MICROSCOPICAL ANALYSIS OF SOME HONEYS FROM KANGRA AND ADJOINING AREAS OF HIMACHAL PRADESH

A

DISSERTATION

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Dated:..... ***(Anita Devi)***

CONTENTS

ABBREVIATIONS USED

%	Per cent
&	And
ºC	Degree Celsius
A. cerana	*Apis cerana*
A. dorsata	*Apis dorsata*
A. mellifera	*Apis mellifera*
cm	Centimeter
e.g.	*Exempli gratia*; For example
et al.	*Et alia*; and others
etc.	*et cetera*; and other
Fig.	Figure
gm	Gram
i.e.	*id* est; that is
L.	Linnaeus
M	Metre
Ml	Mililitre
Mm	Milimetre
Rpm	Revolutions per minute
sp.	Species (Singular)
sec.	Second
spp.	Species (Plural)
Sq. Km.	Square Kilometre
viz.	*Videlicet*; namely

Beekeeping industry, one of the important agricultural and forest based rural industries in India, is mainly involved in production of commercial quantities of honey, using essentially colonies of the Indian hive bee, *Apis cerana*. Beekeeping is entirely dependent on the types of flowering plants available in any given area. It is not only the total abundance, that is only important, but also the duration of time for which bee forage is available. Nectar and pollen are the raw materials of beekeeping industry. Pollen analysis of honey shows the possibility of determining the botanical, geographical and ecological origin of honey from the pollen grains they contain. This is based on the fact that honeybees collect their food from plants, especially those that offer high concentration of high quality of nectar (Agwu and Unekwe, 1992).

Pollen is practically the sole source of proteins, amino acids, lipids, starch, sterols, minerals and vitamins that are needed by the honeybees for the production of larval food and for the development of newly emerged bees (Gary, 1992). Whereas, nectar is the reward offered to bees in return for their indispensable services in cross-pollination. It is composed almost entirely of sugars and water, but the proportion of these ingredients varies widely (Crane, 1990). While foraging on plants for nectar and pollen, honeybees incidentally reciprocate by performing valuable pollination services. Bees and certain flowering plants have, therefore, evolved a well adjusted system of interdependence. Establishment of this relationship between flowering plants and their pollinators is one of the most significant events of organic evolution (Deodikar, 1962; Martin, 1992). The importance of bees in pollination ecology of the tropics is tremendous and consequently of great relevance to agriculture, honey production, forestry and generally in the maintenance of genetic flow and balance among cultivated and wild economic plants (Noor *et al*., 2009).

The importance of understanding the composition of honey from a health point of view is also valuable. It was found to be a suitable alternative for healing wounds and burns, and a product that can be used in health treatments (Molan, 2001; Lusby *et al*., 2002; Gallardo-Chacon *et al*., 2008; Lay-flurrie, 2008; Won *et al*., 2009). Moreover, there is increase in honey consumption in recent years which can be attributed to the general increase in living standard and a higher interest in natural and beneficial health products (Arvanitoyannis and Krystallis, 2006).

Pollen grain is an integral part of plant, also called as male gametophyte.Each pollen produced by meiotic cell division of pollen mother cells is present in pollen sacs

of anthers. Pollens are essential food elements for honeybees and it is their main protein source (Michner, 2000). Pollen grains possess an unusual compound known as sporopollenin found in outer wall, the exine, which makes them resistant to treatment by acetolysis during palynological studies.

Each pollen grain has its own special structural feature which indicates its origin. These features can be used in identification such as size, shape, aperture (type and number) and exine sculpture. Vorwhol (1990) suggested that pollen grains should be defined by the length and breadth, instead of diameter. Shape plays a minor role in identification of pollen grains. However, Sawyer (1981) describes shape an important feature in pollen identification. Pollen and nectar availability to worker bees fluctuates with time of year and flowering of different plant species (Free, 1993). The attractiveness of honeybees to a particular crop in flowering stage depends upon many factors including the quality and quantity of pollen, concentration of flowers, number of competing insects, attractiveness of competing crops, distance of crops from colony and their innate floral preferences (Free, 1977). Different crops are attractive to bees at different times of the year. Each worker honeybee usually confines her attention to a single species on its foraging expedition (Akratanakul, 1987). This curious behaviour of bees, called 'floral fidelity', explains their significance in plant pollination. Among all the pollinating insects, honeybees show the highest degree of floral fidelity and are therefore, the most efficient pollinators. Floral fidelity of bees combined with their preference for better nectar and pollen has been a major factor in the process of natural selection (Deodikar and Suryanarayana, 1972; Butler, 1974; Verma, 1990).

The plants which provide nectar and pollen to bees are known as bee plants. The bee plants can be divided into three categories, i.e. those visited by bees for pollen only, those visited for both pollen and nectar, and those visited for nectar only. There are at least four hundred species of plants which are either major or minor sources of pollen and nectar to Indian hive bees, *Apis cerana* F. (Deodikar and Suryanarayana, 1972; Crane and Walker, 1984). It is obvious that all the plant species are not available in any one locality and a given plant species may also show variations in its utility to bees in different localities or during different years. Information on the utility of each of these plants species, its distribution, abundance and preferences for any climate or soil etc. is of great importance to beekeepers (Suryanarayana, 1978; Mattu, 1982). Thus, the success in beekeeping depends not only upon the better strains of bee but also

on the abundance and richness of nectar and pollen sources around an apiary. Plentiful forage coupled with favourable ecological conditions indicates tremendous possibilities for developing modern beekeeping in a country (Mattu *et al.*, 1988).

Honeybees while foraging on the flowers of different entomophilous plants for collecting nectar, also gather some pollen with it. This pollen is retained in the ripened honey which is subsequently stored in the honey combs. The microscopical examination of these pollen grains in the honey is known as 'melissopalynology' and any final confirmatory evaluation of bee plants is incomplete without the study of melissopalynology (Deodikar, 1965; Louveaux *et al*., 1978; Nair, 1985; Sharma, 1989; Caccavari and Fagundez, 2010, Feas *et al.*, 2010). Melissopalynology also known as melittopalynology, is the branch of palynology which deals with the study of the botanical and geographical distribution of honey by subjecting honey sediments, and therefore pollen, spores and other fungal spores contained therein to microscopic analysis. By extension, it also includes the study of pollen in the honey as well as the source of the pollen. Pollen grains are a product of the anthers by meiotic division and they are male gametophyte of flowers of vast vegetations.

Thus, melissopalynology is helpful in both quantitative and qualitative pollen analysis of honey samples (Louveaux *et al*., 1978). Quantitative analysis is used for confirming the botanical sources of unifloral and multifloral honeys, whereas, qualitative analysis helps in the identification of geographical origin of honey samples because local floras have characteristic plant associations that are reflected in the corresponding spectrum of pollen types represented in the local honeys (Maurizio, 1975; Nair, 1985). Honey pollen analysis also tells the seasons of honey extraction during the annual cycle. The scope of microscopical analysis of comparative evaluation of honeys originated from different physiographic regions and in detecting the adulteration of honeys (Chaturvedi, 1983). Pollen analysis also enables the identification of honeys contaminated by poisonous plants (Chaubal and Deodikar, 1965; Shubharani *et al*., 2012).

Melissopalynogical studies has been conducted in details in different parts of the world (Louveaux, 1966; Barth, 1971a, b; Adams *et al.*, 1979; D'Albore, 1980; Adams and Smith, 1981; Vorwohl, 1981; Zmarlicki, 1984; Pearson and Braiden, 1990; Seijo *et al.*, 1992; Piazza and Oddo, 2004; Fortunato *et al.*, 2006; Bilisik *et al.*, 2008; Luz and Barth, 2012; Agwu *et al*., 2014; Makhloufi *et al*., 2015). Similarly in India,

fairly good work has been done in different parts of India by various investigators and fairly good lists of bee plants of Punjab, Kashmir, Uttar Pradesh, Maharashtra, Karnataka, Bihar, Tamilnadu and Himachal Pradesh have been published (Nair, 1964; Chaubal and Deodikar, 1965; Sharma and Nair, 1965; Atwal *et al*., 1970; Divan and Rao, 1971; Deodikar and Suryanarayana, 1972; Chandran and Shah, 1974; Naim and Phadke, 1976; Chaubal and Kotmire, 1980; Seethalakshmi, 1980; Chanda and Ganguly, 1981; Chaturvedi,1983; Sharma, 1992; Singh, 2003; Gowda *et al*., 2005; Mattu, 2007; Chakraborti and Bhattacharya, 2011; Shubharani *et al*., 2012; Tiwari *et al*., 2012; Singh *et al*., 2013; Mahendran *et al*., 2015). However, very little has been done to identify and evaluate the important honey plants of Himachal Pradesh, which has great potential for beekeeping (Sharma, 1996; Verma, 2006; Rana, 2008; Kaur, 2009; Jamwal, 2013; Sunita, 2013).Thus present studies are a step in the direction of knowing and working out the floral resources of Kangra and adjoining areas of Himachal Pradesh from beekeeping point of view.

In view of increased application of honey pollen analysis and bee botany to apiculture, the present investigations were undertaken with the following objectives in mind:

1. Microscopical analysis of honey samples from Kangra and adjoining areas of Himachal Pradesh.
2. Identification of major, medium and minor sources of pollen and nectar to honeybees in Kangra and adjoining areas of Himachal Pradesh.
3. Preparation of a floral calendar of honey plants of Kangra and adjoining areas of Himachal Pradesh.

Present melissopalynological studies will help in identifying important honey plant resources of Kangra and adjoining areas of Himachal Pradesh. It will provide the first hand knowledge of economically important honey plant resources of Kangra, Himachal Pradesh. Data generated from the present investigation would lead to conservation of bioresources in general and honey plant resources in particular. Melissopalynological research will lead to clues for some new bio-resources useful for pharmacological and clinical research.

The beginning of pollen analysis of honey date back to year 1895 when Pfister, by microscopic examination of a number of honey samples, showed that it is possible to determine the geographical source of honey samples by observing the pollen grains suspended in it. Later, it was Young (1908), who studied pollen type or North American honeys. Fehlmann (1911) analysed the pollen spectrum of Swiss honeys and was the first to state the differentiation between floral honey and honeydew. However, by the dawn of twentieth century for about two decades there was not much advancement in the field of microscopic examination of honey until Armbruster *et al.* (1929, 1934) and Zander (1932, 1937) identified more than a thousand pollen types which were of great importance for palynological analysis of honeys.

Further developments of microscopic investigation of honey taken up in European countries. In Britain, a noticeable work was from Niethammer (1931) who studied the microscopical and biochemical aspects of honey. Allen (1935) worked on European bee plants. Deans (1939) examined pollen from heather honey, while Mikkelson (1948) identified cruciferous types from honey analysis. Later, microscopic examination of honey samples was conducted on a wider scale in different parts of the world (Koch, 1933; Grandi, 1934; Hazslinsky, 1938; Lunder, 1945; Martimo, 1945; Vieitez, 1948; Maurizio, 1949a, b; Mendia, 1959). Hodges (1958) presented a beautiful and exhaustive work on colour differentiation of pollen loads of honeybees.

Detailed melissopalynological and bee botanical investigations were carried out extensively in Europe, America, Australia and Africa (Demianowicz, 1966; Louveaux, 1966; Barth, 1971; Maurizio, 1975, 1979; Adams *et al*., 1979; D'Albore, 1980; Adams and Smith, 1981; Battaglini and D'Albore, 1981; Vorwohl, 1981; Zmarlicki, 1984; Imperatiz-Fonseca *et al*., 1985; Ueno, 1985; Pearson and Braiden, 1990; Seijo *et al*., 1992; Barth *et al*., 1998; Piazza and Oddo, 2004; Fasasi and Malaka, 2006; Floris *et al*., 2007; Ceglinskla, 2008; Adekanmbi and Ogundipe, 2009; Oliveira and Berg, 2010; Sabo *et al*., 2011; Song *et al*., 2012; Nair *et al*., 2013; Agwu *et al*., 2014; Makhloufi, 2015). However, a little work has been done on such aspects in India (Chaubal and Deodikar, 1965; Chaturvedi, 1977, 1983; Seethalakshmi, 1980; Nair, 1985; Suryanarayan *et al*., 1981; Mattu *et al*., 1988; Sharma, 1989; Jhansi *et al*., 1991; Mahajan *et al*., 2000; Balasubramanyam and Reddy, 2003; Mattu *et al*., 2005; Sivaram and Anita, 2005; Swetha and Gowda, 2007; Reddy and Reddy, 2008; Mattu and Mattu, 2007; Mattu, 2009; Ponnuchamy, 2011; Shubharani *et al*., 2012; Tiwari *et al*., 2012; Singh *et al*., 2013; Sunita, 2013; Azmi *et al*., 2015).

POLLEN ANALYSIS OF AMERICAN HONEYS

Oertel (1949) studied the honey and pollen plants of Louisiana in United States and identified *Acer* spp., *Salix* sp., *Rubus* sp., *Trifolium repens, Zea mays, Eupatorium* spp. and *Solidago* spp. as major pollen plants, whereas, *Nyssa* spp., *Gossypium* spp., *Melilotus alba*, *Polygonum* spp. and *Vitis* spp. were major nectar plants. Simililarly, Kremer (1950) identified *Taraxacum officinale* as important nectar plant of United States during early spring. Pellet (1951, 1952) analyzed some honeys from United States and found *Robinia pseudoacacia, Vitex* sp. and *Aralia* sp. as important bee plants during autumn season. Arnold (1954) described 28 major and minor honey plants of Florida. Milum (1957) listed the major, medium and minor sources of nectar and pollen in Illinois. Youse (1958) made a taxonomic study of 60 pollen types collected by honeybees in United States and described *Geranium* sp., *Melilotus alba, Tilia americana* and *Polygonum* sp. as important pollen plants.

Wilson *et al.* (1959) reported 118 flowering plant species as important nectar and pollen sources in Colorado region of United States. *Brassica napus* was identified as a major honey plant of Canada (Palmer, 1960). Santos (1961) analyzed some honey samples collected from Brazil and reported 17 important honey plants. In all the samples, the highest percentage of pollen came from *Eucalyptus* sp. ranging from 27-91 per cent. White (1962) stressed the importance of *Brassica napus* var. *oleifera* as a good source of honey in Argentina. Flechtman *et al*. (1963) performed melissopalynological studies on some Brazilian honey samples in Sau Paulo state. The most important source of honey was *Vernonia* sp. which produced very light coloured honey, whereas, the darkest honey was produced by bees working on sugarcane crops. Oertel (1967) listed the bee forage plants in some regions of North-East, North-Central, South-East plains and South-West of United States.

Dubbs (1968) described *Onobrychis ratina* as an important honey source of United States. Barth (1969, 1970a, b) microscopically analysed some honey samples from Brazil and reported *Eucalyptus* sp., *Vernonia* sp., *Ricinus* sp., *Citrus* sp. and *Baccharis* sp. as important pollen sources. Julliano (1970) enlisted 60 major nectar and pollen plants of the states of Rio-Grande, both wild and cultivated along with their flowering periods. Santos (1970) prepared a floral map including *Hyptis suaveolens, Vernonia phosphorea* and some climpers as important sources of Rio de Janeiro state of

Brazil. Stejskal (1971) listed 15 important pollen yielding plants of Venezuela region of Brazil grown in the valleys and humid areas.

Peppino *et al.* (1973) carried out microscopic analysis of 265 honey samples from Argentina. The study showed *Carduus* sp., *Eucalyptus* sp., *Helianthus* sp. and *Trifolium* sp. as the most commonly represented plants. Santos (1974) analysed some Brazilian honey samples and confirmed the presence of pollen grains of *Eucalyptus* sp., *Mequinia* sp. and *Baccharis* sp. Adams *et al.* (1979) compared the nectar samples collected from hives and extracted honey. The study revealed that *Tilia* sp. pollen grains were bigger in size than those of *Melilotus* sp. and *Lotus* sp. It was also suggested that size alone is not responsible for differential disappearance of some pollen grains from nectar or honey samples. Analysis of 206 honey samples collected from different beekeeping regions of Quebec showed the presence of following pollen types: *Trifolium hybridium*, *Solidago* sp. and *Salix* spp. (Feller-Demalsy and Hamontagne, 1979).

Iwama and Melhem (1979) found 55 pollen types in 23 honey samples taken from two colonies in Sao-Paulo state of Brazil. Dominant pollen grains were from *Eucalyptus* sp., *Petroselinum* sp. and *Alchornia* sp. Lieux (1981) carried out the pollen analysis of 68 commercial honey samples from Mississippi area and showed that two third of them contained less than 20,000 pollen grains per 10 gm of honey. The important plants were *Salix* sp., *Glycine max, Rubus* sp. and *Trifolium repens.* Thinmann and Aymard (1982) studied the bee forage of Venezuela region and observed that honeybees foraged on 62 native and introduced plant species.

Imperatriz-Fonseca *et al.* (1985) conducted preliminary study of Brazilian honeys. 57 samples of honey from *A. mellifera* were analysed. Unifloral honeys were represented by *Eucalyptus* spp. and *Citrus* spp. Feller-Demalsy *et al.* (1987) carried out microscopic analysis of 36 samples of honeys from Alberta, Canada. Results indicated pollen types characteristic of the province were: Brassicaceae, *Melilotus* spp. and *Trifolium repens.* Almost all the honeys were unifloral with two types predominating: *Trifolium repens* and Brassicaceae. Honeydew elements were present in very small quantities. Further, Feller-Demalsy *et al.* analysed 29 honey samples from the province of Manitoba in Canada. Almost all the honeys studied were unifloral with three major pollen types: *Melilotus* spp., *Lotus corniculatus* and Brassicaceae. Secondary pollens were represented by *Melilotus* spp., Brassicaceae (others), *Trifolium repens,*

Fagopyrum esculentum, Lotus corniculatus and *Helianthus annuus.* Barth (1990) performed pollen analytical studies on more than 400 honey samples from different regions of Brazil. Pollen spectra indicated that 190 of them were monofloral honeys and the most common plant species were *Eucalyptus* and *Citrus* alongwith some members of families from Compositae, Mimosoideae and Rubiaceae etc.

Barth *et al.* (1998) performed palynological analysis of honey samples of *A. mellifera* collected from a mangrove area near Rio de Janeiro, Brazil. *Laguncularia racemosa* was most abundant species of the area including some individuals of *Avicennia tomentosa*. 27 pollen types were recognised belonging to 22 plant families. The most frequent pollen types from polliniferous species belong to Asteraceae, Euphorbiaceae, Fabaceae, Myrtaceae and Arecaceae. The most frequent pollen types from nectariferous species were *Goton* sp., *Eucalyptus* sp., *Eupatorium maximilianii, Gochnatia polymorpha, Mimosa bimucronata, M. pudica, Spondias* sp. and Sapindaceae.

Carvalho *et al.* (2001) carried out qualitative and quantitative analysis of the honey samples collected by *Melipona scutellarisi* in North-Eastern Brazil. 28 pollen types were found with *Eucalyptus* spp. and *Psidium* sp. as dominant pollen types, whereas, *Bauhinia* sp., *Caesalpinia* sp. and *Mimosa verrucata* were secondary pollen sources. The families Caesalpiniaceae (14%), Mimosaceae (25%) and Myrtaceae (56%) were the most represented in the pollen spectrum. Similarly, Barth (2004) reported the occurrence of several types of pollen grains in the sediment of honey samples, propolis and pollen load of Apiinae and Meliponinae in Brazil. Important pollen types found were: *Senecio braziliensis, Citrus* sp., *Eucalyptus* sp., *Allophylus* sp., *Baccharis* sp., *Cecropia* sp., *Vernonia* sp., *Mimosa scabrella, Mimosa caesalpiniaefolia, Hyptis umbrosa, Eupatorium* sp., *Antigonon* sp., *Terminalia* sp., *Salvia* sp. and of families Asteraceae, Myrtaceae, Sapindaceae, etc.

Malacalza *et al.* (2005) analysed 63 honey samples collected from different regions of province of Buenos Aires in Argentina. The most frequent unifloral honeys were from *Eucalyptus* spp, *Lotus* spp and *Helianthus annuus.* Sodre *et al.* (2007) analysed 58 honey samples from two North Eastern states Piaui (38 samples) and Ceara (20 samples) of Brazil. The major pollen types in the state of Ceara were: *Mimosa caesalpiniaefolia, M. verrucosa, Borreria verticillata, Serjania* sp. and Fabaceae pollen types, while, in state of Piaui it was *from Piptagenia* sp., *Mimosa caesalpiniaefolia, M.*

verrucosa, Tribouchina sp. *and Croton urucurana*. Similarly, Malacalza *et al.* (2007) conducted the characterization of 144 honey samples on the basis of melissopalynology and physico-chemical analysis from different regions of the province of Buenos Aires, Argentina.

Corbella and Cozzolino (2008) reported the combination of multivariate techniques and pollen count analysis to classify honey samples according to botanical sources from Uruguay. Honey samples from *Eucalyptus* spp., *Lotus* spp., *Salix* spp., *Scutia buxifolia* and Myrtaceae were analysed using melissopalynology. However, Naab *et al.* (2008) studied the characteristics of 59 unifloral honeys of *Condalia microphylla, Centaurea solstitialis* and *Prosopis* spp. along with their physico-chemical properties from La Pampa in Argentina.

Burdick *et al.* (2010) performed palynological characterization of honey samples and also identified plant sources for wildflower honey production in Canada. The dominant ones identified were: red clover, white clover, sweet white clover, dandelion, cherry and maple. Traces of a variety was of plants also found, which included: *Ulmus americana, Tilia americana, Viola sororia, Cucurbita pepo, Solidago* sp., *Chenopodium album, Daucus carota, Potentiala recta, Impatiens capensis, Hibiscus syriacus, Polygonum lapathi, Rubus* sp., *Verbascum thapsus, Melilotus alba*, etc.

Similarly, Oliveira and Berg (2010) performed pollen analysis on 17 honey samples collected from Caatinga area from Nova Soure city of Brazil. A total of 73 pollens were identified belonging to 30 families, 64 genera and 30 species. There was highest representation of native species such as *Chamaecrista nictitans, C. ramose, C. swainsonii* and *Capaifera martii* (Caesalpiniaceae); *Aeschynomene martii, Zornia sericea* (Fabaceae); *Herissantia tiubae* (Malvaceae); *Mimosa arenosa, M. quadrivalvis, M. sensitiva, M. tenuiflora, M. ursine, Piptadenia moniliformis* and *Plathymenia reticulate* (Mimosaceae); *Ziziphus joazeiro* (Rhamnaceae). Later, quantitative and qualitative analysis of honeys was conducted, along with study of vegetation cover in Caceres-Mato Grosso State. The important species identified were: *Cecropia pachystachya, Mimosa pudica* and *Myracrodruon urundeuva* (Santos *et al.*, 2011).

Luz and Barth (2012) carried out pollen analysis of honey samples collected from two Brazilian mangroves. The most predominant pollen types identified were:

Gochnatia velutina, *Eupatorium maximilianii*, *Mimosa pudica*, *M. bimucronata*, *Eupatorium maximilianii*, *Spondias* sp., *Laguncularia racemosa*, *Eucalyptus* sp., *Vernonia* sp., *Dombeya* sp., *Croton* sp. and members of families Asteraceae, Mimosaceae, Euphorbiaceae, Lythraceae, Moraceae, Poaceae, Rubiaceae, Sapindaceae and Tiliaceae.

POLLEN ANALYSIS OF ASIAN HONEYS

In Asian continent, apart from India, melissopalynological studies have been conducted extensively mainly in Pakistan, Bangladesh, Nepal, Sri Lanka, Japan, China and Israel on a wider scale.

Indian honeys

In India, Deodikar and Thakar (1953) were probably the first to initiate the pollen analysis of honey samples of twelve major nectar sources from Mahabaleshwar hills of Maharashtra. Sen and Banerjee (1956) observed the over abundance of one anemophilous sporomorph while analyzing the pollen content of honey sample obtained from a garden near Calcutta. Mittre (1958) performed microscopic analysis of 10 samples of Indian honeys known under the names of Lucknow honey, Kashmir honey, Almora honey, Sunderbans honey, Haridwar honey, Lotus honey and Nepal honey. Thakar *et al*. (1962) prepared a floral calendar of major and minor bee forage plants of Mahabaleshwar hills. Phadke (1962) while studying the physicochemical composition of major unifloral honeys of Mahabaleshwar hill, reported that *Carvia callosa* honey contained unusual amount of non-reducing sugars. Chaubal and Deodikar (1963) studied pollen grains of some poisonous plants in honey samples from Western Ghats. *Clematis* spp., *Datura arborea*, *Lasiosiphon* sp., *Euphorbia* sp. and *Lobelia nicotianaefolia* were important poisonous plants.

Pollen analytical studies were conducted on 76 samples of Indian honeys collected from Peninsular, Indogangetic, Eastern and Himalayan region including Nepal by Nair (1964). Nectar and pollen yielding plants reported were: *Plectranthus* sp., *Brassica* sp., *Citrus* sp., *Sapindus* sp., *Alnus* sp., *Nephelium* sp., *Holoptelea* sp., *Eugenia* sp., *Putranjiva* sp. and some palms. Sharma and Nair (1965) analysed 13 honey samples from Uttar Pradesh. *Nephelium* sp., *Rumex* sp.and members of families; Euphorbiaceae, Rosaceae, Brassicaceae, Liliaceae, Meliaceae and Myrtaceae were the predominant ones. Chaubal and Deodikar (1965) carried out microscopic analysis of

various honey samples from Western Ghats. Pollen grains of *Rosa multiflora, Impatiens balsamina, Ocimum* sp., *Polygonum* sp., *Brugmansia* sp. and *Heracleum* sp. were seen in the samples. Singh and Singh (1971) reported *Plectranthus rugosus* as the major honey plant resource from Kashmir valley. Sharma (1970a) studied bee flora of Kangra area of Himachal Pradesh by analyzing pollen loads collected during the months of June to August. Twenty pollen types were identified with preference of bees for pollen of family Poaceae. Other anemophilous pollen plants visited by bees were of families Cyperaceae, Arecaceae, Chenopodiaceae and Utricaceae. Similarly, Sharma (1970b) also conducted pollen load studies in the month of September in the same area. He reported 13 pollen types including those of *Phoenix* sp. and *Mimosa* sp. in higher frequencies. Besides these, three anemophilous taxa such as *Phoenix* sp., Chenopodiaceae and Poaceae were also represented in the pollen loads. Sharma (1972) studied the pollen grains of *Datura stramonium*. He suggested it to be a major honey plant besides its medicinal value in temperate regions of India. Chaturvedi (1973) analysed 192 pollen loads collected during January to April from Banthra area of Lucknow. All loads were unifloral. In January, brassicaceous pollens were dominant; in February, *Asphodelus* sp. and brassicaceous pollens; in March, asteraceous and cucurbitaceous pollens and in April, cucurbitaceous, *Citrus* sp., poaceous pollens were predominant. Chandran and Shah (1974) studied annual cycle of Kodai hills of Tamilnadu and reported that honey flow in these hills was only during April to June. Important nectar and pollen sources were: *Bidens* sp., *Eucalyptus* sp., *Pyrus* sp., *Prunus domestica, Cedrella toona, Syzygium cumini* and *Melilotus* sp.

Suryanarayana (1978) analysed honey samples collected from Mahabaleshwar hills in Maharashtra. Pollen of *Carvia callosa* along with *Smithia* sp. and *Impatiens* sp. were reported. Microscopical analysis showed 13,000 to 21,000 pollen grains per 10gm of Karvi honey. Ganguly (1979) carried out melissopalynological studies on 18 honey samples collected from different parts of India. He showed that number of pollen grains with reticulate surface were more than non-reticulate ones. Seethalakshmi (1980) analysed 12 honey samples from Maharashtra, Uttar Pradesh, Jammu and Kashmir, Bihar, Andhra Pradesh, Tamil Nadu, Karnataka and Kerala. These studies indicated that Indian honeys fall under category of Group I to III of International Commission of Bee Botany i.e. having absolute pollen count from 10,000-5,00,000 per 10 gm of honey. Major sources were: *Brassica* sp., *Eucalyptus* sp., *Syzygium cumini, Nephelium*

litchi, Hevea sp., *Isodon* sp. and *Tamarindus* sp. Chaubal (1980) analysed honey samples from Padgaon in Maharashtra. These studies showed that members of families Myrtaceae, Lamiaceae, Rubiaceae, Acanthaceae and Combretaceae were major bee plants in this region.

Similarly Chanda and Ganguly (1981) investigated the honey samples collected from different parts of India such as Karnataka, Kerala, Orissa, West Bengal and Andhra Pradesh palynologically. Most of the samples had pollen of entomophilous plants with a small percentage of anemophilous types. Suryanarayana *et al*. (1981) made pollen analysis of honey samples of litchi (*Nephelium litchi*) and jamun (*Syzygium cumini*) collected from Pune belt in Maharashtra. The absolute pollen count varied from 4,500 to 18,133 in litchi honeys and it was about 42,000 in jamun honeys. The pollen spectrum of litchi honeys reflected the pollen types of *Datura* sp., *Lagerstroemia* sp., *Nephelium* sp. and *Amaranthus* sp., whereas, in jamun honeys important pollen types were: *Syzygium* sp., *Cedrella* sp., *Xeromphis* sp. and *Terminalia* sp. Sadruddin and Tripathi (1985) made studies on the honey samples from Eastern Uttar Pradesh. 27 samples were identified including *Brassica campestris, Eucalyptus* sp., *Azadirachta indica, Emblica officinalis, Moringa* sp., *Morus alba* and *Adhatoda* sp. etc.

Singh (1989) studied pollen spectrum of 21 honey samples collected from 10 localities of North-East India. He observed the following *sporomorphs*: *Brassica* sp., *Helianthus* sp., *Clematis* sp., *Ageratum* sp., *Solanum* sp. and *Wendlandia* sp. Other pollen sources were: *Adhatoda* sp., *Bauhinia* sp., *Polygonum* sp., *Mussaendra* sp., *Parkia* sp., *Senecio* sp., *Ocimum* sp., *Acer* sp. and members of families Malvaceae, Rosacea, Lamiaceae, Euphorbiaceae, Asteraceae, Myrtaceae, Rubiaceae, Papilionaceae and Rutaceae. Both unifloral and multifloral honeys were present in this region.

Sharma (1989) performed pollen analysis of honey samples and pollen loads collected from 30 different localities of Himachal Pradesh and revealed the presence of predominant, secondary, important minor and minor pollen sources. Major pollen sources reported were: *Trifolium* sp., *Plectranthus* sp., *Eucalyptus* sp., *Sapindus* sp., *Brassica* sp., *Fagopyrum* sp., *Citrus* sp., *Nephelium* sp., *Tilia* sp., *Pyrus* sp., *Prunus* sp., *Robinia* sp., *Medicago* sp., *Dalbergia* sp., *Adhatoda* sp., *Salix* sp., *Salvia* sp. etc., whereas, minor pollen components found were: *Amaranthus* sp., *Ageratum* sp., *Vernonia* sp., *Sonchus* sp., *Solidago* sp., *Potentilla* sp., *Bidens* sp. and members of

families Lamiaceae, Asteraceae, Poaceae, Acanthaceae, Rhamnaceae, Rosaceae and Papilionaceae.

Similarly, studies on pollen spectrum of 14 honey samples from different localities of Jammu and Kashmir were made by Sharma (1990). Different sporomorphs present were: *Ehretia* sp., *Moringa* spp., *Syzygium cumini, Malus* sp., *Prunus* spp., *Pyrus* spp., *Rubus nivens, Citrus* spp., *Nephelium* sp., *Brassica* spp., *Trifolium* spp., *Medicago sativa, Althaea* sp., *Viburnum nervosum* etc. Jhansi *et al.* (1991) analysed pollens of rock bee honey samples of summer season collected from Prakasam district of Andhra Pradesh. All samples were multifloral and contained about 57 pollen types. *Cassia fistula, Teminalia alata, Bauhinia racemosa, Feronia elephantum, Lagerstroemia parviflora, Zizyphus xylopyrus, Phyllanthus* sp., *Soymida febrifuda, Syzygium cumini, Dalbergia latifolia* and *Caesalpinia bonduc* constituted fairly reliable nectar sources for honey bees in this area during summer months.

Sharma (1992) performed physico-chemical and bee botanical analysis of honey samples from different localities of Jammu and Kashmir. In these samples major pollen grains were from *Salix* sp., *Plectranthus* sp., *Rumex* sp., *Artemisia* sp., *Brassica* sp., *Impatiens* sp., *Fragaria* sp., *Polygonum* sp., *Zea mays* and members of families Rosaceae, Myrtaceae, Sapindaceae, etc. Similar studies were also conducted by Soni (1993) on honeys of *A. cerana* colonies collected from North-east Himalayan region. Study revealed hat five honeys samples were unifloral and four were multifloral. *Brassica* sp., *Wendlandia* sp., *Solanum* sp., *Helianthus* sp., *Ageratum* sp., *Ocimum* sp., *Adhatoda* sp., *Mussaendra* sp. and members of families Malvaceae, Myrtaceae, Euphobiaceae, Lamiaceae, etc. wer e major honey plant resources.

Panda and Padhi (1995) studied bee flora in Orissa. In forest areas, excellent sources of bee pastures were: *Shorea robusta, Terminalia tomentosa, Adina cardifolia, Trewia nudiflora, Acacia catechu, Dalbergia sissoo, Terminalia arjuna, Eucalyptus* sp., *Anthocephalus cadambu, Bombax ceiba, Schleichera oleosa, Tamarindus indica,* etc., whereas, the cultivated vegetation included: *Oryza sativa, Triticum* spp., *Sorghum vulgare, Pennisetum* sp., *Zea mays, Phaseolus mungo, Phaseolus aureus, Cicer arientinum* and *Lathyrus sativus. Brassica* spp., *Sesamum indicum, Guizotia abyssinica, Helianthus annuus, Carthamus tinctorius* were oilseed crops which were important sources of bee forage.

Chandran *et al.* (1995) discussed the prospects of *A. mellifera* beekeeping in Cumbum valley of Tamilnadu. Major bee forage sources were: *Abutilon indicum, Aegle marmelos, Cajanus cajan, Ceiba pentandra, Citrus* spp., *Cocos nucifera, Gossypium* sp., *Mangifera indica, Psidium guajava, Punica granatum, Ricinus communis, Zea mays* etc. Lakshmi and Singh (1996) reported *Manihot esculenta* as an excellent source of bee forage in Pune,Maharashtra. Whereas, Rao *et al*. (1996) carried out studies on the management of *A. cerana* colonies in coastal area of Orissa. *Acacia* sp., *Aegle marmelos, Bombax ceiba, Brassica juncea, Citrus aurantifolia, Cassia occidentalis, Cocos nucifera, Cucurbita pepo., Luffa* sp., *Momordica charantia, Moringa oleifera, Pongamia pinnata, Sesamum indicum, Psidium guajava* and *Tridax procumbens* were the sources of pollen and nector to honey bees. Abrol (1996) studied the floral biology of *Acacia modesta* and identified it as a source of forage to honeybees in Jammu city. Kumar and Kashyap (1996) studied the diversity of bee flora in lower Kullu valley of Himachal Pradesh and its impact on honey production. 38 plant species were recorded as sources of nectar and/or pollen to honeybees.Bottle brush, white clover, safeda, soapnut and olive were major sources of summer honey and *Plectrnthes* sp. in autumn honeys.

Kalpana and Ramanujam (1997) carried out melittopalynological studies on 204 honey samples from various apiaries of *A. cerana indica* in some coastal districts of Andhra Pradesh. The important bee plants of East Godavari districts were: *Sapindus* sp., *Eucalyptus* sp., *Borassus* sp., *Anacardium* sp. and *Cocos* sp. In Krishna district, *Borassus* sp. represented the chief bee plant followed by the weeds *Hygrophila* sp. and *Phoenix* sp. *Sapindus* sp., *Borassus* sp. followed by *Hygrophila* sp., *Mimosa* sp. and *Cleome* sp. constituted the chief plants of Gutur district.

Lakshmi and Suryanarayana (1997 a) reported *Ceiba pentandra* as a source of forage to honey bees. Samples of pollen loads and honeys were collected from *A. cerana* and *A. mellifera* colonies. Unifloral honeys were produced during kapok blooming season. Later, melittopalynological analysis of nine honey samples collected from *A. dorsata* colonies revealed the presence of *Pterocarpus santalinus* as a predominant pollen type in four samples and in remaining five samples it was found as secondary pollen type (Lakshmi and Suryanaryana, 1997b). Lakshmi and Suryanarayana (1997c) carried out pollen analysis of 53 honey samples and several pollen stores collected from rock bee colonies in the forest areas of Andhra Pradesh.

They revealed 324 plant species useful as forage to rock bees and of these, 18 were found to contribute to the unifloral honeys. These were: *Syzygium cumini, Terminalia* sp., *Pterocarpus santalium, Helicteres* sp., *Spondias* sp., *Stercullia* sp., *Pongamia* sp., *Schleichera* sp., *Aegle* sp., *Eucalyptus* spp., *Citrus* sp., *Desmodium* sp., *Guizotia* sp., *Helianthus annuus, Pterolobium,* etc.

Rao and Lakshmi (1998) described *Cajanus cajan* species as important bee forage crop of India. Rao (1998) surveyed the bee flora of Chitapalli, Andhra Pradesh. They reported 45 flowering plants which yield nectar and pollen to honeybees. Of these, 8 were nectar yielding; 10 were pollen yielding and remaining were both pollen and nectar yielding. Important sources were: *Citrus* spp., *Guizotia abyssinica, Cucurbita maxima, Mangifera indica, Pennisetum* sp., *Brassica* sp., *Eucalyptus* sp., *Grevillea* sp. and *Santalum album* etc. Joshi *et al.* (1998a) identified *Samanea saman* as a common arboreal bee forage plant in India. Joshi *et al.* (1998b) conducted melittopalynological investigations on 38 samples of honeys collected from *A. cerana, A. dorsata, A. florea* and *Trigona iridipennis* colonies at Pune, Maharashtra. Of these 28 were unifloral and 10 were multifloral honeys. A total of 52 pollen types were identified of which 13 types were common to three species of *Apis*. *Ageratum conyzoides, Amaranthus* sp., *Cocos nucifera* and members of family Commelinaceae were visited by all bee species. February to July constituted the main flow season with major contributions of nectars from *Bombax ceiba, Lannea coromandelica, Limonia acidissima, Moringa oleifera, Peltophorum pterocarpum, Pongamia pinnata, Syzygium cumini* and *Tamarindus indica.* Species of *Cyanotis, Eucalyptus* and *Alternanthera sessilis* contributed to unifloral honeys during minor flow season i.e. September-December. Rana *et al.* (1998) surveyed the different beekeeping areas of Himachal Pradesh. They reported a few pockets in district Kangra, Una, Solan, Sirmour which were suitable for stationary beekeeping. *Brassica spp., Eucalyptus sp., Toona sp., Dalbergia sp., Citrus sp., Litchi sp.* were important nectar sources. Some sites in Chamba, Shimla and Kinnaur districts having *Fagopyrum sp.* and *Plectranthus sp.* were considered suitable for keeping bees only during July to October.

Sharma *et al.* (1998) studied resource partitioning of bee flora in *A. mellifera* and *A. cerana colonies* in mid hill conditions of Himachal Pradesh. Both of these bee species visited some plants like *Rubus ellipticus, Malus domestica* and *Prunus armeniaca*. During early summer, they gathered maximum nectar from *Eucalyptus*

hybrida and *Toona ciliata*. However, *A. mellifera* additionally visited *Lonicera angustifolia, Cnicus argyracanthus, Calendula officinalis, Trifolium repens* and *Corniculata* sp. Both bee species visited four plants in later part of summer, six in rainy season and nine in autumn. In winter, *Prunus puddum, Brassica campestris* and *Prinsepia utilis* were exploited.

Kallesha *et al.* (1999) studied the pollen spectra of honeys from *A. mellifera* colonies at Dharwad in Karnataka. A total of 26 pollen types were recorded in eight samples studied. The predominant pollen types found were: *Sapindus detergens, Eucalyptus* sp., *Solidago* sp., *Santalum* sp., *Eucalyptus* sp., *Felicium* sp., *Moringa oleifera, Azadirachta* sp. and *Dalbergia sissoo*.

Vardhrajan *et al*. (2000) studied the common herb *J. simplex* and *O. umbellate* found in Mannampandal village of Nagai district, Tamilnadu, and indicated their significance as good nectar sources for *A. florea*. Mahajan *et al.* (2000) palynologically analysed 9 honey samples of *A. florea* collected from six villages of East and West Khandesh of Maharashtra. During these studies 5 honey samples were found unifloral which were recognized with the presence of *Lannea coromandlica, Guizotia abyssinica, Caesalpinia* sp., *Terminalia* sp. and *Flacourtia latifolia* as predominant pollen types.

Agashe and Rangaswamy (2001) performed analysis of thirteen *A. cerana* and two *A. dorsata* squeezed/extracted honey samples from Dakshina Kannada in Karnataka. Palynological characterization of samples showed that both *A. dorsata* honeys were multifloral. Of thirteen *A. cerana* honey samples, ten were categorized as unifloral and three were delegated to multifloral category. Nair and Nair (2001) studied beekeeping by Kannikars in Southern Western Ghats of Kerala. Whereas, Raju and Rao (2001) studied bee forage plants of *A. cerana indica* at Visakhapatnum. Important sources were: *Alangium salvifolium, Anacardium occidentale, Tridax procumbers, Tecoma stans, Bauhinia purpurea, Tamarindus indica, Crataeva magna, Ocimum americanum, Azadirachta indica, Sapindus emarginatus, Sterculia foetida, Tectona grandis*, etc.

Gatoria *et al*. (2002) studied the potential of beekeeping in India and listed the bee flora of different regions of India. Important floral resources of different regions included: *Plectranthus* sp., *Robinia* sp., *Fagopyrum* sp., *Dalbergia sissoo, Acacia*

modesta, *Syzygium* sp., *Toona* sp., *Eucalyptus* sp., *Brassica* sp., *Sapindus* sp., *Trifolium alexandrinum*, *Cajanus Cajan*, *Gossypium hirusutum*, *Zizyphus* spp. etc.

Balasubramanyam and Reddy (2003) collected multifloral honeys of *A. dorsata* and *A. florea* (wild) and *A. cerana indica* (apiary) from the plains, hills and Western Ghats of Karnataka. The studies revealed the occurrence of horticultural (*Mangifera indica*, *Helianthus annuus*, *Brassica juncea* and *Pongamia pinnata*); plantation (*Tamarindus*, *Cocus nucifera* and *Eucalyptus* spp.) and forest (*Sapindus emarginatus*, *Syzygium caryophyllatum* and *Borassus flabellifera*) along with many minor floral sources. Chaudhary (2003) analysed the performance of *A. mellifera* in North-eastern Haryana. He evaluated the floral resources for their utility to honeybees. Honeybees foraged on 123 plant species, of which 88 provided both pollen and nectar. Seven plants including *Brassica juncea*, *Eucalyptus* sp. and *Helianthus annus* served as major sources of pollen. Four major beekeeping seasons corresponding to mustard, Eucalyptus, sunflower and Khair flowering were recorded along with, two minor seasons with toria and Eucalyptus flowering.Laskhmi and Kamble (2003) carried pollen analysis of honey samples of *A. dorsata* and *A. cerana* collected from Chintapalli hills during flowering period of Sandan. These studies revealed *Qugeinia oojeinensis* as a predominant source of honey.

Gowda *et al*. (2005) attempted to document the diversity and species richness of bee flora of Chintamani area of Karnataka. It was observed that foraging workers of *A. cerana* visited more than 100 species of bee flora which comprised of herbs, shrubs and trees. Three species viz., fingermillet, castor and coconut were categorized as pollen sources, eight species viz., neem, mango, drumstick, pigeon pea, teak, silver oak, *Cassia fistula* and *Sapindus* sp. were categorised as only nectar sources, whereas, 16 of them were both pollen and nectar sources.

Mattu *et at.* (2005) conducted melissopalynological and physico-chemical studies on honey samples and pollen loads colleted from 30 localities of Himachal Pradesh and 25 localities of Jammu and Kashmir of the North-West Himalayas. These investigations revealed that dominant spormorphs were: *Plectranthus* sp., *Salix* sp., *Brassica* sp., *Trifolium* sp., *Toona* sp., *Sapindus* sp., *Berberis* sp., *Impatiens* sp., *Pyrus* sp., *Prunus* sp., *Fagopyrum* sp., *Citrus* sp., *Nephelium* sp., *Tilia* sp., *Robinia* sp., *Medicago* sp., *Dalbergia* sp., *Eucalyptus* sp., *Adhatoda* sp., *Helianthus* sp., *Salvia* sp., *Cassia* sp., *Rubus* sp., *Prinsepia* sp., *Taraxacum* sp., *Polygonum* sp., and *Syzygium* sp.

However, minor pollen components represented were: *Solidago* sp., *Potentilla* sp., *Amaranthus* sp., *Ageratum* sp., *Sonchus* sp., *Aster* sp., *Phyllanthus* sp., *Bombax* sp., *Corthamus* sp. and members of families Rosaceae, Caesalpiniaceae, Asteraceae, Myrtaceae, Ranunculaceae etc. It was observed that honey samples mostly had pollen of entomophilous plants with a small percentage of anemophilous types. . Sivaram and Anita (2005) studied honey yielding plants and honey flow seasons of Karnataka. About 150 plants during summer season (March-April) and about 117 plants during winter provided to be good sources for commercial honey production.

Sood *et al*. (2006) conducted survey on the honey plants of the Northwest Himalaya. Important plants identified were: *Albizzia lebbek, Allium cepa, Arctium lappa, Cynodon dactylon, Cynogolssum glochidiatum, Eruca sativa, Erythrina suberosa, Phloex drummondii, Phoenix sylvestris, Plectranthus coesta, Plectranthus rugosus* etc. Verma (2006) recorded 168 plant species constituting the bee flora of Hamirpur district and reported 28 plant species as major pollen and nectar source like *Brassica* sp., *Eucalyptus camaldulensis, Sapindus mukorosii, Woodfordia fruticosa* etc. About 26 species were identified as medium honey resources like *Berberis* spp., *Cassia fistula, Pyrus pashia, Murraya koenigii* etc. Besides these, 96 plants species were identified as minor pollen sources which belonged to different families. 11 samples of A. cerana F. honey were collected. Of these, 5 were unifloral and 6 were multifloral.

Bhatia (2007) studied the bee flora of lower Shivalik Hills of Kangra (Himachal Pradesh). A total of 109 plant species were recorded out of which Eucalyptus, *Citrus* spp., Litchi, mustard and berseem were found to be the major honey plants, while khair, sisham, arjun, basuti and cucurbits were observed to be of medium utility. Mattu (2007) carried out computer assisted melissopalynological and bee botanical studies in Himachal Himalaya with reference to climate change; conducted mellissopalynological and bee botanical on honey plant resources on western Himalaya in relation to climate change and studied beekeeping, pollinators and climate change in Himachal Pradesh.

Rana (2008) recorded 191 plant species constituting the bee flora of Solan district and reported 32 plant species as major pollen and nectar source like *Brassica* sp., *Taraxacum officinale, Bombax ceiba, Helianthus annus, Raphanus sativus, Acacia catechu, Trifolium* sp. *Dalbergia sissoo, Citus* sp. etc. About 31 species were identified as medium honey resources like *Adhatoda vasica, Mangifera indica, Murraya koenigii, Berberis* sp., *Prunus* sp., *Legerstroemia indica* etc. Besides these plants 110 species

were identified as minor pollen sources which belonged to different families 9 samples of *Apis cerana* F. honey were collected, out of which 2 samples were unifloral and 7 were multiflora in nature.

Bera *et al.* (2009) melissopalynologically analysed 11 honey samples from Kamrup reserve forests, Assam. The study showed that the majority of honey samples were unifloral with *Brassica nigra, Salmalia malabricum, Coriandrum sativum, Mimosa pudica* and *Syzygium cumini.* Similarly, Bhargava *et al.* (2009) carried out pollen analytical studies on 10 *Apis cerana indica* honey samples from Chickmagalur district of Karnataka and found *Cocos nucifera* and *Coffee* sp. as predominant pollen types. The pollen count ranged from 4000 to 800000 in different honey samples. The other important pollen morphotypes recorded were: *Eucalyptus globulus, Coffea arabica, Cocos nucifera, Hevea braziliensis, Coriandrum sativum, Terminalia chebula, Cassia* sp., *Croton* sp., *Areca catechu, Syzygium cumini, Nerium oleander* and members of families Asteraceae, Euphorbiaceae, Fabaceae,Poaceae, etc.

Attri (2010a) conducted melissopalynological studies of thirty five *A. cerana* summer honey samples from Chamba district of Himachal Pradesh. 18 samples were classified as unifloral, whereas, 17 were multifloral. A total of 63 families were recognized as major sources of pollen and nectar. *Malus domestica, Prunus armenica, Prunus persica, Prunus amygdalus, Pyrus communis, Plectranthus rugosus, Berberis* sp., *Cassia fistula, Syzygium cumini, Grewia* sp., *Citrus* sp., etc. were identified as important pollen types. Similarly, Attri (2010b) also carried out pollen analysis of thirty five honey samples extracted in autumn and early winter seasons from different localities of Chamba district in Himachal Pradesh. Of these, seven honey samples were unifloral and twenty eight were multifloral. The predominant sporomorphs were: *Fagopyrum* spp., *Plectranthus* spp., *Salvia* spp., *Rosaceae* spp.**,** *Bauhinia* spp., *Fagopyrum spp* and members of families Labitae and Asteraceae.

Sharma and Gupta (2010) studied the qualitative and quantitative evaluation of *Plectranthus rugosus* as a nectar source to honeybees and also studied its honey potential. Honey produced from the source was watery white and mild in flavour. The honey potential of the shrub was also worked out, where the average volume of honey from the flowers of *P. rugosus* was comparatively higher in the species growing in moist regions than that to the species seen in the dry regions (1.41µl/flower and 1.17µl respectively). But when the solute concentration was studied, it showed significantly

higher value (42.33%) in the species growing in the the dry area rather then species growing in the moist areas (28.47%). However, the above conditions showed no effect on the nectar-sugar content, which was mainly dependent upon the age of the flower. The freshly opened flowers showed nectar-sugar content of 0.32mg/flower which increased to 0.53ml/flower which is 24 hours old, this further declied after 48 hours i.e., 0.43ml/flower. Based on the bush density and the amount of nectar-sugar ratio, the honey potential of *P. rugosus* was worked out to be 128.7kg/ha in the experimental area.

Sharma and Kumar (2010) conducted study to causes of slothful development of beekeeping in Mandi and Kullu districts of Himachal Pradesh. The awareness level of farmers regarding scientific beekeeping and the constrains faced by them in adopting this vocation on commercial scale was studied and suggestions to overcome these constrains were provided. Sontakke and Mohapatra (2010) studied the status of beekeeping in Orissa. While, Thakur *et al*. (2010) carried out the studies in different parts of Himachal Pradesh to identify the pockets for production of mono-floral quality honey. The potencial pockets for *Plectranthus* honey were found near Rampur Bushehar, Kumarsain, Matiana in Shimla district; Jeori, Bhavanagar, Neugalsari in Kinnaur district; Rajgarh, Chhichariadhar and Nauladhar in Sirmour district; Kullu, Sainj and Banjar in Kullu district and Pandoh in Mandi district of the state. Important belts of *Prunus puddum* were found near Jogindernar, Rewalsar (Mandi); Palampur (Kangra); Sarianj; Piplughat (Bliaspur) and Shogi (Shimla). Areas from Khoksar to Udaipur in Lahaul and from Gramphoo to Chhatru in Spiti were found to be very productive where wild thyme honey and aphid honeydew honey was extracted from June to September. Higher areas near Banjar, Jalori Pass, Bhunter, Raison, Patlikuhal and Naggar in Kullu district were found to have potencial for extraction of horse chestnut honey, while, areas near Palampur and Chintpurani in Kangra district were found having potencial for *Syzygium cumini* honey.

Timande and Tembhare (2010) performed palynological characterization on honey samples of little honeybee, *A. florae* from ten different localities of Wardha district of Maharashtra. All honey samples were found unifloral. In winter combs, the pollen types represented the native plants such *as Sphaeranthus indicus, Lagascea mollis, Bidens pilosa, Acacia nilotica and Sapindus emarginatus.* Whereas, in summer honeys *Citrus* sp., *Sorghum vulgare, Raphanus sativum, Coriandrum sativum,*

Sphaeranthus indicus, *Terminalia arjuna* and *Mangifera indica* were predominant sources. Yadav and Gupta (2010) performed physico-chemical characterisation of 58 honey samples and also studied the floral sources of different regions of Himachal Pradesh and adjoining areas of Haryana and Punjab.

Tiwari *et al.* (2010) conducted pollen analysis of 21 honey samples of rock honeybee from Garhwal Himalaya, India. The study revealed that the members of families Asteraceae, Brassicaceae, Betulaceae, Myrtaceae, Rosaceae and Rubiaceae were represented as predominant pollen types, whereas, members of families Acanthaceae, Balsaminaceae, Lamiaceae, Onagraceae, Ericaceae, Polygonaceae and Hippocastanaceae were represented as secondary sources of pollens. However, some species such as *Echinops*, *Scurulla*, *Dipsacus*, *Sedum*, *Citrus*, *Juglans*, *Bombax*, *Geranium* and *Plectranthus* were found as important minor pollen types.

Chakraborti and Bhattacharya (2011) performed qualitative and quantitative analyses of 10 honey samples from West Bengal. Of these, four samples were unifloral and the remaining six were multifloral. The important pollen types identified in honey samples were: *Phoenix paludosa*, *Sonneratia apetala*, *Bruguiera* sp., *Avicinia* sp., *Acanthus ilicifolius*, *Ceriops* sp., *Syzygium* sp., *Borassus* sp., *Sesamum* sp., *Coriandrum* sp., *Brassica* sp., *Peltophorum* sp and members of families Compositae, Poaceae and Onagraceae. Similarly, Ponnuchamy (2011) carried out melissopalynological studies from *A. cerana* bee hives located at four different sites at Pondicherry. Plant systematic studies revealed 41 families of phanerogams representing 80 pollen types from 42 honey samples harvested seasonally. Pollen types of *Lannea* sp., *Dodonaea* sp., *Phoenix* sp., *Cocos* sp., *Acacia* sp. and *Borassus* sp. were predominant pollen types. However, three Arecaceae members were observed with consistent abundances in most of the samples.

Quamar and Chauhan (2011) analysed spider-web honey samples collected from the open mixed tropical teak (*Tectona grandis*) dominating deciduous forests and the nearby areas of Khedla village of Betul district in Madhya Pradesh. The study revealed the dominance of pollen of trees and herbs, whereas shrubs, fern spores and algal remains were meagre. Amongst the trees, *Madhuca indica*, *Holoptelea* sp., *Lannea coromandelica*, *Emblica officinalis* and *Aegle mermelos* were dominating with fair presence of *Schleichera oleosa*, *Syzygium* sp., *Grewia* sp., *Flacourtia* sp., *Acacia* sp., Anacardiaceous and Sapotaceous pollens. On the other hand, the ground vegetation

was represented by the good number of *Xanthium* sp., *Capsicum frutescens*, Poaceous, Caryophyllaceous and Brassicaceous pollens. However, exceptional high frequencies of P*ogostemon* sp., *Hyptis* sp., Lamiaceous and Asteraceous in almost all the samples.

Ramnath and Venkataramegowda (2012) conducted pollen analysis of 30 honey samples collected from different locations of Western Ghats, Karnataka. Among them, 8 samples were found unifloral, whereas, 22 were multifloral. In unifloral honey samples, *Sapindus laurifolia, Areca catechu, Acacia* sp., *Mangifera indica, Terminalia bellerica, Syzygium* sp., *Pongamia pinnata* and *Eucalyptus* sp. were predominant pollen sources. Shubharani *et al.* (2012) investigated 20 honey samples collected from *Apis cerana* and *Apis dorsata* colonies located at 14 different locations at Coorg district of Karnataka. A total of 91 pollen types belonging to 42 families were identified. The dominant pollen types represented in the honey samples were: *Coffea* sp., *Cocos nucifera, Aster* sp., *Scheffleria* sp., *Syzygium* sp., *Terminalia* sp., *Brassica* sp., *Croton* sp., *Oryza sativa* etc.

Sivaram *et al.* (2012) performed melissopalynological analysis of 15 honey s amples of *A. cerena* and *A. dorsata* colonies collected from Karnataka region of Nilgiri Biosphere, South India. Only one sample was unifloral, which contained *Coffea* sp. as predominant pollen, while, remaining 14 honey samples were multifloral in nature. The important sporomorphs found were: *Schefflera* sp., *Butea monosperma, Cocos nucifera, Justicia simplex, Coffea* sp., *Bombax* sp., *Areca catechu, Terminalia sp., Ricinus communis, Croton* sp., *Eucalyptus* sp., *Ipomea* sp., *Tridax procumbens, Crotalaria* sp., *Dendrocalamus strictus, Sapindus* sp. *Clerodendron* sp., *Justicia simplex, Anonna squmosa, Anacardium occidentale, Mimosa pudica, Bauhinia* sp., *Mussaenda* sp., *Polyalthia* sp., *Thespesia* sp., *Eupitorium odoratum, Hibiscus* sp., *Justicia simplex,Tamarindus* sp., *Albizia lebbeck, Dendrocalamus strictus, Tecoma stans, Brassica* sp., *Ageratum* sp., *Pongamia pinnata, Samanea saman, Cyprus* sp., *Delonix regia, Gliricidia* sp., *Cassia fistula, Psidium guajava, Sapindus* sp., *Santalum album, Vitex nigundo, Pongamia pinnata,* etc.

Similarly, Tiwari *et al.* (2012) carried out pollen analysis on 10 honey samples collected from Kamad (Uttarakashi) of Garhwal Himalaya. A total of 19 pollen morphotypes were identified. Some important among them were: *Alnus nepalensis, Sarcococca coriacea, Chenopodium album, Fagopyrum dibotrys, Coriandrum sativum, Juglans regia, Prinsepia utilis, Strobilanthes alatus, Loranthus pulverulenta, Rosa*

brunonii, Rhododenderon arboretum, Impatiens spp., *Rhamnus virgatus, Citrus* sp., *Symplocos paniculata,* Asteraceous, Rosaceous, Poaceous and Lamiaceous pollens.

Upadhyay and Bera (2012) microscopically analysed 34 honey samples collected from the East coastal districts of Orissa. Of these, 26 samples were unifloral, whereas, 8 were multifloral. Sixty two plant genera was identified, of which most prevalent were: *Phoenix* sp., *Borassus* sp., *Cocos* sp., *Eucalyptus* sp., *Brassica* sp., *Barringtonia* sp., *Syzygium* sp., *Schleichera* sp., *Zizyphus* sp., *Pongamia* sp., *Dalbergia* sp., *Psidium* sp., *Coriandrum* sp., *Mangifera* sp., *Lycopersicon* sp., *Mimosa* sp., *Citrus* sp. and *Moringa* sp. Pollen grains of Arecaceae were the characteristic elements of coastal vegetation represented in twenty nine sam

Sunita (2013) conducted melissopalynology studies on 33 honey samples, collected mainly from Kangra and Hamirpur hills of Himachal Pradesh. Studies indicated that *citrus* sp., *Acacia* sp., *Bauhinia* sp., *Woodfordia* sp., *Prunus* sp., *Adhatoda* sp., *Eucalyptus* sp., *Brassica* sp., and members of families Myrtaceae and Rutaceae were predominant pollen source; Secondary pollen source present were *Emblica* sp., *Murraya* sp., *Mangifera* sp., *Vicia* sp., *Punica* sp., *Grewia* sp., *Ageratum* sp., *Carissa* sp., Syzygium sp., Brassica sp., Salvia sp., Bombax sp., Cedrela sp., Vitex sp., *Eribotrya* sp., *cassia* sp., *Melia* sp., etc. and important minor and minor pollen source reported were *Rosa* sp., *Carica* sp., *Aegle* sp., *Rumex* sp., *Allium* sp., *litchi* sp., *Butea* sp., *Ocimum* sp., *Zea* sp., and members of famililes Cucurbitaceae, Polygonaceae, Fabaceae, Rosaceae and Apocynaceae etc.

Jamwal (2013) analysed melissopalynologically 31 honey samples, collected from Mandi and Kullu hills of Himachal Pradesh. Studies revealed that dominant sporomorphs were: Grewia *optiva, citrus sp., Mangifera indica, Eucalyptus sp., Syzygium cumini, Trifolium sp., Brassica sp., Cadrela toona, Eriobotrya japonica* and *Prinsepia utilis etc.* However, minor pollen components represented were*: Murraya koengii, Zea mays, Cannabis sativa, Ocimum sp., salvia sp., Psidium guajava, Chenopodium album* and member of families Apiaceae, Sapindaceae etc.

Ponnuchamy et al. (2014) carried out pollen analysis of 42 honey samples near Puducherry, South India. During the three years, yielded 80 pollen taxa: 72 dicotyledonous and 8 monocotyledonous, encompassing 41 botanical families. Major pollen grains of Arecaceae (29%), Anacardiaceae (14%) and Mimosaceae (11%).

Upadhyay *et al.* (2014) performed melissopalynological analysis of 51 honey samples. A total of 82 angiospermic taxa belonging to 44 families were identified. 37 honey samples were proved to be unifloral and remaining samples were found to be multifloral. The predominant nectariferous taxa were*: Acanthus ilicifolius, Aegiceras corniculatum, Alstonia scholaris, Brassica nigra, Coriandrum sativum, Syzygium cumini , Zizyphus jujuba* etc. Secondary pollen taxa reportd were: *Annacardium occidentale, Antigonon leptopus, Mimosa pudica, Phoenix sylvestris, Grewia tiliaefolia* etc. Bhattacharya (2014) conducted melissopalynological studies of honey samples collectesd from 17 blocks of Nadia district, West Bengal, India. It showed the dominance of *Partheninum* sp., pollen in 25 different pollen tyes belonging to 19 different families.

Layek *et al*. (2015) microscopically analysed 8 honey samples and 374 pollen loads collected during May to August from Bankura district, West Bengal. Melissopalynological analysis revealed that all the honey sample were unifloral in origin. *Trianthema portulacastrum* was the major source of pollen and nectar. Pollen analyses of honey samples reveals that 32 plant taxa have been visited by the bees species. Those are *Acacia auriculiformis, Acacia nilotica, Alternanthera paronychioides, Amarathus spinosus, Anthocephalus cadamba, Borassus flabellifer, Bridelia retusa, Capsularis, Corchorus olitorius, Croton bonplandianum, Cucurbita maxima,Evolvulus nummularis,Lemaireacereus sp., Leucaena leucocephala, Lippia nodiflora, luffa cylindrica, Momordica charantia, Peltophorum pterocarpum, Semecarpus anacardium, Sesamum indicum, syzygium reticulatum, Tamarindus indica, Terminalia arjuna, Triantherma portulacastrum, Tridax procumbens, Vitex negundo, Vitis quadragularis* and *Ziziphus mauritiana.* Recently, Mahendran *et al.*,(2015) carried out pollen analysis on 4 honey samples collected from Theni district of Tamilnadu. All the samples were multifloral and around 32 pollen morphotypes were observed.

Japanese and Nepalese honeys

In Japan, Inoue (1957) described 10 important honey sources including *Prunus* sp., *Brassica campestris*, *Aesculus* sp., *Castanea* sp. and *Astragalus sinicus* etc. Similary, Suzuki *et al*. (1969) reported *Portulaca grandiflora, Macleya cardata* and *Thea sinensis* as major honey plants. Moreover, *Soppora japonica* was identified as a

important nectar source by Haragsim and Machna (1969). Matsuura *et al.* (1974) found that members of Asteraceae, Leguminosae and Brassicaceae were important bee plants in Southern Japan during spring season. Sakai and Matsuka (1982) on their study of honey sources of Japan reported that honey from *Astragalus* sp. was most expensive and best used by Japanese consumers. Other important honey sources were: *Helianthus* sp., *Brassica* sp., *Fagopyrum esculentum, Prunus* sp., *Trifolium* sp., *Acer* sp., *Tilia* sp., *Robinia* sp. etc. Similarly, Sasaki *et al.* (1984) also reported *Astragalus* sp. as the most important honey plant in Japan. Other major sources were *Robinia pseudoacacia, Aesculus* sp., *Medicago* sp. and *Citrus* sp.

Kafle (1984) surveyed the bee flora of Kathmandu valley and enlisted 156 plants. Among these, 44 plant species namely, *Aesandra butyracea, Brassica* spp., *Callistemon* spp., *Citrus* spp., *Eucalyptus* spp., *Fagopyrum esculentum, Grevillea robusta, Guizotia abyssinica, Innula cappa, Psidium guajava, Prunus cerasoides, Punica granatum, Solidago longifolia, Castanopsis indica, Elscholtzia fruticosa, Fraxinus floribunda* were major bee forages. Kafle (1984) and Maskey (1989) reported three main flows of pollen and nectar. The first, spring flow (February-March) was supported by *Callistemon lanceolatus, Eucalyptus* spp., *Berberis* sp., *Trifolium repens, Pyrus pashia, Pyracantha crenulata, Fraxinus floribunda, Bauhinia* spp. and *Leucoceptrum cranum*. The second flow reported April to May period followed by a period of dry and dearth conditions. The period from September until end of November was reported as third main flow season of the year. The study enlisted *Prunus cerasoides, Fagopyrum esculentum, Aesandra butyraceae, Brassica campestris, Helianthus annuus, Innula cappa, Solidago longifolia* and *Vernonia talaumifoli* as major forage plants. Maskey (1989, 1992) observed slight variation in honey flow season. The study revealed that first honey flow was contributed by *Trifolium repens* (April-May), second by *Brassica campestris* (November-February-March) and third by the presence of two or more nectar and pollen sources designated as mixed seasons (September-October). Shrestha *et al.* (1994) carried out the morphological study of pollen from some Nepalese bee floral plants. The study included 84 major bee plants belonging to 38 different families along with 163 micro-photographs.

Partap and Verma (1996) recorded 113 plant species constituting the bee flora of the Kathmandu valley. Important morphotypes belonged to families Acanthaceae, Anacardiaceae, Apiaceae, Asteraceae, Bignoniaceae, Cucurbitaceae, Euphorbiaceae,

Fabaceae, Juglandaceae, Lamiaceae, Lytheraceae, Meliaceae, Myrtaceae, Rosaceae, Sapindaceae, Tiliaceae, Vitaceae, Violaceae, etc. Similarly, melissopalynological studies of *A. cerana* honey were conducted from Jumla by Anonymous (1996). The study reported the occurrence of about 103 plant species constituting the bee forage sources of the region. Most important among these were: *Aesculus carnea*, *Ageratum conyzoides*, *Berberis* spp., *Brassica* spp., *Clematis* spp., *Helianthus annuus*, *Fagopyrum esculentum*, *Malus domestica*, *Indigofera* sp., *Plectranthus mollis*, *Plectranthus rugosus*, *Prinsepia utilis*, *Prunus cerasoides*, *Fragaria indica*, *Guizotia abyssinica*, *Rosa macrophylla*, *Rubus* spp. etc.

Bista and Shivakoti (2001) conducted a study to identify the bee flora and develop a floral calendar at Kabre area of Dolakha district. A total of 119 important plant species were identified. Of these, 47 species were found as major sources for honeybees. Spring season (mid-March to mid-June) and autumn season (mid-Sept to Oct) were identified as honey flow periods having a number of floral plants such as *Guizotia abyssinica*, *Fraxinus floribunda*, *Prunus cerasoides*, *Pyrus communis*, *Castanopsis indica*, *Brassica* spp., *Citrus* spp., *Berberis* spp., *Rubus* spp., *Rhododendron* spp. and *Trifolium* spp. While, winter season (mid-Nov to Feb) was the critical dearth period with a few flowering plants like *Reinwardtia indica*, *Pogestemon glaber*, *Caesalpinia* spp. and *Eupatorium* spp.

Pakistani and Chinese honeys

In Pakistan, Shahid and Qayyum (1977) listed 122 bee plants found in Northwest Frontier Province of Pakistan. Of these, *Dalbergia sissoo*, *Acacia modesta*, *Adhatoda vasica*, *Malus sylvestris*, *Eriobotrya japonica*, *Trifolium* spp., *Brassica campestris*, *Zea mays*, *Citrus* spp., *Phoenix* spp., *Zizyphyus jujuba*, *Psidium guajava* and *Plectranthus rugosus* were recorded as major sources for production of surplus honey. Manzoor and Muhammed (1980) reported *Helianthus annuus* as an important honey plant in Pakistan. Makhdoomi and Chohan (1980) surveyed bee flora of West Punjab and Northwest Frontier Province of Pakistan. Important sporomorphs were: *Adhatoda vasica*, *Trifolium alexandrinum*, *Medicago sativa*, *Acacia modesta*, *Cedrela toona*, *Eucalyptus* spp., *Plectranthus rugosus* and *Eriobotrya japonica*. Kamal *et al.* (2002) performed physico-chemical analysis of five different types of unifloral honey i.e. *Zizyphus mauritiana*, *Acacia modesta*, *Trifolium repens*, *Citrus* sp. and *Eucalyptus*

sp. harvested from *A. mellifera* colonies from Punjab and Northwest Frontier Province of Pakistan.

Bibi *et al.* (2008) conducted microscopic analysis of seven commercial honey samples collected from Austria, Pakistan, Canada, Germany, Australia, Germany and America for determining the total amount of pollen grains, their relative frequencies and detection of heavy metal in honey samples. Pollen types belonging to 12 families were identified, which included Brassicaceae, Sapindaceae, Cannabaceae, Convolvulaceae, Myrtaceae, Pinaceae, Cupressaceae, Asteraceae, Moraceae, Fabaceae, Corylaceae and Loranthaceae.

Noor *et al*. (2015) palynologically analysed the pollen loads from pollen sources of honeybees in Islamabad, Pakistan. A total of 40 plant species were identified of these important pollen yielding plants *viz. Brassica campestris, Callistemon citrinus, Citrus sinensis, Eriobotrya japonica, Parthenium hysterophorus, Chenopodium album, Abelmoscus esculentus, Ageratum conyzoides, Bauhinia variegata, Bombax ceiba, Cassia fistula, Dalbegia sissoo, Grewia asiatica, Jacaranda mimosifolia, Lagerstroemia indica, Litchi chinensis, Melilotus indica, Prunus persica, P. armenica, Pongamia pinnata*, etc.

In China, Focke (1968) analysed 33 honey samples and found *Trifolium* sp., *Robinia* sp., *Frangula* sp., *Lamium* sp. and *Tilia* sp. as major bee plants. Similarly, Den-Feng and Wen-Cheng (1981) reported some important nectar plants of China. They were: *Melilotus* sp., *Nephelium* sp., *Medicago* sp., *Eucalyptus* sp., *Brassica campestris, Citrus* sp., *Astragalus* sp., *Fagopyrum* sp., *Tilia* sp. and *Robinia* sp. Further, Yue-Zhen (1984) studied the important bee plants of China and reported *Fagopyrum* sp., *Meliotus* sp., *Robinia* sp., *Brassica* sp., *Gossypium* sp., *Tilia* sp., *Zizyphus* sp., *Eucalyptus* sp. and *Citrus* sp. as major bee floral plants.

Shikui and Zaiji (1989) and Zhen-Ming *et al.* (1992) reported different species of *Eurya* as important bee forage in hill areas of Southern China. These studies reported the existence of 80 species of *Eurya*, among which *Eurya muricata, E. brevistyla, E. groffii, E. loguiana, E. alata, E. chinensis, E. hebeclados, E. nitida* and *E. megatrichocarpa* were very important for beekeeping. Xu (1993) described 543 nectar and pollen plants belonging to 109 families from China. Among these, 44 plants were major nectar and 24 were major pollen sources.

Song *et al.* (2012) performed qualitative and quantitative melissopalynological analysis of 19 honeys collected from the central region of Shanxi Province, North China. A diverse spectrum of 61 pollen types from 37 families was identified. Of these, 14 samples unifloral, whereas, the remaining samples were multifloral. Bee favoured families (occurring in more than 50% of the samples) included Caprifoliaceae (found in 10 samples), Laminaceae (10), Brassicaceae (12), Rosaceae (12), Moraceae (13), Rhamnaceae (15), Asteraceae (17), and Fabaceae (19). In the unifloral honeys, the predominant pollen types were: *Ziziphus jujuba* (in 5 samples), *Robinia pseudoacacia* (3), *Vitex negundo* var. *heterophylla* (2), *Sophora japonica* (1), *Ailanthus altissima* (1), Asteraceae type (1) and Fabaceae type (1).

Other Asian honeys

Baptist and Punchihewa (1980) carried out studies on bee forage and reported *Tectonia* sp., *Eucalyptus* sp., *Sesamum* sp., *Brassica juncea*, coconut, rubber, etc. as the important nectar and pollen plants in Sri Lanka. Manley (1980) reported *Acacia* sp., *Zizyphus* sp., *Pteropyrum* sp. etc. as major honey sources in Northern Oman. Church and White (1980) recorded some important honey sources like *Eucalyptus* sp., *Citrus* sp., *Medicago* sp., *Prunus* sp., *Trifolium* sp., *Salvia* sp. and *Robinia* sp. from Cyprus. Khanbash (1998) studied bee plants of Yemen and identified over 100 species of plant.

Sajwani *et al.* (2007) collected 48 honey samples from 14 locations in Muscat and Al Batinah regions of Oman to determine the floral sources and identify pollen types that would indicate the pollen ecological origins. A total of 122 pollen types, representing 50 families were identified. 32 honey samples were found unifloral, whereas, remaining 16 were multiforal. The pollen data indicated that *Zizyphus spinachristi, Prosopis julifloria, Prosopis cineraria* were main nectar and pollen sources during winter. By contrast during summer *Acacia tortilis, Citrus sp., Maerua crassifolia, Phoenix dactylifera, Prosopis julifloria, Prosopis cineraria* were more important nectar sources.

Recently, Noor *et al.* (2015) tabulated around 730 plants which involved in honey production in South Asia. Asteraceae and Euphorbaceae proved to be major sources of pollen and nectar. The result shows 41% herbs, 34% trees, 19.50% shrubs and 3.2% vines contributes to honey production.Similarly, Azmi *et al.* (2015) melissopalynological analysed 11 types of pollens which were collected from the

L.terminata foragers in Malaysia. However only 9 types of the pollens were successfully identified. The identified pollens were: *Murraya paniculata*, *Citrus hystrix*, *Calophyllum inophyllum*, *Ixora coccinea*, *Bougainvillea glabra*, *Mimosa pudica*, *Asystasia gangetica* and *Suregada multiflora*. *Ixora coccinea* was the most dominant pollen collected by *L. terminata*. Most dominant pollen were: *Ixora coccinea* (36.78%), followed by *Citrus hystric* (29.27%), and Murraya paniculata (21.05%). Other minor pollen were *Mimosa pudica*(13.56%), *Callophyllum inophyllum* (7.15%), *Asystasia gangetica*(4.3%), *Bougainvillea glabra* (Type 1) (3.73%) and unidentified pollen 1 (3.65%). However, unidentified pollen 2 (1.86%) and *Bougainvillea glabra* (0.86%) were considered as occasional pollens. (0.86%).

POLLEN ANALYSIS OF AUSTRALIAN AND AFRICAN HONEYS

Blake and Roff (1956, 1958) surveyed honey flora of South Eastern Queensland in Australia. About 77 trees, shrubs and herbs which were of great importance to beekeepers were listed. Results indicated predominant pollen types of *Eucalyptus* spp., *Trifolium repens*, *Casuarina* sp., *Citrus* sp., *Acacia* spp. and *Medicago sativa*, etc. Roff (1966) identified *Glycine javanica* as major nectar source in some parts of Australia. It was found as minor source of pollen and yielded light coloured honey with good flavour. Blake and Roff (1972) gave the systematic account of honey flora of Queensland and reported that major sources of pollen and nectar were: *Eucalyptus* sp., *Tristania* sp., *Banksia* sp., *Acacia* sp., *Casuarina* sp. etc. Macfarlane and Beresford (1982) reported that *Cytisus polmensis* was foraged by honeybees for pollen and nectar in New Zealand.

Seijo *et al.* (2003) conducted melissopalynological studies on 75 *Eucalyptus* honey samples from different countries *viz.*, 22 from Australia, 13 from Portugal and 40 from Northwest Spain, in which a total of 145 pollen types were identified. Of these, only *Eucalyptus* sp., *Acacia* sp., *Brassica* sp., *Ligustrum* sp., *Plantago* sp., *Echium* sp., *Rumex* sp., *Taraxacum* sp., *Trifolium* sp. and *Vicia* sp. pollens were present in honeys from all three countries. In Australian honeys, those belonging to the families were: Myrtaceae, Fabaceae, Asteraceae, Proteaceae and Euphorbiaceae, along with *Raphanus* sp., *Echium* sp. *and Citrus* sp were the most abundant pollen types. In the Portuguese honeys, the presence of Fabaceae, Rosaceae and Cistaceae along with *Castanea* sp. and *Erica* sp. were the secondary pollen types. While in Spain, Fabaceae, Asteraceae,

Boraginaceae, Cistaceae and Scrophulariaceae were the families with highest quantity of pollen types in the samples along with *Castanea* sp., *Cytisus* sp., *Erica* sp., *Lotus* sp., *Salix* sp. and *Rubus* sp. as important secondary pollen types.

Fasasi and Malaka (2006) performed physico-chemical characterization of honeys in Logos Metropolis in Nigeria. Melissopalynological studies were conducted on seven honey samples from Opi-Nsukka in Nigeria. The results yielded a total of 77 plants belonging to 40 families of flowering plants. Some important honey plants identified were: *Lannea microcarpa, Senna* spp., *Daniellia oliveri, Parkia biglobosa, Hymenocardia acida, Lophira lanceolata, Syzygium guineense, Parinari* spp., *Elaeis guineensis, Alchornea cordifolia* and members of families Combretaceae/ Melastomataceae (Njokuocha and Ekweozor, 2007).

Adekanmbi and Ogundipe (2009) analysed three honey samples collected from the African honeybee, *Apis mellifera adansonii* in Lagos, Nigeria. The important nectar sources identified from the honey samples were: *Tridax procumbens* and *Elaeis guineensis* belonging to the families Asteraceae and Palmae. Other pollen taxa recovered belonged to the families Mimosaceae, Euphorbiaceae, Sapotaceae and Anacardiaceae provided a clue on the ecological origin of the pollen grains in the honey samples.

Adeonipekun (2012) carried out palynological analysis of honeycomb and a honey sample from an apiary in Lagos State of Southwest Nigeria. A total of 36 species of plant were identified with abundant occurrence of *Pterocarpus santalinoides,* family Meliaceae and Olacaceae. Typical honey pollen of Nigeria include: *Lannea microcarpa, Senna* spp., *Daniellia oliveri, Lophira lanceolata, Syzygium guineensis, Parinari* spp., *Elaeis guineensis, Parkia biglobosa, Hymenocardia acida, Alchornea cordifolia, Berlinia glandifolia, Tridax procumbens, Chromolaena odorata, Combretum* spp., *Nympheae lotus, Parinari kerstingi, Lannea* spp., *Syzygium* sp., *Entada abysinica, Butyrospermum paradoxum* and members of families Combretaceae/Melastomataceae, Poaceae, etc. However, Ayansola and Davies (2012) investigated the honeybee (*Apis mellifera andasonii*) floral resources in Southwestern Nigeria. Forty nine species of melliferous plants belonging to different families were identified. The major nectar and pollen producing plants were: *Cola nitida, Mangifera indica, Coffea arabica, Cola acuminata, Capsicum annum, Alstonia congensis, Cucurbita maxima, Lycopersicon esculentum, Manihot esculenta, Musa sapientum,*

Struchium sparganophora, *Theobroma cacao*, *Tapinanthus* sp., *Zea mays* and *Tridax procumbens.*

Rateb and Hussein (2012) carried out pollen analysis on ten honey samples collected from different geographic regions of Libya. Pollens from 16 plant genera belonging to 10 plant families were identified: Myrtaceae, *Eucalyptus camaldulensis*; Leguminaceae, *Acacia dealbata*, *Hedysarum coronarium*, *Medicago sativa*, *Trifolium incarnatum* and *Vicia* sp.; Rhamnaceae, *Ziziphus spina-christi*; Rutaceae, *Citrus* spp.; Compositae, *Carthamus lanatus*, *Echinops ritro* and *Taraxacum* sp.; Cruciferaceae, *Diplotaxis erucoides*; Palmacae, *Phoenix dactylifera*; Polygonaceae, *Rumex* sp.; Agavaceae, *Agave Americana* and Labiatae, *Ocimum* sp. Similarly, Yang *et al.* (2012) melissopalynologically analysed fifty Corsican chestnut grove honeys. *Castanea sativa* was strongly overrepresented in almost all the honey samples and was accompanied by *Rubus* sp., *Quercus ilex*, *Anthyllis hermanniae*, *Myrtus communis*, *Genista* sp., *Erica arborea*, *Cistus creticus* and *Fraxinus ornus.*

Nair *et al.* (2013) melissopalynologically analysed 10 Algerian honey samples. A total of 36 pollen taxa were identified. Seventy per cent of samples belonged to the group of monofloral honeys and represented by *Eucalyptus globulus*, *Thymus vulgaris*, *Citrus* sp. and *Lavandula angustifolia*. Multifloral honeys comprised 30 per cent of the honey samples, with pollen grains of *Lavandula stoechas* (28.49%) as the most prevalent pollen type. Similarly, Salman and Azzazy (2013) performed melissopalynological analysis of 22 honey samples collected from El-Sharkyia Governorate of Egypt. A total of 34 pollen types were identified, representing 19 plant families. Out of 22 honey samples, 10 samples were found monofloral, while, 12 samples were multifloral. *Citrus* sp., *Acacia* sp., *Eucalyptus* sp., *Vicia* sp., *Brassica* sp., *Borago* sp. and *Calendula* sp. constituted the chief nectar and pollen sources for honey during the spring season. Whereas, *Trifolium* sp., *Cucurbita* sp., *Gossypium* sp., *Helianthus annuus* and Caryophyllaceae were found to be the fewer contributors in nectar collection by the honeybees .Apiaceae were the important nectar and pollen sources during the summer. However, some families such as Poaceae, Lamiaceae and Caryophyllaceae were found to be the fewer contributors in nectar collection by the honeybees.

Agwu *et al.* (2014) carried out analytical examination on 4 honey samples from four localities of Kogi state of Nigeria. A total of 21 pollen types were recorded, some

predominant pollen types included *Leuceana glauca*, *Parkia biglobosa*, *Elaeis guineensis*, *Phyllanthsis* sp. and *Bombax buonopozese.*

Recently, Makhloufi (2015) performed melissopalynological studies on 116 honey samples in Northen region of Algeria. Fifty one of them proved to be monofloral and were mainly from four botanical sources viz., *Eucalyptus* spp., *Hedysarum coronarium*, *Pimpinella anisum* and *Citrus* spp. These honeys could be differentiated from honeys from neighbouring countries by the presence of specific associated pollen. Besides the main pollen species, the characteristic 12 pollen types in the four monofloral Algerian honeys in this study were: *Acacia* sp., Brassicaceae, *Carduus* sp., *Centaurea* sp., *Convolvulus arvensis*, *Eucalyptus* spp., *Olea europaea*, *Papaver rhoeas*, *Pimpinella anisum*, *Trifolium* spp., *Rubus* sp. and *Vicia* sp. Moreover, regional differences in the pollen composition were also observed.

POLLEN ANALYSIS OF EUROPEAN HONEYS

Griebal (1931) was first who, while distinguishing the Overseas, Central and European honeys, observed that the pollen grains of families Mangoliaceae and Asteraceae were predominant in Overseas honeys. Evenius (1933) found variations in average amount of sediment present in the honey samples collected from Switzerland and Germany and these variations ranged from 1.4 to 2.0 ml per 10 gm of honey. The unifloral nature of honeys was confirmed by him as they were derived from *Heracleum* sp. and *Calluna* sp. Maurizio (1949a, b) carried out quantitative analysis of honey samples and based on the total number of pollen grains present in sediment, he distinguished five group of honeys. Goetze (1954) recommended the planting of *Salix* sp., *Robinia* sp., *Acer* sp., *Tilia* sp., *Rhamnus* sp. and *Trifolium* sp. so as to cover the gaps between nectar flows. Evenius (1958) distinguished different groups of honeys according to the amount of sediment present in 150 gm of honey. Four groups were found to contain; 0.035ml; 0.035 to 0.10 ml; 0.10 to 0.20ml and more than 0.20 ml quantities of sediment. Further, Evenius (1960) analysed various honey samples from Germany and revealed that *Trifolium repens*, *Trifolium pratense* and Brassicaceae pollens were predominant.

Ruttner (1956) conducted melissopalynological studies on 178 samples in Austria. He categorised four types of honeys namely: flower/honeybee, honeydew/flower and honeydew. Flower honey was mainly derived from *Trifolium*

spp., whereas, honeydew was mainly derived from *Picea excelsa*. Loken (1958) identified *Tilia* sp., *Aesculus* spp. and Rananculaceous members, which were toxic to bees. Ruttner (1961) reported that Austrian honey consist mainly of pollen grains of *Loranthus* sp., however, besides this, other pollen grains were: *Onobrychis* sp., *Stachys* sp. and *Cerintha* sp. Fossel (1966) reported that pollen grains of *Gentiana aspera* were predominant while performing similar study on 46 honey samples from Austrian uplands. Later, Fossel (1974) surveyed bee flora of Eastern Alps of Austria and found important sources were *Trifolium repens, Acer* sp., *Salix* sp. and *Rumex* sp.

Deans (1957) analysed some British honeys. The important bee plants were *Trifolium repens, Calluna vulgaris, Rubus* sp., *Pyrus* sp., *Prunus* sp. and some Brassicaceous members. Similarly, Pelimon (1960, 1966) performed pollen analysis of honey samples of Romania and reported *Robinia pseudoacacia, Castanea sativa, Tilia* sp. as major honey plants. Besides them, *Echium vulgare, Trifolium* sp., *Lotus corniculatus* were other important honey sources. Hodges (1958, 1978) prepared a floral calendar of bee plants of England and analysed the annual variation in first flowering dates of eight key plants.

Louveaux (1958) observed that *Brassica napus* var. *oleifera*, an important honeybee plant resource with pale yellow coloured honey. Barbier (1958) studied a number of single-sourced French honeys and showed great differences in their pollen content ranging from 172 to 1,28,250 pollen grains per 10 gm of honey. Maurizio and Louveaux (1966) performed pollen analysis of various honeys from different parts of Europe. *Brassica napus, Aesculus* sp., *Tilia platyphylla, Diplotaxis* sp., etc. were found as major nectar and pollen plants. Similarly, Bernardini and D'Albore (1971) reported *Trifolium pratense, Vicia* sp., *Erica arborea, Stachys annua, Onobrychis* sp. as important nectar plants. Further, Marletto and Ronchietto (1972) found *Salvia pratensis, Onobrychis viciafolia* and *Epilobium angustifolium* to be most attractive plants for bees in Italy.

Persano Oddo and D'Albore (1975) surveyed some bee plants of Italy and found *Eucalyptus* sp., *Onobrychis* sp., *Erica* sp., *Salvia* sp., *Quercus* sp., in spring; *Rubus* sp., *Trifolium pratense, Eucalyptus* sp., *Lythrum* sp., *Castanea* sp. in summer season and *Odontiles, Hedera* sp. and Brassicaceous members in autumn season. D'Albore and D'Ambrosio (1976) surveyed six different areas of Italy and gave quantitative pollen analysis of honey. *Castanea* sp. was found to be most predominant. Studies were

conducted on honey samples collected during March for finding out their botanical origin revealed that *Quercus* sp., *Trifolium pratense*, *Onobrychis* were quite predominant, while, *Castanea* sp. was restricted to a limited area (D'Albore and Piastrelli, 1977).

Battaglini and D'Albore (1981) performed pollen analytical studies on honey samples from Italy. *Brassica napus, Medicago* sp., *Taraxacum vulgare*, *Helianthus annuus, Trifolium repens, Daucus* sp., etc. were major pollen sources in Italian honeys. Bortoli (1983) conducted melissopalynological studies on 37 honey samples from different localities of Italy during April to August. Important sources investigated were: *Trifolium repens, Salix* sp., *Prunus* sp., *Rubus* sp., *Robinia pseudoacacia* and *Taraxacum officinale*. Pollen analysis of Polish honey samples revealed *Cynaglossum* sp. and *Myosotis* sp. as predominant types with five million pollens per 10 gm of honey. Honey samples with 20,000 pollen grains per 10 gm were considered as poor source (Demianowicz, 1955). Further, Demianowicz (1962) analysed unifloral honeys from six species of Lamiaceae and showed that number of pollen grains varied greatly i.e. 204 to 2606 per gm of honey. Again, Demianowicz (1964, 1966) analysed the pollen spectrum of unifloral Polish honeys. Quantitative analysis of honeys showed wide variation in pollen content. Pollen grains were recorded maximum in number in honeys derived from *Cynoglossum* sp., whereas, *Fagopyrum* sp. and *Trifolium* sp. had smallest number of pollen grains in honey.

Thomas (1983) surveyed pollen loads and found *Chrysanthemum* sp., *Eucalyptus* sp., *Trifolium repens, Rubus* sp. as predominant types in both rural and urban environment. Hazlinszky (1955) revealed that geographical origin of honeys could be found out by conducting the pollen analysis of honeys. He further described that *Stachys annua* and *Stachys erecta* both were best honey plants after *Robinia* sp. in Hungry. Pollen spectrum of honeys from North and South Moravia as analysed by Kropacova (1969) revealed that pollens of *Brassica napus, Prunus* sp., *Pyrus* sp. were predominant in Northern honeys, whereas, *Tilia* sp., *Trifolium* sp. and *Acacia* sp. were characteristic of Southern honeys. Kropacova and Nedbalova (1971) conducted similar studies on 150 samples from West Moravia. Most of the honey samples were multifloral characterized by presence of *Robinia* sp. Further, Kropacova and Nedbalova (1976) performed quantitative and qualitative analysis of 180 samples from different parts of Czechoslovakia and indicated that most of samples were multifloral with maximum amount of *Acacia* pollen.

Melissopalynological studies were conducted on smaller scale in many European countries. Martin d'Alte (1951) performed pollen analytical studies on 35 honey samples from different parts of Portugal and observed that best honeybee plant resource was *Eucalyptus* sp. Howes (1953) described some major nectar plants of Spain along with their local names. He also described botanical features of some plants such as loquat, lemon and fir. Maurizio (1958) categorized some honey samples from Switzerland according to the amount of pollen present in them. Differences in the pollen counts were discussed in relation to sainfoin, lucerne and rape honeys. Maurizio (1959) investigated various indicators including cells of various algae; spores and hyphae of fungi; various animal constituents and pollen grains of wind pollinated grasses showing the presence of honeydew in honey samples. Further, Maurizio (1962) conducted pollen analysis of honey samples from individual colonies in the same apiary and gave description about dark aromatic, bright yellow and light aromatic honeys.

Jato *et al.* (1991) carried out palynological analysis of 94 honey samples from Province of Orence in Northwest Spain and found *Castania sativa*, *Rubus* spp., *Lotus corniculatus*, etc. as predominant plant resources. Further, Seijo *et al.* (1992) made an attempt to palynologically characterize 60 samples of honeys from the province of La Coruiia in Northwest Spain. Of these, 37 were multifloral and remaining 23 were unifloral. Important pollen types found were: *Rubus* sp., *Castanea* sp., *Eucalyptus* sp., *Erica* sp. and *Genista* sp. Similarly, Seijo *et al.* (1997) analysed pollen content for 530 honeys from Galicia in North-West Spain. 212 honeys were classified as unifloral (83 sweet chestnut honeys, 60 eucalypt honeys, 49 blackberry honeys, 12 heather honeys and 8 Fabaceae honeys). Karabournioti (2000) carried out analysis of pollen and honeydew elements in 180 honey samples from different areas of Greece using standard methods of melissopalynology. In six unifloral honeys (orange, sunflower, cotton, thyme, fir and pine), 28 pollen types were identified. Individual honeys contain 15-23 pollen types such as *Eucalyptus sp.*, *Helianthus annuus*, *Trifolium sp.*, *Erica sp.*, *Castanea sativa* and members of families Brassicaceae, Apiaceae, Asteraceae and Hypericaceae, etc.

Kaya *et al.* (2005) conducted the pollen analysis of 13 honey samples from Turkey. The study revealed that only one sample was unifloral, while, 12 were multifloral. The important morphotypes consisted of *Hedera helix*, *Gossipium*, sp.,

Trifolium sp., *Sophora* sp., *Rhododendron* sp., *Castanea sativa, Paganum harmala, Helianthus* sp., *Lotus* sp., *Rubus* sp., *Salvia* sp., etc. Fortunato *et al.* (2006) analysed the pollen loads of honeybees in Udine province of Northern Italy. The most important pollen types were: *Taraxacum officinale, Salix* sp., *Fraxinus* sp., *Populus* sp, *Corylus* sp., *Papaver* sp. and members of families Liliaceae, Manoliaceae, Salicaceae, etc.

Floris *et al*. (2007) carried out pollen analysis of honeys of Sardinia in Italy. The melliferous plants include more than 200 species, which allow the production of unifloral and polyfloral honeys including typical production from asphodels, thistle, strawberry-tree and other such as eucalyptus and citrus. Gebremichael (2007) conducted melissopalynological analysis of honey and botanical investigations of bee plants of Atakilty, Tigray in Ethopia. Thirty nine plant species were found as nectar and pollen sources in the area were: *Aloe berhana, Bidens pachyloma, Cparis ethyrocarpus* and *Justicia shimperina.*

Ceglinskla (2008) analysed 23 samples of spring specific honeys collected from apiaries located in 12 communes in Rzeszow area of Poland. 42 pollen taxa were identified, of which 31 nectariferous and 11 non-nectariferous anemophilous plants. Among nectariferous plants, highest pollen frequency was found for Brassicaceae (95.7%), *Rubus* sp. (91.3%) and *Prunus* sp. (86.9%) respectively. The anemophilous pollen were recorded in all samples with highest Poaceae (69.8%), 50% for *Quercus* sp. and *Rumex* sp. while lowest 10% for *Cerealia* sp., *Corylus avellana* and *Humulus lupulus*. However, Deniela *et al.* (2008) performed palynological and physico-chemical studies on 15 Christ's thorn (*Paliurus spina christi*) honeys from Croatia.

Atanassova *et al.* (2009) analysed 17 honey samples from five localites in Central Bulgaria. Fifty-eight pollen types of nectariferous plants were identified with two monofloral honeys of *Robinia pseudoacacia* and *Stachys* sp. The most important nectar producing plants belonged to families Rosaceae (*Prunus* sp., *Malus* sp., *Pyrus* sp., *Rubus* sp., *Fragaria* sp. etc.) Lamiaceae, Brassicaceae and Fabaceae. However, numerous species producing high quantity of nectar during the dry periods include: *Centaurea cyanus, Cirsium* sp., *Echium vulgare, E. italicum* etc.

Pires *et al.* (2009) studied the pollen spectrum and physicochemical characteristics of 23 unifloral heather (*Erica* sp.) honeys of North Portugal. All honey samples were classified as monofloral. The families Fabaceae and Rosaceae provided

the greatest number of pollen types followed by *Eucalyptus* sp. present in 69.6% of the samples.

Aronne *et al.* (2010) applied support vector machines to the melissopalynological data obtained by the analysis of *Castanea sativa* honeys from Sorrento Peninsula, Italy. The methodology was based on the elaboration of palynological data with statistical learning methodologies and this innovative solution provides a simple yet powerful tool to detect the origin of honey samples.

Benay *et al.* (2010) performed melisopalynological analysis on 30 honey samples collected from Ankara city of Turkey. A total of 46 taxa of pollens were identified, 35 of which were at family level and 11 were at genus level in 27 honey samples. However, three honey samples were found artificial. The pollen grains of Fabaceae, Aceraceae, Boraginaceae, Poaceae, Asteraceae, Apiaceae, Caryophyllaceae, Rosaceae, Hedysarum, Brassicaceae and Fagaceae were recognized as dominant and secondary groups. While, the pollen grains of *Plantago*, Cistaceae, Geraniaceae, Cucurbitaceae, Liliaceae, Caryophyllaceae, *Rumex* sp., Plantaginaceae, *Echium*, Campanulaceae, Salicaceae, Chenopodiaceae, Lamiaceae and Ericaceae were identified as the minor groups.

Further, Stawiarz and Wroblewska (2010) conducted melisopalynological analysis of 73 samples of multifloral honeys collected from Sandomierska upland area of Poland. The study revealed that honey samples found to contain pollen grains of 103 taxa (75 nectariferous and 28 non-nectariferous ones) belonging to 52 botanical families. Amongst nectariferous plants, main nectar flow was provided by the Brassicaceae (including *Brassica napus*), *Prunus* sp., *Trifolium repens*, *Anthriscus* sp., *Salix* sp., *Taraxacum* sp. and *Phacelia* sp. However, among the non-nectariferous plants, highest frequency was reported for family Poaceae.

Sabo *et al.*, (2011) analysed the palynological properties of 8 honey samples commercially produced in Varazdin County in Northern Croatia. Each sample was examined to determine the pollen percentage, pollen spectrum and botanical origin. 6 samples were unifloral, while, 2 were multifloral with 20 different types of pollen grains were identified in the samples. The dominant group of pollen grains consisted of *Castanea sativa*, *Brassica napus* and *Trifolium pratense* each in two samples respectively.

Atanassova *et al.* (2012) conducted the melissopalynological studies on 15 honey samples from Bulgaria. The study revealed that the main honeys came from *Robinia pseudoacacia*, *Helianthus annuus*, *Brassica* spp., *Tilia* spp. and *Vicia* spp. However, the botanical origins of unifloral honey samples were identified as *Lotus* spp., *Coriandrum sativum*, *Daucus*-type, *Stachys*-type, *Salix* spp., *Prunus* spp., *Castanea sativa*, *Paliurus spina-christi*, *Sophora japonica* and *Amorpha* spp. Recently, Svecnjak *et al.* (2015) performed melissopalynological analysis 632 honey samples from Croatia, from which 506 samples were assigned to one of nine unifloral honey type.

Microscopical analysis was conducted on different honey samples of honeybees *viz., A. cerana* F., *A. dorsata* L. and *A. mellifera* L. collected from Kangra and adjoining areas of Himachal Pradesh. Himachal Pradesh is predominantly a hill state presents varied climate, topography and geology resulting in diversified flora. Climate is the main factor which determines the composition of the flora of any other areas. There are four major agro-climatic zones in Himachal Pradesh which can be classified as sub-tropical (low lying hills), sub-temperate (mid hills), temperate (high hills and interior valley) and dry cold zone (trans- Himalaya).

i) Sub-tropical Zone

This zone comprises of valleys and low lying hills near the plains of Punjab and Haryana. Altitude in this zone varies from 350 to 1000 metres with an annual rainfall between 600 to 1000 mm. This zone is very fertile and can be subjected to intensive cultivation.

ii) Sub-temperate Zone

This zone comprises of mid hills and the altitude varies from 1000 to 1500 metres above mean sea level. The climate of this zone is moderate with annual precipitation ranging from 900 to 1000 mm.

iii) Temperate High Zone

This zone comprises of high hills and interior valley areas with altitudes varying from 1550 to 3000 metres above mean sea level. Annual rainfall varies from 900 to 1000 mm and snowing in winter is a usual feature.

iv) Cold and Dry Zone

This zone lies between 3000 to 3700 metres above mean sea level. Annual rainfall is scanty and varies from 250 to 400 mm. This zone is extremely cold and minimum temperature on an average comes down to -15^0 C.

Beekeeping is wide spread with several potential honey producing areas in first three zones and also in a few warmer pockets of cold and dry zone. Field work of honey yielding plants was carried out in different localities of Kangra and adjoining

areas of Himachal Pradesh. This is a hilly state situated in the heart of Western Himalayas between 30^0 22' to 30^0 12' North latitude and between 75^0 45' and 79^0 04' East longitude. To the East, it forms India's border with Tibet, to the the North lies state of Jammu & Kashmir, Uttarakhand in the South-East, Haryana in the South and Punjab in the West. The entire territory of Himachal Pradesh is almost wholly mountainous with altitudes ranging between 350 to 6,975 metres above the sea level. Average rainfall in state is on an average of 1600 mm, although it varies from a minimum of 350 mm at Lahaul-Spiti to a maximum of 4400 mm at Dharamshala (Balokhara, 2015).

Present investigations were conducted in Kangra and adjoining areas of Himachal Pradesh. It lies in between 31^0 40' to 32^0 25' N and 70^0 35' to 77^0 5' E. The district has a geographical area of 5,739 km. It is bounded in Southwest by Una district, Gurdaspur district of Punjab in Northwest, Lahaul-Spiti and Chamba districts in North, Kullu and Mandi districts in East and in south it touches the Hamirpur. The district is crisscrossed by mountain ranges and valleys. The ranges include The Dhaula Dhar, The Hathi Dhar and The Paporal range. The Dhauladhar starts from right bank of river Beas, passes through Bhagal area above Kangra and Palampur covering Bara Bhangal. The Hathi Dhar forms boundary between Kangra and Chamba. The Paprola range separate Bir Banghal from Kangra valley. There is variable climate condition in the district from humid to sub-humid, sub-tropical zone and wet to humid sub-temperate zone. Moreover, Kangra valley is meeting place of Eastern and Western monsoon which causes high rainfall in Dharamshala making it the wettest place in Himachal Pradesh (Balokhra, 2015).

Flowering Plants (wild and ornamental) which were visited by honeybees to collect pollen and nectar were collected from different zones of Kangra and adjoining areas of Himachal Pradesh during different seasons from 2014 to 2015. These plants were identified with the help of local floras and taxonomists from Department of Biosciences, Himachal Pradesh University, Shimla and CSIR-Institute of Himalayan Bioresource Technology, Palampur, Himachal Pradesh. A floral calendar of honey yielding plants of Kangra hills indicating their taxonomic status, geographic location, honey potentiality and period of flowering have been prepared.

HONEY POLLEN ANALYSIS

Analysis of pollen recovered from honey samples has long been used to identify their floral sources and even their geographical origins (Maurizio, 1975). This method gives a cumulative pollen spectrum of the nectar sources contributing to the honey over the whole period during which it was accumulated (Adams *et al*., 1979; Adams and Smith, 19 81).

Collection of honey samples

Honey samples of honeybees *viz*., *A. cerana*, *A.dorsata* and *A.mellifera* were collected from different localities of Kangra and adjoining areas of Himachal Pradesh having different altitudes, latitudes and agro-climatic conditions. Places of collection were: Dhaliara (480 m), Jwali (494 m), Raja ka talab (532 m), Jwalamukhi (620 m), Bairghata (640 m), Thural (661 m), Kangra (720 m), Shahpur (779 m), Paraur (969 m), Rajot (972 m), Paprola (987 m), Chamunda (1059 m), Ropa (1064 m), Sudher (1338 m) and Bundla (1513 m). (Table 1; Fig. 1). These collections were made mainly during the major honey flow seasons (i.e. February to June) of the year 2015.

Preparation of Slides

Reference pollen slides of honey samples were prepared according to the method of Louveaux *et al.* (1978), modified by Iwama and Melhem (1979). For the preparation of pollen slides of honey, 10 gm of honey was dissolved in 20 ml of hot distilled water at 40^0C. This solution was poured equally into different centrifuge tubes and centrifuged at 2500-3000 rpm for 10 minutes. The supernatant liquid was drained off with a fine pipette. The sediment was dispersed again and transferred into another centrifuge tube, centrifuged again for five minutes and sediment was separated. It was then acetolysed by adding sulphuric acid and acetic anhydride in ratio 1:9. The tube was then placed in a water bath for ten minutes at 70^0C and centrifuged after incubation for five minutes. The centrifuge tube was filled with distilled water and a drop of strong detergent (teepol) was added. It was again centrifuged for five minutes and a drop of glycerine and water mixture (1:1) added to the sediment. Then this sediment solution was transferred to the slides which were placed in an oven (40 to 45^0C) to get surplus water evaporated. The pollen grains were mounted in glycerine gelatin.

IDENTIFICATION, COUNTING AND RECORDING OF POLLEN GRAINS

The pollen grains obtained from honey samples by honey pollen analysis along with pollen grains (intact anthers) collected from major honey plant resources from the area (about 5 km) surrounding the apiaries were examined microscopically. Identification of different pollen types were done with the help of pollen slide collection of Sociology and Behavioural Ecology Research Laboratory of Department of Biosciences, Himachal Pradesh University, Shimla, and standard works of Erdtman (1960) and Nair (1964, 1985). The pollen types were then confirmed by comparing them with the reference pollen slides available in the pollen herbarium of the Palynology Laboratory, National Botanical Research Institute, Lucknow.

After the identification of different pollen types, counting was done with the help of a haemocytometer (Louveaux *et al*., 1978; Seethalakshmi, 1980; Suryanarayana *et al*., 1981; Sharma, 1989). Absolute pollen count and percentage of pollen types were calculated and pollen spectra were constructed on the basis of these percentages (Sharma and Nair, 1965; Vorwohl, 1981; Chaturvedi, 1983). The honey samples were considered rich, poor and extremely poor in pollen, if total number of pollen grains per 10 gm of honey were 1,00,000; 20,000 to 1,00,000 and below 20,000, respectively (Maurizio, 1975).

Frequencies of pollen grains were presented according to the system adopted by Louveaux *et al. (*1978). The following terms have been used for frequency classes: 'Predominant pollen' (having more than 45% of the pollen grains counted); ‘Secondary pollen' (16 to 45%); 'Important minor pollen' (3 to 15%) and ‘Minor pollen' (less than 3%). Honey sample was termed as 'Unifloral honey' if it is having 45 per cent or more grains of a single pollen type and honey sample with several pollen types in considerable percentage was termed as 'Multifloral honey' (Iwama and Melhem, 1979; Chaturvedi, 1983).

PREPARATION OF REFERENCE SLIDES

Reference slides were prepared from the pollen grains collected from various localities of Kangra and adjoining areas of Himachal Pradesh. For preparation of reference slides of pollen grains, two methods were followed:

Acetolysis method

The reference pollen slides were prepared by dipping the anthers or whole flowers of identified plants in acetic acid and keeping them overnight. In the morning, the pollen material was transferred to heat resistant centrifuge tubes and covered with 5 ml mixture of acetic anhydride and sulphuric acid. This acetolysis mixture was prepared by adding acid drop by drop, to nine times the volume of acetic anhydride. This reaction mixture was heated in a water bath at 70^0C, stirred thoroughly and transferred to the centrifuge. After centrifugation, 10 ml of water alcohol mixture was added to the sediment and it was shaken thoroughly. After acetolysis and washing, one third of suspension in the centrifuge tube was transferred to another tube. It was centrifuged again and to the sediment was added the following reagents: 2 ml of glacial acetic acid, 1 or 2 drops of saturated sodium chlorate solution and 2 or 3 drops of conc. hydrochloric acid. After centrifuging the reaction mixture again, the sediment was washed with distilled water and suspended in a few drops of mixture of glycerine and water in ratio 1:1. It was then centrifuged and supernatant was drained off with a pipette and the pollen grains were mounted in the glycerine jelly (Louveaux *et al.*, 1978).

Glycerine jelly method

Direct Fuschin Stain Method: For the preparation of reference slides, anthers (pollen grains) were collected from located in experimental apiaries flowers in small plastic bottles and stored in Diethyl ether or Ethyl alcohol. Anthers were then transferred to a small watch glass having Diethyl ether. Anthers were teased to get pollen grains out, while keeping the anthers in diethyl ether. One spot of pollen grains was made on two slides within the pre-marked area on the slide. Spot of first slide was covered with normal glycerine gelatin and that of second slide was covered with a mixture of a drop of glycerine gelatin and a little of Basic Fuschin red stain. Slides were heated on spirit lamp for a few seconds so as to spread the material. Both the slides were covered with cover slips gently. Slides were sealed with either nail polish or paraffin wax and were preserved after identification in a freezer.

POLLEN LOAD STUDIES

Pollen load studies provide useful information regarding bee preferences, related to flowering changes of bee forage plants (Sharma, 1970a, b; Deodikar and Suryanarayana, 1977).

Collection of Pollen Loads

Pollen loads of different honeybees (*Apis* spp.) viz., *A. cerana, A. dorsata* and *A. mellifera* were collected regularly at weekly intervals from local apiaries of different areas of Kangra and adjoining areas from February to October 2015 (Table 1; Fig. 1). The pollen loads were collected from the hind legs of incoming bees during different hours of the day.

Preparation of Slides

For the pollen load analysis, the pollen pellets were dispersed in water. The solution was then acetolysed according to the method of Erdtman (1960) and Sharma (1970a, b). 1 ml of 50 per cent glycerine was added to the sediment which was then transferred to the slides. The smear was then allowed to dry and washed with several drops of ether. This pollen smear was mounted in glycerine gelatin and covered with a cover glass. The slide thus prepared was sealed and studied microscopically. The field data and pollen herbarium of Palynology Laboratory, National Botanical Research Institute, Lucknow formed the basis for identification of various pollen types. The terms used in describing the pollen loads are those used by Chaturvedi (1973, 1977): Unifloral (with one pollen type) and Multifloral (with more than one pollen type) loads.

SURVEY WORK

Survey work of honey yielding plants was carried out in different localities of kangra and adjoining areas of Himachal Pradesh. Flowering plants (wild and ornamental) which were visited by honey bees to collect pollen and nectar were collected from different localities of Kangra and adjoining areas of Himachal Pradesh during different seasons of experimental year. These plants were identified with the help of local floras and taxonomists from Department of Biosciences, Himachal Pradesh University, Shimla; Punjabi University, Patiala; Forest Research Institute, Dehradun and National Botanical Research Institute, Lucknow. A floral calendar of honey yielding plants of Kangra and adjoining areas of Himachal Pradesh, indicating their taxonomic status, geographic location, honey potentiality and period of flowering have been prepared.

The abbreviated titles of the periodicals in the references are indicated according to "Serial sources for the Biosis Data Base TM 2006 Volume".

Table 1: Physiographic details of different places of collection of honey samples of *Apis cerana* F., *Apis dorsata* L. and *Apis mellifera* L. from Kangra and adjoining areas of Himachal Pradesh.

Sr. No.	Locality	Geographical Position		Altitude (m)	Honeybee species
		Latitude (N)	Longitude (E)		
1.	**Dhaliara**	$32^0 10'$	75^0 55'	480	*Apis dorsata*
2.	**Jwali**	32^0 08'	76^0 00'	494	*Apis cerana*
3.	**Raja ka Talab**	32^0 12'	75^0 54'	532	*Apis cerana*
4.	**Jwalamukhi**	31^0 52'	76^0 19'	620	*Apis cerana*
5.	**Bairghata**	31^0 53'	76^0 29'	640	*Apis cerana*
6.	**Thural**	31^0 55'	76^0 27'	661	*Apis mellifera*
7.	**Kangra**	32^0 06'	76^0 18'	720	*Apis cerana*
8.	**Shahpur**	32^0 13'	76^0 10'	779	*Apis mellifera*
9.	**Paraur**	32^0 05'	76^0 27'	969	*Apis cerana*
10.	**Rajot**	32^0 02'	76^0 35'	972	*Apis cerana*
11.	**Paprola**	32^0 03'	76^0 38'	987	*Apis cerana*
12.	**Chamunda**	32^0 09'	76^0 24'	1059	*Apis mellifera*
13.	**Ropa**	32^0 34'	$76^0$32'	1064	*Apis dorsata*
14.	**Sudher**	32^0 09'	76^0 32'	1338	*Apis cerana*
15.	**Bundla**	32^0 13'	$76\ ^0$19'	1513	*Apis cerana*

Microscopical analysis was conducted on different honey samples of honeybees *viz.*, *A. cerana* F., *A. dorsata* L. and *A. mellifera* L. collected from Kangra and adjoining areas of Himachal Pradesh, so as to identify important pollen and nectar resources of this region. Different honey samples were collected during summer season. Places of collection of different honey samples were: Dhaliara (480 m), Jwali (494 m), Raja ka talab (532 m), Jwalamukhi (620 m), Bairghata (640 m), Thural (661 m), Kangra (720), Shahpur (779 m), Paraur (969 m), Rajot (972 m), Paprola (987 m), Chamunda (1059 m), Ropa (1064 m), Sudher (1338 m) and Bundla (1513 m). All honey samples were analyzed microscopically for different pollen types.

For presenting the pollen analytical data, honey samples were classified on the basis of the localities of their production. Results are summarized as follows:

1. Dhaliara Honey

Honey sample collected during summer season was amber in colour. It was found to be quite rich in pollen content.

Honey pollen analysis indicated that it was multifloral honey with different types of pollen grains (Tables 2, 3; Fig. A). Secondary pollen grains present were of *Emblica officinalis* (Euphorbiaceae, 23.93%) and *Murraya koenigii* (Rutaceae, 18.62%). Important minor pollen grains were of *Cedrela toona* (Meliaceae, 13.19%); *Rosa* sp. (Rosaceae, 14.39%); *Taraxacum officinale* (Asteraceae, 10.92%) and *Acacia* sp. (Fabaceae, 10.06%). Minor pollen grains belonged to *Ageratum conyzoides* (Asteraceae, 2.89%) and members of families Rutaceae (2.28%); Cucurbitaceae, (2.41%) and Fabaceae (1.31%).

2. Jwali Honey

Honey sample collected during summer season was light yellow in colour. Pollen sediment was rich in pollen.

Microscopic analysis of honey sample indicated that it was a unifloral honey with predominant pollen grains of *Citrus* sp. (48.74%) (Tables 2, 3; Fig. B). Secondary pollen grains present were of *Campsis grandiflora* (Bignoniaceae, 16.91%) and *Mangifera indica* (Anacardiaceae, 14.83%). Important minor pollen grains belonged to *Litchi chinensis* (Sapindaceae, 4.09%); *Carica papaya* (Caricaceae, 3.14%) and

Dalbergia sissoo (Meliaceae, 3.04%). Minor pollen grains belonged to *Zizyphus* sp. (Rhamnaceae, 2.89%); *Allium* sp. (Amaryllidaceae, 2.65%); *Ageratum conyzoides* (Asteraceae, 1.87%); *Cucurbita* sp. (Cucurbitaceae, 1.84%).

3. Raja ka talab Honey

Honey sample collected during summer season was amber in colour. Pollen sediment was rich in pollen.

Microscopic analysis of honey sample indicated that it was a multifloral honey with a fairly good amount of pollen grains (Tables 2, 3; Fig. C). Secondary pollen grains present were of *Adhatoda vasica* (Acanthaceae, 26.74%); *Mangifera indica* (Anacardiaceae, 19.67%) and *Punica* sp. (Punicaceae, 16.29%). Important minor pollen grains belonged to *Bombax* sp. (Bombacaceae, 10.84%); *Caesalpinia* sp. (Fabaceae, 9.33%); *Carissa* sp. (Apocynaceae, 5.33%) and *Aegle* sp. (Rutaceae, 8.54%). Minor pollen grains were of Myrtaceae (3.78%), Asteraceae (2.97%) and Papilionaceae (1.84%) members respectively.

4. Jwalamukhi Honey

Honey sample collected during the summer season was dark amber in colour. The pollen sediment was rich in pollen content.

Honey pollen analysis indicated that it was mutifloral honey with a variety of pollen grains (Tables 2, 3; Fig. D). Secondary pollen grains present were of *Murraya koenigii* (Rutaceae, 22.21%); *Ageratum conyzoides* (Asteraceae, 17.51%); *Dalbergia sissoo* (Fabaceae, 16.0%) and *Grewia* sp. (Tiliaceae, 16.64%). Important minor pollen types belonged to *Citrus* sp. (Rutaceae, 5.59%); *Rumex hestatus* (Polygonaceae, 4.56%); *Mangifera indica* (Anacardiaceae, 4.5%) and *Cassia fistula* (Fabaceae, 3.13%). Minor pollen grains were of *Zizyphus* sp. (Rhamnaceae, 2.18%); *Eucalyptus* sp. (Myrtaceae, 2.10%); *Melia* sp. (Meliaceae, 1.51%); Poaceae (1.42%); Rosaceae (1.05%); Cucurbitaceae (1%) and members of Apiaceae (0.93%).

5. Bairghata Honey

The honey sample collected during the summer season was light amber in colour. The pollen sediment was poor in pollen.

It was also a unifloral honey with predominant pollen grains of *Moringa oleifera* (Moringaceae, 48.40%) (Tables 2, 3; Fig. E). Secondary pollen grains were of *Grewia optiva* (Tiliaceae, 22.32%). Important minor pollen grains were of *Grevillea robusta* (Proteaceae, 11.22%); *Melia azedarach* (Meliaceae, 5.12%)*; Butea monosperma* (Fabaceae, 4.19%); *Jacaranda mimosifolia* (Bignoniaceae, 3.47%) and *Dalbergia sissoo* (Fabaceae, 3.03%). Minor pollen grains were of *Albizia lebbeck* (Fabaceae 1.17%) and *Murraya koengii* (Rutaceae, 1.08%).

6. Thural Honey

Honey sample collected during the summer season was light brown in colour. The pollen sediment was poor in pollen.

Pollen analysis of honey sample revealed that predominant pollen grains were of *Mangifera indica* (Anacardiaceae, 53.40%) (Tables 2, 3; Fig. F). Secondary pollen grains were of *Litchi chinensis* (Sapindaceae, 22.15%). Important minor pollen types belonged to *Helianthus annuus* (Asteraceae, 11.36%); *Brassica campestris* (Brassicaceae, 9.09%) and a Lytheraceae (3.43%) member. Minor pollen grains were of *Leucaena leucocephala* (0.57%).

7. Kangra Honey

Honey sample collected during the summer season was yellow in colour. Pollen sediment was rich in content.

It was a multifloral honey with mixed floral association of pollen types (Tables 2, 3; Fig. G). Microscopic analysis of honey indicated that secondary pollen grains present were of *Brassica* sp. (Brassicaceae, 20.62%); *Syzygium cumini* (Myrtaceae, 18.84%); *Prunus* sp. (Rosaceae, 19.48%) and *Albizzia* sp. (Fabaceae, 16.05%). Important minor pollen grains were of *Callistemon citrinus* (Myrtaceae, 4.71%); *Murraya koenigii* (Rutaceae, 4.49%); *Adhatoda vasica* (Acanthaceae, 6.42%) and *Fragaria* sp. (Rosaceae, 3.24%). Minor pollen grains belonged to *Pinus* sp. (Pinaceae, 1.9%); *Leucaena* sp. (Fabaceae, 2.06%) and Asteraceae members (2.19%).

8. Shahpur

Honey sample of summer season was light amber in colour. The pollen sediment was extremely poor in pollen.

Microscopical analysis of honey indicated that it was a multifloral honey with mixed floral sources (Table 2, 3 Fig. H). Secondary pollen grains were of *Syzygium* sp. (Myrtaceae, 24.12%) and *Hibiscus* sp. (Malvaceae, 17.18%). Important minor pollen grains of *Grevillea* sp. (Proteaceae, 4.02%), *Allium* sp. (Amaryllidaceae, 0.98%), *Bauhinia* sp. (Fabaceae, 6.30%), *Grewia* sp. (Tiliaceae, 4.96%), *Callistemon* sp. (Myrtaceae, 9.68%) and members of family Rutaceae (8.06%). Minor pollen grains were of *Albizzia* sp. (Fabaceae, 1.20%), *Acacia* sp. (Fabaceae, 4.75%), *Dalbergia* sp. (Fabaceae, 5.06%), *Cassia* sp. (Fabaceae, 3.96%), *Taraxacum* sp. (Asteraceae, 1.05%) and members of families Apocynaceae (1.99%), Brassicaceae (2.99%) and Malvaceae (2.98%).

9. Paraur Honey

The honey sample collected during the summer season was watery white in colour. The pollen sediment was poor in pollen.

It was a unifloral honey with predominant pollen grains of *Eucalyptus* sp. (Myrtaceae, 49.20%) (Tables 2, 3 Fig. I). Secondary pollen grains were of *Eriobotrya* sp. (Rosaceae, 17.46%) and *Callistemon* sp. (Myrtaceae, 20.63%). Important minor pollen grains were of *Murraya* sp. (Rutaceae, 5.82%) and *Jacaranda* sp. (Bignoniaceae, 4.23%). Minor important pollen grains were of Fabaceae (1.58%) and Papaveraceae (1.08 %) members.

10. Rajot Honey

Honey sample collected during the summer season was dark amber in colour. The pollen sediment was found to be rich.

Pollen analysis of honey sample revealed that predominant pollen grains were of Myrtaceae family (45.46%) (Tables 2, 3; Fig. J). Secondary pollen grains present were of *Rosa* sp. (Rosaceae, 16.01%) and *Sechium edule* (Cucurbitaceae, 17.36%). Important minor pollen grains present were of *Foeniculum* sp. (Apiaceae, 3.23%); *Ageratum conyzoides* (Asteraceae, 3.82%); *Sonchus* sp. (Asteraceae, 4.23%) and *Bauhinia variegata* (Fabaceae, 4.12%). Minor pollen grains belonged to *Rubus* sp. (Rosaceae, 1.65%); *Hypericum* sp. (Hypericaceae, 1.11%); *Vicia* sp. (Fabaceae, 1.79%) and Cucurbitaceae (1.22%) members.

11. Paprola Honey

Honey sample collected during the summer season was light yellow in colour. Pollen sediment was poor in pollen content.

Microscopic analysis of honey revealed that it was a multifloral honey with different types of pollen grains (Tables 2, 3; Fig. K). Secondary pollen grains present were of *Adhatoda vasica* (Acanthaceae, 19.23%); *Grewia* sp. (Tiliaceae, 16.71%) and *Trifolium* sp. (Fabaceae, 23.61%). Important minor pollen grains were of *Salvia* spp.(Lamiaceae, 4.41%); *Bombax* sp. (Bombaceae, 7.23%); *Eruca sativa* (Brassicaceae, 5.66%); *Fragaria* sp. (Rosaceae, 10.10%) and *Cassia fistula* (Fabaceae, 5.64%). Minor pollen grains belonged to *Vitex negundo* (Verbenaceae, 2.21%) and members of Malvaceae (1.09%); Bignoniaceae (2.11%); Myrtaceae (2%) respectively.

12. Chamunda honey:

Honey sample collected during the summer season was light amber in colour. The pollen sediment was poor in pollen content.

Honey pollen analysis revealed that it was a unifloral honey with predominant pollen grains of *Duranta* sp. (Verbenceae, 46.15%) (Tables 2, 3; Fig. L). Secondary pollen grains were of *Citrus* sp. (Rutaceae, 16.86%) and *Brassica* sp. (Brassicaceae, 17.58%). Important minor pollen grains belonged to *Litchi* sp. (Sapindaceae, 3.25%), *Woodfordia* sp. (Lytheraceae, 4.45%), *Rosa* sp. (Rosaceae, 4.38%) and *Emblica* sp. (Enphorbiaceae, 4.0%). Minor pollen grains represented by members of families Asteraceae (1.67%) and Malvaceae (1.66%).

13. Ropa Honey

Honey sample collected during summer season was light yellow in coloured. Pollen sediment was rich in pollen content.

Microscopic analysis of honey sample indicated that it was a multifloral honey with a great variety of pollen grains (Tables 2, 3; Fig. M). Secondary pollen grains present were of *Eriobotrya japonica* (Rosaceae, 24.5%); *Callistemon citrinus* (Myrtaceae, 22.16%) and *Dalbergia sissoo* (Fabaceae, 20.83%). Important pollen grains present were of *Grewia* sp. (Fabaceae, 14.16%); *Acacia* sp. (Fabaceae, 3.83%) and *Litchi* sp. (Lamiaceae, 7.0%). Minor pollen grains belonged to *Ocimum* sp.

(Lamiaceae, 1.62%); *Emblica officinalis* (Euphorbiacaceae, 2.28%); *Ipomoea* sp. (Convolvulaceae, 1.6%); *Albizzia* sp. (Fabaceae, 1.0%) and members of family Asteraceae (1.02%).

14. Sudher Honey

Honey sample collected during summer season was dark yellow in colour. The pollen sediment was rich in content.

Microscopic analysis of honey indicated that it was a unifloral honey with *Bauhinia variegata* (Fabaceae, 45.41%) as the predominant plant species (Tables 2, 3; Fig. N). Secondary pollen grains present were *Grewia* sp. (Tliaceae, 17.66%) and *Bombax* sp. (Bombacaceae, 16.03%). Important minor pollen grains were *Pyrus* sp. (Rosaceae, 3.37%); *Grevillea robusta* (Prateaceae, 3.19%); *Plectranthus* sp. (Lamiaceae, 4.10%) and *Psidium gaujava* (Myrtaceae, 3.11%). Minor pollen grains belonged to *Aesculus* sp. (Sapindaceae, 1.50%); *Althaea* sp. (Malvaceae, 1.41%); *Abelomoschus* sp. (Malvaceae, 1.07%); *Dahlia* sp. (Asteraceae, 0.75%) and *Robinia* sp. (Fabaceae, 2.4%).

15. Bundla Honey

Honey sample collected during the summer season was dark amber in colour. Pollen sediment was rich in pollen content.

Microscopic analysis of honey indicated that it was a multifloral honey with a good representation of a variety of floral types (Tables 2, 3; Fig. O). Secondary pollen grains present were *Camelia* sp. (Theaceae, 26.41%); *Prunus* sp. (Brassicaceae, 17.15%); *Vitex negundo* (Verbenaceae, 16.03%) and *Trifolium* sp. (Fabaceae, 13.92%). Important minor pollen grains were *Adhatoda vasica* (Acanthaceae, 4.93%); *Plectranthus* sp. (Lamiaceae, 4.89%); *Grevillea robusta* (Proteaceae, 5.12%) and *Jacaranda* sp. (Bignoniaceae, 3.66%).Minor pollen grains were *Rumex* sp. (Polygonaceae, 3.2%); *Aesculus* sp. (Sapindaceae, 2.07%); Rutaceae (1.06%) and Cucurbitaceae (1.56%) members respectively.

In Kangra and adjoining areas of Himachal Pradesh, a total of 63 pollen types of different species and families of plants were reported in honey samples collected from different sites. Of these, 7 pollen types were predominant; 23 were secondary and 33 were of important minor and minor pollen types. Predominant pollen types were: *Citrus*

sp. (Plate F 45); *Duranta* sp. (Plate G 53; I 65) and Myrtaceae members. Secondary pollen types recorded were: *Campsis grandiflora* (Plate B 9); *Punica* sp. (Plate F 42); *Grewia optiva* (Plate G 52); *Litchi chinensis* (Plate F 46); *Brassica campestris* (Plate B, 12); *Syzygium cumini* (Plate E 33; I 63); *Albizzia* sp.(Plate C 21,22; H 60) *Hibiscus rosa-sinensis* (Plate D 30; I 61); *Callistemon citrinus* (Plate D 31; I 62); *Sechium edule* (Plate C 20); *Camelia sinensis* (Plate G 51) and *Vitex negundo* (Plate G 54; I 66); etc. Whereas, important minor and minor pollen types present were: *Taraxacum officinale* (Plate A 7); *Rumex* spp. (Plate E 40); *Jacaranda mimosifolia* (Plate B 10; H 59); *Salvia* spp. (Plate D 25); *Psidium guajava* (Plate D 32); *Leucaena leucocephala* (Plate C 23); *Ipomea* sp. (Plate B 16; C 17); *Althea rosea* (Plate D 29); *Abelmoschus esculentus* (Plate D 28) and *Dahlia pinnata* (Plate A 5) etc.

FLORAL CALENDAR:

A floral calendar is a time table that indicates approximate date and duration of blossoming period of the honey or the pollen plants in an area. It also includes density, distribution and honey potential of the regional bee flora. Preparation of a floral calendar for any specific area needs detailed studies of seasonal changes in vegetation pattern or agroecosystems of the area, the foraging tendencies of the bees and the manner in which the honeybee colonies interact with their floral environment. So, an accurate and detailed calendar often require several years of repeated recording and refinement of information (Chaubal and Kotmire, 1980; Lakshmi and Suryanarayana, 1997c; Sharma, 1989; Tiwari *et al.,* 2010).

The bee forage calendar is most valuable tool for Apiculture extension workers to help the beekeepers to manage their colonies when and where in a particular area. For migratory beekeeping, these floral calendars are required with migratory routes, as it helps in selecting the most suitable places for the bees. Besides this, basic data of floral calendar can be useful in conserving the important sources of nectar and pollen with natural vegetation. It can also be helpful in production of organically produced and unpolluted insecticide free honey. Floral calendar information can be useful in taking new beekeeping projects in new areas and also to increase sources of income. Separate floral calendars are required for different ecological regions in beekeeping practiced areas.

During the preparation of Floral calendar, flora of Kangra and adjoining areas of Himachal Pradesh was deeply investigated and a floral calendar was prepared, under which 219 plants of different species and families were observed and recorded with their: common and botanical names, distribution in the area, flowering season and sources of nectar or pollen. In the studied area of Kangra and adjoining areas of Himachal Pradesh, out of 219 different plants species, 49 were recorded as major source of pollen and nectar, 39 were medium and 55 were found as minor pollen and nectar source (Table 4).

In Floral calendar, the major nectar and pollen sources recorded were: *Helianthus annus, Taraxacum officinale, Bombax ceiba, Brassica* sp., *Eruca sativa, Raphanus sativus, Rhododendron arboreum, Carica papaya, Cucurbita* spp., *Terminalia* spp., *Kalanchoe integra, Cucumis* spp., *Delbergia sissoo, Trifolium* spp., *Acacia catechu, Aesculus indica, Woodfordia fruticosa, Moringa oleifera, Callistemon citrinus, Eucalyptus camaldulensis, Psidium gaujava, Syzygium cumini, Sesamum indicum* etc., whereas, honey plants investigated as medium nectar and pollen sources were: *Adhatoda vasica, Justicia pubigera, Acer* spp., *Carissa caranda, Asclepias curassavica, Cardus onopardios, Dahlia pinnata, Zinnia elegans, Impatiens glandulifera, Berberis* spp., *Brassica* spp., *Cardamine* spp., *Opuntia* spp., *Cannabis sativa, Benincasa* spp., *Emblica officinale, Acacia arabica, Cassia fistula, Erythrina suberosa, Delonix regia, Indigofera* sp., *Salvia* spp. etc.

Honey plants represented the minor nectar and pollen sources in floral calendar were: *Allium sativum, Allium cepa, Mangifera indicia, Bidens pilosa, Foeniculum vulgare, Heracleum* sp., *Ageratum conyzoides, Calendula officinalis, Eupatorium* sp., *Jacaranda mimosifolia, Cynoglossum* sp., *Albizzia julibrissin, Albizzia lebbek, Albizzia stipulata, Glycine max, Rumex hestatus* etc. and number of other members of families: Acantheceae, Agavaceae, Amaryllidaceae, Anacardiaceae, Apiaceae, Apocynaceae, Arecaceae, Asteraceae, Bignoniaceae, Boraginaceae, Caprifoliaceae, Chenopodiaceae, Convolvulaceae, Cucurbitaceae, Euphorbiaceae, Fabaceae, Fagaceae, Geraniaceae, Lamiaceae, Liliaceae, Linaceae etc.

Table 2: Pollen spectrum of honey samples of honeybee species (*Apis cerana* F., *Apis dorsata* L. and *Apis mellifera* L.) collected from Kangra and adjoining areas of Himachal Pradesh.

Locality	Season	Month of Collection	Colour of honey	Unifloral or Multifloral	Predominant pollen type	Secondary pollen type	Important minor pollen types	Minor pollen types
1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**
Dhaliara	Summer	June	Amber	Multifloral	-	*Emblica officinalis, Murraya koenigii*	*Cedrela toona, Rosa* sp., *Taraxacum officinale, Acacia* sp.	*Ageratum conyzoides*, Rutaceae, Cucurbitaceae, Fabaceae
Jwali	Summer	June	Light yellow	Unifloral	*Citrus* sp.	*Campsis grandiflora, Mangifera indica*	*Litchi chinensis Carica papaya, Dalbergia sissoo*	*Zizyphus* sp., *Allium* sp., *Ageratum conyzoides*, cucurbitaceae
Raja ka talab	Summer	May	Amber	Multifloral	-	*Adhatoda vasica, Mangifera indica, Punica* sp.	*Bombax* sp., *Caesalpinia* sp., *Carissa* sp., *Aegel* sp.	Myteraceae, Asteraceae, Papilionaceae

Contd... Table 2

Jwalamukhi	Summer	June	Dark amber	Multifloral	-	*Murraya koenigii, Ageratum conyzoides, Dalbergia sissoo, Grewia* sp.	*Citrus* sp., *Rumex hestatus, Mangifera indica, Cassia fistula*	*Zizyphus* sp., *Eucalyptus* sp., *Melia* sp., Poaceae Rosaceae, Cucurbitaceae, Apiaceae
Bairghata	Summer	May	Light amber	Unifloral	*Moringa oleifera*	*Grewia optiva*	*Grevillea robusta, Melia azedarch, Butea monosperma, Jacaranda mimosifolia, Dalbergia sissoo*	*Albizzia lebbeck, Murraya Koenigii*
Thural	Summer	June	Light brown	Unifloral	*Mangifera indica*	*Litchi chinensis*	*Helianthus annus, Brassica campestris, Lytheraceous*	*Leucaena leucocephala*
Kangra	Summer	June	Yellow	Multifloral	-	*Brassica* sp., *Syzygium cumini, Prunus* sp., *Albizzia* sp.	*Callistemon citrinis, Murraya koenigii, Adhatoda vasica, Fragaria* sp.	*Pinus* sp., *Leucaena* sp., Asteraceae

Contd…… Table 2

1	2	3	4	5	6	7	8	9
Shahpur	Summer	June	Light Amber	Multifloral	-	*Syzygium* sp., *Helianthus* sp.	*Grevillea* sp., *Allium* sp., *Bauhinia* sp., *Grewia* sp., *Callistemon* sp., Rutaceae	*Albizzia* sp., *Acacia* sp., *Dalbergia* sp., *Cassia* sp., *Taraxacum* sp., Apocynaceae, Brassicacea, Malvaceae
Paraur	Summer	May	Watery white	Unifloral	*Eucalyptus* sp.	*Eriobotrya* sp., *Callistemon* sp.	*Murraya* sp., *Jacaranda* sp.	Fabaceae, Papaveraceae
Rajot	Summer	June	Dark amber	Multifloral	Myrtaceae	*Rosa* sp., *Sechium edule*,	*Foeniculum* sp., *Ageratum conyzoides*, *Sonchus* sp., *Bauhinia variegata*	*Rubus sp.*, *Hypericum sp.*, *Vicia* sp., Cucurbitaceae
Paprola	Summer	June	Light yellow	Multifloral	-	*Adhatoda vasica*, *Grewia* sp., *Trifolium* sp.	*Salvia* spp., *Bombax* sp., *Eruca sativa*, *Fragaria* sp., *Cassia fistula*.	*Vitex negundo*, Malvaceae Bignoniaceae, Myrtaceae.

Contd…… Table 2

1	2	3	4	5	6	7	8	9
Chamunda	Summer	May	Light Amber	Unifloral	*Duranta repens*	*Citrus* sp., *Brassica* sp.,	*Litchi* sp., *Woodfordia* sp., *Rosa sp., Emblica* sp.	Asteraceae, Malvaceae
Ropa	Summer	June	Watery white	Multifloral	-	*Eriobotrya japonica, Callistemon citrinus, Dalbergia sissoo*	*Grewia* sp., *Acacia* sp., *Litchi* sp.	*Ocimum sp., Emblica officinalis, Ipomea* sp., *Albizzia* sp., Asteraceae
Bundla	Summer	May	Dark amber	Multifloral	-	*Camelia* sp., *Prunus* sp., *Vitex negondo, Trifolium* sp.	*Adhatoda vasica, Plectranthus* sp., *Grevillea robusta, Robusta* sp., *Jacaranda* sp.	*Aesculus* sp., Rutaceae, Cucurbitaceae
Sudher	Summer	June	Dark Yellow	Unifloral	*Bauhinia variegata*	*Grewia* sp., *Bombax* sp.	*Pyrus* sp., *Grevillea robusta Plectranthus* sp., *Psidium guajava*	*Aesculus* sp., *Althea* sp., *Abelomoschus* sp., *Dahlia* sp., *Robinia* sp.

Predominant pollen type = 45% and above
Secondary pollen type = 16 to 45%
Important minor pollen type = 3 to 15%
Minor pollen type = < 3%

Table 3: Frequency distribution of pollen types in honey samples of honeybee species (*Apis cerana* F., *Apis dorsata* L. and *Apis mellifera* L.) collected from Kangra and adjoining areas, Himachal Pradesh. (expressed as percentage of total number of pollen grains)

Plant Species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Acacia sp.	10.06							4.75					3.83		
Abelomoschus															1.07
Adhatoda sp.			26.74				6.42				19.23				4.93
Aegle sp.			8.54												
Aesculus sp.														1.50	2.07
Ageratum sp.	2.89	1.87		17.51						3.82					
Albizzia sp.					1.17		16.05	1.12	1.1						
Allium sp		2.65						0.98							
Althaea sp.														1.41	
Apiaceae				0.93											
Apocynaceae								1.99							
Asteraceae			2.97				2.19					1.67	1.02		
Bauhinia sp.								6.30		4.12				45.41	
Bignoniaceae											2.11				
Bombax sp.											7.23			16.03	
Brassica sp.						9.09	20.62					17.58			
Brassicaceae								2.99							
Butea sp.					4.19										
Caesalpinea sp.			9.33												
Callistem on sp.							4.71	9.68	20.63				22.16		
Camelia Sp.															26.41
Carica sp.		3.14													

Contd... Table 3

Plant species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Cassia sp.				3.13				3.96			5.64				
Cedrela sp.	13.19														
Citrus sp.		48.74		5.59								16.86			
Cucurbita sp**.**										17.36					
Cucurbitaceae	2.41	1.84		1						1.22					1.56
Dahlia sp.														0.75	
Dalbergia sp.		3.04		16.0	3.03			5.06					20.83		
Emblica sp.	23.93											4.0	2.28		
Eruca sp.											5.66				
Eriobotrya sp.									17.46				24.5		
Eucalyptus sp.				2.10					49.20						
Fabaceae	1.31								1.58						
Foeniculum sp										3.23					
Fragaria sp.							3.24				10.10				
Grevillea sp.					11.22			4.02						3.19	5.12
Grewia sp.			16.64		21.32			4.96			16.71		14.16	17.66	
Helianthus sp.						11.36									
Hibiscus sp.								17.18							
Hypericum sp.										1.11					
Ipomoea sp.													1.6		
Jacaranda sp.					3.47				4.23					3.36	
Leucaena sp.						0.57	2.06								
Litchi sp.		4.09				22.13						3.25	7.0		

Contd... Table 3

Plant species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Lytheraceae						3.43									
Malvaceae								2.98							
Mangifera sp.		14.83		4.5		53.40									
Melia sp.				1.51	5.12										
Moringa oleifera					48.40										
Murraya sp.	18.62			22.21	1.08		4.49		5.82						
Myrtaceae			3.78							45.96	2.0				
Ocimum sp.													1.62		
Papaveraceous									1.08						
Papilionaceae			1.84												
Pinus sp							1.9								
Plectranthus sp.														4.10	4.89
Poaceae				1.42											
Psidium sp.														3.11	
Prunus sp.							19.48								17.15
Punica sp.			16.29		2.94										
Robinia sp.														24.0	
Rosa sp.	14.39									16.01		4.38			
Rosaceae				0.72											
Rubus sp.										1.65					

Contd..... Table 3

Plant species	**1**	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**
Rumex sp.				4.56											3.2
Rutaceae	2.28							8.06							1.06
Salvia sp.											4.41				
Sechium sp.										3.7				17.36	
Sonchus sp.										4.23					
Syzygium sp.							18.84	24.12							
Taraxacum sp.	10.92							1.05							
Trifolium sp.											23.61				13.92
Vicia sp.										1.79					
Vitex sp.											2.21				
Woodforbia sp.												4.45			
Zizyphus sp.		2.89		16.0	3.03			5.06					20.83		

Table 4: Major, medium and minor honey plants of Kangra and adjoining areas of Himachal Pradesh.

Family/Plant species	Common name	Honey Potentiality	Flowering period	Distribution	Nature/Economic importance
1	2	3	4	5	6
Acanthaceae					
Adhatoda vasica Nees	Basuti	N^2P^2	Apr-Nov	Throughout	Shurb(w)
Justicia pubigera Nees	Bankas	N^2P^2	Aug-Oct	Mid & high hills	Herb(w)
Rungia parviflora Nees	Rungia	N^3P^3	Jul-Aug	Valley, low & mid hills	Herb, Weed(w)
Aeraceae					
Acer spp.	Great maple	N^2P^2	Mar-Apr	Mid & high hills	Avenue tree, Timber(w/c)
Agavaceae					
Agave Americana L.	Century plant	N^3P^3	Sept-Nov	Valley, low & mid hills	Shurb(c)
Amaranthaceae					
Amaranthus paniculatus L.	Amaranth	P^2	Jun-Jul	Throughout	Herb, Crop(c)
Amaryllidaceae					
Allium cepa L.	Onion	N^3P^3	May-Jun	Throughout	Herb, Vegetable(c)
Allium sativum L.	Garlic	N^3P^3	May-Jun	Throughout	Herb, Vegetable(c)
Anacardiaceae					
Mangifera indica L.	Mango	N^3P^3	Mar-Apr	Valley & low hills	Fruit tree, Fuel & Timber(c)
Rhus spp.	Sumac	N^3P^3	May-Jun	Mid & high hills	Tree/Shrub(w)
Apiaceae					
Coriandrum sativum L.	Corriander	N^3P^3	May-Jun	Throughout	Herb, Condiment(c)
Daucus carota L.	Carrot	N^2P^3	Mar-May	Throughout	Herb, Vegetable(c)
Foeniculum vulgare Mill.	Funnel	N^3P^3	Aug-Sept	Throughout	Herb, Condiment(c)
Heracleum spp.	Hogweed	N^3P^3	May-Jul	Throughout	Herb(w)

Contd... Table 4

Apocynaceae					
Carissa caranda L.	Karandas	N^2P^2	Apr-May	Throughout	Shrub, preservation(w/c)
Arecaceae					
Phoenix spp.	Wild date plam	N^2P^3	May-Jul	Valley & low hills	Shrub, Fruit tree(w)
Asclepiadaceae					
Asclepias curassavica L.	Milkweed	N^2P^2	Apr-Jun	Valley, low & mid hills	Shrub, Fibre(w)
Asteraceae					
Ageratum conyzoides L.	Ageratum or Goat weed	N^3P^3	Jul-Sept	Throughout	Herb, Ornamental(w/c)
Artemisia spp.	Mugwort	N^3P^3	Aug-Oct	Mid & high hills	Herb, Ornamental(w/c)
Aster spp.	Star-wort	N^3P^3	Oct-Nov, Jul-Sept	Throughout	Herb, Ornamental(w/c)
Bidens pilosa L.	Badi-gumbri	N^3P^3	Jun-Sept	Throughout	Herb(w)
Calendula officinalis L.	Marigold	N^3P^3	May-Jul	Valley, low & mid hills	Herb, Ornamental(w/c)
Cardus onopardiodes Fisch.	Musk thistles	N^2P^2	May-Aug	Throughout	Herb, Weed(w)
Centaurea cyanus L.	Cornflower	N^1P^1	Feb-Apr	Throughout	Herb, Ornamental(c)
Chrysanthemum spp.	Chrysanthemum	N^3P^3	May-Sept	Throughout	Herb, Ornamental(w/c)
Cichorium intybus L.	Chichory	N^3P^3	May-Aug	Throughout	Herb, Weed(w)
Cosmos sulphureus Cav.	Cosmos	N^3P^2	Sept-Nov	Throughout	Herb, Ornamental(w/c)
Dahlia pinnata	Dahlia	N^2P^2	Jul-Jan	Throughout	Herb, Ornamental(c)
Eupatorium spp.	Throughwort	N^3P^3	Jul-Sept	Throughout	Herb(w)
Helianthus annuus L.	Sunflower	N^1P^1	Jul-Sept	Throughout	Herb, Oilseed, Ornamental, Fodder(w/c)
Helichrysum arenarium	Paper flower	N^2P^3	Feb-Jun	Valley, low & mid hills	Herb, Ornamental(c)
Senecio spp.	Ragwort	N^3P^3	Jun-Sept	Throughout	Herb, Weed(w)
Solidago longifolia Schrad.	Golden rod	N^2P^3	Jun-Sept	Throughout	Herb, Ornamental(w/c)

Contd... Table 4

Sonchus spp.	Sow thistle	N^3P^3	Jun-Oct	Throughout	Herb, Weed(w)
Tagetus erectus L.	Marigold	N^3P^3	Jul-Oct	Throughout	Herb, Aromatic, Ornamental(w/c)
Taraxacum officinale Weber.	Dandelion	N^1P^1	Mar-Sept	Throughout	Herb, Juicy weed(w)
Tussilago farfara L.	Coltsfoot	N^3P^3	Apr-Jun	Valley, low & mid hills	Herb, Medicinal(w)
Zinnia elegans Jacq.	Zinnia	N^2P^2	Jun-Sept	Valley, low & mid hills	Herb, Ornamental(c)
Balsaminaceae					
Impatiens balsamina L.	Pink balsam	N^1P^2	Jul-Sept	Throughout	Herb, Ornamental(c)
Impatiens glandulifera Royle	Balsam	N^2P^2	Jul-Sept	Throughout	Herb, Aromatic, Medicinal(w/c)
Berberidaceae					
Berberis balsamina L.	Berberry	N^2P^2	Apr-Jun	Throughout	Shrub, Fruit,Dye,Medicinal (w)
Berberis lycium Royle	Raisin Berberry	N^2P^2	Apr-Jun	Throughout	Shrub, Fruit , Medicinal (w)
Bignoniaceae					
Campsis grandiflora	Trumpet vine	N^2P^3	May-Aug	Valley, low & mid hills	Climber, Ornamental(c)
Tachoma stans L.	Sonnpatti	N^2P^3	Apr-June	Valley, low & mid hills	Ornamental(c)
Jacaranda mimosifolia D. Don	Jacaranda	N^3P^3	May-Jun	Valley, low & mid hills	Tree, Ornamental(w/c)
Bombacaceae					
Bombax ceiba L.	Silk cotton tree	N^1P^1	Feb-Mar	Throughout	Fodder tree, fibre, Timber (w)
Boraginaceae					
Cordia dichotoma Forster F.	Lasora	N^1	Mar-Apr	Valley, low & mid hills	Edible, Medicine(w/c)
Cynoglossum spp.	Hounds Tongue	N^3P^3	Jun-Sept	Valley, low & mid hills	Herb(w)

Contd... Table 4

Ehretia acuminata R. Br. Prodr.	Ivory Wood	N^1P^2	Feb-Apr	Valley, low & mid hills	Avenue tree,Fruit, Fodder, Timber(w/c)
Brassicaceae					
Brassica campestris L.	Mustard	N^1P^1	Dec-May	Throughout	Herb, Oilseed(c)
B. campestris var. sarson	Sarson	N^1P^1	Sept-Mar	Throughout	Herb, Oilseed,Vegetable(c)
Brassica juncea (L.) Cosson	Indian mustard	N^1P^1	Feb-Mar	Throughout	Herb, Oilseed(c)
Brassica napus L. Var. glauca (Roxb.) Schutz	Rape	N^1P^1	Dec-Mar	Throughout	Herb, Oilseed,Vegetable(c)
Brassica napus var. toria L.	Toria	N^1P^1	Dec-Mar	Throughout	Herb, Oilseed,Vegetable(c)
Brassica regusa (Roxb.) Bailey	Rai	N^1P^1	Dec-Mar	Throughout	Herb,Vegetable(c)
B. oleracea capitata L.	Cabbage	N^2P^2	Feb-Mar	Throughout	Herb,Vegetable(c)
B. oleracea botrytis L.	Cauliflower	N^2P^2	Feb-Mar	Throughout	Herb,Vegetable(c)
Brassica rapa L.	Turnip	N^2P^2	Feb-Apr	Throughout	Herb,Vegetable(c)
Cardamine spp.	Cardamine	N^2P^2	Jan-Feb	Throughout	Herb, Medicinal(w)
Eruca sativa Mill	Rocket Salad	N^1P^1	Dec-Mar	Throughout	Herb, Oilseed, Fodder(c)
Raphanus sativus L.	Radish	N^1P^1	Feb-Mar	Throughout	Herb,Vegetable(c)
Cactaceae					
Opuntia spp.	Prickly Pear	N^2P^2	Apr-May	Throughout	Shrub, Weed (w)
Cannabinaceae					
Cannabis sativa L.	Hemp	N^2P^2	Jun-sept	Throughout	Weed, Alkaloid fibre (w/c)
Capparidaceae					
Crataeva religiosa Forst.	Barna	N^2P^3	Apr-May	Valley, low & mid hills	Tree (w/c)
Caprifoliaceae					
Dianthus caryophyllus L.	Carnation	N^3P^3	Apr-Jun	Throughout	Herb, Ornamental(c)
Lonicera spp.	Honey Suckle	N^3P^3	May-Aug	Valley, low & mid hills	Climber (w/c)

Contd... Table 4

Caricaceae					
Carica papaya L.	Papaya	N^1P^1	May	Valley & low hills	Tree, fruit edible (c)
Chenopodiaceae					
Combretaceae					
Terminalia bellirica (Gaertn.) Roxb.	Bahera	N^1	Mar-june	Valley, low & mid hills	Timber, Fuel, Medicine(w/c)
Terminalia chebula Retz.	Harada	N^1	Apr-Aug	Valley, low & mid hills	Fodder, Edible, Medicine(w/c)
Terminalia spp.	Myrobalan	N^1P^1	Apr-May	Valley, low & mid hills	Tree, Timber, Fruit, Medicinal, Fuel, Tanning, Dyeing (w/c)
Quisqualis indica L.	Malti	N^2	May-Oct	Valley, low & mid hills	Ornamental(c)
Convolvulaceae					
Convolvulus arvensis L.	Convolvulus	N^3P^3	Apr-Sept	Throughout	Weed(w)
Ipomoea batatas Lam.	Sweet Potato	N^2P^3	Aug-Nov	Throughout	Herb,Vegetable, Climber(c)
Ipomoea pulchella Roth.	Railway Creeper	N^3P^3	Aug-Nov	Throughout	Herb,Climber (w)
Cuscuta reflexa Roxb.	Amar-Bel	P^3	Jul-Oct	Throughout	Herb,Parasitic, Succulent, Medicinal (w)
Crassulaceae					
Kalanchoe integra (Medik.) Kuntz	Biskhapra	N^1P^1	Sept-Dec	Throughout	Medicine(w/c)
Cucurbitaceae					
Benincasa spp.	Petha	N^2P^2	Apr-May	Valley, low & mid hills	Climber, Vegetable(c)
Coccinia grandis (L.)Voigt	Kunduru	N^2	Jan-July	Throughout	Climber, Vegetable, Medicine(c)
Cucumis spp.	Cucumber	N^1P^1	Jul-sept	Valley, low & mid hills	Climber(c)
Cucurbita pepo L.	Pumpkin	N^1P^1	Apr-May	Throughout	Climber, Vegetable(c)

Contd... Table 4

Cucurbita maxima L.	Great Pumpkin	N^1P^1	Feb-Apr	Throughout	Climber, Vegetable(c)
Luffa cylindrica L.	Ridged Gourd	N^3P^3	Jul-sept	Throughout	Climber(c)
Momordica charantia L.	Bitter Gourd	N^3P^3	Jun-sept	Throughout	Climber, Vegetable (c)
Sechium edule SW.	Chayote	N^2P^2	JULY-NOV	Throughout	Climber, Vegetable (C)
Ericaceae					
Rhododendron arboreum Smith	Alpine Rose	N^1P^1	Mar-May	Mid & high hills	Tree (w)
Euphorbiaceae					
Emblica officinalis Gaertn.	Indian Gooseberry	N^2P^2	Mar-May	Valley, low & mid hills	Tree, Medicinal (c)
Euphorbia royleana Bros.	Euphorbia	N^3P^3	Apr-May	Valley, low & mid hills	Shrub, Juicy, Hedge plant (w/c)
Hevea brasiliensis Muell. Arg.	Rubber tree	N^1P^3	May-Jul	Valley, low & mid hills	Tree, Ornamental(c)
Mallotus philippensis (Lam.)Mwell.-Arg.	Kamala	N	Sept-Nov	Valley, low & mid hills	Medicine, Fuel-wood (w)
Ricinus communis L.	Castor oil plant	P^2	May-Aug	Valley, low & mid hills	Shrub, Oilseed, Soft wood (w/c)
Fabaceae					
Acacia arabica Willd.	Acacia	N^2P^2	May-Jul	Valley, low & mid hills	Tree, Fodder, Medicinal, Tanning industry, Dyeing, Ornamental (w/c)
Acacia catechu (L.f.) Willd.	Acacia	N^1P^1	Apr-Jul	Valley, low & mid hills	Tree, Timber, Fodder, Fuel (w/c)
Albizzia julibrissin Durazz.	Pink Siris	N^3P^3	Apr-May	Valley, low & mid hills	Timber, Fuel-wood (w/c)
Albizzia lebbek Benth.	Siris	N^3P^3	Apr-May	Valley, low & mid hills	Tree, Timber, Fodder, Fuel (w/c)

Contd... Table 4

Albizzia stipulata Roxb.	Oai	N^3P^3	May-June	Valley, low & mid hills	Tree, Timber, Fodder, Fuel (w/c)
Bauhinia vahlii Wight & Arn.	Camel's foot	N^2P^3	Mar-May	Throughout	Tree, Fodder,Fuel,Vegetable (w)
Bauhinia variegata L.	Kachnar	N^2P^3	Feb-Apr	Throughout	Tree, Fodder, Fuel, Vegetable, Ornamental (w)
Bauhinia purpurea L.	Geranium tree	N^2P^3	Mar-Apr	Throughout	Tree, Fodder, Fuel, Vegetable, Ornamental (w)
Butea monosperma (Lam.) Kuntze	Palas	N^3P^3	May-Sept	Valley, low & mid hills	Tree, Fodder, Fuel, Food for lac insect, Medicinal (w)
Caesalpinia decalpetala (Roth.) Alston	Kingari	N^2	Feb-Sept	Valley, low & mid hills	Fodder, Medicinal (w)
Cassia fistula L.	Indian laburnum	N^2P^2	Apr-Jul	Valley, low & mid hills	Avenue tree (w)
Cajanus cajan L.	Pigeon Pea	N^3P^3	May-Sept	Valley, low & mid hills	Jhy nh.k,
Dalbergia sissoo Roxb.	Sissoo	N^1P^1	Mar-May	Valley, low & mid hills	Tree, Timber, Fodder, Fuel, Shade (w)
Erythrina suberosa Roxb.	Coral tree	N^2P^2	May-Jun	Valley, low & mid hills	Tree (w/c)
Delonix regia Raf.	Gulmohr	N^2P^2	May-Jun	Valley, low & mid hills	Avenue tree (w/c)
Glycine max Merr (L.)	Soyabean	N^3P^3	Jul-Aug	Throughout	Herb, Oilseed(c)
Indigofera spp.	Indigofera		Jun-Aug	Throughout	Shrub (w)
Leucaena leucocephala (Lam.) De Wit	Ipil-Ipil	N^3P^1	May-Oct	Valley& low hills	Small tree, Fodder, Fuel (w/c)
Medicago sativa L.	Alfalfa	N^1P^2	May-Aug	Throughout	Herb, Fodder (w/c)
Melilotus spp.	Mellilot	N^1P^2	Mar-Jul	Throughout	Herb, Fodder (c)
Pisum sativum L.	Garden Pea	N^3P^3	Mar-Jul	Throughout	Herb, Vegetable (c)

Contd... Table 4

Robinia pseudoacacia L.	Black locust	N^1P^2	Apr-Jun	Throughout	Tree, Fuel, Ornamental, Timber (w/c)
Tamarindus indica L.	Tamarind	N^3P^3	Mar-May	Valley, low & mid hills	Avenue tree,Condiment, Fruit, Oil (c)
Trifolium alexandrinum L.	Egyptian clover	N^1P^1	Apr-Jul	Throughout	Herb, Fodder (w/c)
Trifolium pratense L.	Red clover	N^1P^2	Apr-Jul	Throughout	Herb, Fodder (w/c)
Trifolium repens L.	White clover	N^1P^1	Apr-Jul	Throughout	Herb, Fodder, Cover crop (w/c)
Vicia spp.	Field beans	N^3 P^1	Apr-Aug	Throughout	Crop, Edible, Fodder (w/c)
Fagaceae					
Castanea sativa Mill	Sweet Chestnut	N^3P^3	May-Sept	Throughout	Tree, Timber, Seed, Nuts, Edible (w/c)
Quercus spp.	Oak	N^2P^3	Apr-Jul	Throughout	Timber tree (w/c)
Geraniaceae					
Geranium spp.	Geranium	N^3P^3	May-Sept	Throughout	Herb, Ornamental(c)
Hypericaceae					
Hypericum spp.	Hypericum	P^1	Apr-Oct	Throughout	Shrub, Twigs used as toothbrush, seed as Condiment for flavoring curry (w)
Juglandaceae					
Juglans regia L.	Walnut	P^2	Mar	Mid & high hills	Tree, furniture, dyeing & Tanning industry (w/c)
Lamiaceae					
Mentha viridis L.	Mint	N^3	Jul-Oct	Throughout	Aromatic herb (w/c)
Ocimum basilicum L.	Basil	N^2P^3	Jun-Sept	Valley, low & mid hills	Herb (w/c)
Ocimum sanctum L.	Tulsi	N^2	Apr-Nov	Throughout	Aromatic herb, Medicinal (w/c)
Origanum vulgare L.	Marjoram	N^2P^2	Jul-Sept	Valley, low & mid hills	Aromatic herb, Oil (w)

Contd... Table 4

Plectranthus coesta Buch. Ham.	Shain	N^1P^2	Sept-Oct	Mid & high hills	Under shrub (w)
Plectranthus gerardianus Wall. Ex Benth.	Shain	N^1P^2	Aug-Oct	Mid & high hills	Under shrub (w)
Plectranthus rugosus Wall. Ex Benth.	Shain	N^1P^2	Aug-Nov	Mid & high hills	Shrub (w)
Salvia spp.	Red Sage	N^2P^2	Jul-Oct	Throughout	Herb, Medicinal(w)
Stachys spp.	Woundwort	N^2P^3	Jun-Sept	Throughout	Herb (w)
Liliaceae					
Asphodelus tenuifolius Cav.	Piazi	N^3P^2	Jul-Oct	Throughout	Herb (w)
Lilium spp.	Lilium	P^3	May-Jun	Valley, low & mid hills	Herb, Ornamental (c)
Linaceae					
Linum spp.	Flax	N^3P^3	Feb-Mar	Throughout	Herb, Oilseed, Fibre (w/c)
Lytheraceae					
Lagerstroemia indica L.	Pride of India	N^2P^2	Jul-Sept	Throughout	Timber, Ornamental (w/c)
Woodfordia fruticosa (L.) Kurz	Dhawi	N^1P^1	Mar-Apr	Throughout	Shrub, Dye, Medicinal, Fodder, Fuel (W)
Malvaceae					
Abelmoschus esculentus L.	Lady's finger	N^2P^2	Jul-Sept	Throughout	Herb, Vegetable (c)
Althaea rosea Cav.	Hollyhock	N^2P^2	Jul-Oct	Valley, low & mid hills	Herb, Ornamental (c)
Gossypium arboreum L.	Cotton	N^1P^2	Jul-Sept	Valley, low & mid hills	Shrub (c)
Hibiscus rosa sinensis L.	Chinese Rose	N^2P^2	Mar-Apr	Valley, low & mid hills	Shrub, Ornamental (c)
Malva sylvestris L.	Mallow	N^2P^3	Jun-Oct	Valley, low & mid hills	Herb, Ornamental (c)

Contd... Table 4

Malvaviscus arboreus	Malvaviscus	N^2P^2	Whole Year	Valley, low & mid hills	Shrub, Ornamental (c)
Meliaceae					
Azadirachta indica A. Juss.	Mangosa	N^2P^3	May-Sept	Valley & low hills	Avenue tree, Forest tree (w)
Cedrela toona Roxb. Ex Rottl. & Willd	Cedrela	N^1P^2	Mar-Jun	Valley, low & mid hills	Tree, Woody, Furniture (w)
Moraceae					
Morus alba L.	Mulberry	P^2	Mar-Apr	Throughout	Tree, Silkworm rearing, Fruit edible (w/c)
Moringaceae					
Moringa oleifera Lam.	Drumstick tree	N^1P^1	Jan-Mar	Low & mid hills	Tree, Perfumes & Lubricants, Fertilizer, Gum, Fodder, Vegetable, Antibacterial properties (c)
Musaceae					
Musa sapientum L.	Banana	N^2P^3	Mar-Dec	Valley, low & mid hills	Giant herb, Fruit (c)
Myrtaceae					
Callistemon citrinus (Curt) Skeels	Bottle Brush	N^1P^1	Mar-Oct	Valley & low hills	Tree, Ornamental (c)
Eucalyptus camaldulensis Dehn.	Eucalyptus	N^1P^1	May-Jun	Valley & low hills	Avenue tree, Fuel wood, Charcoal,Paper pulp, Termite resistant timber, Medicinal (w/c)
Psidium guajava L.	Guava	N^1P^1	May-Jun	Valley, low & mid hills	Tree, Fruit (c)
Syzygium cumini (L.) Alston	Jambolan	N^1P^1	Apr-Jun	Valley, low & mid hills	Avenue tree, Fruit (w/c)
Ongraceae					

Contd... Table 4

Epilobium spp.	Willow Herb	N^2P^2	Jun-Sept	Throughout	Herb (w)
Papaveraceae					
Argemone Mexicana L.	Prickly Poppy	P^3	May-Jul	Valley, low & mid hills	Herb (w)
Eschscholzia californica	Californian Poppy	N^3P^1	Mar-Jun	Valley, low & mid hills	Herb, Ornamental (c)
Papaver rhoeas L.	Poppy	N^3P^3	Mar-May	Throughout	Herb, Ornamental (c)
Pedaliaceae					
Sesamum indicum L.	Sesamum	N^1P^1	Jul-Sept	Throughout	Crop, Oilseed (c)
Plantaginaceae					
Plantago spp.	Plantago	N^2P^1	Mar-Sept	Throughout	Herb (w)
Poaceae					
Bambusa bambos (L.) Voss	Bamboo	N^3P^3	Nov-Dec	Valley, low & mid hills	Tree, Forest,Wood,Furniture (w)
Cynodon doctylon L.	Dub Grass	P^3	May-Sept	Throughout	Fodder (w)
Sorghum vulgare Pers.	Sorgum	P^1	May-Jun	Throughout	Crop, Grain, Fodder (c)
Zea mays L.	Maize	P^1	Jul-Aug	Throughout	Grain, Fodder (c)
Polygonaceae					
Fagopyrum sagittatum Moench.	Buck Wheat	N^1P^2	Jun-Sept	Throughout	Herb, Grain, Fodder (c)
Polygonum spp.	Polygonum	N^3P^3	Jun-Sept	Throughout	Herb, Weed (w/c)
Rumex hastatus D. Don	Almor	N^3P^3	Jun-Oct	Throughout	Herb (w)
Rumex nepalensis spreng	Halhaley	N^3P^3	Jun-Oct	Mid hills	Herb (w)
Rumex spp.	Rumex	N^3P^3	Jun-Oct	Throughout	Herb (w)
Portulacaceae					
Portulaca grandiflora Hook	Portulaca	N^2P^1	Jun-Sept	Throughout	Herb, Ornamental (c)
Proteaceae					

Contd... Table 4

Grevillea robusta A. Cunn. Ex. R.Br.	Silky Oak	N^1P^1	Apr-May	Valley, low & mid hills	Avenue tree, Timber, Ornamental (c)
Punicaceae					
Punica granatum L.	Pomegranate	N^2P^1	Apr-May	Valley, low & mid hills	Shrub/Tree, Fruit (c)
Punica nana L.	Wild Pomegranate	N^2P^1	Apr-May	Valley, low & mid hills	Shrub/Tree, Fruit (c)
Ranunculaceae					
Anemone spp.	Wood anemone	P^3	Apr-Jun	Valley, low & mid hills	Ornamental (w/c)
Caltha spp.	Marsh marigold	N^3P^2	Apr-Jul	High hills	Herb (w)
Clematis spp.	Clematis	N^2P^2	Mar-May	Valley, low & mid hills	Climber, Medicinal (w)
Delphinium roylei Munz.	Larkspur	N^3P^3	Mar-May	Valley, low & mid hills	Herb, Ornamental (c)
Ranunculus arvensis L.	Butter cup	N^3P^3	May-Jun	Throughout	Herb (w)
Rhamnaceae					
Zizyphus jujuba Mill.	Chinese date	N^1P^3	Jul-Sept	Valley, low & mid hills	Tree,Fruit,Fodder, Oilseed (w/c)
Rosaceae					
Eriobotrya japonica Thunb. Lindley	Loquat	N^1P^1	Feb-Mar & Sept-Oct	Valley, low & mid hills	Fruit tree (c)
Fragaria vesca L.	Strawberry	N^2P^2	May-Sept	Mid & high hills	Herb, Fruit, Ornamental (c)
Prinsepia utilis Royle	Bekhal	N^2P^2	Sept-Nov	Mid & high hills	Shurb (w)
Prunus amygdalus Batsch.	Almond	N^1P^1	Mar-Apr	Mid & high hills	Fruit tree (c)
Prunus armeniaca L.	Apricot	N^1P^1	Mar-Apr	Mid & high hills	Fruit tree (c)
Prunus avium L.	Cherry	N^1P^1	Mar-Apr	Mid & high hills	Fruit tree (c)
Prunus cerasoides D. Don.	Wild Cherry	N^1P^1	Oct-Nov	Mid & high hills	Fruit tree (w/c)

Contd... Table 4

Prunus domestica L.	Plum	N^2P^1	Feb-Mar	Mid & high hills	Fruit tree (c)
Pyrus pashia Buch-Ham. Ex D. Don	Wild Pear	N^2P^2	Feb-Mar	Mid & high hills	Fruit tree (w)
Pyrus persica(L) Batsch	Peach	N^1P^1	Feb-Mar	Mid & high hills	Fruit tree (c)
Pyrus communis L.	Pear	N^2P^1	Feb-Apr	Mid & high hills	Fruit tree (c)
Rosa macrophylla Lindey	Rose	N^3P^1	Mar-May	Throughout	Shrub, Ornamental (c)
Rosa moschata Miller	Wild Rose	N^3P^1	Apr-Jun	Throughout	Shrub, Ornamental (w/c)
Rubus spp.	Berries	N^2P^2	Apr-Jun	Throughout	Shrub, Climber, Hedges, Fruit (w/c)
Rubiaceae					
Wendlandia exserta (Roxb.) DC	Chanlai	N^2P^1	Nov-Feb	Valley, low & mid hills	Tree, Toothbrush, Fodder, Medicinal (w)
Wendlandia heynei Sant & Merch.	Pansara	N^2P^1	Apr-June	Valley, low & mid hills	Fodder(w)
Rutaceae					
Aegle marmelos L. Correa	Bel	N^2P^2	Mar-June	low & mid hills	Edible, Medicinal (w)
Citrus aurantifolia (Christm) Swingle	Lemon	N^1P^1	Mar-Apr	Throughout	Fruit tree (c)
Citrus grandis (L.) Osbeck	Pumelo	N^1P^1	Mar-Apr	Throughout	Fruit tree(c)
Citrus jambhiri Lush.	Jambhiri	N^2	Sep-Oct	low & mid hills	Edible(c)
Citrus limetta Risso	Sweet lemon	N^1P^1	Mar-Apr	Throughout	Fruit tree (c)
Citrus medica L.	Citron	N^1P^1	Mar-Apr	Throughout	Fruit tree (c)
Citrus reticulata Blanco	Mandarin orange	N^1P^1	Mar-Apr	Throughout	Fruit tree (c)
Citrus sinensis L.	Sweet orange	N^1P^1	Mar-Apr	Throughout	Fruit tree (c)
Murraya koenigii Spreng	Curry leaf plant	N^2P^2	Mar-Apr	Valley, low & mid hills	Shrub, Ornamental, Medicinal (w/c)
Scrophulariaceae					

Contd... Table 4

Antirrhinum majus L.	Antirrhinum	N^2P^2	May-Jun	Valley, low & mid hills	Herb, Ornamental (c)
Scrophularia spp.	Fig figwort	N^1P^2	Jul-Sept	Throughout	Herb, Weed (w/c)
Salicaceae					
Salix babylonica L.	Weaping willow	N^1P^1	Feb-Mar	Throughout	Tree, Timber(w/c)
Sapindaceae					
Aesculus indica Colebr.	Horse Chestnut	N^1P^1	May-Jun	Mid & high hills	Timber, Fodder, Medicinal (w/c)
Litchi chinensis Sonner	Litchi	N^1P^1	Feb-Mar	Valley, low & mid hills	Fruit tree (c)
Sapindus mukorosii Gaertn.	Soap nut	N^1P^1	May-Jun	Valley, low & mid hills	Avenue tree, Fruit used as Soap, Timber (w/c)
Solanaceae					
Capsicum spp.	Chillies	N^3P^3	Jul-Aug	Throughout	Herb, Vegetable (c)
Datura stramonium L.	Thorn apple	P^3	Jun-Sept	Throughout	Herb, Medicinal (w)
Lycopersicum esculentum Mill.	Tomato	N^3P^3	Mar-Oct	Throughout	Herb, Vegetable (c)
Solanum melongena L.	Brinjal	N^3P^3	Jun-Aug	Throughout	Shrub, Ornamental (c)
Theaceae					
Camellia sinensis (L.) Kuntze	Tea	N^1P^1	Oct-Nov	Valley, low & mid hills	Shrub, Coloring material, Beverage (c)
Tiliaceae					
Grewia optiva Dumm. Ex Burret	Beol or Bhemal	N^1P^1	May-Jul	Throughout	Tree, Fruit, Fodder, Timber (w/c)
Tilia spp.	Limeb basswood	N^1	Jun-Aug	Throughout	Avenue tree, Ornamental, Timber (w/c)
Verbenaceae					
Caryopteris spp.	Caryopteris	N^2P^3	Mar-Apr	Throughout	Shrub (w)
Duranta repens L.	Duranta	N^2	Jul-Sept	Throughout	Ornamental(c)

Contd... Table 4

Vitex negundo L.	Indian privet	N^1P^2	May-Jun	Throughout	Shrub, Insect repellent, Medicinal (w)
Violaceae					
Viola odorata L.	Sweet violet	N^3P^3	Jun-Aug	Throughout	Herb, Ornamental, Medicinal (w/c)
Vitaceae					
Vitis vinifera L.	Grapes	N^3P^3	May-Jun	Throughout	Shrub,Fruit (c)

N^1 = Major nectar source
N^2 = Medium nectar source
N^3 = Minor nectar source
W = Wild
C = Cultivated

P^1 = Major pollen source
P^2 = Medium pollen source
P^3 = Minor pollen source
Throughout = Valley, low, mid & high hills

PERCENTAGE CONTRIBUTION OF DIFFERENT PLANT SPECIES TO HONEY SAMPLES FROM KANGRA AND ADJOINING AREAS OF HIMACHAL PRADESH.

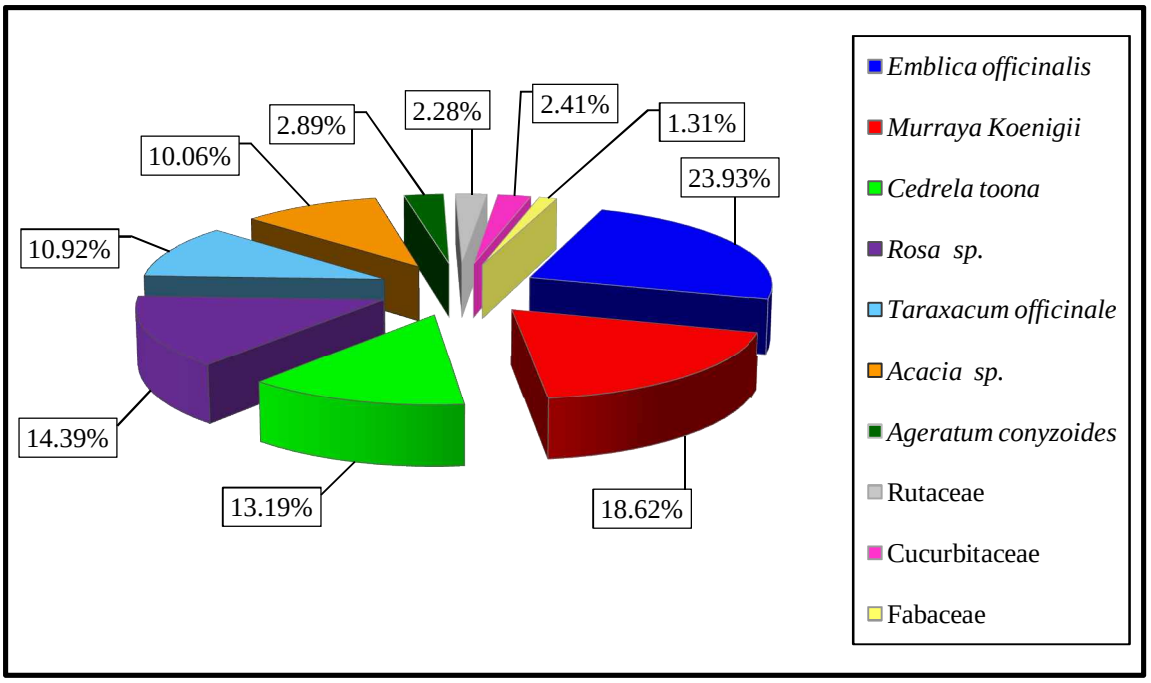

Fig. A : Dhaliara Honey

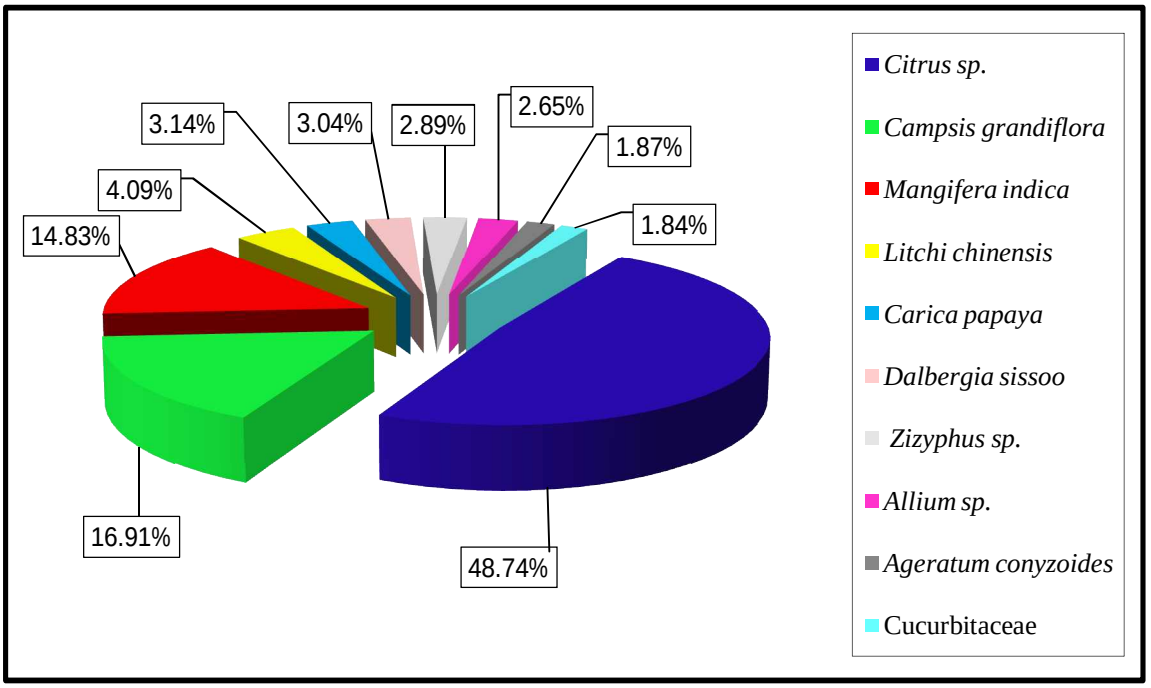

Fig. B : Jwali Honey

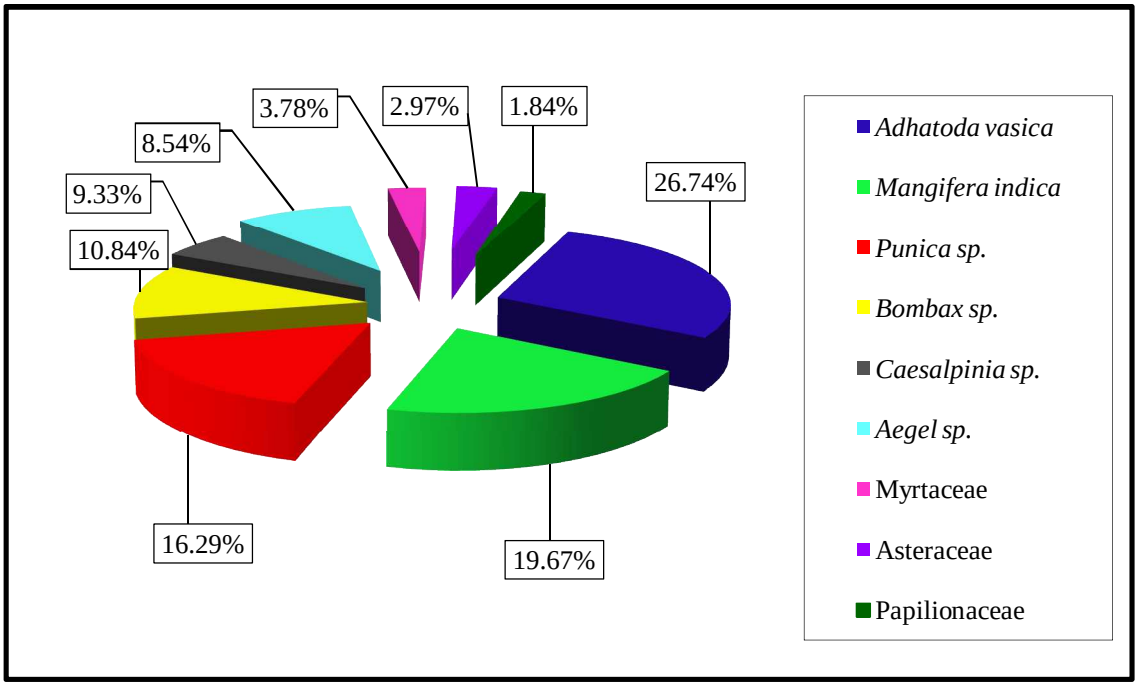

Fig. C : Raja ka talab Honey

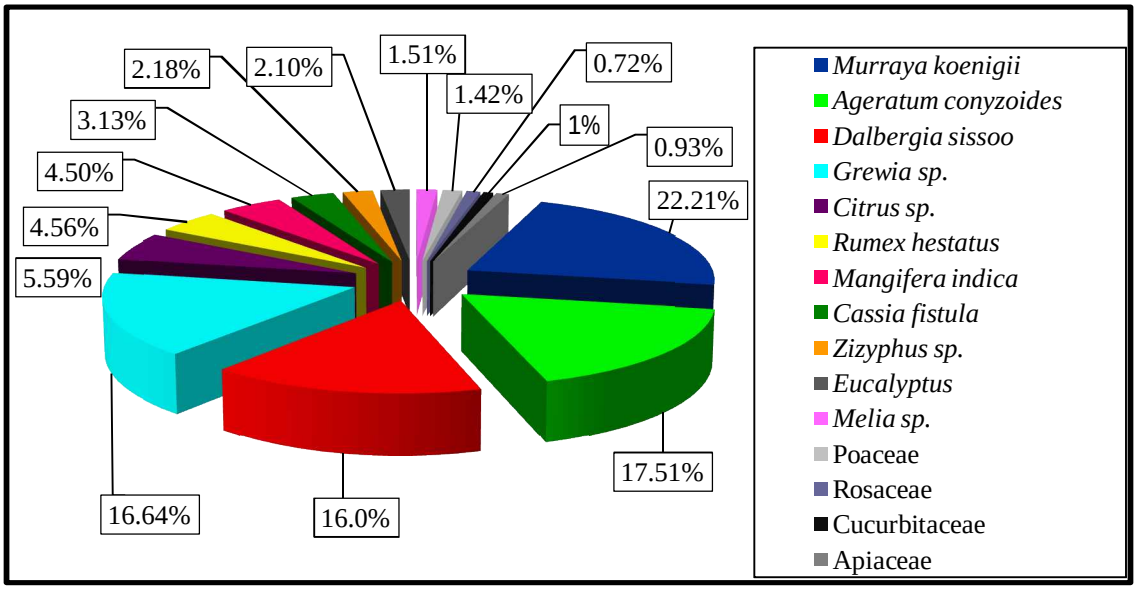

Fig. D : Jwalamukhi Honey

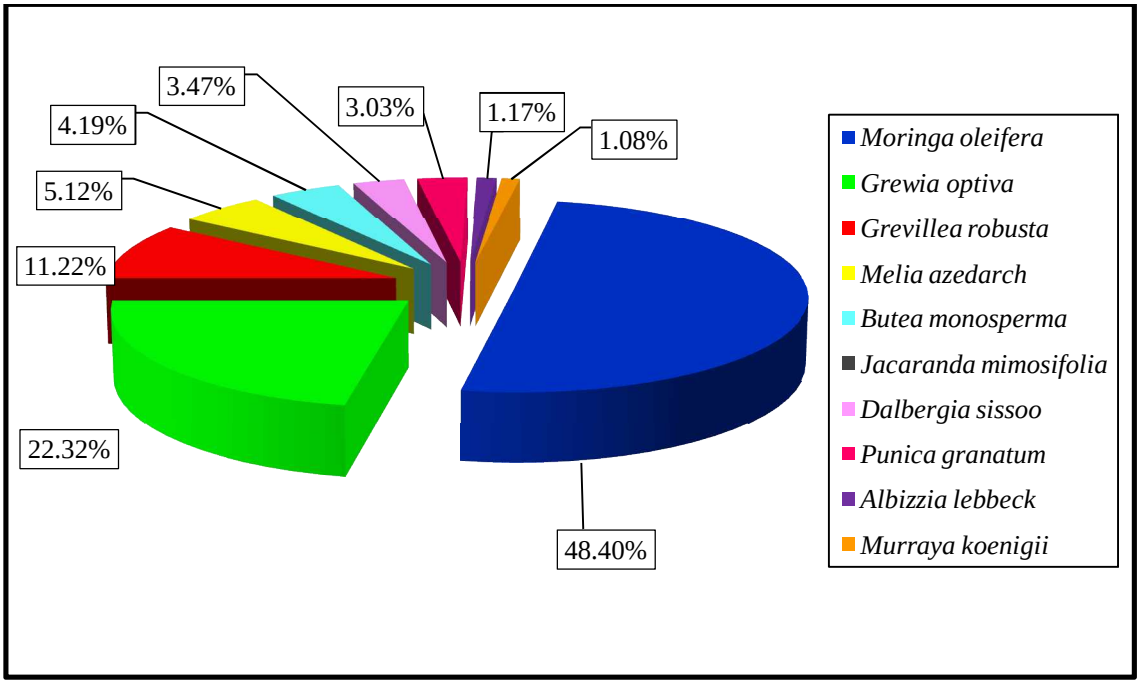

Fig. E : Bairghata Honey

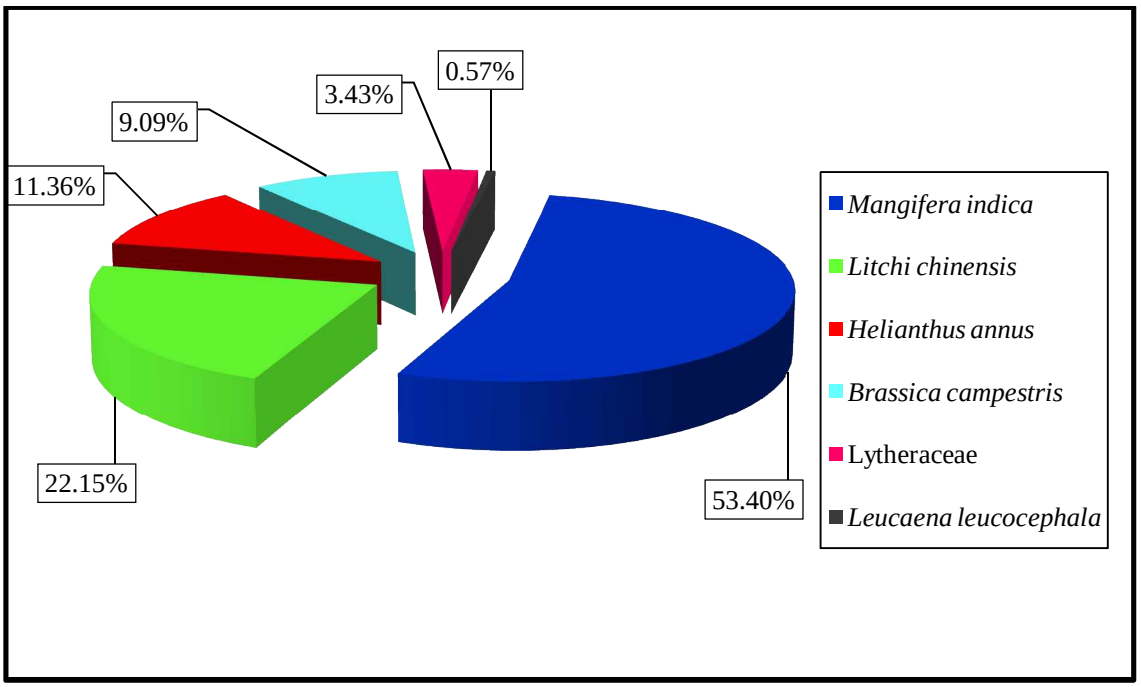

Fig. F : Thural Honey

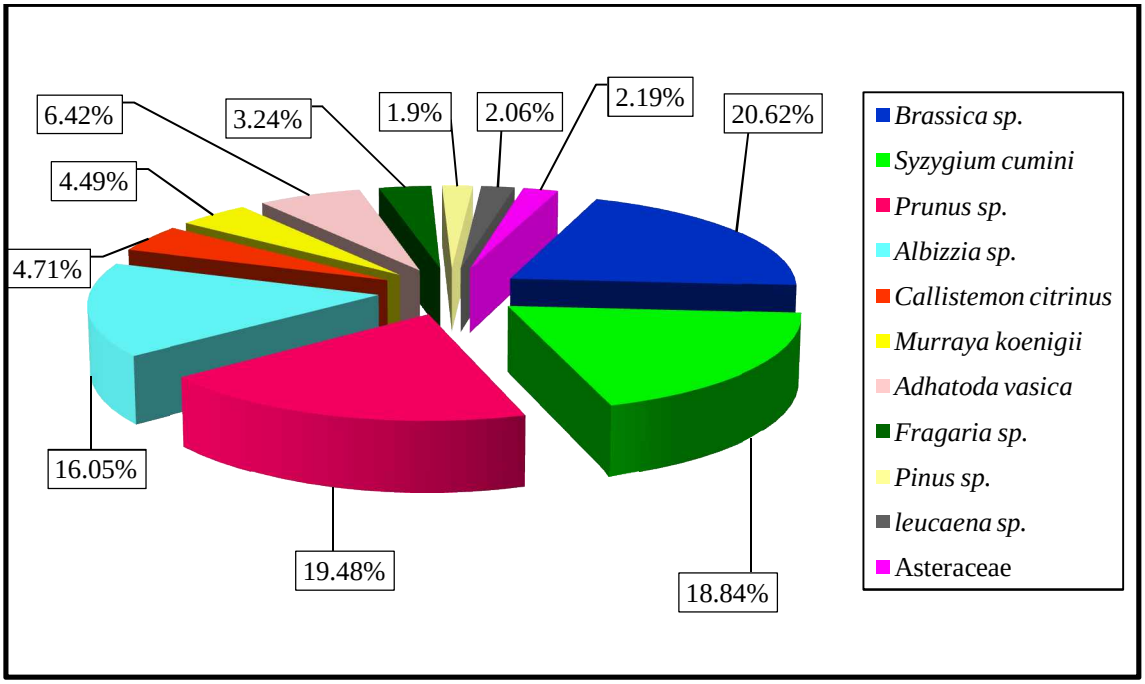

Fig. G : Kangra Honey

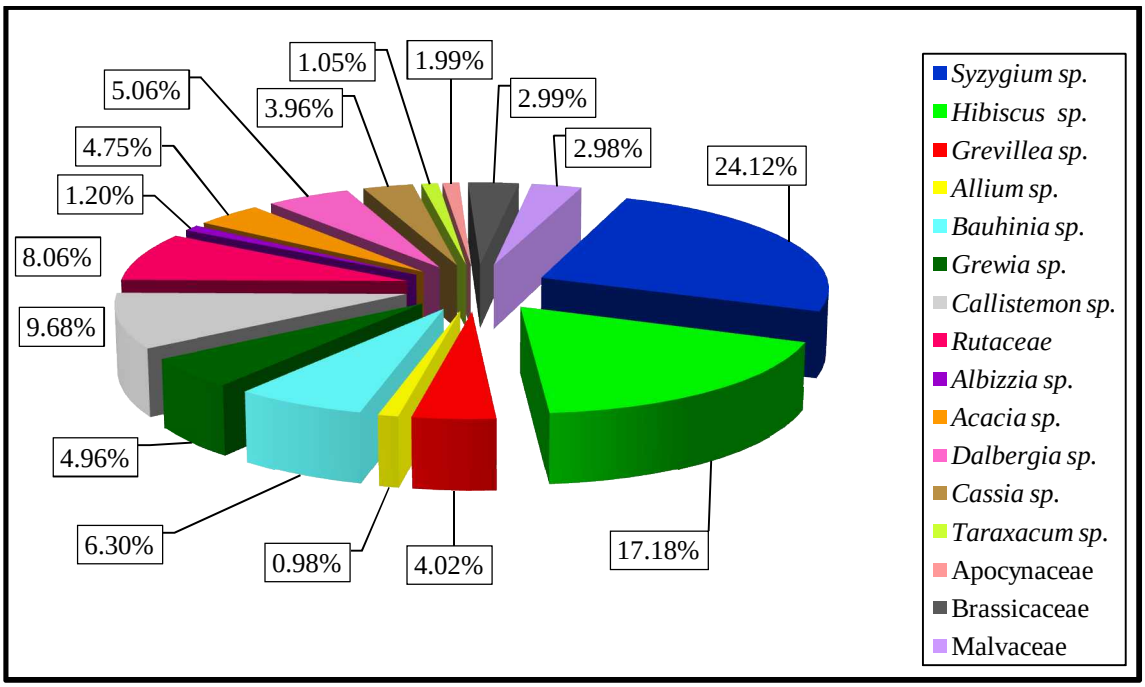

Fig. H : Shahpur Honey

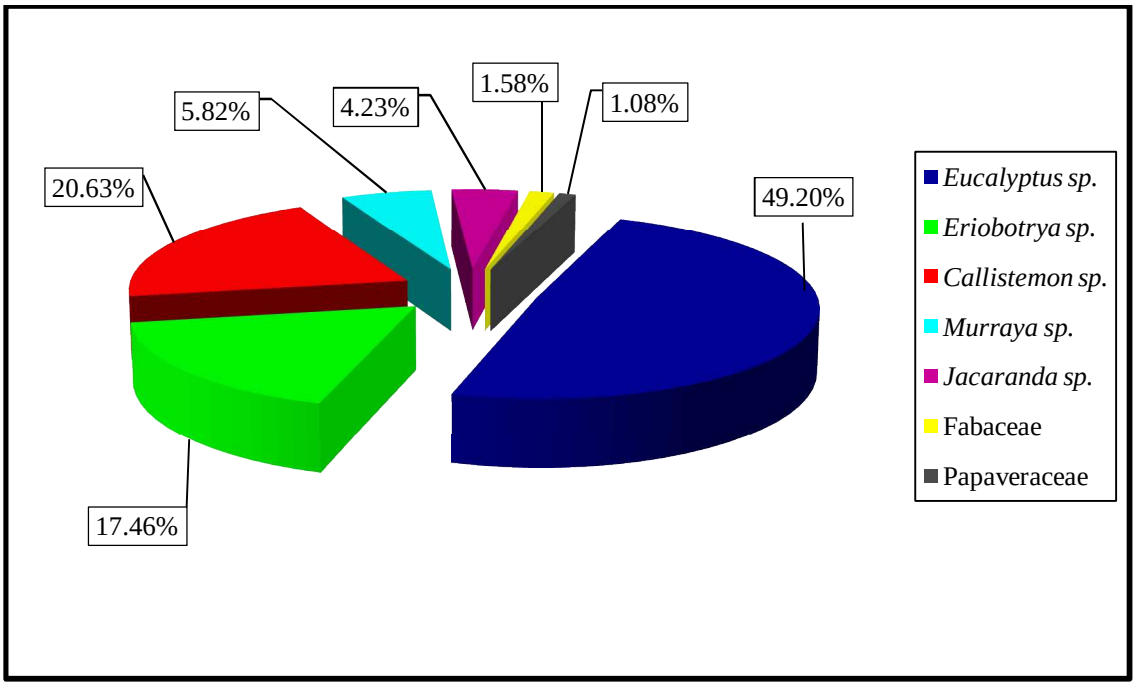

Fig. I : Paraur Honey

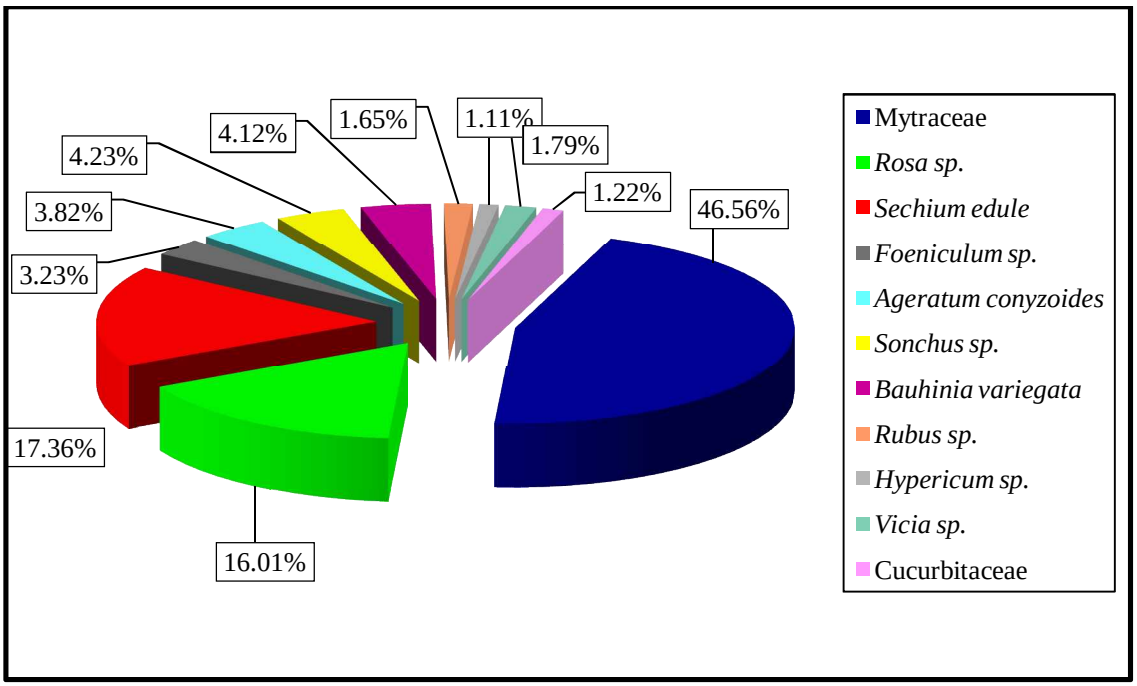

Fig. J : Rajot Honey

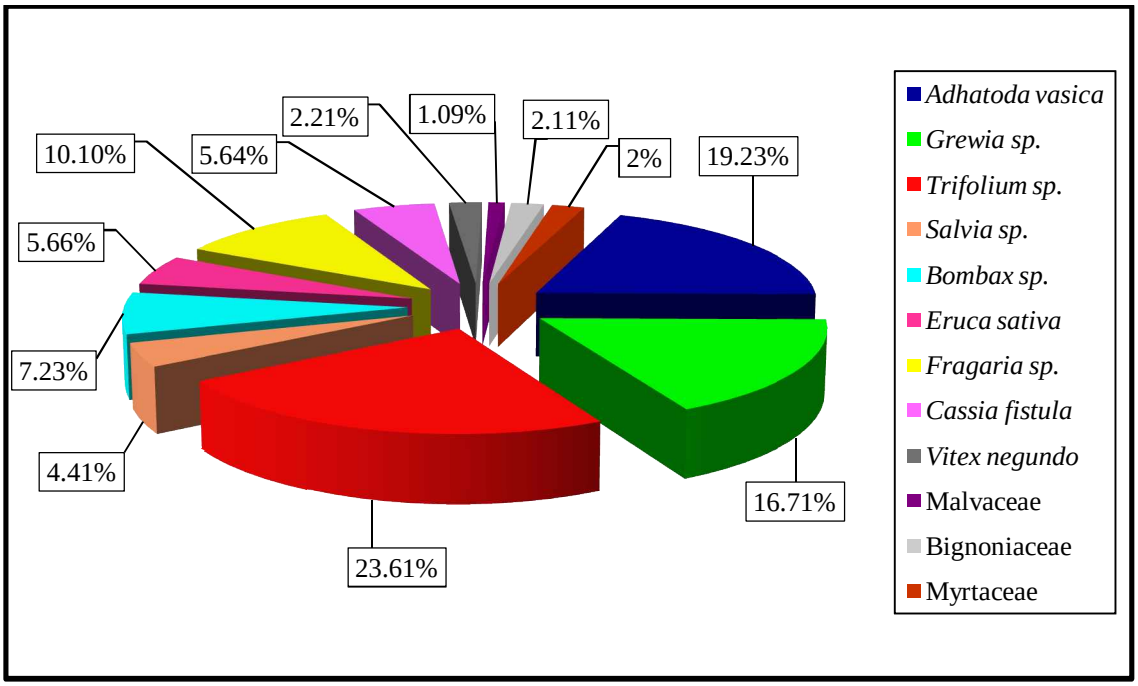

Fig .K : Paprola Honey

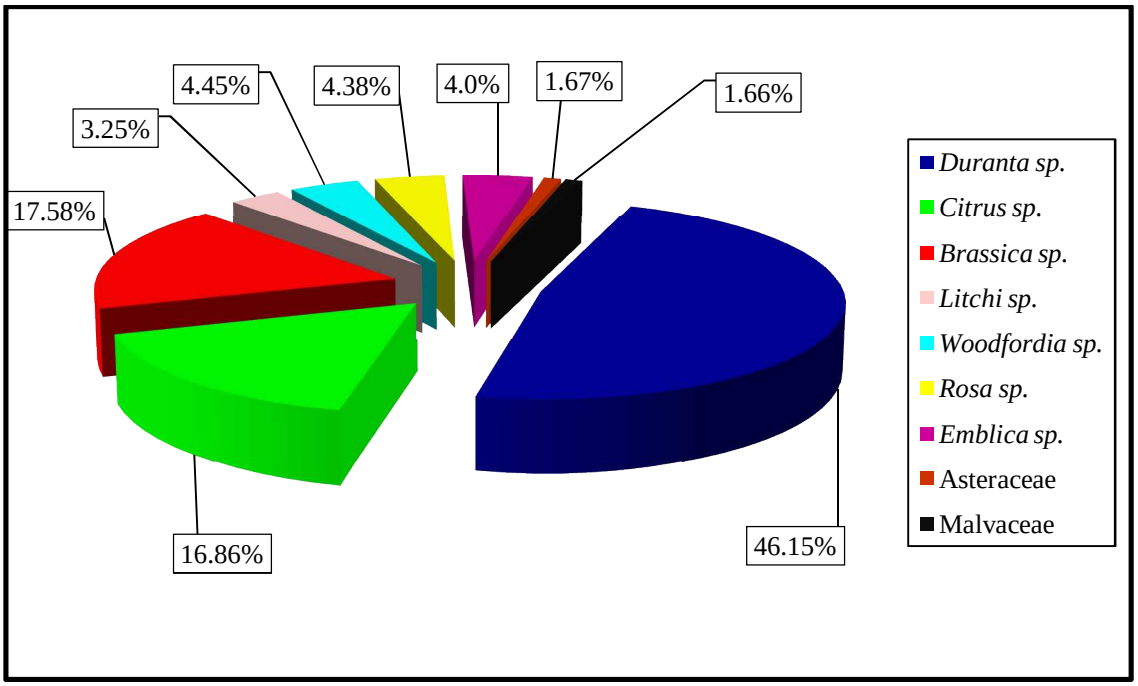

Fig. L : Chamunda Honey

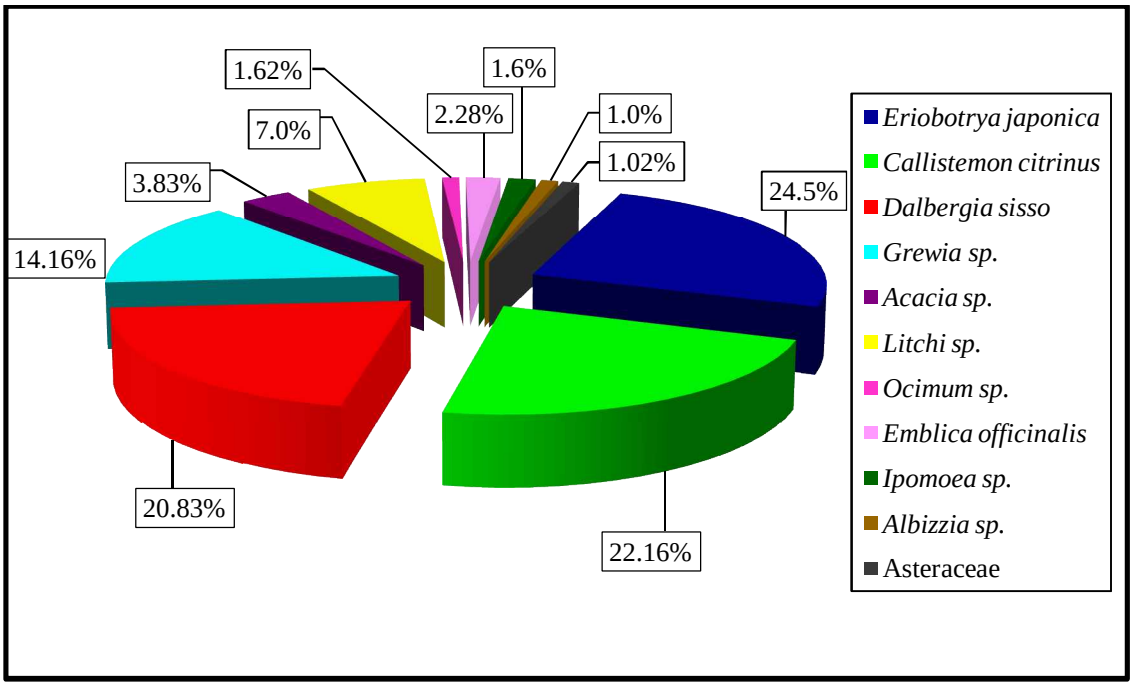

Fig. M : Ropa Honey

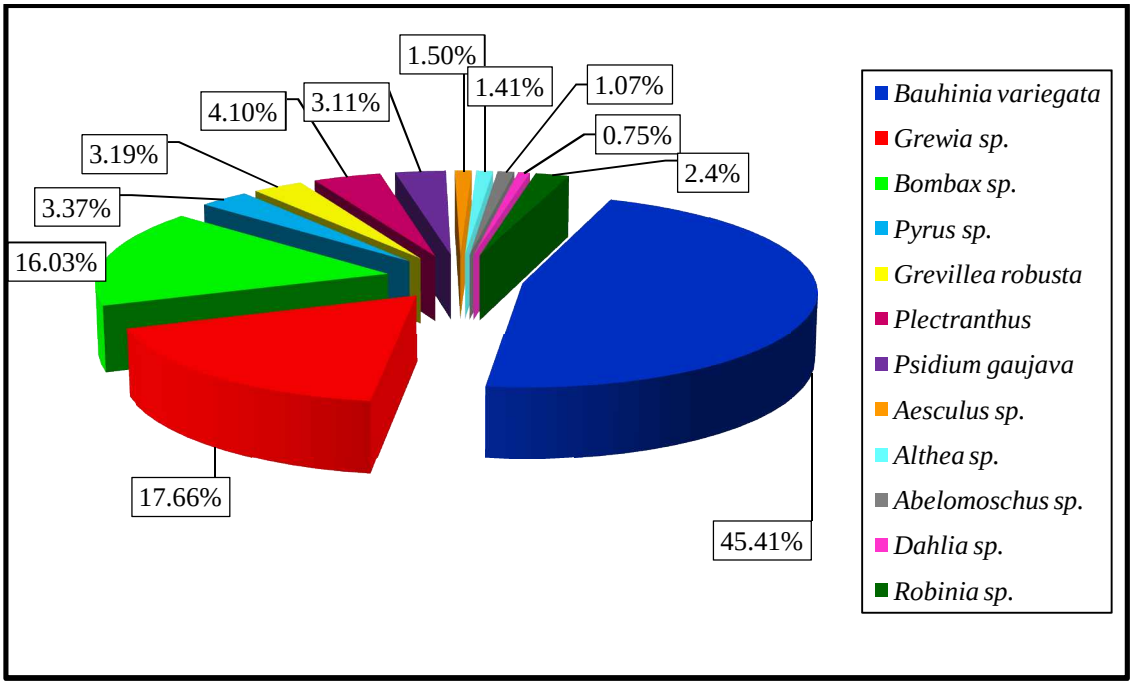

Fig. N : Sudher Honey

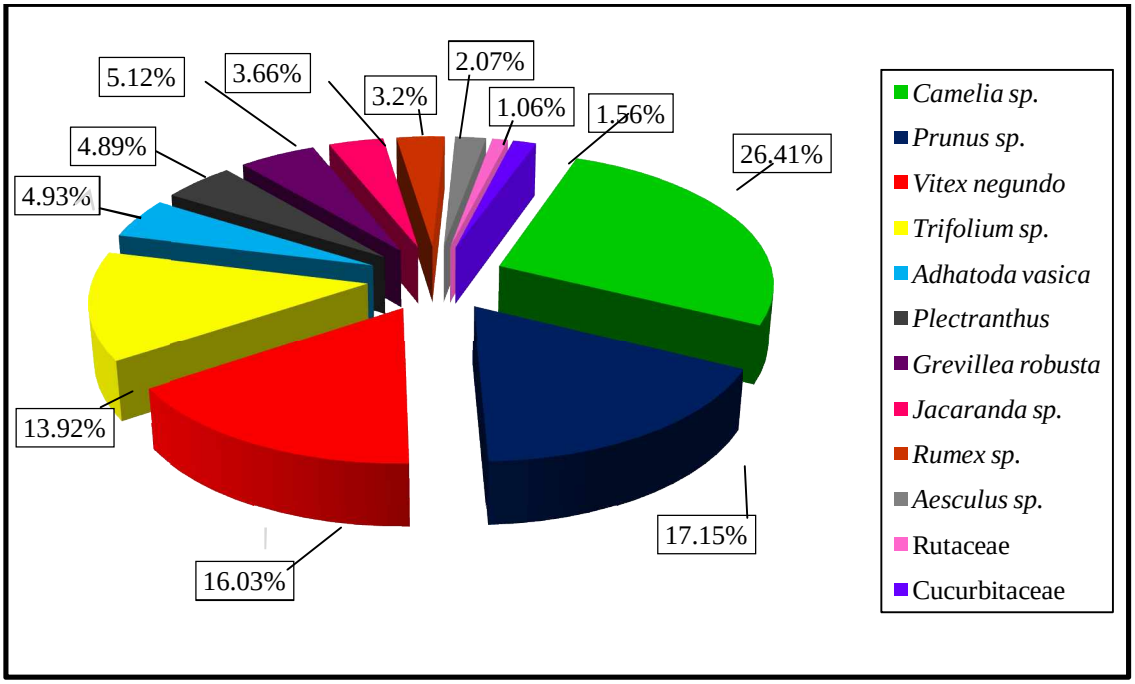

Fig. O : Bundla Honey

Microscopical analysis of some honey samples collected from domesticated/feral colonies of Indian hive bee, *Apis cerana*, Rock bee *Apis dorsata* and Europian bee, *Apis mellifera* were made in different localities of Kangra and adjoining areas having different altitudes and agro-climatic conditions. Such studies were helpful to determine the geographical and botanical origin of different honeys.

Microscopical analysis of Kangra honeys along with an extensive survey of honey plant resources of this region was made and is being discussed as follows:

Ageratum sp. (Asteraceae)

Pollen analysis revealed *Ageratum* sp. as the secondary pollen type in Jwalamukhi (17.51%) honey of summer season (Tables 2, 3; Fig. D). *Ageratum* was reported as an important minor pollen type in Rajot (3.82%) and minor pollen source in Dhaliara (2.89%) and Jwali (1.87%) honeys of summer season. Earlier in Shimla, it was represented as an important minor source during summer (8.08%) and autumn (9.56%) seasons (Sharma, 1989). Seethalakshmi (1980) also reported it as an important minor pollen source in Kerala (4.65%) and Tamilnadu (8.96%) honeys. *Ageratum* sp. was earlier identified as an important pollen source by Mahajan *et al.* (2000). Verma (2006) reported it as an important minor pollen type in Nadaun (14.10%) and Bhoranj (6.05%) honeys of summer season. In Dumehar, it was present as an important minor source (6.23%) and as minor pollen source in Dharampur (2.02%) and Darlaghat (1.82%) honeys of summer season (Rana, 2008). It was present as a secondary pollen type in Plasare (16.93%) area of Himachal Pradesh (Kaur, 2009). *Ageratum* sp. was reported as secondary pollen source in Jawalamukhi (17.51%) honey, as an important minor pollen source in Nagrota Bagwan (5.78%) and Panchrukhi (3.82%) honey and as a minor pollen source in Dehra (2.89%) and Jwali (1.84%) honeys of Kangra hills (Sunita, 2013). It was observed as a secondary pollen type in Mandi (19.23%) honey and as an important minor pollen type in Balh (3.92%) honey of autumn season in Mandi hills of Himachal Pradesh (Jamwal, 2013). Recently, Dhiman (2014) reported *Ageratum* sp. as the secondary pollen type in Bathu (28.04%) honey of summer season. *Ageratum* was reported as an important minor pollen type in Bangana (7.01%), Lalhari (4.30%), Panjawar (10.09%) and Santokhgarh (6.15%) honeys of summer season in Una hills.

Bidens sp. (Asteraceae)

Bidens sp. was present as an important minor source in Paprola (4.41%) honey of summer season (Tables 2, 3; Fig. J). Chaturvedi (1983) observed *Bidens* sp. as important pollen type in Almora (13.0%) honey of Uttarakhand. But Sharma (1989) reported it as a secondary pollen source from Nahan (20.61%) area of Himachal Pradesh. *Bidens* sp. was also observed as important minor pollen type in Zambian honey (D'Albore *et al.*, 1989). Sharma (1990) found *Bidens* sp. as secondary pollen source in Banihal (20.83%) and as the important minor source in Ramban (4.11%) and Awantipura (4.10%) honeys of Jammu and Kashmir. Kallesha *et al.* (1999) also reported *Bidens* sp. as important minor pollen type in honey samples collected from Dharwad area of Karnataka. Verma (2006) reported Bidens sp. as secondary pollen source in the summer honeys of Awahdevi (17.64%) and Chakmoh (16.26%). But Rana (2008) reported *Bidens* sp. as important minor pollen source in Arki (6.39%) honey of summer season. It was also found as an important minor source in Gagret (4.1%) and minor source in Una (3.0%) honeys of summer season (Kaur, 2009). Similarly, Sunita (2013) reported it as an important minor pollen source in Paprola (4.14%) honey of Kangra hills and in Hamirpur hills, it was found as a secondary pollen source in Chakmoh (18.91%) and Awah Devi (17.46%) honey. Jamwal (2013) reported it as secondary pollen source in Gagal (16.48%) honey of summer season in Mandi hills of Himachal Pradesh. Recently, Dhiman (2014) reported it as important minor source in Ambota (4.01%), Kuriala (9.05%) and Panjawar (4.25%) honeys of summer season in Una hills.

Helianthus sp. (Asteraceae)

Microscopical analysis of honey sample collected during summer season indicated *Helianthus* sp. as important minor pollen source in Thural (11.36%) honey of summer season (Tables 2, 3; Fig. F). Chaturvedi (1983) reported it as a predominant pollen source from South Ranikhet (34.4%) and secondary source from East Ranikhet (18.6%) area of Uttarakhand. *Helianthus* sp. was observed as predominant pollen source in Raipur (45.03%); secondary pollen source in Sundernagar (25.38%), Kasauli (22.49%) and Bilaspur (21.62%) honeys of autumn season. It was also found as important minor pollen source in Nahan (6.13%) honey of summer season (Sharma, 1989). Viraktamath *et al.* (1999) also identified it as an important pollen source in *A.*

cerana F. honeys from Dharwad (Karnataka). *Helianthus* sp. was also reported as important minor pollen source in honey samples collected from Dharwad area of Karnataka (Kallesha *et al.,* 1999). Rana (2008) reported it as secondary pollen source in Kandaghat (16.51%) honey of summer season. While, Kaur (2009) reported *Helianthus* sp. As an important minor pollen source in Pinjore (4.69%) honey of summer season. Sunita (2013) identified it as an important minor pollen source in Jaisinghpur (7.0%) honey of Kangra hills of Himachal Pradesh. Moreover, Jamwal (2013) also reported it as secondary pollen source in Sundernagar (24.50%) honey and as important minor pollen source in Jarol (11.36%) honey in Mandi hills of Himachal Pradesh. Recently, Dhiman (2014) reported *Helianthus* sp. as important minor pollen source in Panjawar (8.29%) honey of summer season in Una hills of Himachal Pradesh.

Taraxacum sp. (Asteraceae)

Taraxacum sp. was found as Important minor pollen source in Dhaliara (10.92%) and minor pollen source in Paraur (1.05%) honeys of summer season (Tables 2, 3; Fig. A,H). Earlier, Shah and Shah (1976) reported it as a major source of pollen and nectar to honeybees in Kashmir valley. Sharma (1989) found it as a secondary pollen source in Mandi (17.87%); important minor pollen source in Arki (11.35%) and minor pollen source in Nirmand (4.46%) honeys of summer season. It was found as the secondary pollen source in Nalagarh (31.12%); Narkanda (19.21%) and Sabathu (17.26%) honeys and important minor pollen source in Chopal (18.57%) and Rajgarh (3.56%) honeys of autumn season. In Shimla area, it was found as minor pollen source. Verma (2006) reported Taraxacum sp. as a minor pollen source in Jangallberi (2.42%) honey of summer season. Rana (2008) reported Taraxacum sp. as a secondary pollen source in Sabathu (16.30%) honey of summer season. Kaur (2009) identified it as an important minor pollen source in summer honeys of Ramshahar (2.09%) and Una (1.05%) areas respectively. Sunita (2013) reported it as a secondary pollen source in Ranital (19.01%) honey and as an important minor pollen source in Dehra (10.92%) honey of Kangra hills and as secondary pollen source in Tauni Devi (17.94%) honey of Hamirpur hills 0f Himachal Pradesh. It was also observed as secondary pollen source in Larji (21.7%); as an important minor source in Sarabai (12.3%), Garsa (11.36%) and as a minor source in Katrain (2.1%) honeys of autumn season in Kullu hills of Himachal Pradesh (Jamwal, 2013). Recently, Dhiman (2014) reported *Taraxacum* sp. as minor pollen source in Kuriala (3.07%) honey of summer season in Una hills, Himachal Pradesh.

Brassica sp. (Brassicaceae)

Brassica sp. was found as secondary pollen source in Kangra (20.62%) and Chamunda (17.58%) honey Whereas, it was present as a important minor pollen source in Thural (9.09%) honey of summer season (Tables 2, 3; Fig. F, G, L). Some researchers have observed it as a predominant pollen source in North-East Himalayas (65.05%); Haldwani and Almora (69.02% and 56% respectively) areas of Uttarakhand; secondary pollen source in Tehri Garhwal, Uttarakhand (23.60%) and Bhattind (Kashmir, 16.44%); as important minor pollen source in Kasauni, Uttaranchal (4.6%) honey (Nair, 1964; Sharma and Nair, 1965; Seethalakshmi, 1980; Chaturvedi, 1983). Sharma (1989) also reported *Brassica* sp. as secondary pollen source in Raipur, Rajgarh, Nalagarh and Narkanda (25.10%, 19.41%, 18.63% and 16.92% respectively); important minor pollen source in Hatkoti (12.14%) and Nahan (5.52%) and as minor source in Solan (2.51%) area of Himachal Pradesh. Verma (2006) reported *Brassica* sp. as predominant pollen source in Awahdevi (48.03%) and secondary pollen source in Dhaneta (930.64%) honeys of summer season. Rana (2008) reported it as secondary pollen source in the summer honeys of Kunihar (17.64%) and as minor pollen type in Solan (1.26%) honey. Kaur (2009) observed it as a predominant pollen source in Mittian (45.23%) and in Chandigarh (46.06%) honeys of winter and spring seasons respectively. Jamwal (2013) reported it as secondary pollen source in Riwalsar (20.00%) honey of autumn season and an important minor pollen type in summer and autumn honeys of Jarol (9.09%) and Kataula (10.37%) respectively. Sunita (2013) reported it as predominant pollen source in Awah Devi (50.03%) as secondary pollen source in Dhaneta (28.6%), Nadaun (16.49%) and as important minor source Bara (9.1%) area of Hamirpur hills of Himachal Pradesh. Recently, Dhiman (2014) reported *Brassica* sp. as important minor pollen source in Bangana (5.07%) honey and as a minor pollen source in Panjawar (2.07%) honey of summer season in Una hills of Himachal Pradesh.

Ipomoea sp. (Convolvulaceae)

Pollen analysis of summer honey indicated *Ipomoea* sp. as a minor pollen source in Ropa (1.6%) honeys of summer season (Tables 2, 3; Fig. M). Earlier, it was reported as a secondary, important minor and minor pollen source in winter honey sample of Kamrup district, Assam (Sarma and Saharia, 2011). Shubharani *et al*. (2012)

revealed it as a secondary, important minor and minor pollen source in Gonikoppa, Virajpet and Bagamandala honeys of Coorg district of Karnataka. Similarly, Sunita (2013) identified it as a minor pollen source in Pragpur (2.6%) and Jaisinghpur (1.6%) honeys of summer season in Kangra hills of Himachal Pradesh. In Hamirpur hills, it was present as an important minor pollen source in Nadaun (3.7%) and as a minor pollen source in Bhota (0.9%) honeys of Himachal Pradesh.

Acacia sp. (Fabaceae)

Pollen analysis revealed *Acacia* sp. as important minor pollen source in summer honeys of Dhaliara (10.06%), Shahpur (4.75%) and Ropa (3.83%) (Tables 2, 3; Fig. A, H , M). Earlier, it was reported as predominant pollen source in Malaysian honey (Maishihal and Kiew, 1989). Sharma (1989) also observed it as a secondary pollen source in Raipur (18.67%); Hamirpur (17.28%) and Bilaspur (16.05%) honeys of Himachal Pradesh. Seethalakshmi (1980) reported it as an excellent important minor pollen type in Kodaikanal (Tamilnadu, 12.82%) honey. Similarly, Virakthamath *et al.* (1999) also reported it as an important pollen source to *A. cerana* F. in Dharwad, Karnataka. Verma (2006) reported it as minor pollen source in Chakmoh (1.57%) honey of summer season. *Acacia* sp. was also identified as a secondary (19.95%) and as an important minor (4.75%) pollen source in summer honeys collected from Pinjore and Panchkula areas respectively (Kaur, 2009). Jamwal (2013) found it as a secondary pollen source in summer honeys of Jogindernagar (17.97%). Recently, Sunita (2013) reported it as predominant pollen source in Chadiar (45.07%) and as an important minor pollen source in Dehra (10.06%), Ranital (4.69%) and Jaisinghpur (3.83%) honey of Kangra hills of Himachal Pradesh. Recently, Dhiman (2014) reported *Acacia* sp. as secondary pollen source in summer honeys of Peeplu (17.07%), Panjawar (16.45%) honeys and as an important minor source in summer honeys of Bangana (6.29%) in Una hills of Himachal Pradesh.

Albizzia sp. (Fabaceae)

Pollen analysis of summer honeys indicated that it was present as a secondary pollen source in Kangra (16.05%) and as a minor pollen source in Bairghata (1.17%), Shahpur (1.20%) and Ropa (1.0%) honeys of summer season (Tables 2, 3; Fig. E, G, H & M). Earlier, Lakshmi and Suryanarayana (1999) also observed *Albizzia* sp. as a

secondary pollen type in honeys from deciduous forest of Andhra Pradesh. In contrary to this, Lakshmi and Wakode (2003) reported it as an important minor and minor pollen source in samples analysed from different parts of the country. Shwetha and Gowda (2007) reported *Albizzia lebbek* as an important minor pollen type in Bangalore (15.26%) honey of summer season. Shubharani *et al*. (2012) also observed it as a secondary and important minor pollen source in Kutta and Gonikoppa honey of Coorg district of Karnataka. Recently, Sunita (2013) reported it as a secondary pollen source in Palampur (17.41%) honey and as an important minor pollen source in Ranital (8.93%) and Nagrota Bagwan (3.55%) honeys of Kangra hills. In Hamirpur hills, it was present as a minor pollen source in Rangar (1.30%) and Badsar (2.06%) honeys of Himachal Pradesh.

Bauhinia sp. (Fabaceae)

Bauhinia sp. was found as predominant source in Sudher (45.41%) honey and important minor source in Shahpur (6.30%) and Rajot (4.12) honeys of summer season (Tables 2, 3; Fig. H, J , N). Earlier it was observed as a medium pollen source in various honey samples of Himachal Pradesh (Sharma, 1989). Similar honey potentiality was also reported by Kohli (1958) and Atwal *et al.* (1970) in Punjab; Sharma & Raj (1985) in Kangra Shiwaliks, Himachal Pradesh and Deodikar (1970) in Jammu & Kashmir. Nair (1964, 1985) and Singh (1989) also observed the similar honey spectrum for this plant in different parts of North-east Himalayas and indogangetic plains. Verma (2006) reported it as secondary pollen source in Hamirpur proper (16.56%) honey, as important minor source in Jangalberi (6.98%) honey, as minor pollen type in Badsar (2.14%) honey of summer season. Jamwal (2013) reported it as secondary pollen type in honey samples of Mandi (16.25%). It was also reported as a predominant pollen source in Dharamshala (45.41%); as a secondary pollen source in Chadiar (16.74%) and as an important minor pollen source in Panchrukhi (4.12%) honey of Kangra hills of Himachal Pradesh (Sunita, 2013). Recently, Dhiman (2014) reported Bauhinia sp. as important minor source in Lalhari (8.59%) honey and as a minor pollen source in Bangana (0.06%) in Una hills of Himachal Pradesh.

Salvia spp. (Lamiaceae)

Pollen analysis of honey samples revealed *Salvia* sp. as a important minor source in Paprola (4.41%) honey of summer season (Tables 2, 3; Fig. K). Sharma (1989) also reported this plant source as a predominant, secondary, important minor and minor pollen source from different parts of Himachal Pradesh. *Salvia* sp. was also observed as a predominant and secondary pollen source in various honey samples collected from Dharwad in Karnataka (Kallesha *et al.,* 1999). However, Verma (2006) reported *Salvia* sp. as an important minor pollen type in Utpur (4.64%) honey and minor source in Jangalberi (1.10%) honey. Shwetha and Gowda (2007) found *Salvia officinalis* as a minor pollen type (2.28%) in autumn honey sample collected from Bangalore. Kaur (2009) identified it as an important minor honey pollen source in Pinjore (3.64%) honeys of summer season. Moreover, Jamwal (2013) also reported it as predominant pollen source in Sandhole (60.59%); secondary pollen type in Sundernagar (22.16%) and as an important minor pollen source in Mandi (11.53%), Karsog (6.9%) and Bauh (5.78%) honeys of autumn season in Mandi hills. While, in Kullu hills, it was represented as a secondary source of pollen in Bajaura (33.59%) and Garsa (19.0%); as an important minor pollen source in Larji (7.1%) and as a minor pollen type in Bhekli (1.57%) honeys of autumn season.

Woodfordia sp. (Lytheraceae)

Pollen analysis of honey samples revealed *Woodfordia* sp. as important minor pollen source in Chamunda (4.45%) honey of summer season (Tables 2, 3; Fig. L). Recently, it was reported as secondary pollen source in Kataula (17.43%) and as an important pollen source in Nerchowk (6.52%) honeys of summer season in Mandi hills of Himachal Pradesh. While in Kullu hills, it was present as a secondary pollen source in Banjar (25.24%) honeys of summer season (Jamwal, 2013). Moreover, Sunita (2013) reported it as a secondary pollen source in Jwali (16.91%), Pragpur (16.1%) and as an important minor pollen type in Chadiar (3.0%) honey of Kangra hills of Himachal Pradesh. Recently, Dhiman (2014) reported *Woodfordia* sp. as minor pollen source in Santokhgarh (1.04%) and Mehatpur (1.05%) honeys of summer season in Una hills of Himachal Pradesh.

Cedrella sp. (Meliaceae)

Cedrella sp. was present as a important pollen source in Dhaliara (13.19%) honey of summer season (Tables 2, 3; Fig. A). Earlier, Suryanarayana *et al.* (1981) found it a secondary pollen source in Kodikanal, Tamilnadu (26.47%) honey. However, Nair (1964) and Sharma and Nair (1965) reported it as the minor pollen source from Indogangetic (2.2%) and Pithoragarh (0.5%) areas of Uttaranchal. *Cedrella* sp. was reported as predominant pollen source in Hamirpur (45.12%); secondary pollen source in Sundernagar (19.23%) and Kangra (18.93%) and as important minor pollen source in Nahan (12.14%) honeys of summer season (Sharma, 1989).

Different research workers have reported it as the major source of nectar from different parts of country like Punjab (Chaudhari, 1977a,b); Kashmir (Deodikar, 1970; Saraf, 1972); Maharashtra (Chaubal and Deodikar, 1965) and Uttar Pradesh (Kohli, 1958; Singh, 1983). However, Chandran and Shah (1974) observed it as the minor source in Tamilnadu. In Pakistan and Bangladesh, it has been found as a good source of nectar to bees (Makhdoomi and Chohan, 1980; Dewan, 1980). Verma (2006) reported *Cedrella* as minor pollen source in Awahdevi (1.58%) and Dhaneta (2.10%) honeys as important minor source in Chakmoh (3.10%) honey of summer season. Rana (2008) reported *Cedrella* sp. as secondary pollen source in Darlaghat (23.38%) and Sabathu (21.16%) honeys of summer season. *Cedrella* sp. was also reported as important minor and minor pollen source in summer honeys of Una (9.11%) and Diggal (2.98%) areas respectively (Kaur, 2009). Jamwal (2013) found it as a secondary pollen source in Rewalsar (23.21%), Gagal (18.68%) and Nerchowk (16.15%) honeys of summer season in Mandi hills of Himachal Pradesh. Recently, Kavita (2014) reported *Cedrella* sp. was present as a secondary pollen source in Bangana (22.07%) honey of summer season, important minor pollen source in Thana Kalan (10.01%) honey of summer season and as minor pollen source in Bathu (1.29%) honey in Una hills of Himachal Pradesh.

Callistemon citrinus (Myrtaceae)

Melissopalynological studies indicated *Callistemon citrinus* as a secondary pollen source in Ropa (22.16%) and Paraur (20.63%); as an important minor pollen source in Shahpur (4.43%) and Kangra (4.71%) honeys of summer season (Tables 2, 3:

Fig. G, H, I , M). Earlier, Kallesha *et al*. (1999) reported it as a minor pollen source in winter honey samples collected from Kamrup district of Assam. Kallesha and Viraktamath (2000) while studing the pollen sources of *A. mellifera* at Dharwad, Karnataka, found *Callistemon* sp. as a minor source to honeybees. Similarly, Premila *et al*. (2005) revealed it as important honeybee foraging plant of Kerala. Sunita (2013) identified it as a secondary pollen source in Jaisinghpur (22.16%); as an important minor pollen source in Nagrota Surian (4.43%), Kangra (4.71%) and as a minor pollen source in Baijnath (2.2%) honey of Kangra hills. In Hamirpur hills, it was observed as a secondary pollen source in Bhota (18.5%), Utpur (18.09%) and Chakmoh (20.34%) honey of Hamirpur hills of Himachal Pradesh.

Eucalyptus sp. (Myrtaceae)

Eucalyptus sp. was present as predominant pollen source in Paraur (49.20%) of summer season (Tables 2, 3; Fig. I) and minor pollen sources in Jwalamukhi (2.10%) honeys respectively. Different investigators have reported different pollen frequencies of the plant from various parts of country like Lucknow (96.5%); Ranikhet (12.5%); Jeolikote (2.5%); Haldwani (1.7%); Kodaikanal (55.12%); Baruipur (4%); Kerala (2%) and Indogangetic region (1.3%) (Nair, 1964; Sharma and Nair, 1965; Seethalakshmi, 1980; Chanda and Ganguly, 1981; Chaturvedi, 1983). Sharma (1989) also reported it as predominant pollen source in Nahan (46.66%) honeys and as secondary pollen source in Nalagarh (24.01%) and Bilaspur (20.74%) honeys of summer season. Verma (2006) reported *Eucalyptus* sp. as predominant pollen source in Bhoranj (50.06%) honey and as minor pollen type in Chakmoh (1.05%) honey of summer season. It was also present as predominant pollen source in Bangalore (49.10%) honey during autumn season (Shwetha and Gowda, 2007). Rana (2008) reported *Eucalyptus* as predominantly present in Dumehar (49.20%) and secondary pollen source in Arki (29.47%) and Dharampur (26.52%) honeys of summer season. It was found predominantly in Sundernagar (49.20%) and as secondary pollen source in Pandoh (23.23%) honeys of summer season (Jamwal, 2013). Sunita (2013) revealed it as predominant pollen source in Bhoranj (45.09%) as a secondary pollen source in Nadaun (16.25%) in Hamirpur hills and as important minor pollen source in Palampur (5.12%) and Baijnath (4.1%) honeys of Kangra hills of Himachal Pradesh. Recently, Dhiman (2014) reported *Eucalyptus* sp. as secondary pollen source in Mehatpur (17.10%), and Bathu (19.45%) honeys of summer season in Una hills of Himachal Pradesh.

Syzygium sp. (Myrtaceae)

Pollen analysis revealed *Syzygium* sp. as secondary pollen source in summer honey of Kangra (18.84%) and Shahpur (24.12%) honeys of summer season (Tables 2, 3; Fig. F & G). Earlier, it was reported as predominant pollen source in Champaran (76.92%), Castlerock (80.13%), Mahabaleshwar (86.21%) and Mujaffarpur (87.30%) honeys of summer season (Suryanarayana *et al.*, 1981). Sharma (1989) found it as the secondary pollen source in Sundernagar (16.74%), Kangra (16.28%), Nahan (13.98%) and as an important minor pollen source in Bilaspur (7.44%) honey of summer season. *Syzygium* sp. was reported as predominant pollen source in Pune (80.45%) honey (Joshi *et al*., 1998a, b). Verma (2006) reported *Syzygium* sp. as an important pollen source in summer honey of Dhaneta (7.50%). Shwetha and Gowda (2007) found it as secondary pollen source in Bangalore (35.53%) honey of summer season. Rana (2008) found it as predominant pollen type in Kunihar (48.16%) honey of summer season. Shubharani *et al.* (2012) while investigating honey samples from Coorg district of Karnataka found *Syzygium* sp. as an important pollen source. Jamwal, (2013) found it as secondary pollen type in Sandhole (16.98%) honey of summer season in Mandi hills of Himachal pradesh. Pollen analysis revealed it as a secondary pollen source in Ranital (19.53%), Kangra (18.84%) honeys of Kangra hills and as an important minor pollen source in Dhaneta (9.74%), Jangal Beri (7.5%) and as minor source in Bhaleth (2.4%) honeys of Hamirpur hills of Himachal Pradesh (Sunita, 2013). Recently, Dhiman (2014) reported *Eucalyptus* sp. as secondary pollen source in Mehatpur (17.10%), and Bathu (19.45%) honeys of summer season in Una hills of Himachal Pradesh.

Rosa sp. (Rosaceae)

Microscopical investigations indicated *Rosa* sp. as secondary pollen source in Rajot (16.01%) and important minor pollen type in Dhaliara (14.39%) and Chamunda (4.38%) honeys of summer season (Tables 2, 3; Fig. A, J , L). *Rosa* sp. was also found as important minor pollen source in Kullu (9.19%) and Janot (5.37%) honeys of summer season, whereas, it was found as secondary pollen source in Sundernagar (19.08%) honey of autumn season (Sharma, 1989). Chanda and Ganguly (1981) observed it as the important minor and minor pollen source in honey samples from Narsipatham (Andhra Pradesh, 12%) and Palghat (Kerala, 1.5%) respectively. Verma (2006) reported *Rosa* sp. as an important minor pollen source in Jungalberi (8.61%)

honey of summer season. Rana (2008) found it as an important minor pollen source in Dharampur (14.92%) honey of summer season. Similarly, *Rosa* sp. was found as an important minor pollen source in Kumarhatti (4.38%) honey of spring season (Kaur, 2009). Recently, Jamwal (2013) found it as secondary pollen source in Sundernagar (20.83%) honey of autumn season. Similarly, Sunita (2013) also reported it as secondary pollen source in Panchrukhi (16.01%) and as an important minor pollen source in Baijnath (1.69%) honey of Kangra hills of Himachal Pradesh. Recently, Dhiman (2014) reported *Rosa* sp. as an important minor pollen source in Kuriala (5.48%) honey of summer season in Una hills of Himachal Pradesh.

Citrus sp. (Rutaceae)

Citrus sp. was found as a predominant pollen source in Jwali (20.17%) and as secondary pollen source in Chamunda (16.86%) and important minor pollen source in Jwalamukhi (5.59%) honeys of summer season (Tables 2, 3; Fig. B, D & L). Sharma (1989) observed *Citrus* sp. as predominant pollen in source Bilaspur (48.40%) and Mandi (45.65%); secondary pollen source in Baijnath (34%) and Kangra (20.63%) and as important minor pollen source in Chamba (11.68%); Sundernagar (10.66%) and Arki (10.32%) honeys of summer season. Suryanaryana *et al.* (1981) found it as important minor and minor pollen source in honey samples from Sitakundu (West Bengal, 2.94%) and Castlerock (Karnataka, 4.12%) respectively. Atwal *et al.* (1970) and Chaudhari (1977a,b) reported *Citrus* spp. as major honey source in Punjab. However, Naim and Phadke (1976) observed it as minor pollen and nectar source in Bihar. Sharma (1990) also found *Citrus* sp. as important minor pollen source in Rajouri (4.30%) and Batot (12.3%) honeys of Jammu and Kashmir. Verma (2006) reported it as secondary pollen source in Nadaun (23.53%); Awahdevi (20.63%) and Dhaneta (28.42%) honeys and as important minor pollen type in Bhoranj (3.00%) honey of summer season. Rana (2008) reported it as secondary pollen source in Solan (24.42%) honey and as an important minor pollen source in Arki (11.18%) honey of summer season. Jamwal (2013) found it as predominant pollen source in Mandi Proper (46.01%) honey, secondary pollen source in Pandoh (22.53%) and Kataula (18.34%) honeys of summer season. *Citrus* sp. was also reported as a predominant pollen source in Jwali (46.74%); as a secondary source in Nagrota Surian (18.57) and as important minor source in Jawalamukhi (5.59%) and Jaisinghpur (14.16%) honeys of Kangra hills of Himachal Pradesh (Sunita,

2013). Recently, Dhiman (2014) reported *Citrus* sp. as an secondary pollen source in Santokhgarh (20.17%) and as minor pollen source in Lalhari (2.15%) honeys of summer season in Una hills of Himachal Pradesh.

Litchi chinensis (Sapindaceae)

Pollen analysis of summer honeys indicated *Litchi chinensis* as a secondary honey source in Thural (22.15%) and as a impotant minor pollen in Ropa (7.0%), whereas a minor pollen source in Jwali (4.09%) and Chamunda (3.25%) honeys of summer season (Tables 2, 3; Fig. B, F, L, M). Sharma (1989) while melissopalynologically analysing 30 different honey samples found it as a predominant pollen source in Himachal Pradesh. It was also reported as a predominant pollen source in 14 honey samples and as secondary pollen type in 3 samples among various Indian honey samples analysed (Lakshmi and Wakhle, 2003). *Litchi chinensis* was also found also as a major source of nectar and pollen to honeybees in North-west Himalayan region (Sood *et al.*, 2006). Jamwal (2013) identified it as a secondary honey source in Harabagh (30.11%) and Jarol (22.15%) areas of Mandi hills of Himachal Pradesh.

Grewia spp. (Tiliaceae)

Microscopical investigations indicated *Grewia* sp. as a secondary pollen pollen type in Bairghata (21.32%), Sudher (17.66%), Paprola (16.71%) and Raja ka talab (16.64%) and as an important minor pollen type in Shahpur (4.96%) honeys of summer season (Tables 2, 3; Fig. C, E, H, K,N). *Grewia optiva* was found as a major source of nectar and pollen to honeybees in Northwest Himalayan region (Sood *et al.*, 2006). Singh and Sharma (2007) also identified *Grewia optiva* as an important source of nectar during April-May in low hills of Himachal Pradesh. Jamwal (2013) reported *Grewia* sp. as a predominant pollen source in Sandhole (47.16%); secondary pollen type in Mandi (21.32%) and as an important minor pollen type in Kotli (3.45%) honeys of summer season in Mandi hills of Himachal Pradesh. Whereas, it was found as a secondary honey pollen source in Larji (17.8%) and as important minor source of pollen in Katrain (6.0%) honeys of summer season in Kullu hills of Himachal Pradesh.

Besides the above sporomorphs, members of other families were also present in summer honeys collected from Dhaliara, Jwali, Raja ka talab, Jwalamukhi, Bairghata Thural, Kangra, Shahpur, Paraur, Rajot, Paprola, Chamunda, Ropa, Sudher and Bundla

areas of Kangra of Himachal Pradesh such as *Adhatoda vasica* (Asteraceae 4.93-26.74%); *Abelomoschus* sp. (Malvaceae, 1.07%); *Aegle* sp. (Rutaceae, 8.54%); *Aesculus* sp. (Hippocastanaceae, 1.50-2.07%); *Allium* sp. (Amaryllidaceae, 0.98-2.65%); *Althea* sp. (1.41%)); *Bombax* sp. (Bombacaceae, 7.23-16.03%); *Butea monosperma* (Fabaceae, 4.19%); *Camelia* sp. (Tiliaceae, 26.41%); *Campsis grandiflora* (Bignoniaceae, 16.91%); *Carica papaya* (Caricaceae, 3.14%); *Cassia fisstula* (Fabaceae, 3.13-5.64) *Dahlia* sp. (Asteraceae, 0.75%); *Dalbergia sissoo* (Fabaceae, 3.03-16%) *Emblica* sp. (Euphorbiaceae, 2.28-23.93%); *Eriobotrya japonica* (Rosaceae, 17.46-24.5%); *Eruca sativa* (Brassicaceae, 5.66%); *Foeniculum* sp. (Apiaceae, 3.23%); *Fragaria* sp. (Rosaceae, 3.24-10.10%); *Grevillea* sp. (Proteaceae, 3.19-11.22%); *Hibiscus* sp. (Malvaceae, 17.18%); *Hypericum* spp. (Hypericaceae, 1.11%); *Jacaranda mimosifolia* (Bignoniaceae, 3.36-4.23%); *Leucana* sp. (Fabaceae, 0.57-2.06%); *Mangifera* sp. (Anacardiaceae, 4.5-53.40%); *Melia* sp. (Meliaceae, 1.51-5.12%); *Moringa oleifera* (Moringaceae, 48.40%); *Murraya* sp. (Rutaceae, 1.08-22.21%); *Ocimum* sp. (Lamiaceae,1.62%) *Pisum* sp. (Fabaceae, 1.95-2.09%); *Plectranthus* sp. (Lamiaceae, 4.10-4.89%); *Psidium guajava* (Myrtaceae, 3.11%); *Punica* sp. (Punicaceae, 2.94-16.29%); *Prunus* sp. (Rosaceae, 17.15-19.48%); *Robinia* sp. (Fabaceae, 24%); *Rumex* sp. (Polygonacae, 3.2-4.56%); *Rubus* sp. (Rosaceae, 1.65%); *Sonchus* sp. (Asteraceae, 4.23%); *Vicia* sp. (Fabaceae, 1.79%); *Vitex* sp. (Verbenaceae, 2.21%); *Zizyphus* sp. (Rhamnaceae, 2.18-2.89%) and members of families Apiaceae (0.93%); Apocynaceae (1.99%); Asteraceae (1.02-2.97%); Bignoniaceae (2.11%); Brassicaceae (2.99%); Cucurbitaceae (4.09%); Fabaceae (1.31-1.58%); Malvaceae (1.66-2.98%); Myrtaceae (2-45.96%); Papaveraceae (1.08%); Papilionaceae (1.84%); Rosaceae (0.72%) and Rutaceae (1.06-8.06%).

Present investigations revealed that honey sample collected from Jwali, Bairghata, Thural, Paraur, and Sudher was unifloral in nature, whereas, honey samples collected from Dhaliara, Raja ka talab, Jwalamukhi, Kangra, Shahpur, Rajot, Paprola, Ropa and Bundla were multifloral in nature. Seethalakshmi (1980), Chaturvedi (1983), Sharma (1989), Sharma (1990), Singh (1989) and Sharma (1996) also observed uniflorality and multiflorality in various honey samples collected from the North-West and the Northeast Himalayan regions. Above studies, indicated multifloral and multiseasonal pollen spectra due to rich and heterogenous floral association in the studied areas. Normally, people in the hills practice beekeeping in a traditional way and

in most of the cases beekeepers leave one or two combs filled with honey and brood during honey extraction. In the next season, these combs are harvested and again developed combs with rich store are left over for bees. This is one of the reasons for obtaining multifloral and multiseasonal pollen spectra. Some honey samples also indicated the presence of some pollen from plants blooming in autumn season. The possible reason for this is sticking of pollens to old combs (Tiwari *et al.*, 2012). There is also short variation in flowering period of same plants which may be early in some region and late in others and difference in honey extraction period of same season may result in differed percentage of plants in different honey samples. Based on above studies and those conducted by some earlier workers it was concluded that following points need to be emphasized for the future research work:

1. Kangra and its adjoining areas are rich in bioresources due to a variety of climatic and topographical conditions. It has great potential to provide adequate bee forage to honeybees.
2. Assessment of bioresources including honey plant resources and their utilization pattern for hilly and plain areas.
3. Sustainable use of natural resources should be ensured.
4. Floral diversity should be conserved and maintained to encourage the wild pollinators including honeybees.
5. Beekeepers should not restrict their investigations to cultivated crops or trees but also take into account the wild herbs, shrubs, bushes and weeds in the fields.
6. There are vast possibilities of planting useful avenue trees along new roads in rural areas and cultivated clovers and other plants to stop soil erosion under various soil conservation and river valley projects.
7. Plants to be cultivated should be such that they must have other economic values in addition to being good honey plants.
8. Floral maps should be prepared for Kangra and adjoining areas of Himachal Pradesh.
9. Detailed ecological and biochemical studies should be conducted on excellent nectar sources.
10. There are many missing gaps regarding various aspects of bee botany and melliferous resources which should be studied.

11. Use of chemical pesticides should be discouraged and that of biopesticides be encouraged.

12. Use of broad spectrum pesticides should be avoided because they are much more harmful to pollinators and floral resources.

13. Programmes related to conservation and maintenance of honey plant resources should be launched among farmers and general public.

14. Like other agri-inputs, conservation of melliferous resources should be included in programmes of agriculture and horticulture departments.

15. For double-fold benefit, area based scientific beekeeping should be encouraged among the farmers. Need based research activities should be taken up.

Insects and plants are mutually dependent upon each other. Many insects including honey bees depend upon the plants for energy to maintain their activities, whereas, plants in turn depend for pollination on insects. This energy relationship between plants and nectar gathering insects is a necessary basis for studying the foraging behaviour, crop pollination and honey production. Honey bees while foraging on the flowers of different entomophilous plants for collecting nectar, also gather some pollen with it. This pollen is retained in the ripened honey which is subsequently stored in the honey combs. The microscopical examination of these pollen grains in the honey is known as 'melissopalynology' and any final confirmatory evaluation of bee plants is incomplete without the study of melissopalynology.

Melissopalynology is helpful in both quantitative and qualitative pollen analysis of honey samples. Quantitative analysis is used for confirming the botanical sources of unifloral and multifloral honeys, whereas, qualitative analysis helps in the identification of geographical origin of honey samples because local floras have characteristic plant associations that are reflected in the corresponding spectrum of pollen types represented in the local honeys. Honey pollen analysis also tells the seasons of honey extraction during the annual cycle. The scope of microscopical analysis of honey is of immense value in comparative evaluation of honeys originated from different eco-geographic regions in detecting the adulteration of honeys and in identification of honeys contaminated by poisonous plants.

Microscopic analysis was conducted of various honey samples collected from Indian hive bee, *Apis cerana* F., Rock bee, *Apis dorsata* L. and European bee *Apis meliferra* L. colonies located in Kangra and adjoining areas of Himachal Pradesh with different altitudes and agro-climatic conditions. The places of collection of honey samples were: Dhaliara (480 m), Jwali (494 m), Raja ka talab (532 m), Jwalamukhi (620 m), Bairghata (640 m), Thural (661 m), Kangra (720 m), Shahpur (779 m), Paraur (969 m), Rajot (972 m), Paprola (987 m), Chamunda (1059 m), Ropa (1064 m), Sudher (1338 m) and Bundla (1513 m). The collections were made mainly during summer season (May and June) of year 2015. Present investigations were made in order to know important pollen and nectar resources useful to honeybees in Kangra and adjoining areas of Himachal Pradesh.

Microscopic analysis of various honey samples revealed *Citrus* sp. as predominant sporomorph in Jwali honey; *Moringa oleifera* in Bairghata honey; *Mangifera indica* in Thural honey; *Eucalyptus* sp. in Paraur; Myrtaceae in Rajot honey; *Duranta repens* in Chamunda honey and *Bauhinia variegata* in Sudher honey of summer season. These studies on summer honey samples so revealed the following secondary pollen sources: *Emblica officinalis* and *Murraya koenigii* in Dhaliara; *Campsis grandiflora* and *Mangifera indica* in Jwali; *Adhatoda vasica, Mangifera indica* and *Punica* sp. in Raja ka talab; *Murraya koenigii*, *Ageratum conyzoides*, *Dalbergia sissoo* and *Grewia* sp. in Jwalamukhi; *Grewia optiva* in Bairghata; *Litchi chinensis* in Thural; *Brassica* sp., *Syzygium cumini*, *Prunus* sp., and *Albizzia* sp. in Kangra; *Syzygium* sp., *Helianthus* sp. and *Hibiscus* sp. in Shahpur; *Eriobotrya* sp. and *Callistemon* sp. in Paraur; *Rosa* sp. and *Sechium edule* in Rajot; *Adhatoda vasica*, *Grewia* sp. and *Trifolium* sp. in Paprola; *Citrus* sp. and *Brassica* sp. in Chamunda; *Eriobotrya japonica*, *Callistemon citrinus* and *Dalbergia sissoo* in Ropa; *Grewia* sp. and *Bombax* sp. in Sudher; *Camelia* sp., *Prunus* sp., *vitex negundo* and *Trifolium* sp. in Bundla honeys of summer season.

Microscopic analysis of summer honeys revealed *Acacia* sp., *Adhatoda* sp., *Aegel* sp., *Ageratum* sp., *Allium* sp., *Bauhinia variegata*, *Salvia* sp., *Bombax* sp., *Brassica campestris*, *Butea monoserma*, *Caesalpinia* sp., *Callistemon* sp., *Carissa* sp., *Cassia* sp., *Cedrella* sp., *Citrus* sp., *Dalbergia* sp., *Emblica* sp., *Eruca sativa*, *Foeniculum* sp., *Fragaria* sp., *Grevillea* sp., *Grewia* sp., *Helianthus* sp., *Jacaranda mimosifolia*, *Litchi* sp., *Mangifera* sp., *Melia azedarch*, *Murraya* sp., *Plectranthes* sp., *Pyrus* sp., *Psidium guajava*, *Rosa* sp., *Rumex hestatus*, *Sonchus* sp., *Taraxacum* sp., *Woodfordia* sp., and members of families Lytheraceae and Rutaceae as important minor pollen sources.

Microscopic anlaysis of summer honey revealed *Abelmoschus* sp., *Acacia* sp., *Aesculus* sp., *Ageratum conyzoides*, *Albizzia* sp., *Allium* sp., *Althea* sp., *Cassia* sp., *Dahlia* sp., *Dalbergia* sp., *Eucalyptus* sp., *Hypercium* sp., *Ipomea* sp., *Leucaena* sp., *Melia* sp., *Murraya koenigii*, *Ocimum* sp., *Pinus* sp., *Robinia* sp., *Rubus* sp., *Sonchus* sp., *Taraxacum* sp., *Zizyphus* sp., and members of families Apiaceae, Asteraceae, Bignoniaceae, Brassicaceae, Cucurbitaceae, Euphorbiaceae, Fabaceae, Malvaceae, Myrtaceae, Papaveraceae, Papilionaceae, Rosaceae and Rutaceae as minor pollen types.

Present pollen analytical studies indicated that summer honey of Jwali, Bairghata, Thural, Paraur, Chamunda and Sudher were unifloral, whereas those from Dhaliara, Raja ka talab, Jwalamukhi, Kangra, Shahpur, Rajot, Paprola, Ropa and Bundla were multifloral in nature.

Honey pollen analysis indicated that honey samples from Kangra and adjoining areas of Himachal Pradesh contained pollen grains of both entomophilous and anemophilous types. The anemophilous types were: *Psidium* guajava Sudher and Bundla, *Pinus* sp. in Kangra, and Poaceous members in Jwalamukhi honeys of summer season. All other morpho types like *Eucalyptus* sp., *Brassica* sp., *Cedrella* sp., *Taraxacum* sp. and *Trifolium* sp. etc. as recorded in various honey samples belonged to entomophilous types.

Further these studies revealed that honeys from Kangra and adjoining areas of Himachal Pradesh fall under the category of Group I to group III formed by International Commission for Plant Bee Relationship i.e. honeys having absolute pollen count from 10,000 to 50,000 10/gm of honey, Kangra and adjoining areas of Himachal Pradesh, having varied topographical conditions, presented a wide range of pollen types in different honey samples. The honey belonging to different sources, but from the same locality and from the same season, had similar pollen spectrum for the associated species, but their individual percentages differed.

Present melissopalynological and bee botanical investigations in Kangra and adjoining areas revealed a total of 219 plants species as nectar and pollen sources. Of these, 49 were major; 39 were medium and 55 plants were minor pollen source. *Centaurea cynus, Helianthus annus, Taraxacum officinale, Bombax ceiba, Brassica* sp., *Eruca sativa, Raphanus sativus, Rhododendron arboreum, Carica papaya, Cucurbita* spp., *Terminalia* spp., *Kalanchoe integra, Cucumis* spp., *Delbergia sissoo, Trifolium* spp., *Acacia catechu, Aesculus indica, Woodfordia fruticosa, Moringa oleifera, Callistemon citrinus, Eucalyptus camaldulensis, Psidium gaujava, Syzygium cumini, Sesamum indicum, Grevillea robusta, Eriobotrya japonica, Prunus amygdalus, prunus armeniaca, Pyrus persica, Citrus* spp., *Litchi chinensis, Sapindus mukorosii, Camellia sinensis* and *Grewia optiva* were major sources of pollen and nectar to honeybee in Kangra and its adjoining areas, whereas, *Adhatoda vasica, Justicia pubigera, Acer* spp., *Carissa caranda, Asclepias curassavica, Cardus onopardios, Dahlia pinnata, Zinnia elegans, Impatiens glandulifera, Berberis* spp., *Brassica* spp., *Cardamine* spp.,

Opuntia spp., *Cannabis sativa, Benincasa* spp., *Emblica officinale, Acacia arabica, Cassia fistula, Erythrina suberosa, Delonix regia, Indigofera* sp., *Salvia* spp., *Lagerstroemia indica, Abelomoschus esculentus, Althaea rosea, Hibiscus rosa-sinensis, Malvaviscus arboreus, Epilobium* spp., *Clematis* spp., *Prinsepia utilis, Pyrus pashia, Rubus* spp., *Murraya koenigii, Aegle marmelos, Antirrhinum majus* and *Origanum vulgare* were medium nectar and pollen resources. Whereas, Minor nectar and pollen sources were: *allium sativum, Allium cepa, Mangifera indicia, Salvia* sp., *Foeniculum vulgare, Heracleum* sp., *Ageratum conyzoides, Calendula officinalis, Eupatorium* sp., *Jacaranda mimosifolia, Cynoglossum* sp., *Albizzia julibrissin, Albizzia lebbek, Albizzia stipulata, Glycine max, Rumex hestatus* etc. and other members belonged to families Acantheceae, Agavaceae, Amaryllidaceae, Anacardiaceae, Apiaceae, Apocynaceae, Arecaceae, Asteraceae, Bignoniaceae, Boraginaceae, Caprifoliaceae, Chenopodiaceae, Convolvulaceae, Cucurbitaceae, Euphorbiaceae, Fabaceae, Fagaceae, Geraniaceae, Lamiaceae, Liliaceae, Linaceae, Malvaceae, Meliaceae, Moraceae, Musaceae, Papaveraceae, Plantaginaceae, Poaceae, Polygonaceae, Portulacaceae, Punicaceae, Ranunculaceae, Rhamnaceae, Rosaceae, Rubiaceae, Solanaceae, Verbenaceae, Violaceae and Vitaceae.

Minor nectar and pollen sources were: *Mangifera indica, Coriandrum sativum, Sonchus spp., Tagetus erectus, Cichorium intybus, Eupatorium spp., Seneceo spp., Bidens pilosa, Foeniculum vulgare, Ageratum conyzoides, Calendula officinalis, Eupatorium* sp., *Jacaranda mimosifolia, Ipomoea spp., Albizzia spp., Glycine max, Rumex hestatus, Papaver rhoeas* etc. and other members belonged to families as Acantheceae, Agavaceae, Amaryllidaceae, Anacardiaceae, Apiaceae, Apocynaceae, Arecaceae, Asteraceae, Bignoniaceae, Boraginaceae, Caprifoliaceae, Chenopodiaceae, Convolvulaceae, Cucurbitaceae, Euphorbiaceae, Fabaceae, Fagaceae, Geraniaceae, Lamiaceae, Liliaceae, Linaceae, Malvaceae, Meliaceae, Moraceae, Musaceae, Papaveraceae, Plantaginaceae, Poaceae, Polygonaceae, Portulacaceae, Punicaceae, Ranunculaceae, Rhamnaceae, Rosaceae, Rubiaceae, Solanaceae, Verbenaceae, Violaceae and Vitaceae.

Based on present melissopalynological studies in Kangra and adjoining areas and those of earlier investigators, it is proposed that there is an urgent need to conduct such studies on following important aspects by future workers in this field. To produce a computer assisted pollen data bank of honey plant resources of the Himalayan region;

to generate a complete database on the diversity and abundance of various melliferous resources of Himalayan region; pollen analysis of honey samples from different parts of the Himalayan region; identification of major, medium and minor sources of pollen and nectar to honeybees and preparation of floral calendars; to recommend measures for the conservation of depleting melliferous flora; to work out the honey potentials of different melliferous resources present in the Himalayan region; to strengthen research and development activities at institutional level; to enhance capacity building among researchers/ extension workers, farmers and other stakeholders; to take up studies on pollinator-plant interactions; to study the pollination requirement of economically important crops; to encourage farmers and private sector including NGOs for creating awareness regarding the importance of melliferous resources and apiforestry programmes.

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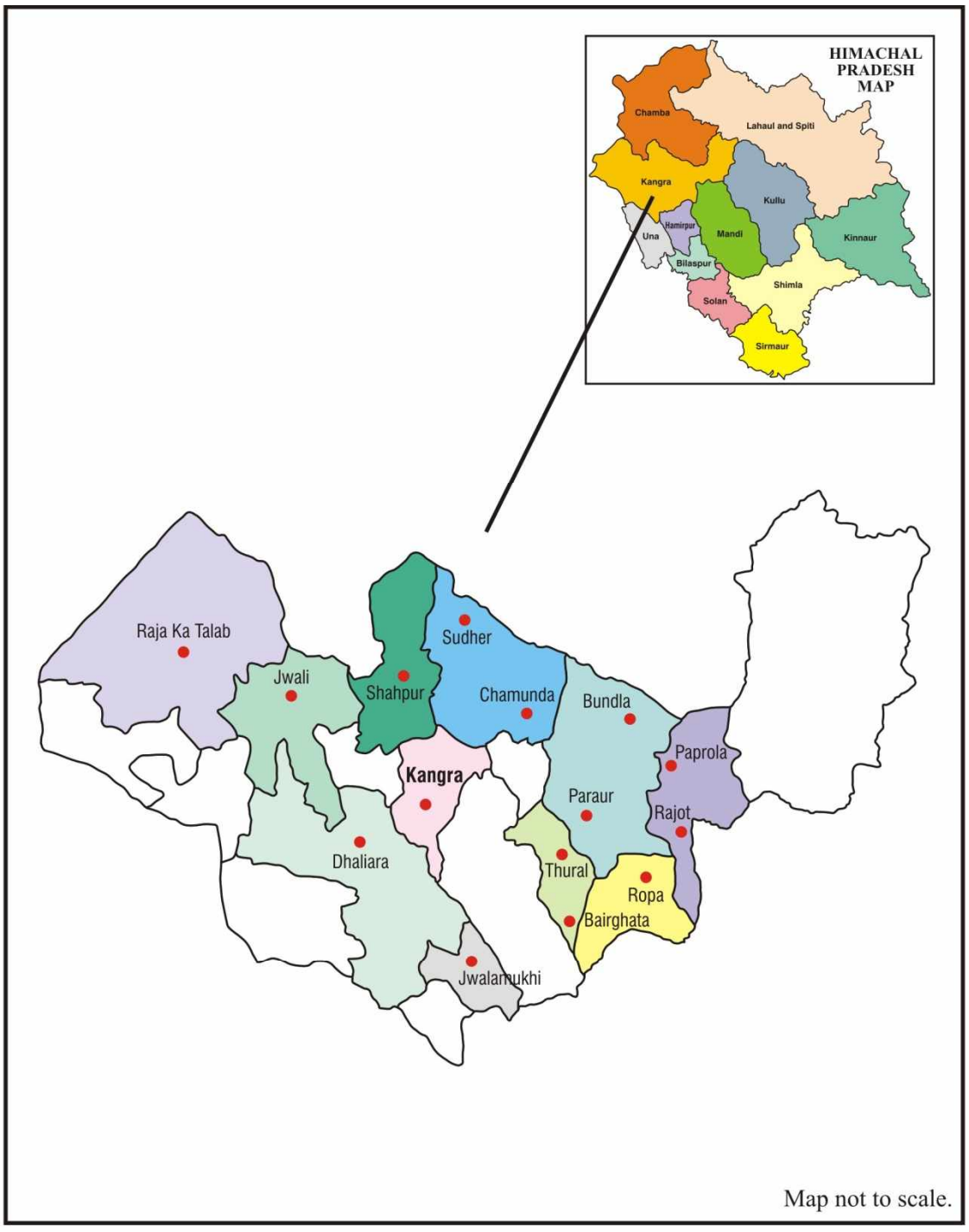

Map showing places of collection of honey samples from Kangra and adjoining areas of Himachal Pradesh.

1) Dhaliara	2) Jwali	3) Raja Ka Talab	4) Jwalamukhi
5) Bairghata	6) Thural	7) Kangra	8) Shahpur
9) Paraur	10) Rajot	11) Paprola	12) Chamunda
13) Ropa	14) Bundla	15) Sudher	