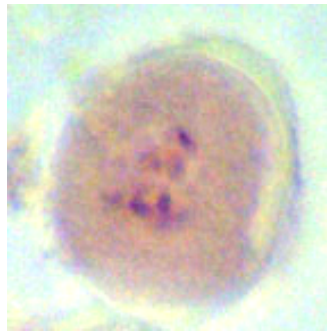
(132)



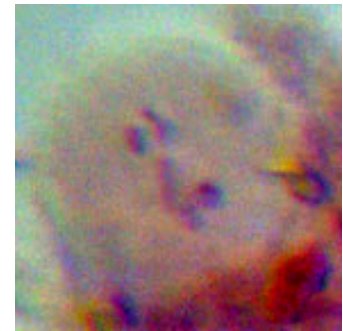
(133)



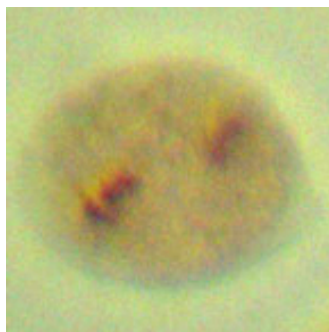
(134)



(135)



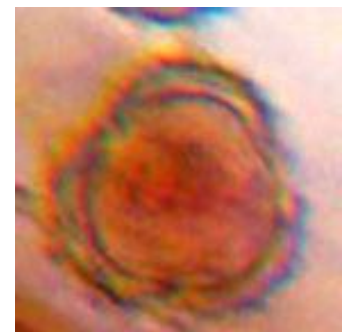
(136)



(137)



(138)



(139)

Figs. 131-139: *Crepis japonica* (L.) Benth. (V.N. 131)

Fig. 131. Photograph of living plant, **Fig. 132.** Photomicrograph of somatic metaphase plate. **Fig. 133.** Camera lucida drawing of the same. **Fig. 134.** Ideogram of the above. **Fig. 135.** Diakinesis with 8 bivalents. **Fig. 136.** M-I. **Fig. 137.** M-II. **Fig. 138.** Tetrad (normal). **Fig. 139.** Pollen grain.

The karyotype consists of two types of chromosomes with centromere at median point and sub-median region. The chromosome length ranged from 0.6 to 1.6 μm with mean length 1.1 μm and absolute length 9 μm . TF % is 42.2. Karyotype formula is M_{8+sm_8} .

Meiosis is normal. Diakinesis with eight bivalents (Fig. 136-137) are observed. Metaphase-II (Fig. 138), normal tetrads (Fig 139), tricolpate, triplicate, pollens are encountered (Fig.140). Pollen stainability is 98.4 percent.

Table 23: Chromosome measurement in *Crepis japonica* (L.) Benth.

Chrom. Pairs	Long Arm (µm)	Short Arm (µm)	Total Length (µm)	r-value	Relative Length (µm)	Position of Centromere
I	0.8	0.8	1.6	1	17.7	M
II	0.8	0.8	1.6	1	17.7	M
III	0.8	0.4	1.2	2	13.3	sm
IV	0.8	0.4	1.2	2	13.3	sm
V	0.8	0.4	1.2	2	13.3	sm
VI	0.4	0.4	0.8	1	8.8	M
VII	0.4	0.4	0.8	1	8.8	M
VIII	0.4	0.2	0.6	2	6.6	sm

4.1.23 *Crassocephalum crepidioides* (Benth.) S. Moore (2n=40, V.N. 105)

Locality: Alok Nagar (C. Nepal), 1220 msl

The plant is perennial herb, erect, glabrous or hispid-pubescent. Leaves alternate, entire to pinnately dissected, margins dentate. Capitula discoid, solitary to corymbose, nodding pedunculate, few- to many-flowered. Involucre oblong or campanulate, calyculate, bracts in 1 row, free, with membranous margin. Receptacle flat, epaleate. Disc florets bisexual, fertile, brick red, tube expanded above with 5 linear to lanceolate lobes. Anthers linear, ecalcarate and ecaudate, with lanceolate or deltoid apical appendage. Style branches linear, truncate, penicillate, tipped with well-defined subulate appendage of fused papillae. Cypsela cylindrical, ribbed. Pappus of many, fine, white bristles.

Chromosome number determined for this taxon is 2n=40. The somatic chromosome number determined from the root tip cell is shown in Fig. 144 and camera lucida drawing in Fig. 145. Its ideogram is represented in Fig. 146. The chromosome measurements are given in Table 24.

The karyotype consists of three types of chromosomes with centromere at median point, median region and sub median region. The chromosome length ranged from 0.4 to 3.0 μm with mean length 1.0 μm and absolute length 20.6 μm . TF % was 42.2. Karyotype formula is $M_{22}+m_2+sm_{16}$.

Table 24: Chromosome measurement in *Crassocephalum crepidiodes* (Benth.) S. Moore (V.N. 105)

Chrom. Pairs	Long Arm (μm)	Short Arm (μm)	Total length (μm)	r-value	Relative Length (μm)	Position of Centromere
I	1.7	1.3	3.0	1.3	9.7	m
II	0.8	0.8	1.6	1	7.7	M
III	0.8	0.8	1.6	1	7.7	M
IV	0.8	0.4	1.2	2	5.8	sm
V	0.8	0.4	1.2	2	5.8	sm
VI	0.8	0.4	1.2	2	5.8	sm
VII	0.8	0.4	1.2	2	5.8	sm
VIII	0.8	0.4	1.2	2	5.8	sm
IX	0.8	0.4	1.2	2	5.8	sm
X	0.4	0.4	0.8	1	3.8	M
XI	0.4	0.4	0.8	1	3.8	M
XII	0.4	0.4	0.8	1	3.8	M
XIII	0.4	0.4	0.8	1	3.8	M
XIV	0.4	0.4	0.8	1	3.8	M
XV	0.4	0.4	0.8	1	3.8	M
XVI	0.4	0.2	0.6	2	2.9	sm
XVII	0.4	0.2	0.6	2	2.9	sm
XVIII	0.2	0.2	0.4	1	1.9	M
XIX	0.2	0.2	0.4	1	1.9	M
XX	0.2	0.2	0.4	1	1.9	M



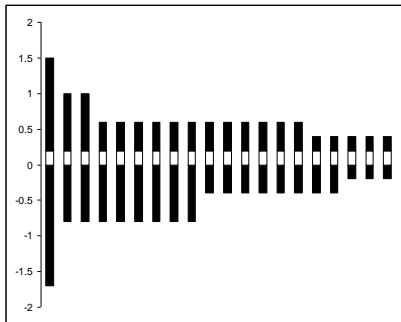
(140)



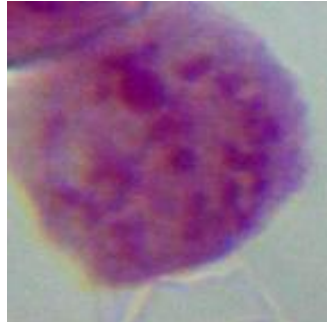
(141)



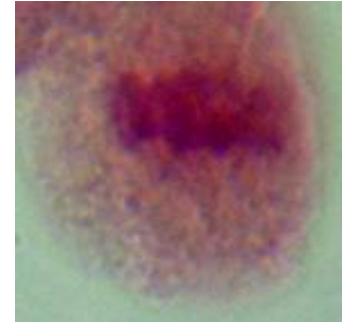
(142)



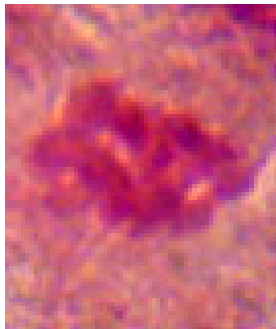
(143)



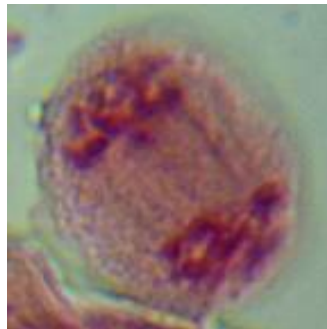
(144)



(145)



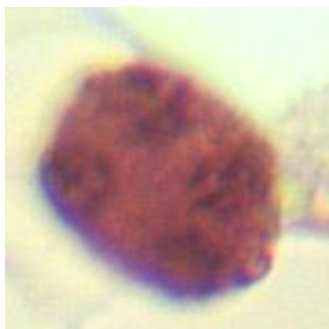
(146)



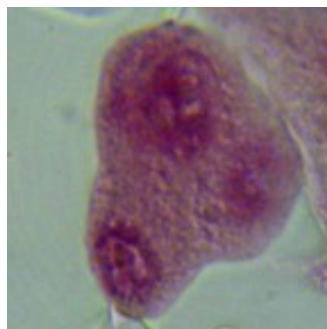
(147)



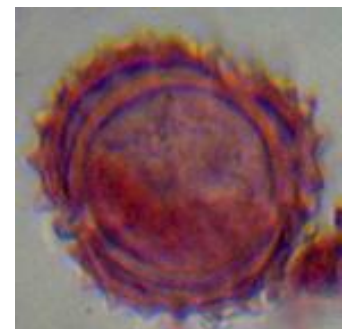
(148)



(149)



(150)



(151)

Figs. 140-151: *Crassocephalum crepidioides* (Benth.) S.Moore (2n=40, V.N. 105)

Fig. 140. Photograph of living plant. **Fig. 141.** Photomicrograph of somatic metaphase plate. **Fig. 142.** Camera lucida rawing of the same. **Fig. 143.** Ideogram of the above. **Fig. 144.** Diakinensis with 20 bivalents. **Fig. 145.** M-I. **Fig. 146.** Early A-I. **Fig. 147.** A-I with chromatin bridges. **Fig. 148.** T-I. **Fig. 149.** T-II normal. **Fig. 150.** Normal tetrad. **Fig. 151.** Pollen grain.

Meiotic behaviour is normal in this taxon. Diakinesis with 20 bivalents and nucleolus (Fig. 145) is observed. Metaphase-I with sticky nature (Fig. 146), early anaphase I with spindle fibre (Fig. 147), anaphase-I with chromatin bridges (Fig. 148), telophase II normal (Fig. 149), tetrads normal (Fig. 151), pollen grains triporate, circular are observed (Fig. 152). Pollen stainability is 97. 1percent.

4.1.24 *Dichrocephala integrifolia* (L. f.) Kuntze (2n=18, V.N. 119)

Locality: Godawari (C. Nepal), 1515 msl

The plant is annual herb. Leaves alternate, petiolate, oblong-obovate to linear-oblong in outline, dentate or lyrate-pinnatifid, lobes serrate, hairy on both sides. Capitula disciform, small, subglobose, in terminal panicles, pedunculate, peduncles bracteate. Involucres somewhat flattened or cup-shaped, bracts in 2 rows, equal, glabrous, oblong, with fimbriated, membranous margins. Receptacle hemispherical. Marginal florets female, fertile, many, corolla whitish or yellow, tubular, 2- or 3-denticulate, with few glands. Disc florets bisexual, fertile, fewer than marginal flowers, corolla yellowish green, tubular below, campanulate above, laxly glandular with 4 triangular lobes. Anthers oblong, ecalcarate and ecaudate, with minute, triangular apical appendage. Style as long as corolla, with 2 short branches; appendages lanceolate. Cypselas obovate, slightly compressed, basically and apically with few glands, otherwise glabrous and shiny. Pappus usually 0 in ray florets, 0 or 1 or 2 caducous bristles in disc florets.

Table 25: Chromosome measurement in *Dichrocephala integrifolia* (L. f.) Kuntze (V.N. 119)

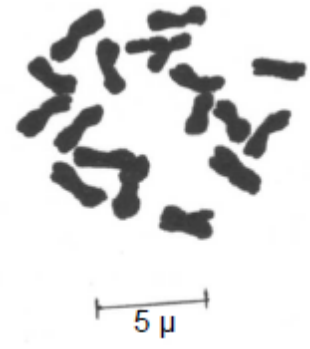
Chrom. Pairs	Long Arm (µm)	Short Arm (µm)	Total Length (µm)	r-value	Relative Length (µm)	Position of Centromere
I	0.8	0.4	1.2	2	11.5	Sm
II	0.4	0.4	0.8	1	7.6	M
III	0.8	0.8	1.6	1	15.3	M
IV	0.8	0.8	1.6	1	8.9	M
V	0.4	0.4	0.8	1	7.6	M
VI	0.4	0.4	0.8	1	7.6	M
VII	0.8	0.8	1.6	1	15.3	M
VIII	0.8	0.8	1.6	1	15.3	M
IX	0.4	0.4	0.8	1	7.6	M



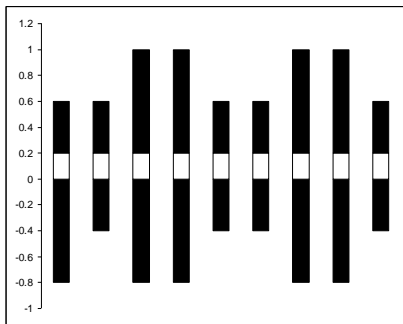
(152)



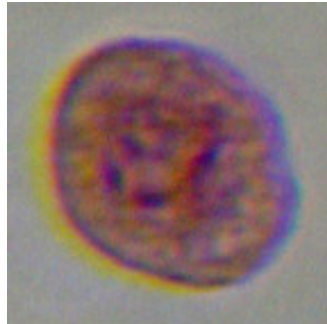
(153)



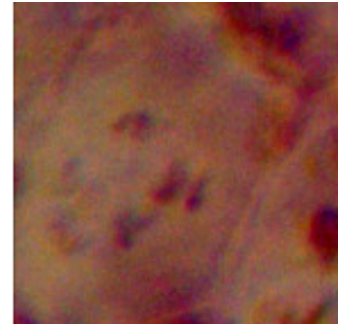
(154)



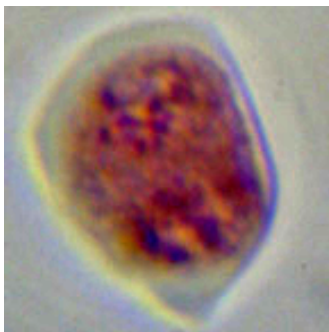
(155)



(156)



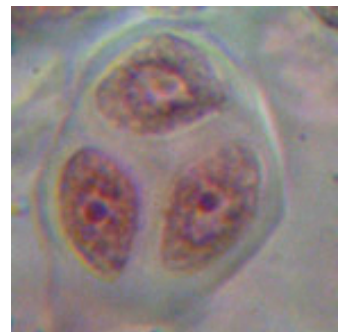
(157)



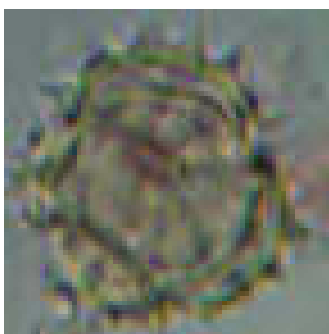
(158)



(159)



(160)



(161)

Figs. 152-161: *Dichrocephala integrifolia* (L. f.) Kuntze (V.N. 119)

Fig. 152. Photograph of living plant. **Fig. 153.** Photomicrograph of mitotic metaphase plate. **Fig. 154.** Camera lucida drawing of the same. **Fig. 155.** Ideogram of above. **Fig. 156, 157** Diakinesis showing 9 bivalents. **Fig. 158 A-I.** **Fig. 159** Dyad. **Fig. 160.** Pollen tetrad (normal). **Fig. 161.** Pollen grain.

Chromosome number determined for this taxon is $2n=18$. The somatic chromosome number determined from the root tip cell is shown in Fig. 154 and camera lucida drawing in Fig.155. Its ideogram is represented in Fig. 157. The chromosome measurements are given in Table 25.

Mitotic metaphase chromosomes are of two types. viz. centromeres are median points and sub-median regions. The chromosomes length ranged from 0.8 to 1.2 μm with mean length 1.2 μm and absolute length 11.8 μm . TF % is 46. Karyotype formula is $M_{16}+sm_2$.

Meiosis is normal. Diakinesis with nine bivalents (Fig.157, 158), telophase I, (Fig.160), dyad (Fig.161), normal tetrads (Fig.162) and triporate, circular pollens are observed (Fig.163). Pollen stainability is 79.1 percent.

4.1.25 *Eclipta prostrata* (Linn.) Linn. ($2n=22$, V.N. 120)

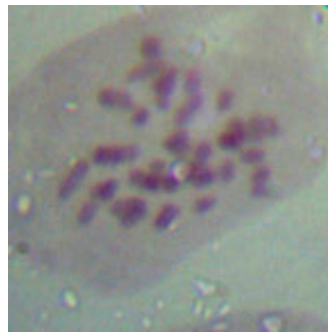
Locality: Janakpurdham (C. Nepal), 700 msl

The plant is a procumbent perennial herb, diffuse or erect, strigose pubescent or hirsute. Leaves opposite, sessile or shortly petiolate, lanceolate-linear, entire or remotely toothed. Capitula radiate, small, few-flowered, pedunculate, solitary or in pairs in upper leaf axils. Involucres campanulate or hemispherical. Receptacle flat or convex. Ray florets female or sterile, corolla white, tube somewhat compressed, much shorter than lamina, glabrous, lamina oblong-elliptic, truncate, entire or 2- or 3-toothed, ciliate above, glandular-pilose on back of base. Style shortly bifid. Cypsela oblong, 3-angled. Pappus a ring of delicate hairs. Disc florets bisexual, corolla white, tubular below, campanulate above, shortly 4- or 5-lobed. Anthers linear, obtuse at base with ovate to round apical appendage. Style oblong, apex deltoid, papillose outside. Cypsela oblong, compressed. Pappus a ring of fine minute hairs or 0.

Chromosome number determined for this taxon is $2n=22$. The somatic chromosome number determined from the root tip cell is shown in Fig. 164 and camera lucida drawing in Fig. 165. Its ideogram is represented in Fig. 166. The chromosome measurements are given in Table 26.



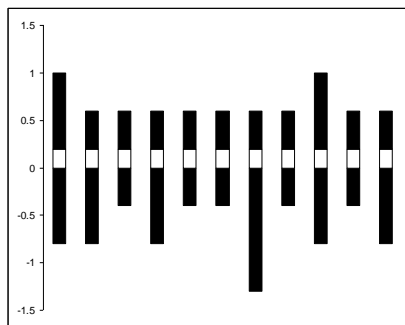
(162)



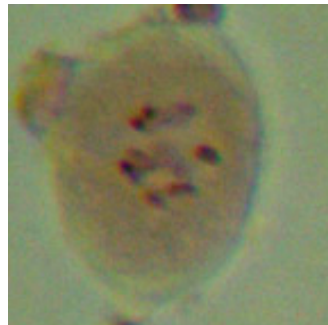
(163)



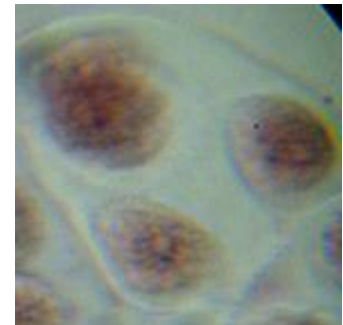
(164)



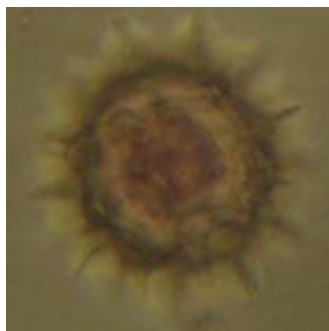
(165)



(166)



(167)



(168)

Figs. 162-168: *Eclipta prostrata* (Linn.) Linn. (V.N. 120)

Fig. 162. Photograph of living plant. **Fig. 163.** Photomicrograph of mitotic metaphase plate. **Fig. 164.** Camera lucida drawing of the same. **Fig. 165.** Ideogram of above. **Fig. 166.** Diakinesis showing 11 bivalents. **Fig. 167.** Pollen tetrad (normal). **Fig. 168** Pollen grain.

Three types of somatic chromosomes are observed. Centromeres are at median points, sub-median regions and sub-terminal regions. The chromosome length ranged from 0.8 to 1.6 μm with mean length 1.2 μm and absolute length 13.3 μm . TF% is 46. Karyotype formula is $M_{14}+sm_6+st_2$. Pollen stainability is 73.3%.

Meiosis is normal. Diakinesis with eleven bivalents (Fig. 167), normal tetrads (Fig. 168) and spheroidal, echinate pollens (Fig. 169) are observed. Pollen stainability is 85.1 percent.

Table 26: Chromosome measurement in *Eclipta prostrata* (Linn.) Linn. (V.N. 120)

Chrom. Pairs	Long Arm (µm)	Short Arm (µm)	Total Length (µm)	r-value	Relative Length (µm)	Position of Centromere
I	0.8	0.8	1.6	1	12.8	M
II	0.8	0.4	1.2	2	9.6	Sm
III	0.4	0.4	0.8	1	6.4	M
IV	0.8	0.4	1.2	2	9.6	Sm
V	0.4	0.4	0.8	1	6.4	M
VI	0.4	0.4	0.8	1	6.4	M
VII	1.3	0.4	1.7	3.2	12.9	St
VIII	0.4	0.4	0.8	1	6.4	M
IX	0.8	0.8	1.6	1	12.8	M
X	0.4	0.4	0.8	1	6.4	M
XI	0.8	0.4	1.2	2	9.6	Sm

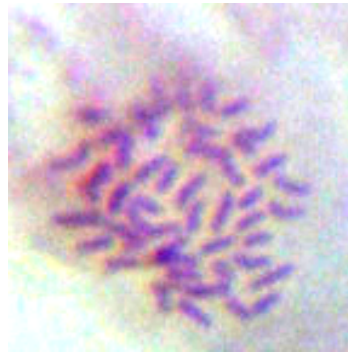
4.1.26 *Eupatorium adenophorum* Spreng. (2n=50, V.N. 106)

Locality: Godawari (C. Nepal), 1515 msl

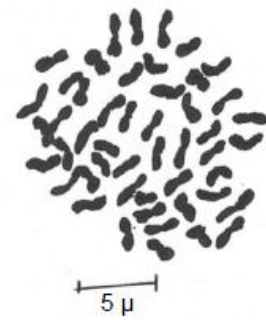
The plant is perennial, decumbent herb up to 1m tall. Leaves 2-8x5.5cm, rhomboid-ovate, coarsely serrate, acute, glandular on nerves beneath. Heads terminal, corymbose. Florets white. Achenes 5-angled, black. Pappus hairs dirty white. Flowering and fruiting period March to October.



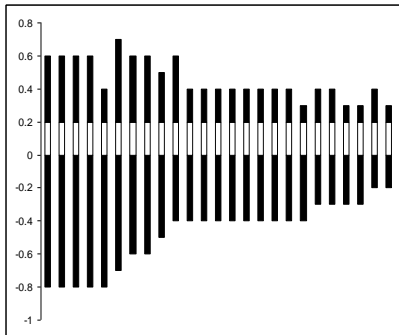
(169)



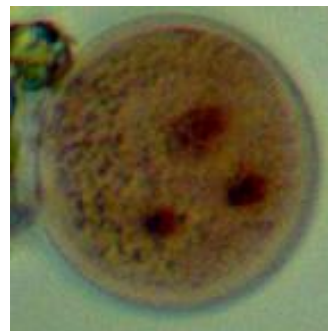
(170)



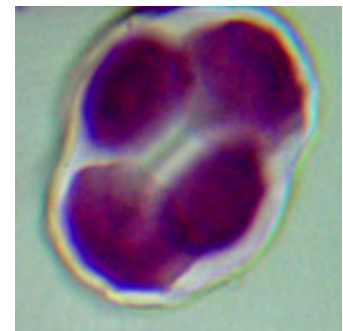
(171)



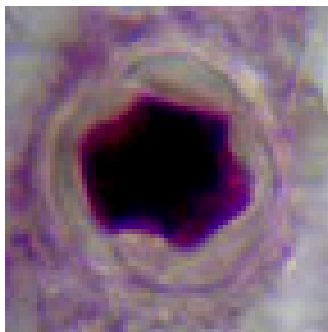
(172)



(173)



(174)



(175)

Figs. 169-175: *Eupatorium adenophorum* Spreng. (V.N. 106)

Fig. 169. Photograph of living plant. **Fig. 170.** Photomicrograph of somatic metaphase plate. **Fig. 171.** Camera lucida drawing of the same. **Fig. 172.** Ideogram of the above. **Fig. 173.** T-II with non-synchronized division. **Fig. 174.** Pollen tetrad. **Fig. 175.** Pollen grain.

Chromosome number determined for this taxon is $2n=50$. The somatic chromosome number determined from the root tip cell is shown in Fig. 171 and camera lucida drawing in Fig. 172. Its ideogram is represented in Fig. 173. The chromosome measurements are given in Table 27.

The karyotype consists of four types of chromosomes with centromere at median point, median region, sub-median region and sub-terminal region. The chromosome length ranged from 0.3 to 1.2 μm with mean length 0.7 μm and absolute length 18.4 μm . TF % is 34.7. Karyotype formula is $M_4+m_{12}+sm_{26}+st_8$.

Table 27: Chromosome measurement in *Eupatorium adenophorum* Spreng. (V.N. 106)

Chrom. Pairs	Long Arm (μm)	Short Arm (μm)	Total Length (μm)	r- value	Relative Length (μm)	Position of Centromere
I	0.8	0.4	1.2	2	6.5	sm
II	0.8	0.4	1.2	2	6.5	sm
III	0.8	0.4	1.2	2	6.5	sm
IV	0.8	0.4	1.2	2	6.5	sm
V	0.8	0.2	1.2	4	5.4	st
VI	0.7	0.5	1.2	1.4	6.5	m
VII	0.6	0.4	1	1.5	4.3	m
VIII	0.6	0.4	1	1.5	5.4	m
IX	0.5	0.3	0.8	1.6	4.3	m
X	0.4	0.4	0.8	1	4.3	M
XI	0.4	0.2	0.7	2	3.2	sm
XII	0.4	0.2	0.6	2	3.2	sm
XIII	0.4	0.2	0.6	2	3.2	sm
XIV	0.4	0.2	0.7	2	3.2	sm
XV	0.4	0.2	0.6	2	3.2	sm
XVI	0.4	0.2	0.6	2	3.2	sm
XVII	0.4	0.2	0.6	2	3.2	sm
XVIII	0.4	0.2	0.6	2	3.2	sm
XIX	0.4	0.1	0.5	4	2.7	st
XX	0.3	0.2	0.5	1.5	2.7	m
XXI	0.3	0.2	0.5	1.5	2.7	m
XXII	0.3	0.1	0.5	3	2.1	st
XXIII	0.3	0.1	0.4	3	2.1	st
XXIV	0.2	0.2	0.4	1	2.1	M
XXV	0.2	0.1	0.3	2	1.6	sm

Meiosis is irregular. Telophase-II with non-synchronized division (Fig. 174.), pollen tetrad normal (Fig. 175) and tricolpate and triporate pollens (Fig. 176) are observed. Pollen stainability is 95.2 percent.

4.1.27 *Erigeron annuus* L. (2n=16, V.N. 144)

Locality: Godawari (C. Nepal), 1515 msl

Perennial herb, prostrate. Leaves alternate, dentate, narrowly elliptic. Capitula radiate, solitary, corymbose or paniculate, pedunculate. Involucres hemispherical or campanulate, bracts in several rows, linear, often hairy. Receptacle flat or slightly convex, epaleate. Ray florets female in 1 row, rarely 2 rows, corolla white, tube cylindrical with short narrow, bifid lamina. Disc florets few, bisexual, fertile, corolla yellow, tube cylindrical, sometimes slightly widened above, 5(4)-lobed. Anthers

ecalcarate and ecaudate, with linear-lanceolate, apical appendage. Style branches narrowly oblong, flattened, tip triangular with short pollen-sweeping hairs outside. Cypsela oblong, compressed, usually margined, glabrous or pubescent. Pappus bristles few or copious, in 2 distinct rows.

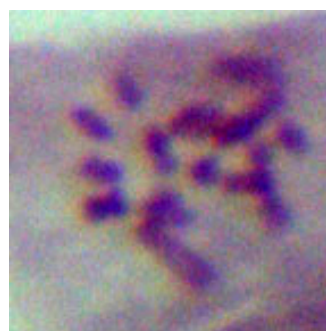
Chromosome number determined for this taxon is $2n=16$. The somatic chromosome number determined from the root tip cell is shown in Fig. 178 and camera lucida drawing in Fig. 179. Its ideogram is represented in Fig. 180. The chromosome measurements are given in Table 28.

The karyotype consists of three different types of chromosomes with centromere at median point, median region and sub-median region. The chromosome length ranged from 0.6 to 1.6 μm with mean length 0.7 μm and absolute length 6.2 μm . TF% 41.9. Karyotype formula is $M_{4+} m_4 + sm_8$.

Meiosis could not be studied in this taxon due to the lack of suitable flower buds. Pollen stainability is 98.2 percent.



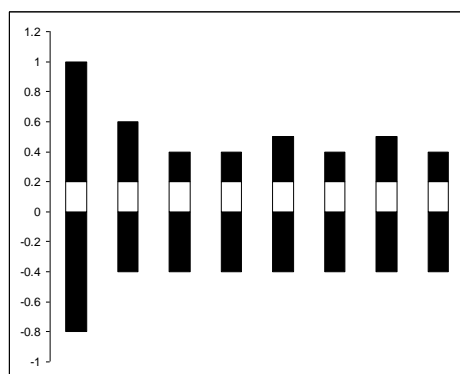
(176)



(177)



(178)



(179)

Figs. 176-179: *Erigeron annuus* L. ($2n=16$, V.N. 144)

Fig. 176. Photograph of living plant. **Fig. 177.** Photomicrograph of somatic metaphase plate. **Fig. 178.** Camera lucida drawing of the same. **Fig. 179.** Ideogram of the above.

Table 28: Chromosome measurement in *Erigeron annuus* L. (V.N. 144)

Chrom. Pairs	Long Arm (µm)	Short Arm (µm)	Total Length (µm)	r- value	Relative Length (µm)	Position of Centromere
I	0.8	0.8	1.6	1	25.8	M
II	0.4	0.4	0.8	1	12.9	M
III	0.4	0.2	0.6	2	9.6	sm
IV	0.4	0.2	0.6	2	9.6	sm
V	0.4	0.3	0.7	1.3	11.2	m
VI	0.4	0.2	0.6	2	9.6	sm
VII	0.4	0.3	0.7	1.3	11.2	m
VIII	0.4	0.2	0.6	2	9.6	sm

4.1.28 *Galinsoga parviflora* Cav. (2n=16, V.N. 122)

Locality: Alok Nagar (C. Nepal), 1190 msl.

The plant is annual herb, glabrous or pilose. Leaves opposite, petiolate, ovate, sometimes faintly crenate on margins. Capitula radiate, pedunculate, in small cymes, terminal or axillary. Involucres broadly campanulate or hemispherical, bracts in 1 or 2 rows, ovate, membranous. Receptacle conical, paleate, paleae flat, membranous. Ray florets female, fertile, branches of ray florets linear-lanceolate, corolla white, strap-shaped. Disc florets bisexual, fertile; corolla yellow, cylindrical, 5-toothed. Anthers oblong, bases faintly sagittate, with sub orbicular apical appendages. Style linear, disc florets linear-lanceolate with small subulate terminal appendage, papillose on outer faces. Cypsela of ray florets obconical or obpyramidal, usually dorsiventrally compressed, enclosed by group of connate involucral bracts and palea. Pappus 0 or of linear or narrowly ovate, fimbriate, laciniate or aristate scales.

Chromosome number determined for this taxon is 2n=16. The somatic chromosome number determined from the root tip cell is shown in Fig. 182 and camera lucida drawing in Fig. 183. Its ideogram is represented in Fig. 184. The chromosome measurements are given in Table 29.



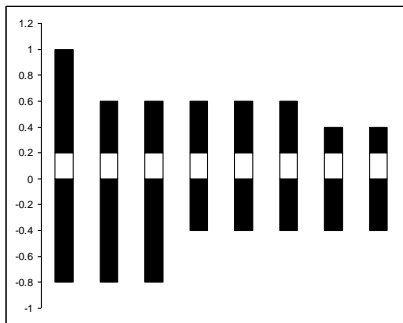
(180)



(181)



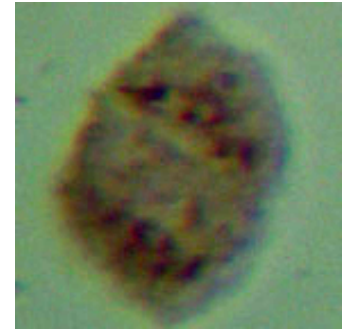
(182)



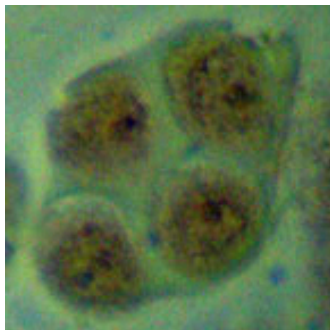
(183)



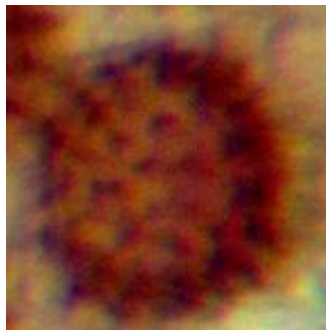
(184)



(185)



(186)



(187)

Figs. 180-187: *Galinsoga parviflora* Cav. (V.N. 122)

Fig. 180. Photograph of living plant. **Fig. 181.** Photomicrograph of somatic metaphase plate. **Fig. 182.** Camera lucida drawing of the same. **Fig. 183.** Ideogram of the above. **Fig. 184.** Diakinesis showing 8 bivalent. **Fig. 185** A-II with sticky chromosomes. **Fig. 186.** Pollen tetrad. **Fig. 187.** Pollen grain.

Two types of chromosomes are observed with centromere at median points and sub-median regions. The chromosome length ranged from 0.6 to 1.7 μm with mean length 1.01 μm and absolute length 8.1 μm . TF% was 42. Karyotype formula is M_8+sm_8 .

Meiosis is regular. Metaphase- I with eight bivalents (Fig. 185.), Anaphase-I with one laggard (Fig. 186), normal pollen tetrads (Fig. 187) and circular, echinate, small pollen are observed. (Fig.188). Pollen stainability is 98.9 percent.

Table 29: Chromosome measurement in *Galinsoga parviflora* Cav. (V.N. 122)

Chrom. Pairs	Long Arm (μm)	Short Arm (μm)	Total Length (μm)	r- value	Relative Length (μm)	Position of Centromere
I	0.8	0.8	1.6	1	21.8	M
II	0.8	0.4	1.2	2	15.8	sm
III	0.8	0.4	1.2	2	15.8	sm
IV	0.4	0.4	0.8	1	10.5	M
V	0.4	0.4	0.8	1	10.5	M
VI	0.4	0.4	0.8	1	10.5	M
VII	0.4	0.2	0.6	2	7.8	sm
VIII	0.4	0.2	0.6	2	7.8	sm

4.1.29 *Gnaphalium affine* D. Don (2n=14, V.N. 123)

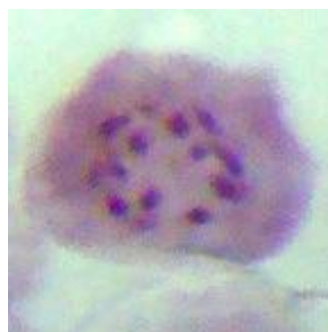
Locality: Lukla (E. Nepal), 2800 msl

The plant is annual, erect herb, 30 cm. tall. Stem wooly, tomentose. Leaves 2-5cm long, lower leaves oblong-spathulate, upper leaves linear lanceolate, wooly tomentose on both surfaces. Heads golden yellow, clustered in dense terminal corymbs. Achenes linear, pappilose. Pappus hairs white. Flowering and fruiting is in February to November.

Chromosome number determined for this taxon is 2n=14. The somatic chromosome number determined from the root tip cell is shown in Fig. 190 and camera lucida drawing in Fig. 191. Its ideogram is represented in Fig. 192. The chromosome measurements are given in Table 30.



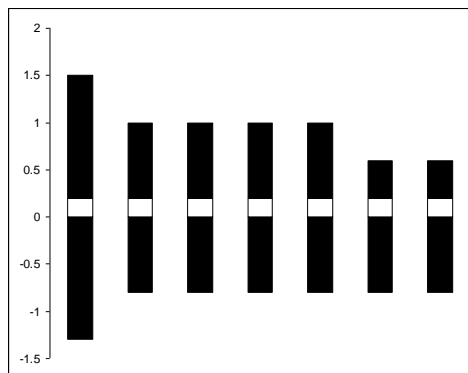
(188)



(189)



(190)



(191)

Figs. 188-191: *Gnaphalium affine* D. Don. (V.N. 123)

Fig. 188. Photograph of living plant. **Fig. 189.** Photomicrograph of somatic metaphase plate. **Fig. 190.** Camera lucida drawing of the same. **Fig. 191.** Ideogram of the above.

Two types of chromosomes are observed, centromere with at median points and submedian regions. The chromosome length ranged from 1.2 to 2.6 μm with mean length 1.7 μm and absolute length 12.06 μm . TF% was 46.4. Karyotype formula is $M_{10}+sm_4$.

Meiosis could not be studied in this taxon due to the lack of suitable flower buds. Pollen stainability is 76.9 percent.

Table 30: Chromosome measurement *Gnaphalium affine* D. Don (V.N. 123)

Chrom. Pairs	Long Arm (μm)	Short Arm (μm)	Total Length (μm)	r- value	Relative Length (μm)	Position of Centromere
I	1.3	1.3	2.6	1	21.5	M
II	0.8	0.8	1.6	1	14.2	M
III	0.8	0.8	1.6	1	14.2	M
IV	0.8	0.8	1.6	1	14.2	M
V	0.8	0.8	1.6	1	14.2	M
VI	0.8	0.4	1.2	2	10.7	sm
VII	0.8	0.4	1.2	2	10.7	sm

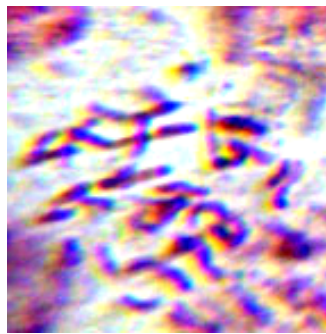
4.1.30 *Gnaphalium purpureum* L. (2n=28, V.N. 133)

Locality: Thimi (C. Nepal), 1250 msl

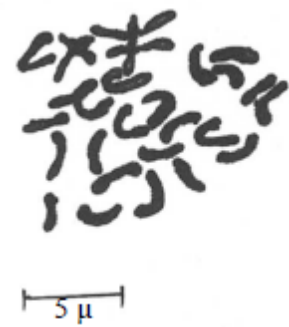
The plant is annual, erect, herb, 50 cm tall. Stem thin with white cottony tomentum. Leaves 2-8cm long, obovate- spathulate, apiculate, glabrate above, white wooly beneath, narrowed at base, broadly rounded and shortly mucronate at apex, entire. Heads in short spicate clusters 2 mm across. Involucral bracts, 3-4 seriate, outermost brown, occasionally pink at apex, oblong spathulate, obtuse- acute, with white wooly tomentum at base. Ray florets female with filiform corolla at mouth. Disc florets bisexual. Achenes oblong, smooth. Pappus hairs white, united at base.



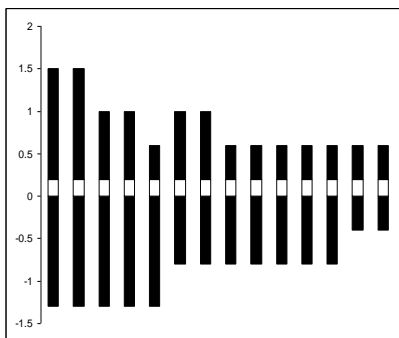
(192)



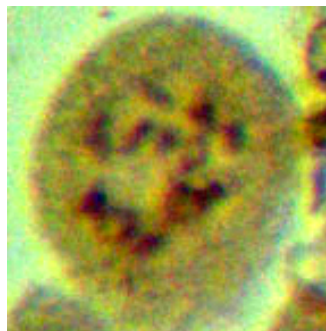
(193)



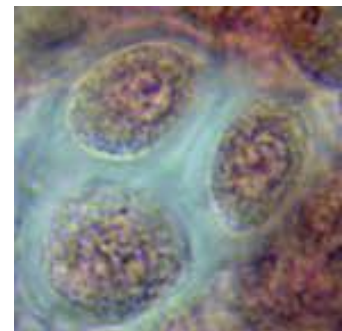
(194)



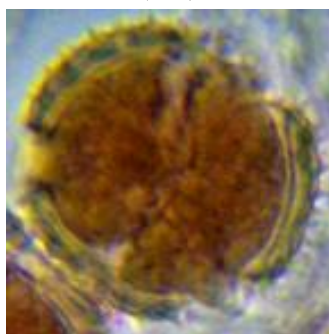
(195)



(196)



(197)



(198)

Figs. 192-198: *Gnaphalium purpureum* D. Don (V.N. 133)

Fig. 192. Photograph herbarium specimen. **Fig. 193.** Photomicrograph of somatic metaphase plate. **Fig. 194.** Camera lucida drawing of the same. **Fig. 195.** Ideogram of the above. **Fig. 196.** Diakinesis with 14 bivalents. **Fig. 197.** Pollen tetrads. **Fig. 198.** Pollen grain.

Chromosome number determined here for this taxon is $2n=28$. The somatic chromosome number determined from the root tip cell is shown in Fig. 194 and camera lucida drawing in Fig. 195. Its ideogram is represented in Fig. 196. The chromosome measurements are given in Table 31.

The karyotype consists of four different types of chromosomes with centromere at median point, median region, sub-median region and sub-terminal region. The chromosomes length ranged from 0.8 to 2.6 μm with mean length 1.6 μm . and absolute length 19.9 μm . TF % is 40.7. Karyotype formula is $M_{12+} m_{4+} sm_{10+} st_2$.

Meiosis is regular. Diakinesis with fourteen bivalents (Fig. 197), normal tetrads (Fig. 198) and triporate pollens (Fig. 199) are observed. Pollen stainability is 94.5 percent.

Table 31: Chromosome measurement in *Gnaphalium purpureum* L. (V.N. 133)

Chrom. Pairs	Long Arm (μm)	Short Arm (μm)	Total Length (μm)	r-value	Relative Length (μm)	Position of Centromere
I	1.3	1.3	2.6	1	11.8	M
II	1.3	1.3	2.6	1	11.8	M
III	1.3	0.8	2.1	1.6	9.5	m
IV	1.3	0.8	2.1	1.6	9.5	m
V	1.3	0.4	1.7	3.2	7.7	st
VI	0.8	0.8	1.6	1	7.3	M
VII	0.8	0.8	1.6	1	7.3	M
VIII	0.8	0.4	1.2	2	9.3	sm
IX	0.8	0.4	1.2	2	9.3	sm
X	0.8	0.4	1.2	2	9.3	sm
XI	0.8	0.4	1.2	2	9.3	sm
XII	0.8	0.4	1.2	2	9.3	sm
XIII	0.4	0.4	0.8	1	3.8	M
XIV	0.4	0.4	0.8	1	3.8	M

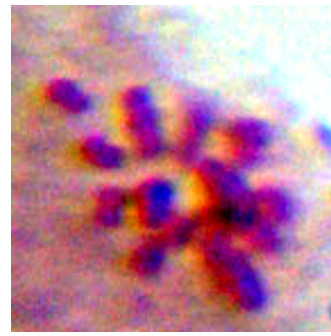
4.1.31 *Ixeris Polycephala* Cass. ($2n=16$, V.N. 134)

Locality: Godawari (C. Nepal), 1520 msl

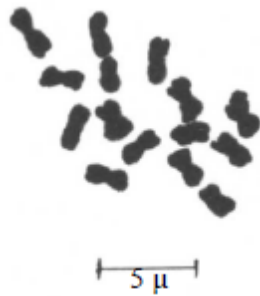
The plant is annual herb, flaccid, 30cm tall. Stem, erect, glabrous. Leaves 5-0.4-0.6 cm, radical and cauline, linear or linear- lanceolate, acuminate, entire or sometimes slightly toothed. Heads few, small, erect in terminal corymbs. Ray florets pale yellow. Achenes brown yellow, ribbed. Pappus hairs yellowish white. Flowering and fruiting February to April.



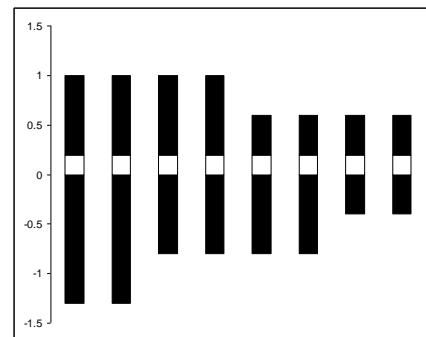
(199)



(200)



(201)



(202)

Figs. 199-202: *Ixeris polycephala* Cass. (V.N. 134)

Fig. 199. Photograph of living plant. **Fig. 200.** Photomicrograph of somatic metaphase plate. **Fig. 201.** Camera lucida drawing of the same. **Fig. 202.** Ideogram of the above.

Chromosome number determined for this taxon is $2n=16$. The somatic chromosome number determined from the root tip cell is shown in Fig. 201 and camera lucida drawing in Fig. 202. Its ideogram is represented in Fig. 203. The chromosome measurements are given in Table 32.

The karyotype consists of three types of chromosomes with centromere at median point, median region and sub-median. The chromosome length ranged from 0.8 to $2.1\mu\text{m}$ with mean length $1.4\mu\text{m}$. and absolute length $11.4\mu\text{m}$. TF% 42.1. Karyotype formula is $M_8+m_4+sm_4$. Pollen stainability is 84.5 percent.

Table 32: Chromosome measurement in *Ixeris polycephala* Cass. (V.N. 134)

Chrom. Pairs	Long Arm (µm)	Short Arm (µm)	Total Length (µm)	r-value	Relative Length (µm)	Position of Centromere
I	1.3	0.8	2.1	1.6	5.8	m
II	1.3	0.8	2.1	1.6	5.8	m
III	0.8	0.8	1.6	1	5.8	M
IV	0.8	0.8	1.6	1	3.8	M
V	0.8	0.4	1.2	2	5.8	sm
VI	0.8	0.4	1.2	2	7.7	sm
VII	0.4	0.4	0.8	1	2.9	M
VIII	0.4	0.4	0.8	1	2.9	M

4.1.32 *Parthenium hysterophorus* L. (2n=34, V.N. 124)

Locality: Kirtipur (C. Nepal), 1330 msl

The plant is an annual herb. Stem simple below, branching above into large open panicle. Leaves alternate, sessile, simple, elliptic or ovate in outline, deeply bipinnatisect, margins entire. Capitula radiate, small in terminal panicles. Involucres campanulate or hemispherical, bracts in 2 or 3 rows, imbricate, outer somewhat smaller than inner. Receptacle convex, paleate. Ray florets female, fertile. Style bifid, branches linear-lanceolate, obtuse. Cypsela compressed, keeled, crowned with persistent corolla, surrounded by inner involucral bract and 2 lateral, concave, receptacular paleae, pappus of 2 recurved awns, forming apparent margin to cypselas, but free from them, hidden by the 2 receptacular paleae to which they are attached at base. Disc florets bisexual, functionally male, small, corolla white, funnel-shaped, 5-toothed. Anthers with apical appendage, obtuse at base. Style undivided. Ovary of disc florets abortive.

Chromosome number determined for this taxon is 2n=34. The somatic chromosome number determined from the root tip cell is shown in Fig. 205 and camera lucida drawing in Fig. 206. Its ideogram is represented in Fig. 207. The chromosome measurements are given in Table 33.

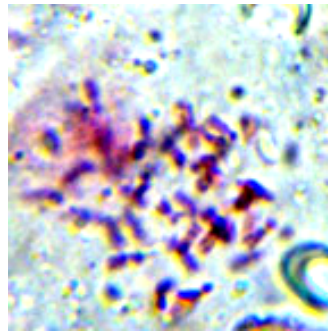
Somatic chromosomes are of three types centromere at median points sub-median regions and sub-terminal regions. The chromosome length ranged from 0.4 to 1.6 µm with mean length 0.9 µm and absolute length 16.9 µm. TF% is 43. Karyotype formula is $M_{22}+sm_{10}+st_2$.

Meiosis is irregular. Metaphase-I in groups formed multivalents (Fig. 208), early anaphase having repulsive nature and with spindle fibre (Fig. 209), early anaphase I (Fig. 210), late anaphase I (Fig. 211), early telophase I (Fig. 212), late telophase (Fig.

213) normal tetrads (Fig. 214) and hexaporate circular pollens (Fig. 215) are observed. Pollen stainability is 97.1 percent.



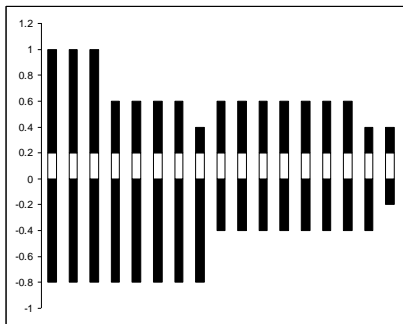
(203)



(204)



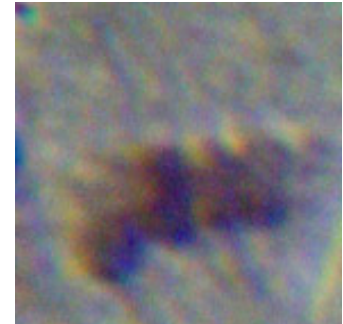
(205)



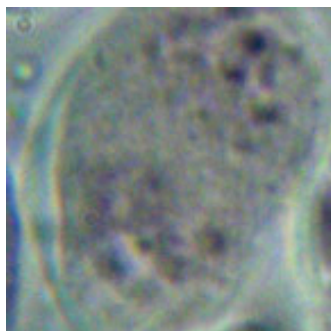
(206)



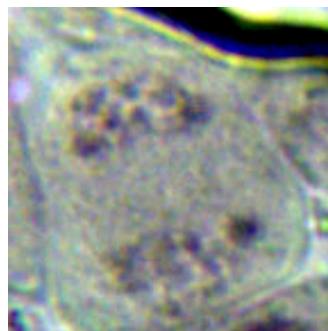
(207)



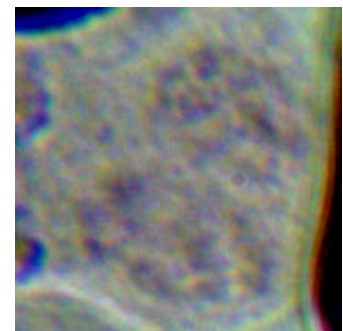
(208)



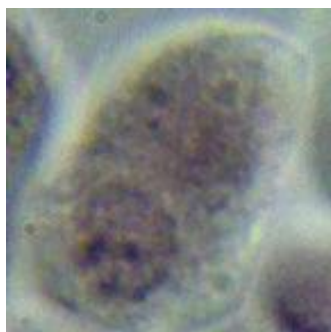
(209)



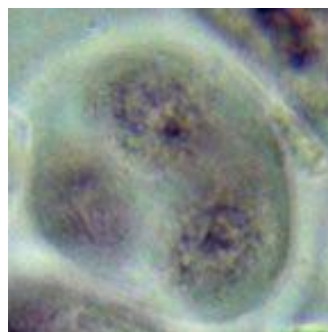
(210)



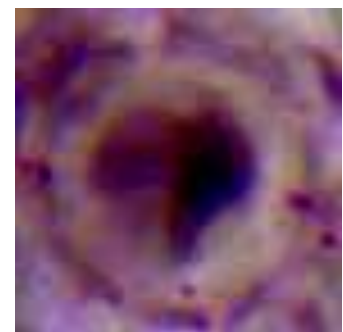
(211)



(212)



(213)



(214)

Figs. 203-214: *Parthenium hysterophorus* L. (V.N. 125)

Fig. 203. Photograph of living plant. **Fig. 204.** Photomicrograph of somatic metaphase plate. **Fig. 205.** Camera lucida drawing of the same. **Fig. 206.** Ideogram of the above. **Fig. 207.** M-I. **Fig. 208.** A-I. **Fig. 209.-210.** A-I. **Fig. 211.** T-I. **Fig. 212.** T-I. **Fig. 213.** Tetrad. **Fig. 214.** Pollen grain.

Table 33: Chromosome measurement in *Parthenium hysterophorus* L. (V.N. 124)

Chrom. Pairs	Long Arm (μm)	Short Arm (μm)	Total Length (μm)	r-value	Relative Length (μm)	Position of Centromere
I	0.8	0.8	1.6	1	3.6	M
II	0.8	0.8	1.6	1	3.6	M
III	0.8	0.8	1.6	1	9.8	M
IV	0.8	0.4	1.2	2	7.4	sm
V	0.8	0.4	1.2	2	7.4	sm
VI	0.8	0.4	1.2	2	7.4	sm
VII	0.8	0.4	1.2	2	7.4	sm
VIII	0.8	0.2	1.0	4	6.1	st
IX	0.4	0.4	0.8	1	4.9	M
X	0.4	0.4	0.8	1	4.9	M
XI	0.4	0.4	0.8	1	4.9	M
XII	0.4	0.4	0.8	1	4.9	M
XIII	0.4	0.4	0.8	1	4.9	M
XIV	0.4	0.4	0.8	1	4.9	M
XV	0.4	0.4	0.8	1	4.9	M
XVI	0.4	0.2	0.6	2	3.6	sm
XVII	0.2	0.2	0.4	1	2.4	M

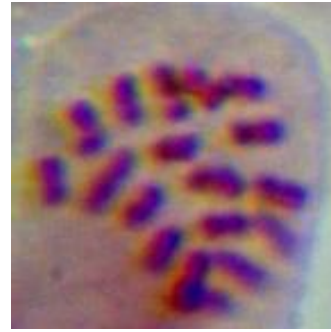
4.1.33 *Rhynchospermum verticillatum* Reinw. (2n=18, V.N. 138)

Locality: Godawari (C. Nepal), 1515 msl

The plant is annual herb 50 cm tall, branched, slender. Leaves 2.5- 10x 0.8-2 cm lanceolate, coarsely toothed, membranous. Heads axillary, shortly stalked, often one in every axil along the branches. Ray florets white, disc florets yellowish green. Flowering and fruiting in August to October. Chromosome number determined here for this taxon is 2n=18. The somatic chromosome number determined from the root tip cell is shown in Fig. 217 and camera lucida drawing.



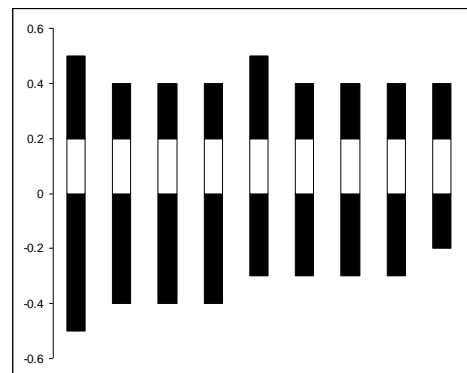
(215)



(216)



(217)



(218)

Figs. 215-218: *Rhynchospermum verticillatum* Reinw (V.N. 138)

Fig. 215. Photograph of living plant. **Fig. 216.** Photomicrograph of somatic metaphase plate. **Fig. 217.** Camera lucida drawing of the same. **Fig. 218.** Ideogram the above.

The karyotype consists of three different ty in Fig 218. Its ideogram is represented in Fig. 219. The chromosome measurements are given in Table 34.

The karyotype consists of three types of chromosomes with centromere at median point, median region and submedian region. The chromosome length ranged from 0.5 to 0.8 μm with mean length 0.5 μm and absolute length 5.1 μm. TF % is 39.2. Karyotype formula is $M_{4+} m_{8+} sm_6$.

Meiosis could not be studied in this taxon due to the lack of suitable flower buds. Pollen stainability is 72.9 percent.

Table 34: Chromosome measurement in *Rhynchospermum verticillatum* Reinw. (V.N. 138)

Chrom. Pairs	Long Arm (μm)	Short Arm (μm)	Total Length (μm)	r- value	Relative Length (μm)	Position of centromere
I	0.5	0.3	0.8	1.6	12.8	m
II	0.4	0.2	0.6	2	9.6	sm
III	0.4	0.2	0.6	2	9.6	sm
IV	0.4	0.2	0.6	2	9.6	sm
V	0.3	0.3	0.6	1	6.4	M
VI	0.3	0.2	0.5	1.5	6.4	m
VII	0.3	0.2	0.5	1.5	6.4	m
VIII	0.3	0.2	0.5	1.5	6.4	m
IX	0.2	0.2	0.4	1	9.6	M

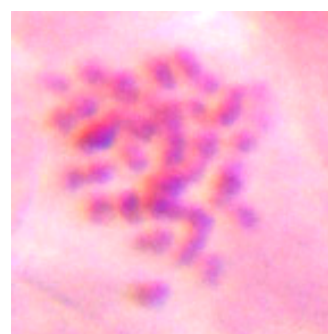
4.1.34 *Senecio laetus* Edgew. (2n=36, V.N. 146)

Locality: Godawari (C. Nepal), 1530 msl

The plant is annual, erect, herb, about 1m tall. Stem corymbosely branched. Leaves radical and cauline, radical leaves lyrate pinnatifid with auricled petiole, cauline leaves pinnatifid with auricled base. Heads bright yellow in terminal corymbs. Achenes pale brown, ribbed. Pappus pale yellow. Flowering and fruiting in March to November.



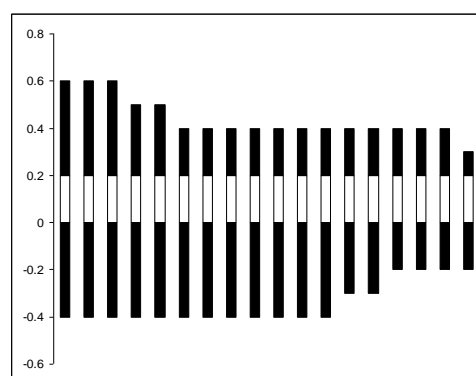
(219)



(220)



(221)



(222)

Figs. 219-222: *Senecio laetus* Edgew. (V.N. 146)

Fig. 219. Photograph of living plant. **Fig. 220.** Photomicrograph of somatic metaphase plate. **Fig. 221.** Camera lucida drawing of the same. **Fig. 222.** Ideogram of the above.

Chromosome number determined for this taxon is $2n=36$. The somatic chromosome number determined from the root tip cell is shown in Fig. 221 and camera lucida drawing in Fig. 222. Its ideogram is represented in Fig. 223. The chromosome measurements are given in Table 35.

Karyotype consists of chromosomes with centromeres at median point, median region and sub-median region. The chromosome length ranged from 0.3 to 0.8 μm with mean length 0.5 μm and absolute length 10.3 μm . TF% 41.7. Karyotype formula is $M_{12+} m_8+sm_{16}$. Pollen stainability is 76.9 percent.

Table 35: Chromosome measurement in *Senecio laetus* Edgew. (V.N. 146)

Chrom. Pairs	Long Arm (μm)	Short Arm (μm)	Total Length (μm)	r- value	Relative Length (μm)	Position of Centromere
I	0.4	0.4	0.8	1	5.8	M
II	0.4	0.4	0.8	1	5.8	M
III	0.4	0.4	0.8	1	5.8	M
IV	0.4	0.3	0.7	1.3	6.7	m
V	0.4	0.3	0.7	1.3	6.7	m
VI	0.4	0.2	0.6	2	5.8	sm
VII	0.4	0.2	0.6	2	5.8	sm
VIII	0.4	0.2	0.6	2	5.8	sm
IX	0.4	0.2	0.6	2	5.8	sm
X	0.4	0.2	0.6	2	5.8	sm
XI	0.4	0.2	0.6	2	5.8	sm
XII	0.4	0.2	0.6	2	5.8	sm
XIII	0.3	0.2	0.5	1.5	4.8	m
XIV	0.3	0.2	0.5	1.5	4.8	m
XV	0.2	0.2	0.4	1	3.8	M
XVI	0.2	0.2	0.4	1	3.8	M
XVII	0.2	0.2	0.4	1	3.8	M
XVIII	0.2	0.1	0.3	2	2.9	sm

4.1.35 *Sonchus asper* (L.) Hill (2n=18, V.N. 107)

Locality: Kirttipur (C. Nepal), 1330 msl

The plant is annual, erect. Root stalky, vertical. Stem straight, branchy, glabrous below, 70-80 cm in height. Leaves integral or emarginate-incised, with sharp incisions and prickly marginal denticles, elongate-ovoid, rigid, pointed, less often blunt, radical and lower leaves are narrowed toward winged petiole; middle and upper leaves sessile, with wide amplexicaul base. The lower leaves (together with petiole) 9-17 cm in length, larger than middle (6-7 cm in length) and upper ones (1.5-3 cm in length). Inflorescences are calathidia, aggregated at the end of stalk and branches in small umbrella-shaped corymbs. Flower stalks and involucre are covered with dark glandular hairs, sometimes the hairs are absent at the upper parts of flower stalk. All flowers in calathidia are bisexual, ligular, yellow. Hemicarps are bright-brown, elongate-obovoid, 2.5-3 mm in length, 0.75-1 mm in width, flattened, with three longitudinal ribs on each side, hairs simple, white, pappus caducous.

Chromosome number determined for this taxon is $2n=18$. The somatic chromosome number determined from the root tip cell is shown in Fig. 225 and camera lucida drawing in Fig. 226. Its ideogram is represented in Fig. 227. The chromosome measurements are given in Table 35.

The karyotype consists of two different types of chromosomes with centromere at median point and sub-median regions. The chromosome length ranged from 0.6 to 1.6 μm with mean length 1.0 μm and absolute length 9.4 μm . TF % is 40. Karyotype formula is $M_8 + sm_{10}$.

Meiosis is normal in these taxa. Ring bivalents in two rows observed at Metaphase-I (Fig. 228), diakinesis with nine bivalent (Fig. 229), Anaphase-I with non-oriented chromosome (Fig. 230), normal tetrads (Fig. 231), hexagonal pollens (Fig. 232) are observed. Pollen stainability is 96.9 percent.



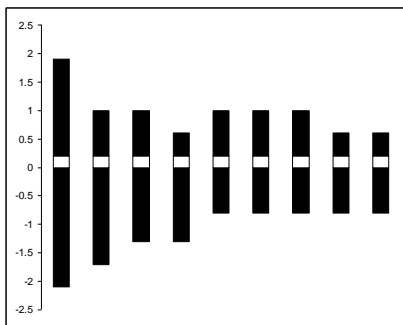
(223)



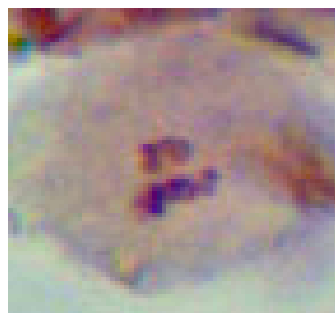
(224)



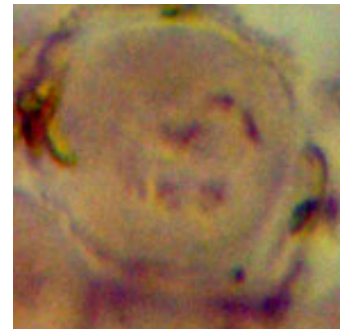
(225)



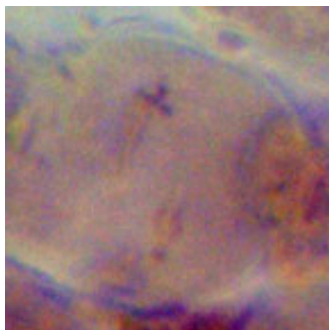
(226)



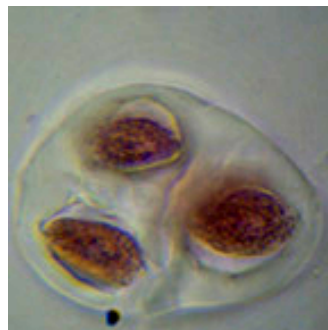
(227)



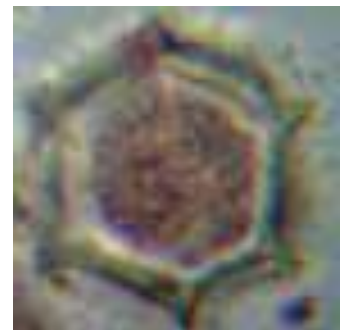
(228)



(229)



(230)



(231)

Figs. 223-231: *Sonchus asper* (L.) Hill (V.N. 107)

Fig. 223. Photograph of living plant. **Fig. 224.** Photomicrograph of somatic metaphase plate. **Fig. 225.** Camera lucida drawing of the same. **Fig. 226.** Ideogram of the above. **Fig. 227.** M-I. **Fig. 228.** Daikinesis showing 9 bivalents. **Fig. 229.** A-I **Fig. 230.** Pollen tetrads. **Fig. 231.** Pollen grain.

Table 36: Chromosome measurement in *Sonchus asper* (L.) Hill (V.N. 107)

Chrom. Pairs	Long Arm (μm)	Short Arm (μm)	Total Length (μm)	r-value	Relative Length (μm)	Position of Centromere
I	0.8	0.8	1.6	1	17.0	M
II	0.4	0.4	0.8	1	9.0	M
III	0.8	0.4	1.2	2	13.0	sm
IV	0.4	0.2	0.6	2	6.0	sm
V	0.8	0.4	1.2	2	13.0	sm
VI	0.4	0.4	0.8	1	9.0	M
VII	0.8	0.4	1.2	2	13.0	sm
VIII	0.4	0.4	0.8	1	9.0	M
IX	0.8	0.4	1.2	2	13.0	sm

4.1.36 *Sonchus arvensis* L. (2n=18, V.N. 139)

Locality: Baneshwor (C. Nepal), 1280 msl

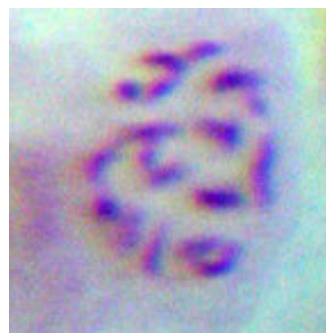
The plant is perennial, erect, herbaceous 1.2 m tall, glabrous, hollow with milky sap. Leaves alternate, sessile, clasping, glabrous, dentate. Leaves 1.5-30 cm long and shining above. Lower leaves lyrate pinnatifid, middle and upper leaves, oblong linear and with spine, dentate margins. The Flower heads few 2.5-5 cm across, terminating branches of inflorescence. Peduncles glabrous. Flowers bright yellow. Involucral bracts clothed with long hairs tipped with greenish yellow bracts. Ray floret yellow disc floret absent. Achenes scarcely compressed, longitudinally ribbed.

Chromosome number determined for this taxon is $2n=18$. The somatic chromosome number determined from the root tip cell is shown in Fig. 234 and camera lucida drawing in Fig. 235. Its ideogram is represented in Fig. 236. The chromosome measurements are given in Table 36.

Two types of chromosomes have observed with centromere at median points and sub-median regions. The chromosome length ranged from 0.8 to 1.6 μm with mean length 1.1 μm and absolute length 10 μm . TF% is 44. Karyotype formula is $M_{12}+sm_6$. Pollen stainability is 91.2 percent.



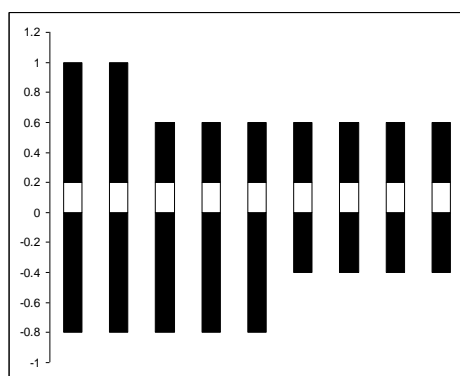
(232)



(233)



(234)



(235)

Figs. 232-235: *Sonchus arvensis* L. (V.N. 139)

Fig. 232. Photograph of living plant. **Fig. 233.** Photomicrograph of somatic metaphase plate. **Fig. 234.** Camera lucida drawing of the same. **Fig. 235.** Ideogram of the above.

Table 37: Chromosome measurement in *Sonchus arvensis* L. (V.N. 139)

Chrom. Pairs	Long Arm (μm)	Short Arm (μm)	Total Length (μm)	r-value	Relative Length (μm)	Position of Centromere
I	0.8	0.8	1.6	1	16	M
II	0.8	0.8	1.6	1	16	M
III	0.8	0.4	1.2	2	12	sm
IV	0.8	0.4	1.2	2	12	sm
V	0.8	0.4	1.2	2	12	sm
VI	0.4	0.4	0.8	1	8	M
VII	0.4	0.4	0.8	1	8	M
VIII	0.4	0.4	0.8	1	8	M
IX	0.4	0.4	0.8	1	8	M

4.1.37 *Spilanthes calva* DC. (2n=36, V.N. 108)

Locality: Godawari (C. Nepal), 1530 msl

The plant is annual, rarely perennial herbs, often prostrate and rooting at nodes, found often in damp places. Leaves opposite, simple, ovate to linear, entire or sinuate, glabrous. Capitula radiate, many-flowered, usually on long peduncles, terminal or axillary. Involucre campanulate, bracts in 2 or 3 rows, outer membranous, shorter than receptacle. Receptacle convex, sometimes elongated, paleate, paleae boat-shaped, enclosing florets. Ray florets female, fertile, corolla yellow or white, strap-shaped, tube hairy, with elliptic, usually 2-lobed lamina somewhat longer than tube. Disc florets bisexual, fertile; corolla yellow, tubular below, expanded above, 4- or 5-toothed. Anthers with small, obtuse apical appendage, base obtuse or minutely sagittate. Style branches of ray florets linear, of disc florets oblong, truncate, minutely penicillate. Cypsela elliptic or obovate, 3- or 4-angled, compressed, margins hyaline or ciliate. Pappus 0 or of 2 or 3 bristles.

Table 38: Chromosome measurement in *Spilanthes calva* DC. (V.N. 108)

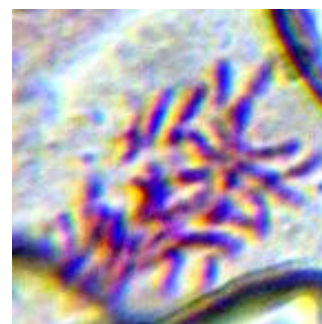
Chrom. Pairs	Long Arm (µm)	Short Arm (µm)	Total Length (µm)	r- value	Relative Length (µm)	Position of Centromere
I	1.3	0.8	2.1	1.6	12.1	m
II	0.8	0.8	1.6	1	9.4	M
III	0.8	0.4	1.2	2	7.1	sm
IV	0.8	0.4	1.2	2	7.1	sm
V	0.8	0.4	1.2	2	7.1	sm
VI	0.8	0.4	1.2	2	7.1	sm
VII	0.8	0.4	1.2	2	7.1	sm
VIII	0.8	0.2	1	4	5.9	st
IX	0.4	0.4	0.8	1	4.7	M
X	0.4	0.4	0.8	1	4.7	M
XI	0.4	0.4	0.8	1	4.7	M
XII	0.4	0.4	0.8	1	4.7	M
XIII	0.4	0.2	0.6	2	3.5	sm
XIV	0.4	0.2	0.6	2	3.5	sm
XV	0.4	0.2	0.6	2	3.5	sm
XVI	0.2	0.2	0.4	1	2.3	M
XVII	0.2	0.2	0.4	1	2.3	M
XVII	0.2	0.2	0.4	1	2.3	M

Chromosome number determined for this taxon is $2n=36$. The somatic chromosome number determined from the root tip cell is shown in Fig. 238 and camera lucida drawing in Fig. 239. Its ideogram is represented in Fig. 240. The chromosome measurements are given in Table 37.

The karyotype consists of 4 different types of chromosomes with centromere at median point, median, sub median and sub terminal regions. The chromosome length ranged from 0.4 to 2.1 μm with mean length 0.9 μm . and absolute length 16.9 μm . TF % was 39.0. Karyotype formula is $M_{16}+m_2+sm_{16}+st_2$. Pollen stainability is 81.2 percent.



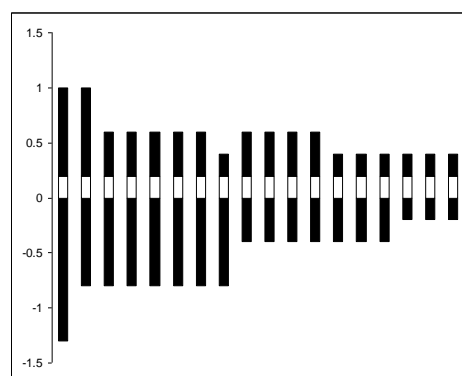
(236)



(237)



(238)



(239)

Figs. 236-239: *Spilanthes calva* DC. (V.N. 108)

Fig. 236. Photograph of living plant. **Fig. 237.** Photomicrograph of somatic metaphase plate. **Fig. 238.** Camera lucida drawing of the same. **Fig. 239.** Ideogram of the above.

4.1.38 *Spilanthes acmella* (L.) Murray (2n=36, V.N. 125)

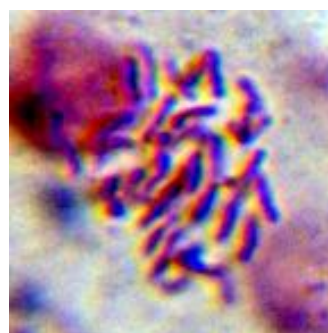
Locality: Lalitpur (C.Nepal), 1280 msl

The plant annual ascending herb, 10 cm tall, is branching more or less, hairy. Leaves triangulate, opposite, 2.5-by1.3-3.8 cm, ovae, acute or sub optuse, irregular crenate-serrate or sometimes entire, glabrous, base usually acute, petioles 0.6-1.6 cm long, pubescent. Heads 0.6-1.3 cm long, ovoid, solitary. Involucral bracts oblong-lanceolate, subacute, pubescent, less than half as long as the head of flowers. Ray -flowers and ligules very often absent, the latter when present minute. Pappus 0. Achenes oblong.

Chromosome number determined for this taxon is $2n=36$. The somatic chromosome number determined from the root tip cell is shown in Fig. 242 and camera lucida drawing in Fig. 243. Its ideogram is represented in Fig. 244. The chromosome measurements are given in Table 38.



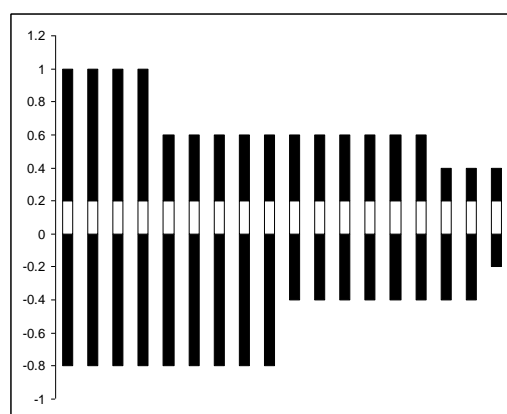
(240)



(241)



(242)



(243)

Figs. 240-243: *Spilanthes acmella* (L.) Murray (V.N. 140)

Fig. 240. Photograph of living plant. **Fig. 241.** Photomicrograph of somatic metaphase plate. **Fig. 242.** Camera lucida drawing of the same. **Fig. 243.** Ideogram of the above.

Somatic chromosomes are of two types with centromere at median point and sub-median region. The chromosomes length ranged from 0.6 to 1.6 μm with mean length 1.1 μm and absolute length 20.1 μm . TF% was 43.5 Karyotype formula is $M_{22} + sm_{14}$.

Meiosis could not be studied in this taxon due to the lack of suitable flower buds. Pollen stainability is 81.3 percent.

Table 39: Chromosome measurement in *Spilanthes acmella* (L.) Murray (V.N. 125)

Chrom. Pairs	Long Arm (μm)	Short Arm (μm)	Total Length (μm)	r -value	Relative Length (μm)	Position of Centromere
I	0.8	0.8	1.6	1	8.5	M
II	0.8	0.8	1.6	1	8.5	M
III	0.8	0.8	1.6	1	8.5	M
IV	0.8	0.8	1.6	1	8.5	M
V	0.8	0.4	1.2	2	6.3	sm
VI	0.8	0.4	1.2	2	6.3	sm
VII	0.8	0.4	1.2	2	6.3	sm
VIII	0.8	0.4	1.2	2	6.3	sm
IX	0.8	0.4	1.2	2	6.3	sm
X	0.4	0.4	0.8	1	4.2	M
XI	0.4	0.4	0.8	1	4.2	M
XII	0.4	0.4	0.8	1	4.2	M
XIII	0.4	0.4	0.8	1	4.2	M
XIV	0.4	0.4	0.8	1	4.2	M
XV	0.4	0.4	0.8	1	4.2	M
XVI	0.4	0.2	0.4	2	0.4	sm
XVII	0.4	0.2	0.4	2	0.4	sm
XVIII	0.2	0.2	0.4	1	2.0	M

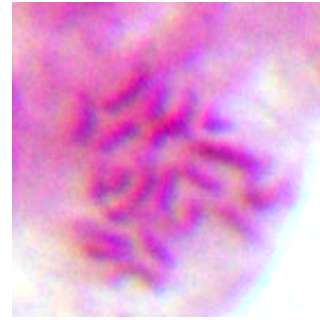
4.1.39 *Stevia rebaudiana* (Bertoni) Bertoni (2n=22, V. N. 131)

Locality: Kuleshwor (C. Nepal), 1285 msl

The plant is erect, perennial, herb about 2ft tall. Stem woody. Leaf simple, opposite, margins slightly serrate, acute apex. It possesses an extensive root system and brittle stems producing small, elliptic leaves. The leaves are sessile, oppositely arranged lanceolate to oblanceolate in shape and serrated above the middle. The tiny white florets are perfect, borne in small corymbs of 2–6 florets. Corymbs are arranged in loose panicles. Achenes, slender about 3 mm in length, each achene have about 20 persistent pappus bristles.



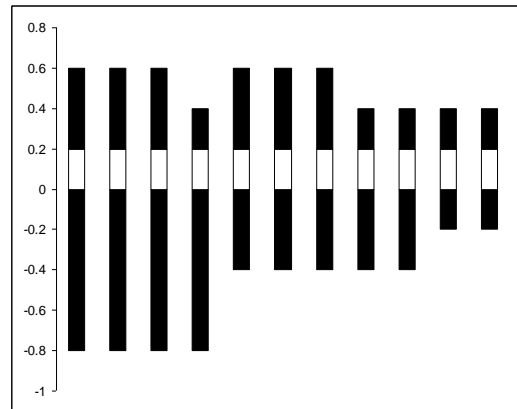
(244)



(245)



(246)



(247)

Figs. 244-247: *Stevia rebaudiana* (Bertoni) Bertoni (V. N. 132)

Fig. 244. Photograph of living plant. **Fig. 245.** Photomicrograph of somatic metaphase plate. **Fig. 246.** Camera lucida drawing of the same. **Fig. 247.** Ideogram of the above.

The karyotype consists of two different type of chromosomes with centromere at median point, sub-median and sub-terminal regions. The chromosome length ranged from 0.4 to 1.2 μm with mean length 0.8 μm and absolute length 9 μm . TF % is 37.7. Karyotype formula is M10+sm12. Pollen stainability is 61.3 percent.

Chromosome number determined for this taxon is $2n=22$. The somatic chromosome number determined from the root tip cell is shown in Fig. 246 and camera lucida drawing in Fig. 247. Its ideogram is represented in Fig. 248. The chromosome measurements are given in Table 139.

Table 40: Chromosome measurement in *Stevia rebaudiana* (Bertoni) Bertoni (V. N. 131)

Chrom. Pairs	Long Arm (µm)	Short Arm (µm)	Total Length (µm)	r-value	Relative Length (µm)	Position of Centromere
I	0.8	0.4	1.2	2	3.4	sm
II	0.8	0.4	1.2	2	3.4	sm
III	0.8	0.4	1.2	2	3.4	sm
IV	0.8	0.2	1	2	6.8	sm
V	0.4	0.4	0.8	1	10.3	M
VI	0.4	0.4	0.8	1	10.3	M
VII	0.4	0.4	0.8	1	10.3	M
VIII	0.4	0.2	0.6	2	5.17	sm
IX	0.4	0.2	0.6	2	5.17	sm
X	0.2	0.2	0.4	1	6.8	M
XI	0.2	0.2	0.4	1	6.8	M

4.1.40 *Tagetes patula* L. (2n=24, V.N. 109)

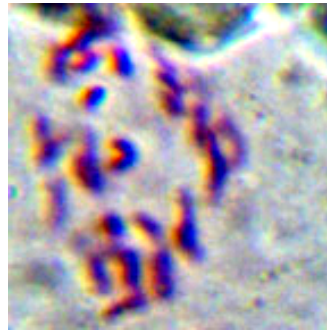
Locality: Minbhawan (C. Nepal), 1210 msl

The plant is annual herbs, usually erect, glabrous, and strongly aromatic. Stems simple or diffusely branched. Leaves opposite or alternate, sessile, base expanded with several, narrow, linear segments, pinnate or rarely simple, lobes lanceolate to narrowly elliptic, margins sharply serrate. The leaves coated with oily glands that produce a pungent scent. Capitula usually radiate, few-flowered, solitary on long peduncles or corymbosely arranged. Involucre cylindrical; bracts usually in 1 row, outer ones minute, inner ones connate. Receptacle flat, epaleate. Ray florets female, fertile, corolla pale yellow to lemon-yellow, strap-shaped. Style branches linear-lanceolate. Disc florets bisexual, fertile; corolla yellow, tubular, expanded above, 5-fid. Anthers with bases obtuse; apical appendage lanceolate. Style branches narrowly oblong, truncate and penicillate or with deltoid appendage, papillose on outer faces. Cypsela linear, narrowed to base, compressed or angled. Pappus of few scales, sometimes awned.

Chromosome number determined here for this taxon is $2n=24$. The somatic chromosome number determined from the root tip cell is shown in (Fig. 253) and camera lucida drawing in (Fig. 254). Its ideogram is represented in (Fig. 255). The chromosome measurements are given in Table 41.



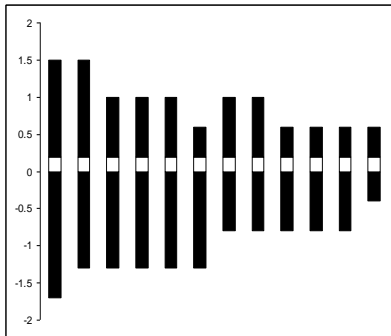
(248)



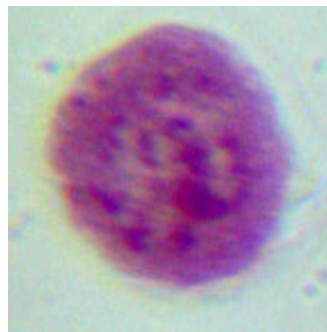
(249)



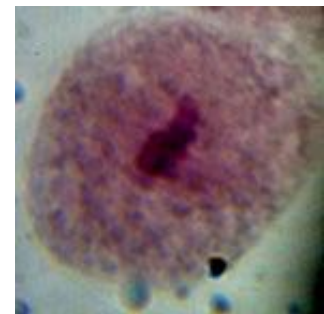
(250)



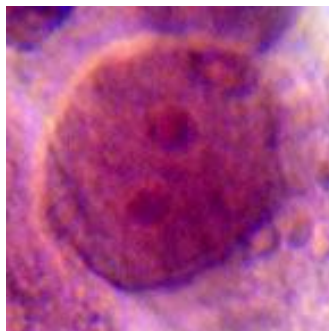
(251)



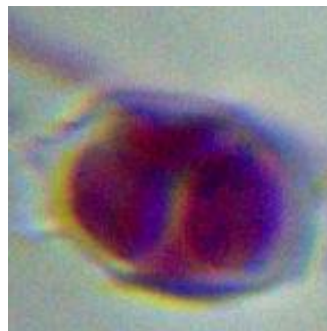
(252)



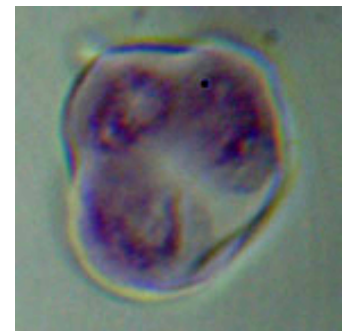
(253)



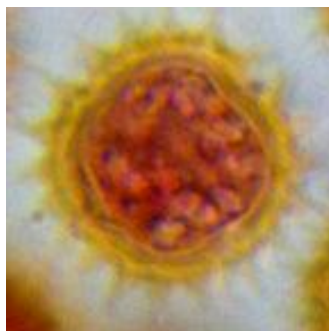
(254)



(255)



(256)



(257)

Figs. 248-257: *Tagetes patula* L. (V.N. 109)

Fig. 248. Photograph of living plant. **Fig. 249.** Photomicrograph of mitotic metaphase plate. **Fig. 250.** Camera lucida drawing of the same. **Fig. 251.** Ideogram of above. **Fig. 252.** Diakinesis showing 12 bivalents. **Fig. 253.** M- I **Fig. 254.** A-I with lagging chromosomes. **Fig. 255.** Dyad. **Fig. 256.** Tetrad. **Fig. 257.** Pollen grain.

The karyotype consists of four types of chromosomes with centromere at median point, median region, sub median region and sub terminal region. The chromosome length ranged from 0.8 to 3.0 μm with mean length 1.7 μm . and absolute length 21.2 μm . TF% is 40.5. Karyotype formula is $M_8+m_8+sm_6+st_2$.

Meiosis is normal. Daikinesis with twelve bivalents has observed (Fig. 256). Metaphase- I with chromosomes at equatorial plane. (Fig. 257), Anaphase-I with lagging chromosomes (Fig. 258), Dyad (Fig. 259), normal tetrads (Fig. 260) and triplicate, echinate pollens (Fig. 261) are observed. Pollen stainability is 96.4 percent.

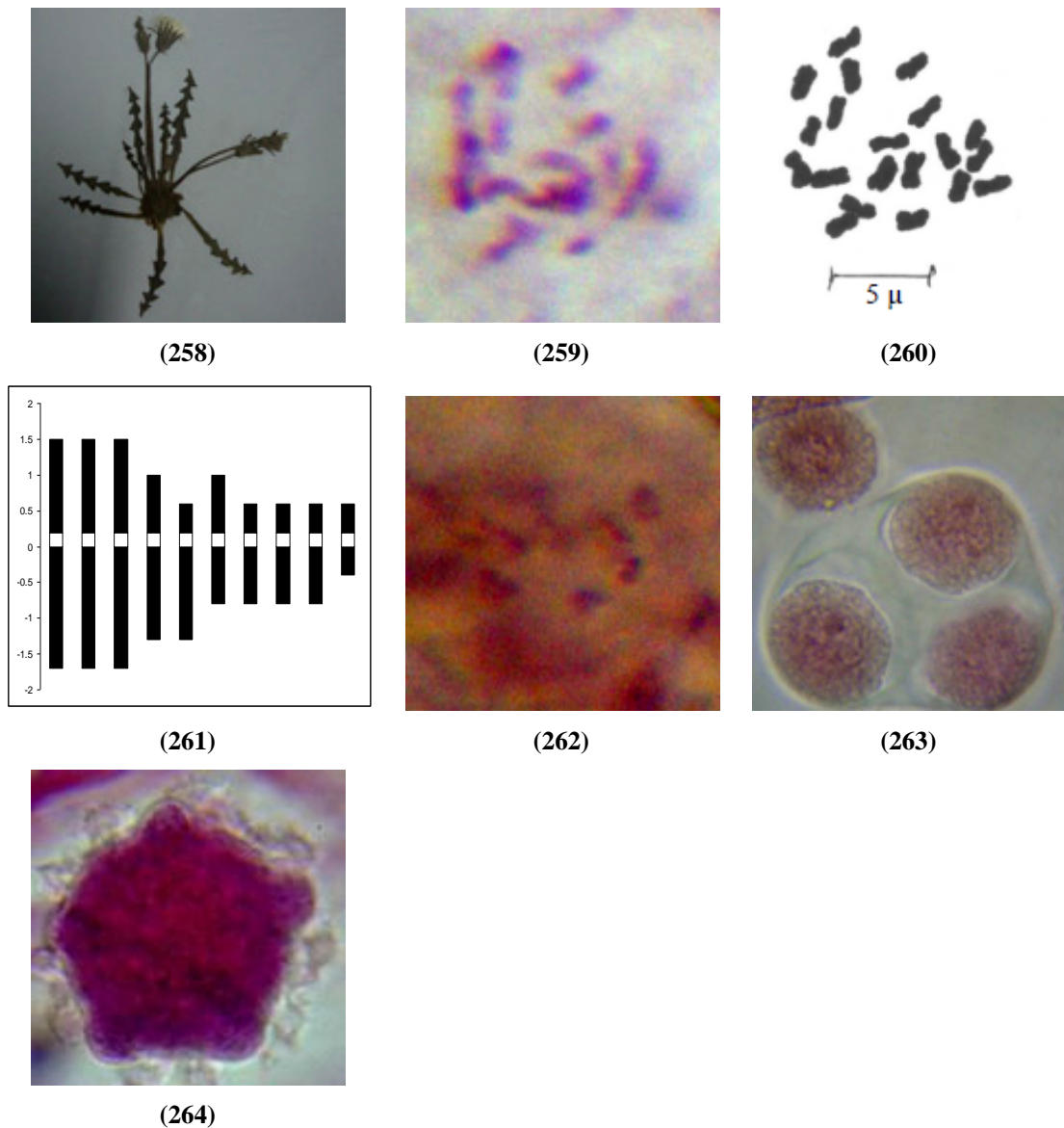
Table 41: Chromosome measurement in *Tagetes patula* L. (V.N. 109)

Chrom. Pairs	Long Arm (μm)	Short Arm (μm)	Total Length (μm)	r- value	Relative Length (μm)	Position of Centromere
I	1.7	1.3	3.0	1.3	14.1	m
II	1.3	1.3	2.6	1	12.2	M
III	1.3	0.8	2.1	1.6	9.9	m
IV	1.3	0.8	2.1	1.6	9.9	m
V	1.3	0.8	2.1	1.6	9.9	M
VI	1.3	0.4	1.7	3.2	8.0	st
VII	0.8	0.8	1.6	1	7.5	M
VIII	0.8	0.8	1.6	1	7.5	M
IX	0.8	0.4	1.2	2	5.6	sm
X	0.8	0.4	1.2	2	5.6	sm
XI	0.8	0.4	1.2	2	5.6	sm
XII	0.4	0.4	0.8	1	3.7	M

4.1.41 *Taraxacum officinale* F.H. Wigg. (2n=20, V.N. 110)

Locality: Lukla (C. Nepal), 2800 msl

The plant is herbaceous perennial with a rosette of jagged, irregularly lobed leaves produced from a long, thick, fleshy taproot that can descend more than 1 m. The leaves may be nearly smooth-margined, saw-toothed, or deeply cut. The single flowering stalk, sometimes over 50 cm tall, and bears a head of tiny yellow flowers. The flowering stalk is hollow and elongates with age. Fruiting heads produce tiny (3-5 mm) brown "seeds" (achenes), each carried by a "parachute" of white, fluffy hairs on a stalk. White, bitter, milky juice exudes from the plant where it is cut or broken, this stains hands brown and is difficult to remove.



Figs. 258-264: *Taraxacum officinale* L. (V.N. 110)

Fig. 258. Photograph of living plant. **Fig. 259.** Photomicrograph of mitotic metaphase plate. **Fig. 260.** Camera lucida drawing of the same. **Fig. 261.** Ideogram of above. **Fig. 262.** Diakinesis showing 10 bivalents. **Fig. 263.** Tetrad (normal). **Fig. 264.** Pollen grain.

Chromosome number determined for this taxon is $2n=20$. The somatic chromosome number determined from the root tip cell is shown in Fig. 263 and camera lucida drawing in Fig. 264. Ideogram is represented in Fig. 265 and chromosome measurement is given in Table 42.

The karyotype consists of four types of chromosomes with centromere at median point, median region, sub-median region and sub-terminal region. The chromosome

length ranged from 0.8 to 3.0 μm with mean length 1.8 μm and absolute length 18.8 μm . TF % is 39.8. Karyotype formula is $M_4+m_8+sm_6+st_2$.

Meiosis is normal. Daikinesis with ten bivalents has observed (Fig. 266). Normal tetrads (Fig. 267), pentagonal pollens (Fig. 268) are observed. Pollen stainability is 91.5 percent.

Table 42: Chromosome measurement in *Taraxacum officinale* F.H. Wigg. (V.N. 110)

Chrom. Pairs	Long Arm (μm)	Short Arm (μm)	Total Length (μm)	r-value	Relative Length (μm)	Position of Centromere
I	1.7	1.3	3.0	1.3	15.9	m
II	1.7	1.3	3.0	1.3	15.9	m
III	1.7	1.3	3.0	1.3	15.9	m
IV	1.3	0.8	2.1	1.6	11.2	m
V	1.3	0.4	1.7	3.2	9.0	st
VI	0.8	0.8	1.6	1	8.5	M
VII	0.8	0.4	1.2	2	6.3	sm
VIII	0.8	0.4	1.2	2	6.3	sm
IX	0.8	0.4	1.2	2	6.3	sm
X	0.4	0.4	0.8	1	4.2	M

4.1.42 *Tridax procumbens* L. (2n=26, V.N. 137)

Locality: Pokhara (W. Nepal), 700 msl

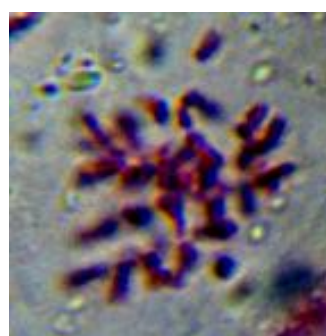
The plant is annual herbs, usually hairy, prostrate or ascending. Leaves opposite, petiolate, toothed or pinnately cut with segments few, narrow. Capitula radiate, on long peduncles, solitary. Involucre campanulate, bracts in 2 or 3 rows. Receptacle flat or convex, paleate, paleae membranous, keeled but scarcely clasping. Ray florets female, fertile, corolla yellow or creamy, strap-shaped. Disc florets persistent bisexual, fertile, corolla yellow or greenish, cylindric, 5-lobed or 5-toothed. Anthers with bases sagittate, apical appendages narrowly deltoid. Style branches of ray florets shortly linear-lanceolate, of disc florets much longer, acuminate with subulate appendage, hairy on outer faces. Cypselas obconical, villous. Pappus of many plumose bristles.

Chromosome number determined for this taxon is $2n=26$. The somatic chromosome number determined from the root tip cell is shown in (Fig. 270) and camera lucida drawing in (Fig. 271). Its ideogram is represented in (Fig. 272). The chromosome measurements are given in Table 43.

The karyotype consists of four types of chromosomes with centromere at median point, median region, sub-terminal region and sub-terminal region. The chromosome length ranged from 0.8 to 2.6 μm with mean length 1.6 μm and absolute length 20.9 μm . TF % is 44.4. Karyotype formula is $M_{18}+m_4+sm_2+ st_2$. Pollen stainability is 73.5 percent.



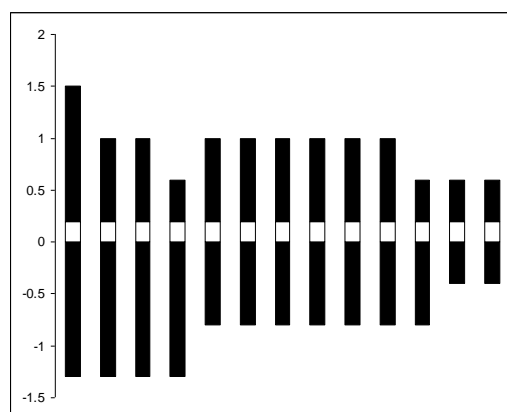
(265)



(266)



(267)



(268)

Figs. 265-268: *Tridax procumbens* L. (V.N. 137)

Fig. 265. Photograph of living plant. **Fig. 266.** Photomicrograph of mitotic metaphase plate. **Fig. 267.** Camera lucida drawing of the same. **Fig. 268.** Ideogram of above.

Table 43: Chromosome measurement in *Tridax procumbens* L. (V.N. 137)

Chrom. Pairs	Long Arm (µm)	Short Arm (µm)	Total Length (µm)	r- value	Relative Length (µm)	Position of Centromere
I	1.3	1.3	2.6	1	12.4	M
II	1.3	0.8	2.1	1.6	10.0	m
III	1.3	0.8	2.1	1.6	10.0	m
IV	1.3	0.4	1.7	3.2	8.1	st
V	0.8	0.8	1.6	1	7.6	M
VI	0.8	0.8	1.6	1	7.6	M
VII	0.8	0.8	1.6	1	7.6	M
VIII	0.8	0.8	1.6	1	7.6	M
IX	0.8	0.8	1.6	1	7.6	M
X	0.8	0.8	1.6	1	7.6	M
XI	0.8	0.4	1.2	2	5.7	sm
XII	0.4	0.4	0.8	1	3.8	M
XIII	0.4	0.4	0.8	1	3.8	M

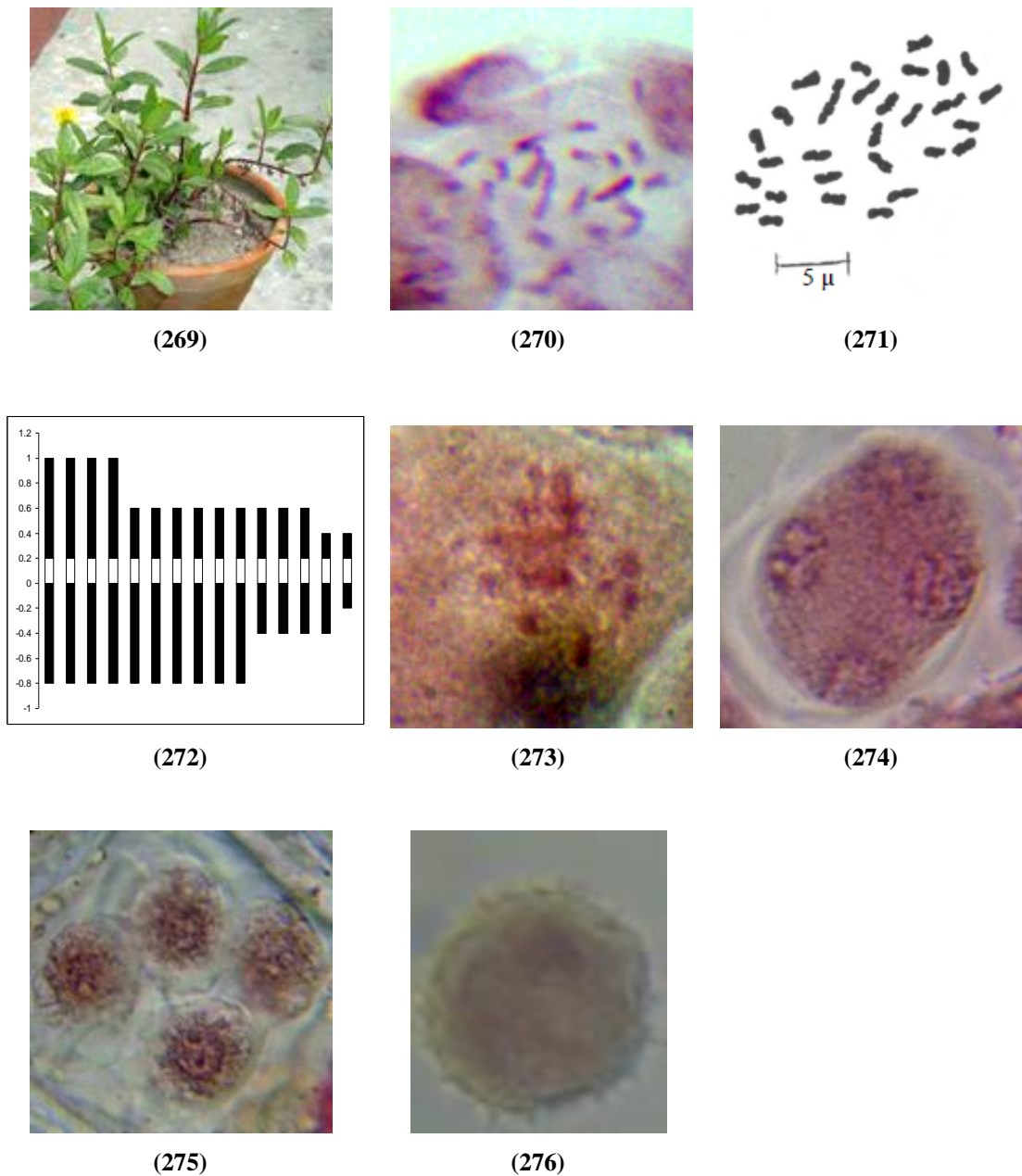
4.1.43 *Wedelia wallichii* Less. (2n=30, V.N. 126)

Locality: Kuleshwar (C. Nepal), 1210 msl

The plant is a perennial prostrate herb, 30-60 cm tall, much branched. Leaves simple, opposite, sessile, 1-5 cm long and 0.3-1 cm broad, lanceolate, narrowed at both ends, oppressed hairs on both sides. Flowers yellow in auxillary and terminal head. Head radiate 0.5-1 cm in diameter.

Chromosome number determined here for this taxon is 2n=30. The somatic chromosome number determined from the root tip cell is shown in Fig. 274 and camera lucida drawing in Fig. 275. Its ideogram is represented in Fig. 276. The chromosome measurements are given in Table 44.

Mitotic chromosomes are of two types viz. centromere at median points and sub-median regions. The chromosome length ranged from 0.4 to 1.6 µm with mean length 1.2 µm and absolute length 18.6 µm. TF% is 42.3. Karyotype formula is $M_{16+sm_{14}}$.



Figs. 269-276: *Wedelia wallichii* Less. (V.N. 145)

Fig. 269. Photograph of living plant. **Fig. 270.** Photomicrograph of mitotic metaphase plate. **Fig. 271.** Camera lucida drawing of the same, **Fig. 272.** Ideogram of above. **Fig. 273.** M-I . **Fig. 274 .**T-II. **Fig. 275.** Tetrad. **Fig. 276.** Pollen grain.

Meiosis is normal in this taxon. Metaphase-I with fifteen bivalents has observed (Fig. 277), Telophase-II with four microspores (Fig. 278), normal tetrads (Fig. 279), triporate echinate pollens (Fig. 280) are observed. Pollen stainability is 90.5 percent.

Table 44: Chromosome measurement in. *Wedelia wallichii* Less. (V.N. 126)

Chrom. Pairs	Long Arm (µm)	Short Arm (µm)	Total Length (µm)	r- value	Relative Length (µm)	Position of Centromere
I	0.8	0.8	1.6	1	9.4	M
II	0.8	0.8	1.6	1	9.4	M
III	0.8	0.8	1.6	1	9.4	M
IV	0.8	0.8	1.6	1	9.4	M
V	0.8	0.4	1.2	2	7.0	sm
VI	0.8	0.4	1.2	2	7.0	sm
VII	0.8	0.4	1.2	2	7.0	sm
VIII	0.8	0.4	1.2	2	7.0	sm
IX	0.8	0.4	1.2	2	7.0	sm
X	0.8	0.4	1.2	2	7.0	sm
XI	0.4	0.4	0.8	1	4.7	M
XII	0.4	0.4	0.8	1	4.7	M
XIII	0.4	0.4	0.8	1	4.7	M
XIV	0.4	0.2	0.6	2	3.5	sm
XV	0.2	0.2	0.4	1	2.3	M

4.1.44 *Xanthium strumarium* L. (2n=32, V.N. 111)

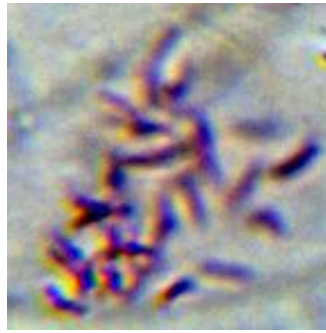
Locality: Kirtipur (C. Nepal), 1330 msl

The plant is coarse, annual herb. Leaves alternate, petiolate, simple, 5-7.5 cm long with deeply toothed margin. Capitula and florets unisexual. Male capitula globose, many-flowered, involucre short, bracts few, narrow, in 1 or 2 rows, receptacle hemispherical, paleate, corolla tubular, 5-toothed; anthers with small apical appendage, base obtuse; filaments connate, ovary abortive, style undivided. Female capitula ovoid, 2-flowered, involucre completely enveloping 2 female flowers, 2-locular within, apex 1- or 2-beaked, corolla 0, style branches long, linear, acute, tips exerted on inner face of each terminal beak near its base, cypselas obovoid or oblong, solitary in each involucre chamber and involucre enlarging, hardening with prominent hooked spines, shed as 2-celled unit, pappus 0.

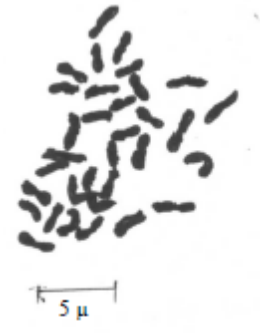
Chromosome number determined here for this taxon is $2n=32$. The somatic chromosome number determined from the root tip cell is shown in Fig. 282 and camera lucida drawing in Fig. 283. Its ideogram is represented in Fig. 284. The chromosome measurements are given in Table 45.



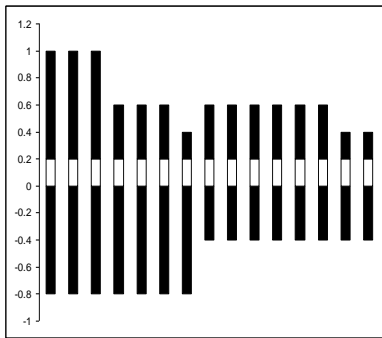
(277)



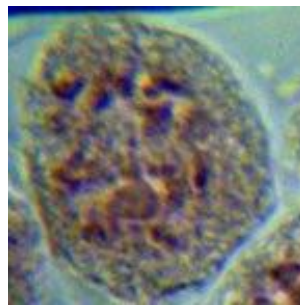
(278)



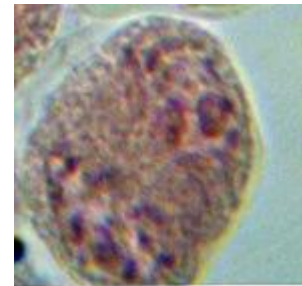
(279)



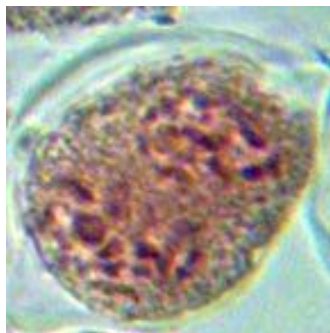
(280)



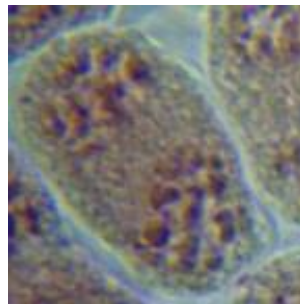
(281)



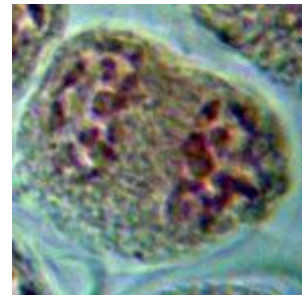
(282)



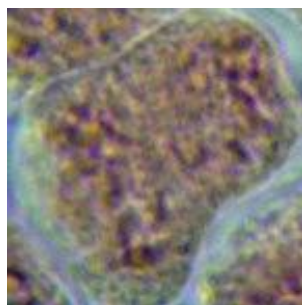
(283)



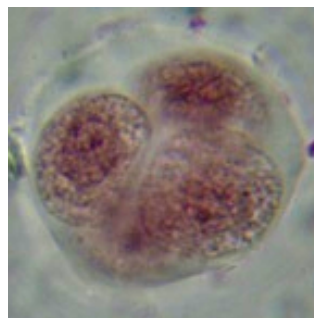
(284)



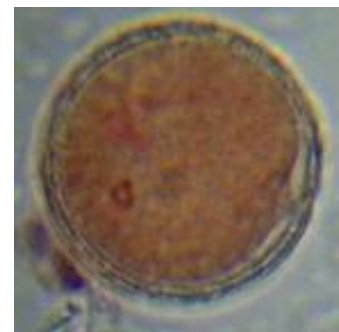
(285)



(286)



(287)



(288)

Figs. 277-288: *Xanthium strumarium* L. (V.N. 111)

Fig. 278. Photograph of living plant. **Fig. 278.** Photomicrograph of mitotic metaphase plate. **Fig. 279.** Camera lucida drawing of the same, **Fig. 280.** Ideogram of above. **Fig. 281.** Diakinesis showing 16 bivalents. **Fig. 282- 285 .T-I.** **Fig. 286.** A- II. **Fig. 287.** Tetrad. **Fig. 288.** Pollen grain.

The karyotype consists of three types of chromosomes with centromere at median point, sub median region and sub terminal region. The chromosome length ranged from 0.4 to 1.6 μm with mean length 0.9 μm and absolute length 15.8. μm . TF % is 43.0 Karyotype formulas is $M_{18+} sm_{12+} st_2$.

Meiosis is normal. Daikinesis with sixteen bivalents at Metaphase-I (Fig. 285), Anaphase-I with two laggards (Fig. 286), normal Telophase-I (Fig. 287), Anaphase-II (Fig. 288), late Telophase-I (Fig. 289), tetrads with abortive microspores (Fig. 290), triplicate circular pollens (Fig. 291) are observed. Pollen stainability is 92.7 percent.

Table 45: Chromosome measurement in *Xanthium strumarium* L. (V.N. 111).

Chrom. Pairs	Long Arm (μm)	Short Arm (μm)	Total Length (μm)	r- value	Relative Length (μm)	Position of Centromere
I	0.8	0.8	1.6	1	10.1	M
II	0.8	0.8	1.6	1	10.1	M
III	0.8	0.8	1.6	1	10.1	M
IV	0.8	0.4	1.2	2	7.5	sm
V	0.8	0.4	1.2	2	7.5	sm
VI	0.8	0.4	1.2	2	7.5	sm
VII	0.8	0.2	1	4	6.3	st
VIII	0.4	0.4	0.8	1	5.0	M
IX	0.4	0.4	0.8	1	5.0	M
X	0.4	0.4	0.8	1	5.0	M
XI	0.4	0.4	0.8	1	5.0	M
XII	0.4	0.4	0.8	1	5.0	M
XIII	0.4	0.4	0.8	1	5.0	M
XIV	0.4	0.2	0.6	2	3.7	sm
XV	0.4	0.2	0.6	2	3.7	sm
XVI	0.2	0.2	0.4	2	2.5	sm

4.1.45 *Zinnia elegans* Jacq. (2n=24, V.N. 127)

Locality: Ghantaghar (C. Nepal), 1300 msl

The plant is perennial herb, sometimes shrubby. Leaves opposite, sessile or shortly petiolate, simple, bases connate and sheathing stem, margins entire, roughly hairy. Capitula radiate, large, solitary, terminal on long, hollow peduncle swollen below capitulum. Involucre narrowly or broadly campanulate or sub-cylindric, bracts in 3 to

many rows, oblong or obovate, imbricate, apices rounded with darker or discoloured summit band at or near apex. Receptacle conical to concave with embracing disc florets. Ray florets female, fertile, corolla strap-shaped, discolorous, outer surface grayish- white, inner surface reddish or brownish red, persistent. Cypsela 3-angled or dorsiventrally compressed. Pappus 0. Disc florets bisexual, fertile, corolla brownish yellow, tubular, 5-toothed. Anthers with small apical appendage, base obtuse. Style branches long, linear, obtuse or sub-truncate. Cypsela obovate, 3-angled or compressed. Pappus of 1 or 2 awns.

Chromosome number determined for this taxon is $2n=24$. The somatic chromosome number determined from the root tip cell is shown in Fig. 294 and camera lucida drawing in Fig. 295. Its ideogram is represented in Fig. 296. The chromosome measurements are given in Table 46.

Somatic division shows three types of chromosomes having centromere at median points, median regions and sub-median regions. The chromosome length ranged from 0.4 to 1.3 μm with mean length 1.4 μm and absolute length 17.2 μm . TF % is 44.9. Karyotype formula is $M_{16}+m_2+sm_6$. Pollen stainability is 72.7 percent.

Table 46: Chromosome measurement in *Zinnia elegans* Jacq. (V.N. 127)

Chrom. Pairs	Long Arm (μm)	Short Arm (μm)	Total Length (μm)	r- value	Relative Length (μm)	Position of Centromere
I	1.3	0.8	2.1	1.5	12.5	m
II	0.8	0.8	1.6	1	9.9	M
III	0.8	0.8	1.6	1	9.9	M
IV	0.8	0.8	1.6	1	9.9	M
V	0.8	0.8	1.6	1	9.9	M
VI	0.8	0.8	1.6	1	9.9	M
VII	0.8	0.4	1.2	2	7.4	sm
VIII	0.8	0.4	1.2	2	7.4	sm
IX	0.8	0.4	1.2	2	7.4	sm
X	0.4	0.4	0.8	1	4.9	M
XI	0.4	0.4	0.8	1	4.9	M
XII	0.4	0.4	0.8	1	4.9	M



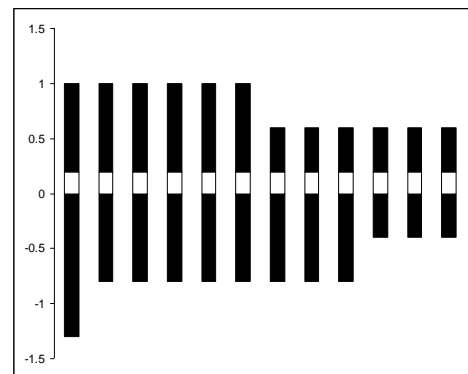
(289)



(290)



(291)



(292)

Figs. 289-292: *Zinnia elegans* Jacq. (V.N. 127)

Fig. 289. Photograph of living plant. **Fig. 290.** Photomicrograph of mitotic metaphase plate. **Fig. 291.** Camera lucida drawing of the same. **Fig. 292.** Ideogram of above.

4.2 Discussion

There is always a space for new criteria to be added in the phylogeny of systematics. In this concern, one of the important aspects to reconstruct the systematic phylogeny is considered as cytogenetics to be included in the morphology of plants. In other words, the indispensable value of cytogenetics consists of characters such as chromosome numbers, karyomorphology and meiotic behavior which cannot be overlooked to attend the dynamic nature of plant systematics and phylogeny.

Nepal is home to diverse floral vegetation in its wide ranging habitats from the plains to the mountains. It is recognized that though the botanical exploration have been undertaken in Nepal since a long time, the genetic diversity of the Nepalese flora is little known till now.

It is also noteworthy that the number of the Nepalese plant species is in a state of depletion because of habitat destruction and degradation and their genetic diversity is threatened. Thus conservation of genetic diversity has become a major issue today and it is likely to be urgent to know variation and evolution of the Himalayan plants. For this purpose, the phylogenetic relationships among the flora are also a necessary task for the country.

Some of the steps in accounting genetic diversity in plants have to be chromosome number, karyomorphology and species relationships, change in symmetry of karyotype, change in absolute length of chromosomes, relative size of chromosomes and satellite numbers if any, B-chromosomes if any, basic number, polyploidy, meiosis, pollen morphology including viability and phyletic tree of the flora. In this context, the research in some members of the family Asteraceae are presented here to widen the knowledge in cytogenetic field of the Nepalese flora.

4.2.1 Karyomorphology and species relationships

Numerical and structural variations in the chromosomes are the principle basis of karyotype evolution that brings about important clue in solving phylogenetic and evolutionary problem. Thus karyotype evolution can contribute to speciation. Speciation due to numerical and structural changes has been reported in the members of the several families e.g. in Piperaceae, (Das Gupta & Dutta 1976), Balsaminaceae (Govindrajan & Subramanian 1986), Solanaceae (Kayastha & Sharma 1988).

The cytological approach in the taxonomic accounts on interrelationships and evolution of plants have been exemplified by various authors viz. Babcock (1942) in *Crepis*, Joshi (1977) in Linaceae, Wagle (1984) in Euphorbiaceae, Fujishima (1988) & Vaidya (2005) in Ranunculaceae, Sakya (1991, 1999) in Primulaceae, Sheidai *et al.* (2000) in Asteraceae, Manandhar (2005) in Leguminosae.

The taxa of Asteraceae included in the present study fall into ten tribes viz. Astereae, Anthemideae, Calenduleae, Cichorieae, Cynareae, Eupatorieae, Heliantheae, Helineae, Inuleae and Senecioneae. Forty-five species within thirty-three genera have been carried out. These are *Aster barbellatus*, *A. ageratoides*, *A. peduncularis* sub.sp. *nepalensis*, *Conyza canadensis*, *Dichrocephala integrifolia*, *Erigeron annuus*, *Rhynchospermum verticillatum* from tribe Astereae. *Artemisia abronatum*, *A. indica*,

A. vulgaris and *Chrysanthemum morifolium* from tribe Anthemideae; *Calendula officinalis* from tribe Calenduleae; *Crepis japonica*, *Sonchus asper*, *Sonchus arvensis*, *Taraxacum officinale* and *Ixeris polycephala* from tribe Cichorieae; *Centaurea cyanus* and *Cirsium arvense* from tribe Cynareae; *Ageratum conyzoides*, *A. houstonianum*, *Eupatorium adenophorum* and *Stevia rebaudiana* from tribe Eupatorieae; *Galinsoga parviflora*, *parthenium hysterophorous*, *Xanthium strumarium*, *Eclipta prostrata*, *Zinnia elegans*, *Bidens pilosa*, *Coreopsis grandiflora*, *Tridax procumbens*, *Wedelia wallichii*, *Spilanthes acmella* and *S. calva* from tribe Heliantheae; *Tagetes patula* from tribe Helineae; *Anaphalis triplinervis* var. *triplinervis*, *Gnaphalium affine*, *G. purpureum*, *Blumea fistolosa*, *B. lacera*, *B. lacera* var. *glandulosa*, *B. laciniata* and *B. mollis* from tribe Inuleae and *Senecio laetus*, *Crassocephalum crepidioides* from tribe Senecioneae.

There are variations in chromosome size, chromosome number and chromosome morphology in Asteraceae. In the present study with the exception of a few species, the taxa are characterized by small and medium sized chromosome, the length ranging from 0.3 to 3.8 micron. The shortest chromosomes are observed in *Eupatorium adenophorum* (0.3 μ), *Senecio laetus* (0.3 μ) and largest in *Conyza canadensis* (3.4 μ). In the tribe Eupatorieae four species are characterized by small and medium sized chromosomes. Among them, in *Ageratum conyzoides*, the chromosome length ranged from 0.8 to 2.1 μ m and in *A. houstonianum* the chromosome length ranged from 0.6 to 1.6 μ m. Karyomorphology is different in these two species. Karyotype of *A. conyzoides* is $M_6+m_4+sm_8+st_2$ and that of *A. houstonianum* is $M_{12}+sm_6$. In *A. houstonianum* only two types of chromosome are observed. The earlier karyotype report for *A. conyzoides* consisted with comparatively long chromosome having median to nearly median and nearly sub-median (Rajalaxmi, 2001). The range of chromosome length is nearly similar but slight variations in karyomorphology are observed with a pair of sub-terminal chromosome in *A. conyzoides*. The morphology of both the plants is slightly different as flower colour of *A. conyzoides* is white where as that of *A. houstonianum* is purple. Karyotypes reported by Rajalaxmi (2001) for *A. houstonianum* also consisted with median and sub-median chromosomes. In *Eupatorium adenophorum* the length of chromosome ranged from 0.3 to 1.2 μ m and in *Stevia rebaudiana* it is 0.4 to 1.2 μ m. Karyotype of *Eupatorium adenophorum* is $M_4+m_{12}+sm_{26}+st_8$ having graded chromosomes. In present study in *Eupatorium*

adenophorum presence of four pairs of sub-terminal chromosomes indicates advanceness over other three taxa. This advanceness reflects on its external morphology having rhomboid-ovate, coarsely serrate, acute, glandular on nerves beneath leaves with corymbose head. *Stevia rebaudiana* has $M_{10}+sm_{12}$ karyotype. These taxa show slightly specialized karyotypes with high chromosome numbers. This is specially represented in morphological structures such as the leaves are sessile, oppositely arranged, lanceolate to oblanceolate in shape, and serrated above the middle.

The tribe Anthemideae with two genera *Artemisia* and *Chrysanthemum* are characterized by small and medium sized chromosomes. The two genera are different in morphological nature. The former has small leaves with small flowers and latter consists of larger leaves with larger flowers. Range of chromosome length is not so much variable among four taxa, *Artemisia abrotanum* (0.6-2.1 μ), *A. indica* (0.6-2.1 μ), *A. vulgaris* (0.4-1.2 μ) and *Chrysanthemum morifolium* (0.8-2.1 μ). Taxa of this tribe exhibit symmetrical karyotype. In three species of *Artemisia* karyomorphology is different having $M_{18}+m_4+sm_{12}+st_2$ in *A. abrotanum*, $M_{20}+m_2+sm_{10}$ in *A. indica* and $M_{16}+sm_{18}$ in *A. vulgaris*. Among three species of *Artemisia*, the graded chromosomes in *A. abrotanum* shows slight specialized. The morphological structure of leaf also shows highly dissected pattern than in others. The taxa *Chrysanthemum morifolium* ($M_{20}+m_4+sm_{12}$) also shows symmetrical karyotypes. Tanaka and Shimotomai (1961) investigated karyotype in four diploid species of *Chrysanthemum* and found that the taxa differ from each other in chromosome size. The differences in chromosome size in four diploid species investigated by the authors have indicated relatively distant relationships. In the species *Chrysanthemum lineare* they found three pairs of satellite chromosomes.

The five species from tribe Cichorieae are characterized by small and medium sized chromosomes in present investigation. In *Crepis japonica* the chromosome length ranged from 0.6 to 1.6 μ m with karyotype M_8+sm_8 . The karyotype of different species of *Crepis* reported by Anagnostopoulos (1997) had satellited chromosomes. In the two species of genus *Sonchus* karyomorphology and chromosome length is dissimilar. Karyotype of *Sonchus asper* is M_8+sm_{10} and that of *Sonchus arvensis* is $M_{12}+sm_6$. Length of chromosome ranged from 0.6 to 1.6 μ m in *Sonchus asper* and 0.8 to 1.6 μ m in *Sonchus arvensis*. Major components of chromosome is having centromeres at

middle point in *Sonchus arvensis* but in *Sonchus asper* major component of chromosomes are sub-median types.

In *Taraxacum officinale* chromosome length ranged from 0.8 to 3.0 μm . Karyotype ($M_4+m_8+sm_6+st_2$) revealed with graded chromosomes. In *Ixeris polycephala* chromosome length ranged from 0.8 to 2.1 μm and Karyotype is $M_8+m_4+sm_4$ having three types of chromosomes. Among five species in the tribe mostly symmetrical karyotype are observed. *Sonchus arvensis* may be considered as primitive in comparison to other member of the tribe. Range of chromosome length and the less specialized karyotype with karyotype formula $M_{12}+sm_6$. Joshi (1988) studied karyomorphology of polyploidy form and revealed the occurrence of comparatively advance karyotype having the formula $M_8+m_{22}+sm_6$.

The eleven taxa of ten genera from tribe Heliantheae investigated are characterized by small and medium sized chromosomes. In *Galinsoga parviflora* the chromosome length ranged from 0.6 to 1.6 μm . The karyotypes (M_8+sm_8) shows two types of chromosomes with centromere at median points and sub-median regions. In *Parthenium hysterophorus* the chromosomes length ranged from 0.4 to 1.6 μm and karyotype ($M_{22}+sm_{10}+st_2$) has three types of chromosomes with centromere at median point, sub-median and sub-terminal regions. Major component of chromosome is with centromere at median point. The karyotypes of two taxa *Galinsoga parviflora* and *Parthenium hysterophorus* are different from each other. Morphological character, are also different in two taxa. Alternate, sessile, simple, elliptic, deeply bipinnatisect leaves are found in *Parthenium hysterophorus* and opposite, petiolate, ovate, sometimes faintly crenate, leaves in *Galinsoga parviflora* have been found. *Parthenium hysterophorus* is seen to be advance than *Galinsoga parviflora*.

In *Xanthium strumarium* ($2n=32$) the chromosome length ranged from 0.4 to 1.6 μm . Karyotype ($M_{18}+sm_{12}+st_2$) is with three types of chromosomes with centromere at median point, sub-median and sub-terminal regions. Major components of chromosomes are with centromere at middle points and median regions. Three types of chromosomes having karyotype formula $M_2+m_{26}+sm_8$ ($2n=36$) was reported by Joshi (1988) for this species. In *Eclipta prostrata* ($2n=22$) the chromosome length ranged from 0.8 to 1.6 μm and karyotype is with having three types of chromosomes ($M_{14}+sm_6+st_2$). Major component of chromosome is with centromere at median point.

In *Zinnia elegans* the chromosome length ranged from 0.4 to 1.3 μm and karyotype ($M_{14}+m_4+sm_6$) is having three types of chromosomes. Major component of chromosome is with centromere at median point. *Bidens pilosa* the chromosome length ranged from 0.4 to 2.1 μm and karyotype ($M_{16}+m_2+sm_{14}+st_4$) is having graded chromosomes. In *Coreopsis grandiflora* the chromosome length ranged from 0.6 to 1.6 μm and karyotype ($M_{14}+sm_{12}$) have two types of chromosome with centromere at median points and sub-median regions. In *Tridax procumbens* the chromosome length ranged from 0.8 to 2.6 μm and karyotype is having ($M_{18}+m_4+sm_2+st_2$) graded chromosomes.

In *Wedelia wallichii*, the chromosome length ranged from 0.4 to 1.6 μm and karyotype is having ($M_{16}+sm_{14}$) two types of chromosomes with centromere at median points and sub-median regions. In *Spilanthes acmella* the chromosome length ranged from 0.6 to 1.6 μm and karyotype $M_{22}+m_2+sm_{14}$ is having three types of chromosomes. Major component of chromosomes are with centromere at median point. In *Spilanthes calva* the chromosome length ranged from 0.4 to 2.1 μm and karyotype ($M_{16}+m_2+sm_{16}+st_2$) is having graded chromosomes. In all eleven species of tribe Heliantheae in present study, the length of chromosomes are more or less similar and major component of chromosome with centromere at median point except *Spilanthes calva* in which major component of chromosome is with centromere at sub-median regions. This shows homogeneity of the genus within the tribe. In most of the taxa in this tribe the position of the centromere are found at median point on this basis the taxa of this tribe shows primitive nature. General morphology of the taxa also verifies it as most of the taxa possesses perennial habit with woody stem.

Chromosome number and karyotypes of *Bidens pilosa* and *Spilanthes calva* are nearly similar having some chromosomes with centromere at sub-terminal regions. *B. pilosa* has two pairs of chromosomes with centromere at sub-terminal regions. It seems that *B. pilosa* is advance than *Spilanthes calva*. This advancedness reflects on the morphology of *Bidens pilosa* that has pinnate leaf, spiny achenes, slightly hard stem.

The seven taxa of five genera from tribe Astereae are characterized by small, medium and large sized chromosomes. Three species of *Aster* are *Aster ageratoides*, *A. barbellatus* and *A. peduncularis* subsps. *nepalensis*. The length of chromosome in all three species is more or less similar. The chromosome length ranged from 0.8 to 2.1

μm in *A. ageratoides*. 0.4 to 1.6 μm in *A. barbellatus* and 0.6 to 2.1 in *A. peduncularis* subsps. *nepalensis*. Karyotype ($M_{14}+m_{10}+sm_{10}+st_2$) consists of graded chromosomes in *Aster ageratoides*. In *A. barbellatus* karyotype ($M_{14}+sm_{26}$) consists of two types of chromosomes having major component of chromosome with centromere at sub-median regions. In *A. peduncularis* subsps. *nepalensis*, karyotype ($M_{18}+m_4+sm_{18}$) consists of three types of chromosome component with centromere at median point, median and sub-median regions. *A. barbellatus* and *A. peduncularis* subsps. *nepalensis* have same chromosome number ($2n=40$). Karyotypes are also more or less similar. General morphology is also more or less similar with perennial habits in both species. Constancy in chromosome number ($2n=40$) and karyomorphology indicates homogeneity of the species. *A. ageratoides* ($2n=36$) has less chromosome number with different karyotypes which indicate slight asymmetry of chromosomes showing a few chromosomes ($M_{14}+m_{10}+sm_{10}+st_2$) with centromere at sub-terminal region. This asymmetry reflects on morphology having hairy, serrate margined leaves.

The length of chromosome ranged from 1.2 to 3.4 μm in *Conyza canadensis*, from 0.8 to 1.2 μm in *Dichrocephala integrifolia*, from 0.6 to 1.6 μm in *Erigeron annuus*, and from 0.5 to 0.8 μm in *Rhynchospermum verticillatum*. Ratio of long and short chromosomes is slightly variable. In *Conyza canadensis* karyotype ($M_2+m_8+sm_8+st_4$) consists of four types of chromosomes with centromere at median point, median, sub-median and sub-terminal regions. In *Dichrocephala integrifolia*, karyotype ($M_4+m_4+sm_8$) consists of three types of chromosomes and in *Erigeron annuus* ($2n=16$) major component of chromosomes is with centromere at sub-median regions. The karyotype ($M_{10}+m_2+sm_6$) consists of three types of chromosomes with centromere at median point, median and sub-median regions in *Rhynchospermum verticillatum*. Different karyomorphology in these five genera of the same tribe suggests its origin from different parental sources or it may be due to chromosomal repatterning.

The eight species of three genera from tribe Inuleae are characterized by small and medium sized chromosomes. The species *Anaphalis triplinervis* are existed by small chromosomes. The chromosome length in *Anaphalis triplinervis* ranged from 0.4 to 1.6 μm . Karyotype ($M_{14}+sm_{12}+st_2$) consists of three types of chromosomes with centromere at median point, sub-median and sub-terminal regions. The length of chromosome ranged from 1.2 to 2.6 μm in *Gnaphalium affine*, 0.8 to 2.6 μm in

Gnaphalium purpureum. Karyotype ($M_{10}+sm_4$) consists of two types of chromosomes with centromere at median point and sub-median regions in *Gnaphalium affine*. Major components of chromosomes are with centromere at middle point. Karyotype ($M_{12}+m_2+sm_{10}+st_2$) consists of graded chromosomes in *Gnaphalium purpureum*. Regarding the different karyomorphology of the same genus *Gnaphalium* it is suggested that the difference may due to chromosomal repatterning.

Among the above three taxa *Gnaphalium affine* is forward in primitiveness which is denoted by least number of chromosomes ($2n=14$) with only two types of centromeric position and ratio of longest and shortest chromosome is same in the two species of *G. affine* and *G. purpureum*). *G. purpureum* shows advancedness having a few chromosomes with centromere at sub-terminal region when compared to *G. affine*. However, general morphological characters look similar in all three taxa. Yet few differences are observed such as woolly stem in *G. affine*, thin stem in *G. purpureum* and white-woolly stems in *Anaphalis triplinervis*.

Among the five species of genera *Blumea* from the tribe Inulae, the length of chromosomes ranged from 0.6 to 1.6 μm in *B. fistulosa*, *B. lacera* var. *glandulosa*, *B. laciniata*, *B. lacera* except in *Blumea mollis* in which chromosomes length range is 0.8 to 2.6. Karyotype is different among all of them. Karyotype ($M_{12}+sm_{10}$) is having two types of chromosomes with centromere at median point and sub-median regions in *B. fistulosa* and *B. laciniata* ($M_{12}+sm_6$). Karyotype ($M_{14}+sm_{14}+st_4$) consists of three different types of chromosomes with centromere at median point, sub-median and sub-terminal regions in *B. lacera* var. *glandulosa*. Karyotype ($M_{14}+st_2$) consists of two different types of chromosomes with centromere at median point and sub-terminal region in *B. lacera*. Karyotype ($M_8+m_2+sm_4+st_8$) is with graded chromosomes in *B. mollis*. Similarity in size of chromosomes and karyomorphology indicates the homogeneity of the taxa within this tribe. *B. fistulosa* ($2n=22$) and *B. mollis* ($2n=22$) have similar chromosome number but have different karyotypes. *B. fistulosa* has symmetrical karyotype while *B. mollis* has asymmetrical one. So *B. mollis* shows advancedness over *B. fistulosa* that is denoted by ratio of long and short chromosomes. Among *B. laciniata* ($2n=18$) and *B. lacera* ($2n=16$) the former is primitive than latter which is indicated by ratio differentiation and T.F. percentage. *B. lacera* var. *glandulosa* ($2n=32$) also seems to be advanced being polyploidy nature and presence of sub-terminal chromosomes when compared to other species of the genus *Blumea*.

The two genera from tribe Cynareae are characterized by small, medium and large sized chromosomes. In *Centaurea cyanus* the length of chromosome ranged from 0.8 to 2.6 μm and karyotype revealed the graded chromosomes ($M_{12}+m_6+sm_2+st_4$). Major component of chromosomes is with centromere at middle point and sub-median region. In *Cirsium arvense* the length of chromosome ranged from 0.8 to 1.2 μm and karyotype ($M_{16}+sm_{14}+st_4$) revealed three types of chromosomes and major components are with centromere at median point and sub-median region. The Karyotype formula ($M_6+m_{18}+sm_8+st_2$) for *Cirsium arvense* was reported by Joshi (1988). From the viewpoint of chromosome number and karyomorphology *C. arvense* seems to be primitive than *Centaurea cyanus*. Morphological characters of *C. arvense* such as grooved stem and branching at top reflect its primitiveness.

The two genera from tribe Senecioneae are characterized by small and large sized chromosomes. The chromosome length ranged from 0.4 to 3.0 μm in *Crassocephalum crepidioides* and karyotype ($M_{22}+m_2+sm_{16}$) consists of three types of chromosomes. Major component of chromosomes are with centromere at median region. The chromosome length ranged from 0.3 to 0.8 μm in *Senecio laetus* and karyotype ($M_{12}+m_8+sm_{16}$) consists of three types of chromosomes. Karyomorphology is nearly similar in both the taxa. Morphological characters also look similar in both of them.

The only one taxa from the tribe Calenduleae in present study is *Calendula officinalis* and is characterized by small and large sized chromosomes. The chromosome length ranged from 0.4 to 2.6 μm . There is also more variation in the ratio of longest and shortest chromosomes (6.5). The karyotype ($M_{16}+m_4+sm_8$) shows symmetrical chromosomes. Morphology also shows primitiveness such as achenes longer than the involucre, curved, boat-shaped, dorsally muricate, not beaked and outer longer portion ventrally crested.

The single taxa *Tagetes patula* from the tribe Helineae in present study is characterized by small and large sized chromosomes. The chromosome length ranged from 0.8 to 3.0 μm and karyotype formula is $M_8+m_8+sm_6+st_2$. In this taxa karyotype show asymmetrical condition having two sub-terminal chromosomes. Morphologically this taxa seems to be advanced such as presence of oil gland and lanceolate leaves with zig zag margine.

4.2.2 Change in symmetry of Karyotype

The plants with symmetrical karyotypes are primitive and asymmetrical ones are advanced. Such conclusions are made by Darlington (1937) and Stebbins (1950, 1968) in different plant species. The primitiveness and advancedness reflect on phenotype sometimes. Manandhar (2005) and Vaidya (2005) also have denoted such conclusions. The plants studied in present research, both primitive as well as specialized karyotypes are encountered.

The four taxa from the tribe Anthemideae are investigated presently. In three species of *Artemisia* in the present investigation, asymmetrical as well as symmetrical karyotypes are observed. All three species show primitive as well as advanced morphological characters. *A. abronatum* with perennial habit and finely dissected leaves possessed asymmetrical karyotype with sub-terminal chromosomes. *A. indica* is with karyotype having slightly asymmetrical chromosomes with centromere at median point, median and sub-median regions. This species also shows some primitive morphological characters like perennial habit and lobed leaves. Morphological nature of *A. vulgaris* shows advanced as well as primitive characters like perennial habit, woody stem and alternate simple leaves having symmetrical karyotype. Symmetrical karyotypes are found in *Chrysanthemum morifolium* with 3 types of chromosomes having majority of them with centromere at median point (10 pairs). This also reflects morphological characters such as perennial habit and opposite leaves. So in the tribe Anthemideae the taxa *A. abronatum* seems to be advanced than others. This is verified by morphological characters also.

Seven taxa from the tribe Astereae are studied in present research. All three species of *Aster* in present investigation show specialized karyotypes. Four types of chromosomes are with centromere at median point, median, sub-median and sub-terminal regions. Morphology of this genus also shows advanced nature with hairy leaves and serrate margins in *Aster ageratoides*, triplinerved leaves in *Aster barbellatus*. *Aster peduncularis* subsp. *nepalensis* also shows advanced as well as primitive characters such as perennial habit, ovate leaves with coarsely serrate margins. Asymmetrical karyotype found in *Conyza canadensis* with four types of chromosomes having centromere at median point, median, sub-median and sub-terminal regions shows some advanced morphology such as Inflorescence paniculate.

Karyotype of *Dichrocephala integrifolia* is found to be symmetrical one with only 2 types of chromosomes having centromere at median point and sub-median region. Morphology shows both primitive as well as advanced nature such as annual habit, lyrate large leaves and globose heads in this taxa. Symmetrical karyotype is shown by *Erigeron annuus* with 3 types of chromosomes having centromere at median point, median and sub-median regions. Primitive morphological characters such as perennial habit, large difference between shortest (0.6 μm) and longest (1.6 μm) chromosomes support the symmetry of karyotype in this taxa. Asymmetrical karyotype is found in *Rhynchospermum verticillatum* having three types of chromosomes with centromere at median point, median and sub-median regions. Morphology of this plant also shows some advanced characters such as annual habit, slender branched stem, coarsely toothed leaves with axillary heads. Among five genera investigated from tribe Astereae, the genus *Aster* seems to be advanced over others.

The Only one taxa is investigated from the tribe Calenduleae. Karyotype ($M_{16}+m_{4+sm_8}$) of *Calendula officinalis* shows slightly asymmetrical chromosomes with centromere at median point, median and sub-median regions. The longest and shortest chromosomes ratio indicates its advanceness. Annual habit, sparsely branched stem and large oblong- lanceolate leaves show advanceness of this taxa.

Five taxa from the tribe Cichorieae are studied presently. Slightly asymmetrical karyotype is found in *Crepis japonica* with two types of chromosomes having centromere at median point and sub-median region. The *Ixeris Polycephala* also shows asymmetrical karyotype having three types of chromosomes with centromere at median point, median and sub-median regions. Morphology of this plant also shows some advanced characters such as annual habit, membranous linear-lanceolate leaves etc. Symmetry of karyotype in *Sonchus asper* indicates primitiveness having only two types of chromosomes with centromere at median point and sub-median regions. But morphology of this plant shows some advanced characters such as annual habit, cauline oblanceolate leaves with toothed auricle. Primitive karyotype symmetry is found in *Sonchus arvensis* having only two types of chromosomes with centromere at median point and sub-median region. Morphology of this plant also shows some primitive characters such as perennial habit and glabrous, hollow stem with milky sap. Karyotype is asymmetrical in *Taraxacum officinale* having four types of chromosomes with centromere at median point, median, sub-median and terminal

regions. Morphology of this plant shows some primitive characters such as biennial habit, basal leaves forming a rosette above the central tap root, the heads borne singly on a hollow stem and exudes a milky sap when broken. The taxa *Taraxacum officinale* seems to be advanced over others from the tribe Cichorieae with some sub-terminal chromosomes and advanced morphological characters (leaves with smoothed margin saw toothed and deeply cut margin).

The two taxa studied from the tribe cynareae have asymmetrical karyotypes with four types of chromosomes having centromere at median point, median, sub-median and (two pairs) sub-terminal regions in *Centaurea cyanus* and the taxa also shows advanced morphological characters such as annual habit and lanceolate leaves. Asymmetrical karyotypes found in *Cirsium arvense* is with 3 types of chromosomes having centromere at median point, sub-median and (2 pairs) sub-terminal regions. This taxa also shows advanced morphology such as annual habit, pinnatifid leaves with spiny margins. Two genera studied in present investigation from the tribe cynareae, when compared, the genus *Centaurea* seems to be advanced over the genus *Cirsium* that verifies from morphological characters also.

In four taxa studied from the tribe Eupatorieae show symmetrical karyotypes in the two species of genus *Ageratum* viz. *Ageratum conyzoides* and *A. hostonianum* these are having 3-nerved leaves but *A. hostonianum* have purplish flowers and *A. conyzoides* have white flowers. *Eupatorium adenophorum* and *Stevia rebaudiana* have slightly asymmetrical karyotypes with a few sub-terminal chromosomes in both the taxa. These taxa are with perennial habit having hard stem. So in the tribe Eupatorieae, *Ageratum* seems to be primitive than *Eupatorium* and *Stevia*.

Only one taxa is researched from the tribe Helinieae in present study. Asymmetrical karyotype is found in *Tagetes patula* having four types of chromosomes with centromere at median points, median, sub-median and terminal regions. Morphology of this plant also shows some advanced characters such as annual or perennial habit, pinnately compound leaves, narrow lance-shaped leaflets.

Eleven taxa are studied presently from the tribe Heliantheae. In *Bidens pilosa* karyotype is asymmetrical with four types of chromosomes with centromere at median points, median, sub-median and sub-terminal regions. It also reflects with

advanced morphological characters such as annual habit, ovate-lanceolate leaves with serrate margins. Symmetrical karyotype is found in *Coreopsis grandiflora* with only 2 types of chromosomes having centromere at median points and sub-median region. This taxa also shows primitive morphological characters such as perennial habit and linear large leaves. Slightly asymmetrical karyotype is found in *Eclipta prostrata* with 3 types of chromosomes having centromere at median points sub-median and sub-terminal regions. Morphology of this taxa shows primitive characters such as perennial habit, creeping stem and sub-sessile leaves. Asymmetrical karyotype found in *Galinsoga parviflora* having 2 types of chromosomes with centromere at median point and sub-median region in equal number (4 pairs) also have evidenced advanced morphological characters such as annual habit, young parts densely pubescent, oblong elliptic terminal as well as axillary leaves. In *Parthenium hysterophorus* karyotype is asymmetrical having three types of chromosomes with centromere at median point, sub-median and sub-terminal (1 pair) regions. Morphology of this plant also shows some advanced characters such as annual habit, small radiate heads, alternate irregularly dissected leaves. Asymmetrical karyotype is revealed in *Spilanthes calva* having four types of chromosomes with centromere at median point, median, sub-median and terminal regions. Morphology of this plant also shows some advanced characters such as annual habit, erect ascending stem and discoid conical heads. Slightly advanced karyotype symmetry is found in *Spilanthes acmella* having two types of chromosomes with centromere at median point and sub-median region. Morphology of this plant also shows some advanced characters such as annual habit, triangulate, opposite leaves.

The karyotype is asymmetrical in *Tridax procumbens* having graded chromosomes. The morphology of this taxa shows some advanced characters such as annual hairy, prostrate herbs with radiate capitula. Symmetrical karyotype is found in *Wedelia wallichii* having only two types of chromosomes with centromere at median points and sub-median regions. It also exhibits some primitive morphological characters such as perennial habit and opposite-sessile leaves. Slightly asymmetrical karyotype is found in *Xanthium strumarium* having four types of chromosomes with centromere at median point, median, sub-median and terminal region. It also exhibits some advanced morphological characters such as annual habit, stout stem and spirally arranged leaves. Slightly primitive karyotype is found in *Zinnia elegans* having 3

types of chromosomes with centromere at median points, median and sub-median regions. This taxa also exhibits some primitive characters such as perennial habit and hardy plants with erect stems. Among the ten genera from the tribe Heliantheae investigated in the present study, the genera *Bidens*, *Parthenium*, *Spilanthes*, *Tridax* and *Xanthium* seem to be advanced over rest of the genera this verifies from the above morphological characters as well as from symmetry of karyotypes.

Eight taxa presently investigated from the tribe Inuleae. In *Anaphalis triplinervis* var. *triplinervis*, karyotype is asymmetrical having some sub-terminal chromosomes. All the five species of *Blumea*, in the present study, possess both symmetrical and asymmetrical karyotypes. Only two types of chromosomes with centromere at median point and median region with a pairs of satellite in their short arms found in *B. fistulosa* shows symmetrical karyotype with primitive morphological characters such as capitula in small sessile clusters arranged in interrupted spikelike terminal racemes. In *B. lacera* var. *glandulosa* two types of chromosomes with centromere at median points and sub-terminal regions (two pairs) were observed. It shows asymmetrical karyotype having advanced morphology such as annual habit and simple alternate leaves. Only two types of chromosomes with centromeres at median point and sub-median regions in *B. laciniata* shows slightly asymmetrical karyotype with advanced morphological characters such as annual habit and many branched stem. Slightly asymmetrical karyotype is seen in *B. lacera* having two types of chromosomes with centromere at median points and sub-terminal regions with many flower heads shows advanceness of the plant. Asymmetrical karyotype with four types of chromosomes having centromere at median point, median, sub-median and sub-terminal regions is seen in *B. mollis*. Advanced morphological characters such as annual habit, glandular hairs and elliptical leaves with silky villous on both surfaces supports its symmetry.

Karyotype of *Gnaphalium affine* is lightly asymmetrical having 2 types of chromosomes with centromere at median points and sub-median regions. It is also supported by wooly annual habit, with linear lanceolate upper leaves. Asymmetrical karyotype found in *Gnaphalium purpureum* is having four types of chromosomes with centromere at median point, median, sub-median and sub-terminal (2 pairs) regions. Annual habit with thin white cottony tomentose stem and spatulate leaves reflects its symmetry. Among the five species investigated presently from tribe

Inuleae, the taxa *B. mollis* seems to be advanced one. It is supported by karyotype symmetry.

Among the two taxa researched from the tribe Senecioneae, the karyotype of *Crassocephalum crepidioides* seems to be symmetrical one with three types of chromosomes having centromere at median point, median and sub-median regions. It shows primitive morphological characters such as head nodding in terminal peduncled corymbs. The karyotype of *Senecio laetus* shows three types of chromosomes having centromere at median points, median and sub-median regions (8 pairs). Morphology of this plant also shows somewhat advanced characters such as annual habit, leaves pinnatifid with auricled base.

The primitive and advanced karyotypes were categorized on the basis of centromeres at the chromosomes such as the chromosomes having centromere at middle point, median, sub-median, sub-terminal and terminal regions. Asymmetrical karyotypes possess many chromosomes with centromeres at sub-terminal and terminal regions. Asymmetrical karyotypes show great differences in size between largest and smallest chromosomes where as symmetrical ones consist of chromosomes that are similar in size with more chromosomes having centromere at middle point, median and sub-median regions (Vaidya, 2005).

4.2.3 Change in absolute length of chromosome

There is remarkable variations in absolute length of chromosomes among the different taxa of Asteraceae in present study. Change in absolute length of the chromosomes play a great role in evolution of plants (Stebbins 1950, 1968). Higher absolute lengths, move towards primitiveness of the taxa (Stebbins, 1968).

Tropical plants have higher absolute lengths when compared to those of temperate and/or alpine species and diploid plants consist of high absolute length than that of polyploid plants (Sakya, 1991).

Absolute length in four taxa of tribe Anthemideae are: 26.7 μ m in *Artemisia abrotanum* (2n=36), 20.4 μ m. in *A. indica* (2n=32), 11.6 μ m in *A. vulgaris* (2n=34) and 23.1 μ m in *Chrysanthemum morifolium* (2n=36). The highest absolute length is

observed in taxa *Chrysanthemum morifolium* and lowest is in taxa *Artemisia vulgaris*. The taxa *Artemisia abrotanum* is nearer to *Chrysanthemum morifolium*.

Among the seven species of Astereae, the absolute length of *Aster barbellatus* (2n=40) is 26.7µm that of *A. ageratoides* (2n=36) is 20.4µm, *A. peduncularis* subsp. *nepalensis* (2n=40) is 23.6 µm, *Conyza canadensis* (2n=22) is 25.7µm, *Dichrocephala integrifolia* (2n=18) is 11.8µm, *Erigeron annuus* (2n=16) is 6.2µm and *Rhynchospermum verticillatum* (2n=18) is 5.1µm. The highest absolute length is observed in the taxa *Aster barbellatus* and lowest is in *Rhynchospermum verticillatum*. The taxa *Aster barbellatus* is closer to *A. peduncularis* subsp. *nepalensis*.

Five species of Chicorieae shows the great variations in their absolute length. Absolute length of chromosomes in: *Crepis japonica* (2n=16) 9µm, *Ixeris polycephala* (2n=16) 11.4 µm, *Sonchus asper* (2n=18) 9.4µm, *Sonchus arvensis* (2n=18) 10µm and *Taraxacum officinale* (2n=20) 18.8µm are determined. The highest absolute length is observed in *Taraxacum officinale* (18.8µm) and lowest is in *Crepis japonica* (9µm). The species *Crepis japonica* is nearer to *Ixeris polycephala* and *Sonchus asper* is nearer to *Sonchus arvensis*.

Absolute length in two taxa of tribe Cynareae are: 19.9µm in *Centaurea cyanus* (2n=24) and 19.1µm in *Cirsium arvense* (2n=34). The absolute length in both species is almost similar. The species *Cirsium arvense* is little far from *Centaurea cyanus*.

Four species of Eupatorieae shows great variations in absolute lengths. The two species of the genus *Ageratum* differed in their absolute lengths. Absolute length in the *Ageratum conyzoides* (2n=20) is 14µm and that of *Ageratum houstonianum* (2n=18) is 10.2µm. The absolute length of *Eupatorium adenophorum* (2n=50) is 18.4µm and that of *Stevia rebaudiana* (2n=22) is 9µm. The highest absolute length observed is in *Eupatorium adenophorum* and lowest is observed in *Stevia rebaudiana*. The species *Ageratum conyzoides* is closer to *Ageratum houstonianum*.

Likewise absolute length in 11 species of Heliantheae shows remarkable variations. Absolute length recorded in the present study are: *Bidens pilosa* (2n=36) 19.2µm, *Coreopsis grandiflora* (2n=26) 14.3µm, *Eclipta prostrata* (2n=22) 13.3 µm, *Galinsoga parviflora* (2n=16) 8.1µm, *Parthenium hysterophorus* (2n=34) 16.9 µm, *Spilanthes acmella* (2n=36) 20.1µm and *S. calva* (2n=36) 16.9 µm, *Tridax*

procumbens (2n=24) 20.9 µm, *Wedelia wallichii* (2n=30) 18.6 µm, *Xanthium strumarium* (2n=32) 15.8 µm and *Zinnia elegans* (2n=24) 17.2µm. The highest absolute length is observed in taxa *Tridax procumbens* and lowest is in *Eclipta prostrata*. The taxa *Spilanthes acmella* is closer to *S. calva*.

Absolute length in eight species of Inuleae are: 13µm in *Anaphalis triplinervis* var. *triplinervis* (2n=28), 12.0µm in *Blumea fistulosa* (2n=18), 8.4µm in *Blumea lacera* var. *glandulosa* (2n=32), 10.8µm in *Blumea laciniata* (2n=18), 8.4µm in *Blumea lacera* (2n=18) and 17.3µm in *Blumea mollis* (2n=22), 12.06µm in *Gnaphalium affine* (2n=14), 19.9µm in *Gnaphalium purpureum* (2n=28). The highest absolute length is observed in taxa *Gnaphalium purpureum* and lowest is in *Blumea lacera*.

Likewise absolute length in two species of tribe Senecioneae are 20.6µm in *Crassocephalum crepidioides* (2n=40) and 10.3µm in *Senecio laetus* (2n=36). The absolute lengths in both species show great variations. Both the taxa are tetraploids and are collected from temperate zone.

Absolute length of *Tagetes patula* (2n=24) is 21.2 µm. This is only one species studied from tribe Helineae. Absolute length is 21.9 µm in *Calendula officinalis* (2n=28). It is only one species studies from tribe Calenduleae. Both the taxa are diploid and collected from temperate zone.

4.2.4 Relative size of chromosome

The difference between largest and smallest chromosomes reflects the nature of the karyotypes. Higher is the ratio greater is the asymmetry (Vaidya, 2005). The reduction of chromosome size may be due to loss of heterochromatic regions (Stebbins, 1950) and their size is believed to be controlled by genotype. Similar reduction in size was reported in *Crepis* by Babcock and Cameron (1934).

In the tribe Eupatorieae smallest chromosome is observed in *Eupatorium adenophorum* ranging from 0.3 to 1.2µm and the longest chromosome is in *Ageratum conyzoides* ranging from 0.8 to 2.1µm. The chromosome in the taxa *Eupatorium adenophorum* is asymmetrical ($M_4+m_{12}+sm_{26}+st_8$) indicating its advancement between the two.

In the tribe Anthemideae smallest chromosome is observed in *Artemisia vulgaris* ranging from 0.4 to 1.2 μ m and longest is observed in *Chrysanthemum morifolium* ranging from 0.8 to 2.1 μ m. The chromosome in the taxa *Artemisia vulgaris* is symmetrical with $2n=M_{16}+sm_{18}$ showing its primitiveness between the two.

In the tribe Chicorieae longest chromosome is observed in *Taraxacum officinale* ranging from 0.8 to 3.0 μ m and smallest are in *Crepis japonica* and *Sonchus asper* ranging from 0.6 to 1.6 μ m. The chromosome in *Taraxacum officinale* is asymmetrical among all taxa of this tribe.

In the tribe Heliantheae, smaller chromosome are found in *Parthenium hysterophorus*, *Xanthium strumarium*, *Wedelia wallichii* ranging from 0.4 to 1.6 μ m and longest is in *Tridax procumbens* ranging from 0.8 to 2.6 μ m. The chromosomes in the taxa *Bidens pilosa* ($2n=M_{16}+m_2+sm_{14}+st_4$) and *Spilanthes calva* ($2n=M_{16}+m_2+sm_{16}+st_2$) are asymmetrical showing its advancedness over all other taxa studied in this tribe.

In the tribe Astereae smallest chromosome is found in *Rhynchospermum verticillatum* ranging from 0.4 to 0.8 μ m and longest is in *Conyza canadensis* ranging from 1.2 to 3.4 μ m. The chromosomes in the taxa *Aster ageratoides* ($2n=M_{14}+m_{10}+sm_{10}+st_2$) and *Conyza Canadensis* ($2n=M_2+m_8+sm_8+st_4$) are asymmetrical. Both of them show advancedness over other studied taxa of this tribe.

In the tribe Inuleae smaller chromosomes are observed in *Anaphalis triplinervis* var. *triplinervis* ranging from 0.4 to 1.6 μ m and longest are in *Gnaphalium affine* ranging from 1.2 to 2.6 μ m. The chromosomes in the taxa *Anaphalis triplinervis* var. *triplinervis* are more asymmetrical with ($2n=M_{14}+sm_{12}+st_2$) than that of *Gnaphalium affine* ($M_{10}+sm_4$) comparatively.

In the tribe Cynareae smaller chromosomes are observed in taxa *Cirsium arvense* ranging from 0.8 to 1.2 μ m and longer are in *Centaurea cyanus* ranging from 0.8 to 2.6 μ m. The chromosomes in the taxa *Centaurea cyanus* are more asymmetrical ($M_{12}+m_6+sm_2+st_4$) than that of *Cirsium arvense* ($M_{16}+sm_{14}+st_4$).

In the tribe Senecioneae smaller chromosomes are observed in taxa *Senecio laetus* ranging from 0.3 to 0.8 μ m and longer are in *Crassocephalum crepidioides* ranging from 0.4 to 3.0 μ m. The taxa *Crassocephalum crepidioides* is more primitive than *Senecio laetus* in chromosome length.

In the tribe Calenduleae small chromosomes are observed in taxa *Calendula officinalis* ranging from 0.4 to 2.6 μ m and in the tribe Helineae long chromosomes are observed in *Tagetes patula* ranging from 0.8 to 3.0 μ m. The karyotype with $2n=M_8+m_8+sm_6+st_2$ in the taxa *Tagetes patula* is more asymmetrical of the tribe Helineae compared to that of the taxa *Calendula officinalis* ($2n=M_{16}+m_4+sm_8$) of the tribe Calenduleae.

4.2.5 Basic number

The basic number generally defined as the lowest known ancestral gametophytic chromosome number present in the taxa. The analysis of world chromosome number data on many species showed that closely related species do often share a common basic number. The genera with only single basic chromosome number or its multiple are for taken as monobasic genera, with two basic chromosome numbers as dibasic genera and with more than two base numbers come under polybasic genera.

The basic chromosome number played a great role in formulating phylogenetic speciations. The basic chromosome numbers vary widely in the family Asteraceae and thus is referred as highly evolved one.

Presently meiotic studies of twenty taxa have been performed. The present determination and previous reports of chromosomes number of the species exhibited great variations in their basic numbers. This view was also supported by Manandhar (2005).

The present study includes three taxa from the tribe Astereae viz. *A. ageratoides*, *A. peduncularis* subsp. *nepalensis* and *Dichrocephala integrifolia*. The haploid chromosome number $n=18$ for *Aster ageratoides*; $n=20$ for *Aster peduncularis* subsp. *nepalensis* and $n=9$ for *Dichrocephala integrifolia* are determined presently. Multibasic number $x=5, 8, 9$ and 10 for the genus *Aster*, $x=9$ for *Dichrocephala integrifolia* are suggested by Darlington and Wylie (1955). Presently studied taxa could be polyploid forms of these basic numbers.

The haploid chromosome number $n=14$ for the taxa *Calendula officinalis* of the tribe Calenduleae is determined in present investigation. Darlington and Wylie (1955) suggested different basic numbers for this species such as $x=7, 8$ and 9 . Basic number $x=8$ was reported for *Calendula officinalis* by Gupta *et al.* (1972). Thus *Calendula officinalis* could be found in tribasic forms.

The three taxa from tribe Cichorieae are included presently. The haploid chromosome number in present investigation is $n=8$ for *Crepis japonica*, $n=9$ for *Sonchus asper* and $n=10$ for *Taraxacum officinale*. Earlier base number for *Crepis japonica* $x=9$ determined by gupta *et al.* (1972). The basic number $x=8$ for *Crepis japonica*, $x=7, 8, 9$ for *Sonchus asper* and $x=8$ for *Taraxacum officinale* are suggested by Darlington and Wylie (1955).

In present study, two taxa *Eupatorium adenophorum* and *Ageratum conyzoides* investigated from the tribe Eupatorieae. Haploid number $n=25$ has been determined for this species in present study. The two base numbers $x=10$ and $x=17$ are suggested by Darlington and Wylie (1955) for the taxa *Eupatorium adenophorum*. Grant (1953) made a cytotaxonomic study on American *Eupatorium* and concluded that 10 and 17 are the two basic numbers of the genus *Eupatorium*. Peng and Hsu (1978), working on Taiwan compositae, reported base number $x=10$ for *Eupatorium* genus. The somatic chromosome number $2n=50$ determined in present study for *Eupatorium adenophorum* may be the multiple form of $x=10$. Previously reported taxa ($2n=51$) by Khonglam and Singh (1980) could be evolved form of basic number $x=17$. It could be concluded that, the tribe Eupatorieae is existed with two basic numbers $x=10, 17$.

The meiotic analysis shows $n=10$ in the taxa *Ageratum conyzoides* in present study. Darlington and Wylie (1955) suggested $x=10$ basic number for the species *Ageratum conyzoides*.

A wide range of basic numbers ($x=5, 7, 8, 9, 10, 11, 13$) exist in the tribe Inuleae (Darlington & Wylie 1955). In the present study two taxa *Anaphalis triplinervis* var. *triplinervis* and *Gnaphalium purpureum* are investigated with $n=14$ in both species. Thus present investigation supports the existence of the basic number $x=7$. Primitive genera represent lowest basic number ($x=5$) whereas relatively advanced genera represent higher numbers ($x=11, 13$) and ($x=7, 8, 9$) occupy intermediate position in the tribe Inuleae according to Hutchinson (1926).

Six taxa from Heliantheae viz. *Bidens pilosa*, *Eclipta prostrata*, *Galinsoga parviflora*, *Parthenium hysterophorous*, *Wedelia wallichii* and *Xanthium strumarium* are investigated presently and $n=18, n=11, n=8, n=17, n=15$ and $n=16$ have been found respectively. The basic chromosome number of *Bidens* has been reported by

Darlington and Wylie (1955) as $x=12$. In the present study the chromosome number $2n=36$ in *Bidens pilosa* is recorded. The number $n=12$ could be haploid number for *Bidens pilosa*.

The haploid chromosome number $n=11$ for the genus *Eclipta prostrata* in present study has been recorded. This number confirmed the earlier result by Gupta (1969). Basic chromosome number $x=11$ was suggested by Darlington and Wylie (1955) for this taxa.

The haploid chromosome number $n=8$ has been determined for taxa *Galinsoga parviflora* in present study. Stuessy (1977) strongly suggested the base number $x=8$ for the genus *Galinsoga*. Darlington and Wylie (1955) also suggested $x=8$ for this species. The basic chromosome number $x=17$ was suggested by Darlington and Wylie (1955) for *Parthenium hysterophorus*. The haploid chromosome number $n=17$ has been determined for taxa *Parthenium hysterophorus* in present study. Meiosis reveals $n=15$ in the taxa *Wedelia wallichii* in present study. According to McVaugh (1984) *Wedelia* is a cytologically complex genus with an apparent aneuploid series of base numbers ranging from $x=10$ to $x=15$.

Darlington and Wylie (1955) reported the basic chromosome number $x=9$ and $x=18$ for *Xanthium strumarium*. In present study haploid number $n=16$ is determined for this taxa.

The earlier basic number $x=7$ for taxa *Tagetes patula* of the tribe Helineae was suggested by Gupta (1969). The haploid chromosome number $n=12$ determined in present study tallies with Sharma (1970). The basic number $x=8$ has been suggested by Darlington and Wylie (1955) for this species.

One taxa *Crassocephalum crepidioides* of the tribe Senecioneae is meiotically investigated in present study with haploid number $n=20$. The basic chromosome number $x=10$ is suggested by Darlington and Wylie (1955) for this taxa.

4.2.6 Chromosome number

In the species of family Asteraceae various chromosome numbers are reported in the present study. Changes in chromosome number play an important role in plant evolution and they are the bearers of the genes or hereditary factors (Stebbins, 1950).

From the tribe Astereae *Aster barbellatus*, *A. ageratoides*, *A. peduncularis* subsp. *nepalensis*, *Conyza canadensis*, *Dichrocephala integrifolia*, *Erigeron annuus* and *Rhynchospermum verticillatum* have been investigated. Present chromosome counts for *A. barbellatus* ($2n=40$) and *A. peduncularis* subsp. *nepalensis* ($2n=40$) are perhaps new records. The diploid count $2n=22$ for *Conyza canadensis* in present study is different from $2n=18$ (Hollingsworth *et al.*, 1992; Huber & Baltisberger, 1992). It reveals that this taxa is found in different cytotypes. Present chromosome count $2n=18$ for *Dichrocephala integrifolia* tallies with previously determined number by Peng and Hsu (1978), and Morton (1993). Present chromosome count $2n=16$ for *Erigeron annuus* is different from the reports $2n=26$ (Chojnacki *et al.*, 1982; Chojnacki *et al.*, 1980) and $2n=27$ (Nesom, 1978; Dmitrieva, 2000). This may be due to intraspecies variations among the taxa. The diploid chromosome count for *Rhynchospermum verticillatum* ($2n=18$) tallies with the report of Peng and Hsu (1977, 1978).

From the tribe Anthemideae *Artemisia abronatum*, *A. indica*, *A. vulgaris* and *Chrysanthemum morifolium* have been studied. Chromosome count for *Artemisia abronatum* is $2n=36$ which is similar to the result of Kreitshitz and Valles (2003) but it is different from previous reports $2n=20$ (Mathew & Mathew, 1988); $2n=18$ (Johnson & Brandham, 1997; Kreitschitz & Vallès, 2003). It may be found in euploid (tetraploid) form that is suggested by above authors (Johnson & Brandham, 1997; Kreitschitz & Vallès, 2003). Chromosome count determined for *Artemisia indica* is $2n=36$ in present count is perhaps new report for Nepal. Diploid number ($2n=34$) for *Artemisia vulgaris* tallies with Khatoon and Ali (1993) but it differs from previous reports $2n=18$ (Magulaev, 1992); $2n=36$ (Nirmala & Rao, 1984) and $2n=54$ (Nirmala & Rao, 1984). Thus *Artemisia vulgaris* has been found to be in polyploid forms. Present chromosome count ($2n=36$) in *Chrysanthemum morifolium* tallies with the result ($2n=36$) by Guo *et al.* (2012).

From tribe Calenduleae *Calendula officinalis* is included in present study. Present chromosome count for this species $2n=28$ tallies with Vachova (1978) but it differs with $2n=32$ by Czapik, 1989; Baltisberger and Huber, 1987; Pogan *et al.* 1990 and Murín, 1997. It has been found in two cytotypes.

From tribe Cichorieae *Crepis japonica*, *Sonchus asper*, *Sonchus arvensis*, *Taraxacum officinale* and *Ixeris polycephala* are included in present study. Present chromosome

count $2n=16$ for *Crepis japonica* is diploid which is also confirmed by the result of previous haploid number $n=8$ that is determined by Mathew and Mathew (1988), and Gupta and Gill (1989). Chromosome count $2n=18$ for *Sonchus asper* in present study is similar to the reports of Nazarova (1984, 1989); Nishikawa (1984) and Kiehn *et al.* 2000. However $2n=36$ was reported by Kuzmanova and Georgieva (1976), and Belaeva and Siplivinsky (1976). This species is found to be in polyploid forms. Chromosome number $2n=18$ for *Sonchus arvensis* is similar to the reports of Prabha and Roy (1986), and Mathew and Mathew (1988), but it is different from the reports $2n=34$ by Joshi (1988); Kuzmanov *et al.* (1986); Nazarova (1984, 1989); Dmitrieva (1987) and Gorzko *et al.* (1980). This species may be found in polyploidy and aneuploid forms. The diploid chromosome number for *Ixeris polycephala* is $2n=16$. This number tallies with the reports of Pak and Kawano (1990), and Kim and Ko (1991). Pak and Kawano (1990) reported the diploid number $2n=14$. So this species may be found in two cytotypes $2n=14$ and $2n=16$. Chromosome count of *Taraxacum officinale* $2n=20$ in the the present study is different from previous reports $2n=24$ by Zhai *et al.* (1997); Kartashova *et al.* (1974); Kashin *et al.* (2003); Dmitrieva (2000) and Verduijn (2004). The number $2n=32$ (Kashin *et al.* 2003) and $2n=26$ (Gupta & Garg 1987) has also been reported for this taxa. Thus in this taxa intraspecific variations seem to be established.

From tribe Cynareae, *Centaurea cyanus* and *Cirsium arvense* have been researched in present study. Present chromosome count $2n=24$ for *Centaurea cyanus* tallies with the reports of Arohonka (1982), Huber and Baltisberger (1989). Presently encountered number $2n=34$ for *Cirsium arvense* is different from $2n=31$ reported by Joshi (1988). It is perhaps the new number for this species.

From tribe Eupatorieae *Ageratum conyzoides*, *A. houstonianum*, *Eupatorium adenophorum* and *Stevia rebaudiana* are included in present study. At present the diploid chromosome number $2n=20$ encountered in *Ageratum conyzoides* tallies with the result of Nirmala and Rao (1981) but differs from previous different reports viz. $2n=40$ by Mathew and Mathew (1983, 1988), Xie and Zheng (2003); $2n=38$ by Chen *et al.* (2003) and $2n=30$ by Morton (1993). So it is found in aneuploid and polyploid forms. Chromosome count in *Ageratum houstonianum* is $2n=18$ which differed from previous report $2n=20$ (Nazeer *et al.*, 1981; Sharma and Dharke, 1981; Mathew and A. Mathew, 1983; George *et al.*, 1989 and Morton, 1993). Present number may be in

aneuploid form. Present observation in *Eupatorium adenophorum* shows $2n=50$ while in previous report it was $2n=51$ (Khonglam & Singh 1980). This species is found to be existed with higher polyploid forms. Chromosome number $2n=22$ for *Stevia rebaudiana* tallies with the report of Frederico *et al.* (1996).

From tribe Heliantheae *Bidens pilosa*, *Coreopsis grandiflora*, *Eclipta prostrata*, *Galinsoga parviflora*, *parthenium hysterophorous*, *Spilanthes acmella*, *S. calva*, *Tridax procumbens*, *Wedelia wallichii*, *Xanthium strumarium* and *Zinnia elegans* are included in present study. Chromosome number in *Bidens pilosa* var. *minor* ($2n=36$) determined in present study tallies with Sharma (1970) but number $2n=72$ (Banerjee, 1971) and $2n=48$ (Pilz, 1980) are different from present number. This taxa also has been found in polyploid forms which is evidenced from the haploid number $n=12$ by Keil and Stuessy (1975). Present chromosome count $2n=26$ for *Coreopsis grandiflora* tallies with the report of Mathew and Mathew (1988), and Gupta and Gill (1981).

Chromosome count for *Eclipta prostrata* ($2n=22$) is similar to the number reported by Dutta and Shaha (1971) and Nirmala and Rao (1986). Chromosome number for *Galinsoga perviflora* is $2n=16$ which tallies with the reports of Gopinathan and Babu (1982), Nirmala and Rao (1984) and Jose and Mathew (1995).

Chromosome count for *Parthenium hysterophorus* is $2n=34$. Same number was reported by Bakale and Srinivasu (1986). Nirmala and Rao (1984) and Piazzano *et al.* (1998) but it is different from $2n=36$ reported by Mathew and Mathew (1988). It may be found in two cytotypes. Chromosome number $2n=36$ in *Spilanthes acmella* is different from the report ($2n=46$) that was observed by Nirmala and Rao (1981, 1984, 1989). The chromosome number $2n=52$ is also noted by Mathew and Mathew (1988). Thus various numbers are found for this species.

Likewise present chromosome number for *S. calva* $2n=36$ is different from the result $2n=72$ by Jose and Mathew (1995). This species has been found also in polyploid form which is confirmed from basic number $x=12$ by Darlington and Wylie (1955) for this species. Chromosome count in present study for *Tridax procumbens* is $2n=26$ which is different from the reports $2n=36$ by Sidhu and Pelia (1987), Baltisberger (1990), Nirmala and Rao (1981, 1984, 1985), Xie and Zheng (2003). This species has been found in two cytotypes.

Chromosome number $2n=30$ for *Wedelia wallichii* in present investigation is perhaps new record for this species. Chromosome count $2n=32$ in present study for *Xanthium strumarium* is different from the reports of $2n=34$ by Mohamed (1997), $2n=36$ by Love and Love (1982), Bakale and Srinivasu (1988), Mathew and Mathew (1988), Jose and Mathew (1995), Rostovtseva (1979), Sidhu (1979), Bir and Sidhu (1980), Skalinska (1974) and Joshi (1988). Chromosome number $2n=24$ for *Zinnia elegans* in present investigation tallies with the previous reports (Banerjee, 1971; Gupta *et al.*, 1983; Mathew and Mathew, 1988; Zhao *et al.*, 1990; Nirmala and Rao, 1984, 1990; Murín, 1993; Jose and Mathew, 1995; Huang and Zhao, 1995 and Chen *et al.*, 2003) but it is different from the report $2n=36$ by Gupta *et al.* (1983). This species has been found in polyploid forms which is confirmed by the haploid number $n=12$ (Powell & Powell, 1978; Razaq *et al.*, 1988, 1994; Banerjee, 1971; Husaini & Iwo, 1990; Gupta & Gill, 1989; Jose & Mathew, 1995).

From tribe Helineae *Tagetes patula* is included in the present study. Chromosome number $2n=24$ for *Tagetes patula* determined tallies with the report ($2n=24$) of Nirmala and Rao (1984, 1986) but differs from the report $2n=48$ (Probatova *et al.*, 1991; Murín, 1993; and Serrato-Cruz *et al.*, 2000).

From tribe Inuleae *Anaphalis triplinervis* var. *triplinervis*, *Gnaphalium affine*, *G. purpureum*, *Blumea fistulosa*, *B. lacera*, *B. lacera* var. *glandulosa*, *B. laciniata* and *B. mollis* are included in present study. Present report $2n=28$ for *Anaphalis triplinervis* var. *triplinervis* tallies with Sharma (1970). Previously the chromosome number for *Blumea fistulosa* were found to be $2n=18$ (Gupta & Gill, 1979; Mathew & Mathew, 1988) and $2n=30$ (Gupta, 1983; Gupta & Gill, 1989). Present count for this species ($2n=22$) is new number. Likewise present chromosome number for *Blumea lacera* is $2n=18$ tallies with Nirmala and Rao (1984, 1990). For this species $2n=36$ has been reported by Peng and Hsu (1977, 1978).

Present chromosome count for *Blumea lacera* var. *glandulosa* ($2n=32$) is different from previous reports $2n=(18, 22)$ by Verma and Vijayavalli (1998) and ($2n=36$) by Mathew and Mathew (1975). This is the case of intraspecies variations among the taxa. Chromosome number for *Blumea laciniata* $2n=18$ tallies with Peng and Hsu (1977) and Sharma (1970). Present diploid number ($2n=22$) for *Blumea mollis* is similar to the report of Verma and Vijayavalli (1998) but it is different from the

previous report ($2n=18, 20$) by Verma and Vijayavalli (1998). The various numbers found for this species are due to the existence of different cytotypes. Chromosome number for *Gnaphalium affine* ($2n=14$) in present study is similar to the report of Nishikawa (1984). Present chromosome number $2n=28$ for *Gnaphalium purpureum* tallies with the reports of Sidhu and Bir (1983), and Peng and Hsu (1977, 1978).

Crassocephalum crepidioides and *Senecio laetus* are included from the tribe Senecioneae in present study. Chromosome count of *Crassocephalum crepidioides* ($2n=40$) tallies with the counts of Baltisberger, 1990; Morton, 1993; Daniela, 1997; Henderson 1973, and Mathew and Mathew, 1988. The chromosome count for *Senecio laetus* is $2n=36$ which is perhaps the new count for this species.

4.2.7 Satellites

Satellite, a small terminal segment of a chromosome separated from the rest by nucleolar constriction, play a significant role in the study of karyotypes (Sakya, 1991). Satellites are directly related to those portions of the chromosome which form the nucleoli and are separated from the rest of the chromosome by a secondary constriction. Gates (1911) reviewed in detail the relationship between nucleoli and satellites. It is known that most diploid species bear only one pair of satellite which is usually located at the end of the short arm of a chromosome with a sub-terminal centromere (Stebbins, 1950). Satellites at long arms of chromosomes also has been encountered in a member (*Delphinium vestitum*) of Ranunculaceae (Vaidya, 2005).

In present investigation chromosome bearing satellite is observed in only one species *Blumea fistulosa* of the tribe Inuleae. A pairs of satellite observed in short arms of the chromosomes in this taxa. However, satellited chromosomes have been noted in many taxa of Asteraceae by previous authors. Three pairs of satellited chromosome were observed by Tanaka and Shimotomai (1961) in some species of the genus *Chrysanthemum*. However, two pairs of satellited chromosomes were noted in ananeuploid ($2n=31$) taxa *Cirsium arvense* by Joshi (1988). Anagnostopoulos (1997) noted satellites chromosomes of some of Asteraceae species of *Crepis*.

4.2.8 Polyploidy

Polyploidy is one of the major evolutionary forces in plants and in particular in the largest angiosperm family Asteraceae. This chromosome set multiplication directly

impacts the nuclear DNA contents, in terms of variation at holoploid and monoploid levels. Other karyological changes such as aneuploidy or dysploidy might produce genome size alterations as well, therefore, are playing also a relevant role as evolutionary forces. All these factors may promote speciation, thus have systematic implications (Vallès *et al.* 2012).

Polyploid species can exhibit higher ecological tolerance than their progenitor species. From the evolutionary standpoint meiotic instability may be considered as a source of variation whereas the reduced gametes and somatic doubling increase the level of polyploidy (Koul, 1964). Polyploidy may occur due to abnormal cell division either during mitosis commonly or during metaphase I in meiosis.

Polyploidy, is one of the best known evolutionary process and in addition it is the most rapid method of producing radically different but vigorous and well-adapted genotypes. Polyploids are better adapted than diploids to cold and other adverse conditions (Vaidya, 2005). Chromosome counts suggest that between 30 and 80 % of angiosperm species are polyploids, while genomic studies of selected model and crop species reveal evidence of extensive ancient genome-wide multiplications (Blanc & Wolfe, 2004; Bowers *et al.*, 2003 and Cui *et al.*, 2006). Higher percentage of polyploidy is found in perennial herbs (Stebbins 1968). Grant (1971) suggested that the tendency for polyploidy is strong in herbaceous dicotyledons.

Chemical mitotic inhibitory agents such as colchicine or dinitroanilines are used to induce polyploidy in crop plants. A typical example is the production of tetraploid watermelon plants (Compton *et al.*, 1996). Comai (2005) suggested that tetraploids are the most common class of euploids. According to him, there are several disadvantages of polyploidy, both documented and theoretical. They include the disrupting effects of nuclear and cell enlargement.

In the present study almost all species have been found in polyploid forms. The diploids to heptaploids are revealed in the present investigation.

From tribe Eupatorieae *Ageratum conyzoides* ($2n=20$), *A. houstonianum* ($2n=18$), *Eupatorium adenophorum* ($2n=50$) and *Stevia rebaudiana* ($2n=22$) have been investigated. All the taxa studied from this tribe are found to be polyploid forms. *Ageratum conyzoides* has found to be descending triploid with basic number $x=7$

presently but it has been found that *Ageratum conyzoides* growing in the hotter parts of India was a tetraploid with $2n=40$ (Kaul, 1965a). It was reported as a stable polyploid that possesses high reproduction capacity due to high seed fertility (Kaul, 1967). Two chromosome races $2n=20$ and $2n=40$ were established as diploid and tetraploid for this species by Gupta (1969). Somatic chromosome analysis revealed that *Ageratum houstonianum* has been found to be descending triploid form with basic number $x=7$ at present study. Somatic chromosome number $2n=40$ for this species was determined by Shukur *et al.* (1977).

Eupatorium adenophorum ($2n=50$) has been found to be a heptaploid one in present study with basic number $x=7$, however $2n=51$ had showed by Khonglam and Singh (1980). So the later could be a polyploid of base number $x=17$. Grant (1953) concluded two basic numbers $x=10$ and $x=17$ numbers for the genus *Eupatorium*. Moreover polyploidy has played a major role in the evolution of *Eupatorium* (Peng & Hsu, 1978). Darlington and Wylie (1955) also suggested two basic numbers $x=10, 17$ for this genus. *Stevia rebaudiana* of the same tribe found to be ascending triploid form with base number $=7$ in present study.

The species of two genera *Artemisia* and *Chrysanthemum* from tribe Anthemideae have been worked presently viz. *Artemisia abrotanum* ($2n=36$), *A. indica* ($2n=32$), *A. vulgaris* ($2n=34$) and *Chrysanthemum morifolium* ($2n=36$). All three species of the genus *Artemisia* have been found to be in polyploid forms in present study. *Artemisia indica* ($2n=32$) has been found to be ascending pentaploid form with basic number $x=6$ and *A. abrotanum* ($2n=36$) found to be normal hexaploid form with basic number $x=6$. Similar result was observed by Li *et al.* (2010). *Artemisia vulgaris* ($2n=34$) has found to be descending hexaploid form of basic number $x=6$. Oliva and Valles (1994) was found the basic chromosome number $x=8$ for *Artemisia vulgaris*.

The species *Chrysanthemum morifolium* in present study ($2n=36$) has found to be hexaploid form with basic number $x=6$. Basic number $x=9$ was suggested by Darlington and Wylie (1955) for this species. It is generally considered that in the genus *Chrysanthemum* has several rounds of allopolyploidization from low ploidy $2n=28$ to high ploidy $2n=58$ (Fedorov, 1969). According to Wang *et al.*, (2010), the colour also changes as the ploidy level increases. Yellow colour is primitive whereas white, purple and red are thought to be evolved from yellow sequentially. Orange,

pink and complex colours are formed at last. According to Lawrence (1980) many domestic autopoloid plants are larger than their corresponding diploids.

The taxa *Calendula officinalis* ($2n=28$) from tribe Calenduleae in present investigation has been found to be tetraploid form with basic number $x=7$. Previously $x=7, 8, 9$ were suggested by Darlington and Wylie (1955).

From the tribe Astereae *Aster ageratoides* ($2n=36$), *A. barbellatus* ($2n=40$), *A. peduncularis* var. *nepalensis* ($2n=40$) have been found as polyploids of base number $x=6$ in present study. *Aster ageratoides* has been found in normal hexaploid form, *A. barbellatus* and *A. peduncularis* var. *nepalensis* have been found in descending heptaploid form in present study of base number $x=6$. Basic chromosome number for *Aster ageratoides* ($x=9$) was suggested by Darlington and Wylie (1955). In the tribe Astereae base number 4, 5, 6, 7, 8, 9 and 11 were reported by Gupta (1969). The taxa *Conyza canadensis* ($2n=22$) has been found to be descending tetraploid form of base number $x=6$. Darlington and Wylie (1955) have suggested $x=9$ for this species. The taxa *Dichrocephala integrifolia* ($2n=18$) and *Rhynchospermum verticellatum* ($2n=18$) have been found in triploid forms of base number $x=6$ in present study from the same tribe Astereae.

From the tribe Inuleae eight taxa have been included in present investigation. The taxa *Anaphalis triplinervis* var. *triplinervis* with $2n=28$ in present study is found in tetraploid form of base number $x=7$ in present study. Polyploidy, for the first time, was reported for *Anaphalis* by Huziwara (1957). *Gnaphalium affine* could be diploid ($2n=14$) and *G. purpureum* ($2n=28$) found to be tetraploid form of base number $x=7$. In the present study of same tribe Inuleae. The genus *Gnaphalium* is also existed with chromosome number $2n=14$ and $2n=16$ in *Gnaphalium polycaulum* (Verma & Vijayavalli, 1998).

All five species of *Blumea* studied presently from the same tribe Inuleae found to be polyploid forms. *B. lacera* var. *glandulosa* ($2n=32$) has been found to be descending pentaploid form of base number $x=7$. Gupta (1969) reported haploid number $n=10$ for this species. *B. lacera* ($2n=18$) and *B. laciniata* ($2n=18$) have been found to be descending triploid forms of base number $x=7$ in present study. Basic numbers $x=8, 9, 10, 11$ are observed by Peng and Hsu (1978). *B. fistulosa* ($2n=22$) and *B. mollis*

($2n=22$) found to be ascending triploid forms of base number $x=7$ in present study. Five haploid chromosome numbers are known in genus *Blumea* $x=8, 9, 10$ and 11 or 12 according to Mathew and Mathew (1975). The authors consider that $x=10$ in *Blumea* could be the earlier evolved condition from which the lower constitutions have been evolved. This was an interesting case of dysploidy in a single species.

Centaurea cyanus and *Cirsium arvense* two taxa are included from the tribe Cynareae in present study. The taxa *Centaurea cyanus* ($2n=24$) has been found to be tetraploid form with the basic number $x=6$ in present study. The same number was previously reported by Strid (1987). According to Garcia jacas *et al.* (1998) tetraploidy is common for the taxa *Centaurea*. The species *Cirsium arvense* ($2n=34$) seems to be a descending hexaploid form in present investigation of base number $x=6$. However, Mehra *et al.* (1965) reported $n=17, 18$ for this species. So it is possible that in this species, the original basic number was $x=6$ and higher haploid numbers may be secondarily derived ones.

Five taxa from the tribe Cichorieae included in present study. The taxa *Sonchus arvensis* ($2n=18$) and *Sonchus asper* ($2n=18$) have found to be normal triploid forms with basic number $x=6$. The count ($2n=36$) by Joshi (1988) for *Sonchus arvensis* was different. The latter count may be of hexaploid form of this species.. *Taraxacum officinale* ($2n=20$) has found to be ascending triploid form with basic chromosome number $x=6$ in present investigation. But different somatic number for this species determined by previous authors are: $2n=16$ (Kashin *et al.*, 2003; Verduijn, 2004), $2n=24$ (Kartashova *et al.*, 1974; Kashin *et al.*, 2003; Dmitrieva, 2000; Verduijn, 2004), $2n=26$ (Gupta & Garg, 1987), $2n=32$ (Lavrenko & Serditov, 1987; Kashin *et al.*, 2003). The basic number for this species $x=8$ was determined by Darlington and Wylie (1955). So this species has been found in polyploid forms as well as in different cytotypes. The different cytotypes with variable basic chromosome numbers play great role in speciation of this taxa. *Crepis japonica* ($2n=16$) and *Ixeris polycephala* ($2n=16$) of the same tribe have been found to be descending triploid forms of base number $x=6$ in present study.

Two taxa *Crassocephalum crepidioides* and *Senecio laetus* from the tribe Senecioneae included in present investigation. *Crassocephalum crepidioides* ($2n=40$) has found to be descending heptaploid form of base number $x=6$ and *Senecio laetus* ($2n=36$) has

found to be hexaploid form of same base number in present study. Recently Ornduff *et al.* (1963, 1967) have proposed a base number of $x=10$ for Senecioneae. A similar observation was made by Baltisberger (1990), Morton (1993), Daniela (1997), Henderson (1973), Mathew and Mathew (1988) for *Crassocephalum crepidioides*.

From the tribe Heliantheae eleven taxa have been included in present investigation. The Basic chromosome number $x=12$ for *Bidens pilosa* has been proposed by Darlington and Wylie (1955). *Bidens pilosa* ($2n=36$) has been found in hexaploid form with basic chromosome number $x=6$ in present study. Mariano and Marin-Morales (1999) found in two different polyploid numbers: $2n=48$ and $2n=72$ indicating that polyploidy is an important evolutionary process for this genus.

Coreopsis grandiflora ($2n=26$) has been found in ascending tetraploid form with basic number $x=6$ in present study. Haploid number $n=13$ (Gupta & Gill, 1989) and $n=12$ (Jose & Mathew, 1995) was reported for this species. Darlington and Wylie (1955) was suggested two basic numbers $n=12, 13$ for this species. *Eclipta prostrata* ($2n=22$) has been found in descending tetraploid form with basic number $x=6$ and haploid number $n=11$ in present study. Haploid number $n=12$ was reported by Husaini and Iwo (1990) for this species. *Galinsoga perviflora* ($2n=16$) has been found in descending triploid form of base number $x=6$ and haploid number $n=8$ in present investigation. Similar haploid number reported by many authors (Appendix) for this species. However, $n=16$ was also reported by Canne (1983) for this species. *Parthenium hysterophorus* ($2n=34$) has been found to be descending hexaploid form with haploid number $n=17$ and basic number $x=6$ in present study. Haploid number $n=17$ was made by Nirmala and Rao (1984), Piazzano *et al.* (1998), Turner *et al.* (1979), Henderson *et al.* (1977), Xie and Zheng (2003). Basic number for *P. hysterophorus* is $x=9, 8$ according to Darlington and Wylie (1955). So presently studied species could be an aneuploid one. In the genus *Parthenium* the apomictic and polyloid species was also found by Grant (1971).

Spilanthes acmella ($2n=36$) in present study has been found in hexaploid form with basic number $x=6$. Somatic chromosome number $2n=46$ by Nirmala and Rao (1981, 1984, 1989), $2n=52$ by Mathew and Mathew (1988) have been reported. This may be the case of intraspecific variations and it is one of the clue for speciation in this species. *Spilanthes calva* ($2n=36$) in present study might be hexaploid form with basic number

$x=6$. Polyploid count ($2n=72$) for this species was also reported previously (Jose & Mathew 1995). The basic chromosome number $x=12$ is suggested by Darlington and Wylie (1955). Thus species seems to be found in higher polyploid forms. The polyploidy seems to play role in evolution for this species.

Xanthium strumarium is an ascending aneuploid plant with $2n=32$ in present investigation. The chromosome number ($2n=36$) have been reported by different authors (Love & Love, 1982; Joshi, 1988; Bakale & Srinivasu, 1988; Mathew & Mathew, 1988; Jose & Mathew 1995). Thus *Xanthium strumarium* seem to be normal hexaploid form of basic number $x=6$ with haploid number=16. The two basic chromosome number $x=8$ and 9 are also suggested by Darlington and Wylie (1955) for this species.

Tridax procumbens with $2n=24$ chromosome number is found to be tetraploid form in present study. A similar observation was made by Fazili *et al.* (2011). Hexaploids are also recorded by Gupta (1969) with 18 bivalents in same species. The latter author also have observed cytomixis in this species. It is concluded that *Tridax procumbens* have been found to be in both tetraploid form and hexaploid form in nature. *Wedelia wallichii* ($2n=30$) in present study has been found in pentaploid form with basic number $x=6$. The basic number $x=10$ was suggested by Turner and Irwan (1960) for this species. *Zinnia elegans* with chromosome number $2n=24$ has been found to be tetraploid form of basic number $x=6$ in present investigation. Similar results were shown by various authors (Appendix). However, different result ($2n=36$) is also obtained by Gupta *et al.* (1983). Basic number $x=12$ was suggested by Darlington and Wylie (1955). *Z. elegans* is found in many varieties with different coloured flowers in nature. Polyploids with larger flowers have been induced and introduced in culture (Elliott, 1958).

From the tribe Helineae *Tagetes patula* is included in present study. *Tagetes patula* ($2n=24$) has been found to be tetraploid form of base number $x=6$ in present study. Previous report $2n=48$ (Probatova *et al.*, 1991; Serrato-Cruz *et al.*, 2000) may be of octaploid form of this taxa.

4.2.9 Meiosis

Meiosis is a complex process and is of great significance in the life cycle of plants and animals which reproduce sexually. Meiosis helps in keeping the number of chromosomes constant in the species. Variation in meiosis is the root cause of evolution (Shukla and Chandel, 1988).

In present investigation twenty species from nineteen genera of Asteraceae have been carried out meiotically. Most of the taxa such as *Ageratum conyzoides*, *Artemisia indica*, *Aster ageratoids*, *Aster peduncularis* subsp. *nepalensis*, *Bidens pilosa* var. *minor*, *Crepis japonica*, *Crassocephalum crepidioides*, *Dichrocephala integrifolia*, *Eclipta prostrata*, *Galinsoga parviflora*, *Gnaphalium purpureum*, *Tagetes patula*, *Taraxacum officinale*, *Wedelia wallichii* and *Xanthium strumarium* show regular meiotic divisions. Slightly irregular meiosis has been observed in the taxa *Anaphalis triplinervis* var. *triplinervis*, *Calendula officinalis*, *Eupatorium adenophorum* and *Parthenium hysterophorus*.

In pollen mother cells of most of the taxa rod bivalents are observed at diakinesis in present study. The occurrence of more rod bivalents in most of the taxa suggests that evolution among the taxa might have been taken place mainly by traslocation (Sakya, 1991).

Ageratum conyzoides and *Eupatorium adenophorum* from the tribe Eupatorieae are meiotically studied. In *Ageratum conyzoides* though meiosis is normal, little irregularities have been seen. Non-synchronized division has observed at telophase-II. The tetraploid *Ageratum conyzoides* exhibited a normal meiosis and high seed formation was noted by Kaul (1965a). Regular meiosis has been observed in *Ageratum conyzoides* by Gupta *et al.* (1972) also. An irregular meiosis has been observed in the taxa *Eupatorium adenophorum* with non-synchronized division at telophase-II during present investigation. In this taxa sticky nature has occurred.

The two taxa *Anaphalis triplinervis* var. *triplinervis* and *Gnaphalium purpureum* from the tribe Inuleae have been investigated meiotically in present study. *Anaphalis triplinervis* var. *triplinervis* with sticky bivalents show irregular meiosis. It may bring variability in species. The haploid chromosome number (n=14) of *Gnaphalium purpureum* confirms the earlier report by Mathew and Mathew (1988). Ring bivalents

have observed in this taxa. Triad pollens are also observed frequently. The haploid number $n=7$ was encountered by Mehra and Remanandan (1975).

The taxa *Artemisia indica* is included in present study from the tribe Anthemideae. The meiosis is normal with a few irregularities. Some irregularities are: formation of dyads, triads etc. Formation of dyads may due to separation of nuclei immediately after telophase-I by cross wall.

The three taxa at present study from the tribe Astereae include *Aster ageratoides*, *A. peduncularis* subsps. *nepalensis* and *Dichrocephala integrifolia*. The haploid chromosome number for *Aster ageratoides* is $n=18$. Dyad has been observed in this species. Dyads are formed after T-I without undergoing division of chromosomes. Egizia *et al.* (1994) suggested that the separation of chromatids followed by cytokinesis resulted dyads which do not undergo the second division and directly develop microspores with the reduced chromosome numbers. Tetrad with abortive microspores has observed in this taxa. The haploid chromosome number in *A. peduncularis* subsps. *nepalensis* ($n=20$) has noted in the present study. In this taxa, rod bivalents and non-synchronized chromosomes are observed. Presence of rod bivalents indicates the failure of pairing due to reduced homology between the members of the two genomes and due to structural differences in the karyotype (Vaidya, 2005). Meiotic pairing has been regarded as a good criterion of involvement for the formation of polyploidy. In *Dichrocephala integrifolia* meiosis is normal though few irregularities have occurred.

Six taxa from the tribe Heliantheae are meiotically investigated in present study viz. *Bidens pilosa*, *Eclipta prostrata*, *Galinsoga parviflora*, *Parthenium hysterophorus*, *Wedelia wallichii* and *Xanthium strumarium*. Meiotic behavior of *Bidens pilosa* is found to be completely normal in present study. The present haploid number for this taxa is $n=18$. Previously haploid number $n=12$ was reported by Gill (1978a, 1978b), and Keil and Stuessy (1977). Higher ploid $n=36$ was noted by Nirmala and Rao (1981), Shrama (1970), Keil and Stuessy (1977), Banerjee (1971), Robinson *et al.* (1981). Polyploid origin of the species is supposed to have played a great role in evolution. Present haploid number ($n=11$) for *Eclipta prostrata* confirms the earlier reports by Razaq *et al.* (1988, 1994) but it is different from $n=12$ by Husaini and Iwo (1990). So, two races $x=11$ and 12 are existed in this species. Present haploid

chromosome number $n=8$ for *Galinsoga parviflora* confirms the previous reports (Banerjee, 1971; Gupta & Garg, 1987; Gill & Omoigui, 1988 and Husaini & Iwo, 1990). In this species haploid chromosome numbers $n=16$ (Canne, 1983, Weedin & Powell, 1978) had also been noted. Meiosis in this taxa is almost normal in presently studied individuals. However, absence of pairing among meiotic chromosomes, presence of quadrivalents, anaphase bridges and laggards during meiosis also was noted by Gopinathan and Babu (1982) for this taxa.

In *Parthenium hysterophorus* multivalents have been observed during present investigation. The formation of multivalent may be due to allopolyploidy (Stebbins, 1950). According to McVaugh (1984) *Wedelia* is a cytologically complex genus with an apparent aneuploid series of base numbers ranging from $x=10$ to $x=15$. In present study gametophyte chromosome number $n=15$ is observed in this taxa *Wedelia wallichii* but meiosis is quite normal. The present haploid chromosome number is $n=16$ for *Xanthium strumarium*. The earlier report ($n=18$) was reported by Sarkar *et al.* (1982), Mathew and Mathew (1988), and Gupta and Gill (1989). Although the meiotic behavior in this taxa is normal, two laggards are observed at anaphase-I. As the meiosis is regular, high pollen stainability has been seen at present investigation.

In the tribe Calendulae only one taxon *Calendula officinalis* is studied. Haploid chromosome number $n=14$ has observed in present observation. Earlier haploid number ($n=16$) was reported by Gupta (1969). So *Calendula officinalis* may be existed with two haploid numbers. Regular meiosis was observed in this species by Gupta *et al.* (1972).

The only one taxa *Crassocephalum crepidioides* from the tribe Senecioneae is investigated meiotically in present study. The present haploid number $n=20$ confirmed earlier reports (Henderson, 1973; Gill & Omoigui, 1987; Mathew & Mathew, 1988). Although, a laggard, chromatin bridges and stickyness have been observed at T-I, normal meiotic behavior has found in present investigation.

The three taxa *Crepis japonica*, *Sonchus asper* and *Taraxacum officinale* have studied from the tribe Cichorieae meiotically. Haploid chromosome number of *Crepis japonica* $n=8$ at present study confirms the earlier reports (Mathew & Mathew, 1988; Gupta & Gill, 1989). Chromosome number $n=10$ for *Taraxacum officinale* at present

study is perhaps new haploid number for this species. This new chromosome number may have evolved from basic number $x=8$. An analysis of meiosis reveals $n=9$ in *Sonchus asper*. Meiosis is normal with few ring bivalents. Stickyness has observed at A-I. This number had reported earlier by Razaq *et al.* (1994, 1988); Mulligan (1984); Ghaffari (1989); Prabha (1989); Gupta and Gill (1989); Gill (1978a & 1978b) but $n=18$ was observed by Carr *et al.* (1999).

Tagetes patula is investigated from the tribe Helineae. Spindle fibre with a single precocious chromosome has observed at M-I. A single laggard has observed at T-I.

The meiotic behavior of different taxa of present study indicated that in most of the taxa the cryptic structural alternations might have taken place during the evolution. This may be due to translocations, inversions and polyploidy. Presence of laggards and bridges may be due to inversion heterozygote. The laggards may be also due to delayed disjunction occurred during A-I as a consequence change in homology. Precocious movement of chromosomes may be due to early disjunctions and non-oriented chromosomes. Such abnormal behavior may be due to structural changes in chromosomes. Stickyness in chromosomes may be due to hybrid nature of the plant. Stickyness may also be occurred by rough handling of materials and chemical defects. These changes lead to the evolution of the species.

4.2.10 Pollen morphology and stainability

Palynological study has been utilized to indicate relationships among the taxa of different families (Bashir & Khan, 2003; Kulkarni 2012). Several authors (Wodehouse, 1935; Meo *et al.*, 1988; Dawer, *et al.*, 2002; Qureshi *et al.*, 2002; Meo and Khan, 2006; Hayat *et al.*, 2010; Ahmad *et al.*, 2012) have revealed that pollen morphology including viability of pollens are important clues in determining relationships among the members of Asteraceae. In present study both pollen morphology and stainability estimation of some species of the family Asteraceae have been made.

The present study has shown that there is a great diversity in pollen morphology and stainability in taxa of Asteraceae. Zafer *et al.* (2007) have mentioned that palynological research has proved useful in dealing critical and disputed taxonomic

problems and quantity or/and quality of the pollen produced by a plant is an important component of reproductive success.

The circular, echinate, large and triporate pollens seem to be primitive ones that have been found in *Ageratum conyzoides*, *Calendula officinalis*, *Crassocephalum crepidioides* among the studied taxa. Echinate, spheroidal and hexaporate pollens have been found in *Aster peduncularis* subsp. *nepalensis*. Spheroidal and hexaporate features have been regarded as comparatively advanced ones. Besides, diversity in the surface of exine, pollen aperture plays an important role in demarcating definite evolutionary levels and used for the establishment of interspecies relationships (Kulkarni, 2012).

In most of the presently studied taxa pollens are triporate, spheroidal, pentagonal or hexagonal and with spinules or echinate exine wall. These characters show that these taxa are well adapted for wind pollination. Some taxa with circular, echinate, large and triporate pollens are *Ageratum conyzoides*, *Calendula officinalis*, *Crassocephalum crepidioides* that seem to be primitive ones among the studied taxa. Spheroidal, echinate and triporate pollens have been recorded in *Anaphalis triplinervis*, *Artemisia indica*, *Aster ageratoides*, *Crepis japonica*, *Dichrocephala integrifolia*, *Wedelia wallichii* and *Bidens pilosa* in present research seem to be little advanced compared those taxa with circular pollens. It is interpreted that the species where the pollen grains are longer than wide, this is attributed as a structural adaptation for effective dispersal by wind while the circular nature of some of the pollen grains are related to structural adaptation for effective pollination by insects (Gimenes, 1991; Edeoga *et al.*, 1996; Mbagwu and Edeoga, 2006).

The characteristics of pollen spine has its significance in evolution and at specific and generic levels in the classification of Asteraceae (Zafar *et al.*, 2007). Similarly, Pinar and Donmez (2000) reported that spine cavities of pollen exine can be utilized as diagnostic characters in the genera of Asteraceae. In addition the pollen morphology of different Asteraceae taxa studied by several researchers have reported that the exine feature has an important in taxonomy and phylogenetic classification (Skvarla *et al.*, 1977; Mbagwu and Edeoga, 2006).

The pollen of Asteraceae has many features of interest, the sculpturing of exine is, as a rule, highly elaborated but there are tendencies of simplifications and loss of

sculpturing in anemophilous taxa. One taxa, in present investigation, *Xanthium strumarium* has been found to be with smooth walled pollens. Thus anemophily is regarded as a derived condition and the reduction in sculpturing of exine appears to be closely related to the different pollination methods (Kulkarni, 2012).

Wodehouse (1935) has suggested that the reduction series from long to minute spines is important in Asteraceae. For example, the occurrence of spines and its absence indicate a trend of evolution of spine reduction in the tribe Cichorieae. Genera with spinate pollen, exhibit a primitive feature as compared to the genera with spineless pollen. The feature may be used in establishing relationships at generic and specific levels of the tribe Cichorieae (Wodehouse, l. c.). Meo and Khan (2004) recognized 3 groups in *Scorzonera* (Cichorieae - Asteraceae) on the basis of exine thickness.

In present research, large echinate, circular and pentagonal pollens are observed in *Eclipta prostrata* and *Eupatorium adenophorum*; hexagonal, pentaporate, circular, echinate pollens are observed in *Galinsoga parviflora*; hexaporate, circular, spinate pollens are observed in *Parthenium hysterophorus*, *Sonchus asper* and *Taraxacum officinale*; triporate, circular with large spine walled pollens are observed in *Tagetes patula*. The taxa with circular and triporate pollens have been interpreted as primitive compared to the taxa with spheroidal and multiporate ones. In this aspect, Hoot (1991) has indicated that triporate pollens are considered to be most primitive pollen type and polyporate pollen grains are considered to be secondarily derived one (Kulkarni, 2012).

Three presently studied taxa of the genus *Artemisia* have similar pollen morphology viz. echinate pollens. There are previous reports also to show that related taxa have somewhat identical features in pollen morphology (Wodehouse, 1935; Qureshi *et al.*, 2002). In this concern, Hayat *et al.* (2010) have demonstrated that presence of spinules is a diagnostic character for *Artemisia* of tribe Anthemideae of the family Asteraceae. It is also interpreted that pollen morphology is a diagnostic feature for *Artemisia* and recognized as an excellent taxonomic marker (Martin *et al.*, 2001).

Different species of *Sonchus* have revealed echinate and tetrazonocolporate pollens in present study. The pollen morphological study by Qureshi *et al.* (2002) in different species of *Sonchus*, such as *S. uliginous*, *S. arvensis*, *S. asper*, *S. maritimus*, *S.*

oleraceous and *S. palustris* from Pakistan having tetrazonocolporate pollen grains with maximum spine length, has confirmed present result. In this context, Dafni and Firmage (2000) have suggested that the exine sculpture and spine morphology are important for the differentiation of species.

In the present study it is a general feature that polyploid taxa have larger pollen grains compared to those of diploid ones. There are reports to state that pollen size increases corresponding with ploidy level (Meo *et al.*, 1988; Manandhar, 2005).

The taxa have shown high pollen stainability ranging from 61.3-98.9 percent during present investigation. The highest pollen stainability was found in *Galinsoga parviflora* (98.9 %). Present report tallies with the report by Gopinathan and Babu (1982) that have revealed 100 % pollen viability in *Galinsoga parviflora* and *G. cilliata* from India. In this context, pollen viability has been considered to be an important parameter of pollen quality (Dafni & Firmage, 2000).

In present study the stainability recorded in triporate to hexaporate pollens of *Zinnia elegans* showed 72.7%. High percentage (97.9%) of pollen fertility was pointed in this taxa by Ramalingan *et al.* (1971) previously.

The lowest stainability have been seen in *Stevia rebaudiana* (61. 3%) among the presently the studied taxa. Previous report of low pollen viability in this taxa due to irregularities producing unbalanced gametes during meiosis has also been indicated by de Oliviera *et al.* (2004).

The quantity and quality of the pollen produced by a plant is an important component of reproductive success. In this context, pollen viability is considered to be an important parameter of pollen quality (Dafni & Firmage 2000).

The behavior of the chromosomes at meiosis affects pollen viability. Irregular meiosis often leads to low pollen viability with the exception of a few (Sakya, 1991). It has been reported that meiotic irregularities do not effect pollen viability percentage sometimes because the irregularities during meiosis do not reach up to maturity level so that there is no possibility of formation of mature grains (Manandhar, 2005). However, if meiosis is regular, for example, chromosomes pair and segregate normally; sterility of the pollen grain is not expected to occur because of cytological

reasons (Boff & Schifino-Wittmann, 2002). Singh and Roy (1986), while studying the inter-specific hybrid between *Solanum melongena* and *S. surattense*, have mentioned that pollen sterility may be observed in the absence of extensive meiotic irregularities

The abnormalities like laggards, non-orientation chromosomes at T-II, tetrads with variable number of spores lead to the formation of deficient pollen grains resulting the sterility of pollens (Vaidya, 2005). Tri-colpate and multicolpate pollen grains indicated the possibility of hybridization process in the genus due to possession of many deformed and sterile pollens and intraspecific variability of pollen grain. The pollen grains in studied genera are triporate with spinules which shows the primitive nature of the genus. Hara (1969) suggested that diploid plants tend to have triporate pollen grains in general and number of aperture increases in higher polyploids. Polyploidy affects in genetic barrier (Stebbins, 1968). The author has stated that the reduced fertility is greater when their diploid progenitors are homozygous. Multivalents and clumping of chromosomes at meiotic metaphase show these plants to be autopolyploids. They could bear pollen grain with unreduced or deficient chromosomes. So there are usually rather difficult to cross. The variation in pollen fertility might also be attributed to the amount of structural changes present in the karyotypes of the species.

It has been reported that polyploids and apomictic taxa have developed irregular meiosis and ultimately affecting viability of pollens (Oliviera *et al.*, 2004). Joshi (1968) has observed the disturbance of polarity of the grains resulting in different pollen shapes in the members of umbelliferae with the treatment of chemicals resulting in the formation of sterile pollen grains.

The literature (Huang, 1972; Meo *et al.*, 1988; Manandhar, 2005; Hayat *et al.*, 2010) has suggested that palynomorphology of the taxa has played an important role in the formulation of phylogenetic groupings.

4.2.11 Phylogenetic Relationships

Studies on forty five taxa within ten tribes of the family Asteraceae collected from Nepal suggest that there is indication of several different haploid chromosome numbers $n=6, 7, 8, 9, 10, 11, 12, 14, 16, 17, 18$ and 20 . It might be suggested that both primary and secondary base numbers are found to be involved in the evolution of

these taxa. Most of the members investigated have been found to be polyploids showing ascending or descending aneuploidy. Thus the phylogenetic relationships might be drawn to suggest that the members of Asteraceae family have arisen from an unknown stock and basic numbers are more than one. The presently investigated taxa have suggested that the primary base numbers have been $x=6$ or 7 indicating dibasic nature of the family. Thus after having chromosome number and karyomorphological investigations of the several taxa of above mentioned tribes, it can be concluded that two main branches are given rise from an unknown stock during the evolution of the family Asteraceae.

One main branch starts with the tribe Cichorieae with basic number $x=6$. The members of the tribe Cichorieae seem to have basal position of the branch having more primitive characters among the studied taxa with basic number $x=6$ from the stand points of their morphological as well as cytological back grounds. The species *Crepis japonica* ($2n=16$) and *Ixeris polycephala* ($2n=16$) of the tribe are descending aneuploid derivatives of triploid nature. The other line of development in this tribe is having normal triploid members such as *Sonchus asper* ($2n=18$) and *Sonchus arvensis* ($2n=18$). Both the species of the genus *Sonchus* are almost in the same level having same chromosome numbers and with more or less similar morphology. This genus seems to be most primitive having only median and sub-median chromosomes (*Sonchus asper*, $2n=18=M_8+sm_{10}$; *Sonchus arvensis*, $2n=18=M_{12}+sm_6$). *Taraxacum officinale* ($2n=20$) is also a triploid member within this tribe. However it is an ascending aneuploid form. *Taraxacum officinale* seems to be in higher position in the tribe with more chromosome numbers having sub-terminal chromosomes ($2n=20=M_4+m_8+sm_6+st_2$).

One taxa, from the tribe Helineae, *Tagetes patula* ($2n=24$) studied in present research is originated from basic number $x=6$. Karyomorphology ($2n=24=M_8+m_8+sm_8+st_2$) shows that it is higher in position to the tribe Cichorieae. The species shows advanced morphological characters such as lanceolate leaves with oil gland, serrate margin and is strongly aromatic.

Seven taxa studied from the tribe Astereae have originated from basic number $x=6$ but they are with more advanced karyomorphology and morphology compared to Cichorieae and Helineae. Therefore this tribe lies little above the tribe Cichorieae and

Helineae. There are two types of polyploids in the tribe. First line of development has been due to normal polyploidy viz. *Aster ageratoides*-hexaploid ($2n=36$), *Rhynchosperum verticillatum*-triploid ($2n=18$), *Dichrocephala integrifolia*-triploid ($2n=18$). The second line has all aneuploid taxa viz. *Erigeron annuus*-descending triploid ($2n=16$), *Conyza canadensis*-descending tetraploid ($2n=22$). *Aster barbellatus* ($2n=40$) and *A. peduncularis* ($2n=40$) are also descending aneuploids of heptaploidy ($2n=42$). Among the members studied presently *Aster baarbellatus* and *Aster peduncularis* lie in the same level with higher position having advanced morphological characters such as stiff stem and glandular leaves and with high chromosome numbers. However *Aster ageratoides* seems be in highest position in the tribe with more chromosome numbers having sub-terminal chromosomes ($2n=36=M_{14}+m_{10}+sm_{10}+st_2$).

Four taxa studied from the tribe Anthemideae have also been originated from the basic number $x=6$. This tribe seems to have affinity with the tribe Astereae having same type of karyotype (*Artemisia abronatum*, $2n=36=M_{18}+m_4+sm_{12}+st_2$). *Chrysanthemum morifolium* ($2n=36$) and *Artemisia abronatum* ($2n=36$) of this tribe are hexaploid members where as other two species viz. *Artemisia indica* ($2n=32$) and *A. vulgaris* ($2n=34$) are aneuploid derivatives of base number $x=6$. *A. vulgaris* has evolved through descending aneuploidy and *A. indica* has been originated from ascending aneuploidy. The taxa *Chrysanthemum morifolium* and *A. abronatum* may be in the level of development with same number of chromosomes and with similar morphological characters.

The tribe Cynareae occupies little higher position among members of basic number $x=6$. The tribe shows affinity with Anthemideae as well as Heliantheae. *Centaurea cyanus* ($2n=24$) studied, from the tribe Cynareae, is a tetraploid individual where as *Cirsium arvense* ($2n=34=M_{16}=sm_{14}=st_4$) is a descending aneuploid species.

Eleven taxa studied from the tribe Heliantheae are in top position among the tribes with base number $x=6$. The tribe is suggested to have three main branches. First branch is with normal polyploids viz *Zinnia elegans* ($2n=24$), *Wedelia wallichii* ($2n=30$) *Spilanthes acmella* ($2n=36$), *S. calva* ($2n=36$) and *Bidens pilosa* ($2n=36$). Second branch has three aneuploid taxa *Galinsoga perviflora* ($2n=16$), *Eclipta prostrata* ($2n=22$), *Parthenium hysterophorus* ($2n=34$) with descending triploid,

descending tetraploid and descending hexaploid respectively. The third one is with ascending aneuploids viz. *Tridax procumbens* ($2x=26$), *Coreopsis grandiflora* ($2n=26$) and *Xanthium strumarium* ($2n=32$). The karyotype of *Bidens pilosa* ($2n=36=M_{16}+m_4+sm_{14}+st_2$) shows evolved character compared to those of all taxa suggesting terminal position of the branch.

Another branch from the unknown stock starts with the members of different tribes with basic number $x=7$. The tribe Calenduleae occupies the basal position among tribes with this basic number. *Calendula officinalis* ($2n=28=m_{16}+m_4+sm_8$) is under taken research from this tribe. It is having some affinity with the tribe Inuleae in its karyomorphology.

Eight taxa are studied from the tribe Inuleae. This tribe contains one diploid i.e. *Gnaphalium affine* ($2n=14$) and seven polyploid members. It has five main branches. Two members: *Gnaphalium purpureum* ($2n=28$) and *Anaphalis triplinervis* var. *triplinervis* ($2n=28$) are normal tetraploids. Remaining five members of the tribe belonging to the genus *Blumea* are either ascending aneuploids: *Blumea fistulosa* ($2x=22$) and *B. mollis* ($2n=22=M_8+m_2+sm_4+st_8$) or descending aneuploids: *Blumea lacera* ($2n=18$) and *B. laciniata* ($2n=18$) and *Blumea lacera* var. *glandulosa* ($2n=32$). Karyomorphology suggests that this tribe is in higher position compared to Calenduleae.

The position of the tribe Eupatorieae is terminal among the members with seven basic number so far as the karyotype structures are concerned. Four taxa are studied from this tribe. They are either descending aneuploids: *Ageratum houstonianum* ($2n=18$), *A. conyzoides* ($2n=20$), *Ageratum conyzoides* ($2n=20$) or ascending aneuploids: *Stevia rebaudiana* ($2n=22$) and *Eupatorium adenophorum* ($2n=50$). *Stevia rebaudiana* is placed in rather higher position in morphology and chromosome characters than the genus *Ageratum*. However *Eupatorium adenophorum* ($2n=50=M_4+m_{12}+sm_{26}+st_8$) has occupied the highest position with advanced cytological and morphological characters such as small chromosome size and more chromosome numbers among all the members.

The phylogenetic relationships of Asteraceae family based on morphological and cytological characters show that *Eupatorium adenophorum* of the tribe Eupatorieae

having the most specialized karyotype with karyotype formula $2n=50=M_4+m_{12}+sm_{26}+st_8$ has great affinity to *Blumea mollis* ($2n=22=M_8+m_2+sm_4+st_8$) of the tribe Inuleae. In spite of having great variations in chromosome number, the karyotype determined in this study suggests that the members of different tribes have been evolved from a common stock of unknown basic number which gave rise to aneuploid and polyploid derivatives of basic numbers 6 and 7. The genus *Crassocephalum crepidioides* ($2n=40=M_{22}+m_2+sm_{16}$) of the tribe Senecioneae might have been evolved from the basic number either of 6 or 7. This taxa exhibited affinity to both the stocks. Since other member *Senecio laetus* of the same tribe has the diploid number $2n=6x=36$. There is more probability of evolving this member (*Crassocephalum crepidioides*) from a common basic number $x=6$, the number $2n=40$ being the product of descending aneuploid of $2n=7x=42$.

Ten tribes studied presently have indicated that the taxa included in all tribes are with polyploid and aneuploid forms. In the present investigation only one diploid individual (*Gnaphalium affine*, $2n=14$) was observed. Thus in the family Asteraceae polyploidy has played a major role in speciation.

CHAPTER 5

5. CONCLUSION AND RECOMMENDATIONS

5.1 Conclusion

Forty five taxa grouped into ten tribes within the family Asteraceae are studied in the present investigation. Taxa studied within these ten tribes each contributed to show phylogenetic relationships among them. It is clear that there is a wide range of chromosome number variations in different taxa of this family.

Structural changes (karyomorphological details) are also significant in almost all the presently studied plants. The taxa with chromosome numbers other than basic number have suggested that aneuploids (chromosome number less or more than base numbers), euploids (ascending and descending dysploidy) and polyploids (exact multiplications of chromosome base numbers) this evidence also shows in the present investigation. Irregularities in the meiosis of several presently studied taxa suggests that from the evolutionary standpoint meiotic instability may also be considered as a source of variations. In the present investigation among forty five taxa almost all of them are polyploids, higher number of them are aneuploids members either of ascending or descending one. Thus it can be suggested that numerical variations as well as structural changes can play significant role in the evolution of the various taxa of the family Asteraceae.

Chromosome number for the four taxa (*Artemisia indica*, *Aster barbellatus*, *Aster peduncularis* subsp. *nepalensis* and *Senecio laetus*) studied in the present investigation are new reports. Eleven taxa presently studied have different chromosome number when compared to the previous reports. Chromosome numbers reported here in the remaining other taxa tally with the earlier reports. It can be concluded that all the above mentioned factors may promote speciation, thus having systematic implications.

The chromosome counts for the forty one taxa in the present study are new records for the flora of Nepal.

5.2 Recommendations

Research on chromosome numbers and chromosome structures is important in systematics and evolution to determine and conserve biological wealth of Nepal. In this context, previous reports and present study of cytogenetics of the family Asteraceae suggest that lots of cytological works are yet to be done in this family for new researchers and \ or students etc. A revision of this family is highly desirable where karyomorphological studies and molecular cytogenetics are properly considered. The plants within the family Asteraceae have high medicinal values so phytochemical studies are also recommended. Research on conservational aspects of this family is also recommended for future generation.

CHAPTER 6

6. SUMMARY

Cytogenetical investigation of different members of Asteraceae collected from different regions such as Central, Western and Eastern parts of Nepal have been carried out in detail. They are 45 species included in 33 genera from 10 tribes. These tribes are Anthemideae, Cichorieae, Heliantheae, Astereae, Inuleae, Senecioneae, Calenduleae, Eupatorieae, Cynareae, and Helineae. Five species from chicorieae, eleven species from Heliantheae, seven species from Astereae, eight species from Inuleae, two species from Cynareae, two species from Senecioneae, one species from Helineae, one species from Calenduleae, four species from Anthemideae and four species from Eupatorieae have been studied.

There is a great variation in the chromosome number in presently studied taxa. The chromosome number ranges from $2n=14$ to $2n=50$ with majority of the species having $2n=18$. Lowest chromosome number $2n=14$ is found in *Gnaphalium affine* and highest $2n=50$ is in *Eupatorium adenophorum*. In present study only one taxa e.g. *Blumea fistulosa* is observed with two pairs of satellite chromosomes. In spite of wide range of chromosome number variation, there exist relationships between the different genera and species. The wide range of chromosome numbers may be due to the chromosome biotypes belonging to different groups. From the present and previous studies it is clear that many genera like *Ageratum*, *Artemisia*, *Aster*, *Sonchus* and *Spilanthes* exhibit intraspecific variations among chromosome numbers.

The general features noted in the family Asteraceae is the wide range of chromosome number variations with symmetrical and asymmetrical karyotypes. The length of chromosome ranges from 0.3 to 3.4 μm . The longest chromosomes are found in *Conyza canadensis* and smallest in *Eupatorium adenophorum* and *Senecio laetus*. The absolute length of chromosome ranges from 5.1 to 26.7 μm , highest in *Artemisia abronatum*, *Aster barbellatus* and lowest in *Rynchospermum verticillatum*. Pollen stainability ranges from 61.3 to 98.9 percent. The highest is in *Galinsoga parviflora* and lowest is in *Stevia rebaudiana*. Mainly four types of chromosomes are recorded namely centromere at median point, median region, sub-median region and sub-terminal region. The total form percentage ranges from 35 to 46.4, the highest is in

Dicrocephala integrifolia and lowest in *Sonchus asper*. The various morphological details of the karyotypes in absolute chromosome size, differences in position of centromere, differences in total chromatin length and differences in karyotypes formula vary from generic to specific levels. These variations found in the karyotype parameters suggest that Asteraceae members are characterized by symmetrical to asymmetrical karyotypes. The karyomorphological diversity found in the family shows that the family is still undergoing active speciation.

The basic chromosome numbers $x=6$ and $x=7$ are found in present study. This variability in the number of chromosomes at the basic level could possibly be due to the result of aneuploidy at generic level. Occurrence of aneuploidy in most of the members indicated advancedness of this family.

In the presently investigated taxa almost all species are polyploids, only one taxa *Gnaphalium affine* ($2n=14$) is diploid. Five types of polyploids such as triploids, tetraploids, pentaploids, hexaploids and heptaploid are encountered in present investigation.

Among 45 species investigated presently, the somatic chromosome number of 4 species viz. *Artemisia indica*, *Aster barbellatus*, *Aster peduncularis* var. *nepalensis* and *Senecio laetus* are perhaps new reports in this study. The chromosome number of 11 taxa recorded here are different from the previous reports. Chromosome number and karyotype for 41 taxa are new records for the Nepalese flora.

Meiotic behavior of twenty taxa are investigated presently. Precocious chromosome has observed in *Ageratum conyzoides*. In *Ageratum conyzoides*, *Aster peduncularis* subsp. *nepalensis*, *Calendula officinalis* and *Eupatorium adenophorum*, non-synchronized divisions are observed at different stages. Sticky nature has observed in *Anaphalis triplinervis* var. *triplinervis*. Laggards have been observed in *Galinsoga parviflora*, *Tagetes patula* and *Xanthium strumarium*. Multivalent chromosomes, non-oriented chromosomes and abortive microspores are also encountered during investigation.

Pollen stainability ranging from 61.3-98.9 percent have been observed. Triporate, hexaporate and multiporate pollens have been found. Pollens are circular, spheroidal, pentagonal and hexagonal in shape with spinules and echinate exine wall.

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Appendix

Chromosome numbers and distributions on members of the family

Asteraceae in Nepal

Taxa	Chrom. No.	Authors	Distributions (msl)
<i>Acanthospermum hispidum</i> DC.	n=11	Robinson <i>et al.</i> (1981)	CE. Nepal 500-1100
<i>A. hispidum</i> DC.	2n=22	Nirmala & Rao (1981)	CE. Nepal 500-1100
<i>A. hispidum</i> DC.	n=11	Husaini & Iwo (1990)	CE. Nepal 500-1100
<i>A. hispidum</i> DC.	2n=22	Mathew & Mathew (1988)	CE. Nepal 500-1100
<i>A. hispidum</i> DC.	n=11	Gupta & Gill (1989)	CE. Nepal 500-1100
<i>A. hispidum</i> DC.	2n=22	Nirmala & Rao (1984)	CE. Nepal 500-1100
<i>A. hispidum</i> DC.	2n=22	Nirmala & Rao (1986)	CE. Nepal 500-1100
<i>A. hispidum</i> DC.	2n=22	Jose & Mathew (1995)	CE. Nepal 500-1100
<i>A. hispidum</i> DC.	n=11	Jose & Mathew (1995)	CE. Nepal 500-1100
<i>Achillea alpina</i> L.	2n=36	Nishikawa (1984)	CE. Nepal 1200-1900
<i>Adenocaulon himalaicum</i> Edgew.	2n=46	Nishikawa (1984)	WCE. Nepal 2000-4000
<i>Adenostemma lavenia</i> (L.) Kuntze	n=10	Gupta & Gill (1989), Mathew & Mathew (1983, 1988)	WCE. Nepal 200-2800
<i>A. lavenia</i> (L.) Kuntze	2n=20	George <i>et al.</i> (1989), Lee (1967), Mathew & Mathew (1983, 1988), Masumori (1974), Sidhu & Pelia (1987)	WCE. Nepal 200-2800
<i>Ageratum conyzoides</i> L.	n=20	Gill & Abubakar (1975), Gupta & Gill (1989), Mathew & Mathew (1983)	WCE. Nepal 200-2000
<i>A. conyzoides</i> L.	2n=40	Mathew & Mathew (1983, 1988), Zhen & Cheng (2003)	WCE. Nepal 200-2000
<i>A. conyzoides</i> L.	2n=38	Chen <i>et al.</i> (2003)	WCE. Nepal 200-2000
<i>A. conyzoides</i> L.	n=18	Husaini & Iwo (1990)	WCE. Nepal 200-2000

<i>A. conyzoides</i> L.	n=20II	Keil <i>et al.</i> (1988)	WCE. Nepal 200-2000
<i>A. conyzoides</i> L.	2n=30	Morton (1993)	WCE. Nepal 200-2000
<i>A. conyzoides</i> L.	2n=20	Mallick <i>et al.</i> (2013)	C. Nepal 1280
<i>A. conyzoides</i> L.	n=10	Present count	C. Nepal 1280
<i>A. houstonianum</i> Mill.	2n=40	Shukur <i>et al.</i> (1977)	WC. Nepal 1300
<i>A. houstonianum</i> Mill.	2n=20	George <i>et al.</i> (1989), Mathew & Mathew (1983), Morton (1993), Nazeer <i>et al.</i> (1981), Sharma & Dharke (1981)	WC. Nepal 1300
<i>A. houstonianum</i> Mill.	n=20	King <i>et al.</i> (1976), Razaq <i>et al.</i> (1994)	WC. Nepal 1300
<i>A. houstonianum</i> Mill.	n=10	King <i>et al.</i> (1976), Mathew & Mathew (1983)	WC. Nepal 1300
<i>A. houstonianum</i> Mill.	2n=18	Present count	C. Nepal 1330
<i>Ainsliaea latifolia</i> (D. Don) Sch. Bip	2n=24	Peng & Hsu (1977, 1978)	WCE. Nepal 1700-3500
<i>A. latifolia</i> (D. Don) Sch. Bip	n=12	Malla <i>et al.</i> (1977)	WCE. Nepal 1700-3500
<i>Anaphalis adnata</i> Wall.	n=14	Gupta & Garg (1987), Gupta & Gill (1989), Gupta <i>et al.</i> (1989), Mehra & Sachdeva (1975)	WCE. Nepal 1500-2900
<i>A. busua</i> (Buch.- Ham. Ex D. Don) DC.	n=21	Gupta & Gill (1988, 1989), Gupta <i>et al.</i> (1989)	WCE. Nepal 1500-2900
<i>A. margaritacea</i> (L.) Benth.	n=14	Salter & Pinkava (1979)	CE. Nepal 1800- 3100
<i>A. margaritacea</i> (L.) Benth.	2n=26	Love & Love (1982), Salter & Pinkava (1979)	CE. Nepal 1800- 3100
<i>A. margaritacea</i> (L.) Benth	2n=28	Love & Love (1982)	CE. Nepal 1800- 3100
<i>A. nepalensis</i> Spreng.	n=14	Mehra & Chaudhary (1976)	C. Nepal 1800m
<i>A. royleana</i> DC.	n=14	Vir & Kachroo (1985)	WCE. Nepal 1200-4200
<i>A. triplinervis</i> (Sims) C.B. Clarke	n=14	Mehra & Remanandan (1975)	WCE. Nepal 1800-3300
<i>A. triplinervis</i> (Sims) C.B. Clarke	2n=28	Sharma (1970)	WCE. Nepal 1800-3300

<i>A. triplinervis</i> (Sims) C. B. Clarke	2n=28	Present count	C. Nepal 1900
<i>Arctium lappa</i> L.	n=18	Mehra and Remanandan (1976)	WC. Nepal 2100-3700
<i>A. lappa</i> L.	2n=36	Dmitrieva (1987), Huang <i>et al.</i> (1988), Javurkiva (1980), Magulaev (1979), Morton (1977), Rostovtseva (1983)	WC. Nepal 2100-3700
<i>Artemisia</i> <i>abrotanum</i> L.	n=9	Stahevitch & Wojtas (1988)	C. Nepal 1400
<i>A. abrotanum</i> L.	n=10	Mathew & Mathew (1988)	C. Nepal 1400
<i>A. abrotanum</i> L.	2n=20	Mathew & Mathew (1988)	C. Nepal 1400
<i>A. abrotanum</i> L.	2n=18	Johnson & Brandham (1997), Kreitschitz & Vallès (2003)	C. Nepal 1400
<i>A. abrotanum</i> L.	2n=36	Kreitschitz & Vallès (2003)	C. Nepal 1400
<i>A. abrotanum</i> L.	2n=36	Mallick <i>et al.</i> (2013b)	C. Nepal 1250
<i>A. biennis</i> Willd.	2n=18	Love & Love (1982), Torrell <i>et al.</i> (2001)	WCE. Nepal 3700-4600
<i>A. biennis</i> Willd.	n=9	Khatoon & Ali (1993)	WCE. Nepal 3700-4600
<i>A. capillaris</i> Thunb.	2n=18	Kawano <i>et al.</i> (1995), Kokubugata <i>et al.</i> (2004), Lee (1967), Mendelak & Schweizer (1986), Taniguchi <i>et al.</i> (1975)	C. Nepal 2600- 4300
<i>A. capillaris</i> Thunb.	2n=16	Khatoon & Ali (1993), Qiao <i>et al.</i> (1990), Yan <i>et al.</i> (1989),	C. Nepal 2600- 4300
<i>A. capillaris</i> Thunb.	n=9II	Kawano <i>et al.</i> (1995)	C. Nepal 2600- 4300
<i>A. capillaris</i> Thunb.	n=8	Khatoon & Ali (1993), Razaq <i>et al.</i> (1994),	C. Nepal 2600- 4300
<i>A. capillaris</i> Thunb.	2n=36	Peng & Hsu (1977, 1978)	C. Nepal 2600- 4300
<i>A. capillaris</i> Thunb.	2n=18-20+0- 1B, 22	Morton (1981), Masumori & Yoshiga (1973)	C. Nepal 2600- 4300
<i>A. capillaris</i> Thunb.	2n=27	Kawano <i>et al.</i> (1995), Morton (1981)	C. Nepal 2600- 4300
<i>A. gmelinii</i> Weber ex Stechm	2n=54	Korobkov (2003), Probatova <i>et al.</i> (1998), Probatova (2000), Stepanov & Muratova (1992)	WC. Nepal 2800-4300 Mongolia, China

<i>A. gmelinii</i> Weber ex Stechm	n=18	Khatoon & Ali (1993)	WC. Nepal 2800-4300
<i>A. gmelinii</i> Weber ex Stechm	2n=36	Probatova <i>et al.</i> (2001)	WC. Nepal 2800-4300
<i>A. gmelinii</i> Weber ex Stechm	2n=18	Hoshi <i>et al.</i> (2004), Korobkov (2003)	WC. Nepal 2800-4300
<i>A. incisa</i> Pamp.	2n=16	Kaul & Bakshi (1984)	CE. Nepal 2900- 3800
<i>A. indica</i> L.	2n=32	Mallick <i>et al.</i> (2013a)	C. Nepal 1300
<i>A. japonica</i> Thunb.	2n=18	Lee (1967), Volkova & Boyko (1985), Xiong <i>et al.</i> (1995)	CE. Nepal 1900- 2900
<i>A. japonica</i> Thunb.	2n=36	Hoshi <i>et al.</i> (2004), Kawano <i>et al.</i> (1995), Lee (1967), Masumori (1977), Nishikawa (1984, 1988), Taniguchi (1975), Volkova & Boyko (1986), Wang <i>et al.</i> (2000)	CE. Nepal 1900- 2900
<i>A. japonica</i> Thunb.	2n=37	Nishikawa (1984)	CE. Nepal 1900- 2900
<i>A. japonica</i> Thunb.	n=18II	Kawano <i>et al.</i> (1995)	CE. Nepal 1900- 2900
<i>A. roxburghiana</i> Wall.	2n=18, 36	Kaul & Bakshi (1984)	WC. Nepal 2600-4300
<i>A. vulgaris</i> L.	n=8	Arohonka (1982), Khatoon & Ali (1993), Mulligan (1984), Stahevitch & Wojtas (1988)	CE. Nepal 3100
<i>A. vulgaris</i> L.	2n=18, 18+1-4	Bakshi (1982)	CE. Nepal 3100
<i>A. vulgaris</i> L.	2n=16	Belaeva & Siplivinsky (1975, 1976), Hindakova (1974), Hoshi <i>et al.</i> (2004), James <i>et al.</i> (2000), Kartashova <i>et al.</i> (1974), Kaul & Bakshi (1984), Kiehn <i>et al.</i> (2000), Korobkov (2003), Kuzmanov <i>et al.</i> (1986), Lovrenko <i>et al.</i> (1990, 1991), Malakhova <i>et al.</i> (1979), Morton (1977), Noguchi <i>et al.</i> (1983), Rostovtseva (1979), Volkova & Boyko (1989), Xirau & Siljak- yakovlev (1997), Zhukova & Petrovsky (1976),	CE. Nepal 3100
<i>A. vulgaris</i> L.	n=9	Gupta & Gill (1988, 1989), Gupta <i>et al.</i> (1989)	CE. Nepal 3100
<i>A. vulgaris</i> L.	n=27	Gill & Omoigui (1992)	CE. Nepal 3100
<i>A. vulgaris</i> L.	n=18	Gupta & Garg (1987), Khatoon & Ali (1993)	CE. Nepal 3100
<i>A. vulgaris</i> L.	2n=36	Nirmala & Rao (1984)	CE. Nepal 3100

<i>A. vulgaris</i> L.	2n=18	Magulaev (1992)	CE. Nepal 3100
<i>A. vulgaris</i> L.	2n=40	Nirmala & Rao (1984, 1989)	CE. Nepal 3100
<i>A. vulgaris</i> L.	2n=54	Nirmala & Rao (1984)	CE. Nepal 3100
<i>A. vulgaris</i> L.	2n=34	Khatoon & Ali (1993), Mallick <i>et al.</i> (2013a)	E. Nepal 3100
<i>A. vulgaris</i> L.	2n=24	Sharma (1970)	CE. Nepal 3100
<i>Aster ageratoides</i> var. <i>tenuifolius</i> Kitam.	2n=18, 36	Ito <i>et al.</i> (1994)	C. Nepal 3700
<i>A. ageratoides</i> Kitam.	2n=36	Mallick <i>et al.</i> (2011)	C. Nepal 1300
<i>A. ageratoides</i> Kitam.	n=18	Present count	C. Nepal 1300m
<i>A. diplostephioides</i> (DC.) C.B. Clarke	2n=18	Liu (1999)	WCE. Nepal 3200-4900m
<i>A. barbellatus</i> Grierson	2n=40	Mallick <i>et al.</i> (2013a)	C. Nepal
<i>A. peduncularis</i> sub sp. <i>nepalensis</i> Grierson	2n=40	Mallick <i>et al.</i> (2013b)	C. Nepal 1250
<i>A. thomsoni</i> C.B. Clark	n=9+0-4B	Gupta & Garg (1987), Gupta <i>et al.</i> (1989)	–
<i>A. thomsoni</i> C.B. Clark	n=9	Jee <i>et al.</i> (1987)	–
<i>A. trinervius</i> . <i>ageratoides</i> Roxb.ex D. Don	2n=36	Peng <i>et al.</i> (1998)	WCE. Nepal 1500-2600
<i>Bidens alba</i> (L.) DC.	2n=24 ₁₁	Carr <i>et al.</i> (1999)	–
<i>B. biternata</i> (Lour.) Merr. & Sherff.	n=36	Bir & Sidhu (1980)	WC. Nepal 1100-2000
<i>B. biternata</i> (Lour.) Merr. & Sherff.	n=36, 2n=72	Bir & Sidhu (1979)	WC. Nepal 1100-2000
<i>B. biternata</i> (Lour.) Merr. & Sherff.	2n=72	Jose & Mathew (1995), Sidhu & Bir (1983)	WC. Nepal 1100-2000
<i>B. biternata</i> (Lour.) Merr. & Sherff.	n=36	Gupta & Gill (1988, 1989), Gupta <i>et al.</i> (1989), Mathew & Mathew (1988)	WC. Nepal 1100-2000
<i>B. biternata</i> (Lour.) Merr. & Sherff.	2n=24	Sharma (1988)	WC. Nepal 1100-2000

<i>B. biternata</i> (Lour.) Merr. & Sherff.	n=36	Jose & Mathew (1995), Razaq <i>et al.</i> (1994)	WC. Nepal 1100-2000
<i>B. cernua</i> L.	2n=24	Kuzmanov <i>et al.</i> (1986), Love & Love (1982), , Morton (1977), Murin (1976, 1978), Protova & Sokalovskaya (1989)	W. Nepal 2300- 2600
<i>B. cernua</i> L.	n=12	Gupta & Gill (1988), Gupta <i>et al.</i> (1989), Weedon <i>et al.</i> (1976)	W. Nepal 2300- 2600
<i>B. cernua</i> L.	n=12, 2n=24	Crowe & Parker (1981)	W. Nepal 2300- 2600
<i>B. pilosa</i> var. <i>minor</i> (Blume) Sherff	2n=36	Shrama (1970)	WCE. Nepal 700-2100
<i>B. pilosa</i> var. <i>minor</i> (Blume) Sherff	2n=72	Banerjee (1971), Gadella (1977d, 1982), Nirmala & Rao (1981), Shrama (1970)	WCE. Nepal 700-2100
<i>B. pilosa</i> var. <i>minor</i> (Blume) Sherff	n=12	Gill (1978a, 1978b), Keil & Stuessy (1977)	WCE. Nepal 700-2100
<i>B. pilosa</i> var. <i>minor</i> (Blume) Sherff	n=36	Banerjee (1971), Keil & Stuessy (1977), Nirmala & Rao (1981), Robinson <i>et al.</i> (1981), Shrama (1970)	WCE. Nepal 700-2100
<i>B. pilosa</i> var. <i>minor</i> (Blume) Sherff	2n=48	Pilz (1980)	WCE. Nepal 700-2100
<i>B. pilosa</i> var. <i>minor</i> (Blume) Sherff	2n=36	Mallick <i>et al.</i> (2013)	C. Nepal 1300
<i>B. pilosa</i> var. <i>minor</i> (Blume) Sherff	n=18	Present count	C. Nepal 1300
<i>Bidens tripartita</i> L.	2n=48	Arohonka (1982), Baltisberger (1992), Dmitrieva (1987), Huber & Baltisberger (1992)), Kuzamanov <i>et al.</i> (1986), Krasnikov & Lomonosova (1990), Magulaev (1982), .Morton (1977)	WCE. Nepal 800-3400
<i>B. tripartita</i> L.	2n=36	Stepanov & Muratova (1992)	WCE. Nepal 800-3400
<i>Blainvillea acmella</i> (L.) Philipson	n=17	Gupta & Gill (1989), Razaq <i>et al.</i> (1994)	WCE. Nepal 300-1700
<i>B. acmella</i> (L.) Philipson	n=17	Jose and Mathew (1995)	WCE. Nepal 300-1700
<i>Blumea aromatica</i> DC. Prodr.	2n=18	Peng & Hsu (1977)	WCE. Nepal 300-1700
<i>B. aromatica</i> DC. Prodr.	2n=18	Peng & Hsu (1978)	WCE. Nepal 300-1700
<i>B. balsamifera</i> (L.) DC.	n=10	Daruwalla (1995)	C. Nepal 500

<i>Blumea fistulosa</i> (Roxb.) Kurz	n=9	Mathew & Mathew (1975), Mathew & Mathew (1988)	WCE. Nepal 100-1200
<i>B. fistulosa</i> (Roxb.) Kurz	2n=18	Gupta & Gill (1979), Mathew & Mathew (1988)	WCE. Nepal 100-1200
<i>B. fistulosa</i> (Roxb.) Kurz	2n=30	Gupta (1983), Gupta & Gill (1989)	WCE. Nepal 100-1200
<i>B. fistulosa</i> (Roxb.) Kurz	n=20	Daruwalla (1995)	WCE. Nepal 100-1200
<i>B. fistulosa</i> (Roxb.) Kurz	2n=22	Present count	C. Nepal 600
<i>Blumea lacera</i> (Burm.f.) DC.	2n=36	Peng & Hsu (1977, 1978)	CE. Nepal 150- 350
<i>B. lacera</i> (Burm.f.) DC.	n=11	Gupta & Gill (1989)	CE. Nepal 150- 350
<i>B. lacera</i> (Burm.f.) DC.	n=10	Razak <i>et al.</i> (1988, 1994)	CE. Nepal 150- 350
<i>B. lacera</i> (Burm.f.) DC.	2n=22	Daruwala (1995)	C. Nepal 1515
<i>B. lacera</i> (Burm.f.) DC.	2n=18	Nirmala & Rao (1984, 1990)	CE. Nepal 150- 350
<i>B. lacera</i> (Burm.f.) DC.	2n=18	Present count	C. Nepal 1515
<i>Blumea lacera</i> var . <i>glandulosa</i> (DC.) Hook f.	n=18+2-4b, 18	Mathew & Mathew (1975)	E. Nepal 80-200
<i>B. lacera</i> var . <i>glandulosa</i> (DC.) Hook f.	2n=36	Mathew & Chowdary (1982), Mathew & Mathew (1975), Mathew & Mathew (1988), Verma & Vijayavalli (1998)	E. Nepal 80-200
<i>B. lacera</i> var . <i>glandulosa</i> (DC.) Hook f.	n=18+3b	Mathew & Mathew (1988)	E. Nepal 80-200
<i>B. lacera</i> var . <i>glandulosa</i> (DC.) Hook f.	n=18	Verma & Vijayavalli (1998)	E. Nepal 80-200
<i>B. lacera</i> var . <i>glandulosa</i> (DC.) Hook f.	2n=18	Verma & Vijayavalli (1998)	E. Nepal 80-200
<i>B. lacera</i> var . <i>glandulosa</i> (DC.) Hook f.	2n=22	Verma & Vijayavalli (1998)	E. Nepal 80-200

<i>B. lacera</i> var . <i>glandulosa</i> (DC.) Hook f.	2n=32	Present count	C. Nepal 630
<i>B. laciniata</i> (Roxb) DC.	2n=18	Peng & Hsu (1977), Sharma (1970)	WC. Nepal 300-1100.
<i>B. laciniata</i> (Roxb.) DC.	n=9	Bir & Sidhu (1979, 1980), Sharma (1970), Gupta & Gill (1989)	WC. Nepal 300-1100
<i>B. laciniata</i> (Roxb.) DC.	n=11	Daruwala (1995), Mehra & Remanandan (1975)	WC. Nepal 300-1100
<i>B. laciniata</i> (Roxb.) DC.	2n=18	Present count	C. Nepal 615
<i>Blumea</i> <i>membranacea</i> DC.	n=9, 18 2n=18	Mathew & Mathew (1975, 1988)	C. Nepal 45
<i>B. membranacea</i> DC.	n=22	Mehra & Remanandan (1975)	C. Nepal 450.
<i>B. membranacea</i> DC.	n=9	Daruwala (1995), Gupta & Gill (1989),	C. Nepal 450.
<i>Blumea mollis</i> (D. Don) Merr.Philipp	n=9+1-2	Mathew & Mathew (1978)	WCE. Nepal 200-2000
<i>B. mollis</i> (D. Don) Merr.Philipp	n=11	Daruwala (1995), Gill (1975), Mehra & Remanandan (1975), Verma & Vijayavalli (1998)	WCE. Nepal 200-2000
<i>B. mollis</i> (D. Don) Merr. Philipp	n=9	Gupta & Gill (1989), Verma & Vijayavalli (1998)	WCE. Nepal 200-2000m
<i>B. mollis</i> (D. Don) Merr.Philipp	n=10	Daruwala (1995)	WCE. Nepal 200-2000
<i>B. mollis</i> (D. Don) Merr.Philipp	n=20	Verma & Vijayavalli (1998)	WCE. Nepal 200-2000
<i>B. mollis</i> (D. Don) Merr. Philipp	n=22	Verma & Vijayavalli (1998)	WCE. Nepal 200-2000
<i>B. mollis</i> (D. Don) Merr.Philipp	2n=18	Verma & Vijayavalli (1998)	WCE. Nepal 200-2000m
<i>B. mollis</i> (D. Don) Merr. Philipp	2n=20	Verma & Vijayavalli (1998)	WCE. Nepal 200-2000
<i>B. mollis</i> (D. Don) Merr. Philipp	2n=22	Verma & Vijayavalli (1998)	WCE. Nepal 200-2000
<i>B. mollis</i> (D. Don) Merr. Philipp	2n=22	Present count	C. Nepal 1515m
<i>Blumea oxyodonta</i> DC.	n=9	Mathew & Mathew (1975, 1988), Verma & Vijayavalli (1998)	WC. Nepal 100-2100
<i>B. oxyodonta</i> DC.	2n=18	Mathew & Mathew (1988)	WC. Nepal 100-2100

<i>Blumea oxyodonta</i> DC.	n=10	Daruwala (1995)	WC. Nepal 100- 2100
<i>Blumea procera</i> DC.	n=10	Daruwala (1995)	C. Nepal
<i>Blumea riparia</i> (Blume) DC.	n=9	Malla <i>et al.</i> (1977)	C. Nepal 1500
<i>B. riparia</i> (Blume) DC.	n=10	Daruwala (1995)	C. Nepal 1500
<i>Caesulia axillaries</i> Roxb.	2n=14	Bhandari & Singhir (1977)	WCE. Nepal 150-1500
<i>C. axillaries</i> Roxb.	2n=14	Sidhu & Pelia (1987)	WCE. Nepal 150-1500
<i>C. axillaries</i> Roxb.	n=7	Gupta & Gill (1989), Verma & Vijayavalli (1998), Vihari & Anupriya (1996)	WCE. Nepal 150-1500
<i>C. axillaries</i> Roxb.	2n=14	Verma & Vijayavalli (1998), Vihari & Anupriya (1996)	WCE. Nepal 150-1500
<i>Calendula</i> <i>officinalis</i> L.	n=16	Gupta & Gill (1989), Mehra & Remanandan (1976), Mathew & Mathew (1988),	C. Nepal 2600- 4400
<i>C. officinalis</i> L.	2n=7 ₁₁	Carr <i>et al.</i> (1999)	C. Nepal 2600- 4400
<i>C. officinalis</i> L.	2n=28	Mallick <i>et al.</i> (2011), Murín (1993), Vachova (1978)	C. Nepal 2600- 4400
<i>C. officinalis</i> L.	2n=32	Baltisberger & Huber (1987), Czapik (1989), Murín (1997), Pogan <i>et al.</i> (1990)	C. Nepal 2600- 4400
<i>C. officinalis</i> L.	n=14	Present count	C. Nepal 1300
<i>Carpesium</i> <i>abrotanoides</i> L.	2n=36	Nishikawa (1984)	WCE. Nepal 1400-2200
<i>C. abrotanoides</i> L.	2n=40	Cho (1991)	WCE. Nepal 1400-2200
<i>C. abrotanoides</i> L.	2n=54	Xu <i>et al.</i> (1992)	WCE. Nepal 1400-2200
<i>Carthamus</i> <i>tinctorius</i> L.	n=12	Chatterji & Jayaramu (1981), Ghaffari (1989)	C. Nepal 3000
<i>C. tinctorius</i> L.	2n=24	Chatterji & Jayaramu (1981), Ghaffari (1989), Kliphuis & Barkoudah (1977), Ma <i>et al.</i> (1985), Pillai <i>et al.</i> (1982), Uhrikova & Ferakova (1980)	C. Nepal 3000

<i>Centaurea cyanus</i> L.	2n=24	Arohonka (1982), Bancheva (1998), Dmitrieva & Parfenov (1979), Gupta & Gill (1989), Huber & Baltisberger (1989), Lökvist & Hultgård (1999), Skalinska <i>et al.</i> (1976)	C. Nepal 3700
<i>C. cyanus</i> L.	n=12	Gupta & Gill (1989)	C. Nepal 3700
<i>C. cyanus</i> L.	2n=24	Present count	C. Nepal 1330
<i>Centipeda minima</i> (L.) A. Braun & Asch.	2n=14	Malla <i>et al.</i> (1978)	WCE. Nepal 200-1600
<i>C. minima</i> (L.) A. Braun & Asch.	2n=20	Huber & Baltisberger (1992), Nishikawa (1988), Peng & Hsu (1977, 1978), Razaq <i>et al.</i> (1994)	WCE. Nepal 200-1600
<i>C. minima</i> (L.) A. Braun & Asch.	n=10	Gupta & Gill (1989)	WCE. Nepal 200-1600
<i>Chrysanthemum coronarium</i> L.	2n=9 ₁₁	Carr <i>et al.</i> (1999)	–
<i>C. indicum</i> DC.	n=8	Turner <i>et al.</i>	WCE. Nepal 500-1900
<i>C. morifolium</i> Ramat.	2n=36	Present count	C. Nepal 1200
<i>C. morifolium</i> Ramat	2n=28 to 58	Guo <i>et al.</i> (2012)	
<i>C. arvense</i> Mill.	2n=31	Joshi (1988)	C. Nepal 1330
<i>C. arvense</i> Mill.	2n=34	Mallick <i>et al.</i> (2011)	C. Nepal 1340
<i>Cirsium wallichii</i> DC.	n=17	Gupta & Gill (1988, 1989), Gupta <i>et al.</i> (1989)	C. Nepal 2200
<i>Conyza apurensis</i> Kunth	2n=27 ₁₁	Carr <i>et al.</i> (1999)	–
<i>C. bonariensis</i> (L.) Cronquist	n=18	Strid & Franzen (1981)	WCE. Nepal 1400-1800
<i>C. bonariensis</i> (L.) Cronquist	2n=54	Strid & Franzen (1981)	WCE. Nepal 1400-1800
<i>C. bonariensis</i> (L.) Cronquist	n=27	Razaq <i>et al.</i> (1994), Turner <i>et al.</i> (1979),	WCE. Nepal 1400-1800
<i>C. bonariensis</i> (L.) Cronquist	n=18	Carr <i>et al.</i> (1999)	WCE. Nepal 1400-1800
<i>C. canadensis</i> (L.) Cronquist	n=9	Keil (1981), Keil <i>et al.</i> (1988), Morton (1981), Nesom (1978), Parfitt (1981), Ward & Spellenberg (1988)	WCE. Nepal 450-2500
<i>C. canadensis</i> (L.)	2n=18	Hollingsworth <i>et al.</i> (1992), Huber &	WCE. Nepal

Cronquist		Baltisberger (1992), Lövkvist & Hultgård (1999), Javurková-Jarolímová (1992), Kuzmanov <i>et al.</i> (1986), Nesom (1978)	450-2500
<i>C. canadensis</i> (L.) Cronquist	2n=18	Mallick <i>et al.</i> (2011)	C. Nepal 1280
<i>C. canadensis</i> (L.) Cronquist	2n=22	Present count	C. Nepal 1280
<i>C. japonica</i> (Thunb.) Less.	2n=18	Peng & Hsu (1977, 1978)	WCE. Nepal 600-2600
<i>C. japonica</i> (Thunb.) Less.	n=9	Gupta & Garg (1987), Gupta & Gill (1989), Gupta <i>et al.</i> (1989), Razaq <i>et al.</i> (1994)	WCE. Nepal 600-2600
<i>C. leucantha</i> (D. don) Ludow & Raven	n=9	Gupta & Gill (1979, 1989)	WCE. Nepal 700-1200
<i>C. stricta</i> Willd.	2n=18	Shukur <i>et al.</i> (1977)	WCE. Nepal 700-1200
<i>C. stricta</i> Willd.	n=9	Gupta & Garg (1987), Gupta & Gill (1989), Gupta <i>et al.</i> (1989), Koul <i>et al.</i> (1976a)	WCE. Nepal 700-1200
<i>C. stricta</i> Willd.	n=18	Gupta & Gill (1979, 1989)	WCE. Nepal 700-1200
<i>C. stricta</i> Willd.	n=9+1B	Mathew & Mathew (1988)	WCE. Nepal 700-1200
<i>Coreopsis</i> <i>grandiflora</i> Nutt. ex Chapm.	2n=26	Gupta & Gill (1981), Mallick <i>et al.</i> (2013), Mathew & Mathew (1988)	WC. Nepal 700- 1500
<i>C. grandiflora</i> Nutt. ex Chapm.	n=13	Gupta & Gill (1989)	WC. Nepal 700- 1500
<i>C. grandiflora</i> Hogg ex Sweet	n=12	Jose & Mathew (1995)	WC. Nepal 700- 1500
<i>C. grandiflora</i> Hogg ex Sweet	2n=24	Jose & Mathew (1995)	WC. Nepal 700- 1500
<i>C. grandiflora</i> Hogg ex Sweet	2n=26	Yang (2001)	WC. Nepal 700- 1500
<i>Cotula</i> <i>hemisphaerica</i> (Roxb.) Wall.	n=10	Bir & Sidhu (1980)	C. Nepal 1400- 1800
<i>C. hemisphaerica</i> (Roxb.) Wall	2n=20	Bir & Sidhu (1980)	C. Nepal 1400- 1800
<i>Crassocephalum</i> <i>crepidioides</i> (Benth.) S. Moore	n=20	Gill & Omoigui (1987), Henderson (1973), Mathew & Mathew (1988)	CE. Nepal 1400- 1900

<i>C. crepidioides</i> (Benth.) S. Moore	2n=40	Baltisberger (1990), Daniela (1997), Henderson (1973), Mallick <i>et al.</i> (2013), Mathew & Mathew (1988), Morton (1993)	CE. Nepal 1400- 1900
<i>C. crepidioides</i> (Benth.) S. Moore	n=20	Present count	C. Nepal 1220
<i>Crepis flexuosa</i> (DC.) Benth.	2n=42	Rostovtseva (1983)	C. Nepal 1500
<i>C. flexuosa</i> (DC.) Benth.	2n=14	Gu & Sun (1996), Gu <i>et al.</i> (1993)	C. Nepal 1500
<i>C. japonica</i> (L.) Benth.	n=8	Gupta & Gill (1989), Mathew & Mathew (1988)	WCE. Nepal 230-2900
<i>C. japonica</i> (L.) Benth.	2n=16	Mallick <i>et al.</i> (2013)	C. Nepal 1220
<i>C. japonica</i> (L.) Benth.	n=8	Present count	C. Nepal 1220
<i>C. sancta</i> (L.) Babc.	2n=10	Kuzmanov & Jurukova (1977), Kuzmanov <i>et al.</i> (1981), Strid & Franzen (1981)	W. Nepal 3200
<i>C. sancta</i> (L.) Babc.	n=5	Razaq <i>et al.</i> (1994)	W. Nepal 3200
<i>C. sancta</i> (L.) Babc.	2n=10-12	Dimitrova (1996)	W. Nepal 3200
<i>Dahlia imperialis</i> Roezl, Gart.	n=16	Giannasi (1975), Jose & Mathew (1995)	E. Nepal 1000- 2000
<i>D. imperialis</i> Roezl, Gart.	2n=32	Gatt <i>et al.</i> (1998), Jose & Mathew (1995)	E. Nepal 1000- 2000
<i>D. pinnata</i> Cav.	2n=64	Gatt <i>et al.</i> (1998), Gatt <i>et al.</i> (2000), Gupta & Gill (1981), Murin, (1989), Wang & Li (1987), Zhang (1998)	C. Nepal 2600
<i>D. pinnata</i> Cav.	n=32	Gupta & Gill (1987)	C. Nepal 2600
<i>Dendranthema</i> <i>indicum</i> (L.) Des Moul.	2n=18	Du <i>et al.</i> (1989), Wang <i>et al.</i> (1991, 1993)	E. Nepal 1200
<i>D. indicum</i> (L.) Des Moul.	2n=36	Honda <i>et al.</i> (1997), Khaung <i>et al.</i> (1995, 1997)	E. Nepal 1200
<i>D. indicum</i> (L.) Des Moul.	2n=45	Nakata <i>et al.</i> (1992)	E. Nepal 1200
<i>D. indicum</i> (L.) Des Moul.	2n=54	Khaung <i>et al.</i> (1995)	E. Nepal 1200
<i>Dichrocephala</i> <i>integrifolia</i> (L.f.) Kutnze	2n=18	Mallick <i>et al.</i> (2011), Morton (1993), Peng & Hsu (1978)	WEC.Nepal 800- 3000
<i>D. integrifolia</i> (L.f.) Kutnze	n=9	Gupta & Gill (1988, 1989), Gupta <i>et al.</i> (1989)	WEC. Nepal 800-3000
	n=9	Present count	WEC. Nepal

<i>D. integrifolia</i> (L.f.) Kutnze			800-3000
<i>D. chrysanthemifolia</i> (Blume) DC.	2n=18	Mathew & Mathew (1978), Morton (1993)	W. Nepal 2500
<i>D. chrysanthemifolia</i> (Blume) DC.	n=9	Mathew & Mathew (1988)	W. Nepal 2500
<i>Doronicum roylei</i> DC.	n=30	Vir Jee & Kachroo (1985), Jee <i>et al.</i> (1989)	WC. Nepal 2900-4600
<i>Echinops cornigerus</i> DC.	n=14	Mehra & Remanandan (1976)	WC. Nepal 2400-3300
<i>E. cornigerus</i> DC.	n=15	Sharma (1970)	-
<i>Eclipta prostrata</i> (L.) L.	n=11	Gill & Omoigui (1987, 1988), Jose & Mathew (1995), Koul <i>et al.</i> (1976a), Razaq <i>et al.</i> (1988, 1994), Sidhu & Bir (1979, 1980)	WCE. Nepal 200-1500
<i>E. prostrata</i> (L.) L.	2n=22	Dutta & Shaha (1971), Ge (1989), Ge and Wan (1990), Jose & Mathew (1995), Mallick <i>et al.</i> (2011), Nirmala & Rao (1986), Sidhu (1979), Sidhu & Bir (1983), Tanaka & Tsuji (1978), Xie & Zheng (2003), Xu <i>et al.</i> (1992)	WCE. Nepal 200-1500
<i>E. prostrata</i> (L.) L.	n=12	Husaini & Iwo (1990)	WCE. Nepal 200-1500
<i>E. prostrata</i> (L.) L.	N=11	Present count	WCE. Nepal 200-1500
<i>Elephantopus scaber</i> L.	2n=22	Jones (1979), Nirmala & Rao (1981)	WCE. Nepal 200-1500
<i>E. scaber</i> L.	n=11	Nirmala & Rao (1981)	WCE. Nepal 200-1500
<i>Erigeron acre</i> L.	2n=18	Belaeva & Siplivinsky (1981), Hommel & Wieffering (1979), Krogulevich (1978), Rostovtseva (1979), Siljak-yakovlev (1981)	W. Nepal 2400- 2700
<i>E. acre</i> L.	2n=36	Siljak-yakovlev (1981)	W. Nepal 2400- 2700
<i>E. annuus</i> (L.) Pers.	2n=26	Chojnacki <i>et al.</i> (1980, 1982)	
<i>E. annuus</i> (L.) Pers.	2n=27	Chojnacki <i>et al.</i> (1980), Chojnacki <i>et al.</i> (1982), Dmitrieva (1987), Dmitrieva	C. Nepal 1515

		(2000) Frey <i>et al.</i> (2003), Hill (1995), Krénska & Bijok (1982), Morton (1981), Nesom (1978), Peng & Hsu (1977, 1978), Soliva (1997)	
<i>E. annuus</i> (L.) Pers.	n=27II	Carr <i>et al.</i> (1999)	C. Nepal 1515
<i>E. annuus</i> (L.) Pers.	n=27	Nesom (1978)	C. Nepal 1515
<i>E. annuus</i> (L.) Pers.	n=13	Chojnacki <i>et al.</i> (1982)	C. Nepal 1515
<i>E. annuus</i> (L.) Pers.	n=14	Chojnacki <i>et al.</i> (1982)	C. Nepal 1515
<i>E. annuus</i> (L.) Pers.	n=9	Hong & Zhang (1990)	C. Nepal 1515
<i>E. annuus</i> (L.) Pers.	2n=16	Present count	C. Nepal 1515
<i>E. bellioides</i> DC.	n=9II	Keil <i>et al.</i> (1988)	WCE. Nepal 1400-4300
<i>E. multicaulis</i> DC.	n=9	Gupta <i>et al.</i> (1989)	WCE. Nepal 1000-3500
<i>E. karvinskianus</i> DC.	n=18	Mathew & Mathew (1988), Spooner <i>et al.</i> (1995)	WCE. Nepal 2100
<i>E. karvinskianus</i> DC.	2n=36	De Jong & Nesom (1996), Gupta & Gill (1988, 1989), Mathew & Mathew (1988), Watanabe <i>et al.</i> (1996),	WCE. Nepal 2100
<i>E. karvinskianus</i> DC.	2n=27	De Jong & Nesom (1996), Watanabe <i>et al.</i> (1996)	WCE. Nepal 2100
<i>E. uniflorus</i> L.	2n=18	Belaeva & Siplivinsky (1975), Gadnidze <i>et al.</i> (1998), Kuzmanov <i>et al.</i> (1986), Murin (1978)	WCE. Nepal 2000-4200
<i>E. adenophorum</i> Spreng.	2n=51	Khonglam & Singh (1980)	CE. Nepal 850- 2200
<i>E. adenophorum</i> Spreng	2n=50	Present count	C. Nepal 1310
<i>E. cannabinum</i> L.	2n=20	Druskovic & Lovka (1995), Hollingsworth <i>et al.</i> (1992), Kuzmanov (1975), Lövkvist & Hultgård (1999), Strid & Franzen (1981), Morton (1977), Watanabe <i>et al.</i> (1990)	CE. Nepal 850- 2200
<i>E. capillifolium</i> (Lam.) Small ex Porter & Britton	2n=20	Watanabe <i>et al.</i> (1982)	E. Nepal 200
<i>E. chinense</i> L.	2n=20, 30, 40, 50	Watanabe <i>et al.</i> (1990)	E. Nepal 200
<i>E. chinense</i> L.	2n=20	Watanabe <i>et al.</i> (1990)	E. Nepal 200
<i>E. odoratum</i> L.	2n=60	George <i>et al.</i> 1989), Khonglam & Singh (1980), Mathew & (1988), Shukur <i>et al.</i>	CE. Nepal 400- 1500

		(1977), Xie & Zheng (2003)	
<i>E. odoratum</i> L.	2n=58	Nirmala & Rao (1981, 1984, 1989), Sharma (1970)	CE. Nepal 400-1500
<i>Galinsoga parviflora</i> Cav.	n=16	Canne (1983), Weedon & Powell (1978)	WCE. Nepal 850-3000
<i>G. parviflora</i> Cav.	2n=16	Canne (1983), Gopinathan & Babu (1982), Jose & Mathew (1995), Khonglam <i>et al.</i> (1984), Lökvist & Hultgård (1999), Magulaev (1982), Mallick <i>et al.</i> (2011), Nirmala & Rao (1981, 1984, 1986), Pavone <i>et al.</i> (1981), Peng & Hsu (1977), Probatova & Sokolovskaya (1990), Probatova <i>et al.</i> (1996), Sharma (1970), Ward (1983)	WCE. Nepal 850-3000
<i>G. parviflora</i> Cav.	n=8	Banerjee (1971), Canne (1983), Gill & Omoigui (1987, 1988), Gupta & Garg (1987), Gupta & Gill (1988, 1989), Gupta <i>et al.</i> (1989), Husaini & Iwo (1990), Mathew & Mathew (1988), Razaq <i>et al.</i> (1994), Sharma (1970), Strother (1976)	WCE. Nepal 850-3000
<i>G. parviflora</i> Cav.	2n=32	Jose & Mathew (1995), Magulaev (1982), Nirmala & Rao (1981)	WCE. Nepal 850-3000
<i>G. parviflora</i> Cav.	n=24II	Strother & Panero (2001)	WCE. Nepal 850-3000
<i>G. parviflora</i> Cav.	2n=24	Gopinathan & Babu (1982)	WCE. Nepal 850-3000
<i>G. quadriradiata</i> Ruiz & Pav.	n=16	Dillon (1982), Mulligan (1984), Robinson <i>et al.</i> (1981), Strother & Panero (2001)	C. Nepal 1400-1700
<i>G. quadriradiata</i> Ruiz & Pav.	n=16II	Sundberg <i>et al.</i> (1986)	C. Nepal 1400-1700
<i>G. quadriradiata</i> Ruiz & Pav.	2n=32	Canne (1983),	C. Nepal 1400-1700
<i>G. quadriradiata</i> Ruiz & Pav.	2n=16	Hill (1995)	C. Nepal 1400-1700
<i>G. quadriradiata</i> Ruiz & Pav.	n=16II, c. 16II	Carr <i>et al.</i> (1999)	C. Nepal 1400-1700
<i>G. quadriradiata</i> Ruiz & Pav.	2n=32+0-2B	Lökvist & Hultgård (1999)	C. Nepal 1400-1700
<i>Gnaphalium affine</i> D. Don	2n=14	Nishikawa (1984)	WCE. Nepal 600-3700m
<i>G. affine</i> D. Don	n=7	Hong & Zhang (1990)	WCE. Nepal 600-3700

<i>G. affine</i> D. Don	2n=14	Mallick <i>et al.</i> (2011)	E. Nepal 2800
<i>G. hypoleucum</i> DC.	n=7	Gupta & Gill (1979, 1989), Gupta <i>et al.</i> (1989), Mehra & Remanandan (1975)	W. Nepal 2500
<i>G. polycaulon</i> Pers.	n=8	Verma & Vijayavalli (1998)	CE. Nepal 200-1400
<i>G. polycaulon</i> Pers.	2n=14	Verma & Vijayavalli (1998)	CE. Nepal 200-1400
<i>G. polycaulon</i> Pers.	2n=16	Verma & Vijayavalli (1998)	CE. Nepal 200-1400
<i>G. purpureum</i> L.	2n=28	Peng & Hsu (1977, 1978), Sidhu & Bir (1983)	C. Nepal 1400
<i>G. purpureum</i> L.	n=14	Mathew & Mathew (1988)	C. Nepal 1400
<i>G. purpureum</i> L.	n=7	Mehra & Remanandan (1975)	C. Nepal 1400
<i>G. purpureum</i> L.	2n=28	Present count	C. Nepal 1250
<i>Grangea maderaspatana</i> (L.) Poir.	n=9	Gupta & Gill (1989), Sarkar <i>et al.</i> (1982)	C. Nepal 150
<i>G. maderaspatana</i> (L.) Poir.	n=16	Nirmala & Rao (1990)	C. Nepal 150
<i>G. maderaspatana</i> (L.) Poir.	2n=16	Nirmala & Rao (1984, 1990)	C. Nepal 150
<i>G. maderaspatana</i> (L.) Poir.	2n=18	Nirmala & Rao (1981), Peng & Hsu (1977)	C. Nepal 150
<i>Guizotia abyssinica</i> (L. f.) Cass.	2n=10	Patel <i>et al.</i> (1982)	WCE. Nepal 900-1900
<i>G. abyssinica</i> (L. f.) Cass.	2n=21	Patel <i>et al.</i> (1982)	WCE. Nepal 900-1900
<i>G. abyssinica</i> (L. f.) Cass.	2n=30	Banerjee (1971), Harriman (1978), Hiremath & Murthy (1988, 1992), Joshi (1988), Patel <i>et al.</i> (1982, 1983), Ramachandran & Prasad (1997)	WCE. Nepal 900-1900
<i>G. abyssinica</i> (L. f.) Cass.	n=15	Banerjee (1971), Gupta & Gill (1989), Gill & Omoigui (1992), Murthy (1995)	WCE. Nepal 900-1900
<i>G. abyssinica</i> (L. f.) Cass.	2n=60	Patel <i>et al.</i> (1982)	WCE. Nepal 900-1900
<i>Gynura cusimbua</i> (D. Don) S. Moore	n=20	Mehra & Remanandan (1975)	WCE. Nepal 1500-2500
<i>Helianthus tuberosus</i> L.	2n=102	Kulshreshtha & Gupta (1981), Wcis (1990), Murin (1976, 1978), Murin (1981)	E. Nepal 2300

<i>H. tuberosus</i> L.	n=51	Kulshreshtha & Gupta (1979)	E. Nepal 2300
<i>Hemistepa lyrata</i> (Bunge) Bunge	2n=36	Peng & Hsu (1978)	W. Nepal
<i>Hieracium umbellatum</i> L.	2n=27	Belaeva & Siplivinsky (1975, 1976), Chinnappa & Chmielewski (1987), Guppy (1978), Jalas & Pellinen (1985), Kashin <i>et al.</i> (2003), Krogulevich (1971, 1976, 1978), Lavrenko <i>et al.</i> (1990), Probatova (2005), Rudyka (1988), Shatokhina (2005), Volkova & Boyko (1986), Volkova & Basargin (2002)	W. Nepal 2600
<i>H. umbellatum</i> L.	n=9	Rostovtseva (1983)	W. Nepal 2600
<i>H. umbellatum</i> L.	2n=18	Chrték (2004), Jalas & Pellinen (1985), Kamil (2006), Kashin <i>et al.</i> (2003), Kiehn <i>et al.</i> (2000), Krasnikov (2004), Lavrenko & Serditov (1991), Měsíček (1992), Mráz (2003), Nazarova (1984), Uhrikova & Ferakova (1977),	W. Nepal 2600
<i>H. umbellatum</i> L.	2n=18+0-1B	Lövkvist & Hultgård (1999)	W. Nepal 2600m
<i>Inula cappa</i> (Buch.-Ham. ex D. Don) DC.	n=20	Mehra & Remanandan (1975)	WCE. Nepal 150-2500
<i>I. cuspidata</i> (Wall. ex DC.) C.B. Clarke	n=10	Mehra & Remanandan (1975), Razaq <i>et al.</i> (1994)	E. Nepal 300
<i>I. eupatorioides</i> Wall. ex DC	n=10	Mehra & Remanandan (1975)	E. Nepal 1200-1500
<i>I. racemosa</i> Hook. f.	n=10	Mehra & Remanandan (1975)	WCE. Nepal 2500-3700
<i>Ixeris makinoana</i> (Kitam.) Kitam.	2n=14	Pak & Kawano (1990)	CE. Nepal 1700-2500
<i>I. polycephala</i> Cass.	2n=16	Pak & Kawano (1990), Kim & Ko (1991)	WC 750-1800
<i>I. polycephala</i> Cass.	2n=16	Present count	C. Nepal 1520
<i>Lactuca dissecta</i> D. Don	n=8	Gupta & Gill (1989), Razaq <i>et al.</i> (1994)	WCE. Nepal 500-3100
<i>L. dissecta</i> D. Don	2n=16	Kaul (1974)	WCE. Nepal 500-3100
<i>L. sativa</i> L.	2n=18	Gemeinholzer (2005), Haque & Godward (1985, 1986), Kamel (2004), Koopman <i>et al.</i> (1993), Koopman & Jong (1996), Probatova (2006), Yan <i>et al.</i> (2000)	C. Nepal
<i>L. sativa</i> L.	n=9	Gupta & Gill (1989)	C. Nepal
<i>Laggera aurita</i> (L. f.) Sch. Bip.	n=10	Mathew & Mathew (1975)	E. Nepal 80-200

<i>L. pterodonta</i> (DC.) Benth.	n=10	Mathew & Mathew (1975)	WC. Nepal 1000-1400
<i>Launaea procumbens</i> (Roxb.) Ramayya & Rajagopal	n=9	Gupta & Gill (1989), Razaq <i>et al.</i> (1994)	WC. Nepal 250- 1200
<i>Leontopodium jacotianum</i> Beauverd	n=12	Khatoon & Ali (1988)	WCE. Nepal 2700-4900
<i>L. jacotianum</i> Beauverd	n=14	Khatoon & Ali (1988)	WCE. Nepal 2700-4900
<i>Leucanthemum vulgare</i> Lam.	2n=36	Arohonka (1982), Dmitrieva (1987), Lavrenko <i>et al.</i> (1991), Lökvist & Hultgård (1999), Marchi <i>et al.</i> (1983), Morton (1977, 1981), Stepanov & Muratova (1995)	E. Nepal 2100
<i>L. vulgare</i> Lam.	2n=18	Dempsey <i>et al.</i> (1994), Dmitrieva (2000), Heubl & Lippert (1989), Khandjian (1975), Morton (1977), Nagl & Ehrendorfer (1974), Probatova <i>et al.</i> (1989), Probatova (2000), Rostovtseva (1979), Strid & Andersson (1985), Vogt (2000)	E. Nepal 2100
<i>L. vulgare</i> Lam.	2n=54	Parfitt (1981)	E. Nepal 2100
<i>L. vulgare</i> Lam.	n=9II	Parfitt (1981)	E. Nepal 2100
<i>L. vulgare</i> Lam.	n=9	Rostovtseva (1979)	E. Nepal 2100
<i>L. vulgare</i> Lam.	2n=18+B	Khandjian (1975)	E. Nepal 2100
<i>L. vulgare</i> Lam.	2n=36+0-1B	Dmitrieva (2000)	E. Nepal 2100
<i>Ligularia fischeri</i> (Ledeb.) Turcz.	2n=60	Gurzenkov (1973), Probatova (2005), Rudyka (1990)	WCE. Nepal 2200-4600
<i>L. fischeri</i> (Ledeb.) Turcz.	2n=58	Liu (2004)	WCE. Nepal 2200-4600
<i>L. virgaurea</i> (Maxim.) Mattf. ex Rehder & Kobuski	2n=58, 87	Liu (2004)	W. Nepal 3000
<i>Mikania micrantha</i> Kunth	n=19	King <i>et al.</i> (1976), Robinson <i>et al.</i> (1989)	E. Nepal 700- 1200
<i>M. micrantha</i> Kunth	n=18	Jansen <i>et al.</i> (1984)	E. Nepal 700- 1200
<i>M. micrantha</i> Kunth	2n=72	Ruas & Ruas (1987)	E. Nepal 700- 1200
<i>M. micrantha</i> Kunth	n=17	King <i>et al.</i> (1976), Turner <i>et al.</i> (1979)	E. Nepal 700-

			1200
<i>M. micrantha</i> Kunth	n=19II	Keil <i>et al.</i> (1988)	E. Nepal 700-1200
<i>Myriactis nepalensis</i> Less.	n=18	Gupta & Garg (1987), Gupta <i>et al.</i> (1989)	WCE. Nepal 1400-3900
<i>Notonia grandiflora</i> DC.	n=10	Mathew & Mathew (1988)	W. Nepal 600-1100
<i>N. grandiflora</i> DC.	2n=20	Mathew & Mathew (1988), Nirmala & Rao (1984, 1986)	W. Nepal 600-1100
<i>Parthenium hysterophorus</i> L.	n=c.18	Mathew & Mathew (1988), Razaq <i>et al.</i> (1994), Robinson <i>et al.</i> (1981), Turner <i>et al.</i> (1979)	C. Nepal 600
<i>P. hysterophorus</i> L.	2n=34	Hederson <i>et al.</i> (1977), Nirmala & Rao (1984), Turner <i>et al.</i> (1979), Xie & Zheng (2003)	C. Nepal 600
<i>P. hysterophorus</i> L.	n=17	Hederson <i>et al.</i> (1977), Gupta & Gill (1988, 1989), Gupta <i>et al.</i> (1989), Nirmala & Rao (1981), Peng <i>et al.</i> (1988), Sarkar <i>et al.</i> (1982)	C. Nepal 600
<i>P. hysterophorus</i> L.	n=17II	Carr <i>et al.</i> (1999)	C. Nepal 600
<i>P. hysterophorus</i> L.	2n=36	Mathew & Mathew (1988)	C. Nepal 600
<i>P. hysterophorus</i> L.	2n=34	Present count	C. Nepal 1330
<i>Phagnalon niveum</i> Edgew.	n=9	Razaq <i>et al.</i> (1994)	WC. Nepal 1700-3000
<i>Picris hieracioides</i> L.	2n=10	Dmitrieva (1987), Dobeia <i>et al.</i> (1996), Ge <i>et al.</i> (1989), Gemeinholzer (2005), Kiehn <i>et al.</i> (1991), Kliphius (1977), Kuzmanov & Jurukova (1977), Love & Love (1982), Morton (1977), Natarajan (1981), Nazarova (1984), Nazarova (2004), Rudyka (1990), Vachova (1978), Van Den Brand <i>et al.</i> (1979), Volkova & Boyko (1986)	WCE. Nepal 1800-3800
<i>P. hieracioides</i> L.	n=5	Díez <i>et al.</i> (1984), Mathew & Mathew (1988), Razaq <i>et al.</i> (1994)	WCE. Nepal 1800-3800
<i>P. hieracioides</i> L.	2n=10+0-B	Lökvist & Hultgård (1999)	WCE. Nepal 1800-3800
<i>Prenanthes brunoniana</i> Wall. ex DC.	2n=8	Gupta <i>et al.</i> (1989)	WC. Nepal 2300-3800
<i>Pulicaria dysenterica</i> (L.) Bernh.	2n=20	Love & Love (1982)	C. Nepal 250-2000
<i>Pulicaria</i>	2n=18	Dempsey <i>et al.</i> (1994), Dobeia <i>et al.</i> (1996),	C. Nepal 250-

<i>dysenterica</i> (L.) Bernh.		Hommel & Wieffering (1979), Hollingsworth <i>et al.</i> (1992), Javurková- Jarolímová (1992), Morton (1977), Pogan (1983),	2000
<i>Rhynchospermum</i> <i>verticillatum</i> Reinw.	2n=18	Mallick <i>et al.</i> (2013a), Peng & Hsu (1977, 1978)	C. Nepal 1500- 2500
<i>Saussurea</i> <i>candolleana</i> (Wall.) C.B. Clarke	n=13	Jee <i>et al.</i> (1983)	WCE. Nepal 2400-4400
<i>S. deltoidea</i> subsp. <i>Deltoidea</i> (DC.) Sch. Bip.	2n=34	Shimizu <i>et al.</i> (1984)	WCE. Nepal 2600-3400
<i>S. gnaphalodes</i> (Royle exDC	2n=48	Huang <i>et al.</i> (1996)	WC. Nepal 4900-5300
<i>S. gossypiphora</i> D. Don	n=13	Malla <i>et al.</i> (1979)	CE. Nepal 3500- 5700
<i>S. gossypiphora</i> D. Don	n=18	Fujikawa & Ohba (2003)	CE. Nepal 3500- 5700
<i>S. gossypiphora</i> D. Don	2n=36	Fujikawa & Ohba (2003)	CE. Nepal 3500- 5700
<i>S. graminifolia</i> Wall. ex DC.	2n=32	Fujikawa <i>et al.</i> (2004)	WCE. Nepal 3600-5600
<i>S. heteromalla</i> (D. Don) Hand.-Mazz.	n=17	Koul <i>et al.</i> (1976)	WC. Nepal 550- 4000
<i>S. hieracioides</i> Hook. f.	2n=64	Fujikawa <i>et al.</i> (2004)	WCE. Nepal 3700-4950
<i>S. laminamaensis</i> Kitam.	2n=36	Fujikawa & Ohba (2003)	E. Nepal 3400- 4900
<i>S. leontodontoides</i> (DC.) Hand-Mazz.	2n=30	Fujikawa <i>et al.</i> (2004)	CE. Nepal 4400
<i>S. nepalensis</i> Spreng.	2n=32	Gala <i>et al.</i> (2004)	CE. Nepal 3200- 4900
<i>S. nishiokae</i> Kitam.	2n=36	Amano & Ohba (2000)	WC. Nepal 4500-4900
<i>S. obvallata</i> (DC.) Edgew.	2n=32	Gala <i>et al.</i> (2004), Fujikawa <i>et al.</i> (2004),	CE. Nepal 3800- 4600
<i>Saussurea obvallata</i> (DC.) Edgew.	2n=32+3B	Fujikawa <i>et al.</i> (2004)	CE. Nepal 3800- 4600
<i>S. simpsoniana</i> (Fielding & Gardner) Lipsch.	2n=32	Amano & Ohba (2000), Fujikawa & Ohba (2003)	WCE. Nepal 3800-5600
<i>S. simpsoniana</i>	2n=32+0-2	Fujikawa & Ohba (2003)	WCE. Nepal

(Fielding & Gardner) Lipsch.			3800-5600
<i>S. topkegolensis</i> H. Ohba & S. Akiyama	2n=32	Amano & Ohba (2000), Fujikawa & Ohba (2003)	E. Nepal 3570-4630
<i>S. tridactyla</i> Sch. Bip. ex Hook. f.	2n=36	Amano & Ohba (2000), Fujikawa & Ohba (2003), Fujikawa <i>et al.</i> (2004)	WCE. Nepal 4500-5800
<i>S. uniflora</i> Wall. ex Hook. f.	2n=32	Amano & Ohba (2000)	CE. Nepal 3700-4700
<i>S. werneroides</i> Sch. Bip. ex Hook. f.	2n=32	Gala <i>et al.</i> (2004)	CE. Nepal 3800-5300
<i>Sclerocarpus africanus</i> Jacq. ex Murray	n=22	Gill & Omoigui (1987, 1988)	E. Nepal 200
<i>S. africanus</i> Jacq. ex Murray	n=18	Husaini & Iwo (1990)	E. Nepal 200
<i>S. africanus</i> Jacq. ex Murray	n=11	Jose & Mathew (1995)	E. Nepal 200
<i>Senecio graciliflorus</i> (Wall.) DC.	n=20	Gupta & Garg (1987), Gupta <i>et al.</i> (1989), Mehra & Remanandan (1975)	WCE. Nepal 2500-4600
<i>S. laetus</i> Edgew.	2n=36	Peresnt count	C. Nepal 1515
<i>S. nudicaulis</i> Buch.-Ham. ex C.B. Clarke	n=20	Mehra & Remanandan (1975)	WC. Nepal 1100-2300
<i>S. rufinervis</i> DC.	n=10	Gupta & Gill (1981, 1989), Gupta <i>et al.</i> (1989)	WCE. Nepal 2600-3200
<i>S. rufinervis</i> DC.	n=20	Gupta & Gill (1989)	WCE. Nepal 2600-3200
<i>S. rufinervis</i> DC.	2n=40	Gupta <i>et al.</i> (1989)	WCE. Nepal 2600-3200
<i>S. rufinervis</i> DC.	n=18	Mehra & Remanandan (1975)	WCE. Nepal 2600-3200
<i>S. scandens</i> Buch.-Ham. ex D. Don	n=10	Mathew & Mathew (1988)	CE. Nepal 2100-2800
<i>S. scandens</i> Buch.-Ham. ex D. Don	2n=20	Peng & Hsu (1977, 1978)	CE. Nepal 2100-2800
<i>Sigesbeckia orientalis</i> L.	n=30	Gupta & Garg (1987)	WCE. Nepal 400-2700
<i>S. orientalis</i> L.	n=15	Jose & Mathew (1995), Nirmala & Rao (1981)	WCE. Nepal 400-2700

<i>S. orientalis</i> L.	n=15II	Carr <i>et al.</i> (1999)	WCE. Nepal 400-2700
<i>S. orientalis</i> L.	2n=30	Jose & Mathew (1995), Nirmala & Rao (1984, 1990), Nirmala & Rao (1981)	WCE. Nepal 400-2700
<i>S. orientalis</i> L.	2n=60	Jose & Mathew (1995)	WCE. Nepal 400-2700
<i>Solidago virgaurea</i> L.	2n=18	Belaeva & Siplivinsky (1975), Dmitrieva (1987, 1988), Dmitrieva <i>et al.</i> (1977), Druskovic & Lovka (1995), Garbari (1979), Kartashova <i>et al.</i> (1974), Kuzmanov <i>et al.</i> (1981), Lavrenko & Serditov (1991), Lavrenko <i>et al.</i> (1991), Malakhova <i>et al.</i> (1979), Morton (1977), Rostovtseva (1984), Skalinska (1978), Skalinska <i>et al.</i> (1978), Strid & Franzen (1981)	WC. Nepal 2300-3400
<i>S. virgaurea</i> L.	n=9	Gupta & Garg (1987), Gupta & Gill (1989), Gupta <i>et al.</i> (1989), Rostovtseva (1983)	WC. Nepal 2300-3400
<i>S. virgaurea</i> L.	n=20	Strid & Franzen (1981)	WC. Nepal 2300-3400
<i>S. virgaurea</i> L.	2n=44	Mathew & Mathew (1988)	WC. Nepal 2300-3400
<i>Soliva anthemifolia</i> (Juss.) R. Br.	n=c.59	Gupta & Gill (1980)	WC. Nepal 100-1400
<i>Sonchus asper</i> (L.) Hill	n=9	Ghaffari (1989), Gill (1978c), Gupta & Gill (1989), Gill (1978a), Mulligan (1984), Prabha (1989), Razaq <i>et al.</i> (1994, 1988),	C. Nepal cosmopo-litan
<i>S. asper</i> (L.) Hill	2n=18	Bir & Sidhu (1979, 1980), Kiehn <i>et al.</i> (1988), Kirschner <i>et al.</i> (1982), Kuzmanov & Georgieva (1976), Lövkvist & Hultgård (1999), Morton (1977, 1993), Nazarova (1975, 1984, 1989), Nishikawa (1984), Prabha (1989), Probatova & Sokolovskaya (1981), Probatova (2006), Sidhu (1979), Strid & Franzen (1981), Vogt & Oberprieler (1993), Van Den Brand <i>et al.</i> (1979)	C. Nepal cosmopo-litan
<i>S. asper</i> (L.) Hill	n=9II	Kyhos & Raven (1982), Strid & Franzen (1981)	C. Nepal cosmopo-litan
<i>S. asper</i> (L.) Hill	2n=32	Nirmala & Rao (1984, 1989)	C. Nepal cosmopo-litan
<i>S. asper</i> (L.) Hill	n=18II	Carr <i>et al.</i> (1999)	C. Nepal cosmopo-litan
<i>S. asper</i> (L.) Hill	2n=18+3B	Lövkvist & Hultgård (1999)	C. Nepal

			cosmopo-litan
<i>S. asper</i> (L.) Hill	2n=36	Belaeva & Siolivinsky (1976), Kuzmanova & Georgieva (1980)	C. Nepal cosmopo-litan
<i>S. asper</i> (L.) Hill	2n=18	Mallick <i>et al.</i> (2013b)	C. Nepal 1330
<i>S. oleraceus</i> L.	n=16	Bir & Sidhu (1979), Gill & Omoigui (1992), Gupta & Gill (1989), Husaini & Iwo (1990),), Kliphuis & Wieffering (1979), Koul (1976), Mathew & (1988), Peng & Hsu (1978), Razaq <i>et al.</i> (1988, 1994), Tomb <i>et al.</i> (1978)	WC. Nepal 2300-2800
<i>S. oleraceus</i> L.	2n=32	Arohonka (1982), Al-Bermani <i>et al.</i> (1993), Bir & Sidhu (1979, 1980), Díaz Lifante <i>et al.</i> (1992), Gemeinholzer (2005), Jansen & Stuessy (1980), Hiremath & Chennaveeraiah (1985), Kamel (2004), Kliphuis & Wieffering (1979),) Lavrenko & Serditov (1991), Lökvist & Hultgård (1999), Malallah & Brown (1999), Mathew & Mathew (1988), Nazarova (1975, 19 84, 1989), Nishikawa (1984), Oberprieler & Vogt. (1993), Pangua <i>et al.</i> (1992), Peng & Hsu (1977, 1978), Probatova (2006), Probatova <i>et al.</i> (1996), Sidhu (1979), Vogt & Aparicio (1999), Xu <i>et al.</i> (1992)	WC. Nepal 2300-2800
<i>S. oleraceus</i> L.	n=18	Gupta & Garg (1987), Gupta <i>et al.</i> (1989), Jansen & Stuessy (1980), Van Loon (1980),	WC. Nepal 2300-2800
<i>S. oleraceus</i> L.	n=16II	Carr <i>et al.</i> (1999)	WC. Nepal 2300-2800
<i>S. oleraceus</i> L.	2n=64	Hiremath & Chennaveeraiah (1985)	WC. Nepal 2300-2800
<i>S. oleraceus</i> L.	2=36	Van Loon (1980)	WC. Nepal 2300-2800
<i>S. oleraceus</i> L.	n=10	Sun <i>et al.</i> (2002)	WC. Nepal 2300-2800
<i>S. oleraceus</i> L.	n=9	Sharma (1970)	WC Nepal 2300- 2800
<i>S. wightianus</i> DC.	n=9	Khattoon & Ali (1988), Razaq <i>et al.</i> (1994)	WCE. 600-2500
<i>S. arvensis</i> L.	2n=36	Dmitrieva (1987), Gorzko <i>et al.</i> (1980), Kuzmanov <i>et al.</i> (1986), Nazarova (1984, 1989)	C. Nepal 1300
<i>S. arvensis</i> L.	2n=34	Joshi (1988)	C. Nepal 1300
<i>S. arvensis</i> L.	2n=18	Mallick <i>et al.</i> (2013b), Mathew & Mathew (1988), Prabha & Roy (1986)	C. Nepal 1300

<i>S. arvensis</i> L.	n=27	Mulligan (1984)	C. Nepal 1300
<i>S. arvensis</i> L.	n=9	Mathew & Mathew (1988), Prabha (1989)	C. Nepal 1300
<i>Sphaeranthus indicus</i> L.	n=10	Gupta & Gill (1989), Mathew & Mathew (1988), Mehra & Remanandan (1975), Sarkar <i>et al.</i> (1982), Verma & Vijayavalli (1998)	WCE. Nepal 200-800
<i>S. indicus</i> L.	2n=20	Mathew & Mathew (1988), Nirmala & Rao (1981, 1984, 1990), Rajalakshmi & Jose (2002)	WCE. Nepal 200-800
<i>S. indicus</i> L.	2n=30	Satyanarayan Sahoo & Das (2003)	WCE. Nepal 200-800
<i>S. senegalensis</i> DC.	n=10	Gill & Omoigui (1992)	WC. Nepal 600-1000
<i>Spilanthes acmella</i> (L.) Murray	2n=52	Mathew & Mathew (1988)	C. Nepal 1230
<i>S. acmella</i> (L.) Murray	n=26	Gupta & Gill (1989)	C. Nepal 1230
<i>S. acmella</i> (L.) Murray	2n=46	Nirmala & Rao (1981, 1984, 1989)	C. Nepal 1230
<i>S. acmella</i> (L.) Murray	2n=36	Mallick <i>et al.</i> (2013b)	C. Nepal 1250
<i>S. calva</i> DC.	2n=72	Jose & Mathew (1995)	CE. Nepal 300-2300
<i>S. calva</i> DC.	2n=36	Mallick <i>et al.</i> (2013b)	C. Nepal 1515
<i>S. oleracea</i> L.	2n=78	Mathew & Mathew (1988)	C. Nepal 600-1400
<i>S. oleracea</i> L.	2n=60	Jose & Mathew (1995)	C. Nepal 600-1400
<i>S. oleracea</i> L.	n=30	Jose & Mathew (1995)	C. Nepal 600-1400
<i>S. paniculata</i> Wall. ex. DC.	2n=78	Mathew & Mathew (1988)	WC. Nepal 100
<i>Stevia rebaudiana</i> (Bertoni) Bertoni	2n=22	Frederico <i>et al.</i> (1996), Mallick <i>et al.</i> (2013b), Oliviera <i>et al.</i> (2004)	C. Nepal 1280
<i>Stevia rebaudiana</i> (Bertoni) Bertoni	n=11	Oliviera <i>et al.</i> (2004)	C. Nepal 1280
<i>Synedrella nodiflora</i> (L.) Gaertn.	n=20	Banerjee (1971), Gupta & Gill (1989), Jansen <i>et al.</i> (1984), Mathew & Mathew (1988), Sharma (1970)	E. Nepal 400-900
<i>S. nodiflora</i> (L.) Gaertn.	2n=40	Banerjee (1971), Mathew & Mathew (1988), Morton (1993), Nirmala & Rao (1981), Peng & Hsu (1977), Sharma (1970), Xie & Zheng (2003)	E. Nepal 400-900

<i>S. nodiflora</i> (L.) Gaertn.	2n=36	Nirmala & Rao (1984, 1986)	E. Nepal 400-900
<i>S. nodiflora</i> (L.) Gaertn.	n=18	Nirmala & Rao (1984), Peng & Hsu (1978)	E. Nepal 400-900
<i>S. nodiflora</i> (L.) Gaertn.	n=19	Gill & Omoigui (1992)	E. Nepal 400-900
<i>S. nodiflora</i> (L.) Gaertn.	2n=34	Jose & Mathew (1995)	E. Nepal 400-900
<i>S. nodiflora</i> (L.) Gaertn.	2n=68	Jose & Mathew (1995)	E. Nepal 400-900
<i>Tagetes erecta</i> L.	2n=24	Chen <i>et al.</i> (2003), Ge <i>et al.</i> (1988), Murín (1993), Serrato-Cruz <i>et al.</i> (2000), Wang & Li (1987)	CE. Nepal 1800-2000
<i>T. erecta</i> L.	n=12	Husaini & Iwo (1990), Gupta & Gill (1989), Mathew & Mathew (1980, 1988)	CE. Nepal 1800-2000
<i>T. minuta</i> L.	n=24	Gupta & Gill (1988, 1989), Gupta <i>et al.</i> (1989), Razaq <i>et al.</i> (1994)	WC. Nepal 2400
<i>T. patula</i> L.	2n=24	Nirmala & Rao (1984, 1986)	WCE. Nepal 900-2000
<i>T. patula</i> L.	n=24	Gupta & Gill (1989), Mallick <i>et al.</i> (2013b), Sharma (1970)	WCE. Nepal 900-2000
<i>T. patula</i> L.	2n=48	Probatova <i>et al.</i> (1991), Serrato-Cruz <i>et al.</i> (2000)	WCE. Nepal 900-2000
<i>T. patula</i> L.	n=12II	Carr <i>et al.</i> (1999)	WCE. Nepal 900-2000
<i>T. patula</i> L.	n=10	Sharma (1970)	WCE. Nepal 900-2000
<i>T. patula</i> L.	n=12	Sharma (1970)	WCE. Nepal 900-2000
<i>T. patula</i> L.	2n=20	Chen <i>et al.</i> (2003), Sharma (1970)	WCE. Nepal 900-2000
<i>T. tenuifolia</i> Cav.	n=24II	Strother (1983)	C. Nepal 1900
<i>T. tenuifolia</i> Cav.	n=12II	Keil <i>et al.</i> (1988)	C. Nepal 1900
<i>T. tenuifolia</i> Cav.	n=12	Gupta & Gill (1981, 1989), Keil & Stuessy (1977)	C. Nepal 1900
<i>T. tenuifolia</i> Cav.	2n=24	Lavrenko & Serditov (1987), Luque & Lifante (1991), Peng & Hsu (1977), Serrato-Cruz <i>et al.</i> (2000), Zhai <i>et al.</i> (1997)	C. Nepal 1900
<i>T. tenuifolia</i> Cav.	2n=24+1B	Krasnikov & Lomonosova (1990)	C. Nepal 1900
<i>Taraxacum officinale</i> F.H. Wigg.	2n=24+2B	Dmitrieva (2000)	CE. Nepal 1200-2800

<i>T. officinale</i> F.H. Wigg.	2n=26	Gupta & Garg (1987)	CE. Nepal 1200-2800
<i>T. officinale</i> F.H. Wigg.	2n=32	Kashin <i>et al.</i> (2003)	CE. Nepal 1200-2800
<i>T. officinale</i> F.H. Wigg.	2n=24	Dmitrieva (2000), Kashin <i>et al.</i> (2003), Kartashova <i>et al.</i> (1974), Verduijn (2004), Zhai <i>et al.</i> (1997)	CE Nepal 1200-2800
<i>T. officinale</i> F.H. Wigg.	2n=16	Kashin <i>et al.</i> (2003), Verduijn (2004)	CE.. Nepal 1200-2800
<i>T. officinale</i> F.H. Wigg.	2n=20	Present count	E. Nepal 2800
<i>T. officinale</i> F.H. Wigg.	n=10	Present count	E. Nepal 2800
<i>Tithonia diversifolia</i> (Hemsl.) A. Gray	n=17	Robinson <i>et al.</i> (1981)	E Nepal 800-1500
<i>T. diversifolia</i> (Hemsl.) A. Gray	n=17II	Strother (1983)	E. Nepal 800-1500
<i>T. diversifolia</i> (Hemsl.) A. Gray	n=15	Chatha & Bir (1986)	E. Nepal 800-1500
<i>T. diversifolia</i> (Hemsl.) A. Gray	n=17	Chatha & Bir (1986), Gill & Omoigui (1987), Jose & Mathew (1995), La Duke & Remple (1985)	E. Nepal 800-1500
<i>T. diversifolia</i> (Hemsl.) A.	2n=34	Chen <i>et al.</i> (2003), Jose & Mathew (1995), Wang & Li (1987), Xie & Zheng (2003)	E. Nepal 800-1500
<i>T. rotundifolia</i> (Mill.) S.F. Blake Gray	n=17	Gill & Omoigui (1987), Jose & Mathew (1995), La Duke & Remple (1985), Mathew & Mathew (1988), Robinson <i>et al.</i> (1981)	WC. 900-2300
<i>T. rotundifolia</i> (Mill.) S.F. Blake Gray	2n=34	Jose & Mathew (1995)	WC. 900-2300
<i>Tragopogon gracilis</i> D. Don	2n=12	Mehra & Rao (1980)	WC. 900-2300
<i>Tridax procumbens</i> L.	n=18	Gill & Omoigui (1987, 1988), Gupta & Gill (1989), Husaini & Iwo (1990), Jose & Mathew (1995), Keil & Stuessy (1975, 1977), Khatoon & Ali (1988), Koul <i>et al.</i> (1976), Mathew & Mathew (1988), Nirmala & Rao (1981), Razaq <i>et al.</i> (1988)	WCE. Nepal 100-1500

<i>T. procumbens</i> L.	2n=36	Baltisberger (1990), Nirmala & Rao (1981, 1984, 1985), Sidhu & Pelia (1987), Zheng & Xie (2003)	WCE. Nepal 100-1500
<i>T. procumbens</i> L.	n=13	Gill & Omoigui (1988)	WCE. Nepal 100-1500
<i>T. procumbens</i> L.	2n=26	Mallick <i>et al.</i> (2013a)	W.Nepal 700
<i>Tussilago farfara</i> L.	2n=60	Arohonka (1982), Druskovic & Lovka (1995), Hill (1989), Hollingsworth <i>et al.</i> (1992), Kuzmanov <i>et al.</i> (1986), Liu (2000), Lökvist & Hultgård (1999), Měsíček (1992), Morton (1977), Rostovtseva (1979), Skalinska <i>et al.</i> (1976), Van Den Brand <i>et al.</i> (1979)	W. Nepal 2800-3800
<i>Vernonia anthelmintica</i> (L.) Willd.	2n=20	Ma <i>et al.</i> (1984), Mathew & Mathew (1976, 1982, 1988)	WCE. Nepal 1200-2000
<i>V. anthelmintica</i> (L.) Willd.	n=10	Mathew & Mathew (1975, 1983, 1988)	WCE. Nepal 1200-2000
<i>V. cinerea</i> (L.) Less.	n=9	Ayodele (1999), Bir & Sidhu (1975, 1980), Gill & Omoigui (1987), Gill (1978a, 1978), Gupta & Gill (1989), Koul <i>et al.</i> (1976), Mathew & Mathew (1988), Mehra & Remanandan (1975), Nirmala & Rao (1981), Razaq <i>et al.</i> (1988, 1994)	WCE. Nepal 100-2300
<i>V. cinerea</i> (L.) Less.	2n=18	Adegbite (2004), Ayodele (1999), Bir & Sidhu (1975, 1980), Keeley & Jones (1977), Mathew & Mathew (1982, 1983, 1988), Nirmala & Rao (1984), Xie & Zheng (2003)	WCE. Nepal 100-2300
<i>V. cinerea</i> (L.) Less.	9II	Keil <i>et al.</i> (1988)	WCE. Nepal 100-2300
<i>V. revoluta</i> Buch.-Ham.	n=9	Mehra & Remanandan (1975)	W. Nepal 900
<i>Wedelia wallichii</i> Less.	2n=30	Mallick <i>et al.</i> (2011)	C. Nepal 1210
<i>W. wallichii</i> Less.	n=15	Present count	C. Nepal 1210 m
<i>Xanthium strumarium</i> L.	2n=36	Bakale & Srinivasu (1988), Bir & Sidhu (1980), Joshi (1988), Jose & Mathew (1995), Love & Love (1982), Mathew & Mathew (1988), Rostovtseva (1979), Sidhu (1979), Skalinska (1974)	WCE. Nepal 100-2500
<i>X. strumarium</i> L.	n=18	Bir & Sidhu (1980), Gupta & Gill (1989),	WCE. Nepal

		Jose & Mathew (1995), Koul <i>et al.</i> (1976), Mathew & Mathew (1988), Pinkava & Keil (1977), Razaq <i>et al.</i> (1994), Sarkar <i>et al.</i> (1982), Sidhu (1979)	100-2500
<i>X. strumarium</i> L.	2n=34	Mohamed (1997)	WCE. Nepal 100-2500
<i>X. strumarium</i> L.	2n=32	Present count	C. Nepal 1330
<i>X. strumarium</i> L.	n=16	Present count	C. Nepal 1330
<i>Youngia japonica</i> (L.) DC.	2n=16	Nishikawa (1984)	WCE. Nepal 230-2900
<i>Y. japonica</i> (L.) DC.	n=5II	Byung-Yun <i>et al.</i> (1996)	WCE. Nepal 230-2900
<i>Y. japonica</i> (L.) DC.	n=18II	Carr <i>et al.</i> (1999)	WCE. Nepal 230-2900
<i>Y. japonica</i> (L.) DC.		Kovanda (1978)	WCE. Nepal 230-2900
<i>Y. tenuifolia</i> (Willd.) Babc. & Stebbins	2n=10	Krogulevich (1978), Rudyka (1995), Stepanov (1994)	C. Nepal 3000- 4000
<i>Y. tenuifolia</i> (Willd.) Babc. & Stebbins	n=5	Rostovtseva (1979)	C. Nepal 3000- 4000
<i>Zinnia elegans</i> Jacq.	n=12	Banerjee (1971), Gupta & Gill (1989), Husaini & Iwo (1990), Jose & Mathew (1995), Powell & Powell (1978), Razaq <i>et al.</i> (1988, 1994)	C E. Nepal 8000- 1400
<i>Z. elegans</i> Jacq.	2n=24	Banerjee (1971), Chen <i>et al.</i> (2003), Gupta <i>et al.</i> (1983), Huang & Zhao (1995), Jose & Mathew (1995), Mallick <i>et al.</i> (2011), Mathew & Mathew (1988), Nirmala & Rao (1984, 1990), Zhao <i>et al.</i> (1990)	C E. Nepal 8000- 1400
<i>Z. elegans</i> Jacq.	2n=36	Gupta <i>et al.</i> (1972)	C E. Nepal 8000- 1400
<i>Z p Z. peruviana</i> (L.) L.	n=12II	Lane & Li (1993)	WC. Nepal 1300-2500
<i>Zinni Z. peruviana</i> (L.) L.	n=12	Keil & Pinkava (1976), Turner <i>et al.</i> (1979)	WC. Nepal 1300-2500

2. Scientific Publications based on present research

2.1 Published papers

- i. Mallick, P. K., Manandhar, L. and Vaidya, B. L. (2011). Chromosomes numbers of some taxa of the Nepalese Asteraceae. *BPAS Research* Vol. **30B** No.(1-2) p. 55-68.
- ii. Mallick, P. K., Manandhar, L. and Vaidya, B. L. (2013a). Karyomorphological Observations on some taxa of Asteraceae of Nepal. *Pleione* **7** (1): 219-227.
- iii. Mallick, P. K., Manandhar L. and Vaidya B. L. (2013b). Karyotypic Analysis of Eight species of Asteraceae of Nepal. *The Journal of U. G. C.* Vol. **2**. No.2 p. 50-65.
- iv. Manandhar, L., Vaidya, B. L and Mallick, P. K. (2011). Contribution to the Chromosome Atlas of the Nepalese Flora III. *Bulletin of Pure & Applied Sciences*. Part of Paper. *BPAS Research* Vol. **30B** No.(1-2) p. 1-24.

2.2 Published abstracts

- i. Mallick, P. K., Manandhar, L. and Vaidya, B. L. (2010). Karyomorphological Observations on Some Taxa of Asteraceae of Nepal. *International Conference, Biodiversity, Livelihood and Climate Change in the Himalayas, 12-14 December 2010*, Kathmandu, Nepal.
- ii. Mallick, P. K., Manandhar, L. and Vaidya, B. L.(2012). Karyotypic Study in Five Species of Asteraceae of Nepal. *The Sixth National Conference on Science and Technology, Sept.25-27, 2012*. Kathmandu, Nepal.

2.3 Online publications

- i. Mallick, P. K., Manandhar, L. and Vaidya, B. L. (2011). Chromosome numbers of some taxa of the nepalese Asteraceae. *Bulletin of Pure & Applied Sciences- Botany* Year : 2011, Volume : 30b, Issue : 1and2 First page : (55) Last page: (68) **Print ISSN : 0970-4612. Online ISSN : 2320-3196. Online published on 22 February, 2013.**
- ii. Mallick, P. K., Manandhar, L. and Vaidya, B. L. (2013). Karyomorphological observations on some taxa of Asteraceae of Nepal. *Pleione* 7(1): 219 - 227. 2013. **ISSN: 0973-9467**© East Himalayan Society for Spermatophyte Taxonomy.

2.4 Conference Attained

- i. Participation and Poster presented in International Conference on Biodiversity, Livelihood and Climate Change in the Himalayas, 12-14 December 2010, Kathmandu, Nepal.
- ii. Participation and Paper presented in The Sixth National Conference on Science and Technology, Sept.25-27, 2012. Kathmandu, Nepal.