SYSTEMATIC STUDIES ON GENUS *NEPETA* L. (LAMIACEAE) IN KASHMIR HIMALAYA

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By

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CERTIFICATE

This is to certify that the thesis entitled, **"Systematic studies on genus *Nepeta* L. (Lamiaceae) in Kashmir Himalaya"** is an original piece of work carried out by Tauheeda Hassan for the award of the degree of Doctor of Philosophy in Botany, University of Kashmir. This study has been carried out by her under our supervision and the same has not been submitted elsewhere for this or any other degree before.

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Dedicated
To My
Dear Parents

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In the name of Allah, the Almighty, the Merciful, all praise to Him, who bestowed me with the courage, enough to undertake this study

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The past century has witnessed compilation of Floras of most of the regions of the World. The taxonomists have documented and communicated a better understanding of the floristic resources, as they are indispensable for the botanical progress of a country or a region. Over the same period, much information on the constituent taxa of Floras has been documented: the information pertaining to their taxonomy, nomenclature, distribution, variation, pollen and seed morphology, economic utility, and many other aspects.

Kashmir, naturing beauty on the Earth, has also been a witness to this scenario, the main aim having been to have a thorough insight into and documentation of the overall floristic diversity of the Valley. The floras of several important regions/areas in the Kashmir Himalaya have been worked out. Some of the important floristic works include: Coventry (1923), *Wild Flowers of Kashmir*; Blatter (1928), *Beautiful Flowers of Kashmir*; Stewart (1972), *An Annotated Catalogue of the Vascular Plants of West Pakistan and Kashmir;* Singh and Kachroo (1976), *Forest Flora of Srinagar and Plants of Neighbourhood*; Kachroo *et al.* (1977), *Flora of Ladakh*; Dhar and Kachroo (1983), *Alpine Flora of Kashmir Himalaya*; Polunin and Stainton (1984),

Flowers of the Himalaya; Singh and Kachroo (1994), *Forest Flora of Pir Panjal Range;* Sharma and Jamwal (1998), *Flora of the Upper Liddar Valley of Kashmir Himalaya,* II.

A number of genera in Lamiaceae have been revised/monographed, both on World basis and at regional levels, such as Bentham (1834), *Labiatarum Genera Et Species*; Bentham (1848), in Candolle, *Prodromus Systematis Naturalis Regni Vegetabilis;* Hooker (1885), in *Flora of British India*; Briquet (1896), in Engler and Prantel, *Die Naturlichen Pflanzenfamilien*; Boissier (1879), in *Flora Orientalis*; Pojarkova (1954), in *Flora of USSR*; Turner (1972), in *Flora Europaea*; Hedge and Lamond (1982), in *Flora of Turkey;* and Rechinger (1982), in *Flora Iranica.*

Nepeta Linn, with approximately 300 species, most of which are herbaceous perennials, is one of the largest genera in family Lamiaceae, subfamily Nepetoideae, tribe Mentheae (Pojarkova, 1954; Başer *et al.*, 2000; Jamzad *et al.*, 2003a; Jamzad *et al.*, 2005). Its species are distributed throughout Southwest and Central Asia, Europe, North Africa, North and Central America, Japan, Korea, China, and the Canary Islands (Pojarkova, 1954; Hedge, 1978, 1986; Jamzad *et al.*, 2000). Most of the species are found in Southwestern Asia, especially Iran [where species representative of most sections (12) occur (Rechinger, 1982)], Central Asia and Trans-Caucasia. Rechinger (1982) recognized 63 species in the Flora of Iran, but this number has now increased to 75 (Jamzad and Assadi, 1984; Jamzad, 1991, 1992, 1998, 1999, 2001; Delghandi, 1993). *Nepeta* is the second largest genus of the Indian labiates, with 41 species in all, 37 of which occur in the Western Himalaya (Mukerjee, 1940). In the Kashmir Himalaya, about 27 species have been reported (Stewart, 1972), but some of them are now considered as synonyms of the other species.

Frequent hybridization and introgression, together with substantial age or habitat-linked variation, make *Nepeta* a particularly complex genus. There

are few clear-cut species, and many that imperceptibly merge into their relatives; it is, therefore, very difficult to make a satisfactory key to them. Gynodioecism is also very common with the male sterile flowers, usually smaller than the hermaphrodites.

Many morphological characters in *Nepeta* are variable and some of these, such as indumentum, calyx characters, leaf shape and size, can vary among closely related species. Leaf morphology is variable even within a single species. As a result, diagnostic use of such characters above the species level is problematic. Nutlets are good characters for species recognition (Hedge and Lamond, 1968; Budantsev and Lobova, 1997; Jamzad *et al.*, 2000; Jamzad, 2001; Jamzad *et al.*, 2003a,b), but species in different sections share the same kind of nutlet ornamentation, so their utility in infrageneric classification has been unclear.

In the systematic revision of any group of this genus, the micro-morphological characters of nutlet surface are either totally ignored, or only seldom mentioned, in spite of their stability as characters. Morphology, shape, colour and size of the nutlets were used as diagnostic characters in its classification. Various researchers have shown that micro-morphological characters can be used at generic, specific, and even at varietal level (Husain *et al.*, 1990; Hedge, 1992; Ryding, 1992, 1993, 1995; Duletić-Laušević and Marin, 1999 and Budantsev and Lobova, 1997). In recent years, the importance of scanning electron microscopy (SEM) in the study of nutlet surfaces, and the taxonomic value of nutlet characters has been ascertained in many genera of Lamiaceae (Husain *et al.*, 1990; Demissew and Harley, 1992; Ryding 1993; Budantsev 1993b,c; Marin *et al.*, 1996; Budantsev and Lobova, 1997; and Jamzad *et al.*, 2000). Nutlet morphology in the Lamiaceae has proved useful to varying degrees at different levels of the taxonomic hierarchy (Budantsev and Lobova, 1997). Furthermore, the importance of the

morphology of nutlet surface has already been demonstrated in *Nepeta* (Hedge, 1962, 1992; Rechinger 1982; Ubera, 1982; Ubera and Valdes, 1983; Budantsev 1993b; Budantsev and Lobova, 1997; Jamzad *et al.*, 2000; Mosquero *et al.*, 2002; Padure, 2004: Padure and Toma, 2004).

In contrast, pollen tectum ornamentation has not been used, but it appears to have potential value in classification at the infrageneric level (Jamzad, 2001; Abu-Asab and Cantino, 1992). Although pollen grains in all the species of *Nepeta* are hexazonocolpate and isopolar, there are useful variations among different species in pollen shape, exine ornamentation and shape, number, and size of perforations in the primary lumina. Closely related taxa share the same kind of ornamentation (Jamzad *et al.*, 2000; Jamzad, 2001; Azizian *et al.*, 2001).

Not surprisingly then, the previous infrageneric classifications of the genus, based on such variable and unreliable characters, have been in conflict (monographs: Bentham, 1848; Briquet, 1896; Budantsev, 1993a; and regional floras: Boissier, 1879; Pojarkova, 1954; Rechinger, 1982). For example, Bentham (1848) placed all the *Nepeta* species (109) into eight sections and five subsections, and Briquet (1896) recognized 150 species in two sections and fifteen subsections. Budantsev (1993a) revised the genus, basing his infrageneric system mainly on that of Pojarkova (1954), with minor changes. He recognized 210 species in *Nepeta* under 19 sections and 13 subsections. However, his treatment did not cover all the species recognized till that date, and many of the described taxa have neither been included in his list, nor recognized as synonyms. Three general infrageneric classifications of *Nepeta* are summarised in Table 3.3, showing species placements different from one another. Furthermore, the generic delimitations have been unclear, and the close allies of *Nepeta*, that is *Dracocephalum*, *Drepanocaryum*, *Glechoma*, *Hymenocrator*, *Lallemantia* and *Lophanthus* need to be investigated, and their

relationships with *Nepeta* evaluated.

Nepeta species are widely used in folk medicine because of their antispasmodic, diuretic, antiseptic, antitussive, antiasthmatic or febrifuge, emmenagogue, and sedative activities (Cotrim *et al.*, 1994; Tzakou, *et al.*, 2000; Rapisarda *et al.*, 2001). Catnip tea has been shown to have anticholinergic effects and has been used to relieve intestinal cramps. It is also beneficial for cure of colds, flu and fevers. Catnip has been used for the relief of insomnia (Simon *et al.*, 1984). Among the various medicinal properties, *Nepeta* species are famous for treating cardiovascular complaints, such as angina pectoris, cardiac thrombosis, tachycardia, and weakness of the heart (Sherani, 1887; Avicenna, 1906; Avicenna, 1956).

Many reports on phytochemical analyses of this genus, including essential oil analysis, are found in the literature. Most oils of *Nepeta* species contain nepetalactones as the main components, but some differences in the essential oil composition were detected in several *Nepeta* oils (Dabiri and Sefidkon, 2003a,b; Başer and Demircakmak, 1998; Javidnia *et al.*, 2004). Shell and kernel extracts of *N. pannonica* and *Lavandula vera* seeds contain lipids (Stepanenko *et al.*, 1980).

Despite immense economic importance of its species, the taxonomy of *Nepeta* has not received due attention in the Indian suncontinent, especially in the Kashmir Himalaya. Even though Hooker (1885) gave the first account of *Nepeta* in British India, no serious work on the genus has been undertaken after him to unravel its taxonomic intrigues in a vast country that India is. Hooker (l.c.) has cited 17 species of *Nepeta* from the Kashmir Himalaya. Since then, some foreign, as well as local, workers have attempted to deal with floristics of the genus in this region (Stewart, 1972; Dhar and Kachroo, 1983; Singh and Kachroo, 1994; Sharma and Jamwal, 1998) but, as yet, an

over-all picture of its taxonomic complexity in the Indian subcontinent, including the Kashmir Himalaya, is far from complete. It is in this backdrop that the present study has been undertaken to work out the floristic diversity of *Nepeta* in the Kashmir Himalaya.

1.1. Pollen Morphology

The study of pollen morphology plays an important role in understanding the systematic position and in interpreting the taxa of doubtful relations. There are several reasons for taxonomic use of pollen. Pollen grains are usually very distinctive, easily recognizable and identifiable to the family, genus, and often to the species rank; these features can be used to obtain specific information about the plant. Pollen wall is composed of sporopollenin, which is very durable and does not decay easily, enabling it to remain as a durable natural marker; its identification often being helpful in determining the geographical origin of the plant which produced it. The use of pollen has been known since 1895 when Pfister examined Swiss, French and other European honeys and demonstrated the possibility of determining the geographical origin of honey from the pollen within it.

A large number of palynological investigations on different families and generic complexes have been performed, and in most of the cases these data played a significant role in solving the taxonomic riddles. There are instances where some taxa of controversial affinities were properly arranged on the basis of palynological data. On several occasions, phylogenetic assessments were interpreted on the basis of pollen studies.

The earliest study on pollen morphology was carried out by Erdtman (1945). Several authors like Wunderlich (1967), Henderson *et al.* (1968), Varghese and Verma (1983), Abu-Asab (1990), Harley *et al.* (1992), Wagstaff (1992), Ranjbar *et al.* (1998), and Khandani *et al.* (1998) have

studied the pollen morphology of Lamiaceae. While some of them have concentrated on general shape, measurement and number of colpi, rather than on details of surface sculpture, others such as Bassett and Munro (1986), Abu-Asab and Cantino (1992), Trudel and Morton (1992), and Harley (1992) described pollen structure using SEM. These results have shown the potential value of pollen characters in taxonomy of Lamiaceae. Notwithstanding these publications, the pollen of *Nepeta* seem to have been studied by a few authors only (Wunderlich, 1967) who described the pollen of one or two species of *Nepeta*, either in general accounts of angiosperm pollen or of Lamiaceae pollen.

However, differences in the pollen structure of *Nepeta* became evident from the studies of Jamzad *et al.* (2000), who made use of pollen exine morphology for identification of Iranian *Nepeta* species. She observed pollen of eleven species belonging to two sections in *Nepeta*, but this study was restricted to annual species. Ranjbar *et al.* (2004) examined pollen in section *Cataria* and concluded that the pollen grains of all its species could be characterized as monadic, euprolate to subeuprolate, isopolar hexacolpate, and fossaperturate.

In the present study, pollen of various *Nepeta* species were studied with a view to help in their identification, and to provide a key for the specific delimitation based on pollen characteristics.

1.2. Cytology

Of the 300 species comprising the genus *Nepeta* L., chromosome counts have been made in only about 62 species by various workers (Darlington and Wylie, 1955; Fedöröv, 1969; Aydoğdu, 2002; Aydin, and Dirmenci, 2004). These studies reveal that the somatic numbers of 2n = 16, 18 and 36 are common in the genus, whereas a few species have 2n = 26 and 34.

These counts point to the base numbers x = 8, 9, 13, and 17 for the genus (Darlington and Wylie, 1955; Fedöröv, 1969; Aydoğdu, 2002, and Aydin and Dirmenci, 2004). Rarely, species with chromosome numbers 2n = 14, 24, 28 and 30 have also been reported (Darlington and Wylie, 1955 and Kumar and Subramaniam, 1986) for some species. In the present study, chromosome counts of some *Nepeta* species were also determined.

2.1. Location

The State of Jammu and Kashmir, comprising the Divisions of Ladakh, Jammu and Kashmir, has an area of 2,22,236 sq.km., including those parts which are under the occupation of Pakistan and China. The State is known for its rich natural environmental heritage. Since Bernier culled the world of 'Cachemire' (Lawrence, 2005), the paradise of Indies, much has been written about it, and botanists have also added to this love. The Valley of Kashmir is acknowledged as paradise on the earth for diverse rationale: blooming lush-green valleys, wild-ranging streams cutting across the mountains, walk-in touching mountains with glistering snow peaks that create a sensation and charm, dense evergreen forests that provide a protective cover to the rarest of rear species, crystal-clear lakes, boiling springs, towering Chinars, serpentine rivers, etc.

Ladakh, the region of mountain passes, is a piece of broken moon-land place to witness the unmatched beauty of nature. Lying between 32^{o} to 36^{o} N latitudes and 75^{o} to 80^{o} E longitudes, Ladakh covers a total area of 138,924 sq. km. It comprises two districts- Kargil and Leh; and is the highest place in the Indian Estate of Kashmir, with much of it being over 3,000 m in altitude. The region is a vast arid table-land, the cold desert, mostly formed of mechanically-weathered rocks and granite dust. It is deprived of natural vegetation and often has been termed as the 'Roof of the World', where people live at heights ranging between 2,800 to 5,000 metres above the sea level (Husain, 1998).

Kashmir, administratively one of the provinces of the Jammu and Kashmir State, is situated on the northernmost edge of India. The Valley of Kashmir, a great elliptical bowl, extends from $33^{o}20'$ to $34^{o}54'$ N latitudes and $73^{o}55'$ to $75^{o}35'$ E longitudes (Figs. 2.1, 2.2). It extends roughly 187km in

length and about 116km in breadth along the latitudes of Srinagar. The Vale covers an area of 15,948sq.km (Husain, 1998).

In Rajatarangini, it is stated that the Valley of Kashmir was formerly a lake, which was drained by the great rishi or sage, Kashyapa, grandson of Brahma, by cutting the gap in the hills of Baramulla (Varaha-mula). Some historians say that Kashmir was originally known as Kashyapmar, the abode of Kashyap Rishi. But some others are of the opinion that when the people of KASH caste settled here permanently, the Valley came to be known as Kashmir (Itoo and Bodha, 2004). Kashmir is known by many other names also, for example Kashir (Kashmiri), Kashpeiria (Greek), Shie-in or Kia-shi-lo (Chinese), Kanapal (Tibetans), and Kashart (Dards).

2.2. Topography

The territories forming Kashmir cover a wide area, mostly mountains with an outer fringe of alluvial plains bordering the outer hill region to the south. The entire territories of the Kashmir Valley form two distinct topographic divisions, the mountain ranges and the Valley proper.

It is bordered on the north by China, on the east by Tibet, on the west by Pakistan and on the south by the Indian states of Himachal Pradesh and Punjab. With lofty, snow-covered Himalayan Mountains girdling the Valley, its altitude ranges from 1,600m (Srinagar) to 5,420m (Kolahoi). Kashmir falls in the lesser Himalayan zone of the great Himalayas. The central Himalayan axis bifurcates near Kulu and a branch of it extends towards the northeast of the Valley as the Zanskar range and the other, Pir Panjal Range, extends to the south, southwest and southeast from Muzaffarabad on the Jhelum to Kishtawar on the Chenab, and further east to meet the Zanskar range. It has Great Himalayan Range in the southeast to northwest.

Zojila (3,529m), the lowest pass over the Great Himalayas, connects

the Valley in the east with Zanskar and Ladakh. Ladakh, a cold desert, is one of the most elevated regions of the world (>3,000m). On its north lies the Karakoram Range, beyond which is the Pamir, to the western side of which occurs the Hindukush. Some of the loftiest peaks of the Ladakh Himalaya e.g., K2 or Mt. Godwin Austen (8,610m) are situated in the Karakoram Range. It is the second largest peak in the world after Mt. Everest (Husain, 1998).

The river Jhelum meanders through the Valley of Kashmir from east to west. There is a rich diversity of habitats: lakes, swamps and marshes, springs, rivers, cultivated fields and orchards, graveyards, road sides, waste lands, subalpine and alpine meadows, moderate and steep mountain slopes, permanent glaciers, etc. The mountains with pine-mantled slopes and snow-caped summits, shelter a large number of glades and meadows. The Valley, securely placed in the blossom of the Himalaya, is an oval plain with a girdle of mountains. Its long diameter lies northwest, while its southwest lies parallel to the northwest Himalaya. It abounds in many lakes and marshes. The alpine zone starts from 33,00m and is followed by a region of perpetual snow (Husain, 1998).

The mighty Indus river flows through Ladakh. It is flanked by the Ladakh-Range on the right and the Zanskar-Range on the left. The scanty rains and arid conditions are not conducive for agricultural activities and therefore, cultivation of crops is restricted to the irrigated terraces of Indus river.

2.3. Geology

Geologists, such as Lydeker (1883), believe that about 100 million years have elapsed since the Kashmir Valley, which was once Satisar- a lake, came into present form. For hundreds of millions of years the Kashmir Valley

remained under Tethys Sea and the high sedimentary rock hills, now in the Valley, were once under water. It is believed that the Valley was earlier affected by earthquakes. Once there was such a devastating earthquake, that it broke open the mountain wall at Baramulla, and the water from the Satisar flowed out, leaving behind lacustrine mud, known as the Karewas, along the margins of mountains. The Karewas are found mostly to the west of the river Jhelum, where these table lands attain a height of about 380 metres above the level of Valley. The Karewas protrude towards the east and look like tongue-shaped spurs with deep ravines.

The great revolution of the Upper Carboniferous age converted a large part of Kashmir into a land with volcanic conditions reigning. The volcanic activity was at first of explosive type and contributed fragmentary products which were deposited as agglomerates and pyroelastics, which was in the form of lava flow. It died off in the upper Triassic.

The mountain ranges, though containing some very old rocks, are predominantly a region in which the sediments laid down in vast geosynclines, continuously from the Cambrian to the early Tertiary, have been rigged up and folded. They thus, show enormous thickness of sedimentary rocks, representing practically the whole geological column which have been compressed over thrust and elevated into dry land only since the end of the Mesozoic times. The cover of mountains is formed by granite intrusion of presumably tertiary age (Lydeker, 1883).

Geologists contend that when the earth's jigsaw tectonic plates began to break apart, Ladakh was an isle caught between colliding continents. Sandwiched between India and Asia, Ladakh was lifted high into the air, and then sent by seismic upwelling that transformed sea bottom into towering ranges that, like honeycombs, embraced dozens of deep valleys.

2.4. Glaciation

In the Valley of Kashmir, four or five glaciation periods, with three inter-glaciation periods, have been distinguished (De Terra and Peterson, 1939). The glaciers extended to Srinagar and other parts of the Valley. The upper Karewas are thought to represent the second inter-glacial period deposits. The end of the fourth glaciation marks the final phase of the terrace deposits in Kashmir. Some of the largest Valley glaciers are found in the Karakoram Range. The Siachen-glacier about 72kms in length, and Baltore, Hispar, Rimo, Baifa and Batuna are important valley glaciers of northern Ladakh.

2.5. Soils

The soils of Jammu and Kashmir are loamy and there is little clay content in them. There is sufficient organic matter and nitrogen content in the alluvium of Kashmir, as a result of plant residues, crop stubbles, natural vegetation, and animal excreta. The valley of Kashmir has many types of soils, like Gurti (clay), Bahil (loam), Sekil (sandy), Namble (peats), Surzamin, Lemb, Floating-garden soils, and Karewa soils. No wonder, in Kashmir, the soil is virtually worshipped as a miracle of diversity, as it is a source of wealth of the land.

In Ladakh the highly weathered rocks under the mechanical impact of insolation and frosting result into fine grained, light coloured soils which are deficient in humus content. These soils are rich in potassium, nitrate and phosphate and give good agricultural returns in pockets where irrigation water is available. On the river terraces of Indus and its tributaries the soils are of alluvial nature which are being utilized for the cultivation of vegetables, grim (a type of barley), small millets, fodder and orchards.

2.6. Climate

The Himalayan ranges play the major and pivotal role in determining the climate of the Kashmir Valley. The southern flank of the Pir Panjal mountains certainly acts as an effective barrier to the summer monsoon, the bearer of moisture in the sub-continent. The summer rainfall of the Valley clearly reflects this shadow effect. However, the Greater Himalayas exercise little obstruction influence on the influx of the westerly troughs, which frequent the Valley from the west and the northwest during winter.

On an average, the climate of the Valley is sub-Mediterranean, with bixeric regimes, having two dry spells in June and September, and high precipitation during the cool season. The Kashmir Valley enjoys an enchanting climate for the major part of the year. It has continental climate, marked by four well-defined seasons a year.

Spring marks the beginning of regeneration of almost all life due to increase in daily mean maximum and minimum temperatures, coupled with an increase in day length. In summer, the days are longest with the maximum temperature ranging between 29.5^{o}C to 31.2^{o}C, and the minimum temperature between 18.6^{o}C to 20.6^{o}C. Autumn is a relatively dry season, registering an overall decrease in temperature. The winter season experiences short day-length and temperature dropping even below the freezing point.

The annual rainfall in the Valley is about 75cm, with sufficient rain during March and April, and also during July and August. Precipitation in winter is in the form of snow. Heavy rainfall received during spring helps in melting of snow cover and steady fall in relative humidity. August is the warmest month when temperature rises to 29.5^{o}C. Autumn is associated with increase in relative humidity. January is the coldest month. Maximum relative humidity (80%) occurs during November to December and lowest (71%)

during May.

The climate of Ladakh and Zanskar is very cold, arid and dry. In winters, temperatures are extremely low in Rupsho, the higher plateaus above Tansktse, Rong and Zanskar, while central Ladakh and Nubra possess a comparatively mild climate. The mean maximum and mean minimum temperatures in July read about 25^{o}C and 7^{o}C respectively. In this season the diurnal range of temperature is significantly high, being about 18^{o}C. Under a rarified atmosphere, the heat in the day is intense and there remains large difference in the sun and shade temperatures. On a particular day the mean maximum temperature may read upto 38^{o}C. In January the mean minimum temperature remains below freezing point reading as low as -1.6^{o}C at Leh and -40^{o}C at Dras. In Ladakh the annual range of temperature is about 25^{o}C.

The average annual rainfall is only about 20cm. at Leh, most of which is received in the month of January, March and August. Snowfall is also recorded in various parts of Ladakh in winters. The snow that falls in winters becomes so powdery that it is swept from the flat roofs of houses with brooms.

2.7. Vegetation

The state is well endowed with natural flora and fauna. Natural vegetation is diverse and ranges from lushgreen grass belts, called Margs to evergreen coniferous forests on the mountain slopes; and from scrub vegetation of the foot hills to deciduous forests of Shiwaliks and Pir Panjal. The natural vegetation can be studied under four main categories:

i) Sub tropical vegetation

It includes trees and plants like Neem, Pipal, Shisham, Kikar, Babul, thorny bushes, evergreen shrubs, climbers and tall grasses.

ii) Temperate vegetation

Such forests are dominated by coniferous vegetation and commonly found trees are the species of *Cedrus, Pinus, Abies, Picea, Taxus,* together with the deciduous Elm and Birch.

iii) Alpine pastures (Margs or Meadows)

They are dominated by green grasses. These pastures are found well above the coniferous forests, beyond the tree line. Besides grasses, some dwarf birch and junipers render shrubby tinge to these pastures.

iv) Xerophytic vegetation

This vegetation is found in Ladakh region. *Hippophae rhamnoides* is the dominant natural woody species of the region.

Study Sites

1. Srinagar
2. Dachigam
3. Pampore
4. Awantipora
5. Anantnag
6. Pahalgam
7. Kokernag
8. Duksum
9. Verinag
10. Kishtwar
11. Kulgam
12. Shopian
13. Aharbal
14. Pulwama
15. Yusimarg
16. Tangmarg
17. Gulmarg
18. Baramulla
19. Uri
20. Kupwara
21. Bandipora
22. Thajwas
23. Baltal
24. Amarnath
25. Zojila
26. Drass
27. Kargil
28. Hemis
29. Khardungla
30. Leh
31. Zanskar
32. Lamayuru

3.1. Distribution

The genus *Nepeta* is one of the largest genera with about 300 species (Jamzad *et al.*, 2000; Jamzad *et al.*, 2003a and Kaya & Dirmenci, 2008), which are distributed throughout Southwest and Central Asia, Europe, North Africa, North and Central America, Japan, Korea, China, and the Canary Islands (Pojarkova, 1954; Hedge, 1978, 1986; Jamzad *et al.*, 2000). The greatest diversity and species richness within the genus are found in two regions: Southwestern Asia which is considered as one of the centres of diversity of *Nepeta* species, especially Iran where species representatives of most sections occur (12 sections; Rechinger, 1982) and Western Himalayas, including the Hindukush (Pojarkova, 1954) [Fig. 3.1]. The species grow in various habitats from the seashore to the alpine zone (Pojarkova, 1954).

The distribution of *Nepeta cataria* L. known to occur in Canada is given by Gill (1979). It is native of Eurasia, completely naturalized in North America and now a commonly occurring weed of waste lands and roadsides. It ranges from Nova Scotia (lat. 46^{o}N, long. 60^{o}W) to British Columbia (lat. 50^{o}N, long. 126^{o}W) and southwards in the United States to Oregon, Gorgia, Kansas and Utah. Steyermark (1963) also recorded it from Newfoundland, but no specimen has been found in Canadian herbaria to substantiate this record. It is particularly abundant in southern Ontario and Quebec, but much rare in westwards. The possible reasons for its rarity in the west may be low precipitation and severe winters.

Hutchings and Price (1999) studied geographical and altitudinal distribution of *Nepeta hederaceae*, its habit, biotic factors, structure, physiology and history. The species is native to the British Isles and common throughout, except for western Ireland and northern Scotland, where it is rare. It is not native in Orkney and Shetland, and is absent from the Outer Hebrides. It occurs almost throughout Europe, except in the Balearic Islands,

Crete, the Faroes, Iceland, Spitsbergen and Turkey. It is a weed in Tadzhikistan (Hultén, 1971) and is also found in western and northern Asia to Japan, in Hong Kong and in Tonkin (Hultén, 1971). Pădure and Bădărău (2001) studied chorology of *Nepeta ucranica* in Transylvania Plain. The data raised pertain to phytochorological, ecological and phytocoenological aspects of the species, a xerothermic relict from Transylvania Plain, with special reference on isolated populations from eight different sites. On a restricted territory, small populations of *N. ucranica* L. can be found. Although *N. ucranica* L. is not immediately in danger of extinction, its habitat continues to be severely altered indirectly by man, by herbivores and pollution. The geographical distribution, ecological and phytocoenological aspects of the *N. parviflora* populations has been studied by Pădure (2002). The species is on "*The Romanian Red List of Vascular Plants"* with a restricted area only in Dobrudja. Although the species is not immediately in danger of extinction, its habitat continues to be severely altered indirectly by man, herbivores and repeatable droughts.

Dirmenci (2003) discussed two *Nepeta* L. species (*N. cadmea* Boiss. and *N. sulfuriflora* P. H. Davis) which are closely allied and endemic to Turkey. Phenological period, habitat, altitude, distribution and morphological characters were recorded.

3.2. Taxonomy

The genus *Nepeta* has drawn considerable attention of taxonomists from time to time (Bentham, 1834; Bentham, 1848; Boissier, 1879; Hooker, 1885; Briquet, 1896; Pojarkova, 1954; Turner, 1972' Hedge and Lamond, 1982 and Rechinger, 1982).

The genus is placed in tribe Mentheae of family Lamiaceae (Jamzad *et al*., 2003 and Jamzad *et al*., 2005). Previously Bentham (1834, 1848), Hooker (1885), Briquet (1896), Pojarkova (1954) and Oliver (1979) referred the

genus to tribe Nepeteae. However, Briquet (1896), Pojarkova (1954) and Rendle (2005) placed the genus in subfamily Stachyoideae. Drury (1982) included in Didynamia Gymnospermia.

Worldover various species of *Nepeta* have been reported. Heller and Stearn (1753) recorded 12 species and also mentioned their specific habitats.The first major account of this genus on world basis was given by *de Candoll in Prodromus Systematis Naturalis Regni Vegetabilis* (1848), where he recognised 113 species in it and placed them under 9 sections and 5 sub-sections. 59 species were recognized under 8 sections in Labiatarum *Genera Et. Species* (Bentham, 1834). Later Boissier (1846), in *Diagnoses Plantarum Orientalum Novarum,* recorded 6 species.

Bentham and Hooker (1873-76), in their *Genera Plantarum,* divided the Lamiaceae into 8 tribes and put *Nepeta* in tribe Nepeteae. They recognised 3 sections in the genus, namely *Glechoma*, *Oxynepeta* and *Micronepeta.* Boissier (1879), in *Flora Orientalis,* enlisted and discussed 87 species of the genus, grouping them into two sections, namely *Eunepeta* and *Oxynepeta*. The former comprises 9 sub-sections enlisted as under. *Section Oxynepeta* has no sub-sections.

Eunepeta

- *Spicatae,*
- *Capituliferae,*
- *Catariae,*
- *Longiflorae,*
- *Psilonepetae*
- *Macrostegiae,*
- *Stenostegiae,*
- *Micranthae,*
- *Micronepeta,*

Nepeta nuda and *N. globifera* have been described in *Supplementum of Flora Orientalis* (Boissier, 1888). The most important account of the genus was given by Briquet (1896) in *Die Naturlichen Pflanzenfamilien*, recognising 150 species in two sections and 15 sub-sections. Fernald (1950) recorded two

species of the genus, namely *N. cataria* and *N. grandiflora* from Europe and Caucasus, respectively.

Pojarkova (1954) recognised 82 species in the genus and put them under 10 sections, 7 sub-sections and 30 series. The 10 sections included are:

Glechomanthe,	*Micranthae,*
Spicatae,	*Schizocalyx,*
Capituliferae,	*Orthonepeta,*
Macronepeta,	*Oxynepeta*
Cataria,	*Micronepeta*

Hedge and Lamond (1968) recorded 40 species of the genus from Afghanistan, of which *N. lagopsis, N. ciliaris* and *N. graciliflora* were wrongly recorded. However, only 11 species were recorded from Jammu and Kashmir. Turner (1972) recorded 24 species in *Flora Europaea* and some species were further divided into subspecies as shown below:

N.tuberosa –

subsp.*tuberosa*

subsp.*reticulata*

subsp.*gienensis*

N. nuda –

subsp.*nuda*

subsp.*albiflora*

A group of closely related species, taxonomically difficult and much in need of revision, occuring in the southern part of the Balkan Peninsula in Anatolia were also considered. The species are: *N. sibthorpii, N. heldreichii, N. parnassica, N. dirphya, N. camphorate* and *N. spruneri*

Chakravarty (1976), in *Plant Wealth of Iraq*, recorded *N. glandulosa* Blackclock from northern mountainous regions of Rawanduz (Iraq), while *N. micrantha* Bunge and *N. saturoides* Boiss have been recorded occasionally as cultivated garden plants. Subsequently, Oliver (1979), in *Flora of Tropical Africa*, recorded 5 species. A brief description has been appended with each taxon to help in its identification in the field. The 5 species recorded are *N. petitiana*, *N.biloba*, *N.azurea*, *N. ballotafolia* and *N. robusta*. Later, 11 species have been recorded in *Flora of Syria, Paleastine and Sinai* (George, 1980).

Hedge and Lamond (1982) recorded 33 species of *Nepeta* from Turkey and East Aegean Islands. Some species like *N. janthinostegia* and *N. roopiana* are imperfectly known. 16 species are endemic to Turkey. External nutlet characters (size, shape, surface texture, areole), very important in the Iranian and Afghan species, were found of limited taxonomical value in Turkey. The existing infra-generic classifications are extremely unsatisfactory. On this account these authors have not recognized any sections but have placed the species in three informal groups (designated, A, B and C) based largely on flower colour and inflorescence character.

Two species, namely *N. subsessilis* Maxim. and *N. cataria* L., from Japan have been briefly described (Ohwi, 1984). Key is made on the basis of shape of leaves, petiole length, flower colour, calyx length, and the shape of the calyx teeth. Subsequently, Hedge (1990) recorded 48 species from Pakistan. However, only 22 species were recorded from Jammu &Kashmir. He included some species of doubtful status, such as *N. ciliaris*, *N. glomerulosa*, *N. multicaulis*, *N. spathulifera* and *N. micrantha*. Later, Backer and Brink (1994) recorded only one species, i.e., *N. cataria* , in *Flora of Java*. This species is native to Europe and stated to be cultivated in Java as an ornamental. Dickoré and Nüsser (2000) recorded 14 species from Nanga

Parbat, out of which 11 species, namely *N. clarkei*, *N. connata*, *N. discolor*, *N. eriostachys*, *N. glutinosa*, *N. govaniana*, *N. kokanica*, *N. laevigata*, *N. leucolaena*, *N. linearis* and *N. nervosa* were recorded From Jammu & Kashmir State. Vardhana (2006) recorded 5 species from different places of the world. The considered species are:

N. cataria: native of Europe but found in Kashmir.

N. ciliaris: western temperate Himalayas from Garhwal to Kashmir.

N. elliptica: western temperate Himalayas.

N. floccosa: Kashmir and Ladakh.

N. hindostana: northern India.

From time to time, several workers surveyed the various regions of India and recorded various species of the genus *Nepeta*. Hooker (1885) recorded 31 species from the Indian subcontinent. However, only 17 species were recorded from Jammu & Kashmir. *Nepeta ruderalis* and *N. bombaiensis* were recorded from *Bombay* (Cook, 1906). Subsequently, Bamber (1916) reported 20 species from Punjab and gave a brief description of each. However, only 8 species namely *N. eriostachys*, *N. nervosa*, *N. raphanorhiza*, *N. glutinosa*, *N. cataria*, *N. mollis*, *N. salviaefolia* and *N. clarkei* were recorded from Kashmir Himalayan region. Later, Collett (1921) recorded 11 species in *Flora Simlensis*. Based on petiole morphology, he divided the genus into two groups.

Mukerjee (1940) recorded 41 species of *Nepeta* from India, of which 14 are endemic. However, only 22 species were recorded from Jammu & Kashmir. Only one species, namely *N. hindostana* was reported from Bihar and Orissa (Haines, 1961). Gupta (1968), in *Flora Nainitalensis*, recorded 6 species of the genus, namely *N. ciliaris*, *N. connata*, *N. distans*, *N. elliptica*, *N. leucophylla* and *N. spicata*. Subsequently, 11 species were recorded from

Bashahr Himalayas, and only 7 from Simla Hills (Nair, 1977). Later, 7 species with brief description of each were recorded from Mussoorie (Raizada, 1978).

Chowdhery and Wadhwa (1984) recorded 22 species of the genus from Simla, Chamba, Kinnaur, Lahul and Spiti, Kulu and Kangra. Nine species were recorded and described along with their habitats from Chamoli (Naithani, 1985). Aswal and Mehrotra (1999) recorded 10 species from Lahaul-Spiti with a brief description on each. Subsequently, seven species were described from Kulu District, Himachal Pradesh (Dhaliwal and Sharma, 1999). Later, Bhattacharjee (2004), in Handbook of Medicinal Plants, recorded 4 species and their utility. These are *N. cataria* L., *N. elliptica* Royle ex Benth., *N. hindostana* (Roth.) Haines and *N. graciliflora*.

Kashmir Himalaya is rich in floristic diversity with no exception to genus *Nepeta*. The genus has been reported throughout the entire Kashmir Himalayan range. Stewart (1916-17) recorded 8 species in Flora of Ladakh, Western Tibet. These are: *N. eriostachys, N. floccose, N. glutinosa, N. leucolaena, N. longibracteata, N. nivalis, N. salviaefolia* and *N. Tibetica*. Blatter (1928), however, reported 20 species from Kashmir Himalaya. The author argues that *N. nervosa* and *N. leucolaena* are endemic to Kashmir. Stewart (1972) brought out a check-list of the *Nepeta* species of Kashmir, in his *Annotated Catalogue of the Vascular Plants of West Pakistan and Kashmir*. The list includes 58 species of *Nepeta*. However, only 27 species were recorded from Jammu & Kashmir, of which some are now known as synonyms.

Kachroo *et al.* (1977) recorded 11 species from Kashmir Himalaya. These are: *N. clarkei, N.coerulescens, N. discolor, N. eriostachys, N. floccosa, N. glutinosa, N. laevigata, N. leucolaena,* N. *longibracteata, N. nervosa* and *N. royleana*. Subsequently, two species, namely *N. graciliflora* and *N.*

hindostana were described from Jammu region (Sharma and Kachroo, 1981). Later, Dhar and Kachroo (1983) recorded 28 species with 13 species endemic to Kashmir Himalaya. Polunin and Stainton (1984*)* authored a beautiful piece of work in *Flowers of the Himalaya,* where they recorded 11 species from the Jammu & Kashmir State. Fourteen species were recorded from Sind Valley (Dar and Kachroo, 1992).

Singh and Kachroo (1994) came out with a concise account of the genus *Nepeta* and listed 8 species from Pir Panjal Range. Subsequently, Sharma and Jamwal (1998) enlisted 8 species from upper Liddar Valley of Kashmir Himalaya. Later, 8 species were enlisted from Udhampur (Swami and Gupta, 1998). The listed species are: *N. supina, N. graciliflora, N. govaniana, N. hindostana, N. laevigata, N. leucophylla, N. distans* and *N. ciliaris.* Chaurasia *et al.* (2001) worked on potential aromatic flora of Himalayan cold desert (Ladakh and Lahaul-Spiti). They listed 5 species from this area. Utility of only three species is given as under:

N. discolor - used in cold and cough.

N. floccosa - dried leaves are used as flavour

N. longibracteata - The whole plant is used as a flavouring agent.

Table 3.1: *Nepeta* species recorded from the Jammu & Kashmir State in various works

S. No.	Name of the Flora	No. of *Nepeta* species recorded from Kashmir Himalaya	Name of the species recorded	Reference
1	Flora of Ladakh, Western Tibet	8	*N. eriostachys* *N. floccasa* *N. glutinosa* *N. leucolaena* *N. lengibracteata* *N. nivalis* *N. salviaefolia* *N. tibetica*	Stewart, 1916-17
2	Beautiful Flowers of Kashmir	20	*N. elliptica* *N. nervosa* *N. discolor* *N. salviaefolia* *N. glutinosa* *N. thomsonii* *N. mollis* *N. erecta* *N. leucolaena* *N. eriostachys* *N. cataria* *N. linearis* *N. compestris* *N. clarkei* *N. longibracteata* *N. supina* *N. raphanorhiza* *N. govaniana* *N. spicata* *N. connata*	Blatter, 1928
3	Annotated Catalogue of the Vascular Plants of West Pakistan and Kashmir	27	*N. laevigata* *N. leucolaena* *N. leucophylla* *N. linearis*	Stewart, 1972

			N. longibracteata *N. nervosa* *N. nivalis* *N. pamirensis* *N. paucifolia* *N. raphanorhiza* *N. royleana* *N. tibetica* *N. vakanica* *N. govaniana* *N. glutinosa* *N. floccosa* *N. eriostachys* *N. erecta* *N. elliptica* *N. elata* *N. discolor* *N. connata* *N. coerulescens* *N. clarkei* *N. cataria* *N. campestris* *N. botryoides*	
4	Flora of Ladakh	11	*N. clarkei* *N. coerulescens* *N.discolor* *N. eriostachys* *N. floccosa* *N. glutinosa* *N. laevigata* *N. leucolaena* *N. longibracteata* *N. nervosa* *N. royleana*	Kachroo *et al.*, 1977
5	Flora of Jammu	2	*N. graciliflora* *N. hindostana*	Sharma and Kachroo, 1981
6	Flowers of the	11	*N. discolor*	Polunin and

	Himalaya		*N. erecta* *N. leucophylla* *N. laevigata* *N. glutinosa* *N. clarkei* *N. floccosa* *N. lamiopsis* *N. reyleana* *N. govaniana* *N. longibracteata*	Stainton, 1984
7	Forest Flora of Pir Panjal Range	8	*N. connata* *N. cataria* *N. elata* *N. elliptica* *N. erecta* *N. govaniana* *N. raphanorhiza* *N. laevigata*	Singh and Kachroo, 1994
8	Flora of Upper Liddar Valley of Kashmir Himaliya	8	*N. linearis* *N. connata* *N. nervosa* *N. laevigata* *N. elata* *N. eriostachys* *N. govaniana* *N. erecta*	Sharma and Jamwal, 1998
9	Flora of Udhampur	8	*N. supina* *N. graciliflora* *N. govaniana* *N. hindostana* *N. laevigata* *N. leucophylla* *N. distans* *N. ciliaris*	Swami and Gupta, 1998

Table 3.2: *Nepeta* species recorded from India or its States/regions in various works

S No	Name of the Flora	No. of species recorded	Name of species	Reference
1	Flora of British India	31	*N. botryoides* *N. linearis** *N. connata** *N. eriostachys** *N. nervosa** *N. campestris** *N. elliptica** *N. thomsonii* *N. supina* *N. spicata** *N.lamiopsis* *N. raphanorhiza** *N. discolor** *N. longibracteata* *N. glutinosa** *N. mollis** *N. distans* *N. ciliaris** *N. ruderalis* *N. bombaiensis* *N. cataria** *N. leucophylla* *N. leucolaena** *N. floccosa* *N. grociliflora* *N. govaniana** *N. erecta* *N. clarkei** *N. salviaefolia** *N. nivalis* *N. tibetica*	Hooker, 1885
2	Flora of Bombay	2	*N. ruderalis* *N. bombaiensis*	Cook, 1906
3	Plants of Punjab	20	*N. eriostachys**	Bamber, 1916

			*N. nervosa**	
			N. campestris	
			N. supina	
			N. spicata	
			*N. raphanorhiza**	
			N. discolor	
			*N. glutinosa**	
			*N. mollis**	
			N. distans	
			N. ciliaris	
			N. ruderalis	
			*N. cataria**	
			N. leucophylla	
			N. graciliflora	
			N. govaniana	
			N. erecta	
			*N. clarkei**	
			*N. salviaefolia**	
			N. elliptica	
4	Flora Simlensis	11	*N. linearis*	Collett, 1921
			N. campestris	
			N. elliptica	
			N. spicata	
			N. distans	
			N. ciliaris	
			N. ruderalis	
			N. leucophylla	
			N. graciliflora	
			N. govaniana	
			N. erecta	
5	A Revision of the Labiatae of the Indian Empire	41	*N. linearis**	Mukerjee, 1940
			*N. connata**	
			*N. nervosa**	
			*N. podostachys**	
			*N. elliptica**	
			*N. campestris**	
			*N. eriostachys**	
			*N. spicata**	
			*N. discolor**	

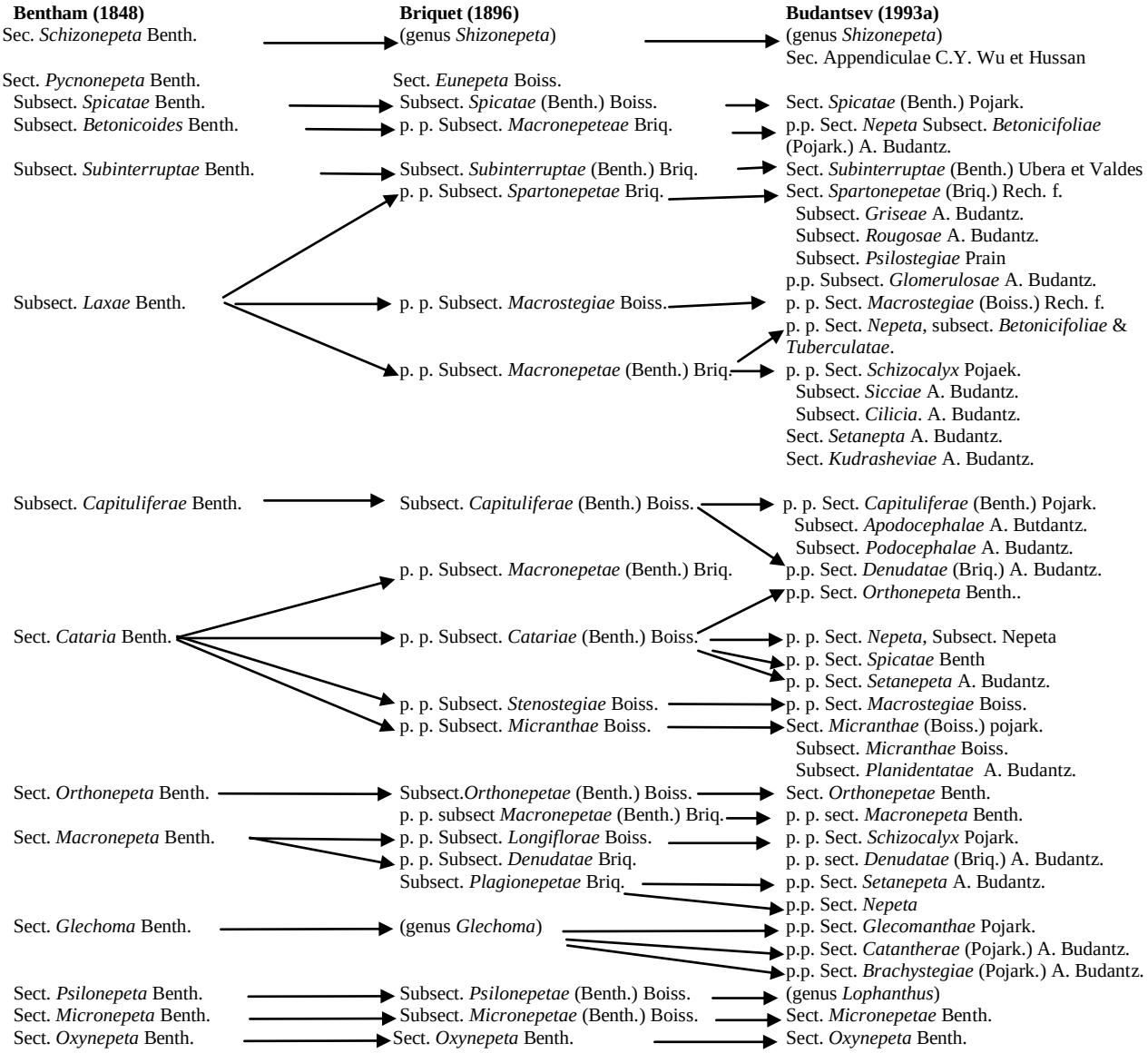
			*N. lamiopsis**	
			*N. longibracteata**	
			N. bracteata	
			N. coerulescens	
			N. supina	
			*N. raphanorhiza**	
			N. spathulifera	
			*N. glutinosa**	
			*N. nivalis**	
			N. pharica	
			*N. floccosa**	
			N. tibetica	
			*N. leucolaena**	
			*N. salviaefolia**	
			*N. govaniana**	
			*N. erecta **	
			*N. clarkei**	
			N. pinetorum	
			N. glomerulosa	
			N. lagopsis	
			*N. mollis**	
			*N. ciliaris**	
			N. distans	
			N. prainii	
			N. leucophylla	
			*N. cataria**	
			N. micrantha	
			N. bombaiensis	
			N. hindustana	
			N. graciliflora	
			N. chenopodiifolia	
			N. suavis	
6	Graya Manual of Botany	2	*N. cataria* *N. grandiflora*	Fernald, 1950
7	Botany of Bihar and Orrisa	1	*N. hindustana*	Haines, 1961
8	Flora Nainitalensis	6	*N. ciliaris** *N. connata** *N. distans*	Gupta, 1968

			*N. ellipica** *N. leucophylla* *N. spicata**	
9	Flora of Bashahr Himalayas	11	*N. campestris* *N. ciliaris* *N. discolor* *N. elliptica* *N. erecta* *N. govaniana* *N. hindustana* *N. laevigata* *N. leucophylla* *N. linearis* *N. mollis*	Nair, 1977
10	Flora of Mussoorie	8	*N. graciliflora* *N. govaniana* *N. ciliaris** *N. distans* *N. laevigata* *N. leucophylla* *N. hindustana* *N. stewartii*	Raizada, 1978
11	Handbook of Indian Flora	3	*N. bombaiensis* *N. ruderalis* *N.clinopodioides*	Drury, 1982
12	Flora of Himachal Pradesh	22	*N. campestris* *N. ciliaris* *N. clarkei* *N. connata* *N. discolor* *N. elliptica* *N. erecta* *N. eriostachys* *N. flocosa* *N. glutinosa* *N. govaniana* *N. graciliflora* *N. N. hindustana* *N. laevigata*	Chowdhrey and Wadhwa, 1984

			N. leucophylla *N. linearis* *N. longibracteata* *N. prainii* *N, nervosa* *N. nivalis* *N. royleana* *N. tibetica*	
13	Flora of Chamoli	9	*N. discolor* *N. distans* *N. eristachys* *N. govaniana* *N. graciliflora* *N. hindustana* *N. laevigata* *N. leucophylla* *N. supina*	Naithani, 1985
14	Flora of Kulu District (Himachel Pradesh)	7	*N. campestris* *N. erecta* *N. govaniana* *N. hindustana* *N. laevigata* *N. leucophylla* *N. raphanorhiza*	Dhaliwal and Sharma, 1999
15	Flora of Lahaul -Spiti	10	*N. nervosa* *N. linearis* *N. eriostachys* *N. laevigata* *N. discolor* *N. longibracteata* *N. glutinosa* *N. nivalis* *N.floccosa* *N. tibetica*	Aswal and Mehrotra, 1999
16	Hand Book of Medicinal Plants	4	*N. cataria* *N. elliptica* *N. hindustana* *N. graciliflora*	Bhattacharjee, 2004

**** Nepeta species recorded from the Kashmir Himalaya***

Table 3.3: Infrageneric classification of genus *Nepeta* in three global reviews



Jamzad and Assadi (1984) discovered two new species of the genera *Nepeta* and *Ajuga* from Iran. The plant discovered in July 1985 was identified as *N. clarkei*. It does not appear to be in general cultivation despite its large size, good blue or purple - coloured flowers and the ease with which it is propagated (Rix, 1986). A new species namely *N. adenophtya* has been discovered from Pakistan by Hedge (1989). Jehan (1989) described *Nepeta alii* from Nushko, Pakistan as a new speciesto science. The species is closely related to *N. floccosa* Benth. and has sessile to sub-sessile leaves and a corolla tube much longer than the calyx. The species has long petioled leaves, with petioles 2-3 times longer than the lumina and a corolla tube shorter than the calyx. Subsequently, *N. binaloudensis* occurring in Iran, was described as a new species (Jamzad, 1991). Jamzad (1992) recorded two new taxa of Labiatae from Iran, namely *Nepeta assadii* and *Satureja kallarica*. Later, Shinwari and Chaudhri (1994) discovered and described new species of the genus *Nepeta* from Gilgit district in Pakistan named as *N. gilgitica*. Belonging to the section *Spicatae,* it is closely related to *N. kokanica*, from which it is distinguished as plants are annual, prostrate and have pectinate bracts in the lower whorl.

Jehan (1996) described another new species, *N. subcaespitosa,* from Ziarat, Quetta, Pakistan. The species is closely related to *N. iranshahrii* Rech. f., but in contrast to this species, which has a dense indumentum of long, white hairs, the new species is almost glabrous, and has cuneate and entire (versus cordate and crenate) leaf base, ovoid (versus capitate) inflorescence, much larger bracts (5-6mm versus 1.5-2mm long) and a somewhat smaller corolla (c.12mm versus 15mm long). Subsequently, a new species - *N. makuensis,* has been reported from Iran (Jamzad, 1998). The species is considered to belong to the section *Psilonepeta,* which is characterised by tubular campanulate calyx constricted in the throat. The hairy ring of the calyx is located in the middle of the tube, while in the other members of the

section the ring occurs at the base of the teeth. Later, Jamzad (1999) recognized two new species, *N. minuticephala* and *N. bokhonica,* from Iran. *N. minuticephala* belongs to the *N. cephalotes*, *N. eremokosmos*, *N. prostrata* group. It is distinguished from other members of the group by its inflorescence, indumentum and leaf texture. *N. bokhonica* belongs to the *N. glomerulosa*, *N. juncea* and *N. praetervisa* group. The most characteristic features of both the new species are a slender, many-stemmed habit and stems covered by herbaceous leaves for the whole of their length.

Jamzad *et al.* (2003c) reported three new species of *Nepeta* from Iran. The Iranian species were investigated as part of a phylogenetic study of the genus. The relationships among species revealed the status of some taxa, including three new species. The new species are recognised by differences in morphology as well as molecular characters. *N. balouchestanica*, *N. mahanensis*, and *N. hormozganica* are described as new and their relationships with closely related taxa are discussed. Subsequently, Dirmenci (2005) discovered a new sub-species of the genus *Nepeta* from Turkey, namely *N. sibthorpii* ssp. *tumeniana*. Diagnostic characters, description, detailed illustrations and taxonomic comments are presented. Its characteristics are compared with those of the related four sub-species of *N. sibthorpii*. The geographical distribution of *N. sibthorpii* ssp. *tumeniana* is mapped. IUCN threatened category and observations on the population are noted. Later, *N. natanzensis* Jamzad occurring in Karkas Mountain in Esfahan Province and *N. trachonitica* Post in northwest of Iran were described as a new species and a new record, respectively (Jamzad, 2006). The new species is related to *N. lasiocephala* Benth. but differs from it in floral characters, indumentum and bracts. These species belong to the natural group of species in sect. *Capituliferae* (Benth.) Pojark., characterised by the capitate inflorescence, corolla and calyx shape.

Shriver (1876, 1877) examined *Nepeta glechoma* for its anomalous behaviour and investigated the floral features viz., flower size, shape of the corolla tube, hair length and calyx shape, etc. Lawrence (1951) gave an account of family Labiatae in which he mentioned various species. He included *Nepeta* among the principal ornamentals. Hedge (1962) studied *Nepeta fissa* and the species allied to it. This study revealed that *N. fissa* is different from its allies in various morphological features. El-Gazzar and Watson (1970a) gave an account of taxonomic study of Labiatae and related genera. Extensive comparative anatomical and morphological observations were made on 400 species (138 genera) of Labiatae including *Nepeta* and Verbenaceae *sensu lato*. Later, the same authors (1970b) also studied some economic implications of the taxonomy of Labiatae. Essential oils extracted from twenty-two genera of the family were examined by gas-liquid chromatography. The results support the taxonomic suggestion that there are two major series of the genera: one oil- rich, and the other oil-poor. *Nepeta* is included in the former.

Sanders and Cantino (1984) studied nomenclature of the subdivisions of the Lamiaceae. A list is provided of all the legitimate names available for application to subtribes, tribes, subfamilies, and segregate families of the Lamiaceae. Also presented are earlier generically based names which are invalid or inoperative under Art. 35.2 of the code. Correct names are provided for the familial subdivisions recognized in three widely accepted systematic treatments of the family. Action by the Sydney Congress that affects nomenclature of the subdivisions of families is discussed. Baden (1985) published his data on the biosystematics of the *Nepeta sibthorpii* group. *Nepeta heldreichii* Hal. has been included in *N. camphorate* Boiss. and Heldr. The two species occur sympatrically on Mt Taygetos and differ only in their indumentum. Crossing experiments also demonstrate interfertility between the two species and suggest that they represent variants of a single species. *N.*

heldreichii is therefore reduced to a variety of *N. camphorata*.

Developmental features of *N. meyeri* Benth. cultivated on Apsheron Peninsula have been studied by Mishurova and Mamedova (1988). The aerial parts of some *Nepeta* species contain essential oil and ursolic acid which has mineralocorticoid, anti - sclerotic and other medicinal properties. In the field and laboratory trials, *N. meyeri* was characterised by an ephemeral rhythm of development and a very short pre-reproductive growth period (40-50 days). Leaf size and shoot and inflorescence lengths are largely dependent on the sowing time, autumn being most suitable. The aerial parts contain 1.8% (of DW) ursolic acid and could become a useful source of this acid. The species is of no interest as an essential oil plant.

Jamzad (1991) came out with a revision of *Nepeta menthoides* and species allied to it. *N. binaloudensis* is described as a new species. *N. elymaitica* Bornm. formerly treated in group Stenostegiae, is placed in *N. menthiodes* group. Similarities of the species in this group are discussed. Altogether 7 species are recognised in this group. An identification key, nomenclature, type localities, specimens seen, distribution map, illustrations, notes and comparison of the species with the other formerly considered groups are presented. Subsequently, growth and development of *N. parviflora* Bieb. cultivated in Apsheron Peninsula was studied by Mishurova and Mamedova (1991). In pot trials between 1986 and 1988, plants raised from seeds harvested from wild plants were assessed for leaf morphology, growth dynamics of reproductive shoots, and flower number during the 1st and 2nd year of cultivation. The data are tabulated. Flowering occurred in the 2nd year, in May, and up to 3 reproductive shoots/plant were produced. The seeds ripened in June, with each plant producing 920±60 seeds. It is concluded that cultivation of *N. parviflora* on the Apsheron Peninsula is feasible. Later, a systematic review was presented (with keys and annotated notes) of species in

the section *Macrostegiae* and newly formed section *Setanepeta* of the genus *Nepeta* (Budantsev 1992a).

Budantsev (1992b,c,d,e) studied the species morphology, transformations in the morphology of inflorescences and taxonomy of the sections *Nepeta*, *Micranthae*, *Micronepeta* and *Sparthonepeta*. The survey brought out by Budantsev (1992b) covering 3 subsections and 25 species of the section, including the section type *N. cataria* (catmint), which has long been cultivated as a medicinal and armatic plant (especially the citral - containing form), contains a key for identifying the species. The author (1992e) recognized 15 species in the section *Sparthonepeta* and assigned them to 4 sub-sections (3 of them new, with latin diagnoses). A new combination is made in the species. *N. glomerulosa* (sub. sp. *ghorana*), and two other subspecies of this species are recognised. Budantsev (1993a) has recognised 212 species of *Nepeta* and put them under 19 sections and 13 sub-sections. Four new combinations are made.

Lendvai (1993) studied *N. parviflora* M. Bieb, an old-new member of the Hungarian flora. This species was collected for the first time in Hungary by Tauscher in 1871. His first data was questioned by later botanists, and the species has never been recognized as a member of the flora of Hungary (Lendvai, 1993). *N. parviflora* was rediscovered by Lendvai in 1992, during a vegetation survey in central Hungary and the author argues that *N. parviflora* should be considered as typical relic species of the loess vegetation in Hungary. Lendvai not completely ruled out the possibility of human introduction due to the isolated occurrence of *N. parviflora* in Hungary far removed from its genetic center. Andalusia (Spain) and Er Rif (Morocco) has been considered as a new locality for *Nepeta amethystine* var. *anticaria* by Diaz Lifante and Parra (1995). Bhellum and Mangotra (1996) studied the family Lamiaceae of district Doda of Jammu and Kashmir State. The paper

puts on record 48 species representing 23 genera of family Lamiaceae collected from district Doda of Jammu and Kashmir state. Recorded in this work are 7 species of *Nepeta*.

The phylogenetic study presented by Jamzad (2001) centres on taxonomic study of species of *Nepeta* L. especially those that are native to Iran but includes a few from the neighbouring countries. Species form five putatively related genera from tribe Mentheae, *Agastache, Lallemantia, Dracocephalum, Hymenocrator* and *Drepanocaryum* are included for comparison. An important part of the project focuses on evaluating the relationship of annual and perennial species to determine whether the annuals are a monophyletic group or whether the annual habit has evolved repeatedly in the genus. In this study a broad range of modern techniques were utilised including electron microscopy, chemosystematics and molecular systematics. Micromorphological studies include pollen and nutlet morphology using electron microscopy. Variation in the pattern of flavonoid and essential oil among species has been characterised using high performance liquid chromatography (HPLC) and gas chromatography-mass spectrometry (GC-MS). Variation in the ITS region of nuclear ribosomal DNA is compared among species.

Dirmenci *et al.* (2004) studied threatened categories of four *Nepeta* L. species endemic to the East Anatolia. Four *Nepeta* L. species endemic to East Anatolia, *N. baytopii* Hedge and Lamond, *N. crinita* Montbret and Aucher ex Bentham, *N. obtusicrena* Boiss. and Kotschy ex Hedge and *N. sorgerae* Hedge and Lamond, are examined. The areas of these species are quite limited. Taxonomic relationships in Turkish *Nepeta* species L. have been worked out by Dirmenci *et al.* (2005) using SDS-PAGE. The genus *Nepeta* is represented with 46 taxa in Turkey. Of these 23 species are endemic. The genus which is recorded in *Flora of Turkey* is an example of some unresolved

taxonomical problems. In this study, the systematic status of some species of *Nepeta* was studied by using seed protein profiles in addition to morphological analysis.

3.3. Morphological Variation

Kokkini and Babalonas (1982) published data on morphological variation in *N. nuda* L. A great morphological variation in the species is reported. It especially refers to the characters which distinguish its two subspecies *nuda* and *albiflora*. Existence of the gynodioecious condition in this species is also firstly noted. The micromorphological and phytochemical studies in two endemic *Nepeta* species in Yugoslavia have been conducted by Husain *et al.* (1989). The micromorphology of trichomes of these species in the mediterranean area was surveyed by scanning electron microscopy (SEM) of leaves, calyx, corolla and nutlets. Transverse thin-walled cells are the exclusive type found in the genus *Nepeta*. Later, Bourett *et al.* (1994) studied the with gland development on leaf surfaces of *Nepeta racemosa*. Trichomes present on the leaf surface of catmint (*Nepeta racemosa* L.) were examined using both scanning and transmission electron microscopy. Three types of trichomes were observed: (a) multicellular, uniseriate, nonglandular hairs, (b) small capitate glands with two cells in the head, and (c) large, peltate glands with four secretory/head cells.

Kolalite (1994a,b) studied dynamics of ultrastructure of capitate and peltate glandular hairs in *Nepeta cataria* and *Dracocephalum moldavica* in connection with glycoprotein and terpene biosynthesis. The variability in morphology and ultrastructure in secretory trichomes of Lamiaceae makes them a good subject for comparative analysis. Subsequently, peculiarities of morphology and ultrastructure of glandular trichomes on leaves of *Nepeta cyanea* Stev., *N. cataria* L. var. *citriodora* Balb. and *Scutellaria baicalensis* Georgi were studied by Kolalite (1996). Secretory cells of *N. cyanea*

exhibited well developed leucoplasts and endoplamic reticulum, where as well developed RER and dictyosomes were found in glandular hairs. In *N. cataria* var. *citriodora*, there are three types of glandular hairs and two types of glands (on unicellular and bicellular stalks). In secretory cells of two types of glandular hairs, there are many leucoplasts and well developed SER. Secretory cells of the third type of glandular hair exhibited dictyosomes and RER. Both types of glands had sheathed leucoplasts and SER. In secretory cells of *S. baicalensis* at the early stage of secretion, abundant RER and protein inclusions were found, as well as dictyosomes. At the late secretion stages in some glands, proliferation of SER and sheathed leucoplasts was noted. Later, Kolalite (1998) also conducted comparative analysis of the ultrastructure of glandular trichomes in two *Nepeta cataria* chemotypes (*N. cataria* and *N. cataria* var. *citriodora*). Glandular trichomes from the leaf surface of two *Nepeta cataria* chemotypes have been examined using transmission and scanning electron microscopy. Peltate glands and capitate hairs type I were found on leaves of *N. cataria*. Both types had single stalk cells. Leaves of *N. cataria* var. *citriodora* bore peltate glands with unicellular or bicellular stalk, capitate hairs type I (with unicellular stalk) and capitate hairs type II (with unicellular or bicellular stalk). Peltate glands of *N. cataria* and of *N. cataria* var. *citriodora* were characterised by numerous leucoplasts sheathed by smooth reticular tubules and smooth endoplasmic reticulum; they are proposed to synthesize terpenes. The secretory cells of capitate hairs type I of *N. cataria* and those of *N. cataria* var. *citriodora* had well developed RER and dictyosomes. They had plastids with protein inclusions. These glands are supposed to produce slime. Capitate hairs type II of *N. cataria* var. *citriodora* had no analogs in *N. cataria*. Their secretory cells exhibited abundance of tubular ER and have unsheathed plastids with starch grains. Probably, these glands synthesize terpenes. The results of the study indicate that there is an obvious difference both in morphology and in ultrastructure of glandular

trichomes in different chemotypes of *N. cataria*.

Rapisarda *et al.* (2001) investigated the micromorphological features of the flowers and leaves of *Nepeta sibthorpii* Benth. The analysis by means of scanning electron microscopy has permitted to characterize both the covering trichomatous garment, abundantly present on the calyx and on the leaves, and the glandular hairs, distributed on the adaxial leaf surface and on the outer surfaces of calyx and corolla, showing also the peculiar features of the epidermal cells, all useful diagnostic elements for the identification of this medicinal plant. The micromorphology and anatomy of nutlets of five *Nepeta* species (*N. cataria*, *N. amethystina* var. *anticaria*, *N. multibracteata*, *N. tuberosa* subsp. *tuberosa* and *N. apuleii*) were studied using light and scanning electron microscopy. The examined taxa were successfully differentiated using epicarp, mesocarp and sclerenchymatic cell layer characteristics. The mucilage secretion of *N. amethystina var. anticaria* nutlet allowed the easy discrimination of this taxon. A key to differentiate the five taxa using carpological characters is provided (Mosquero *et al*., 2002).

Pădure (2004) investigated fruit morphology, anatomy and mixocarpy in *Nepeta cataria* L. *'Citriodora'* and *N. grandiflora* M. Bieb. Two main types of pericarp structure, smooth and sculptured, are described. A detailed description of the anatomy, macromorphology and micromorphology of *Nepeta* nutlets is presented. The mucilage production (mixocarpy) has also been tested. A polytomous morpho-anatomical identification key based on nutlet characters was made. Subsequently, a detailed morphological and anatomical study of leaf and identification key of four extant Romanian species of *Nepeta* were presented by Pădure and Ciocarlan (2004). The results about dichotomic and polytomic keys for *Nepeta* leaves are original. Since the leaf was ignored in previously taxonomic keys, it was necessary to create such identification keys. Anatomical keys are more convincing than

morphological ones, but it is well known that they have low applicability in Botany. Each identification dichotomic and polytomic keys were elaborated based on morphological and anatomical characters Later, Pădure and Toma (2004) studied ultrastructural features of pericarp surface in four species. Two species are endangered in Romania, with restricted area only in Transylvania Plain and Dobrudja region, with a special status on *The Romanian Red List of Vascular Plants.* Two main types of pericarp pattern, smooth and sculptured, are described. A detailed description of macro- and micromorphology of the fruits and SEM images for all taxa are provided.

Pădure (2006) studied morpho-anatomy of flower and inflorescence in *Nepeta* L. in Romania. Original data regarding the inflorescence type and sexual distribution of flower in *Nepeta* are discussed. The flowers of *Nepeta* are hermaphrodite in *N. cataria. N. nuda* ssp. *nuda* is a gynomonoecious plant and the *N. parviflora* and *N. ucranica* ssp. *ucranica* are gynoecious. Morphology of glandular and non-glandular trichomes in calyx, corolla and bracts have been studied for the first time. Three identification keys based on morpho-anatomical characteristics and sexual distribution of flower have been elaborated. Kaya *et al.* (2007) analysed the micromorphology of glandular trichomes of *N. congesta* Fisch. and Mey. var. *congesta*, a species endemic to Turkey, in order to evaluate the usefulness of this feature for systematic purpose. The aerial parts of *N. congesta* var. *congesta* bear an indumentum of glandular and non-glandular trichomes. Two types of glandular trichomes: peltate and capitate were identified. Water - distilled essential oil of the aerial parts of *N. congesta* var. *congesta* was analysed by GC and GC/MS and the main components were found to be 1,8 - cineole (29.9%), germacrene - D (20.3%) and Sabinene (10.3%).

3.4. Anatomy

Taylor (1949) studied initiation and development of galls by *Aylax glechomae* on *Nepeta hederacea*. The eggs were laid on the abaxial surface of many young leaves, usually near veins and towards the leaf base. All cell layers of the leaf contribute to gall development, forming a wall of cells around the larva which fuses above, completely enclosing it. Correlations among comparative observations on pollen grains, stomata and stem anatomy for 125 genera of Labiatae were studied by El-Gazzar and Watson (1968) and the study suggest that the family comprises two main groups. This situation was hinted at by Bentham but is completely obscured by the fashionable classification of Briquet. The rust fungus *Puccinia menthae* Pers. exhibits a very marked preference for members of one group (seventy recorded host species) over the other (only one host species). Hexacolpate pollen and diacytic stomata have been observed in *Nepeta*. Subsequently, Pavlovic *et al*. (1985) studied anatomical features of organs and the essential oils of *N. nuda* L. Plant organs showed mesomorphic characteristics. The leaves had a slightly thickened cuticle. The shoots contained 0.67% essential oil at flowering. Later, Dwivedi (1987) studied seed coat development and pericarp structure in *Nepeta hindostana* (Roth.) Haines. This study reveals that seed coat consists of 1-3 layers of cells. Integumentary tapetum exists in the species. Pericarp is differentiated into three zones: the mucilaginous epicarp, thin walled mesocarp and lignified endocarp.

Sarkar *et al*. (1995) studied leaves of *N. cataria*, containing tannin and volatile oils. The leaves are deltoid-oval with double layers of pallisade, having vascular bundle flanked by 2 smaller bundles in two projections; stem hollow in the middle; leaves, petioles and stems contain glandular and uniseriate multicellular non-glandular hairs. The pericarp structure has been analysed in 37 species representing 13 genera from four tribes of

Nepetoideae. Crystals were present within sclerenchyma region in genera *Mentha*, *Melissa*, *Nepeta* and *Prunella*. Pericarp structure is of taxonomical interest and is mainly correlated with the generic or infrageneric classification of some genera (Duletić-Laušević and Marin, 1999)

3.5. Pollen Morphology

Jamzad *et al*. (2000) studied pollen exine and nutlet surface morphology of the annual species of *Nepeta*. All these have a bi-reticulate exine. The lumina formed by the primary muri may be polygonal, more or less rounded or elongated. Apocolpial primary lumina are smaller than those of the mesocolpia. The apocolpial exine in both groups is bi- reticulate; in one group the muri are shallow and less clearly defined than the deeper, more prominent lumina of the other group. To some extent the size of the apocolpial, and of the mesocolpial, lumina differs within species. Pollen morphology and taxonomy of the genus *Nepeta* sect. *Psilonepeta* in Iran has been described by Azizian *et al.* (2001). Based on the SEM studies, the pollen morphology of 8 species of the sect. *Psilonepeta* native to Iran is described. Differences in size and ornamentation of pollen and other conclusions from morphological and anatomical data, suggest that *N. denudata* should be transferred to sect. *Denudata* supporting Budantsev's treatment.

Ranjabari *et al.* (2004) studied the pollen morphology of section *Cataria* of genus *Nepeta* in Iran. The authors state that pollen grains of all species as monadic, euprolate to subeuprolate, isopolar, hexacolpate and fossaperturate. *N. cataria* had the smallest pollen grains. The tectum is perforate, bireticulate, suprareticulum is clear or not. Species have been grouped into two classes based on exine sculpture. Species with prominent primary muri include *N. menthoids* and *N. binaloudensis*. Species with less prominent primary muri include *N. cataria, N. asterotricha*, *N. crispa* and *N. chinophila N. pogonosperma*. Documentation of pollen morphology of forty

taxa of the genus has been studied by Celenk *et al.* (2008) using light microscopy (LM) and scanning electron microscopy (SEM). The pollen grains are small to large (P = 18.64–63.46μm, E = 15.62–46.33μm), suboblate to perprolate (P/E = 0.86–2.09) in shape and hexacolpate (very rarely tetracolpate) with granular membranes. In examinations of exine ornamentation with SEM, two types of pollen grains were recognized: (1) type I, with microreticulate sculpture; and (2) type II with bireticulate sculpture, type I and II to be divided into two and five subtypes, respectively.

3.6. Nutlet Morphology

Hedge (1962) determined 3 types of nutlet texture, namely smooth without tubercles, flatly tuberculate, and clearly tuberculate, especially towards apex. *N. cilicia* almost always has clearly tuberculate nutlets, while *N. fissa* has flatly tuberculate nutlets, and *N. lamiifolia* partly smooth (Protuberant) nutlets.

Ubera (1982) studied the nutlet surface of 12 *Nepeta* species in the Iberian Peninsula. He attempted to resolve taxonomic problems of 12 species by studying the nutlet surfaces. The nutlet morphology of different species of the genus has also been studied by Ubera and Valdes (1983).

Fruit surface ultrastructure was determined by SEM in 89 species by Budantsev (1993b). Two main fruit surface types viz. smooth and irregular, with some structural variations within each type are recognised. Studies on the geographical distribution of species with different types of fruit surface showed that species with smooth type fruits were found in the eastern parts of the native habitat, and species with rough fruits were found mainly in central and western parts. Subsequently, the ultrastructural features of fruit surface in some genera of tribe Nepeteae were studied by Budantsev (1993c). Later, Budantsev and Lobova (1997) studied fruit morphology, anatomy and taxonomy of tribe Nepeteae. The results of a detailed SEM study of nutlet

morphology in 156 species of tribe Nepeteae are presented. Two main types, smooth and sculptured, are described; within them such sub groups as reticulate, cellular, verrucose and tuberculate are defined. The taxonomic significance of these characters is discussed. Pericarp structure was investigated in 34 species. Mucilaginous tubercles were found on the surface of the nutlets in *Nepeta*, *Drepanocaryum* and *Lophanthus*, and their structure is described. Based on a combination of nutlet morphology, pericarp structure and vegetative and floral features, three informal generic groups are recognised in 10 genera of this widespread tribe.

Kaya and Dirmenci (2008) studied the nutlet surface micromorphology of 39 taxa of the genus *Nepeta* L. in Turkey using stereoscopic and scanning electron microscopy (SEM). The genus is represented by 35 species comprising 40 taxa, of which 19 are endemic (Hedge and Lamond, 1982; Aytaç and Yildiz, 1996; Güner *et al.*, 2000; Dirmenci, 2005). According to surface ornamentations, 3 main types, smooth, partly smooth, and sculptured, and 7 subtypes, undulate-ridged, cellular, reticulate, protuberance, papillate, verrucate, and tuberculate, were identified and illustrated. In addition, the unknown nutlet features of *N. conferta* Hedge and Lamond, *N. crinita* Montbret and Aucher ex Bentham and *N. viscida* Boiss. are given for the first time here in detail.

3.7. Chromosome Studies

Of the 300 species comprising the genus *Nepeta* 62 which constitutes 20.67 % of the entire genus have been worked out in respect of their chromosome count which ranges from 2n = 16 to 2n = 36 (Table 3.4).

Bushnell (1936b) studied cytology of *Nepeta cataria*. Its nucleoli just before synthesis appear bilobed and the lobes are of equal size. Since only one nucleolus is present at synizesis, the nucleoli fuse during the presynizetic stage. The fusion is apparently a slow process and observable in all nuclei.

The haploid chromosome number is n = 16. Two pairs of satellite chromosomes are present. One pair is attached to the nucleolus; the other is free, at diakinensis and interkinensis. At interkinensis, each of the sister nuclei contain sixteen chromosomes, one of which bears a satellite attached to the nucleolus. Sixteen chromosomes are visible also in polar views of the homoeotypic equatorial plates. Its microspore mother nuclei are smaller than those of the other genera studied. Cytological features in some north Indian Labiates has been worked out. Gill (1969) studied cytology of *N. hindustana* and *N. ruderalis*; both have n = 18 and are tetraploid based on x = 9. Another base number x = 17 known for the genus (Darlington and Wylie, 1955) seems to be of secondary origin (Vij and Kashyap, 1976).

Gill (1979) made a cytotaxonomic analysis of the tribe Nepeteae (Lamiaceae) in Canada. The chromosome numbers of four genera and eight species have been determined. The diploid cytotype (n = 9) in *Glechoma hederacea* has been reported for the first time from North America. Reproductive biology and radiation patterns have been studied. The distribution maps of all taxa of this tribe known to occur in Canada are given.

The base numbers of *Nepeta* are 9 to 17 (Darling and Wylie, 1955). However, the report of 2n = 16 in *N. teydea* (Larson, 1960) suggests a new base number of 8. The highest base number of 17 is probably of secondary origin.Seven populations of *Nepeta cataria* were investigated cytologically and in all cases the haploid number of 17 was observed. This agrees with the previous count of 2n = 34 (Mulligan, 1959), but differs from that of Suigura (1940), who obtained 2n = 36. Meiosis and pollen formation are normal with 100% pollen fertility. The haploid number of 9 confirms the previous reports of 2n = 18 in *N. mussini* (Fedöröv, 1969). Meiosis and pollen formation are normal with 75-80% fertile pollen. *N. camphorata* is an occassional garden plant which has escaped from cultivation on Mont Royal, Montreal and

persisted for many years.

Love (1981) reported the chromosome number of 2n = 18 in *N. nuda* L. which is a diploid species. Chromosome numbers are reported for 28 species of angiosperms, of which 19 species were hitherto unknown cytologically (Baden 1984a). Subsequently, Baden (1984b) studied chromosome numbers in the *N. sibthorpii* group. 65 populations were investigated. All species of the group are diploid with basic number of x = 8 and somatic number of 2n = 16. The chromosomes are small, 0.8 - 3μm long, rod-shaped and mostly without constrictions. The karyotypes of all species are similar and comprise 3 groups of chromosomes: one pair of very long (2.5 -3 μm), 5 pairs of medium-sized (1.1 - 2.4μm) and 2 pairs of short (0.8 - 1μm) chromosomes. All chromosomes are metacentric to submetacentric. *N. sphaciotica* and the Olympus type deviate from this pattern possessing in addition to the one pair of very long chromosomes, 4 long and 10 medium-sized and 2 long and 12 medium-sized chromosomes respectively. Rarely, 1-2 satellites on 1-2 chromosomes could be seen. Variable numbers of B-chromosomes were observed in a few *N. sibthorpii* populations. Later, Love (1985) reported the chromosome number of *N. nepetella* L. as 2n = 36. It is considered to be a tetraploid species.

Budantsev *et al*. (1992) worked out chromosome numbers in several genera of the tribe Nepeteae and analysed some problems of their systematics. Chromosome numbers in twelve species of *Nepeta*, three species of *Lophanthus* and one species of *Kudrjaschevia* have been determined. *N. transiliensis* (2n = 18), *N. tyttantha* (2n = 18), *L. chinensis* (2n = 18), *L. elegans* (2n = 16), *L. ouroumitanensis* (2n = 32) and *K. allotricha* (2n = 16) have been investigated for the first time. The morphology and chromosome number of the subspecies of *Nepeta nuda* L. ssp. *lydiae* PH. Davis have been studied for the first time by Aydin and Dirmenci (2004). This subspecies is

one of the two endemic subspecies of *N. nuda* and has spread out commonly in Turkey and the World. Furthermore, the chromosome number of *N. nuda* L. subsp. *lydiae* P.H Davis was determined as 2n = 18.

Table 3.4: Chromosome counts of various species of the genus *Nepeta* recorded by Darlington and Wylie, 1955; Fedorov, 1969; Kumar and Subramaniam, 1986; Aydoğdu, 2002 and Aydin and Dirmenci, 2004)

Species	n	2n	Reference
1. *N. agrestis* loisel	9	18	Contandriopoulos, 1957
2. *N. bucharica* lipsky	17	34	MaTBeeBa, ТихоНоВа 1968δ
3. *N. cadmea*	8	16	Darlington and Wylie, 1955.
4. *N. caesarea*	8	16	Darlington and Wylie, 1955
5. *N. camphorata* Boiss and Heldr.	8	16	Baden, 1984
6. *N. cataria* L.	15	30	Majovsky *et al.* 1970
	16	32	Bushnell, 1936
	17	34	Mulligan, 1959 ; Uhrikova, Murin (I. Slov. fl. I. 1967); Morton, 1973 ; Markova and Thu, 1974 ; Gill, 1979
	18	36	Sugiura, 1937, 1940; Darlington and Wylie, 1955; Lee, 1967; Podlech and Dieterle, 1969; Vakar and Leshukova, 1970; Aydoğdu, 2002.
7. *N. cilicica*	13	26	Darlington and Wylie, 1955
	14	28	
8. *N. concolor*	12	24	Darlington and Wylie, 1955
	13	26	
9. *N. conferta*	8	16	Darlington and Wylie, 1955
10. *N. dirphya* (Boiss.) Heldr. ex Hal.	8	16	Baden, 1984
11. *N. distans* Royle	13	26	Zhukova, 1967
	18	36	Gill, 1969
12. *N. elliptica* Royle	9	18	Gill, 1969
13. *N. erecta* Benth.	18	36	Gill, 1969
14. *N. eriostachys* Benth.	9	18	Gill, 1969
15. *N. fissa*	8	16	Darlington and Wylie, 1955

	9	18	
16. *N. flavida*	8	16	Darlington and Wylie, 1955
17. *N. glechoma*	9	18	Sugiura, 1938, 1940
18. *N. glutinosa* Benth.	9	18	Podlech and Dieterle, 1969
19. *N. govaniana* Benth.	9	18	Gill, 1969
20. *N. graciliflora* Benth.	9	18	Gill, 1969
21. *N. gracilis* Benth.	18	36	Gill, 1969
22. *N. grandiflora* Bieb.	18	36	Sugiura, 1937, 1948; Aydogdu, 2002
23. *N. hederacea* Trev.	9	18	Sugiura, 1940
	18	36	Rutland, 1941; Taylor, 1949
24. *N. heldreichii* Hal.	8	16	Baden, 1984
25. *N.hindostana* Haines	18	36	Gill, 1969; Vij and Kashyap 1975, 1976
26. *N. isaurica*	8	16	Darlington and Wylie, 1955
27. *N. italic*	8	16	Darlington and Wylie, 1955
28. *N. kokanica* Regel	9	18	СоКолоВСКаR, СТРелКоВа 1939; МаТВееВа, ТиХоНоВа 1968δ
	17	34	Aydagdu, 2002
	18	36	Sugiura 1937, 1940
29. *N. leucophylla* Benth.	18	36	Gill, 1969
30. *N. leucostegia* Boiss. and Heldr.	8	16	Baden, 1984
31. *N. linearis* Royle	9	18	Gill, 1969
32. *N. macrantha* Fisch.	9	18	СоКолоВСКаR, СТРелКоВа 1938, 1948; Sugiura 1937, 1940
33. *N. melissifolia* Lam.	9	18	Strid 1965
34. *N. mollis* Benth.	18	36	Gill, 1969
35. *N.mussinii* Spreng	9	18	Sugiura 1936; Floto Gudjonsson 1947
36. *N. nepetella* L.	17	34	Floto Gudjonsson 1947; Aydoğdu, 2002
	18	36	Askell, 1985
37. *N. nervosa* Royle	7	14	Zhukova, 1967
	9	18	Chuksanova and Kaplanbekova, 1971; ЧуКСаНОВа НеоПу6Л
38. *N. nuda* L.	9	18	Sugiura, 1938, 1940; Aydoğdu, 2002
39. *N. nuda* L. subsp. *albiflora*	9	18	Darlington and Wylie, 1955

40. *N. nuda* L. subsp. *Glandulifera*	9	18	Darlington and Wylie, 1955
41. *N.nuda* L. subsp.*lydiae* P.H. Davis	9	18	Aydin and Dirmenci, 2004
42. *N. sibthorpii* group - olympus type	8	16	Baden, 1984
43. *N. parnassica* Heldr. and Sart.	8	16	Baden, 1984
44. *N. phyllochlamys*	8	16	Darlington and Wylie, 1955
45. *N. padostachys* Benth.	9	18	Podlech and Dieterle, 1969; ВолХоВСКиХ НеоПуδл
46. *N. pseudomussinii*	13	26	Floto, Gudjonsson 1947; Aydoğdu, 2002
47. *N. racemosa*	9	18	Darlington and Wylie, 1955
48. *N. raphanorhiza* Benth.	9	18	Gill, 1969
49. *N. ruderalis* Buch.-Ham.	18	36	Gill, 1969; Vij and Kashyap, 1975, 1976
50. *N. schiraziana* Boiss.	8	16	Aryavand 1975
51. *N. sibirica* L.	9	18	СоКолоВСКаR, СТРелКоВа 1948; МаТВееВа, ТиХоНоВа НеоПуδл.
52. *N. sibthorpii* Benth.	8	16	Baden, 1984
53. *N. sphaciotica* P. Davis	8	16	Baden, 1984
54. *N. spicata* Benth.	9	18	Gill, 1969
55. *N. spruneri*	8	16	Baden, 1984
56. *N. stachyoides*	9	18	Sugiura 1941, 1944; Aydoğdu, 2002
57. *N. sulfuriflora*	8	16	Darlington and Wylie, 1955
58. *N. teydea* Webb et. Berth.	8	16	Larson 1958, 1960; Linder, Lambert, 1965
59. *N. transcaucasica* Grossh	9	18	МаТВееВа, ТиХоНоВа 1968
60. *N. transiliensis*	9	18	Budantsev, Zemskova and Semicheva, 1992
61. *N. tyttantha*	9	18	Budantsev, Zemskova and Semicheva, 1992
62. *N. viscid*	8	16	Darlington and Wylie, 1955.

3.8. Reproductive Biology/Embryology

Bushnell (1936a) has summarized the observations made on the embryological features such as formation of the nucellus, integuments, archesporium, and macrospores in certain Labiatae. In all the taxa except for minor differences, in *Monarda fistulosa*, *M. didyma*, *M. punctata*, and *Nepeta cataria*, development of the ovule and macrogametophyte are similar. The ovule is anatropous, has a single massive integument, one-layered nucellus which does not persist, a hypostase tissue and an integumentary tapetum. The chalazal macrospore is the functional one and the embryo sac is of the common seven-celled type. *M. fistulosa* has the largest macrospores. An obturator is developed in all except *Nepeta cataria*. The integument encloses the nucellus only in *M. punctata* and not the other taxa. It is thicker in *M. didyma* and *M. punctata* than in *M. fistulosa* and *N. cataria*. The hypostase is very prominent in *M. fistulosa*, rather prominent in *M. didyma* and *N. cataria*, and not so conspicuous in *M. punctata*. Apparently, *N. cataria* is partially self-compatible and self pollinated. Under natural conditions, the flowers are frequently visited by bees (Clapham *et al*., 1962), which presumably bring about pollination. Under open pollination 4 seeds per calyx are usually observed but in bagged plants the number is reduced to 2 or 3 (Gill, 1979).

Dwivedi and Joshi (1981) have studied sporogenesis and gametogenesis in *N. hindostana.* Subsequently, Svensson and Wigren (1984) studied history and biology of *N. cataria* in Sweden. Syrphid flies, bumble bees and other bees pollinate this rare medicinal plant. Later, the effects of the patch size of catnip, *N. cataria*, on pollinator visitation rates and pollinator limitation was examined by Sih and Baltus (1987). The most important floral visitators are honey bees (*Apis mellifera*), solitary bees (Halictidae), and bumble bees (*Bombus* spp.). Their first goal was to see how spatial variation in patch size affected the rate at which individual flowers received pollinator

visits (visitation rate). Visitation rate was higher in larger patches for honey bees and bumble bees, but lower for solitary bees. Patch size explained 74 - 83% of the variation in visitation rate. Intraspecific isolation also had an effect: isolated patches received relatively few visits. Visitation rate is dependant both on visitor abundance and on the proportion of flowers entered during one visit. All three visitor types were more abundant in larger patches, i.e., flowers showed mutual attraction of pollinators. Anatomically, the phenomenon of polygamy was studied by Daskalova (2005) in some species of *Nepeta*.

3.9. Physiology

The leaf water content and water retaining capacity, cell permeability and pigment contents were studied in pot -or field - grown *N. transcaucasica* under different regimes of water supply, viz. (a) a constant 45 or 75 % of field capacity or a variable 45 - 35% or 75 - 45% of field capacity in containers, and (b) 80 - 85% of field capacity compared with 63% in the field (Karpova *et al*., 1973). Subsequently, Khilik *et al.* (1979) studied phosphorus uptake by *N. transcaucasica*. Superphosphate with labelled P was applied by 3 methods to this plant grown on a southern carbonaceous chernozem soil. Surface application along the row (with out protecting the plants from the fertilizer) or application along each side of the row (20cm from the axis) and incorporation to a depth of 8-10cm gave better 32P uptake than deep (14-16cm) incorporation along the middle of the interrow. Later, Kapelev (1984) investigated factors affecting *N. cataria* var. *citriodora* seed germination. Germination was generally poor and slow, and was optimal at 20^{o}C. The germination energy and rate were highest in mature seeds obtained from shoots on the primary branches and were maximal one year after harvest, decreasing to a minimum after 2.5 years.

3.10. Phytochemistry

The phytochemical details on various species of *Nepeta* are well documented. This study has been conducted mostly on the widespread species like *N. cartaria, N. elliptica, N. leucophylla, N. hindostana, N. teydea, N. cilicia, N. viscida, N. nuda* ssp. *albiflora* and *N. crassifolia* and some on *N. govaniana* and *N. spicata*. Stems, leaves and flowers are known to produce essential oil which contains nepetalactone as the major component. Eisenbraun *et al.* (1980) have found 4aβ, 7α, 7aβ-nepetalactone as the major constituent (95%) of the volatile oil (yield 0.6%) of *N. mussini*, a methylcyclopentane monoterpenoid diastereomeric with the two nepetalactones from *N. cataria*, all having the same absolute configuration at C-7. Stereochemical assignments to the four nepetalactones derived from these neptalactones are also reported. Subsequently, Tagawa and Murai (1980) isolated a new iridoid glucoside, named nepetoglucosylester ($C_{16}H_{24}O_9.H_2O$ mp 106° d) from the leaves of *N. cataria.* Later, Stepanenko *et al.* (1980) studied lipid composition of shell and kernel extracts of *Nepeta pannonica* and *Lavandula vera* seeds. Lipids of *N. pannonica* and *L. vera* seed coat differed from each other substantially. In the lipids of *N. pannonica* kernels free fatty acids with chain lengths C_{20} to C_{35} were found. From *L. vera* the seed coat extract yielded ursolic acid and its acetate and from the seed fat gave dimethyl adipinic acid. The ursolic acid has been isolated to the extent of 3.8% from *N. transcaucasica* after essential oil extraction by Mishurova *et al.* (1981). This provides an opportunity of multipurpose utilization of the raw material. Ahmad *et al.* (1981) examined *N. hindostana* chemically. A new triterpenoid, named nepeticin ($C_{30}H_{50}O_2$, mp 215°) isolated from *N. hindostana*, has been assigned the structure of lup-20(29)-ene-3β, 11α-diol.

Tagawa and Murai (1983) revised the structure of nepetolglucosylester isolated from *N. cataria* as (5R, 8S, 9R)-7-deoxyloganic acid on the basis of

exhaustive 1H- and 13C-NMR spectral studies and chemical transformations. The revised structure was renamed as 5-epideoxyloganic acid ($C_{16}H_{24}O_9$, H_2O, mp 106^o). Subsequently, Murai *et al.* (1984) revised the structure of an iridoid glucoside formerly designated as 5-epideoxyloganic acid, isolated from *N. cataria* to (1R, 5R, 8S, 9S) deoxyloganic acid which is renamed 1,5,9-epideoxyloganic acid. Later, Waller and Johnson (1984) studied metabolism of nepetalactone by *Nepeta cataria* plants, which yielded significant amounts of (G-^{14}C) dihydronepetalactone that were bound to plant components. Isomeric forms of (G-^{14}C) dihydronepetalactone and (G-^{14}C) nepetadiol were synthesized from (G-^{14}C) nepetalactone. Analysis by GC and GC/MS showed that treatment of the plant residues with hot 2NHCl liberated four times as much steam-volatile material, which contained diastereoisomeric dihydronepetalactones. A metabolic scheme is proposed, and possible biological significance of the results is discussed.

Saez *et al.* (1986) investigated *N. nepetella* ssp. *cordifolia* and *N. tuberosa* ssp. *reticulata* phytochemically and showed that the stems contain less phenolic acids than the leaves and flowers. The following compounds were identified by TLC: caffeic acid, ferulic acid, syringic acid, 4-hydroxybenzoic acid, vanillic acid and cis- and trans-p-coumaric acids. They were present mainly as glycosides. A nepetalactone was isolated from *Nepeta elliptica* by Bottini *et al.* (1987). The major component of the essential oil from the aerial parts of *N. elliptica*, gathered in the Kumaun region of India, has been identified as (7R)-trans, trans-nepetalactone primarily by comparison of its IR spectrum with those of its four (7S)-stereoisomers and its mass spectrum and 1H and 13C-NMR spectra with those of its three diastereomers. Ahmad *et al.* (1988) reported the presence of alpha - and beta - amyrin, 10 esters and 6 hydrocarbons in the wax of *N. hindostana*. Subsequently, Bhandari *et al.* (1990) isolated two rare ursane triterpenoids, 2α, 3α-dihydroxyurs-12-en-28-oic acid and 2α, 3β-dihydroxyurs-12-en-28-

oic acid, together with a new triterpene, nepetoic acid identified as 2α-methoxy-3β-hydroxyurs-12-en-28-oic acid from the aerial parts of *Nepeta eriostachiya* as their methyl esters. Their structures were established by chemical and spectroscopic means. Later, different constituents were isolated from *Nepeta eriostachiya* by Bhandari and Garg (1991). These constituents are: 2-octadecanone, palmitic acid, docosanoic acid, tetracosanoic acid, hentriacontanol, friedelin, beta-sitosterol, olcanoic acid, bis-2-ethyl-n-hexylphthalate and stigmasta-3,5-dien-7-one.

Mathela *et al.* (1991) recovered T. coleon U12-methyl ether from *Nepeta leucophylla*. This product was isolated form its roots and its structure and absolute configurations were determined by X-ray analysis. Ahmad *et al.* (1993) isolated a new triterpenoidal aldehyde, nepehinal, from the alcoholic extract of the whole plant of *Nepeta hindostana*. Its structure was established as 1 beta, 3 beta, 11 alpha-trihydroxy-lup-20(29)-en-30-al, though chemical and spectroscopic studies including two dimensional NMR, 13C-NMR spectral assignments of nepeticin have also been revised. Subsequently, the essential oil was obtained by hydrodistillation from dry leaves and flowers of *N. parnassica* by GC and GC/MS and 53 constituents were identified. The major components are cineol (46.4%) and neonepetalactone (3.2%) in the leaves and flowers, citronellol (63.8%) and nepetalactone (7.6%) in the stems (Arnold *et al.*, 1993). Later, Bhandari *et al.* (1993) isolated coleon U12-methyl ether and a previously unreported dehydro coleon U12-methyl ether from the chloroform extract of *N. elliptica*.

Pandey *et al.* (1993) published a paper on ethanolic extract of aerial parts of *Nepeta leucophylla*. The extract, as revealed by chromatographic analysis, comprises two waxy solids which were found to consist of twelve alkanes and six long-chain esters, respectively. Caryophyllene oxide, beta-sitosterol and oleanolic acid in addition of ursolic acid were isolated and

identified by spectral analysis. Başer and Ozek (1994) analysed water-distilled oils from aerial parts, leaves, flowers and branched stems of *N. caesarea*, (an endemic species to Turkey) by GC/MS. Twenty-five compounds constituting 95.1 - 98.1% of the total components were identified. 4α,7α,7aα-nepetalactone (91.20 - 95.34%) was found to be the major component in the oils. Subsequently, the composition of the essential oil isolated from inflorescences of *N. tuberosa* ssp. *tuberosa* was analysed by GC and GC-MS. The oil consisted mainly of menoterpenes (89 percent), 5,9-dehydronepetalactone (69 percent) and geranyl acetate (17 percent) being the main components (Cotrim *et al.*, 1994). Later, new diterpenes dehydroabietan-18-ol acetate, teideadiol 18-monoacetate, teideadiol 18-malonate and teidic acid was isolated from the aerial parts of *Nepeta teydea* by Fraga *et al*. (1994).

Mathela and Kharkwal (1994) examined chemical composition of the essential oil obtained from the aerial parts of *N. govaniana* by GC/MS and GC/FTIR. Of more than 50 components of the oil, 43 have been identified. The oil from *N. govaniana* is characterised by the dominant presence of C_{12} compounds such as pregeijerene (38%) and geijerene (6.8%) besides trans, cis- iridolactone (14%), two nepetalactones (4.8%), as well as some mono- and sesquiterpene hydrocarbons and oxygenated compounds. This is the first record of the occurrence of C_{12} compounds in the oil of a *Nepeta* species. Başer *et al.* (1995), analysed water-distilled essential oils from aerial parts of *N. viscida*, a Turkish endemic species by GC and GC/MS. Forty-one compounds were identified with aplha-terpineol (31.57%) as the major constituent. Subsequently, Takeda *et al.* (1995) isolated a new iridoid glucoside with an unusual stereochemistry, named nepetanudoside from the aerial parts of *N. nuda* ssp. *albiflora*. Later, the essential oils were isolated from Bulgarian populations of *N nuda*, *N. cataria* (two origins) and of the Caucasian endemic *N.grandiflora* by GC/MS, TLC and chemical

transformation. Iridoids of the nepetalactone type were the main constituents, accompanied by other terpenoids (Handjieva and Popov, 1996)

Kokdil *et al.* (1996) analysed composition of the essential oil of *N. nuda* ssp. *albiflora* by means of capillary GC and GC-MS. The main components, accounting for 75.1% of the oil, were found to be 4aα,7α,7aα-nepetalactone (37.5%) and 4aα,7α,7aβ-nepetalactone (37.6%). The sesquiterpene fraction amounted to 14.2% and was dominated by caryophyllene oxide (4.4%). Subsequently, Malizia *et al.* (1996) analysed by GC and GC/MS essential oil content of *N. cataria* obtained from plants collected in full bloom. Fifteen main components representing more than 95 percent of the total oil were identified. Nepetalactone (57.30%), dihydronepetalactone (3.43%), beta-caryophyllene (8.10%), alpha-humulene (1.27%), beta-farnesene (2.14%), caryophyllene oxide (19.35%) and humulene oxide I (1.63%) were the major components. Later, Moghaddam and Hosseini (1996) purified essential oils of *N. crassifolia* by steam distillation and analysed by GC and GC-MS. Thirty five substances out of the 52 detected were identified. The major constituents were found to be stereoisomers of nepetalactones (72.8%) and 1, 8-cineole (9%). 4aα,7β,7aβ-nepetalactone was isolated and identified by 1H- and 13C-NMR.

Sarer and Konuklugil (1996) prepared essential oils of *N. nuda* ssp. *albiflora* by hydrodistillation and analysed by GC/MS. Nineteen components were identified accounting for 98.5% of the oil. The major constituents found were nerolido (31.7%), 1,8-cineole (29.1%) and spathulenol (14.4%). A new iridoid glucoside, nepetacilicioside was isolated from the aerial parts of *N. cilicia* together with the known compound velpetin (Takeda *et al.*, 1996). Subsequently, Bisht *et al.* (1997) analysed chemical composition of the essential oil obtained from the aerial parts of *N. spicata* by GC/MS and GC/FTIR. Out of atleast 43 constituents, 33 have been identified. β-

caryophyllene (27.01%) was found to be the most abundant constituent of the oil along with linalool, germacrene-D and β-caryophyllene oxide as the next major compound. Later, Chalchat and Lamy (1997) brought into cultivation the wild growing *N. cataria* L. cv. *citriodora*. The oils produced from cultivated plants harvested throughout the growing season were analysed by GC and GC/MS. Although 42 components were identified, the oil composition did not depend on the time of harvesting or storage of the plant material prior to distillation. The oil was found to comprise mainly of citronellol, nerol, geraniol and geranial. The highest oil yield was found to be at the time of full flowering.

Khalil *et al.* (1997) isolated a new isopimarane-type diterpene from the ethanol extract of the aerial parts of *N. septemcrenata*. The species is a perennial herb that grows wild in South Sinai. Twenty eight constituents isolated from the essential oils of *N. italica* and *N. sulfuriflora*, prepared by hydrodistillation were identified by capillary GC and GC-MS. The essential oils consisted mainly of 1,8-cineole (80.8%) in the oil of *N. italica* and 61.5% in that of *N. sulfuriflora* (Kokdil *et al.*, 1997a). Subsequently, Kokdil *et al.* (1997b) isolated 23 constituents from the leaves and flowers of *N. cilicia* accounted for 96.6 percent of the oil. Its essential oil was characterised by a high percentage of sesquiterpenes, mainly beta-caryophyllene oxide (40.7%), beta-caryophyllene (15.7%), alpha-copaene (7.3%) and beta-cubebene (6.6%). No nepetalactones were found in the oil. Later, water-distilled oils were analysed by GC/MS from the herbal plants of *N. sulfuriflora* endemic in Turkey (Başer and Demircakmak, 1998).

Başer *et al.* (1998) isolated essential oils from *N. flavida* by GC/MS. Eighty three components were characterized representing 92.8% of the total components detected in the oil with linalool and 1,8-cineole as major constituents. Toxic effects on mice during emgryogenetic period when

exposed to catnip were studied by Bernardi *et al.* (1998). Fraga *et al.* (1998) corrected the structure of two abietane diterpenes previously isolated from *N. teydea* and they have now been named netidiol A and netidiol B.

Kokdil *et al.* (1999) isolated six known menoterpene nepetalactones, 4aα,7α,7aα-nepetalactones (1), 4aα,7α,7aβ-nepetalactone (2), 4aβ,7α,7aβ-nepetalactone (3), 4aβ,7α,7aα nepetalactone (4), 4aα,7β,7aβ-nepetalactone (5), 3α-hydroxy-4aα, 7α,7aα-dihydronepetalactona (= nepetalic acid) (6), and a dimeric 5,9-dehydronepetalactona (7) along with two known steroids B-sitosterol and sitosterol 3-one and triterpene betulinic acid from the hexane extract of *N. nuda* ssp. a*lbiflora*, the acetone extract of the same pant afforded compound 7 in higher yield in addition to compounds 2 and 6, and other compounds. The chemical composition of *N. crassifolia* Boiss. and Buhse oil was analysed by Dabiri and Sefidkon (2003b) from Iran.

Jamzad *et al.* (2003b) published her work on leaf surface flavonoids in Iranian species of *Nepeta* and some related genera. A HPLC survey of leaf surface flavonoids of 38 species and four species of related genera *Agastache*, *Dracocephalum* and *Lallemantia* revealed 14 different flavones, one of which is new (8-hydroxycirsiliol or 5,8,3′,4′-tetrahydroxy-6,7-dimethoxyflavone). In addition, two flavonols were found in *Dracocephalum kotschyii*. Subsequently, Sefidkon and Akbari-nia (2003) studied *N. pogonosperma* Jamzad et. Assadi for essential oil composition in Iran. Later, Mehrabani *et al.* (2004) analysed essential oil by GC/MS from flowering aerial parts of *N. depauperata* Benth., an endemic Iranian plant, obtained by steam distillation. The constituents were identified by their mass spectra and Kovats' indices. Thirty three compounds consisting 82.52% of the total components were identified from the oil obtained with a yield of 0.3% v/w. Among them, spathulenol (31.84%), beta caryophyllene (12.93%) and caryophyllene oxide (10.27%) were the major components of the oil. *N.meyeri* Benth. was also

analysed chemically by Sefidkon and Shaabani (2004) in Iran. Bhattacharjee (2005), in *Handbook of Aromatic Plants* analysed *N. cataria* for essential oil. Its extraction, composition and utility are also noted down.

Pădure *et al.* (2006) analysed the essential oils of *Nepeta* L. in Romania. The essential oils of four species of *Nepeta* L. have been examined. The oils of *N. cataria* and *N. nuda* ssp. *nuda* are characterised by the presence of nepetalactone isomers. Other two species represented by *N. parviflora* and *N. ucranica* ssp. *ucranica* have a rare status within the *Vascular Plant Red List for Romania*. Nepetalactone isomers are not present in the essential oils of the latest two species. All species excepting *N. cataria* have been studied for the first time in Romania from phytochemical point of view. A long chain Ketone (crassifone), a pentacyclic triterpenoid coupled with fatty acid moiety (crassifoate), and an acyclic diterpenoid (crassifol) was isolated from the ethanol soluble part of *Nepeta crassifolia* collected from Kangavar, Iran. Structure of all the metabolities were elucidated with the aid of spectroscopic techniques, including 2D - NMR experiments (Ibrahim and Ali, 2007).

3.11. Pharmacognosy

Pharmacological studies have been carried out with extraction from stems, leaves and flowers etc. of different species of *Nepeta*. Oil extracted was found to be active against microbial activity.

Waller *et al.* (1969) studied physiological effects of feline attractant, cis, trans-nepetalactone on the domestic cat. This biologically active component of catnip (C - labeled) when force-fed to the domestic cat, 86-94 percent of the radioactivity was recovered in the urine, 1 to 2 percent in the faeces, and 1 - 12 percent was collected as carbon dioxide. The major (50 to75 percent) metabolite was α-nepetalinic acid, which was excreted in the urine together with small amounts of dihydronepetalactone, unchanged cis, trans-nepetalactone, and several unidentified compounds. No marked

physiological or histological effects were observed when 20 - 80 milligrams of this compound was administered orally.

Sherry and Koontz (1979) worked out the pharmacological studies of 'Catnip tea'. Weighed samples (400, 800, 1000mg/kg) of the residue left after evaporation of the solvent of a hot water extract of dried *N. cataria* exhibited significant psychotropic activity in chicks. Preliminary comparative chemico-morphological studies of the imported unani drug 'Zufah-yabis' and indigenous drug 'Dyanku' has been carried out by Issar (1980). The imported unani drug Zufa has been identified as *N. bracteata* Benth. The Ladakh drug Dyanku, has been identified as *N. longibracteata* Benth. Comparative studies of both the drugs have been carried out which will be helpful to distinguish Zufa from Dyanku. Sherry *et al.* (1981) studied cold water extract (400-1400mg/kg) and acetone-pretreated hot water extract (200-1220mg/kg) samples of *N. cataria* and were found to be pharmacologically active but the activity was relatively weak and variable.

Sherry and Mitchell (1983) studied the effects of the "lactone-free" hot water extract of catnip (*N. cataria*) on the young chick. The lactone-free portion of the hexane extract of *N. cataria* has been shown to cause a significant decrease in wakefulness and an increase in sleep behaviour, particularly deep sleep in the young chick. This has been found to be less effective in older chicks. Subsequently, Ahmad and Siddiqui (1987) discussed pharmacognostical and elemental aspects of the three herbs viz., *Allium sativum*, *Curcuma longa* and *Nepeta hindostana* in relation to their medicinal importance. Botanical description of the plants, their pharmacological activities, macroscopic and microscopic characters and quantitative analysis is given. Later, beneficial effect of *N. hindostana* in hypercholestremia and experimental myocardial infarction was studied by Arora (1987). Alcoholic extract of *N. hindostana* in a dose of 20mg/kg/day when given to pigs of both

sexes produced a marked hypercholestremic effect over a period 15 days. It also produced some beneficial effects in the histopathology of myocardial infarction.

Arora *et al.* (1987) tested efficacy of lipotab (combination of three plant drugs viz., *Nepeta hindostana*, *Allium sativum* and *Curcuma longa* with $CaCO_3$ as binding agent) on 86 hyperlipidemic and hypercholestremic patients, of which 66 patients were given lipotab and 20 served as a placebo control. Lipotab in a dose of 2 - 3 gm daily was found capable of producing a mean reduction in cholesterol and triglyceride levels in hyperlipidemic patients of upto 26% and 21%, respectively. Symptomatic improvement with special reference to relief in giddiness, insomnia, listlessness, constipation, pedal edema and nocturia were noticed. *N. cataria* has long been known to elicit a unique sequence of responses in the domestic cat. This aspect was studied by Tucker and Tucker (1988). Essential oil from *N. rtanjensis* has been identified as nepetalactone by spectroscopic means (Jovanovic-Durdevic *et al.,* 1989).

Kheterpal and Siddiqi (1989) discussed botanical characters, pharmacognosy, chemistry, pharmacology, clinical studies and antimicrobial activities of *N. hindostana*, used in unani drugs. Subsequently, Uniyal (1990) gave an account of 20 herbs including Dyanku (*Nepeta longibracteata*), Demok (*Microula tibetica*), Kapichung (*Tulipa stellata*), Pashak (*Centaurea depressa*), Taskya (*Caragana Cumeata*) and Parpata (*Arabis tibetica*) etc. along with information on their Ladakh/local names, botanical names, general description, general distribution in the area, parts used and methods of medication. Later, Arora *et al*. (1991) studied pharmcological and texicological aspects of *Nepeta hindostana*. The aqueous extract of *nepeta hindostana* at a dose of 50mg/kg when given intravenously reduced the blood pressure in dogs by 26.87 percent. The effect of aqueous extract on CNS

parameters was studied. It reduced spontaneous motor activity, rearing and grooming, while righting reflex and rectal temperature were not affected in rats in doses up to 1gm/kg. It increased the barbiturate sleeping time in mice.

Lee *et al.* (1995) observed how catnip (*N. cataria*) induces alteration in mental status. Behavioral effects in mice by acute and long - term administration of catnip was studied by Massoco *et al.* (1995). Status of some important medicinal and aromatic plants of Kashmir Himalaya including *Nepeta* has been documented by Siddique *et al.* (1995).

Sonbali *et al.* (2004) studied the composition and antimicrobial activity of the essential oil of *Nepeta crispa* Willd., an endemic species from Iran. The oil was obtained from the aerial parts of the plant and analysed by GC and GC/MS. Twenty-three compounds, accounting for 99.8% of the total oil, were identified. The main constituents were 1,8-cineol (47.9%) and 4aα,7α,7aβ-nepetalactone (20.3%). The antimicrobial activity of essential oil was tested against seven gram-negative or gram-positive bacteria and four fungi. The results of the bioassays showed the interesting antimicrobial activity, in which the gram-positive bacteria, *Bacillus subtilis* and *Staphylococcus aureus*, were the most sensitive to the oil. Also, the oil exhibited a remarkable antifungal activity against all the tested fungi.

3.12. Molecular Studies

Wagstaff *et al*. (1995) studied parsimony analysis of cpDNA restriction site variation in subfamily Nepetoideae. Parsimony analysis of cpDNA restriction site variation supports monophyly of subfamily Nepetoideae. However, a close relationship among Nepetoideae and other gynobasic-styled labiatae is not supported, indicating that a gynobasic style has evolved independently in at least two clades of Labiatae. The inferred relationships are congruent with the classification of Cantino *et al*. (1992) but there is conflict to varying degrees with traditional classifications.

Jamzad *et al.* (2003a) studied phylogenetic relationships in *Nepeta* L. and related genera. The internal transcribed spacers of nuclear ribosomal DNA (nrITS) from 43 species of *Nepeta* and representatives of closely related genera and outgroups were sequenced. Parsimony analysis indicated that *Nepeta* is monophyletic and composed of five major groups. The phylogenetic relationships among species of these groups are congruent with the distribution of some floral characters, including corolla shape, bract texture, and colour and pollen exine ornamentation.

4.1. Taxonomy

The study area was thoroughly surveyed, ensuring collection of the *Nepeta* L. plant material, in the flowering, as well as fruiting, condition. For each plant species, 5-7 specimens were collected from a particular population at a particular time; and their field information was recorded under a specific collection number. The collected plants were dried and preserved using usual taxonomic methods. Photographs of habitats and plant species were taken to enhance the information regarding the specimens and the sites of study.

The detailed processing procedure followed is as under:

Collection of plants

1. Collection

   The points kept in mind during plant collection are:

   - Collection of entire, healthy specimens in case of annual herbs; suitable fertile portions in perennial herbs, and small fertile branches in shrubs and trees.
   - Selection of individuals that were representative of the whole population.
   - Avoiding collecting insect-damaged specimens.
   - Collection of underground parts of the herbaceous plants.
   - Collection of those specimens that contained flowers, fruits, and seeds; because keys are prepared mainly on the basis of these characters.
   - Specimens larger than the size of a herbarium sheet were divided and pressed on a series of sheets.
   - Collection of plants with the leaves intact as different kinds of

foliage in *Nepeta* proves helpful in identification.

2. Field equipments and supplies

Some of the commonly used field equipment and supplies during plant collection and preparation of herbarium specimen are:

- Field press: It is made up of a pair of hardwood or metal.
- Driers or Blotters: These are the sheets of heavy blotting papers of 11 by 16 inch dimensions. Old newspapers were also used as driers.
- Field Notebook: An indispensable item of a plant collector is a permanently bound, small field notebook. It was used to record the field data.
- Digging Tools: Diggers, hammer, garden clippers and heavy sheath knife, etc. were used for digging the plants.
- Collecting Bags: These are plastic bags, used as containers for fresh specimens.
- Hand lens A 10X and 20X hand lens was used for observation and identification.
- Digital Camera: This was used for taking photographs of plants in the field.
- Other field equipments and supplies: Altimeter, Pocket knife, and insect repellants, etc. are some other useful items needed for plant collection.

3. Pressing

Specimens, after being collected (cut or dug), were pressed as soon as possible. The specimen was placed carefully on a pressing sheet taking

care so that there is no folding or overlapping of parts. Plants too large to fit in the 11 × 16-inch fold of a newspaper were bent into a V or M figure. In the press, the specimens in the specimen paper were placed in between two driers or blotters.

4. Drying

Specimens were dried as rapidly as possible to get the best results. In the usual process of drying, the press containing the specimens was placed in the laboratory. After about 24 hours, the press was opened, and the specimens shifted to the fresh blotters. Any folding/overlapping of soft parts of the specimens was rectified at the time of replacement of blotters. The process was repeated for several days, till the specimens were completely dry.

5. Mounting

In this process the dry specimens were mounted on standard herbarium sheets, and a label was affixed at the lower right-hand corner of each such sheet.

6. Preservation

The mounted plant specimens were deposited in the Kashmir University Herbarium (KASH) for preservation, after having been treated with insect-repellants, such as Naphthalene balls and Paradicholorobenzene.

Plant description

Detailed morphological studies of all the collected specimens from different localities were conducted, using 10X and 20X hand lenses,

dissection microscope with 10X and 20X eye pieces, and stereomicroscope. Morphological variations, if any, were recorded. Based on diagnostic morphological characters, dichotomous keys to species were constructed.

For each species included in the present work is given, sequentially , its botanical name, followed by author citation, first valid publication, basionym (if any), synonym(s), type specimen, detailed morphological description, flowering/fruiting period, distribution, chromosome number (where available), and economic utility.

Identification

Fresh, or dried and pressed plant specimens were identified and described in the laboratory of the Centre of Plant Taxonomy. All the available floras, such as *Flora of Pakistan*, *Flora of China*, *Flora of British India*, *Flora Europaea*, *Flora of Turkey*, *Flora of Ladakh* and *Flora of Pir Panjal Range* were consulted for the purpose of identification. Besides, the specimens were matched with the authentically identified specimens in the Herbarium, Centre of Plant Taxonomy, University of Kashmir (KASH), Herbarium Northern Circle of BSI, DehraDun (BSD), and the Herbarium of Forest Research Institute, Dehradun (FRD).

All the specimens examined have been deposited in the Kashmir University Herbarium (KASH), and the germ plasm of some species has also been raised *ex. situ* in the Kashmir University Botanical Garden (KUBG).

4.2. Pollen Morphology

Polleniferous materials were taken from the personal collections and from the specimens deposited in KASH.

The anthers were acetolysed according to the method described by

Erdtman (1952). They were crushed on a fine mesh and the sieved material was transferred to a centrifuge tube containing a mixture of 9:1 acetic anhydride and sulphuric acid. The mixture in the tube was heated, 80 - 100^{o}C, on a water bath till its colour changed to brown. The tubes were then centrifuged at 2000 rpm, and the supernatant decanted. Washed with distilled water at least 3-4 times by centrifugation, the sediment was then treated with 50% glycerine and again centrifuged and decanted. The tubes were then kept upside down on a filter paper and dried at 40^{o}C in an oven till the sediment dried.

A minute piece of glycerine jelly (about 1sq.mm), taken on needle tip, was touched with the pollen-bearing sediment in the centrifuge tube, transferred to a clean glass slide and covered with a glass slip. The slide was gently warmed on a flame and after the jelly melted, cover slip was sealed with wax. Pollen descriptions are based on light microscopy (LM), and scanning electron microscopy (SEM) observations. The glycerine jelly slides (LM) were observed using an Olympus OIC microscope and photographed with a Leica DM LS2. For detailed study and microphotography, objective 40X (sometimes oil immersion objective 100X) and eye piece 10X were used. For SEM studies, pollen was coated with carbon, followed by gold, prior to observation with Hitachi S- 3000H Scanning Electron Microscope at different magnifications.

Measurements of the length of the polar axis, equatorial diameter, colpus length, and exine thickness were made on 8 - 10 fully developed grains per specimen with LM (X400, X1000 magnifications). The terminology used in the description is mostly after Erdtman (1954), Hyde and Adams (1958) and Nayar (1990).

4.3. Cytology

For studies on PMC meiosis, flower buds were removed from spikes and fixed in a solution of ethanol/glacial acetic acid (3:1) and after 24 hours preserved in 70% ethanol. The preserved anthers were squashed and stained in acetocarmine for few minutes. The chromosome counts were made at late prophase-I, metaphase-I and anaphase-1. The desirable PMCs were photographed under oil emersion using 100X objective lens.

5.1. Taxonomic Treatment

5.1.1. LAMIACEAE Martinov, Tekhno-Bot. Slovar: 355. 3 Aug 1820, *nom. alt.*: **Labiatae** Juss., Gen. Pl.: 110. 4 Aug 1789, *nom. cons.*

Annual or perennial herbs or shrubs, chiefly aromatic with some sessile oil glands, glabrous or with an indumentum of simple, branched to stellate-dendroid hairs. Stems usually square (4-angled), bearing the leaves on the flat sides. Leaves exstipulate, opposite and decussate, often whorled, usually simple and pinniveined. Floral whorls or verticillasters double, unipared scorpioid cymes, situated in the axils of foliage leaves or, where the subtending leaves are bract-like, forming spikes or racemes, which are often panicled. Flowers almost always hermaphrodite, highly irregular, 5-merous. Calyx persistent, and accresent in fruit, strongly gamosepalous, tubular or companulate or ovoid, bilabiate to actinomorphic with a 3-lobed upper lip and a 2-lobed lower lip, or a 1-lobed upper lip and a 4-lobed lower lip, or a 1-lobed upper and lower lip, enlarging in fruit or not, veines 5-20. Corolla gamopetalous, zygomorphic and bilabiate to actinomorphic, variously arranged; upper (adaxial) lip entire or emarginate with a 3-lobed lower (abaxial) lip; upper lip of 1-lobe and lower lip 4-lobed; upper lobe wanting and lower lip apparently 5-lobed; or lobes subequal, 4 or 5; tube of corolla sometimes annulate. Stamens variously inserted on corolla, 4, often with 2 (usually anterior pair) longer and 2 (usually posterior pair) shorter (didynamous); 2 (the anterior or lower pair in almost all cases), with usually 2 (posterior or upper pair) staminodes; anther thecae 2-locular or 1-locular (by fusion or not), parallel, divergent or separated by an elongated connective. Pollen tricolpate or 6-colpate, rarely tetracolpate. Ovary 4-lobed, superior of 2-carpels, eventually divided into 4, 1-ovulate loculi; nectary disk often present. Style generally arising from base of the ovary divisions, gynobasic, rarely inserted above base of ovary lobes; stigma equally or unequally bifid. Fruits of 4, sometimes less, dry variously shaped nutlets included within the

calyx; nutletsmucilaginous on wetting (myxospermic) or not; seeds without or with little endosperm; embryo straight or curved.

The family comprises approximztely 220 genera with 3500 species, distributd worldwide, but mostly in the Mediterranean region and SW Asia. India has about 68 genera with 425 species.

5.1.2. *NEPETA*

L., Sp. Pl. 570. 1753; Gen. Pl. ed. 5: 249. 1754; Benth. in DC., Prodr. 12: 370. 1848; Boiss., Fl. Or. 4: 637. 1879; Hook. f., Fl. Brit. Ind. 4: 656. 1885; Briquet in Engler & Prantl, Nat. Pflanzenfam. ed. 1, 4, 3A: 235. 1896; Mukerjee in Rec. Bot. Surv. Ind. 14, 1: 118. 1940; Pojarkova in Komarov, Fl. USSR 20: 286. 1954; Hedge & Lamond in Notes Roy. Bot. Gard. Edinb. 28: 97. 1968; Rech., f., Fl. Iran. 150: 108. 1982; Hedge, Fl. Pak. 192: 59. 1990; Jing Jie Shu, Fl. China 17: 131. 1994.

Erect or ascending, annual or perennial, often aromatic herbs, of varied habit and indumentum; hairs usually simple, rarely branched. Leaves simple, rarely pinnatisect, with entire, crenate or serrate margins, sessile or petiolate. Inflorescence of verticillasters, distant or crowded into spike-like or ovoid heads, or lax pedunculate cymes, borne in axils of upper leaves. Bracts shorter to longer than calyces. Flowers hermaphrodite ormale-sterile. Calyx ± clearly 15-veined or ribbed, 5-toothed, teeth equal or not; ± tubular, bilabiate, little changed in fruit; straight or curved; upper lip 3-dentate, lower 2-dentate, rarely lips entire; tube glabrous within or pilose at throat; throat straight to strongly oblique. Corolla blue, violet, pink, yellow or white, bilabiate; tube straight or curved, included in or exserted from calyx; upper and lower lips relatively short, upper lip erect, concave, emarginated or bifid; lower lip 3-fid, the middle lobe largest, entire or crenulate, narrow at the base, lateral lobes small, usually reflexed.Stamens 4, didynamous, posterior pair longer than the anterior; thecae usually diverging at an angle of 180^0. Style unequally bilobed.

Nutlets ellipsoid to obovoid, apically rounded, smooth or variously tuberculate, mucilaginous on wetting or not; areole (attachment scar) bilobed, of varied length.

Nepeta is one of the largest genera in family Lamiaceae with 300 species. It is the second largest genus of the Indian labiates, with 41 species. It is usually classified into 10 sections, of which 6 are represented in the Kashmir Himalaya. **Plate 1, 2**

Key to Sections of *Nepeta* in the Kashmir Himalaya

1a. Inflorescence paniculate, cymes lax, pedunculate

2a. Verticillasters in dense capitula……4. Sect. *Capituliferae*

2b. Verticillasters not in dense capitula

3a. Calyx short, curved; teeth acuminate; corolla short ……. ……2. Sect. *Cataria*

3b. Calyx long, straight; teeth triangular or narrow triangular; corolla long……6. Sect. *Macronepeta*

1b. Inflorescence not paniculate, spikes condensed.

4a. Verticillasters contiguous apically, sometimes widely spaced basally; cymes, sessile

5a. Leaves pinnate with linear - oblong or ovate segments; bracts smaller than calyx……...1. Sect. *Shizonepeta*

5b. Leaves not pinnate; bracts as long as calyx…….…… ……...3. Sect. *Pycnonepeta*

4b. Verticillaster an ovoid densely congested terminal head or numerous, ± distant, short pedunculate cymes……5. Sect. *Glechomanthe*

6a. Leaves obovate or ovate - rhombic, deeply incised with obtuse rounded lobes, cuneate, petiolate; bracts as long as calyx to longer than flowers……..……. Subsect. 1. *Callistegiae*

6b. Leaves oblong - elliptic, deeply serrate - incised, sessile and amplexicaul; bracts as long as calyx.…. Subsect. 2 *Brachystegiae*

Key to species of *Nepeta* in the Kashmir Himalaya based on vegetative as well as floral characters

1a. Herbs,annual; leaves bipinnatisect ……..…….....1. *N. annua*

1b. Herbs, perennial; leaves simple, not bipinnatisect

2a. Floral leaves or bracts as long as calyx to longer than flowers

……..……..... 17. *N. longibracteata*

2b. Flora leaves or bracts not longer than calyx or flowers, small

3a. Leaves incised; plants densely glandular throughout…….…….…….. 12. *N. glutinosa*

3b. Leaves not incised; plants not densely glandular throughout

4a. Verticillasters forming elongated ± continuous spikes or ovoid heads, sometimes the lowermost verticillasters distant

5a. Leaves entire

6a. Calyx-teeth about half the length of the tube; corolla less than 1.5cm in length ……16. *N. linearis*

6b. Calyx-teeth about as long as tube; corolla 2cm or more in length .....

……..……..6. *N. connata*

5b. Leaves crenate or serrate

7a. Verticillasters crowded in axils of the uppermost leaves; peduncle present up to 2.3mm…….……5. *N. coerulescens*

7b. Verticillasters in globose to ovoid-globose terminal spikes, sometimes widely spaced basally; peduncle absent

8a. Rootstock tuberous …….……..21. *N. raphanorhiza*

8b. Rootstock not tuberous

9a. Leaves triangular-ovate to ovate-lanceolate

10a. Stems basally purplish, usually with scale-like cataphylls; clusters of younger leaves often present in leaf axils……14. *N. kokanica*

10b. Stems not as above; clusters of younger leaves not present in leaf axils

11a. Leaves linear-lanceolate; spikes shorter (2-7.1 cm long)….. …….……18. *N. nervosa*

11b. Leaves ovate or deltoid; spikes longer and slender than those of *N. nervosa* (7.5-9 cm long)

12a. Leaves serrate; nutlets narrow- or broad-oblong

13a. Calyx-teeth hispid; leaves short- or long-petioled

14a. Leaves triangular-ovate, broad-truncate or cordate; calyx-teeth as long as the tube ……..15. *N. laevigata*

14b. Leaves oblong-lanceolate, narrow-truncate; calyx teeth shorter than the tube …… 2. *N. campestris*

13b. Calyx-teeth plumose; leaves sessile or nearly so ……10. *N. eriostachys*

12b. Leaves crenate or crenulate; nutlets ellipsoid

15a. Leaves ovate, greyish-white canescent; ……..…….....7. *N. discolor*

15b. Leavs oblong-triangular, not greyish-white canescent; …….....20. *N. podostachys*

9b. Leaves linear-elliptic, narrow- or broadly-elliptic

16a. Petioles up to 0.5 mm long; leaf margin pectinate-serrate; corolla up to 1.7 cm long……..8. *N. elliptica*

16b. Petioles up to 10 mm long; leaf margin crenate-serrate; corolla up to 1.3 cm long ……..19. *N. paulsenii*

4b. Verticillasters ± clearly separated from each other, or the uppermost loosely congested

17a. Inflorescence branched, paniculate, with prominent peduncles

18a. Corolla up to 11 mm long, with tube included in or exserted from the calyx

19a. Basal leaves suborbicular-avate, white-tomentose; cymes mostly on horizontally-spreading peduncles, ± ovoid-capitate ……11. *N. floccosa*

19b. Basal leaves triangular-ovate, with a greyish indumentum; cymes erect, not horizontally-spreading ……3. *N. cataria*

18b. Corolla more than 11 mm long, with tube clearly exserted from the calyx

20a. Leaves thick, grey-white on both surfaces with a dense covering of stellate-dendriod hairs; verticillasters widely-spaced; calyx teeth ½ to as long as tube; corolla less than 2 cm long….22.*N.salviaefolia*

20b. Leaves not thick-textured, green on both surfaces with a covering of simple eglandular hairs; verticillasters not widely spaced; calyx teeth 1/3 to 3/5 to as long as tube; corolla more than 2 cm long

21a.Corolla yellowish, c. 2.5 cm long ….. 13. *N. govaniana*

21b. Corolla blue, 2-2.5 cm long ….. …….9. *N. erecta*

17b. Inflorescence unbranched, not paniculate, lower verticillasters shortly-pedunculate.....4. *N. clarkei*

Key to species of *Nepeta* in the Kashmir Himalaya based on vegetative characters

1 + Rootstock tuberous ……..2

- Rootstock not tuberous……..4

2 + Leaves petiolate, broad triangular-ovate…….21.*N. raphanorhiza*

- Leaves sessile, linear…….... 3

3 + Leaves amplexicaule or connate, 8-16 × 0.3-2.5 cm……6.*N. connata*

- Leaves non-amplexicaule, 3-8 cm ×1.3-6 mm.....16.*N. linearis*

4 + Leaves sessile, or with petiole upto 3 mm long ……...5

- Leaves clearly petiolate, with petiole more than 4 mm long……7

5 + Stem covered with scale-like leaves basally, with dense and glandular indumentum; leaves deeply serrate- incised……12. *N. glutinosa*

- Stem without scale-like leaves and glandular indumentatum; leaves crenate to serrate 6

6 + Leaves linear-lanceolate, entire to finely serrulate .....18.*N. nervosa*

- Leaves narrow or broadly elliptic, pectinate-serrate.....8.*N. elliptica*

7 + Stem covered with white, dendroid hairs; leaves ovate, thick-textured, grey-white……22.*N. salviaefolia*

- Stem and leaves not as above ……..8

8 + Petioles up to 11mm long 9

- Petioles more than 11mm long.....13

9 + Cluster of young leaves often present in leaf axils, leaf-base cuneate .....19. *N. paulsenii*

- Cluster of young leaves not present, leaf-base truncate or cordate 10

10 + Stem up to 60 cm long; leaves 5 cm or more in length.....2.*N. campestris*

- Stem less than 60 cm long; leaves less than 5 cm in length.....11

11 + Leaves oblong or oblong-triangular; stem up to 45 cm long ……
……20.*N. podostachys*

- Leaves broadly ovate or broad ovate-triangular; stem 10-30 cm long.....12

12 + Leaf margin entire to serrulate, apices ±acute; petiole 3-5mm long.....
……10. *N. eriostachys*
- Leaf margin crenate, apices obtuse; petiole up to 11mm long.....
……7.*N. discolor*

13 + Annual; leaves ± bipinnatisect……...1.*N. annua*
- Perennial; leaves undivided…….14

14 + Leaves mostly present in lower part of stem, lobed, with whitish floccose-tomentose hairs, apices obtuse…….11.*N. floccosa*
- Leaves simple without whitish floccose-tomentose hairs; apices acute….15

15 + Leaves narrow to broad-ovate or ovate-lanceolate; petiole up to 3.5 cm long…….16
- Leaves ovate-elliptic or obovate; petiole up to 1 cm long…….....20

16 + Stem up to 90cm tall; leaves more pubescent…….4. *N. clarkei*
- Stem up to 115 cm tall; leaves less pubescent.....17

17 + Leaves up to 7 cm long, triangular-ovate ……...18
- Leaves more than 7 cm long, ovate or ovate-lanceolate……..19

18 + Leaves thick-textured, greyish; petiole up to 3 cm long……..3.*N. cataria*
- Leaves not thick-textured, green; petiole up to 4 cm long…..15.*N. laevigata*

19 + Leaves 4 - 10 ×2 - 3 cm, margin ± serrate.....9.*N. erecta*
- Leaves 12 - 12.5 × 5.8 - 6.3 cm, margin crenate to serrate……...
……..….13.*N. govaniana*

20 + Leaf-base cuneate, margin deeply-incised with obtuse rounded lobes
……17.*longibracteata*
- Leaf-base cordate, margin crenate ……..21

21 + Cluster of young leaves often present in leaf axils, leaves green, ovate, 3-11×4-12 cm……14.*N. kokanica*
- Cluster of young leaves not present, leaves olive-green, ovate-elliptic, 2 - 5×0.8 - 2.1 cm……5.*N. coerulescens*

Key to species of *Nepeta* in the Kashmir Himalaya based on floral characters

1 + Verticillasters forming elongated ± continuous spikes or ovoid heads, sometimes the lowermost verticillasters distant.....2

- Verticillasters ± clearly separated from each other, or the uppermost loosely congested…….....…… 17

2 + Pedicels 2mm or less long ……. 3

- Pedicels more than 2mm long……... 15

3 +Verticillasters crowded in axils of the uppermost leaves; peduncle present ……5. *N. coerulescens*

- Verticillarters forming terminal or lateral spikes; peduncle absent ……... 4

4 + Paniculate inflorescence; corolla less than 10 mm long……...3. *N. cataria*

- Inflorescence condensed not forming panicles; corolla more than 10 mm long…. 5

5 + Calyx 10 mm or more in length…….. 6

- Calyx less than 10 mm in length……. 8

6 + Inflorescence an ovoid head; calyx-teeth ½ to as long as tube……..16. *N. linearis*

- Inflorescence a longer slenderer spike; calyx-teeth ¾ to as long as tube…… 7

7 + Bracts 6-10 mm long, as long as calyx; nutlets 1.4-1.5 mm long, ellipsoid.....18. *N. nervosa*

- Bracts 4-5 mm long, ½ to as long as calyx; nutlets 1.9-2 mm long, irregular-oblong ……..….....2. *N. campestris*

8 +Corolla 15 mm or more long ……...9

- Corolla 7-15 mm long……10

9 + Bracts as long as calyx to longer than flowers; pedicels 1-1.5 mm long ……17. *N. longibracteate*

- Bracts shorter than calyx or flowers; pedicels less than 1 mm long …….. ……14. *N. kokanica*

10 +Verticillasters up to 30 mm long, forming globose-ovoid heads…… …….21. *N. raphanorhiza*

- Verticillasters elongated, 30-90 mm long, not forming heads ……. 11

11 + Spikes 70 mm or more long; outer bracts broad…….15. *N. laevigata*

- Spikes less than 70 mm long; outer bracts narrow if present……..….. 12

12 + Pedicels absent; calyx 9 mm or more in length……19.*N. paulsenii*

- Pedicels present (0.07-2 mm long); calyx up to 8 mm long……..13

13 + Bracts 9 mm or more long; calyx teeth ½ to as long as tube ….20. *N. podostachys*

- Bracts less than 9 mm long; calyx teeth ca. as long as tube……. 14

14 + Bracts 6 mm or more long; nutlets broad-ellipsoid…….....10. *N. eriostachys*

- Bracts less than 6 mm long; nutlets oblong……..…7. *N. discolor*

15 + Calyx 11-15 mm long, with tube measuring 5-6 mm……..……6. *N. connata*

- Calyx 5-6 mm long, with tube measuring 4- 4.5 mm……... 16

16 + Calyx-teeth as long as the tube; corolla 10-17 mm long.....8. *N. elliptica*

- Calyx-teeth ½ to as long as the tube; corolla 6.5-8 mm long; ……1. *N. annua*

17 + Verticillasters forming loose panicles; peduncle more than 3 cm long, up to 6 cm in length; two lips of corolla equal…….……13.*N. govaniana*

- Verticillasters forming dense panicles; peduncle 3 cm or less in length; two lips of corolla not equal……18

18 + Corolla 18-25 mm in length, deep violet-blue or purple…….. 19

- Corolla 8-17 mm in length, pale lilac to pale violet……..... 20

19 + Calyx 8-9 mm long, with tube measuring 6-7 mm……...9.*N.erecta*

- Calyx 8-12 mm, with tube measuring 8 mm.....12. *N. glutinosa*

20 + Bracts 5-6 mm long; pedicels 3 mm long.....22. *N. salviaefolia*

- Bracts 3-5 mm long; pedicels less than 3 mm long…….. 21

21 + Cymes mostly on long horizontally-spreading peduncles; corolla 8-13 mm in length……..……11. *N. floccosa*

- Cymes erect, not horizontally-spreading; corolla 14-15 mm in length…….
..……..4. *N. clarkei*

5.1.2.1. Section *Shizonepeta* Benth. Lab. Gen et. Sp. 468. 1834.

Annual herbs. Leaves bipinnatisect with linear-oblong segments. Inflorescence a terminal spike. Bracts linear-lanceolate. Calyx tubular, with oblique throat. Stamens exserted.

The section includes 3 species, distributed in Central Asia. It is represented in the Kashmir Himalaya by only one species.

1. ***Nepeta annua*** Pallas, Acta Acad. Sci. Imp. Petrop. 2: 263, f. 12. 1783; Hedge, Fl. Pak. 192: 115. 1990; Jing Jie Shu, Fl. China 17: 146. 1994.

N. multifida L. f., Suppl. 273. 1781, non L. 1754; *N. botryoides* Soland. in Ait., Hort. Kew. ed. 1, 2: 287. 1789; Benth in DC., Prodr. 12: 370. 1848; Hook. f., Fl. Brit. Ind. 4: 657. 1885; Stewart, Ann. Cat. Vasc. Pl. W. Pak. and Kashmir. 618. 1972; *Shizonepeta annua* (Pallas) B. Schischk., in Sched. Herb. Fl. Ross. 10, LXIV: 72. 1936; Grubov, Key Vasc. Pl.Mongolia 214, t. 113, f. 513. 1982. **Plates 3, 17**

Annual herb. Stem erect, tufted, leafy, 20 - 30cm tall, white - pilose. Leaves petiolate; petiole on lower leaves as long as lamina; lamina bipinnatisect, broad - ovate, 10 - 15 × 7 - 13mm, white pilose, abaxially dense, occassionally yellow glandular; lobes or segments linear-oblong to ovate-oblong, margin entire, apex obtuse to rounded. Inflorescence a terminal spike, 2 - 6 × 1 - 1.4cm, subtended by uppermost stem leaves, white pilose; verticillasters numerous, 4 - 10-flowered, contiguous upward, widely - spaced basally. Bracts linear-lanceolate upward, as long as calyx, margin entire, apex acuminate; bracteoles linear-subulate, minute. Pedicel 1 - 4mm. Calyx 5 - 6 × 3.5mm, white - pilose; throat almost straight; teeth subequal, straight, ovate-oblong. Corolla white, 6.5 - 8mm; tube scarcely exserted; lower lip longer than the upper. Anthers ± exserted or the posterior stamens slightly exserted. Nutlets brown, oblong, 1.7 - 2 × 0.8 - 1mm, base acute, apex rounded, with a small

straight basal areole.

Type: Described from C. Siberia, between the Yus and Yenisei rivers (type in P).

Specimens examined: Hemis Nullah, Leh, *Akhter Hussain, H. Tauheeda* & *G. H. Dar* 2798, 2799 (KASH).

Other records: Kashmir: Ladak, Leh, Hemis Nullah, 3650m, *Ludlow and Sherriff* 8468 (BM, E); Nimamud, *Koelz* 2341 (E); Kashmir: Rupshu, Hanle, *T. Thomson* s. n. (K).

Flowering: July - August; Fruiting: August - September.

Distribution: Mongolia, China, Russia, India.

Collection site: Hemis Gompa (Leh).

Ecology: River terraces or wet places; 3500 - 4000m.

Economic importance: Source of an essential oil (cf. Flora of China, 146. 1994).

5.1.2.2. Section *Cataria* Benth. Lab. Gen. et. Sp. 476. 1834. - Nepeta subsect. Stenostegiae Boiss. Fl. Or. IV. 638. 1879. - Nepeta subsect. Macronepeta Briq. in pflanzenfam. IV, 3a, 237. 1896.

Perennial herbs. Flowers in cymes or verticillasters forming racemiform or subpaniculate or spicate inflorescence. Bracts narrow, much shorter than calyx. Calyx narrowly tubular, in fruit broader to ovate, with more or less oblique throat. Corolla small or medium-sized included in calyx to dilated part of tube or to limb, rarely the narrow part of tube slightly longer than calyx; middle lobe of lower lip markedly concave. Nutlets more or less distinctly tuberculate or smooth.

The section includes 2 subsections, 4 series and 22 species, distributed from the Himalaya across Central Asia and encompasses SW Siberia, Middle

Asia, nearly the entire Mediterranean region and the most southerly areas of Central and Eastern Europe. Represented in the present area by only one species.

i. **Subsection *Leiocarpae*** Pojar. nov. in Addenda XIX. 356.

Flowers in many-flowered dense cymes at ends of stem. Calyx not strongly curved, ovoid in fruit. Corolla small, to 10 mm long.

2. *Nepeta cataria* L., Sp. Pl. 570. 1753; Benth. in Dc., Prodr. 12: 383. 1848; Hook. f., l.c. 662; Blatter, Beaut. Flows. Kashmir 2: 116. 1928; Mukerjee in Rec. Bot. Surv. Ind. 14, 1: 132. 1940; Wealth of India, Raw Materials 7: 12. 1966; Hedge and Lamond, in Notes Roy. Bot. Gard. Edinb. 28: 112. 1968; Stewart, Ann. Cat. Vasc. Pl. W. Pak. and Kashm. 619. 1972; Press in Hara *et al*., Enum. Fl. Pl. Nepal 3: 159. 1982; Rech. f., Fl. Iran. 150: 141, t. 131, 552 f. 2. 1982; Kaul, Weed Fl. Kashmir Valley 233. 1986; Zuckerwanik in Vvedensky, Conspect. Fl. As. Med. 9: 54. 1987; Jing Jie Shu, Fl. China 17: 142. 1994.

N. calaminthoides Benth. in DC., Prodr. 12: 382. 1848, *p.p.*

Plates 4, 19

Perennial herb. Stems 50 - 82cm in height, branched, pilose with short hairs. Leaves petiolate; petiole 1 - 2.5cm; lamina triangular-ovate, 1.5 - 6.6 × 2 - 5cm, margin crenate-serrate, base truncate, apex acute. Cymes axillary at base, mostly pedunculate, loose or compact panicles, with separated terminal one. Bracts linear 4.3 - 6mm, shorter than calyx. Pedicels 1-1.5mm. Calyx grey-green, 5 - 7mm, curved, oblique at throat; teeth sub-equal, narrow - triangular, 2.3 - 3.5mm, ciliate. Corolla white, 6.1 - 8.3mm; tube about as long as calyx teeth. Nutlets oblong, darkish - brown, 1.1 - 1.4 × 0.9 - 1mm, with a bilobed lateral areole.

Type: Europe (LINN-726/1-microfiche).

Specimens examined: Kashmir University Campus, *H. Tauheeda* & *G. H. Dar* 2701, 2704 (KASH); Anantnag, *H. Tauheeda* & *G. H. Dar* 2793, 2795 (KASH).

Other records: Kashmir: Avantipura, Kashmir Valley, *Drummond* 15056 (E, K); Wangat, *R. R. Stewart* 18077 (RAW); Srinagar, *R. R. Stewart* 5060 (RAW).

Flowering and Fruiting: June - August.

Distribution: Most of Europe, SW and C. Asia, Himalayas, Nepal.

Collection sites: Kashmir University Campus, Awantipura, Anantnag.

Ecology: Grows well in dry habitats along habitations, waste places; to 2000m.

Chromosome number: 2n = 32, 34 (Kumar and Subramaniam, 1986).

Economic importance: Dried leaves and flowering - tops are used medicinally as a stimulant, tonic, carminative, diaphoretic, and for infantile colic (cf. Flora of China, 143. 1994).

ii. **Subsection *Tuberculatae*** Pojark. nov. in Addenda XIX. 356.

Flowers in compound cymes forming a racemiform or paniculate inflorescence. Calyx strongly curved, with strongly oblique nearly 2-lipped throat, oblong or tubular-ovoid in fruit. Corolla 10-15 mm long.

This subsection is not represented by any species in the Kashmir Himalaya.

5.1.2.3. Section *pycnonepeta* Benth. Lab. Gen et. Sp. 469. 1834. - Sect. Eunepeta subsect. Spicatae Briq. in Pflanzenfam. IV, 3a, 236. 1896.-Sect. Eunepeta subsect. Spicatae Boiss. Fl. Or. IV. 637. 1879.

Perennial herbs. Flowers in verticillasters forming a dense spicate terminal inflorescence. Bracts linear-subulate. Calyx obconical, mostly slightly gibbous dorsally, with straight or oblique, sometimes 2-lipped throat. Corolla

medium-sized, curved tube abruptly expanding into large neck; middle lobe of lower lip with swelling at centre, tapering from broad base. Nutlets smooth.

The section includes 5 subsections and 44 species. This is the most diversified and most widely represented in the western Himalayas, a large number of species occur in Central Asia and Afghanistan, but very few in Iran. Two grow in Caucasus. In the Kashmir Himalaya, this is represented by 14 species.

i. **Subsection *Spicatae*** (Benth.) Pojark. comb. nov.

Oblong cylindrical spicate inflorescence. Calyx with straight throat and subequal linear-subulate teeth; narrow part of corolla tube completely included in calyx or barely exserted; middle lobe of lower lip of corolla entire. Nutlets lustrous.

Key to the species of section *Pycnonepeta* in the Kashmir Himalaya

1+ Inflorescence pedunculate; numerous verticillasters present…2. *N. clarkei*

- Inflorescence sessile; few verticillasters present…….....**.....**2

2+ Leaves entire, sessile……3

- Leaves crenate or serrate, petiolate……..……4

3+ Calyx-teeth about half the length of the tube; corolla less than 1.5 cm in length……...10. *N. linearis*

- Calyx-teeth about as long as tube; corolla 2 cm or more in length…… ……..…….…4. *N. connata*

4+ Verticillasters crowded in axils of the uppermost leaves…… ……..3. *N. coerulescens*

- Verticillasters in globose to ovoid-globose terminal spikes…….5

5+ Rootstock tuberous……....14. *N. raphanorhiza*

- Rootstock not tuberous……...…..6

6+ Leaves triangular-ovate to ovate-lanceolate…….7

- Leaves linear-elliptic, narrow- or broadly-elliptic…….....13

7+ Stems basally purplish; cluster of younger leaves often present in leaf axils ……..……..……..8. *N. kokanica*

- Stems not as above; cluster of younger leaves not present in leaf axils… ……..8

8+ Leaves linear-lanceolate; spikes shorter……...…..11. *N. nervosa*

- Leaves ovate or deltoid; spikes longer…….…….……...9

9+ Leaves serrate; nutlets narrow- or broad-oblong……10

- Leaves crenate or crenulate; nutlets ellipsoid…….....12

10+ Calyx-teeth plumose; leaves sessile or nearly so.....7. *N. eriostachys*

- Calyx-teeth hispid; leaves short- or long-petioled…….....11

11+ Leaves triangular-ovate, broad truncate or cordate; calyx-teeth as long as the tube…….....9. *N. laevigata*

- Leaves oblong-lanceolate, narrow truncate; calyx-teeth shorter than the tube……...1. *N. campestris*

12+ Leaves ovate, grayish-white canescent…….…..5. *N. discolor*

- Leaves oblong-triangular, not grayish-white canescent...13. *N. podostachys*

13+ Petioles upto 0.5 mm long; leaf margin pectinate-serrate; corolla upto 1.7 cm long……...6. *N. elliptica*

- Petioles upto 10 mm long; leaf margin crenate-serrate; corolla upto 1.3 cm long……...12. *N. paulsenii*

1. ***Nepeta campestris*** Benth., Lab. Gen. et Sp. 734. 1835; Benth. in DC., Prodr. 12: 372. 1848; Hook. f., l. c. 658. 1885; Blatter, Beaut. Flows. Kashmir 2: 117. 1928; Mukerjee in Rec. Bot. Surv. Ind. 14, 1: 123. 1940; Stewart, Ann. Cat. Vasc. Pl. W. Pak. and Kashm. 619. 1972; Hedge, Fl. Pak. 192: 81. 1990. **Plates 3, 18**

Perennial herb. Stem erect, 30 - 60cm tall, quadrangular, little-branched. Leaves petiolate; petiole 3.5 - 10mm; lamina oblong-lanceolate, 2.5 - 5 × 1.2 -

2cm, margin serrate, base truncate to assymetric, tip acute. Inflorescence an elongated slender spike, often interrupted basally, 2.5 - 7.5 × 2.0 - 2.5cm. Outer bracts broadly ovate; inner bracts linear, ciliate, as long as calyx. Pedicel absent. Calyx thin-textured, 6 - 10mm long, narrow - obtriangular, eglandular; throat slightly oblique; teeth linear - subulate, shorter than or equalling the calyx - tube. Corolla blue, 12 - 15mm; tube curved, exserted from calyx. Nutlets narrow, irregular - oblong, 1.9 - 2 × 0.7 - 0.9mm, brown, with a small straight basal areole.

Holotype: Kashmir, *Jacquemont* (P- n. v.).

Specimens examined: Gurais, *H. Tauheeda* & *G. H. Dar* 2791, 2792 (KASH).

Other records: Kashmir: Bandipur above Baramulla, *Jacquemont* 1141 (K); Chalibagh, *Jacquemont* 895 (K).

Flowering: May - August; Fruiting: June - September.

Distribution: NW India.

Collection sites: Gurais (Dawar), Bandipora, Pahalgam.

Ecology: Grows in open slopes of hills; 2600 - 3000m.

2. ***Nepeta clarkei*** Hook. f., Fl. Brit. Ind. 4: 663. 1885; Blatter, Beaut. Flows. Kashmir 2: 118. 1928; Mukerjee in Rec. Bot. Surv. Ind. 14, 1: 129. 1940; Stewart in Pak. J. For. 11: 53. 1961; Hedge and Lamond, in Notes Roy. Bot. Gard. Edinb. 28: 105. 1968; Stewart, Ann. Cat. Vasc. Pl. W. Pak. and Kashmir. 619. 1972; Kachroo *et al*., Fl. Ladakh 129. 1977; Rech. f., Fl. Iran. 150: 125, t. 116, 554 f. 11. 1982; Hedge, in Fl. Pak. 192: 88. 1990. **Plates 4, 20**

Perennial herb, with a woody rhizome. Stem 45 - 90cm tall, erect, quadrangular, branched, papillose. Leaves petiolate; petiole on lower leaves up to 3cm, less above; lamina narrow to broad - ovate, 1.5 - 6 × 1 - 5cm, base broad cuneate to cordate, margin serrate, apex acute, eglandular pubescent.

Inflorescence of separated many-flowered verticillasters forming whorls, 1 - 2.1cm long, lowermost verticillaster pedunculate; upper sessile. Bracts linear, 3.5 - 4.5mm, half as long as or equalling the calyx. Pedicels 1-1.5mm. Calyx 7 - 9mm, almost straight, purplish, with eglandular hairs; throat slightly oblique; teeth unequal, triangular, longest upto 4mm. Corolla pink-purple, 1.4 - 1.5cm; tube slightly curved,exserted, widest at throat; upper lip bilobed, straight; lower lip ± speckled. Anthers blue-violet. Nutlets ellipsoid, 2 - 2.5 × 0.9mm, chestnut brown, ± trigonous, apically rounded, with a small straight sub - basal areole.

Type: Kashmir: Tilail, 3350m, *Clarke* (K); Kanylwan, 2280m, *Clarke* (K).

Specimens examined: Gulmarg, Baramullah, *H. Tauheeda* & *G. H. Dar* 2716, 2720, 2753, 2754 (KASH).

Other records: Kashmir: Baltistan, Skardu to Kishen Ganga, *R. R. Stewart* 22971 (RAW); Gadsar, 3650m, *Stainton* 7907 (BM, E); Upper Astor valley, Shankargarh, *R. R. Stewart* 1876 (RAW); Kashmir: Kostorkut, NW Vishensar, 3350m, *O. Polunin* 56/710 (BM, E).

Flowering: May - July; Fruiting: July - September.

Distribution: Pakistan, NW India, Tibet.

Collection sites: Gulmarg, Khreram (Anantnag).

Ecology: A plant of stony slopes and open ground, or of alpine wet places; 2300 - 2700m.

Vern.: Khamyu (Ladakh).

3. ***Nepeta coerulescens*** Maxim. in Bull. Acad. Imp. Sci. St. Petersb. Ser. 3. 27: 529. 1881 (Melang. Bot.11: 306. 1881); Mukerjee in Rec. Bot. Surv. Ind. 14, 1: 125. 1940; Stewart, in Pak. J. For. 11: 52. 1961; Tscherneva in Grubov *et al*., Pl. As. Central. 5: 32. 1970; Stewart, Ann. Cat. Vasc. Pl. W. Pak. and Kashmir. 619. 1972; Kachroo *et al*., Fl. Ladakh 129. 1977; Press in Hara *et al*., Enum. Fl. Pl. Nepal 3: 159. 1982; Hedge, in

Fl. Pak. 192. 1990; Jing Jie Shu, Fl. China 17: 139. 1994.

Nepeta thomsonii Benth. ex Hook. f., Fl. Brit. Ind. 4: 658. 1885; Blatter, Beaut. Flows. Kashmir 2: 122. 1928. **Plates 5, 20**

Perennial aromatic herb. Stem 24 - 52cm tall, pubescent. Leaves petiolate; petiole on basal leaves up to 6mm, decreasing in upper ones; lamina ovate-elliptic, 2 - 5.3 × 0.8 - 2.1cm, densely pubescent, olive - green adaxially, green on the abaxial surface, glandular, margin crenate-serrate or serrate, base truncate to cordate or cuneate, apex acute. Inflorescence in verticillasters on the apical 4 or 6 stem nodes, in oblong or ovoid spikes 3 - 5cm, to 8.5 - 11cm when elongated; verticillasters crowded in axils of upper leaves; peduncle 0.3 - 2.3mm. Bracts bluish, as long as to longer than calyx, linear or linear-lanceolate, apex acuminate, ciliate. Calyx 6 - 7mm, yellow - glandular, throat very oblique; teeth of upper lip broadly triangular-lanceolate, with apex acuminate; teeth of lower lip linear, shorter than half to as long as tube. Corolla blue, 11 - 13mm; tube 4 - 5 × 2.5 - 3mm, exserted from calyx, abruptly dilated into throat 3 - 3.2 × 4 - 4.5mm; upper lip straight, ca. 3mm, 2-lobed; lower lip ca. 6.4mm, not equal to upper lip,middle lobe cordate, ca. 3 × 3.2mm, apex emarginate; lateral lobes reflexed, semicircular, ca. 1.5 × 2.1mm. Nutlets brown, ovoid - broadly obovoid 1.7 - 1.9 × 0.9 - 1mm, glabrous, with a small basal areole.

Type: [China] Kansu occidentale alpina, ad Hoango superiorum, ann. 1880, *Przewalski* s. n. (LE).

Specimens examined: Between Kargil to Zanskar, *Bashir Ahmad* and *Hiralal* 146 (KASH); Zanskar, *H. Tauheeda* & *G. H. Dar* 2776, 2777 (KASH).

Other records: Kashmir: Ladakh, Gya, 4110m, *Ludlow and Sherriff* 8485 (BM, E); Nunu, *Koelz* 2350 (E); Kashmir: Zanskar, Testha, 4110m, *Stainton* 8405 (BM, E); Rupshu, Korzok, 4570m, *Koelz* 2205 (NY, E); Zanskar, Testha, *Koelz* 5589 (K); Kala, *Spencer-Chapman* 879 (K).

Flowering and fruiting: August - September.

Distribution: China, Sinkiang, Tibet, India, Nepal.

Collection sites: Between Parkachey and Abrun Zanaskar.

Ecology: Grassy slopes, stony, alluvial fans, ravine sides, grassy river banks; 3300 - 3800m.

Vern.: Neimlo or Khora (L).

4. ***Nepeta connata*** Royle ex Benth. in Hook., Bot.Misc. 3: 378. 1833; Benth. in DC., Prodr. 12: 371. 1848; Hook. f., l.c. 657. 1885; Blatter, Beaut. Flows. Kashmir 2: 115. 1928; Mukerjee, l.c. 121. 1940; Rao in Bull. Bot. Surv. Ind. 2: 411. 1960; Stewart in Pak. J. For. 11: 52. 1961; Stewart, Ann. Cat. Vasc. Pl. W. Pak. and Kashm. 620. 1972; Kaul, Weed Fl. Kashmir Valley 234. 1986. **Plates 5, 21**

Perennial tuberous herb (woody rootstock). Stem erect, tufted, 17 - 87cm tall, mostly unbranched and solitary, glabrous, leafy. Leaves sessile; lamina linear to linear-lanceolate, 8-17 × 0.3-2.5cm, thick-textured, with a prominent mid-vein, glabrous or pilose, margin entire, base cordate, semi-amplexicaul or connate, apex acuminate. Inflorescence an elongated, ± continuous spike, terminal as well as borne in axils of lower leaves, 4 - 14.5cm long, showy. Inner bracts 11 - 15mm, linear, membraneous, almost as long as calyx. Flowers numerous, congested. Pedicels up to 1.1 cm. Calyx 1.1 - 1.5cm, thin-textured with short hairs; throat straight; teeth subequal, as long as or longer than the tube, linear, ciliate. Corolla blue - violet, 2.5 - 2.6cm; tube exserted, somewhat curved. Nutlets obovoid-ellipsoid, 1.5 - 1.7 × 1 - 1.28mm, brown, smooth, flat-trigonous with a small areole.

Type: Kashmir, *Royle* (LIV).

Specimens examined: Baltal, Sonamarg, *H. Tauheeda* & *G. H. Dar* 2779, 2781 (KASH); Khilanmarg, Baramullah, *H. Tauheeda* & *G. H. Dar* 2782,

2783 (KASH); Drass, Ladakh, *H. Tauheeda* & *G. H. Dar* 2778, 2780 (KASH); Liddar valley, *H. Tauheeda* & *G. H. Dar* 2812 (KASH); Pir Panjal Range, *H. Tauheeda* & *G. H. Dar* 2785, 2786, 2809 (KASH).

Other records: Kashmir: Sonamarg, 2740m, *Stainton* 7934 (BM, E); Kolahoi Valley, 3650m, *O. Polunin* 56/573 (BM, E); Kishen Ganga, 3650m, *Ludlow and Sherriff* 1514 (BM, E); Minimarg, *R. R. Stewart* 19205 (RAW); Khelanmarg, 3050m, *O. Polunin* 56/152, 56/187 (BM, E), *Venning* K 67 (K); Dras, 3050m, *C. Burt* 92 (E); Astor, Gudhai valley, 3500m, *Duthie* s.n. (E); Baltistan, Chatpani nala, 3500m, *Duthie* 18343 (E); Zoji La, *R. R. Stewart* 18432 (RAW); Baltal, 3350m, *Stainton* 8710 (BM, E); Gagangir, 2740m, *Ludlow and Sherriff* 7955 (BM, E); Rajparyan sanctuary, Upper Bringhi, 3050m, *Ludlow and Sherriff* 9374 (BM, E).

Flowering and fruiting: July - September.

Distribution: Pakistan, NW India.

Collection sites: Sonamarg, Zoji La, Khelanmarg.

Ecology: Grows along foot hills, on open slopes of hills, or in grasslands; 2700 - 3600m.

Economic importance: Rootstock or tuber is edible.

5. ***Nepeta discolor*** Royle ex Benth. in Hook., Bot.Misc. 3: 378. 1833; Benth in DC., Prodr. 12: 373. 1848; Hook. f., l.c. 659; Blatter, Beaut. Flows. Kashmir 2: 118. 1928; Mukerjee, l.c. 124; Stewart in Pak. J. For. 11: 53. 1961; Kitamura, Pl. W. Pak. and Afghan. 127. 1964; Hartmann in Bot. Jahrb. 85: 344. 1966; Hedge and Lamond in Notes Roy. Bot. Gard. Edinb. 28: 104. 1968; Tscherneva in Grubov *et al*., Pl. As. Central. 5: 33. 1970; Stewart, Ann. Cat. Vasc. Pl. W. Pak. and Kashmir. 650. 1972; Kachroo *et al*., Fl. Ladakh 129. 1977; Press in Hara *et al*.,

Enum. Fl. Pl. Nepal 3: 159. 1982; Rech. f., Fl. Iran. 150: 128, t. 119, 554 f. 7. 1982; Hedge, in Fl. Pak. 192: 84. 1990; Jing Jie Shu, Fl. China 17: 136. 1994.

N. sabinei T. A. Schmidt in Journ. Bot. 6: 238, t.82 f. 1-4. 1868.

Plates 6, 22

Perennial herb. Stem 10 - 30cm tall, slender, ascending, gray - pubescent. Leaves short - petiolate; petiole 2 - 11mm long; lamina broadly ovate to ovate-cordate, 6 - 20 × 5 - 12mm, occassionally 20 × 14mm, adaxially green, abaxially gray, with yellowish glands, base subcordate, margin crenate, apex obtuse. Inflorescence a congested ovoid or oblong spikes, continuous or interrupted near the base, 3.0 - 5.5cm long. Outer bracts elliptic, ovate-lanceolate, green, acuminate; inner bracts linear-lanceolate, spiny, as long as calyx, ciliate. Pedicels adpressed to axis, to ca. 1.5mm. Calyx 7 - 8mm long, narrow tubular-obtriangular, pubescent, ± membraneous, eglandular pilose to villous; tube 3.5 - 4.5mm long, throat oblique; teeth awned-lanceolate, somewhat unequal, posterior teeth slightly longer, ca. as long as tube. Corolla white, glabrous or slightly villous on upper lip, 1.2 - 1.3cm long; tube curved, exserted, 8 - 10mm long. Nutlets oblong, 1.4 × 0.9mm, dark-brown, smooth, with a small bilobed subbasal areole.

Holotype: NW Himalaya, Syen range and Mussorie, Ann. 1832, *Royle* (K).

Specimens examined: Rajdani Pass, *Naqshi*, *Showkat* and *Kachroo* 1521 (KASH); Heymie, Nooznees and Taiqqer, *Hiralal Pandit* 1234 (KASH); Drass, *A.R. Naqshi* 1531 (KASH); Ladakh, Hemis nullah, *H. Tauheeda* & *G. H. Dar* 2706, 2710 (KASH); Ladakh, Leh, *H. Tauheeda* & *G. H. Dar* 2763, 2765, 2770, 2771, 2775 (KASH).

Other records: Kashmir: Skardu, Askole, 4000m, *Dickson* 24 (E); Astor Valley, *Inayat* 25745 (K); Deosai Plains, very common, *R. R. Stewart* 19981

(RAW),m*uqarrab Shah* and *Jamshed* 240 (E); Drass, 3050m, *Duthie* 11697 (E), 13744 (E); Burzil Pass, *Clarke* 29608 A (K); Zoji La, R. R. Stewart 9981 (RAW); Kashmir: Hushu Valley, *E. Nasir and Webster* s. n. (RAW); Kashmir: Ladakh, Stok, 4570m,m*axwell* 75 (E); Shyok Valley, *Ludlow* 583 (BM, E); Hispar village, 4200m, *O. Polunin* 6311 (BM, E); Kashmir, miron and Rogi, *Jacquemont* 1186 (K); Kashmir: Zoji Pass above Baltal, 3350m, *T. Thomson* (K).

Flowering and fruiting: June - August.

Distribution: Afghanistan, Pakistan, China, Tibet, NW INdia, Nepal.

Collection sites: Drass, Hemis Nallah, Khardungla North Pollu, between Khardung and Khardungla.

Ecology: Grassy or gravelly slopes, forests, thickets; 3050 - 4600m.

Vern.: Shamalolo (L).

6. ***Nepeta elliptica*** Royle ex Benth. in Hook., Bot. Misc. 3: 378. 1833; Benth. in Dc., Prodr. 12: 373. 1848; Hook. f., l.c. 658; Blatter, Beaut. Flows. Kashmir 2: 118. 1928; Mukerjee, l.c. 122; Rao in Bull. Bot. 2: 412. 1960; Wealth of India, Raw Materials 7: 13. 1966; Hedge and Lamond in Notes Roy.Bot. Gard. Edinb. 28: 103. 1968; Stewart, Ann. Cat. Vasc. Pl. W. Pak. and Kashm. 620. 1972; Press in Hara *et al.*, Enum. Fl. Pl. Nepal 3: 159. 1982; Rech. f., l.c. 127. 1982.

N. polystachya Royle ex Benth. in Hook., Bot. Misc. 3: 378. 1833.

Plates 6, 23

Perennial herb. Stems erect, 35 - 70cm tall, branched, quadrangular, leafy. Leaves sessile or with a very short petiole to 0.6mm long; lamina narrowly- or broadly - elliptic, 1 - 3.5 × 0.7 - 1.7cm, margin pectinate-serrate, cordate, apically rounded. Cymes condensed, terminal and lateral, 10 - 11mm × 1 - 1.6cm. Outer bracts ovate-lanceolate to broad - obovate, upto 5 × 4mm.

Pedicels 3 - 4.3mm long. Calyx tubular; throat oblique; teeth unequal, linear, subulate, ciliate, as long as calyx - tube. Corolla white, 1 - 1.7cm. Nutlets 1.2 - 1.6 × 0.8 - 1mm, ellipsoid, rounded above and below, brownish - black, with a bilobed lateral areole.

Type: [NW India] Syen range, *Royle* (LIV).

Specimens examined: Yusmarg, Budgam, *H. Tauheeda* & *G. H. Dar* 2737, 2748 (KASH); Banihal, Ramban, *H. Tauheeda* & *G. H. Dar* 2790 (KASH).

Other records: Kashmir: Banihal, *T. Thomson* (K).

Flowering and fruiting: June - August

Distribution: Himalaya from Pakistan eastwards to Kashmir, NW India (Shimla range), and Nepal.

Collection site: Yusmarg.

Ecology: Grows on open slopes; 2000 - 2800m.

Chromosome number: 2n = 18 (Gill, L. S. 1969; Kumar and Subramaniam, 1986).

Economic importance: Source of an essential oil extracted from the aerial part (Bottini *et al*. 1987).

7. ***Nepeta eriostachys*** Benth., Lab. Gen. et Sp. 734. 1835; Benth in DC., Prodr. 12: 371. 1848; Hook. f., l.c. 657; Blatter, Beaut. Flows. Kashmir 2: 119. 1928; Mukerjee, l.c. 123; Rao in Bull. Bot. Surv. Ind. 2: 412. 1960; Stewart in Pak. J. For. 11: 52. 1961; Stewart, Ann. Cat. Vasc. Pl. W. Pak. and Kashmir. 620. 1972; Kachroo *et al*., Fl. Ladakh 130. 1977; Hedge, in Fl. Pak. 192: 84. 1990. **Plates 8, 25**

Perennial herb with a woody rootstock. Stems erect, 20 - 30cm long, little branched, leafy. Leaves petiolate; petiole up to 3.8 - 4.5mm long; lamina

broad ovate - triangular to oblong, thick textured, up to 3 - 4.3 × 2 - 3cm, greenish, margin entire to serrulate, apex ± acute. Inflorescence a terminal congested spikes, oblong up to 4 - 5.1 × 2.5cm. Bracts elliptic, green, acuminate. Calyx tubular,7 - 10mm long, ± membranous, eglandular pilose; throat oblique; teeth unequal, linear to filiform, ciliate, as long as to longer than tube. Corolla pale - lilac, 10 -13mm long; tube curved, exserted. Nutlets broad - ellipsoid, 1.43 × 0.82mm, dark - brown, smooth, with a small straight subbasal areole.

Type: [Kashmir] In Cashmeriae vallibus Baspa et Paber, in herbosis editioribus, admargines sylvarum etc., *Jacquemont* (P-n.v.).

Specimens examined: Zojila, above Baltal, *H. Tauheeda* & *G. H. Dar* 2785, 2786, 2809 (KASH).

Other records: Kashmir: Astor, *Duthie* 12488 (E); Sangam above Lidarwat, 3500m, *Duthie* 13534 (E); above Shankargarh, *R. R. Stewart* 22759 (RAW); Yamhar Pass, *R. R. Stewart* 12739 (RAW); Kostorkut, 12km NW Visakensar, 3350m, *O. Polunin* 56/709 (BM, E).

Flowering and fruiting: July - September

Distribution: NW India.

Collection sites: Zoji La, Drass.

Ecology: Grows in open grassy slopes; 3000 - 3500m.

Vern.: Zim-thik-le (L).

8. ***Nepeta kokanica*** Briquet in Bot. Tidsskr. 28: 236. 1908; Wendelbo in Nyttmag. Bot. 1: 52. 1952; Stewart in Pak. J. For. 11: 52. 1961; Kitamura, Pl. W. Pak. and Afghan. 128. 1964; Tscherneva in Grubov *et al*., Pl. As. Central. 5: 35. 1970; Stewart, Ann. Cat. Vasc. Pl. W. Pak. and Kashmir. 622. 1972; Zuckerwanik in Vvedensky, Conspect. Fl. As. Med. 9: 51. 1987; Hedge, Fl. Pak. 192: 90. 1990; Jing Jie Shu,

Fl. China 17: 137. 1994.

N. pamirensis Franch. in Bull.mus. Hist. Nat. (Paris) 2: 345. 1896. Pojarkova in Komarov, Fl. URSS 20: 333. 1954; Hedge and Lamond, l.c. 107; Tscherneva in Grubov *et al*., Pl. As. Central. 5: 35. 1970; Stewart, Ann. Cat. Basc. Pl. W. Pak. and Kashm. 624. 1972; Rech. f., l.c. 132; Zuckerwanik in Vvedensky, Conspect. Fl. As. Med. 9: 52. 1987; *N. supina* auctt. non Stev.: Hook. f., Fl. Brit. Ind. 4: 658. 1885; Mukerjee in Rec. Bot. Surv. Ind. 14, 1: 125. 1940; *N. oxicola* Franch. in Bull. Mus. Hist. Nat. (Paris) 2: 346. 1896; *N. pamiro-alaica* Lipsky in Acta Hort. Petrop. 23: 230. 1904; *N. leucocyanea* Rech. f. and Koeie in Kongel Danske Vidensk.-Selsk. Skr. 8, 1: 36, f. 20. 1954; Hedge and Lamond, l.c. 107; *N.minjanensis* Rech. f. and Koeie in Kongel Danske Vidensk.-Selsk. Skr. 8, 1: 38, f. 21. 1954; Kitamura, Pl. W. Pak. and Afghan. 128. 1964. **Plates 11, 29**

Perennial, greenish herb. Stems several, ascending, 20-30cm tall, little branched, with creeping sterile short shoots, rhizome basally purplish with scale-like leaves; indumentum sparsely pilose; leaves distributed over stem. Leaves petiolate; petiole 2 - 8mm long; lamina ± ovate, green, 3-25 x 4-20mm, margin crenate, apically rounded or obtuse; clusters of young leaves often present in leaf axils. Inflorescence a terminal congested ovoid heads or sometimes with a distinct lower verticillaster, 1.7 - 3.5cm long. Bracts 7-9mm long, narrow linear-elliptic. Calyx up to 11mm long, obtriangular tubular; throat oblique; teeth clearly unequal.Corolla 1.1-1.6cm, blue; tube included within calyx, curved. Nutlets oblong - ellipsoid, 1 - 1.28 x 0.9 -1mm, brown, with a straight basal areole.

Type: [USSR, Pamir Alai] Kavuk, 8-13,000 ped., ad glaciers Schtschurowski.et in trajectu Dschiptik [Dzhiptik], *0. Fedtschenko* (LE).

Specimens examined: Nubra, Ladakh, *H. Tauheeda* & *G. H. Dar* 2794, 2796 (KASH).

Other records: Kashmir: Dras, *R.R. Stewart* 22245 (K, RAW); Baltistan: Marop La, *R. R. Stewart* 22281 (K, RAW); Burji La, *Clarke* 29870 A (K); Karpuchu valley, *Duthie* s. n. (K).

Flowering and fruiting: July – August.

Distribution: Afghanistan, Pakistan, Russia, Uzbekistan, Tajikistan, India.

Collection sites: Drass, Hemis Leh.

Ecology: Gravelly alpine alluvial fans and rock crevices; 3050 - 3500m.

9. ***Nepeta laevigata*** (D. Don) Hand.-Mazz., Symb. Sin. 7: 916. 1936; Hedge and Lamond, l.c. 104. Tscherneva in Grubov *et al*., Pl. As. Central. 5: 33. 1970; Stewart, Ann. Cat. Vasc. Pl. W. Pak. and Kashm. 662. 1972; Kachroo *et al*., Fl. Ladakh 131. 1977; Press in Hara *et al*., Enum. Fl. Pl. Nepal 3: 159. 1982; Rech. f., l.c. 126, t. 117, 554 f. 8; Hedge, Fl. Pak. 192: 78. 1990; Jing Jie Shu, Fl. China 17: 135. 1994.

Betonica laevigata D. Don, Prodr. Fl. Nepal. 110. 1825; *Nepeta spicata* Wall. [Cat. 2083. 1829] ex Benth. in Wall., Pl. As. Rar. 1: 64. 1830; Benth. in DC., Prodr. 12: 372. 1848; Hook. f., Fl. Brit. Ind. 4: 659. 1885; Blatter, Beaut. Flows. Kashmir 2: 121. 1928; Mukerjee, l.c. 123; Rao in Bull. Bot. Surv. Ind. 2: 412. 1960; *N. elata* Benth. in Hook., Bot. Misc. 3:378. 1833; *N. spicata* var. elata (Benth.) Benth. in DC., Prodr. 12: 373. 1848; *N. nuristanica* Murata in Acta Phytotax. Geobot. 17: 74. 1958. **Plates 11, 30**

Perennial herb. Stem erect, up to 30 - 85cm tall, branched, quadrangular, white pubescent, sometimes densely pilose below inflorescence axis, leafy. Leaves patiolate; petioles 3.8 - 4cm on lowermost leaves; lamina triangular-ovate, green 3.0 - 6.5 × 2.0 - 3.5cm, margin regularly crenate to serrate, base sub - truncate to cordate, apex acute. Cymes oblong, terminal, continuous congested, 8 - 9.5 × 2cm, subtended by small uppermost stem leaves. Outer bracts 6 - 8mm, broad; innermost bracts linear-filiform as long as calyx. Calyx

up to 8mm, slender, tubular, almost glabrous to finely glandular-papillose; throat slightly oblique; teeth unequal, linear triangular, hispid, sharply long pointed as long as tube. Corolla lilac-blue or white, 1.2 - 1.4cm; tube exserted, curved; upper lip ± straight; lower lip shorter than upper. Nutlets oblong to narrow-oblong, 1.3 - 1.4 × 0.8 - 0.9mm, brown, rounded, minutely granular, bilobed lateral areole.

Type: [NW India, Garwhal] Siranagur [Srinagar], *Kamroop*.

Specimens examined: Aru, Pahalgam, *H. Tauheeda* & *G. H. Dar* 2768, 2769 (KASH); Khilanmarg, *Akhter Hussain* & *G. H. Dar* 2808 (KASH); Pir Panjal Range, *H. Tauheeda* & *G. H. Dar* 2810, 2811 (KASH); Ferozpur Nullah, *H. Tauheeda* & *G. H. Dar* 2816 (KASH); Lidder valley, *H. Tauheeda* & *G. H. Dar* 2814 (KASH).

Other records: Kashmir: Wangar Nullah, Nara Nag, 2280m, *O. Polunin* 56/765 (BM, E); above Pahlgam, 2560m, *O. Polunin* 56/463 (BM, E), *R. R. Stewart* 5739 (K), 12740 (RAW); Sonamarg, *Duthie* 13649 (E), *R. R. Stewart* 7369 (K); Khelanmarg, 3100m, *Venning K.* 104 (K).

Flowering and fruiting: June - August.

Distribution: Afghanistan, Pakistan, NW India, Himalayas to Nepal, SW China.

Collection sites: Pahalgam, Sonamarg, Khelanmarg, Ferozpur Nullah.

Ecology: Grows in open slopes, grasslands, shrub-grasslands, grassy slopes, coniferous and mixed forest margins; 2200 - 3000m.

Chromosome number: 2n = 18 (Gill, L. S. 1969; Kumar and Subramaniam, 1986).

Economic importance: They are used medicinally as a diaphoretic (cf. Flora of China, 136. 1994).

10. ***Nepeta linearis*** Royle ex Benth. in Hook., Bot. Misc. 3: 377. 1833;

Benth in DC., Prodr. 12: 371. 1848; Hook. f., l.c. 657; Blatter, Beaut. Flows. Kashmir 2: 120. 1928; Mukerjee, l.c. 121; Rao in Bull. Bot. surv. Ind. 2: 411. 1960; Stewart in Pak. J. For. 11: 52. 1961; Kitamura, Pl. W. Pak. and Afghan. 128. 1964; Stewart, Ann. Cat. Vasc. Pl. W. Pak. and Kashmir. 623. 1972; Sharma and Kachroo, Fl. Jammu 262. 1981; Rech. f., l.c. 129; Kaul, Weed Fl. Kashmir Valley 234. 1986; Hedge, Fl. Pak. 192: 85. 1990.

Plates 12, 29

Perennial herb. Stems, erect, 25 - 70cm tall, arising from a tuberous or fusiform rootstock, branched or not, leafy. Leaves sessile; lamina linear, 3 - 8cm × 1.5 - 6mm, margin entire, apex acute. Spike an ovoid head, continuous or interrupted, 4 - 5cm long. Inner bracts linear-subulate, ciliate, shorter than calyces. Flowers congested in spikes. Pedicels 1 - 2mm long. Calyx 8 - 10mm, tubular, eglandular-pilose; throat straight, villous; teeth subequal, c. 1/2 to as long as calyx tube, acuminate, ciliate. Corolla lilac, 1 - 1.5cm; tube exserted, slightly curved; upper lip hooded. Nutlets oblong-orbicular, 1.4 - 1.5 × 0.8 - 0.9mm, brown with a bilobed lateral areole.

Type: Kashmir: Sonamarg, 2740m, *Ludlow and Sheriff* 8301 (BM, E), *R. R. Stewart* 6439 (RAW)] Sabatko, *Royle*.

Specimens examined: Dachigam National Park, *H. Tauheeda, Bilal A. Bhat* & *G. H. Dar* 2707, 2712 (KASH); Aru, Pahalgam, *H. Tauheeda* & *G. H. Dar* 2708, 2709 (KASH); Sonamarg, *Zafar Shahdad* & *G. H. Dar* 2738, 271, 2754 (KASH); Lidder Valley, *H. Tauheeda* & *G. H. Dar* 2813 (KASH).

Other records: Kashmir: Sonamarg, 2740m, *Ludlow and Sherriff* 8301 (BM, E), *R. R. Stewart* 6439 (RAW); Baltistan: Deosai, *R. R. Stewart* 19999 (RAW); Kashmir: Kishtawar, Atholi, 1820m, *Stainton* 7558 (BM, E); Kishtawar, Tsingam, 2130m *Ludlow and Sherriff* 9112 (BM, E).

Flowering and fruiting: May - June.

Distribution: Pakistan, NW India.

Collection sites: Dachigam, Kishtwar, Pahalgam, Sonamarg.

Ecology: Grassy slopes; 2200 - 2800m.

Chromosome number: 2n = 18 Gill, L. S. 1969 (Kumar and Subramaniam, 1986).

11. ***Nepeta nervosa*** Royle ex Benth. in Hook., Bot. Misc. 3: 378. 1833; Benth in DC., Prodr. 12: 372. 1848; Hook. f., l.c. 658; Blatter, Beaut. Flows. Kashmir 2: 121. 1928; Mukerjee, l.c. 122; Stewart in Pak. J. For. 11: 52. 1961; Hartmann in Bot. Jahrb. 85: 345. 1966; Stewart, Ann. Cat. Vasc. Pl. W. Pak. and Kashmir. 624. 1972; Kachroo *et al*., Fl. Ladakh 130. 1977; Hedge, in Fl. Pak. 192: 80. 1990; Jing Jie Shu, Fl. China 17: 135. 1994. **Plates 13, 31**

Perennial herb. Stem 30 - 70cm tall, erect, quadrangular, little branched. Leaves sessile or short petiolate; lamina linear-lanceolate or linear-elliptic, 5 - 9 × 0.8 - 1.6cm, green or abaxially gray, hairy, base rounded or cordate, margin serrate, apex acuminate. Spikes short or elongated, cylindric, 2 - 7.1 × 1.5 - 3cm. Outer bracts purplish-bluish, 6 - 10mm, longer than calyx, ovate or lanceolate, apex acuminate or apiculate; inner bracts linear, ciliate, as long as calyx. Flowers sessile. Calyx thin-textured, 6 - 10mm long, narrow obtriangular, eglandular-pilose to villous; throat slightly oblique; teeth subulate-acuminate, shorter than to as long as tube, sparsely villous. Corolla blue, 1.2 - 1.5cm; tube curved, somewhat exserted from calyx. Nutlets ellipsoid, 1.4 - 1.5 × 0.9mm, shiny, black, granular with a small bilobed lateral areole.

Type: Kashmir, *Royle* (LIV).

Specimens examined: Gretnar (Dachigam National Park), *H. Tauheeda*, *G. H.*

Dar and *Anzar Khuroo* 2755, 2797 (KASH).

Other records: Kashmir: Kolahoi valley, 3200m, *O. Polunin* 56/526 (BM, E); Baltal, *T. Thomson* s. n. (K); above Pahlgam, *R. R. Stewart* 21990 (RAW); Burzil, 4100m, *R. R. Stewart* 22095 (RAW); Zoji La Pass, *Jacquemont* s. n. (K); Kashmir: Poonch, Aliabad, *Clarke* s. n. (K).

Flowering and fruiting: August - October.

Distribution: Pakistan, NW India.

Collection sites: Baltal, Dachigam.

Ecology: Grows in sub-alpine and alpine grasslands; 2300 - 3500m.

Chromosome number: 2n = 14 Zhukova, P. G. 1967

2n = 18 Chuksanova, N. A. and Kaplanbekova, S. A. 1971 (Kumar and Subramaniam, 1986).

12. ***Nepeta paulsenii*** Briquet in Bot. Tidsskr. 28: 235. 1908; Rech. f., Fl. Iran. 150: 123, t. 113, 554 f. 4. 1982; Hedge, Fl. Pak. 192: 76. 1990.

N. koelzii Rech. f. in Kongel Danske Vedensk.-Selsk. Skr. 8, 1: 34. f. 18. 1954; *N. oblanceolata* Rech. f. and Edelb. In Kongel Danske Vedensk.-Selsk. Skr. 8, 1: 33. f. 22. 1954; Kitamura, Pl. W. Pak. and Afghan. 128. 1964; Hedge and Lamond, l.c. 103. 1968; Stewart, Ann. Cat. Vasc. Pl. W. Pak. and Kashmir. 624. 1972; *N. podostachys* auct. p.p. non Benth.: Wendelbo in Nyttmag. Bot. 1: 52. 1952; Tscherneva in Grubov *et al*., Pl. As. Central. 5: 35. 1970; Zuckerwanik in Vvedensky, Conspect. Fl. As. Med. 9: 49. 1987.

Plates 14, 32

Perennial, aromatic, clump-forming herb. Stem 30 - 90cm tall, erect or ascending, quadrangular, little branched. Leaves petiolate; petiole on lower leaves up to 9mm decreasing above; lamina linear-elliptic, 1 - 2cm × 3 - 8mm, margin subentire to crenate, cuneate, apex acute, clusters of young leaves often

present in leaf axils. Inflorescence a terminal condensed oblong spike, sometimes lowermost verticillasters distant, 1.5 - 6cm long. Bracts linear, 6 - 9mm, ca. as long as calyces. Calyx 6 - 9mm, narrow tubular-obtriangular, often purplish; eglandular pilose, throat scarcely oblique; teeth subequal, 1/2 to as long as tube. Corolla white, 12.5 - 13mm; tube exserted. Nutlets ellipsoid, 1.16 × 0.55mm, brown, with a small bilobed lateral areole

Type: [Soviet C Asia] Pamir, Jashil Kul, 3900m, 28. 7. 1898, *Paulsen* 970 (C, G)

Specimens examined: Dras, Zojila, *H. Tauheeda* & *G. H. Dar* 2756, 2757 (KASH).

Flowering and fruiting: June - September.

Distribution: NE Afghanistan, adjacent parts of Pamir, Pakistan, India.

Collection site: Hemis Nallah.

Ecology: Grassy or gravelly slopes; 3000 - 3600m.

13. ***Nepeta podostachys*** Benth in DC., Prodr. 12: 372. 1848; Mukerjee, l.c. 122; Hedge and Lamond in Notes Roy.Bot. Gard. Edinb. 28: 102. 1968; Stewart, Ann. Cat. Vasc. Pl. W. Pak. and Kashmir. 625. 1972; Rech. f., Fl. Iran.150: 117. 1982; Hedge, in Fl. Pak. 192: 73. 1990.

N. subincisa Benth. in DC., Prodr. 12: 373. (1848). *N. Paulsenii* Briq. in Bot. Tidsskr. 28: 235 (1908). **Plates 14, 17**

Perennial, aromatic herb. Stem 10 - 45cm tall, erect, branched, with eglandular indumentum of short or long eglandular hairs. Leaves petiolate; petiole 7 - 10mm on lower leaves, shortening above; lamina oblong, oblong-triangular, green, thick-textured, 1.5 - 2.5 × 0.8 - 1.3cm, pilose, base broad truncate, margin crenulate or crenate, apex acute. Spikes congested, ovoid to oblong 3 - 4.5cm, usually distant from upper leaves. Bracts filiform 8 - 11mm long. Calyx 5 - 8mm, green, obtriangular tubular, pilose; throat scarcely

oblique; teeth subequal 1/2 to as long as tube, ciliate, subulate. Corolla white, 1.1 - 1.4cm. Nutlets oblong, 1 - 1.19 × 0.8mm, brown, smooth, with a bilobed subbasal areole.

Type: [Afghanistan, Bamian, Kaloo] In regno Cabulico, *Griffith* (holo-K).

Specimens examined: Leh, Ladak, *H. Tauheeda* 2791, 2792 (KASH).

Flowering: June - August; Fruiting: August - October.

Distribution: Afghanistan, W. Pakistan, India, Pamir-Alai, Russia, Tajikistan.

Collection sites: Khardungla South Pollu, Hemis.

Ecology: Grows along the roadside forests or open dry slopes; 3200 - 4200m.

Vern.: Shangukaram (L).

Chromosome number: 2n = 18 podlech, D. and Dieterle, A. 1969 (Kumar and Subramaniam I: 241. 1986).

14. ***Nepeta raphanorhiza*** Benth., Lab. Gen. et Sp. 734. 1835; Benth. in DC., Prodr. 12: 373. 1848; Hook. f., l.c. 659; Blatter, Beaut. Flows. Kashmir 2: 121. 1928; Mukerjee, l.c. 126; Rao in Bull. Bot. Surv. Ind. 2: 412. 1960; Kitamura, Pl. W. Pak. and Afghan. 128. 1966; Hedge and Lamond, l.c. 121. 1968; Stewart, Ann. Cat. Vasc. Pl. W. Pak. and Kashm. 625. 1972; Rech. f., l.c. 118, t.107, 556 f. 9; Kaul, Weed Fl. Kashmir Valley 224. 1986; Hedge, Fl. Pak. 192: 71. 1990; Jing Jie Shu, Fl. China 17: 138. 1994. **Plates 15, 33**

Perennial tuberous herb. Tuber 7 - 20mm in diameter. Stems numerous, ascending, 10 - 30cm tall, forming loose mats, leafy. Leaves petiolate; petiole 5 - 17mm on lower leaves; lamina broad triangular-ovate green, 0.5 - 2.5 × 0.5 - 2cm, base truncate to cordate, margin serrate, apex acute; tufts of younger leaves often present in leaf axils. Spike a terminal compact ovoid head ± interrupted, subtended by uppermost leaves; Inner bracts linear, c. as long as

calyces. Calyx purplish, 6 - 7mm long, tubular; throat almost straight, teeth somewhat unequal, narrow triangular, 1/2 to as long as tube, ciliate. Corolla purplish, 7 - 12mm; tube shortly exserted, slightly expanded at throat; upper lip hooded; lower lip somewhat longer than upper. Nutlets broadly ovoid, 1 - 1.2 × 0.5 - 0.9mm, light brown, not trigonous, shiny, with a small basal areole.

Type: Kashmir [Kashmir valley, 1670m, *Stainton* 8629 (BM, E); Anantnag, *Chamberlain* 178 (E); Srinagar, above Dal lake, *Chamberlain* 166 (E); Jhelum valley, Baramula to Setoune, 7 May] *Jacquemont* (K, P).

Specimens examined: Pampore, Pulwama, *H. Tauheeda* & *G. H. Dar* 2705, 2713 (KASH); Khrew, Pulwama, *Bilal A. Bhat*, *H. Tauheeda* & *G. H. Dar* 2731, 2733 (KASH).

Other records: Kashmir: Kashmir Valley, 1670m, *Stainton* 8629 (BM, E); Anantnag, *Chamberlain* 178 (E); Srinagar, above Dal lake, *Chamberlain* 166 (E); Kashmir: Kishtawar, *T. Thomson* (K); Aharbal, 2200m, *Stainton* 7836 (BM, E).

Flowering and fruiting: April - June.

Distribution: E. Afghanistan, Pakistan, NW India.

Collection sites: Anantnag, Dachigam, Khrew, Pampore.

Ecology: Grows in dry open slopes or thickets along streams; 1600 - 2300m.

Chromosome number: 2n = 18 Gill, L. S. 1969 (Kumar and Subramaniam, 1986).

5.1.2.4. Section *Capituliferae* (Benth.) Pojark. comb. nov.- Sect. Pycnonepeta subsect. Capituliferae Benth. in DC. Prodr. XII. 397. 1848. - Sect. Eunepeta subsect. Capituliferae Boiss. Fl. Or. IV. 637. 1879; Briq. in Pflanzenfam. IV, 3a, 236.

Perennial herbs or sometimes subshrubs mostly patent-branching at base. Inflorescence consists of a headlike terminal verticillaster and of many

remote pairs of dense headlike semiverticels, these with elongate peduncles and forming a very lax racemiform or paniculate inflorescence or else sessile or partly subsessile and then forming an interrupted spike. Calyx tubular slightly curved, with more or less oblique or nearly 2-lipped throat and narrowly triangular teeth. Corolla-tube curved and abruptly expanding into short neck; middle lobe of lower lip with swelling at base, concave. Nutlets narrowly ellipsoid, smooth, dull.

The section includes 2 subsections, 4 series and 6 species, distributed in W. Himalaya and in Hindu Kush, a number of species grow in the south of Central Asia. In the Kashmir Himalaya, the section is represented by one species.

i. **Subsection *Podocephalae*** Pojark.nov. in Addenda XIX. 354.

All semiverticels with elongate peduncles; aggregate inflorescence loosely racemiform or paniculate. Throat of calyx strongly oblique, nearly 2-lipped.

1. ***Nepeta floccosa*** Benth., Lab. Gen. et Sp. 736. 1835; Benth in DC., Prodr. 12: 380. 1848; Hook. f., l.c. 662; Mukerjee, l.c. 127; Stewart in Pak. J. For. 11: 53. 1961; Kitamura, Pl. W. Pak. and Afghan. 127. 1964; Wealth of India, Raw Materials 7: 13. 1966; Hartmann in Bot. Jahrb. 85: 344. 1966; Hedge and Lamond, l.c. 105. 1968; Stewart, Ann. Cat. Vasc. Pl. W. Pak. and Kashmir. 621. 1972; Kachroo *et al*., Fl. Ladakh 130. 1977; Rech. f., Fl. Iran. 150: 136, t. 125, 596 f.1. 1982; Zuckerwanik in Vvedensky, Conspect. Fl. As. Med. 9: 52. 1987; Hedge, in Fl. Pak. 192: 94.1990; Jing Jie Shu, Fl. China 17: 138. 1994.

N. gilesii Mukerjee in J. Ind. Bot. Soc. 19: 85. 1940; *N. pseudofloccosa* Pojark. in Not. Syst. Leningrad 15: 296, f. 3. 1953; Kitamura, Pl. W. Pak. and Afghan. 129. 1964; Zuckerwanik in Vvedensky, Conspect. Fl. As. Med. 9: 52. 1987; *N. alii* Jehan in Willdenowia 18: 427. 1989. **Plates 8, 9, 22, 26**

Perennial herb, aromatic. Stems several and clump-forming, erect or ascending, quadrangular, much branched, purplish basally, 3 - 12cm long, with whitish floccose-tomentose hairs. Leaves long- petiolate; petiole 1 - 12.5cm long; lamina cordate to triangular - cordate or ovate, 1 - 3.5 × 1- 4cm, rigid, thick, corrugate, white - tomentose to lanate-floccose, margin crenulate to crenate - lobed, apex obtuse. Inflorescence paniculate, condensed, ± ovoid capitate, cymes, mostly on long, horizontally - spreading peduncles, 6 - 8 flowered, 9.8 - 11 × 7 - 10mm. Bracts lanceolate, filiform, ca. half as long as calyx, violet. Pedicels absent to 1mm long. Calyx tubular, curved, often purplish, 6 - 9mm long, densely floccose-villous when young, eglandular; throat very oblique; teeth unequal, usually clearly shorter than tube, narrowly triangular, ciliate. Corolla blue-violet, 8 - 13mm long; tube slender, incurved, exserted beyond calyx, 2 - 4mm long, throat dilated; lobes of upper lip elliptic, 1 - 1.5 × 1mm; lower lip 2 × as long as upper lip, middle lobe 2.5 × 3.5 - 4mm. Nutlets narrow oblong, 2 - 2.3 × 0.5 - 0.9mm, dark - brown, smooth, with a small basal bilobed areole.

Type: [Kashmir] Between Nako and Chango, *Jacquemont* 1921 (K, P).

Specimens examined: Khalsi, Kargil, *Uppeandhar Dhar* 153 (KASH); Ladakh, Kargil to Leh, *Akhter Hussain* & *G. H. Dar* 2745, 2749, 2758-2762 (KASH); Leh, *H. Tauheeda* & *G. H. Dar* 2764, 2667, 2789, 2808 (KASH).

Other records: Kashmir: Ladakh, Leh, Hemis Nullah, 3690m, *Ludlow and Sherriff* 8473 (BM, E); Ladakh, near Stok, *Maxwell* A52, A56 (E); Ladakh, Kargil, 3350m, C. *Burt* 84 (E); Burji La, 3350m, *Clarke* 29002B (K); Kashmir: Rupshu, Kugzil La, 4800m, *Koelz* 2321 (E, NY); Zanskar, *T. Thomson* s. n. (K).

Flowering: May - August; Fruiting: August - September.

Distribution: Afghanistan, Pakistan, Russia, India, Pamir Alai.

Collection sites: Leh, Hemis nallah, Kargil to Leh.

Ecology: Stony alpine slopes, grasslands, valleys; 3000 - 4200m.

Vern.: Shangukaram or Shamalolo (L).

ii. **Subsection *Apodocephalae*** Pojar. nov. in Addenda XIX. 354.

Semiverticels, with possible exception of the lowermost sessile or semisessile; aggregate inflorescence seemingly an interrupted spike. Throat of calyx oblique.

This subsection is not represented by any species in the study area.

5.1.2.5. Section *Glechomanthe* Pojark. nov. in Addenda. XIX. 353.

Perennial herbs. Flowers in remote few-flowered cymes or in a terminal capitate inflorescence. Calyx oblique or 2-lipped throat. Corolla with long tube, gradually and rather weakly dilated above; middle lobe of lower lip more or less hohizontal, flat without swelling at base, gradually tapering to broad base or with rather long broad claw; lateral lobes large, elongate, ovate, nearly as long as upper lip and as wide as its lobes; lower stamens generally much shorter than the upper.

It includes 3 subsections.

Key to subsections of section *Glechomanthe* in the Kashmir Himalaya

1+ Lower stamens slightly shorter than the upper, with anthers diverging at an angle of 180^0 lying under flat upper lip.....iii. *Catantherae*

- Lower stamens much shorter than the upper, with anthers at the level of throat, diverging at nearly a right angle……...2

2+ Bracts linear or narrowly linear, longer than flowers. Nutlets smooth…… …….i. *Callistegiae*

- Bracts lanceolate, half as long as calyx. Nutlets rugulose…… ……...ii. *Brachystegiae*

i. **Subsection *Callistegiae*** Pojark. nov. in Addenda XIX. 353.

Low alpine herbe. Leaves cuneate, with undulate, deeply crenate margin. Flowers in large dense terminal heads formed by crowded verticillasters; floral leaves resembling the cauline. Leaves subtending verticillasters and bracts numerous, longer than fllowers. Calyx obconical, with very oblique nearly 2-lipped throat. Lower stamens much shorter than the upper, with anthers at the level of throat. Nutlets smooth.

This subsection contains two closely related species, distributed in Central Asia. In the Kashmir Himalaya it is represented by one species.

1. ***Nepeta longibracteata*** Benth., Lab. Gen. et Sp. 735.1835; Benth in DC., Prodr. 12: 377.18 Hook. f., l.c. 660; Blatter, Beaut. Flows. Kashmir 2: 119. 1928; Mukerjee, l.c. 124; Wendelbo in Nyttmag. Bot. 1: 53. 1952; Stewart in Pak. J. For. 11: 53. 1961; Hartmann in Bot. Jahrb. 85: 345. 1966; Hedge and Lamond, l.c. 101; Tscherneva in Grubov *et al*., Pl. As. Central. 5: 34. 1970; Stewart, Ann. Cat. Vasc. Pl. W. Pak. and Kashmir. 620. 1972; Kachroo *et al*., Fl. Ladakh 130. 1977; Rech. f., Fl. Iran. 150: 113, t. 104, 554 f. 1. 1982; Zuckerwanik in Vvedensky, Conspect. Fl. As. Med. 9: 48. 1987; Hedge, in Fl. Pak. 192: 68. 1990; Jing Jie Shu, Fl. China 17: 135. 1994.

   Glechoma longibracteata (Benth.) O. Kuntze, Revis. Gen. 518. 1891.

Plates 13, 29

Perennial herb. Stem 9 - 13cm tall, slender, prostrate or ascending, purplish, with an eglandular pilose indumentum. Leaves long petiolate; petiole 7.8 - 8.3mm long; lowermost leaves scale-like; cauline leaves obovate-cuneate or ovate-rhombic, 0.8 - 1.5cm × 5 - 12mm. Inflorescence globose or ovoid, densely congested terminal head, 1.5 - 3.5cm subtended by uppermost small leaves. Bracts purplish, 1.6 - 1.9cm × 0.5 - 0.6mm linear, as long as calyx to

longer than flowers, minutely glandular, margin densely ciliate. Pedicels 1 - 1.5mm long. Calyx straight, narrowly obconical, 7.8 - 8.3mm long; throat oblique; teeth narrow, lanceolate, apex acuminate, unequal, ca. 1/3 length of calyx tube. Corolla blue-violet, 1.5 - 1.8cm, lip with darker spots; upper lip deeply bifid with broad rounded lobes; tube exserted from calyx. Nutlets oblong, 2 × 0.8mm, brown, striated with a bilobed lateral areole.

Type: [Himachal Pradesh] In lapidosismobilibus prope Kang-Rang Ghan-Ti, *Jacquemont* 1665 (K, P).

Specimens examined: Khardungla, Leh, *H. Tauheeda* & *G. H. Dar* 2739, 2746, 2750, 2753, 2770, 2775, 2776 (KASH).

Other records: Kashmir: Ladak, Shaksgam Valley, *Clifford* 6 (K); Stok, 5180m, *Maxwell* 90 (E); Tsakzhun Tso, 5250m, *Koelz* 2416 (E, K, NY, RAW); Depsang Plains, 5200m, *Ludlow* 460 (BM, E); Ke La, *Koelz* 2524a (E); Kardung Pass, *C. Burt* 169 (E); 11 km from Kanji, 4900m, *Brown and Rothera* 111 (K).

Flowering and fruiting: July - August.

Distribution: NE Afghanistan, Pamir-Alai, Pakistan, Russia, India, Tibet, Sinkiang.

Collection sites: Between Khardungla South Pollu to Khargungla.

Ecology: Stony or gravelly alpine slopes; 4000 - 5300m.

Vern.: Prianku (L).

An easily recognized high alpine scree plant.

ii. **Subsection *Brachystegiae*** Pojark. nov. in Addenda XIX. 353.

Perennial herbs, with strongly thickened woody rhizome and sessile leaves. Flowers in remote 1-5-flowered semiverticels; floral leaves resembling cauline leaves but the uppermost much shorter. Bracts lanceolate, half as long

as calyx. Calyx obconical, with oblique throat. Lower stamens much shorter than the upper. Nutlets rugulose, pointed at apex.

This subsection includes one species distributed in Iran (northeast Afghanistan). In the Kashmir Himalaya it is represented by one species.

1. ***Nepeta glutinosa*** Benth., Lab. Gen. et Sp. 735.1835; Benth in DC., Prodr. 12: 377. 1848; Hook. f., l.c. 660; Mukerjee, l.c. 126; Stewart in Pak. J. For. 11: 52. 1961; Hedge and Lamond in Notes Roy.Bot. Gard. Edinb. 28: 101. 1968; Stewart, Ann. Cat. Vasc. Pl. W. Pak. and Kashmir. 621. 1972; Kachroo *et al*., Fl. Ladakh 130. 1977; Rech. f., Fl. Iran. 150: 114, t. 105, 554 f. 2. 1982; Zuckerwanik in Vvedensky, Conspect. Fl. As. Med. 9: 49. 1987; Hedge, Fl. Pak. 192: 69. 1990; Jing Jie Shu, Fl. China 17: 135. 1994.

   N. badamdarica Lipsky in Acta Hort. Petrop. 26: 754. 1909.

   Plate 9, 10, 27

   Perennial tufted herb, stems several, 40 - 70cm, at base with scale - like leaves, densely glandular villous. Leaves sessile; lamina cordate-ovate, 1.3 - 3 × 0.8 - 2.2cm, viscid, glandular, semi-amplexicaul, margin deeply incised-serrate. Spikes numerous, ± distant, many-flowered shortly pedunculate, verticillasters borne in the axils of upper leaves. Bracts 8 - 10mm, linear-lanceolate, as long as calyces. Pedicels 1 - 2.5mm. Calyx narrow tubular, 8 - 12 × 2 - 3mm, straight; throat oblique; teeth unequal, ovate-triangular, c. 1/3 length of calyx tube. Corolla bluish or purplish, 1.8 - 2.2cm; tube slender, much exserted, 2 - 3mm, lower longer than upper. Nutlets greenish brown to brown, broadly ellipsoid, 1 - 1.3 × 0.5 - 0.9mm, bilobed lateral areole.

   Holotype: [W Himalaya] Between Poye and Rici, *Jacquemont* 1713 (P, K).

   Specimens examined: Zanskar, Ladak, *H. Tauheeda* & *G. H. Dar* 2787, 2788, 2815, 2817 (KASH).

Other records: Kashmir: Baltistan, Satpura Nullah, 3800m, *Duthie* s. n. (E); Satpura and Burji passes, to c. 4000m, 1961 *R. R. Stewart* s. n. (RAW); Dras, *R. R. Stewart* 746 (RAW); Chatpani nala, 3200m, *Duthie* 13810 (E); Baltistan, Burji La, *Clarke* 29004 (K); Zanskar, Shagam, 3500m, *Koelz* 2979 (E, NY); Ladak, *Osmaston* 51 (K); Ladak, 8 km from Kanji, 3960m, *Brown* and *Rothera* 144 (K).

Flowering and fruiting: July-September.

Distribution: E and NE Afghanistan, Pakistan, Russia, India, Sinkiang.

Collection sites: Panikher, Zanskar proper, on way to Padam, Bodhkharbu.

Ecology: Alpine grasslands; 3200-4000m.

Vern.: Jatukpa (L).

Chromosome number: 2n = 18 podlech, D. and Dieterle, A. 1969 (Kumar and Subramaniam I: 241. 1986).

The glandular indumentum is a characteristic feature of this species.

iii. **Subsection *Catantherae*** Pojark. nov. in Addenda XIX. 353.

Flowers in remote cymes or semiverticels; floral leaves resembling the cauline leaves but the upper much smaller. Bracts lanceolate-subulate, much shorter than calyx. Calyx tubular or tubular-obconical, with oblique or 2-lipped throat. Lower stamens slightly shorter than the upper. Nutlets finely papillose.

The subsection comprises two Central Asian species. This subsection is not represented by the study area.

5.1.2.6. Section *Macronepeta* Benth. Lab. Gen et. Sp. 482. 1834. - Nepeta subsect. Macronepeta Briq. in Pflanzenfam. IV, 3a, 237. 1896.

High perennial herbs. Calyx tubular, curved, with oblique throat. Corolla medium-sized or large, with narrow curved tube abruptly expanding into wide

neck, the narrow part of tube half as long as calyx; middle lobe of lower lip with flat drooping lobules. Nutlets smooth.

The section includes 3 series and 16 species, distributed mainly in East and Middle Asia, two species in Central Asia. The section is represented by 3 species in the Kashmir Himalaya.

Key to species of section *Macronepeta* in the Kashmir Himalaya

1+ Leaves grey-white on both surfaces; verticillasters widely spaced; corolla less than 2 cm long……..……...3. *N. salviaefolia*

- Leaves green on both surfaces; verticillasters not widely spaced; corolla more than 2 cm long……2

2+ Corolla yellowish, c. 2.5 cm long……....1. *N. govaniana*

- Corolla blue, 2-2.5 cm long……...2. *N. erecta*

1. *Nepeta govaniana* (Wall. ex Benth.) Benth., Lab. Gen. et Sp. 482. 1834; Benth. in DC., Prodr. 12: 388. 1848; Hook. f., l.c. 663; Blatter, Beaut. Flow. Kashmir 2: 116. 1928; Mukerjee, I.c. 129; Hedge and Lamond, l.c. 104. 1968; Stewart, Ann. Cat. Vasc. Pl. W. Pak. and Kashm. 621. 1972; Rech. f., l.c. 156, t. 554 f. 9; Hedge, Fl. Pak. 192: 86. 1990.

Dracocephalum govanianum Wall. [Cat. 2127. 1829] ex Benth. in Wall, Pl. As. Rar. 1: 65. 1830. **Plates 10, 28**

Perennial herb, 53-100 cm tall. Stems quadrangular, eglandular pubescent, little branched, leafy. Leaves petiolate; petiole 1.6 - 3.5cm long; lamina ovate or ovate lanceolate, 12 - 12.5 × 5.8 - 6.3cm, margin crenate to serrate, apex acute. Inflorescence paniculate, pedunculate cymes borne in axils of uppermost leaves, 17 - 17.4cm long. Peduncle 2 - 6cm long. Bracts much smaller than calyces, 6.1 - 6.6mm. Pedicels 3 - 6mm long. Calyx 6 - 8mm long, tubular; throat oblique; teeth unequal, triangular, 1/3 to as long as calyx tube. Corolla 2.3 - 2.6cm, pale yellow; tube exserted, slender below, gracefully

curved; upper lip deeply bifid; lower lip ± as long as upper. Nutlets broadly obovoid, greenish brown, 2.1 - 2.5 × 1.37 - 1.49mm, apically rounded, minutely granular, with a straight basal areole.

Type: [NW India, Himachal Pradesh] Sirmore et Kamaon, *Govan* (K).

Specimens examined: Gulmarg, *H. Tauheeda* & *G. H. Dar* 2729, 2722, 2721 (KASH); Pir Panjal, *H. Tauheeda* & *G. H. Dar* 2730, 2732, 2803, 2804 (KASH); Kishen Ganga valley, *H. Tauheeda* & *G. H. Dar* 2741, 2745 (KASH)

Other records: Kashmir: Kishen Ganga Valley, c. 3800m, *Duthie* 12618 (E); Sinthan Pass, 3350m, *Ludlow and Sherriff* 8188 (BM, E); Kolahoi Valley, 3200m, *O. Polunin* 56/524 (BM, E); Gulmarg, 2600m, *O. Polunin* 56/117 (BM, E); Pir Panjal, *Duthie* 25749 (K); above Tragbol, *Osmaston* 12 (K); Sonamarg, *Kohli* 84 (K); Haramukh, 3650, *Ludlow and Sherriff* 7844 (BM, E); Kashmir: Kamri Pass, c. 3800m, 26. 8. 1892, *Duthie* s. n. (E); Kashmir: Poonch, Aliabad, *Drummond* 14023 (K).

Flowering and fruiting: July-September.

Distribution: Pakistan, NW India.

Collection sites: Gulmarg, Gurais.

Ecology: Grows in humus - rich soils; 2600-3800m.

Chromosome number: 2n =18 Gill, L. S. 1969 (Kumar and Subramaniam, 1986).

Economic importance: Source of an essential oil (Mathela and Kharkwal, 1994).

2. ***Nepeta erecta*** (Royle ex Benth.) Benth., Lab. Gen. et Sp. 482. 1834; Benth. in Dc., Prodr. 12: 388. 1848; Hook. f., l.c. 663; Blatter, Beaut. Flows. Kashmir 2: 116. 1928; Mukerjee, l.c. 129; Rao in Bull. Bot.

Surv. Ind. 2: 412. 1960; Hedge and Lamond, l.c. 104; Stewart, Ann. Cat. Vasc. Pl. W. Pak. and Kashm. 620. 1972; Sharma and Kachroo, Fl. Jammu 262. 1981; Rech. f., l.c. 128, t. 118, 554 f. 10.

Dracocephalum erectum Royle ex Benth. in Hook., Bot. Misc. 3: 380. 1833. **Plates 7, 24**

Perennial herb. Stems erect 65 - 120cm tall, with short pilose eglandular hairs, inflorescence axis usually glandular. Leaves petiolate; petiole in lower leaves 1.9 - 2.6cm long, decreasing above; lamina ovate, green above, paler below, 4 - 9.5 × 2 - 3cm, base cordate, margin ± serrate, apex acute. Cymes separate borne in leaf axils, 5.2 - 9.7cm long, upper ones ± sessile. Peduncle 2 - 2.5cm long. Bracts linear, longer than pedicels, 5 - 6.2mm long. Pedicels 2.1 - 2.9mm long. Calyx 8 - 9.2mm long, almost straight, tubular; throat slightly oblique; teeth somewhat unequal, broad to triangular, longest to c. 3mm. Corolla 1.9 - 2.6cm long, deep violet - blue, tube curved, exserted, abruptly dilated above; upper lip deeply bilobed; lower lip spreading, longer than upper. Nutlets broad - obovoid, 2 - 2.3 × 1 - 1.4mm, dark - brown, minutely granular with a small bilobed subbasal areole.

Type: [NW India, Himachal Pradesh, Kinnaur] Kanaor, *Royle*.

Specimens examined: Aharbal, Shopian, *H. Tauheeda* & *G. H. Dar* 2710, 2740 (KASH); Kishtwar, Doda, *H. Tauheeda* & *G. H. Dar* 2742, 2719, 2724 (KASH); Liddar Valley, *H. Tauheeda* & *G. H. Dar* 2725, 2743 (KASH); Pahalgam, *H. Tauheeda* & *G. H. Dar* 2715, 2744 (KASH); Gulmarg, *H. Tauheeda* & *G. H. Dar* 2702, 2703 (KASH); Pir Panjal Range, *H. Tauheeda* & *G. H. Dar* 2802, 2805 (KASH).

Other records: Kashmir: Sind Valley, Mohanmarg, 2280m, *Ludlow and Sherriff* 8149 (BM, E); Gulmarg, *Stearn* 4 (E); Pahlgam, 2560m, *O. Polunin* 56/470 (BM, E); Liddar Valley, 2000m, *Duthie* 13069 (E); Kishen Ganga Folowai, 2100m, *Ludlow and Sherriff* 1429 (BM, E); Shonthar

Valley, 3050m, *Ludlow and Sherriff* 1516 (BM, E); Tragbol, *Osmaston* 25 (K); Kashmir: Aharbal, 2200m, *Stainton* 7835 (BM, E); Pasar, Wardwan, 2740m, *Stainton* 8623 (BM, E); Kashmir: Kishtwar, Tsingam, 2130m, *Ludlow and Sherriff* 9113 (BM, E).

Flowering and fruiting: June - September.

Distribution: Pakistan, NW India.

Collection sites: Gulmarg, Pahalgam, Aharbal.

Ecology: Grows on humus - rich soils; 2000 - 2700m.

Chromosome number: 2n = 36 (Gill, L. S. 1969; Kumar and Subramaniam, 1986).

3. ***Nepeta salviaefolia*** Royle ex Benth. in Hook., Bot. Misc. 3: 379. 1833; Benth in DC., Prodr. 12: 388. 1848; Hook. f., l.c. 664; Blatter, Beaut. Flows. Kashmir 2: 117. 1928; Mukerjee, l.c. 128; Kitamura, Pl. W. Pak. and Afghan. 128. 1964.

N. leucolaena Benth. ex Hook. f., Fl. Brit. Ind. 4: 662. 1885; Blatter, Beaut. Flows. Kashmir 2: 119. 1928; Mukerjee, l.c. 128; Kitamura, Pl. W. Pak. and Afghan. 128. 1964; Stewart, Ann. Cat. Vasc. Pl. W. Pak. and Kashmir. 623. 1972; Kachroo *et al*., Fl. Ladakh 130. 1977; Hedge, Fl. Pak. 192: 98. 1990; Jing Jie Shu, Fl China 17: 142. 1994. *N. royleana*. R. R. Stewart, Ann. Cat. Vasc. Pl. W. Pak. and Kashmir. 625. 1972 - as *nom. nov*.; *N. stewartii* Raizada in Raizada and Saxena, Fl. Mussoorie 1: 583. 1978 - as *nom. nov*. [*nom. superfl*.]. **Plates 16, 34**

Perennial herb. Stem 50 - 90cm tall, erect, rather slender, branched, white stellate dendroid hairs. Leaves petiolate; petiole up to 10mm on lower cauline leaves, less above; lamina ovate, 5 - 2.7cm, thick, grey-white on both surfaces with a dense covering of stellate-dendroid hairs, base rounded to cordate, margin crenate, apex acute to obtuse. Verticillasters few flowered

borne in the axils of upper leaves and leaf like bracts, widely spaced, in interrupted terminal spikes, short pedunculate basally. Innerbracts lanceolate, much shorter than calyces. pedicel 2 - 3mm long. Calyx 5 - 6mm long, lanate or straight often purplish, often purplish, with very dense indumentum of stellate-dendroid hairs; throat slightly oblique; teeth narrow triangular, subequal, 1/3 to as long as calyx tube. Corolla 1.5 - 1.7cm, lavender; tube slender much exserted; upper lip straight, shortly bifid; lower lip flecked with pink dots. Anthers dark blue. Nutlets linear-oblong, 1.7 - 1.9 × 0.8 - 1mm, black, with an apical tuft of multicellular hairs, minutely granular with a small basal areole.

Holotype: [Kashmir, Baltistan, Kuru to Daghori, *E. Nasir and Webster*; Hasora, Astor valley, [*Schlagintweit*] Zanskar and Ladak {Hanupatta}, 12-13, 000 ft, *T. Thomson* (K).

Specimens examined: Ladak, *Bilal A. Bhat, H. Tauheeda* & *G. H. Dar* 2711, 2714 (KASH); Hemis Nullah, Leh, *Bilal Bhat* and *H. Tauheeda* 2717, 2718, 2736, 2812, 2813, (KASH); Shankaracharya, *H. Tauheeda* & *G. H. Dar* 2723, 2726, 2734 (KASH).

Other records: Kashmir: Baltistan, Satpura Nullah, c. 3500m, *Duthie* 12012 (E,K), Shagarthang valley, 2890m, *Duthie* 12130 (E,K); Baltistan, Kura to Daghori, *E. Nasir and Webster* 5917 (RAW); Hasora, Astor valley, *Schlagintweit* 6916 (E); Ladak, Umlung, *Ludlow* 545 (BM, E); Thalam Buti, 3960m, *Ludlow* 417 (BM, E); Ladak, Zingrul, 4800m, *Koelz* 2495 (E, NY); Snout of Gharesa glacier, 3650, *O. Polunin* 6098 (BM, E); Ladak, Stok, 3960m, *Maxwell* A 36 (E).

Flowering and fruiting: June - August.

Distribution: India, Tibet.

Collection sites: Shankaracharya, Hemis, Shopian.

Ecology: Grows in hill dry slopes and top of the hill; 2000 - 3400m.

Vern.: Bukhsukh (L).

Table 5.1: Quantitative data on some morphological characters in *Nepeta annua* (N = 8)

(mm)	Minimum	Maximum	Mean	Std. Deviation
Stem length	200.00	300.00	260.0000	37.03280
Petiole length	9.00	15.00	12.1250	2.41646
Leaf length	10.00	15.00	13.0625	1.82125
Leaf breadth	7.00	13.00	9.8750	2.03101
Spike length	20.00	60.00	48.5000	14.27285
Peduncle length	.00	.10	.0675	.04234
Bract length	5.00	6.00	5.5625	.39256
Pedicel length	1.00	4.00	2.7375	1.17951
Calyx length	5.00	6.00	5.5625	.39256
C. tube length	3.90	4.50	4.2000	.17728
C. teeth length	1.90	2.30	2.0750	.15811
Corolla length	6.50	8.00	7.4625	.60223

Table 5.2: Quantitative data on some morphological characters in *Nepeta campestris* (N = 8)

(mm)	Minimum	Maximum	Mean	Std. Deviation
Stem length	300.00	600.00	467.5000	108.46329
Petiole length	3.50	10.00	5.5875	2.22739
Leaf length	25.00	50.00	36.3750	10.41890
Leaf breadth	12.00	20.00	15.3750	3.02076
Spike length	25.00	75.00	45.0000	18.15017
Peduncle length	.00	.09	.0537	.04470
Bract length	4.50	5.00	4.7750	.20529
Pedicel length	1.00	1.50	1.2125	.18077
Calyx length	6.00	10.10	8.4375	1.48510
C. tube length	4.50	5.00	4.7750	.20529
C. teeth length	3.00	4.00	3.5625	.37009
Corolla length	12.00	15.10	13.3875	1.17769

Table 5.3: Quantitative data on some morphological characters in *Nepeta cataria* (N = 8)

(mm)	Minimum	Maximum	Mean	Std. Deviation
Stem length	500.00	820.00	650.0000	106.77078
Petiole length	10.00	25.00	18.1250	5.46253
Leaf length	15.00	66.00	43.3750	17.24560
Leaf breadth	20.00	50.00	37.5000	11.64965
Spike length	215.00	490.00	358.1250	101.20480
Peduncle length	15.00	27.00	20.6250	4.13824
Bract length	4.30	6.00	5.0250	.50639
Pedicel length	.50	1.50	.9875	.33139
Calyx length	5.00	7.20	6.1125	.74917
C. tube length	3.50	4.70	4.1500	.41404
C. teeth length	2.30	3.50	2.9250	.40970
Corolla length	6.10	8.30	7.0375	.78000
Valid N (listwise)				

Table 5.4: Quantitative data on some morphological characters in *Nepeta clarkei* (N = 8)

(mm)	Minimum	Maximum	Mean	Std. Deviation
Stem length	450.00	900.00	725.0000	179.60274
Petiole length	30.00	33.00	31.4375	1.11604
Leaf length	15.00	60.00	43.5000	177.74380
Leaf breadth	10.00	50.00	365.0000	144.51891
Spike length	10.00	21.00	16.1250	4.42194
Peduncle length	.00	.09	.0600	.03780
Bract length	3.50	4.50	3.9375	.39256
Pedicel length	.00	.10	.0675	.04234
Calyx length	7.00	9.00	8.1250	.64973
C. tube length	3.90	4.50	4.1750	.25495
C. teeth length	2.80	3.10	2.9500	.11952
Corolla length	14.80	15.10	14.9500	.11952

Table 5.5: Quantitative data on some morphological characters in *Nepeta coerulescens* (N = 8)

(mm)	Minimum	Maximum	Mean	Std. Deviation
Stem length	240	520	363.125	99.24492
Petiole length	2.5	10.3	5.95	2.881468
Leaf length	20	53	38.25	12.15084
Leaf breadth	8	21	15.625	5.097268
Spike length	30	110	67	28.94329
Peduncle length	0.3	2.3	1.3875	0.735697
Bract length	9.5	10.3	9.9375	0.266927
Pedicel length	0.4	0.54	0.47875	0.049982
Calyx length	6	7.3	6.725	0.452769
C. tube length	4	5.2	4.5875	0.442194
C. teeth length	2	2.9	2.4	0.320713
Corolla length	11	13.2	12.275	0.747854

Table 5.6: Quantitative data on some morphological characters in *Nepeta connata* (N = 8)

(mm)	Minimum	Maximum	Mean	Std. Deviation
Stem length	173	870	508.375	255.6878
Petiole length	0	0.09	0.0425	0.045591
Leaf length	80	170	107.875	30.94436
Leaf breadth	3	25	13.125	6.998724
Spike length	40	145	77.625	36.01562
Peduncle length	0.1	0.8	0.45	0.244949
Bract length	11	15.2	13.8875	1.402485
Pedicel length	1	11.6	7.5	3.531895
Calyx length	12	15.6	13.775	1.185327
C. tube length	5	6.3	5.7125	0.451782
C. teeth length	5	6.7	6.025	0.525765
Corolla length	25	26.3	25.775	0.483292

Table 5.7: Quantitative data on some morphological characters in *Nepeta discolor* (N = 8)

(mm)	Minimum	Maximum	Mean	Std. Deviation
Stem length	100.00	300.00	188.7500	69.57781
Petiole length	2.00	11.00	6.9375	2.73127
Leaf length	6.00	21.00	12.8750	5.84166
Leaf breadth	5.00	12.00	10.2500	2.37547
Spike length	30.00	55.00	44.6250	8.74949
Peduncle length	.01	.30	.1100	.09621
Bract length	5.00	6.70	5.8125	.62436
Pedicel length	.80	1.30	1.0500	.16036
Calyx length	7.00	8.20	7.6500	.45670
C. tube length	3.50	4.50	3.9875	.30443
C. teeth length	3.50	4.50	3.9875	.30443
Corolla length	12.70	13.50	13.0375	.26152

Table 5.8: Quantitative data on some morphological characters in *Nepeta elliptica* (N = 8)

(mm)	Minimum	Maximum	Mean	Std. Deviation
Stem length	350.00	700.00	574.0000	120.21766
Petiole length	.20	.70	.4750	.16690
Leaf length	10.00	35.00	24.2500	8.64787
Leaf breadth	7.00	17.00	13.3750	3.66206
Spike length	100.00	110.00	104.6250	3.73927
Peduncle length	.05	.30	.1650	.09971
Bract length	5.00	5.30	5.1500	.11952
Pedicel length	3.00	4.30	3.7250	.46522
Calyx length	5.70	6.30	5.9500	.22039
C. tube length	3.70	4.30	4.0000	.20000
C. teeth length	3.70	4.30	4.0000	.20000
Corolla length	10.00	17.50	14.0000	3.01188

Table 5.9: Quantitative data on some morphological characters in *Nepeta erecta* (N = 8)

(mm)	Minimum	Maximum	Mean	Std. Deviation
Stem length	650.00	1200.00	90.0000	18.43909
Petiole length	19.00	26.00	22.5000	2.44949
Leaf length	40.00	95.00	69.5000	17.64734
Leaf breadth	20.00	30.00	25.0000	3.58569
Spike length	52.00	97.00	75.7500	16.00670
Peduncle length	20.00	25.00	21.6250	83.72734
Bract length	5.00	6.20	5.5625	.42405
Pedicel length	2.10	2.90	2.5250	.29641
Calyx length	8.00	9.20	8.5000	.43425
C. tube length	6.00	7.30	6.6375	.46579
C. teeth length	2.00	2.70	2.3000	.59040
Corolla length	19.00	26.00	22.6250	2.55999

Table 5.10: Quantitative data on some morphological characters in *Nepeta eriostachys* (N = 8)

(mm)	Minimum	Maximum	Mean	Std. Deviation
Stem length	200.00	315.00	269.3750	42.63110
Petiole length	3.80	4.50	4.0750	.23755
Leaf length	30.00	43.00	36.0000	4.56696
Leaf breadth	20.00	30.00	25.3750	3.85218
Spike length	40.00	51.00	45.8750	4.01559
Peduncle length	.06	.10	.0837	.01408
Bract length	6.00	8.10	7.1625	.71701
Pedicel length	.07	.80	.2413	.28832
Calyx length	7.00	10.10	8.2000	1.10324
C. tube length	3.80	4.50	4.0875	.23566
C. teeth length	3.90	4.70	4.4000	.27775
Corolla length	10.00	13.10	11.8250	1.32098

Table 5.11: Quantitative data on some morphological characters in *Nepeta floccosa* (N = 8)

(mm)	Minimum	Maximum	Mean	Std. Deviation
Stem length	30.00	120.00	70.0000	29.51997
Petiole length	10.00	125.00	78.1250	38.26015
Leaf length	10.00	40.00	28.8750	11.30660
Leaf breadth	10.00	35.00	26.7500	9.49812
Spike length	9.80	11.00	10.2625	.42741
Peduncle length	3.80	4.10	3.9500	.11952
Bract length	3.00	4.60	3.8875	.65561
Pedicel length	.01	.20	.0425	.06409
Calyx length	6.00	9.00	7.4250	.99964
C. tube length	2.00	4.00	2.8875	.77356
C. teeth length	1.20	1.70	1.4625	.20659
Corolla length	8.00	13.00	10.3125	1.64962

Table 5.12: Quantitative data on some morphological characters in *Nepeta glutinosa* (N = 8)

(mm)	Minimum	Maximum	Mean	Std. Deviation
Stem length	400.00	700.00	561.2500	103.01699
Petiole length	.00	.10	.0675	.04234
Leaf length	13.00	30.00	20.3750	7.13017
Leaf breadth	8.00	22.00	15.7500	5.54849
Spike length	100.00	170.00	130.8750	26.76051
Peduncle length	2.00	3.00	2.5625	.39978
Bract length	8.00	10.00	9.0875	.83911
Pedicel length	1.00	2.50	1.9000	.48403
Calyx length	8.00	12.00	10.0875	1.47980
C. tube length	7.90	8.30	8.0750	.15811
C. teeth length	2.67	4.00	3.2675	.52717
Corolla length	18.00	22.00	20.2000	1.54550

Table 5.13: Quantitative data on some morphological characters in *Nepeta govaniana* (N = 8)

(mm)	Minimum	Maximum	Mean	Std. Deviation
Stem length	530.00	1010.00	780.0000	164.22980
Petiole length	16.00	35.00	23.0000	6.63325
Leaf length	120.00	125.00	122.0000	2.00000
Leaf breadth	58.00	63.00	60.5000	1.60357
Spike length	170.00	174.00	172.0000	1.69031
Peduncle length	20.00	60.00	40.5000	15.42725
Bract length	6.10	6.60	6.3750	.20529
Pedicel length	3.00	6.00	4.6625	1.08751
Calyx length	6.00	8.00	6.9250	.71664
C. tube length	4.50	6.20	7.0500	.11952
C. teeth length	1.50	2.00	2.4875	.40156
Corolla length	23.00	26.00	24.5000	1.19523

Table 5.14: Quantitative data on some morphological characters in *Nepeta kokanica* (N = 8)

(mm)	Minimum	Maximum	Mean	Std. Deviation
Stem length	200.00	300.00	256.2500	39.25648
Petiole length	2.00	8.00	6.7500	1.98782
Leaf length	3.00	25.00	9.6750	4.71543
Leaf breadth	4.00	20.00	8.8750	3.58775
Spike length	17.00	35.00	26.7500	6.51920
Peduncle length	.00	.09	.0600	.03780
Bract length	7.00	9.00	8.23	.99202
Pedicel length	.07	.10	.0850	.01195
Calyx length	8.00	11.00	9.650	.72061
C. tube length	3.00	4.00	3.4125	.38336
C. teeth length	1.00	2.00	1.3875	.38336
Corolla length	11.00	16.00	14.1000	1.81423

Table 5.15: Quantitative data on some morphological characters in *Nepeta laevigata* (N = 8)

(mm)	Minimum	Maximum	Mean	Std. Deviation
Stem length	300.00	850.00	586.2500	204.86494
Petiole length	38.00	40.20	39.7000	.79102
Leaf length	30.00	65.00	45.0000	11.69860
Leaf breadth	20.00	35.00	27.7500	5.75078
Spike length	80.00	95.00	88.0000	6.04743
Peduncle length	.00	.09	.0625	.03882
Bract length	6.00	8.00	6.9875	.77356
Pedicel length	.01	.03	.0200	.00926
Calyx length	6.00	8.00	6.9875	.77356
C. tube length	3.90	4.30	4.1375	.14079
C. teeth length	3.90	4.30	4.1375	.14079
Corolla length	12.00	14.00	13.0125	.72395

Table 5.16: Quantitative data on some morphological characters in *Nepeta linearis* (N = 8)

(mm)	Minimum	Maximum	Mean	Std. Deviation
Stem length	250.00	700.00	439.3750	179.53188
Petiole length	.00	.09	.0425	.04559
Leaf length	30.00	80.00	60.6250	16.66423
Leaf breadth	1.50	6.00	3.7875	1.60039
Spike length	40.00	50.00	44.3750	3.88909
Peduncle length	.00	.30	.1500	.11952
Bract length	5.00	6.10	5.5500	.44401
Pedicel length	1.00	2.00	1.6625	.36621
Calyx length	8.00	10.10	9.2750	.78876
C. tube length	5.80	6.20	6.0375	.14079
C. teeth length	1.00	4.00	2.5000	1.19523
Corolla length	10.00	15.10	13.1375	1.82282

Table 5.17: Quantitative data on some morphological characters in *Nepeta longibracteata* (N = 8)

(mm)	Minimum	Maximum	Mean	Std. Deviation
Stem length	90.00	131.00	111.8750	17.56163
Petiole length	7.80	8.30	8.0500	.16036
Leaf length	8.00	15.00	11.5000	2.91548
Leaf breadth	5.00	12.00	10.1250	2.69590
Spike length	15.00	35.00	25.0000	8.45154
Peduncle length	.08	.20	.1175	.05148
Bract length	16.00	19.00	17.6500	1.21655
Pedicel length	1.00	1.50	1.3125	.21002
Calyx length	7.80	8.30	8.0750	.19821
C. tube length	9.00	11.00	10.1750	.78513
C. teeth length	3.90	4.20	4.0500	.11952
Corolla length	15.00	18.00	16.3750	1.21743

Table 5.18: Quantitative data on some morphological characters in *Nepeta nervosa* (N = 8)

(mm)	Minimum	Maximum	Mean	Std. Deviation
Stem length	300.00	700.00	488.7500	136.53231
Petiole length	2.90	3.30	3.1000	.13093
Leaf length	50.00	92.00	73.3750	16.01729
Leaf breadth	8.00	16.00	12.8750	3.18198
Spike length	20.00	71.00	49.6250	19.92800
Peduncle length	.80	1.10	.9500	.11952
Bract length	6.00	10.00	8.1750	1.47333
Pedicel length	1.00	1.30	1.1500	.11952
Calyx length	6.00	10.00	8.1750	1.47333
C. tube length	4.90	5.30	5.1000	.13093
C. teeth length	3.00	4.50	3.7500	.59761
Corolla length	12.00	15.00	13.5625	1.08356

Table 5.19: Quantitative data on some morphological characters in *Nepeta paulsenii* (N = 8)

(mm)	Minimum	Maximum	Mean	Std. Deviation
Stem length	300.00	900.00	601.2500	237.09175
Petiole length	8.90	9.30	9.1000	.13093
Leaf length	10.00	20.00	15.1250	3.44083
Leaf breadth	3.00	8.00	6.3750	1.76777
Spike length	15.00	60.00	36.0000	17.49286
Peduncle length	.00	0.09	1.0513	2.84437
Bract length	6.00	9.00	7.9625	1.19515
Pedicel length	.00	.10	.0650	.04175
Calyx length	6.00	9.00	7.9625	1.19515
C. tube length	3.00	4.00	3.6000	.42088
C. teeth length	1.50	2.00	1.7875	.20133
Corolla length	12.50	13.10	12.8750	.24349

Table 5.20: Quantitative data on some morphological characters in *Nepeta podostachys* (N = 8)

(mm)	Minimum	Maximum	Mean	Std. Deviation
Stem length	100.00	450.00	273.3750	123.79584
Petiole length	7.00	10.00	8.4375	1.11604
Leaf length	15.00	25.00	18.5000	3.29502
Leaf breadth	8.00	13.00	11.0000	1.85164
Spike length	30.00	45.00	39.2500	5.11999
Peduncle length	.00	.09	.0600	.03780
Bract length	8.00	11.00	9.6250	1.27475
Pedicel length	1.00	2.00	1.6500	.32071
Calyx length	5.00	8.00	6.4625	1.19993
C. tube length	5.80	6.30	6.0750	.16690
C. teeth length	2.80	3.30	3.0625	.15980
Corolla length	11.00	115.00	25.4375	36.20718

Table 5.21: Quantitative data on some morphological characters in *Nepeta raphanorhiza* (N = 8)

(mm)	Minimum	Maximum	Mean	Std. Deviation
Stem length	100.00	300.00	203.7500	67.38747
Petiole length	5.00	17.00	13.4375	4.36837
Leaf length	5.00	25.00	15.8750	6.15136
Leaf breadth	5.00	20.00	13.5000	4.44008
Spike length	10.00	30.00	19.1250	7.54865
Peduncle length	.01	.10	.0738	.02774
Bract length	5.80	6.30	6.0500	.16036
Pedicel length	.30	.60	.4750	.10351
Calyx length	6.00	7.00	6.4750	.43997
C. tube length	3.90	4.20	4.0500	.11952
C. teeth length	2.00	3.00	2.5375	.37393
Corolla length	7.00	12.00	10.1000	1.78965

Table 5.22: Quantitative data on some morphological characters in *Nepeta salviaefolia* (N = 8)

	Minimum	Maximum	Mean	Std. Deviation
Stem length	500.00	900.00	710.0000	159.19440
Petiole length	9.80	10.20	10.0250	.14880
Leaf length	10.00	50.00	38.5000	14.45189
Leaf breadth	5.00	27.00	19.1250	8.27108
Spike length	40.00	150.00	86.5000	34.45079
Peduncle length	10.00	25.00	15.2500	6.34147
Bract length	5.00	5.30	5.1125	.11260
Pedicel length	2.00	3.00	2.5750	.39188
Calyx length	5.00	6.00	5.6500	.36645
C. tube length	3.50	4.00	3.7750	.20529
C. teeth length	1.00	1.30	1.1500	.11952
Corolla length	15.00	17.00	16.0500	.77828

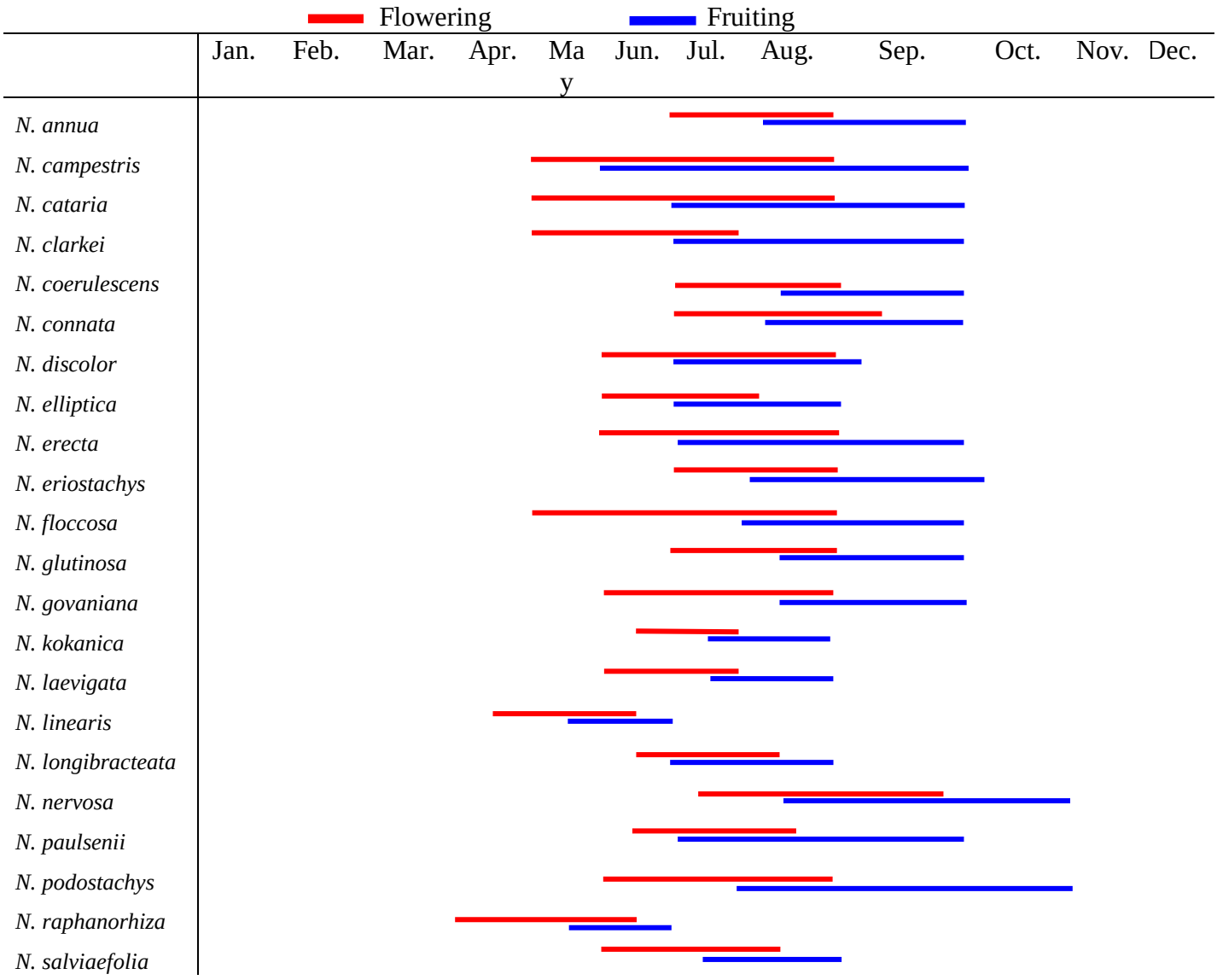


Fig. 5.1: Phenological Calander of *Nepeta* species in the Kashmir Himalaya

5.2. Phytogeoraphy

5.2.1. Distribution of *Nepeta* in the World

The genus *Nepeta* is distributed throughout Central Asia and Europe. The number of species in adjoining countries common with those in the Kashmir Himalaya are summarized in Fig. 5.2. Countries which share highest number of species with Kashmir Himalaya are: Pakistan (16), India (12), Afghanistan (10), China (8) and Russia (7). Japan, Europe and Africa share one species each with the Kashmir Himalaya (Table 5.23).

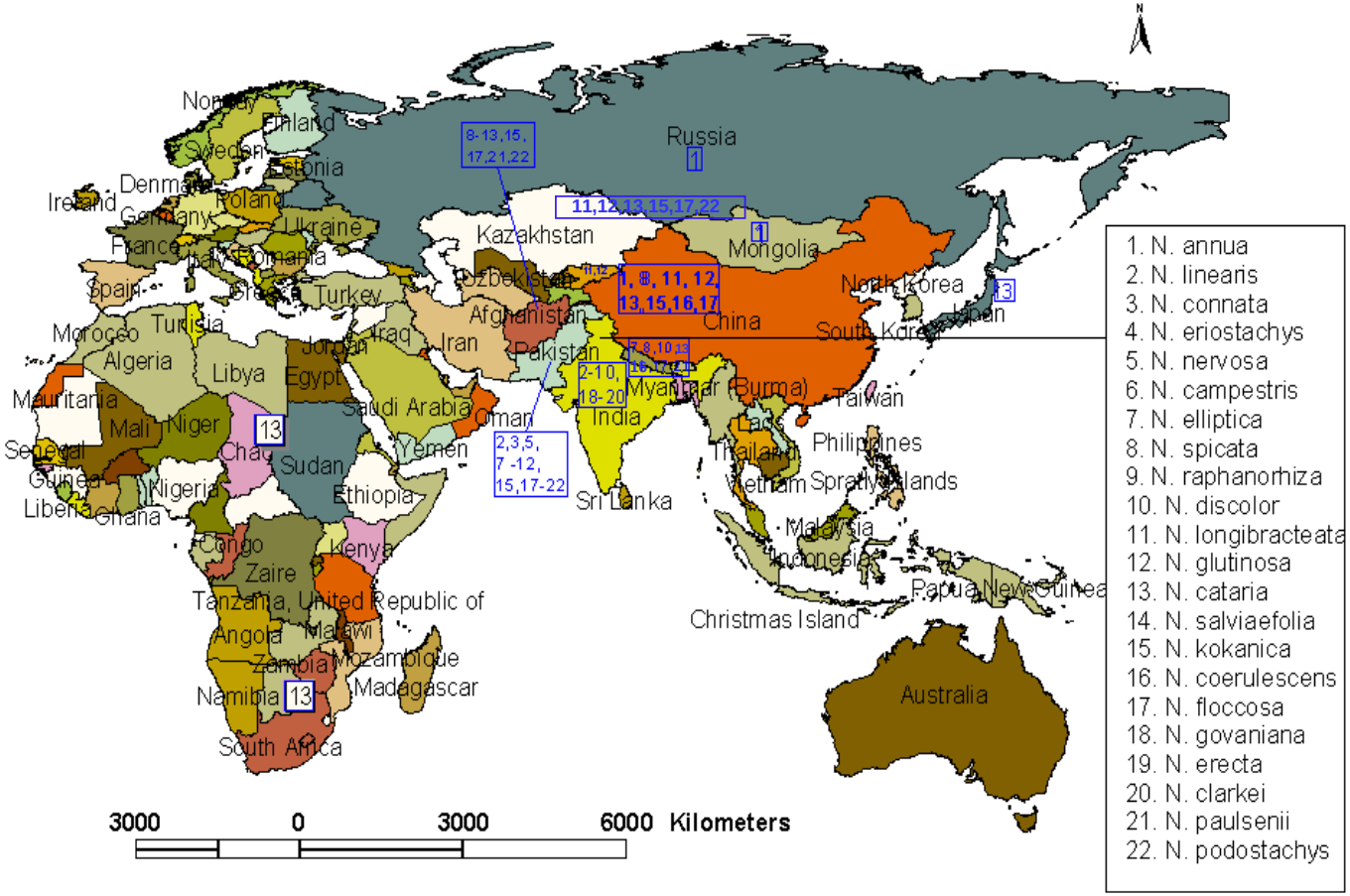


Fig. 5.2: Global distribution of *Nepeta* species reported from the Kashmir Himalaya.

Table 5.23: Number of *Nepeta* species in adjoining countries common with those in the Kashmir Himalaya

Country	Total No. of species	Species common with those in the Kashmir Himalaya
India (incl. KH*)	41	12
Pakistan (incl. parts of KH*)	55	16
Afghanistan	40	10
Nepal	11	5
China	42	8
Japan	2	1
Russia	82	7
Iran	78	0
Iraq	15	0
Turkey	35	0
Europe	24	1
Africa	6	1

*KH = Kashmir Himalaya.

5.2.2. Distribution of *Nepeta* in India

Nepeta constitutes about 27.3% (41 species) of Indian Labiates distributed in every part of country except South (Mukerjee, 1940). The statewise distribution pattern of the genus in the country is summarized in Fig. 5.3.

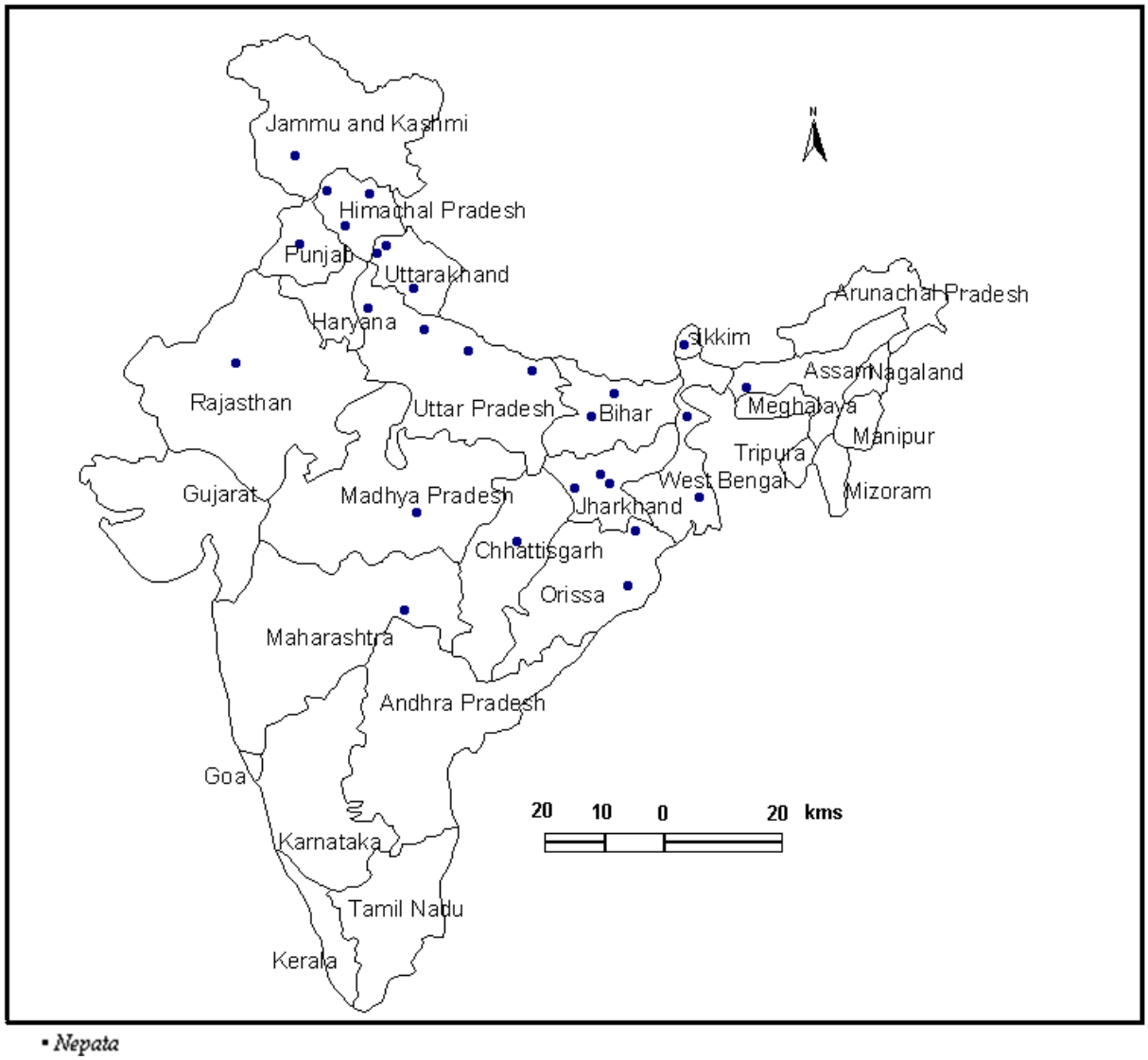
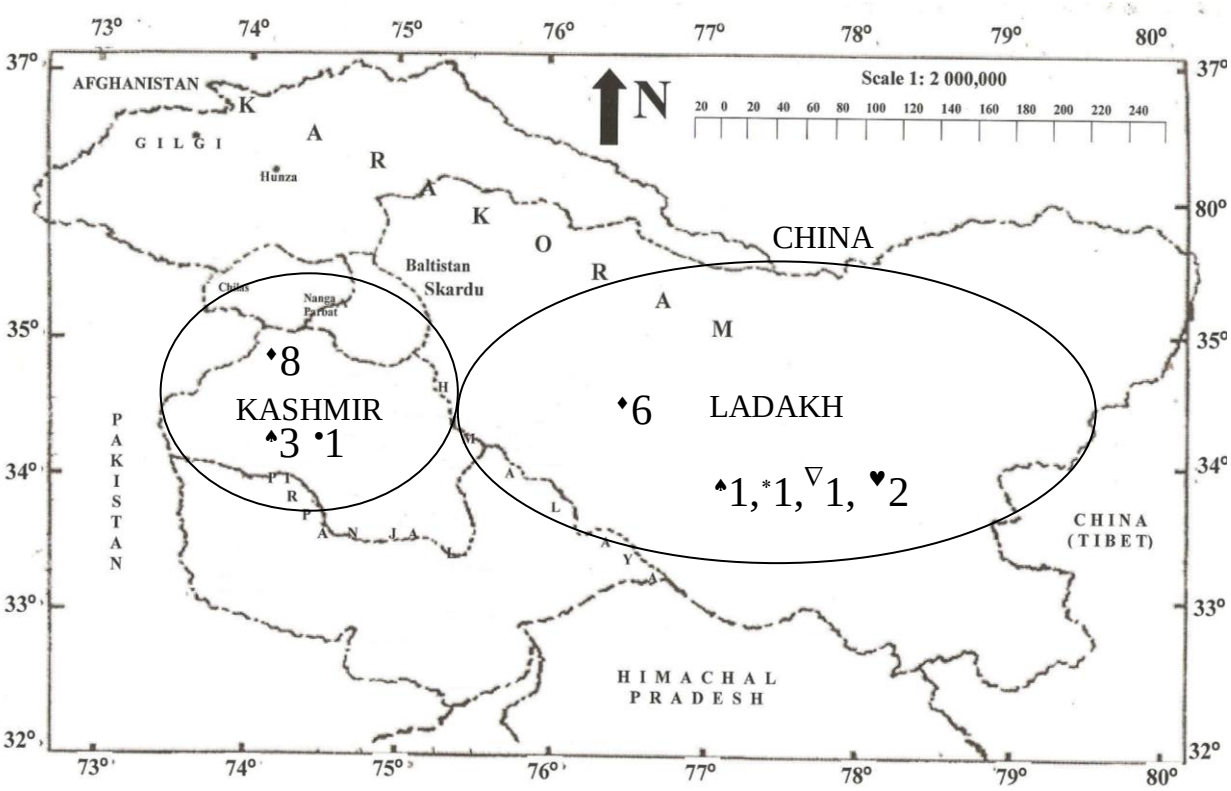


Fig. 5.3: Occurrence of *Nepeta* in different States of India.

5.2.3. Distribution of *Nepeta* in the Kashmir Himalaya

During the course of present study, 22 species were collected from the Kashmir Himalaya (12 from Kashmir and 11 from Ladakh) [Fig. 5.4]. Out of these, 14 belong to sect. *Pycnonepeta*, 8 species including *N. campestris*, *N. clarkei*, *N. connata*, *N. elliptica*, *N. laevigata*, *N. linearis*, *N. nervosa* and *N. raphanorhiza* are restricted to Kashmir region only whereas, 6 species including *N. coerulescens*, *N. discolor*, *N. eriostachys*, *N. paulsenii*, *N.*

kokanica and *N. podostachys* are restricted to Ladakh region only. Sect. *Macronepeta* comprises *N. erecta*, *N. govaniana* and *N. salviaefolia*. The former two are restricted to Kashmir region and latter one occurs in both the regions. Sect. *Cataria* representing only *N. cataria* is restricted to Kashmir region. The other four species including *N. annua* (*Shizonepeta*), *N. floccosa* (*capituliferae*), *N. glutinosa* and *N. longibracteata* (*Glechomanthe*) are represented from Ladakh region only (Table 5.24).



♦: *Pycnonepeta*; ♠: *Macronepeta*; •: *Cataria*; *: *Shizonepeta*; ▽: *Capituliferae*; ♥: *Glechomanthe*

Fig. 5.4: Distribution of *Nepeta* in Kashmir and Ladakh, with number of species in the 6 Sections represented here.

Table 5.24: Species of *Nepeta* in Kashmir and Ladakh regions

Name of species	Kashmir region	Ladakh region	Common to both	Altitudinal range (m. asl)
N. annua	-	+	-	3500-4000
N. campestris	+	-	-	2600-3000
N. cataria	+	-	-	1600-2000
N. clarkei	+	-	-	2300-2700
N. coerulescens	-	+	-	3300-3800
N. connata	+	-	-	2700-3600
N. discolor	-	+	-	3050-4600
N. elliptica	+	-	-	2000-2800
N. erecta	+	-	-	2000-2700
N. eriostachys	-	+	-	3000-3500
N. floccosa	-	+	-	3000-4200
N. glutinosa	-	+	-	3200-4000
N. govaniana	+	-	-	2600-3800
N. kokanica	-	+	-	3050-3500
N. laevigata	+	-	-	2200-3000
N. linearis	+	-	-	2200-2800
N. longibracteata	-	+	-	4000-5300
N. nervosa	+	-	-	2300-3500
N. paulsenii	-	+	-	3000-3600
N. podostachys	-	+	-	3200-4200
N. raphanorhiza	+	-	-	1600-2300
N. salviaefolia	+	+	+	2000-3400

5.3. Pollen Morphology

The pollen of all the species presently examined are monadic, isopolar and hexacolpate (common features of subfamily Nepetoideae; Harley *et al.*, 1992, Jamzad *et al.*, 2000). The shape varies from euprolate to oblate spheroidal, and the average size varies from 13.81±1.11 - 22.60±1.62µm in the polar axis and from 11.80±0.99 - 21.50±1.81µm in the equatorial axis. The other dimension ranges are: 4.22±0.47 - 8.59±0.84µm in the colpus length, and 0.83±0.33 - 4.94±0.54µm in the colpus width (Table 5.25; Plates 35 - 40). The outline in polar axis is rounded or elliptic.

Nepeta species are also distinguished on the basis of exine sculpturing: bireticulate, punctate, and regularly reticulate. The lumina are distinctly patterned; usually irregular and elongated, polygonal - rounded and irregular-rounded; the muri of the reticulations are smooth. The size, shape, colpus length, exine characters and the colpus membrane can be used as diagnostic characteristics in defining the pollen of the *Nepeta* species. Based on their pollen characters, all the species presently studied are diagnosed as under. The terminology used in describing the pollen morphology is after Erdtman (1954) and Hyde and Adams (1958).

1. *Nepeta annua*: Pollen grains subprolate - prolate spheroidal in shape, 22.60±1.62 × 19.16±0.81µm in size, colpi 4.95±0.28 × 1.89±0.44µm, mesocolpia 4.35±0.43µm long, apocolpia 2.98±0.24µm across. Exine 2.47±0.48µm thick, sexine 1.13±0.33µm thick. Sculpture punctate, density of punctae more, colpus margin straight.
2. *Nepeta campestris*: Pollen grains prolate spheroidal in shape, 15.50 ±0.31 × 14.40±0.48µm in size, colpi 5.65±0.60 × 0.83±0.33µm, mesocolpia 6.29±0.38µm long, apocolpia 3.05±0.29µm across. Exine

2.24±0.45µm thick, sexine 0.70±0.31µm thick.

3. *Nepeta cataria*: Pollen grains oblate spheroidal - euprolate in shape, 15.94 ± 0.45 × 14.13 ± 3.79µm in size, colpi 6.82 ± 0.55 × 2.39 ± 0.44µm, mesocolpia 5.31±0.49µm long, apocolpia 3.46±0.53µm across. Exine 1.93±0.41µm thick, sexine 1.01±0.31µm thick. Sculpture bireticulate, lumina elongated.

4. *Nepeta clarkei*: Pollen grains prolate spheroidal - oblate spheroidal in shape, 18.67±1.45 × 18.63±0.49µm in size, colpi 6.78±0.53 × 3.71±0.64µm, mesocolpia 4.91±0.31µm long, apocolpia 3.38±0.34µm across. Exine 2.95±0.26µm thick, sexine 1.28±0.43µm thick.

5. *Nepeta coerulescens*: Pollen grains oblate spheroidal in shape, 18.18 ± 2.25 × 19.24 ± 1.58µm in size, colpi 8.24 ± 0.83 × 3.96 ± 0.31µm, mesocolpia 4.96±0.31µm long, apocolpia 3.10±0.34µm across. Exine 3.95±0.33µm thick, sexine 2.09±0.25µm thick.

6. *Nepeta connata*: Pollen grains subprolate - prolate spheroidal in shape, 17.84±2.31 × l5.58±1.48µm in size, colpi 7.65±0.79 × 3.87±0.52µm, mesocolpia 5.34±0.44µm long, apocolpia 4.25±0.52µm across. Exine 2.99±0.33µm thick, sexine 2±0.19µm thick.

7. *Nepeta discolor*: Pollen grains suboblate - prolate spheroidal in shape, 16.04±0.62 × 16.71±2.32µm in size, colpi 6.07±0.51 × 1.44±0.35µm, mesocolpia 5.31±0.39µm long, apocolpia 3.25±0.38µm across. Exine 3.85±0.39µm thick, sexine 2±0.35µm thick.

8. *Nepeta elliptica*: Pollen grains oblate spheroidal - suboblate in shape, 15.34±1.90 × 18±0.31µm in size, colpi 4.91±0.36 × 3.70±0.61µm, mesocolpia 5.30±0.36µm long, apocolpia

4.10±0.30µm across. Exine 1.03±0.30µm thick, sexine 0.51±0.11µm thick. Sculpture bireticulate, lumina irregular - rounded, lumina size not uniform, muri prominent, colpus margin thick.

9. *Nepeta erecta*: pollen grains subprolate-prolate spheroidal in shape, 18.29±1.09 × l6.19±0.45µm in size, colpi 6.95±0.34 × 2.98±0.32µm, mesocolpia 5.34±0.35µm long, apocolpia 3.35±0.38µm across. Exine 3.01±0.42µm thick, sexine 1.45±0.19µm thick.

10. *Nepeta eriostachys*: Pollen grains subprolate - euprolate in shape, 16.64±1.56 × 12.47±1.22µm in size, colpi 7.73±0.87 × 4±0.25µm, mesocolpia 4.31±0.38µm long, apocolpia 3.09±0.24µm across. Exine 3.49±0.49µm thick, sexine 2.03±0.23µm thick. Sculpture punctate, punctae triangular or irregular, density of punctae less, colpus margin straight or coarsely - straight.

11. *Nepeta floccosa*: Pollen grains subprolate- prolate spheroidal shape, 13.81±l.ll × 11.99±0.40µm in size, colpi 5.69±0.65 × 3.84±0.58µm, mesocolpia 5.81±0.61µm long, apocolpia 3.14±0.30µm across. Exine 1.98±0.47µm thick, sexine 1.05±0.24µm thick.

12. *Nepeta glutinosa*: Pollen grains oblate spheroidal in shape, 18.02±1.21 × 19.02±1µm in size, colpi 9.18±1.25 × 3.03±0.31µm, mesocolpia 6.40±0.38µm long, apocolpia 3.13±0.33µm across. Exine 2.97±0.37µm thick, sexine 2.14±0.34µm thick.

13. *Nepeta govaniana*: Pollen grains prolate spheroidal in shape, 15.45±0.93 × 14.34±0.70µm in size, colpi 7.35±0.44 × 3.50±0.31µm, mesocolpia 6.14±0.46µm long, apocolpia 2.31±0.39µm across. Exine 3.10±0.24µm thick, sexine 1.70±0.15µm thick.

14. *Nepeta kokanica:* Pollen grains prolate spheroidal in shape, 16.10±0.59 × 15.50±0.38µm in size, colpi 4.22±0.47 × 1.01±0.37µm, mesocolpia 4.90±0.45µm long, apocolpia 2.90±0.17µm across. Exine 3.74±0.57µm thick, sexine 1.24±0.42µm thick.

15. *Nepeta laevigata:* Pollen grains prolate spheroidal in shape, 15.03±0.27 × 14.04±0.58µm in size, colpi 5.91±0.44 × 0.93±0.30µm, mesocolpia 6.76±0.57µm long, apocolpia 3.06±0.32µm across. Exine 2.91±0.29µm thick, sexine 0.78±0.47µm thick. Sculpture bireticulate, lumina irregular, muri prominent, secondary lumina star-shaped, colpus margin thick and straight, a thick midrib in the middle.

16. *Nepeta linearis*: Pollen grains subprolate in shape, 15.68±1.13 × 12.04±0.86µm in size, colpi 5.98±0.41 × 1.98±0.27µm, mesocolpia 5.04±0.27µm long, apocolpia 3.08±0.25µm across. Exine 2.96±0.31µm thick, sexine 2±0.3lµm thick. Sculpture bireticulate, lumina irregular - rounded, muri less prominent, colpus margin straight.

17. *Nepeta longibracteata*: Pollen grains prolate spheroidal in shape, 20.21± 0.95 × 17.99±0.75µm in size, colpi 7.62±0.88 × 3.84±0.48µm, mesocolpia 6.35±0.43µm long, apocolpia 3.39±0.36µm across. Exine 2.88±0.58µm thick, sexine 1.05±0.31µm thick.

18. *Nepeta nervosa*: Pollen grains oblate spheroidal-suboblate in shape, 18.93±2.39 × 21.50±1.81µm in size, colpi 7.74±0.77 × 3.05±0.33µm, mesocolpia 5.79±0.48µm long, apocolpia 3.03±0.27µm across. Exine 2.04±0.39µm thick, sexine 0.96±0.39µm thick. Sculpture bireticulate, lumina of the primary muri polygonal - rounded, muri less prominent, colpus membrane thick and finely - granulate.

19. *Nepeta paulsenii*: Pollen grains oblate spheroidal - prolate spheroidal in shape, 16.29±0.60 × 16.26±0.90µm in size, colpi 7.63±0.98 × 3.96±0.35m, mesocolpia 5±0.3lµm long, apocolpia 2.98± 0.21µm across. Exine 1.83±0.49µm thick, sexine 1.40±0.41µm thick. Sculpture punctate, punctae irregular, density of punctae more, colpus margin straight.

20. *Nepeta podostachys*: Pollen grains subprolate in shape, 15.71±1.40 × 11.80±0.99µm in size, colpi 7.62±0.85× 2.83±0.47µm, mesocolpia 5.39±0.33µm long, apocolpia 3.05±0.21µm across. Exine 2.34±0.37µm thick, sexine 1.26±0.35µm thick. Sculpture bireticulate, muri less prominent, colpus margin thick.

21. *Nepeta raphanorhiza*: Pollen grains subprolate - prolate spheroidal in shape, 18.93±1.32 × 16.30±0.79µm in size, colpi 5.85±0.37 × 2.83±0.40µm, mesocolpia 4.95±0.24µm long, apocolpia 2.44±0.36µm across. Exine 2.34±0.40µm thick, sexine 1.39±0.41µm thick.

22. *Nepeta salviaefolia*.: Pollen grains oblate spheroidal in shape, 19.70±0.94 × 20.14±0.79µm in size, colpi 8.59±0.84 × 4.94±0.54µm, mesocolpia 6.01±0.21µm long, apocolpia 3.83±0.46µm across. Exine 1.93±0.31µm thick, sexine 1.04±0.29µm thick. Sculpture bireticulate.

Table 5.25: Pollen morphology of *Nepeta* species in the Kashmir Himalaya

Characters	P(µm) *		E(µm) *		P/E*	Clg(µm) *		Clt(µm) *		Exine (µm) *		Shape
	Mean	Std	Mean	Std		Mean	Std	Mean	Std	Mean	Std	
Nepeta annua	22.60	1.62	19.16	0.81	1.14-1.21	4.95	0.28	1.89	0.44	2.47	0.48	Sp-Ps
N. campestris	15.50	0.31	14.40	0.48	1.06-1.09	5.65	0.60	0.83	0.33	2.24	0.45	Ps
N. cataria	15.94	0.45	14.13	3.79	0.91-1.49	6.82	0.55	2.39	0.44	1.93	0.41	Os-Ep
N. clarkei	18.67	1.45	18.63	0.49	0.94-1.05	6.78	0.53	3.71	0.64	2.95	0.26	Os-Ps
N. coerulescens	18.18	2.25	19.24	1.58	0.90-0.98	8.24	0.83	3.96	0.31	3.95	0.33	Os
N. connate	17.84	2.31	15.58	1.48	1.10-1.18	7.65	0.79	3.87	0.52	2.99	0.33	Sp-Ps
N. discolor	16.04	0.62	16.71	2.32	0.87-1.07	6.07	0.51	1.44	0.35	3.85	0.39	So-Ps
N. elliptica	15.34	1.90	18.00	0.31	0.75-0.94	4.91	0.36	3.70	0.61	1.03	0.30	Os- So
N. erecta	18.29	1.09	16.19	0.45	1.09-1.16	6.95	0.34	2.98	0.32	3.01	0.42	Sp-Ps
N. eriostachys	16.64	1.56	12.47	1.22	1.32-1.34	7.73	0.87	4.00	0.25	3.49	0.49	Ep-Sp
N. floccose	13.81	1.11	11.99	0.40	1.09-1.20	5.69	0.65	3.84	0.58	1.98	0.47	Sp-Ps
N. glutinosa	18.02	1.21	19.02	1.00	0.93-0.96	9.13	1.25	3.03	0.31	2.97	0.37	Os
N. govaniana	15.45	0.93	14.34	0.70	1.06-1.08	7.35	0.44	3.50	0.31	3.10	0.24	Ps
N. kokanica	16.10	0.59	15.50	0.38	1.02-1.05	4.22	0.47	1.01	0.37	3.74	0.57	Ps
N. laevigata	15.03	0.27	14.04	0.58	1.04-1.09	5.91	0.44	0.93	0.33	2.91	0.29	Ps
N. linearis	15.68	1.13	12.04	0.86	1.23-1.30	5.98	0.41	1.98	0.27	2.96	0.31	Sp
N. longibracteata	20.21	0.95	17.99	0.75	1.11-1.12	7.62	0.88	3.84	0.48	2.88	0.58	Ps
N. nervosa	18.93	2.39	21.50	1.81	0.84-0.91	7.74	0.77	3.04	0.33	2.04	0.39	Os-So
N. paulsenii	16.29	0.60	16.26	0.90	0.98-1.02	7.63	0.98	3.96	0.35	1.83	0.49	Os-Ps
N. podostachys	15.71	1.40	11.80	0.99	1.32-1.33	7.62	0.85	2.83	0.47	2.34	0.37	Sp
N. raphanorhiza	18.93	1.32	16.30	0.79	1.13-1.18	5.85	0.37	2.83	0.40	2.34	0.40	Sp-Ps
N. salviaefolia	19.70	0.94	20.14	0.79	0.96-0.98	8.59	0.84	4.94	0.54	1.93	0.31	Os

* Numbers refer to mean and standard deviation. (Std.); P-polar axis; E-equatorial width; Ps-prolate spheroidal; Os-oblate spheroidal; So-suboblate; Sp-subprolate; Ep-euprolate; Os-oblate spheroidal; Clg-colpus length; Clt-colpus width.

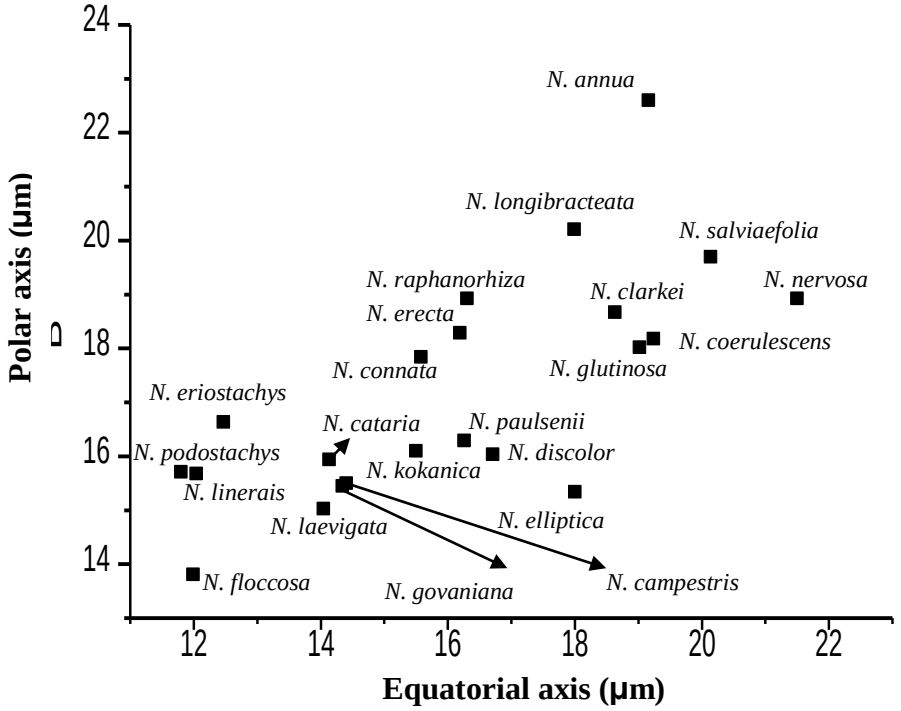


Fig. 5.5: Pollen axis variation among 22 species of *Nepeta* in the Kashmir Himalaya

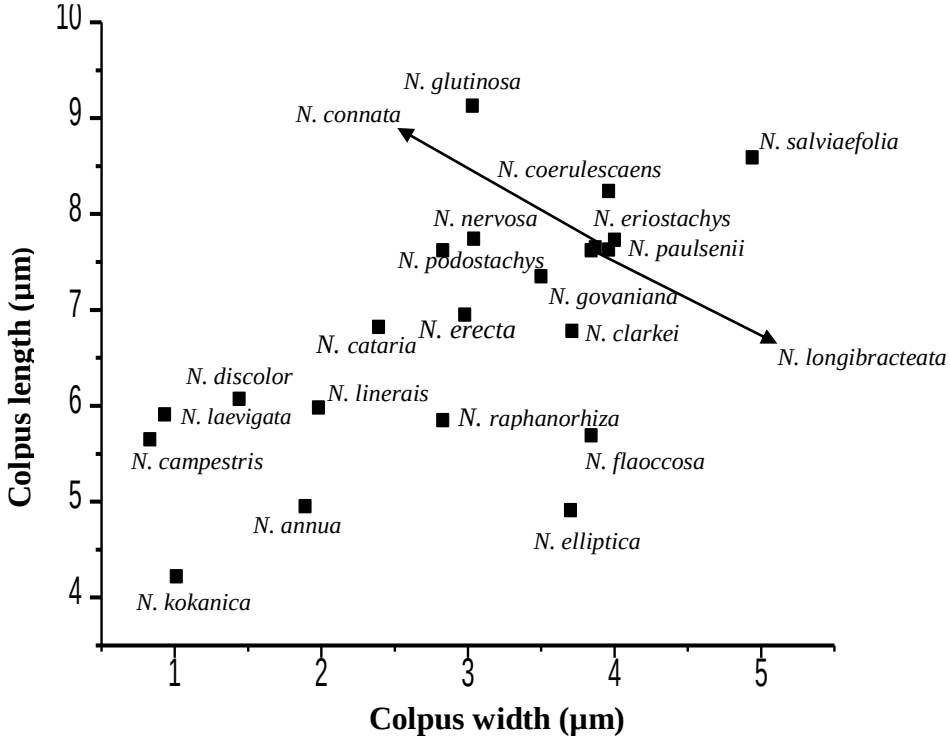


Fig. 5.6: Graphic representation of colpus length – width among 22 species of *Nepeta* in the Kashmir Himalaya

5.5. Chromosome studies

In the present endeavour chromosome counts of 6 species of *Nepeta* inhabiting Kashmir Himalaya have been worked out (Table 5.28; Plate 53), utilizing pollen mother cells (PMCs). With the exception of *N. cataria*, which possesses 2n = 32, rest of the species have 2n = 18, thereby indicating the base numbers x = 9 and x = 16.

Table 5.26: Chromosome numbers of some *Nepeta* species worked out during the present study

Species	Reported count		Present count	
	N	2n	n	2n
N. cataria		30 (Majovsky, *et al.*, 1970)		
	16 (Bushnell, 1936)	32 (Bushnell, 1936)	16	32
	17 (Gill, 1969)	34 (Mulligan, 1959 ; Uhrikova, Murin [I. Slov. fl. I. 1967]; Morton, 1973 ; Markova and Thu, 1974 ; Gill, 1979)		
		36 (Sugiura, 1937, 1940; Darlington, and Wylie, 1955; Lee, 1967; Podlech, and Dieterle, 1969; Vakar and Leshukova, 1970; Aydogdu, 2002).		
N. elliptica		18 (Gill, 1969)	9	18
N. laevigata		18 (Gill,1969)	9	18
N. linearis		18 (Gill, 1969)	9	18
N. nervosa		14 (Zhukova, 1967)		
		18 (Chuksanova and Kaplanbekova, 1971)	9	18
N. salviaefolia			9	18

Nepeta, a high-altitude genus, comprises approximately 300 species, most of which are herbaceous perennials. It is a large widely distributed genus around the world. Annual or perennial herbs, usually aromatic, occasionally gynomonoecious or gynodioecious. Verticillasters in spikes or opposite cymes in racemes or panicles; floral leaves bractlike; bracts narrow, shorter than or longer than flowers. Calyx ± clearly 15-veined or ribbed, tubular, slightly curved or straight; upper lip 3-dentate, lower 2-dentate; throat straight to strongly oblique. Corolla 2-lipped; tube straight or curved, included in or exserted from calyx; upper and lower lips relatively short. Stamens 4, didynamous, posterior pair longer than anterior. NepetStyle unequally bilobed. Nutlets ellipsoid to obovoid (Hedge, 1990).

Relationships of *Nepeta* with *Dracocephalum* and *Lallemantia* are considered as significant so as to treat these three genera are synonymous (Budantsev, 1993a). But, the results of Jamzad *et al.* (2003a) indicate that these genera are not closely related. Previously, analysis of restriction site variation of plastid DNA (Wagstaff *et al*., 1995) showed *Lallemantia* to be a sister genus of *Nepeta*, and in an analysis of plastid rbcl DNA sequences (Kaufmann and Wink, 1994), *Dracocephalum* and *Agastache* belonged to two groups in a clade separate from the *Nepeta* (*Lallemantia* was not included in their study). However, some phytochemical data are congruent with this result

(Jamzad, 2001), showing a close relationship of *Nepeta* to *Lallemantia*, and their distinction from *Dracocephalum*.

During the course of the present study, 22 species of *Nepeta* are recorded from the Kashmir Himalaya. These species are: *N. annua*, *N. elliptica*, *N. discolor*, *N. govaniana*, *N. longibracteata*, *N. glutinosa*, *N. linearis*, *N. connata*, *N. coerulescens*, *N. raphanorhiza*, *N. kokanica*, *N. nervosa*, *N. laevigata*, *N. campestris*, *N. eriostachys*, *N. podostachys*, *N. paulsenii*, *N. floccosa*, *N. cataria*, *N. salviaefolia*, *N. erecta*, and *N. clarkei*.

Each of the species has been described in detail with regard to taxonomy, distribution, pollen morphology, nutlet morphology, utility, etc. *N. discolor*, *N. podostachys* and *N. paulsenii* seem to be closely related with each other in having similar spike length, petiole length and outer bracts. The main difference between them is in the shape of leaves (Fig. 6.1). *N. annua* is the only annual species found in Kashmir; with bipinnatisect leaves, this species has been placed in the new genus S*hizonepeta* by Soviet and Chinese botanists. Its affinities appear to be more with the other few members of this taxon rather than with the annual Pakistan species of *Nepeta* (Hedge, 1990). Except *N. annua*, all other species growing in Kashmir Himalaya are perennial. A distinctive oligomorphic species, namely *N. glutinosa*, is easily recognised by its dense- glandular indumentum, serrate-pectinate leaves and long corollas. *N. longibracteata* is the high-alpine scree plant, differentiated by its floral leaves being longer than flowers.

The inflorescence of *N. raphanorhiza* is somewhat similar to that of *N. podostachys*, but here it is longer than in the former species; furthermore, the nutlets of *N. raphanorhiza* are quite different from those of the latter species.

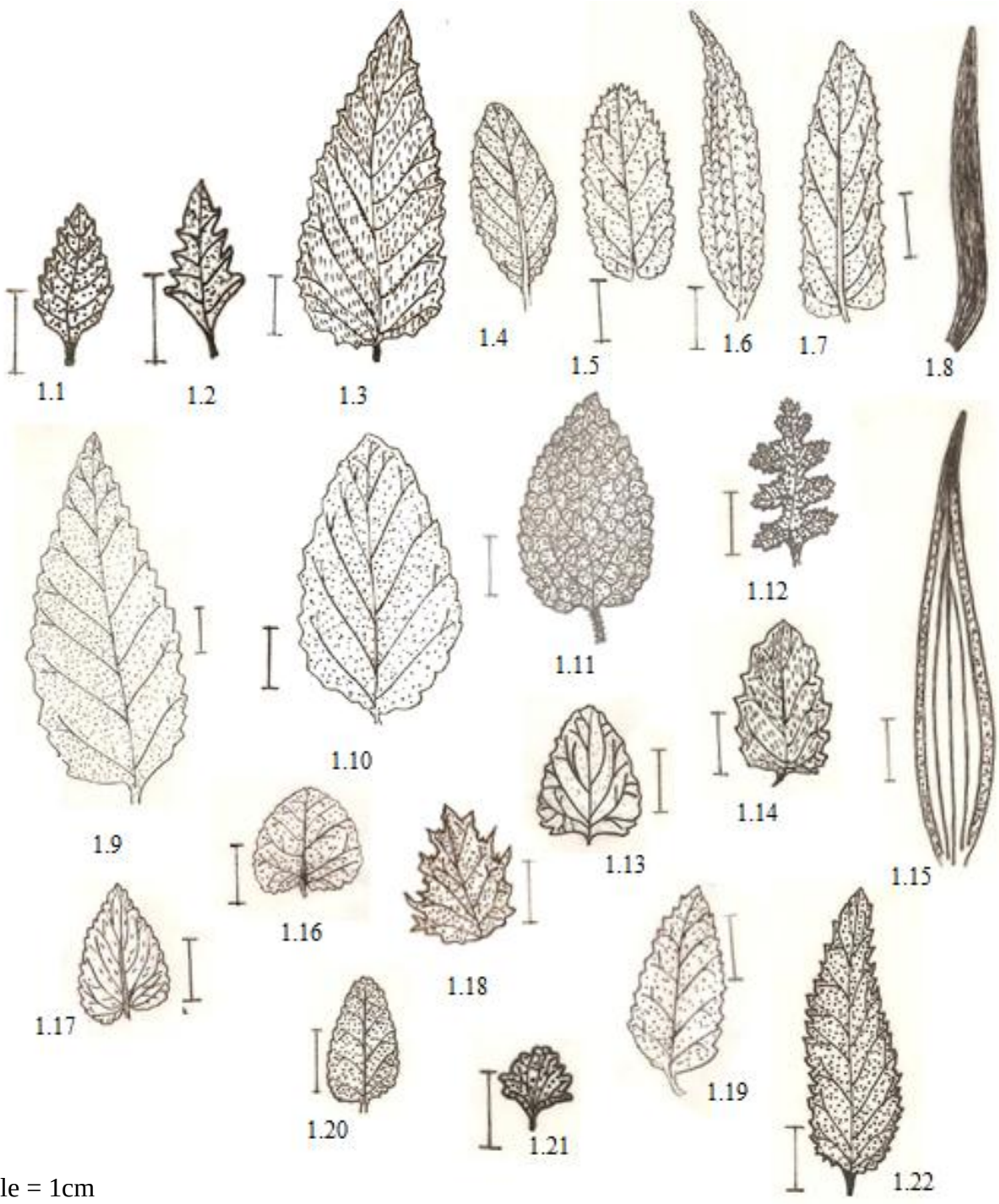
N. podostachys is at the centre of a particularly different complex, concentrated in Afghanistan. Previous authors have sometimes recognized *N. podostachys* as the most variable species, and reduced *N. subincisa* and *N. paulsenii* as synonys within it (Hedge, 1990).

The characteristic features of *N. elliptica* are sessile, apically-rounded leaves with regularly pectinate-serrate margins (Fig. 6.1), and the spicate inflorescence. Some earlier records of the species from Afghanistan and Pakistan (e.g., Hedge and Lamond, 1968; Stewart, 1972) are probably based on mis-identification of *N. subincisa*. In common with its very close allies, i.e., *N. podostachys* and *N. discolor*, *N. paulsenii* is variable in habit, leaf shape, density of indumentum, leaf-toothing and flower colour. Its most characteristic features are the narrow leaves with clusters of young leaves in their axils. *N. laevigata*, growing in a variety of habitats, in some localities a very common plant, is variable in size, leaf dimensions and flower colour, but can be recognized by the petiolate leaves, the generally sparse indumentum, the large outer bracts, and the oblong congested spikes.

N. nervosa is clearly allied to *N. laevigata*, the difference is in the shape of leaf, leaf-toothing, prominent nervation (Fig. 6.1), petiole length and inflorescence length. *N. campestris* is closely related to *N. nervosa*, but with longer spike often interrupted near the base, and oblong-laneceolate leaves, teeth may be broad-triangular. *N. connata* is a handsome and distinct species, almost restricted to shady and dry places of Kashmir. *N. linearis* is similar in several respects to *N. connata*, but differing in the characters of leaf, calyx and corolla. The rather low habit, discolorous leaves, and spicate inflorescence are the characteristic features of *N. discolor*. Its allies are *N. eriostachys* and *N. podostachys.*

N. govaniana, a wet-habitat plant is characterized by almost straight calyx and large yellow falcate corollas; the size of calyx and corolla is almost equal to that of *N. erecta*, with which there is, thus, some resemblance.

N. clarkei is a close ally of *N. erecta* differs from it in having papillose-glandular indumentum. *N. floccosa* is a species of dry slopes or screes. The variation in size, indumentum, bracts, and especially calyx characters, is rather continuous, making its intraspecific division difficult.



Scale = 1cm

Fig. 6.1: Variations in *Nepeta* leaf: 1.1 *N. discolor*; **1.2** *N. paulsenii*; **1.3** *N. coerulescens*; **1.4** *N. salviaefolia.*; **1.5** *N. elliptica*; **1.6** *N. eriostachys*; **1.7** *N. nervosa*; **1.8** *N. linearis*; **1.9** *N. govaniana*; **1.10** *N. erecta*; **1.11** *N. clarkei*; **1.12** *N. annua*; **1.13** *N. raphanorhiza*; **1.14** *N. podostachys*; **1.15** *N. connata*; **1.16** *N. floccosa*; **1.17** *N.cataria*; **1.18** *N. glutinosa*; **1.19** *N. laevigata*; **1.20** *N. kokanica*; **1.21** *N. longibracteata*; **1.22** *N. campestris*.

6.1. Palynology

The pollen grains of different species of *Nepeta* are morphologically heterogeneous. The shape of pollen is not uniform. However, pollen grains of all species examined can be characterized as follows: monadic, isopolar, hexacolpate. The shape varies from euprolate to oblate spheroidal. The average size of pollen grains also varies.

Nepeta pollen show very little interspecific variation when studied under light microscope (LM). These variations are not enough for any sectional groupings within the genus; they, however, prove to be crucial for the classification of individual taxa. In contrast, the exine sculpturing studied through SEM will relatively be enough for the same.

Pollen grains of *N. nervosa, N. salviaefolia, N. elliptica*, *N. erecta and N. glutinosa* have wide colpi (~5). However, pollen grains of *N. floccosa* are distinct in having the smallest polar and equatorial axes among the specimens examined. The polar axis of *N. laevigata* is also smaller than the rest of the pollen in the remaining taxa. The largest pollen grains are found in *N. annua*. The axes variations between *N. glutinosa* and *N. coerulescens,* between *N. linearis* and *N. podostachys,* and also between *N. cataria*, *N. govaniana, N. campestris* and *N. laevigata* are fairly small (Table 5.25; Figs. 5.5-5.6).

The average colpus length varies from 4.22±0.47 to 8.59±0.84µm, and the width from 0.83±0.33 to 4.94±0.54 µm among the pollen of *Nepeta* taxa (Table 5.25). Pollen of three species of *Nepeta* - *N. glutinosa*, *N. coerulescens* and *N. salviaefolia*, can be distinguished from those of the rest of the species by their colpus lengths. Colpus length is greater than 8µm in these three species. Morphological features of *N. connata, N. longibracteata, N. eriostachys* and *N. paulsenii* exhibit similarities in terms of their colpus length-width. However, the pollen shape varies from oblate-spheroidal to euprolate, where as that of *N. longibracteata* is distinctly prolate-spheroidal.

N. eriostachys, *N. paulsenii* and *N. annua* show punctate ornamentation, but *N. eriostachys* is different in having less dense punctae condition. *N. raphanorhiza* and *N. connata* are distinct in having regularly reticulate condition.

Pollen characteristics of the Lamiaceae species, in general, do not correlate well with geographical distribution, altitude or ecological preferences, although the sculpture variation of some *Teucrium* species occurring in Turkey has been attributed by Donmez *et al.* (1999) to the isolated habitat of the species. Pollen of the *Nepeta* species in this study reflected a homogenous nature, regardless of their geographical distribution, similar to most of the Lamiaceae pollen growing in south-east and south-west Asia and Africa (Harley *et al*., 1992; Jamzad *et al*., 2000).

The number of colpi, whether three or six, is the most significant element of the Lamiaceae pollen morphology. However, size and shape of the pollen, exine structure and sculpture, and colpal features, etc. are also important in distinguishing individual taxa.

Pollen of some species of Lamiaceae, as in *Kinostemon* (Cantino and Sanders, 1986) and in *Teucrium* (Abu-Asab and Cantino, 1993; Donmez *et al.*, 1999) bear clearly-defined thickening of the colpus membrane; some species of *Nepeta* possess similar structure.

Colpus margins do not show any peculiar features in most of the Lamiaceae pollen (as in *Acinos*; Kaya and Kutluk, 2007) except Jamzad *et al*. (2000) noting some perforations in *Nepeta*. The margins are also usually uniform in *Nepeta* in Kashmir Himalaya except in some species.

The exine sculpture exhibits variations in the Lamioideae and Nepetoideae subfamilies. It is suprareticulate in all Pogostemenoidae and in most of the Lamioideae. The exine sculpture of the tribe *Ocimeae* (Harlay, 1992; Harley *et al*., 1992) and *Acinos* species (Kaya and Kutluk, 2007) of the

subfamily Nepetoideae are usually reticulate. However, *Nepeta* species show variation from reticulate to punctate.

6.2. Cytology

Table 6.1: *Nepeta* species exhibiting different ploidy levels

Base number (x)	Chromosome number	Ploidy level (x)	Number of species
7	14	2x	1
8	16	2x	21
	32	4x	1
9	18	2x	28
	36	4x	12
12	24	2x	1
13	26	2x	4
14	28	2x	1
15	30	2x	1
17	34	2x	4

Darlington and Wylie, 1955; Fedorov, 1969; Kumar and Subramaniam, 1986; Aydoğdu, 2002 and Aydin and Dirmenci, 2004)

Table 6.2: Species of *Nepeta* existing in two, three and four cytotypes

Name of species	Ploidy level	Chromosome Number	Cytotypes
N. cilicica	2x	26	Two
	4x	28	
N. concolor	2x	24	Two
	2x	26	
N. distans	2x	26	Two
	4x	36	
N. fissa	2x	16	Two
	2x	18	
N. hederacea	2x	18	Two
	4x	36	
N. nepetella	2x	34	Two
	4x	36	
N. nervosa	2x	14	Two
	2x	18	
N. kokanica	2x	18	Three
	2x	34	
	4x	36	
N. cataria	2x	30	Four
	4x	32	
	2x	34	
	4x	36	

Darlington and Wylie, 1955; Fedorov, 1969; Kumar and Subramaniam, 1986; Aydoğdu, 2002 and Aydin and Dirmenci, 2004)

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* Not seen in original

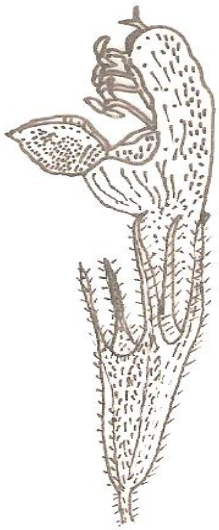
A) Inflorescence

B) Bract

C) Corolla with calyx and stamens

D) Corolla with didynamous condition of stamens

E) Corolla showing dense indumentum on calyx



F) Corolla tube included

Scale:	
A	10mm
B	5mm
C&D	14mm

Plate 1. Some floral parts of *N. elliptica* Royle ex Benth.

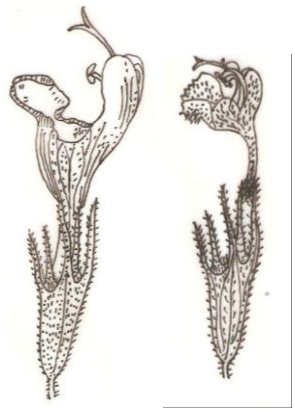
A) Inflorescence

B) Bract

C) Calyx with less indumentum

D) Calyx showing nutlets

E) Corolla with stamens



F) Corolla tube exserted

Scale:	
A	5cm
B	5mm
C	8mm

Plate 2. Some floral parts of *N. erecta* (Royle ex Benth.) Benth.

(A)

(B)

(C)

Plate 3. A) *Nepeta annua*
B) *Nepeta campestris*
C) *Nepeta campestris* showing inflorescence

(A)

(B)

(C)

(D)

Plate 4. A) *N. cataria*
B) *N. cataria* inflorescence
C) *N. clarkei*
D) Flowering stage of *N. clarkei*

(A)

(B)

(C)

(D)

Plate 5. A&B) *N. coerulescens*
C&D) *N. connata*

(A)

(B)

(C)

Plate 6. A) *N. discolor* (Ladakh)
B&C) *N. elliptica*

(A)

(B) (C)

Plate 7. A&B) *N. erecta*
C) *N. erecta* showing inflorescence

(A)

(B)

(C)

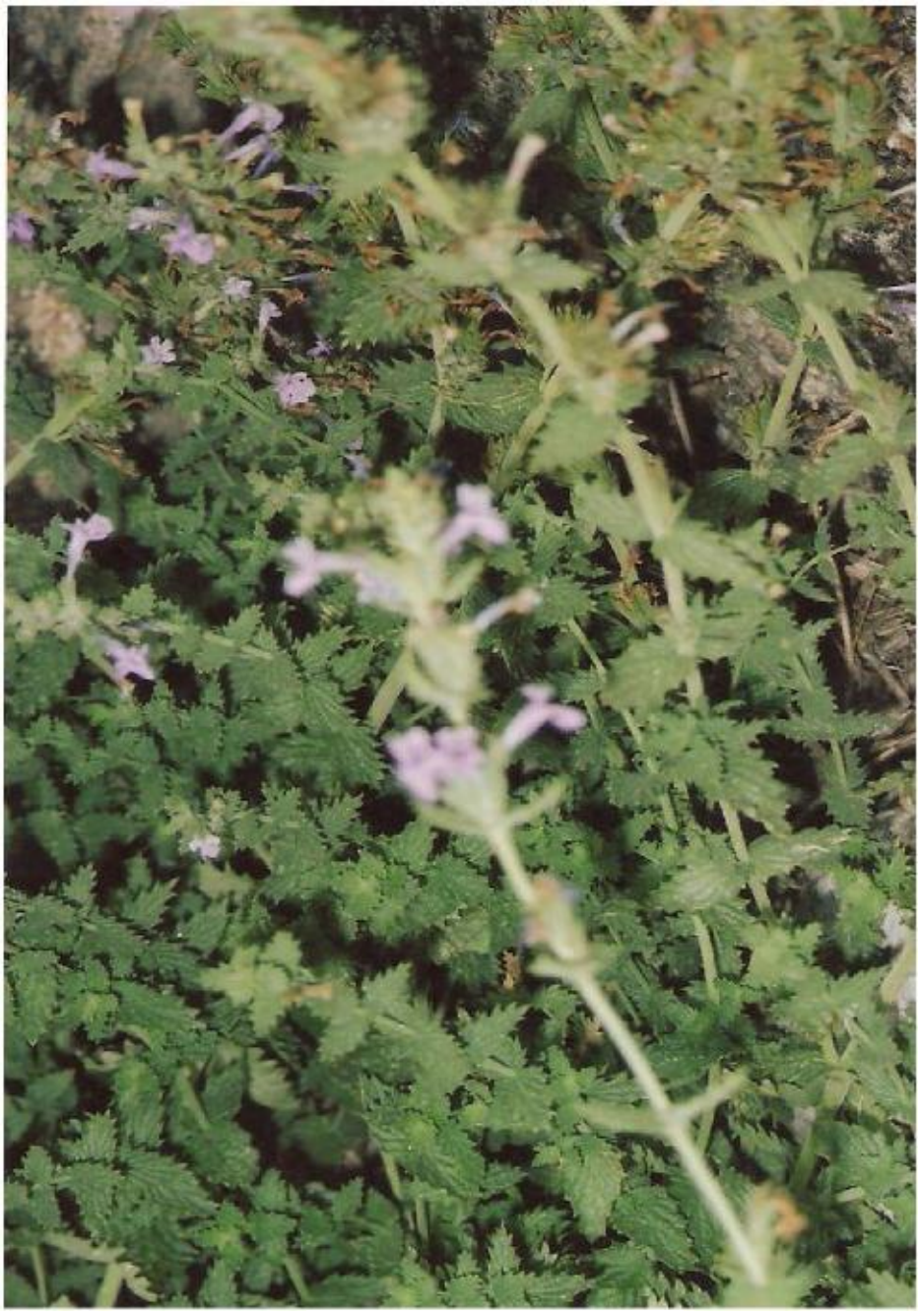
Plate 8. A&B) *N. eriostachys* (Zojila)
C) *N. floccosa* population (Ladakh)

(A)

(B)

(C)

Plate 9. A&B) *N. floccosa* population and inflorescence (Ladakh)
C) *N. glutinosa* population (Zanskar)



(A)

Plate 10. A) *N. glutinosa* inflorescence

(A)

(C)

(D)

Plate 11. A) *N. kokanica*
B&C) *N. laevigata* (Aru Phalgam)

(A)

(B)

(C)

Plate 12. A) *N. linearis*
B) *N. linearis* inflorescence
C) *N. linearis* population (Dachigam)

(A)

(B)

(C)

(D)

Plate 13. A) *N. longibracteata* inflorescence
B) *N. longibracteata* population
C&D) *N. nervosa*

(A)

(B)

(C)

Plate 14. A) *N. paulsenii* population
B) *N. paulsenii* inflorescence
C) *N. podostachys*

(A)

(B)

(C)

Plate 15. A) *N. raphanorhiza* population
B&C) *N. raphanorhiza* inflorescence

(A)

(B)

(C)

(D)

Plate 16. A&B) *N. salviaefolia* inflorescence and population (Ladakh)
C&D) *N. salviaefolia* inflorescence and population (Kashmir)

Plate 19. *Nepeta cataria* L.: a- habit

Plate 21. *Nepeta connata* Royle ex Benth.: a-habit

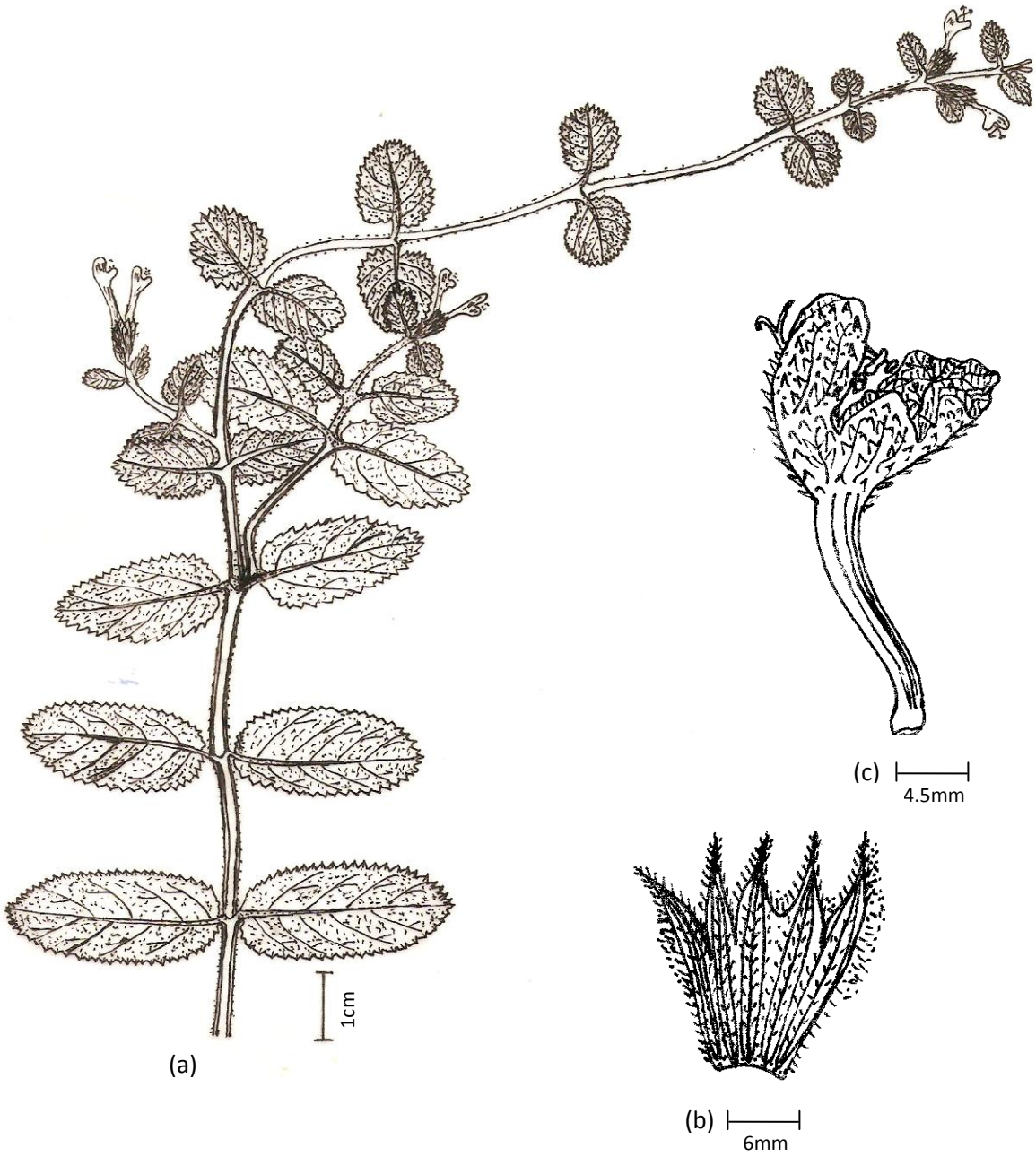


Plate 23. *Nepeta elliptica* Royle ex Benth. : a-habit; b-calyx; c-flower.

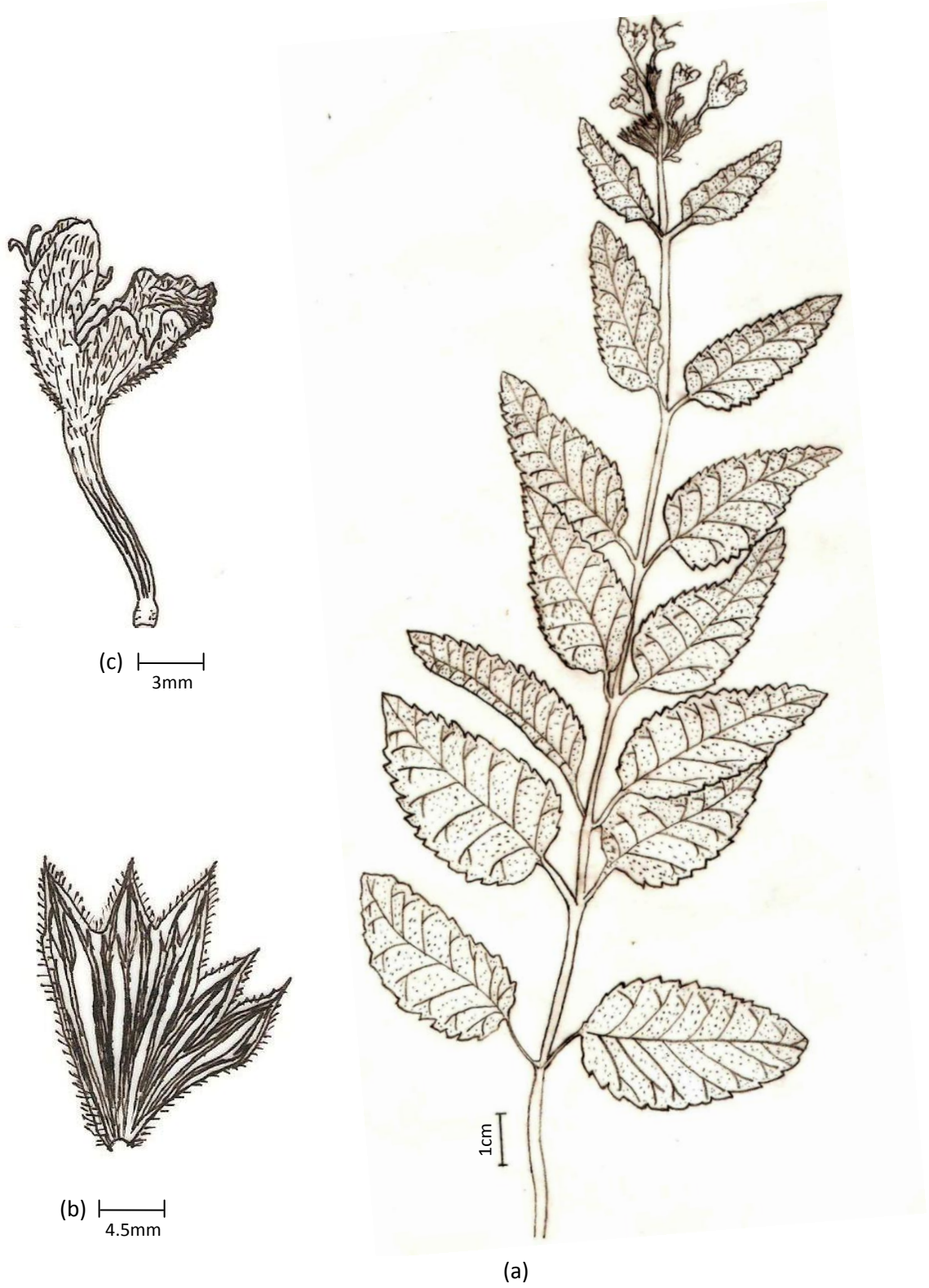


Plate 24. *Nepeta erecta* (Royle ex Benth.) Benth.: a-habit; b-calyx; c-flower.

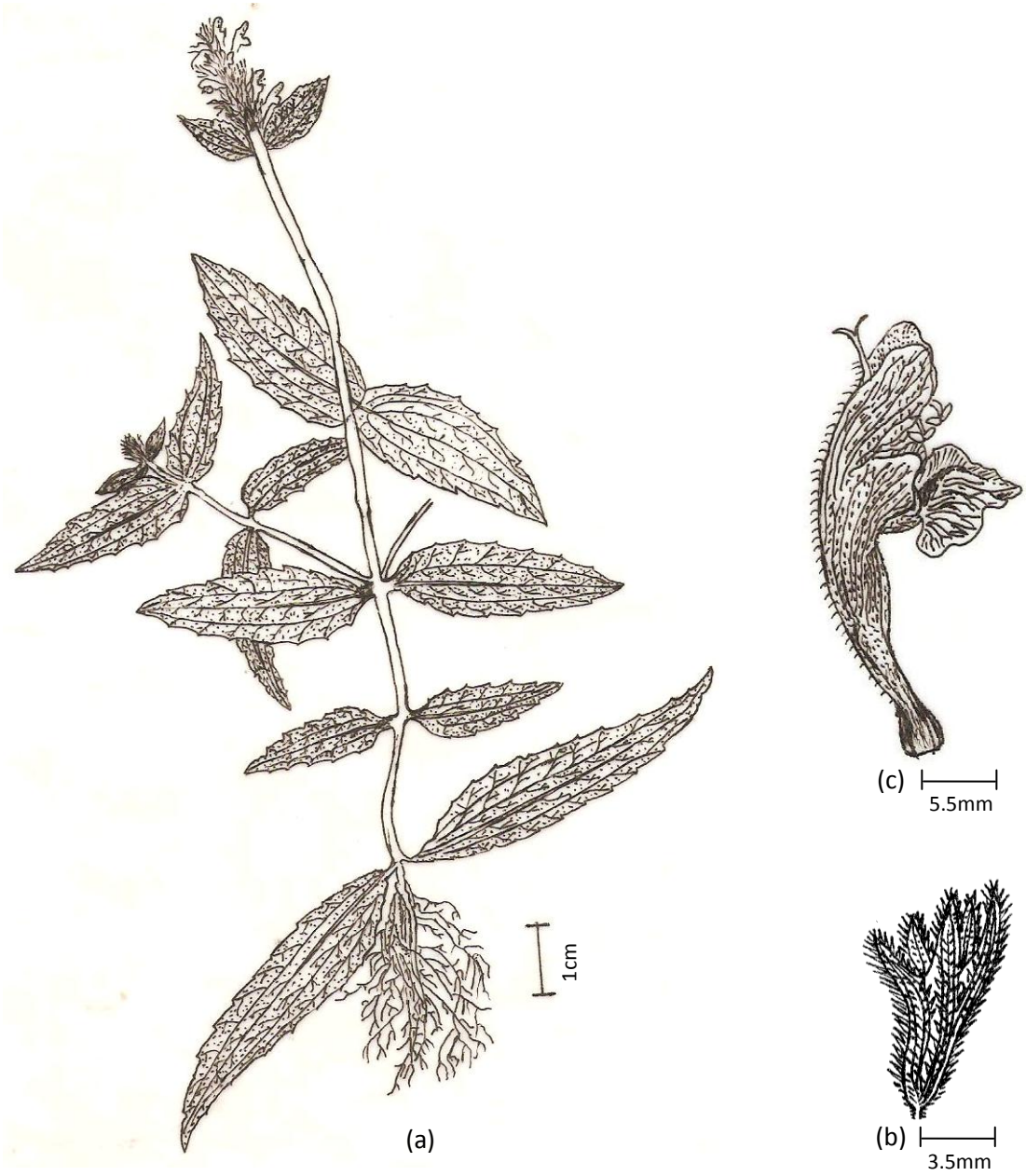


Plate 25. *Nepeta eriostachys* Benth.: a-habit; b-calyx; c-flower.

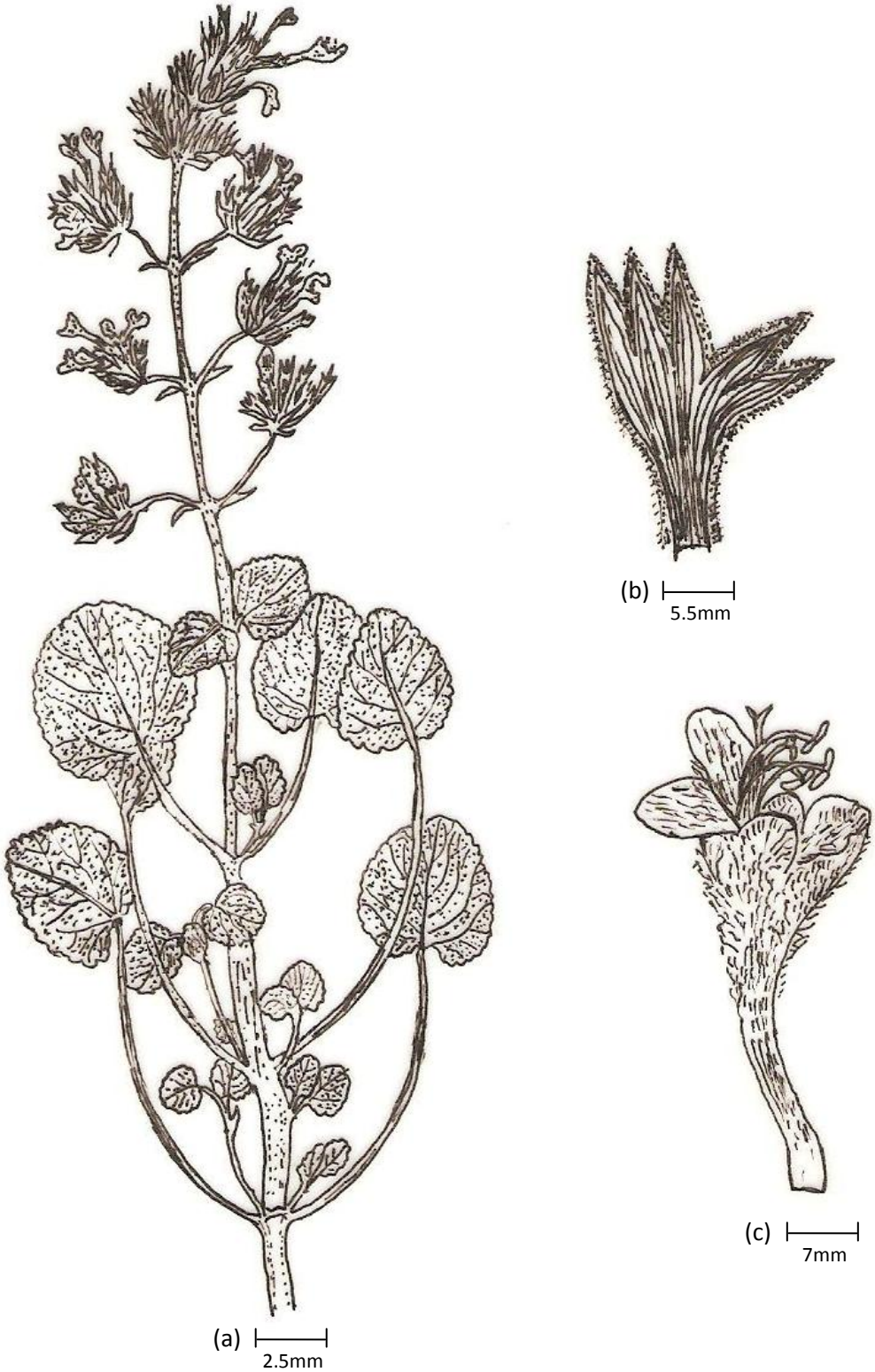


Plate 26. *Nepeta floccosa* Benth.: a-habit; b-calyx; c-flower.

Plate 27. *Nepeta glutinosa* Benth.: a-habit.

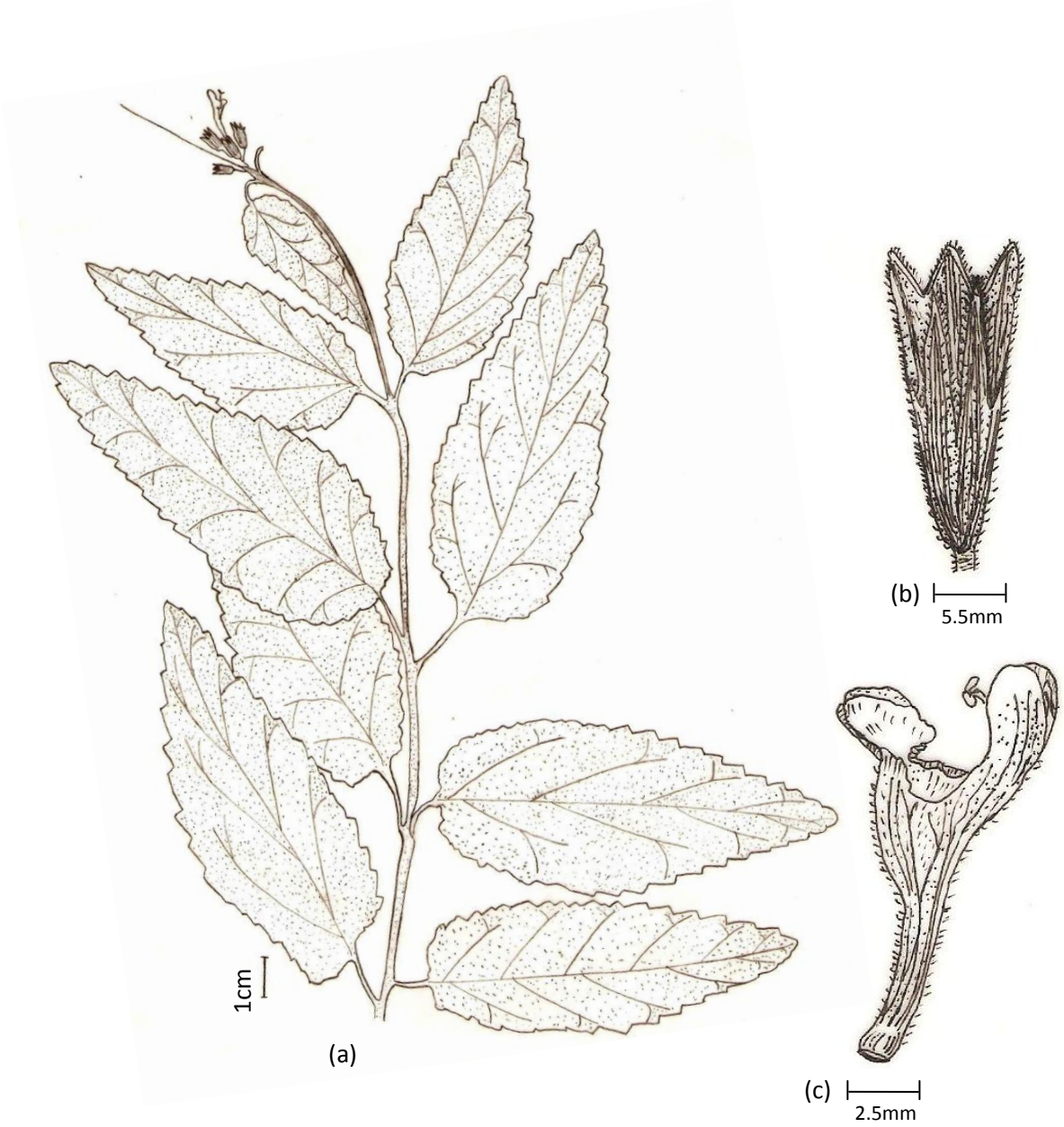


Plate 28. *Nepeta govaniana* (Wall. ex Benth.) Benth.: a-habit; b-calyx; c-flower.

Plate 30. *Nepeta laevigata* (D. Don) Hand.-Mazz.: a-habit

Plate 31. *Nepeta nervosa* Royle ex Benth.: a-habit; b-calyx; c-flower

Plate 32. *Nepeta paulsenii* Briq.: a-habit

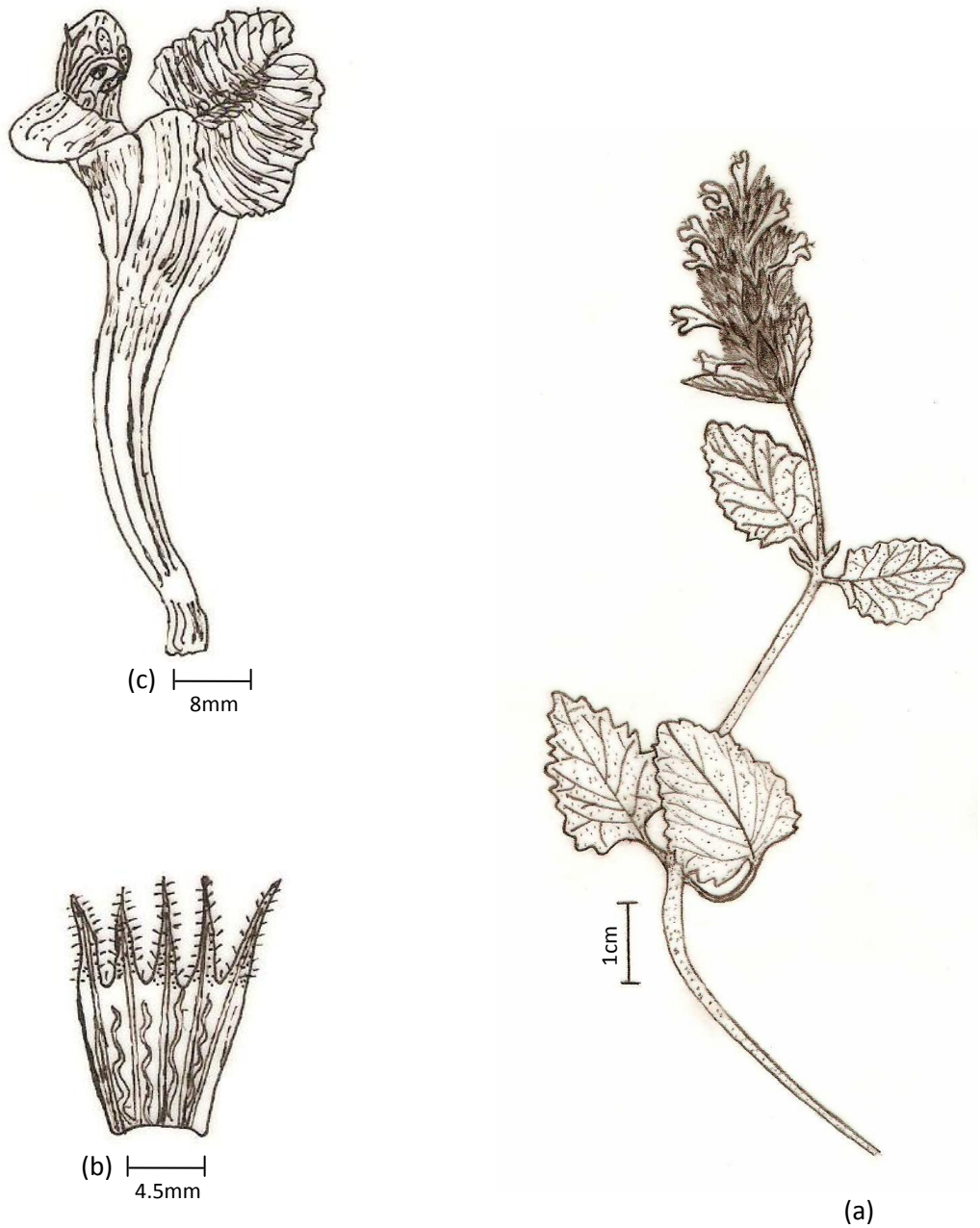


Plate 33. *Nepeta raphanorhiza* Benth.: a-habit; b-calyx; c-flower.

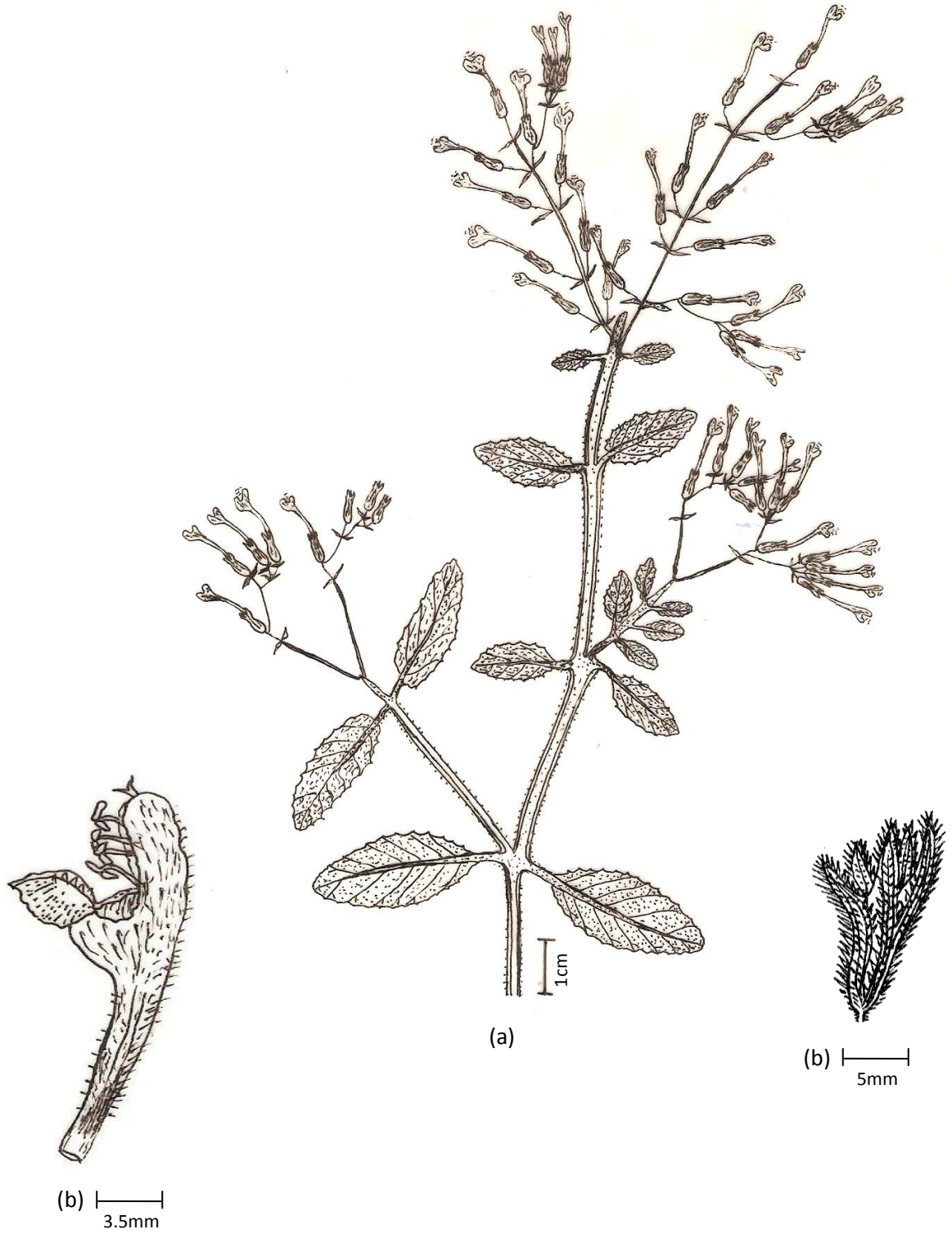


Plate 34. *Nepeta salviaefolia* Royle ex Benth.: a-habit; b-calyx; c-flower.

Plate 18. *Nepeta campestris* Benth.: a-habit.

Plate 20. a) *Nepeta clarkei* Hook.
b) *Nepeta coerulescens* Mixim.

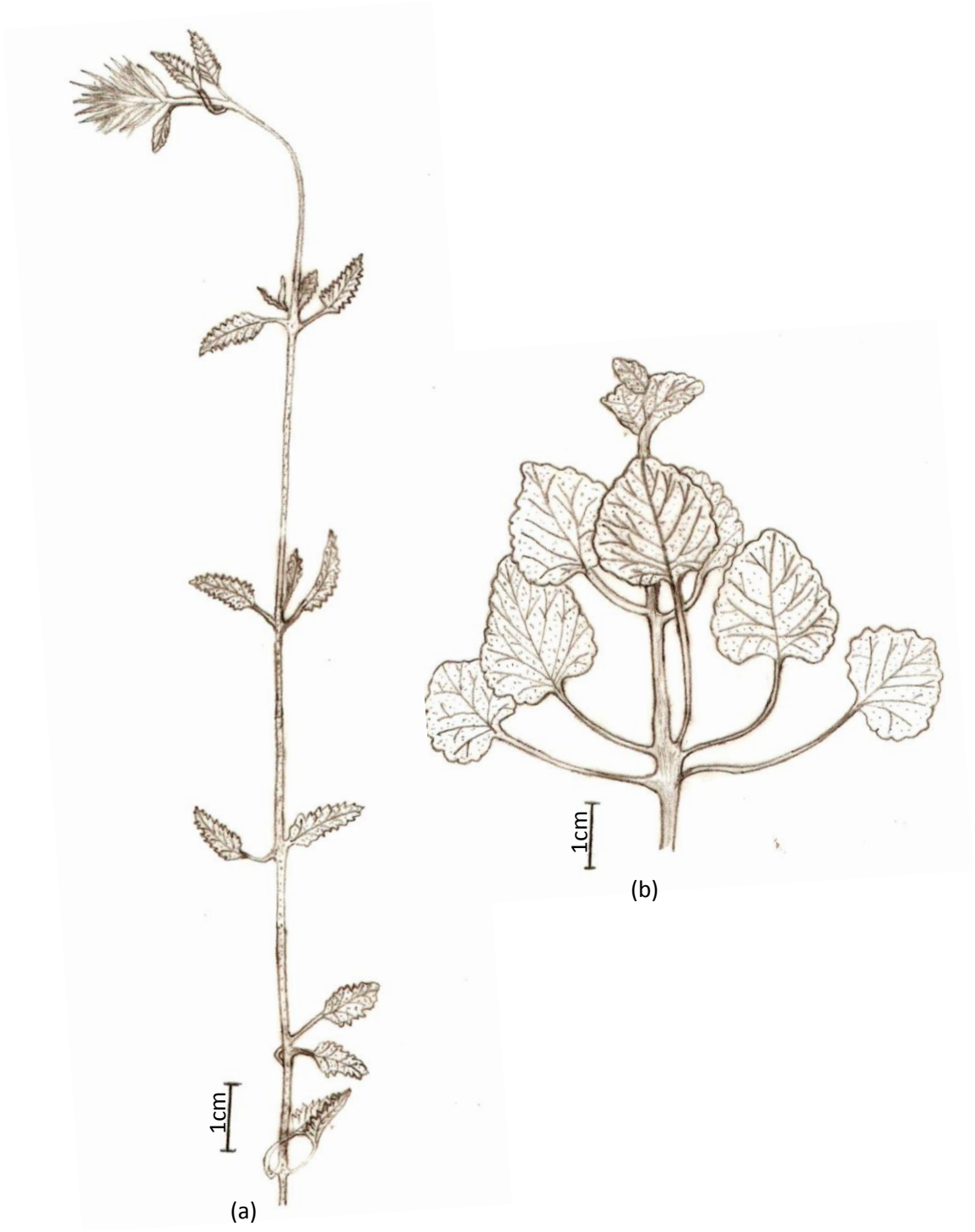
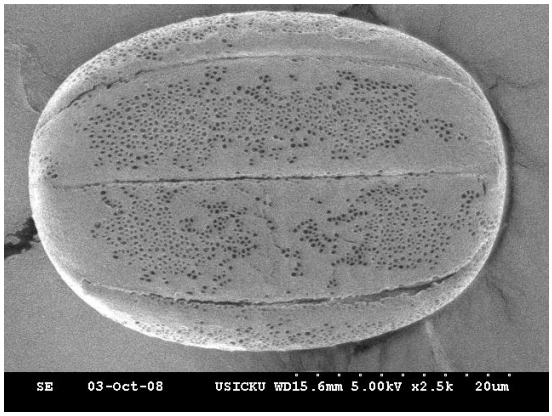


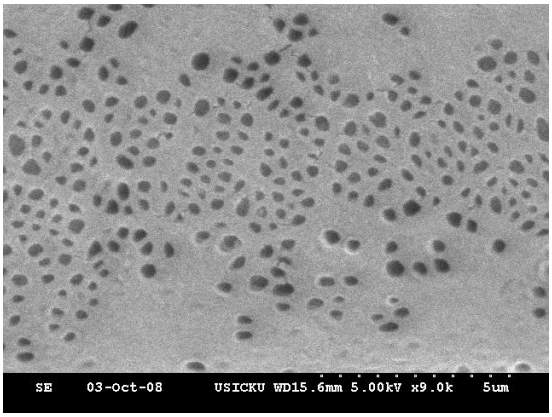
Plate 22. a) *Nepeta discolor* Royle ex. Benth.
b) *Nepeta floccosa* Benth.

Plate 29. a) *Nepeta longibracteata* Benth.
b) *Nepeta kokanica* Briq.
c) *Nepeta linearis* Royle ex. Benth.

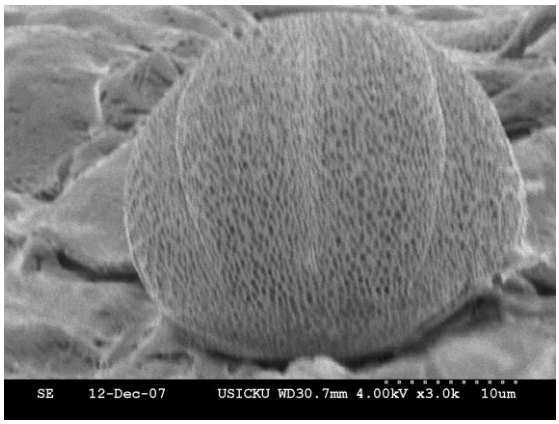
Plate 17. a) *Nepeta podostachys* Benth.
b) *Nepeta annua* Pallas.



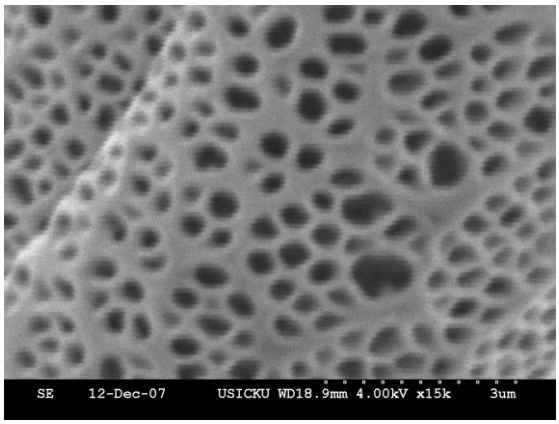
(A)



(B)



(C)

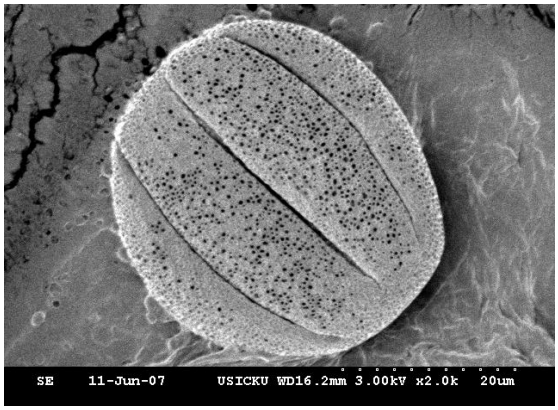


(D)

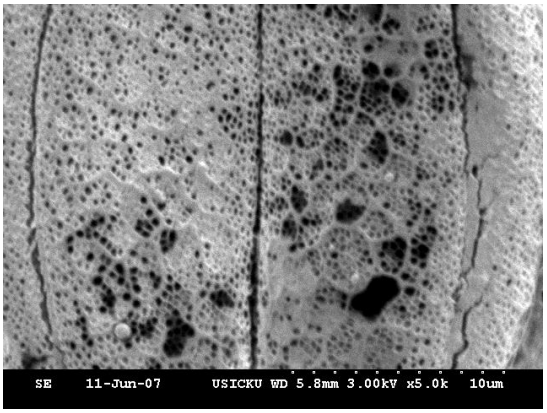
Plate 35. Pollen morphology in *Nepeta* (SEM):

A&B) Punctate ornamentation in *N. annua* and *N. paulsenii*

C & D) *N. elliptica* and *N. podostachys* showing bireticulate ornamentation with prominent primary muri



(A)



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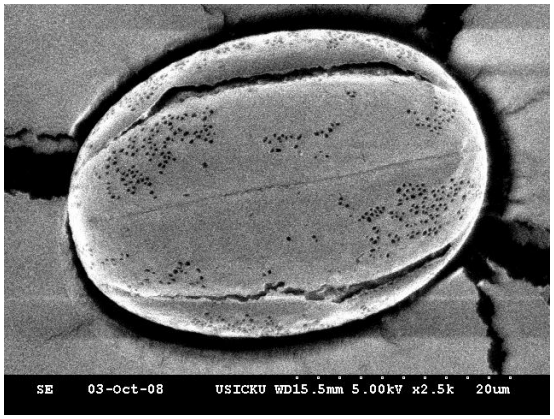
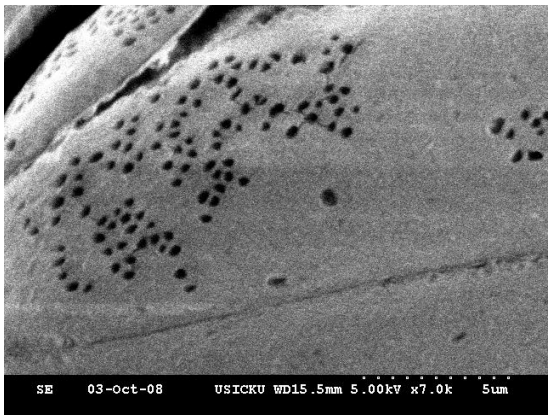


(C)



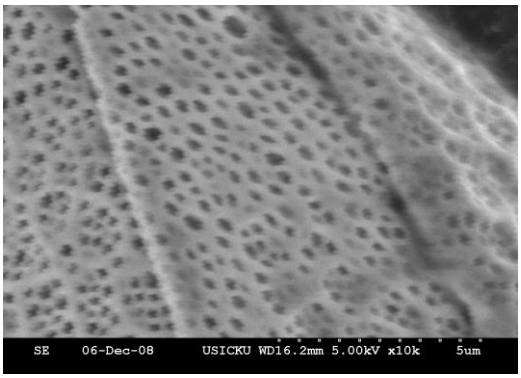
(D)

Plate 36. Pollen morphology in *Nepeta* (SEM):

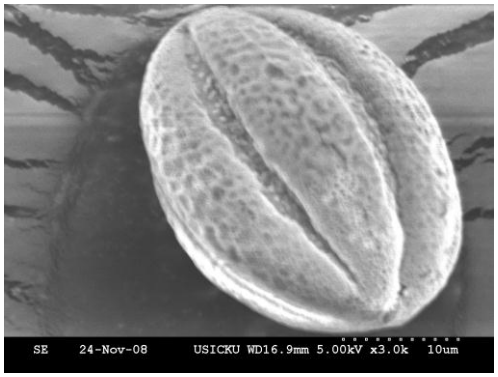
A&B) *N. linearis* showing bireticulate ornamentation with less prominent primary muri

C&D) Punctate ornamentation in *N. eriostachys*

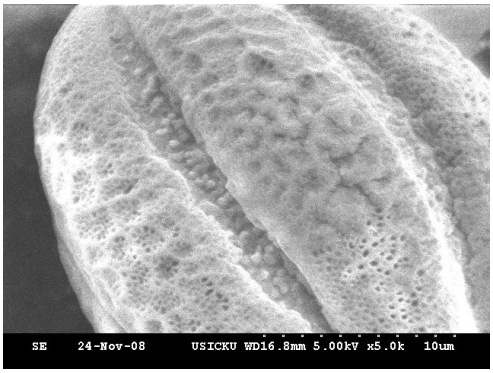
(A)



(B)



(C)



(D)

Plate 37. Pollen morphology in *Nepeta* (SEM):

A&B *N. laevigata* showing secondary lumina star-shaped and a thick midrib in the middle

C&D) *N. nervosa* showing bireticulate sculpture and finely granulate colpus membrane

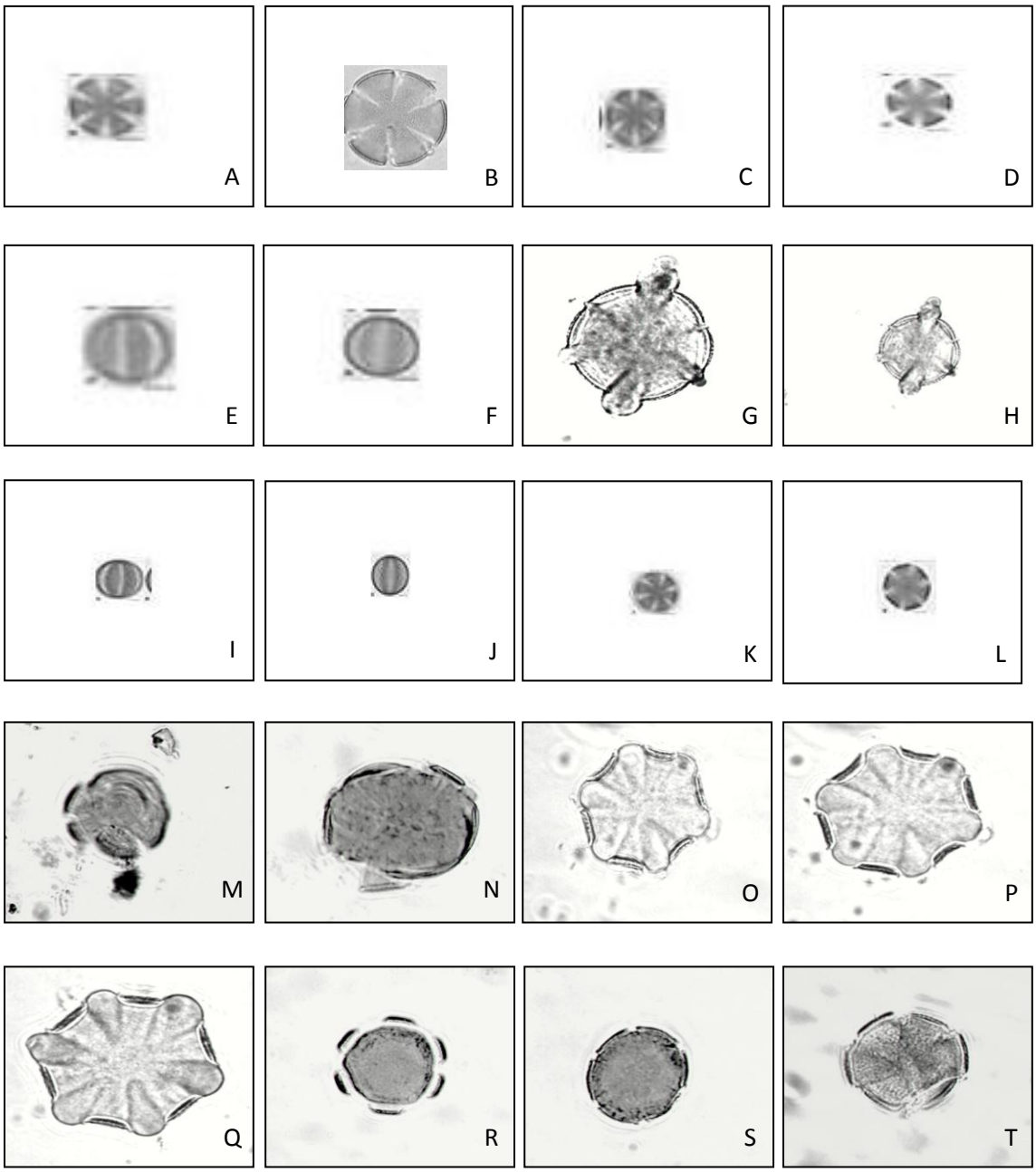


Plate 38. Pollen morphology in *Nepeta*:
A-B, *N. annua*; C-D, E-F, *N. campestris ;* G-H, *N. cataria;* I-L, *N. clarkei;* M-N, *N. coerulescens;* O-Q, *N. connata;* R-T, *N. discolor.*

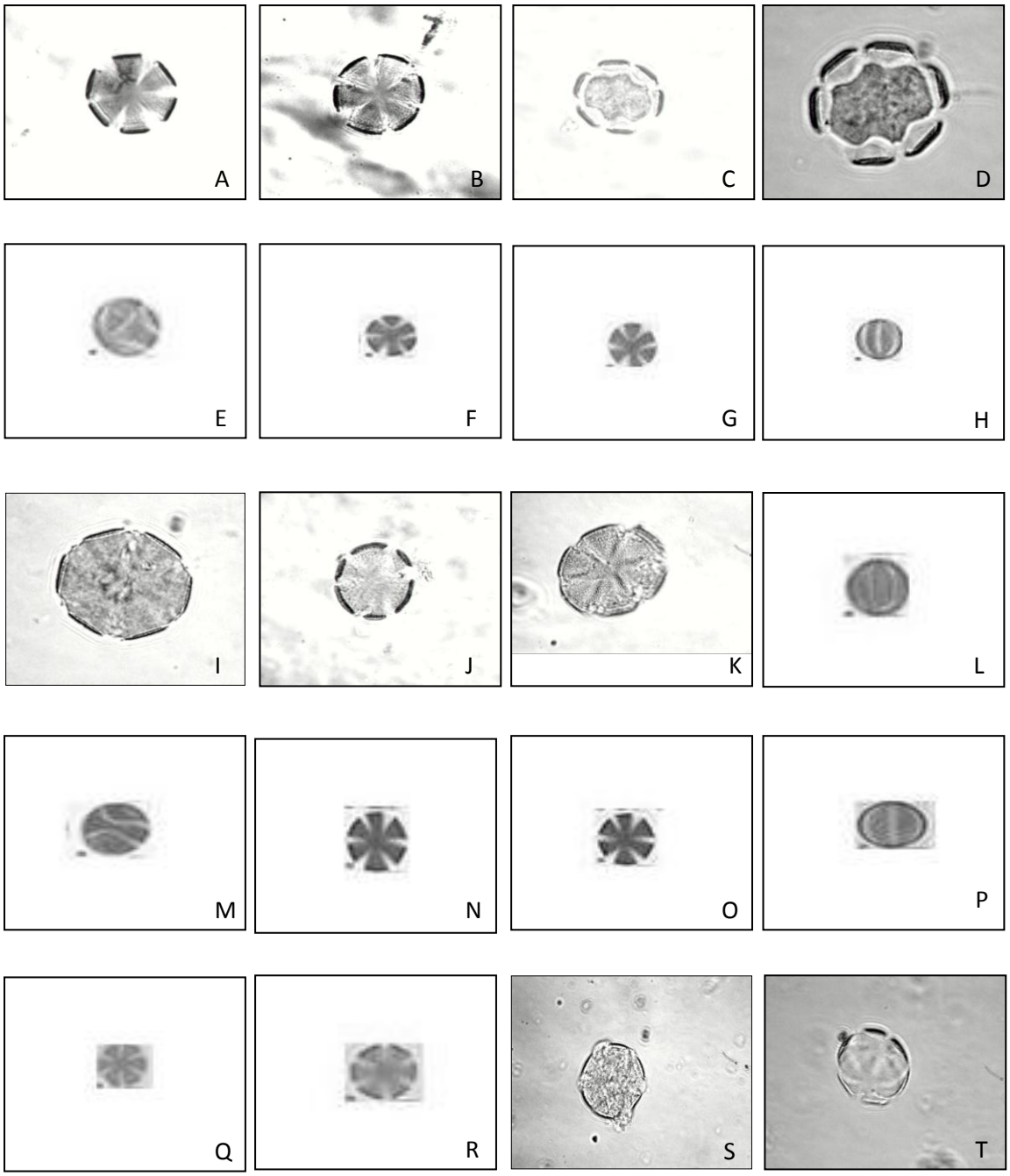


Plate 39. Pollen morphology in *Nepeta*:

A-B, *N. elliptica;* C-D, *N. erecta;* E-H, *N. eriostachys;* I, *N. floccosa;* J-K, *N. glutinosa;* L-O, *N. govaniana;* P-R, *N. kokanica* S, *N.laevigata;* T, *N. linearis.*

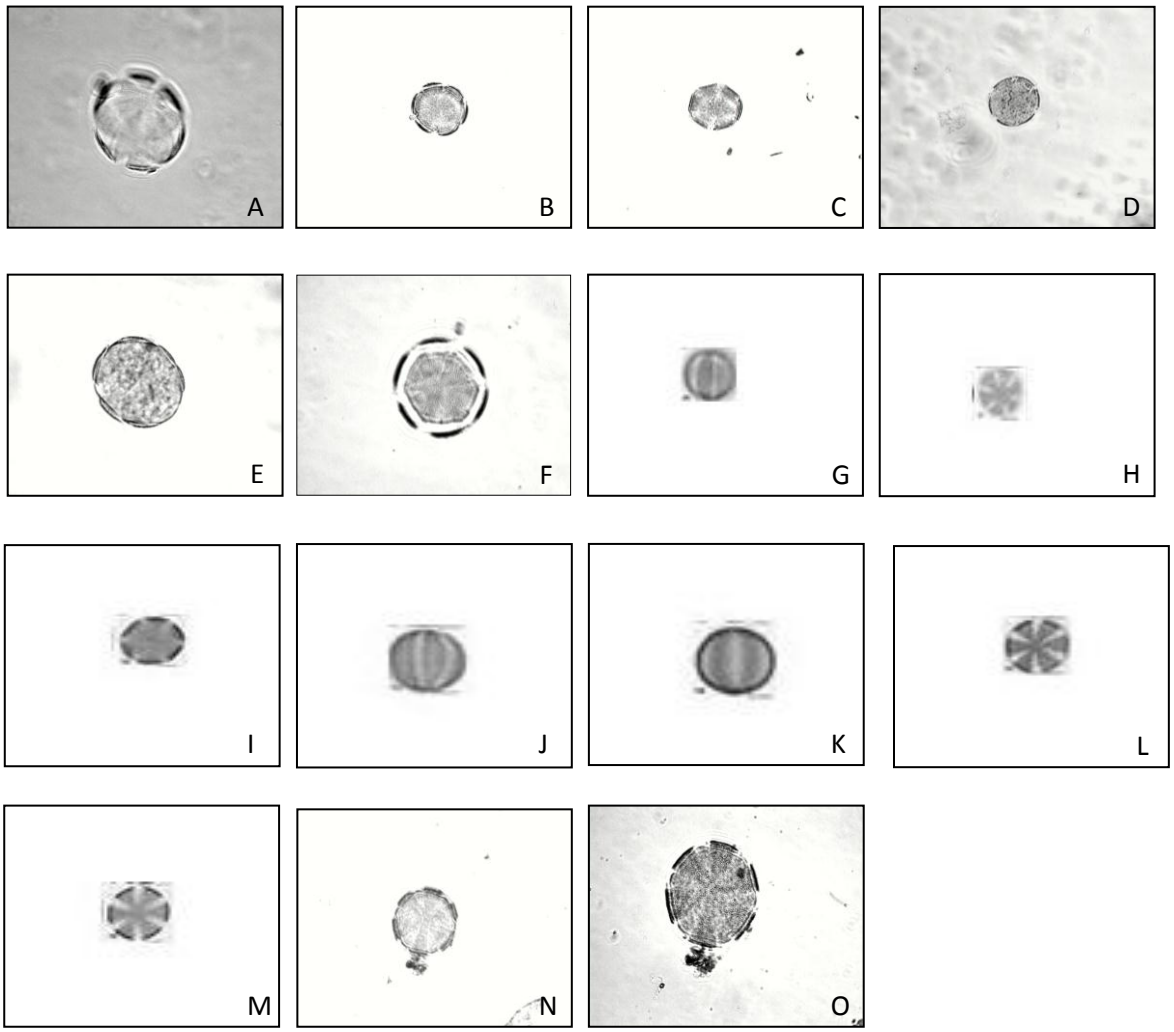


Plate 40. Pollen morphology in *Nepeta*:

A, *N. linearis;* B-D, *N. longibracteata;* E, *N. nervosa;* F, *N. paulsenii;* G-I, *N. podostachys;* J-M, *N. raphanorhiza*; N-O, *N. salviaefolia.*

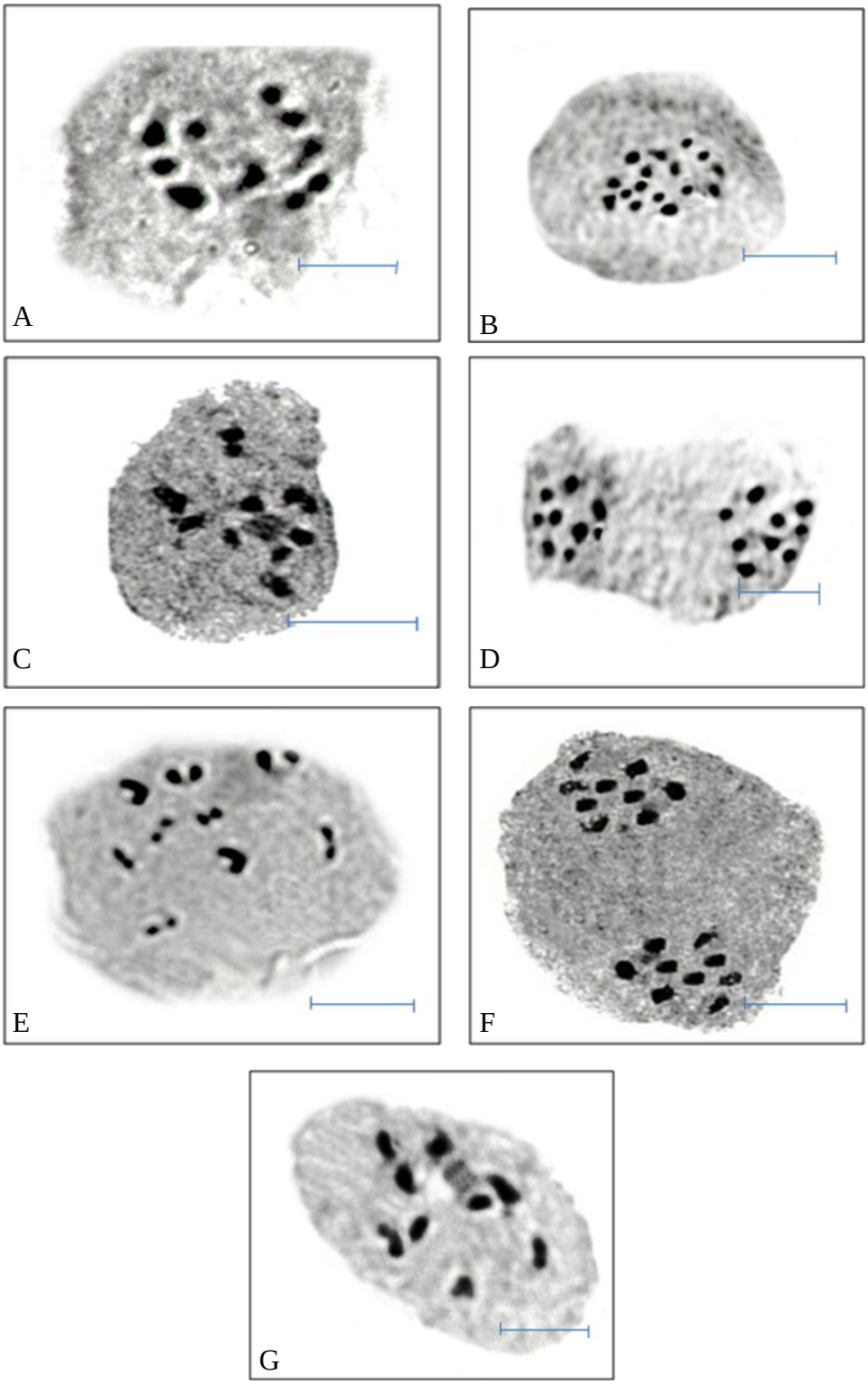


Plate 41. A) *Nepeta salviaefolia* B) *N. cataria*
C & D) *N. elliptica* E) *N. laevigata*
F) *N. linearis* G) *N. nervosa*