Melissopalynological Determination of Pollen Density and Botanical Origin of Autumn Honeys of Kullu Hills, Himachal Pradesh, India

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ABSTRACT

Background: Geographical and botanical origins of honeys are determined by melissopalynological analysis. Pollen contents of 12 autumn honeys collected from Indian honey bee, Apis cerana F. hives located in different localities of Kullu hills of Himachal Pradesh were analysed. Kullu hills having varied geography, climatic condition with diversified and rich flora is ideal for apiculture. So, it is of utmost importance to study the floral richness of the area and preferences of honey bees for nectar and pollen in order to obtain maximum production of a good quality of honey. Thus, the present work was carried out to determine the critical analysis of honey samples and to identify the different pollen types which are major plant sources that contribute to the increase of yield of honey.

Methods: Melissopalynological studies were conducted between 2009 to 2012. Reference pollen slides of honey samples were prepared and identified. Quantitative analysis is done with the help of a haemocytometer and pollen spectra, absolute pollen count as well as percentage of pollen types were calculated. Reference slides were also prepared.

Result: Microscopic analysis yielded that in honey samples, 5 pollen types were present as predominant; 17 were secondary, while, 38 were important minor and minor pollen sources. Out of 12 honey samples analysed, 5 were unifloral, whereas, 7 were multifloral.

In the unifloral honeys, the predominant sporomorphs were: Prunus cerasoides, Eriobotrya japonica, Prinsepia utilis, Plectranthus sp. and Solidago sp. Forty four pollen types were nectariferous, while, 6 were nectarless represented by Cannabis sativa, Juglans regia, Rumex nepalensis, Polygonum sp. and Zea mays. Among different plant families, Lamiaceae (8), Asteraceae (7), Rosaceae (7), Fabaceae (4), Polygonaceae (3) and Apiaceae (2) highly contributed for nectar and pollen sources of honey bee. Twenty five botanical families with 50 different pollen taxa were identified indicating the various plants visited by honeybees and the sources of nectar used in the production of honey. The high concentration and diversity of pollen types showed that the samples were of botanical origin.

Key words: A. cerana, Autumn honey samples, Melissopalynology, Multifloral, Unifloral.

INTRODUCTION

Honey is a natural sweet, flavorful substance produced by honeybees from the nectar of blossoms, from secretion of living parts of plants. Honeybees collect it from nectararies, transform and combine it with specific substances of their own, store and leave in the honeycomb to ripen and mature (White and Landis, 1980). Honey contains sugars, small quantities of proteins, enzymes, amino acids, minerals, trace elements, vitamins, aroma compounds and polyphones. It is widely accepted as a food source and medicine by both modern and ancient generations, traditions and civilizations (Allsop and Miller, 1996; Crane, 1975; Crane, 1999; Jones, 2001).

Honey flavor and variability of honey types depends upon the diversity of nectar sources present in the region. While, foraging for nectar honeybees also collect pollen with it. Nectar is a source of carbohydrates, whereas, pollen is the major source of proteins and amino acid for bee colonies (Tidke and Nagarkar, 2015). By studying the pollen in a sample of honey, it is possible to gain evidence of the geographical location by observing the honey samples for the presence of a combination of pollen that is typical only to that particular location (Louveaux et al., 1978). It is also possible to identify taxonomically the genera of the plants the honey bees visited, although honey may also contain airborne pollen from anemophilous plant species, spore and dust due to electrostatic charge of the worker bee.

Information gained from a given honey sample is useful when substantiating claims of a particular honey source and is also of great importance for quality control and helps to ascertain whether honey is adulterated or not (Maurizio, 1951; Louveaux et al., 1978; Terrab et al., 2003).

Present investigations were conducted on honey samples collected from Indian hive bee, Apis cerana F.
colonies located in different areas of Kullu hills of Himachal Pradesh. Kullu district is located between 31° 58’ 00” North latitude and 77° 06’ 04” East longitude. On the North and North-East, it is bounded by Lahaul-Spiti and Kangra districts, on the East and South-East by Kinnau and Shimla districts. The total area of Kullu is 5,503 sq. km and the average altitude of district is 1,219 metres.

**MATERIALS AND METHODS**

In present investigations (field and laboratory studies were done as a part of Ph.D work during 2009 to 2012) twelve autumn honey samples were procured from domesticated Indian hive bee, A. cerana from different areas of Kullu hills of Himachal Pradesh so as to identify important pollen and nectar sources of this region (Table 1, Fig 1). Collection sites (and elevation in meters) are shown in Table 1. All honey samples collected were raw and unprocessed. The honey samples were subjected to Qualitative and Quantitative analysis. For Qualitative and Quantitative analysis, the methodology recommended by the International Commission for Bee Botany (ICBB) was followed (Louveaux et al., 1978) modified by (Iwama and Melhem, 1979). Identification of different pollen types was done with the help of standard works (Erdtman, 1960; Nair, 1964; Nair, 1985) and pollen slide collection of Sociobiology and Behavioral Ecology Research lab, Department of Biosciences, Himachal Pradesh University, Shimla. For the preparation of pollen slides of honey, 10 gm of honey was dissolved in 20 ml of hot distilled water at 40°C. This solution was poured equally into different centrifuge tubes and centrifuged at 2500 - 3000 rpm for 10 min. 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 acetylated 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°C 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) was added to the sediment. Then, this sediment solution was transferred to the slides which were placed in an oven (40 - 45°C) to get surplus water evaporated. The pollen grains were mounted in glycerine gelatin. Reference slides were prepared from the identified honey plants using Acetolysis Method and Glycerine Jelly Method (Louveaux et al., 1978).

Quantitative analysis is done with the help of a haemocytometer (Suryanarayana et al., 1981; Sharma, 1989). Pollen spectra, absolute pollen count as well as percentage of pollen types were calculated and formulated on the basis of these percentages (Sharma and Nair, 1965). The honey samples were categorized as rich, poor and extremely poor as per total number of pollen grains present in 10 gm of honey i.e., 1,00,000, 20,000 to 1,00,000 and below 20,000 respectively (Maurizio, 1975). The frequencies of pollen grains were recorded according to the system adopted by Louveaux et al., 1978: ‘Predominant pollen’ (>45% of the pollen grains counted); ‘Secondary pollen’ (16 - 45%); ‘Important minor pollen’ (3 - 15%) and ‘Minor pollen’ (<3%). Honey sample was termed as ‘Unifloral honey’ if it was having 45% or more grains of a single pollen type and honey sample’ with several pollen types in considerable percentage was termed as ‘Multifloral honey’ (Chaturvedi, 1983; Sharma, 1989; Iwama and Melhem, 1979).

**RESULTS AND DISCUSSION**

During this study, 12 autumn honey samples produced in the Kullu hills were analyzed (Table 1, Fig 1). Fifty pollen types belonging to 25 different families were recognized in the quantitative analysis (Table 2 and 3; Fig 2 and 3-14). Five of the 12 samples analyzed were considered to be

**Table 1:** Physiographic details of different places of collection of honey samples of Apis cerana F. from Kullu district of Himachal Pradesh.

| Locality | Geographical position | Altitude (metres) |
|----------|-----------------------|------------------|
| Larji1 | 31°71’ | 77°21’ | 1013 |
| Bajauri2 | 32°00’ | 77°29’ | 1086 |
| Sarabai3 | 31°03’ | 77°09’ | 1086 |
| Bhunani4 | 30°75’ | 77°25’ | 1107 |
| Shogi5 | 30°75’ | 77°25’ | 1158 |
| Garsa6 | 31°93’ | 77°11’ | 1176 |
| Mohali7 | 30°75’ | 77°25’ | 1210 |
| Sarvari8 | 31°61’ | 76°93’ | 1233 |
| Katrain9 | 32°06’ | 77°08’ | 1481 |
| Banjar10 | 31°61’ | 76°93’ | 1570 |
| Patlikuhi11 | 30°75’ | 77°25’ | 1578 |
| Bhekhli12 | 30°75’ | 77°25’ | 1775 |

Source: Collected through field work.
Table 2: Pollen spectrum of autumn honey samples of *Apis cerana* F. collected from Kullu hills of Himachal Pradesh.

| Locality | Season | Colour of honey | Unifloral or multifloral | Predominant pollen type | Secondary pollen type | Important minor pollen type | Minor pollen type |
|----------|--------|-----------------|--------------------------|-------------------------|-----------------------|-----------------------------|------------------|
| Larji    | Autumn | Yellow          | Multifloral              | -                       | Cassia sp.,           | Salvia sp.,                 | Cannabis sativa,  |
|          |        |                 |                          |                         | Impatiens officinale,| Adhatoda vasica            | Phoenix sylvestris|
|          |        |                 |                          |                         | Callistemon citrinus  |                            |                  |
| Bajaura  | Autumn | Brown           | Multifloral              | -                       | Impatiens sp.,        | Salvia splendens           | Zea mays,        |
|          |        |                 |                          |                         | Taraxacum officinale,| Tilia sp., Aster sp.       | Coriandrum sativum|
|          |        |                 |                          |                         | Aesculus indica,      | Ageratum conyzoides,       |                  |
|          |        |                 |                          |                         | Taraxacum officinale,| Medicago sp.              |                  |
|          |        |                 |                          |                         | Rumex nepalensis,     | Adhatoda vasica            |                  |
|          |        |                 |                          |                         | Sesamum indicum,      | Salvia officinalis,        |                  |
|          |        |                 |                          |                         | Prunus sp.            | Fagopyrum sp.              |                  |
| Sarabai  | Autumn | Light Brown     | Multifloral              | -                       | Eriobotrya japonica,  | Salvia officinalis,        | Vitis vinifera,  |
|          |        |                 |                          |                         | Fagopyrum sp.         | Taraxacum officinale       | Polygonum sp.    |
|          |        |                 |                          |                         |                       |                            |                  |
| Bhunter  | Autumn | Creamish white  | Unifloral                | Prunus cerasoides       | Impatiens sp.         | Aesculus indica,            | Polygonum sp.,   |
|          |        |                 |                          |                          |                       | Ageratum conyzoides,       | Aster sp.        |
|          |        |                 |                          |                          |                        | Medicago sp.               |                  |
| Shogi    | Autumn | Light Brown     | Multifloral              | -                       | Prunus sp.,           | Brassica sp.,              | Sesamum unindicum,|
|          |        |                 |                          |                         | Eriobotrya japonica,  | Rubus sp.,                 | Aster sp.        |
|          |        |                 |                          |                         | Fagopyrum sp.         | Coriandrum sativum         |                  |
|          |        |                 |                          |                         |                       | Taraxacum officinale       |                  |
| Garsa    | Autumn | Watery white    | Unifloral                | Eriobotrya japonica    | Salvia officinalis,    | Ocimum sp.,                |                  |
|          |        |                 |                          |                          | Medicago sp.          | Coriandrum sativum         |                  |
|          |        |                 |                          |                          |                        | Zea mays,                  |                  |
|          |        |                 |                          |                          |                        | Ocimum basilicum,          |                  |
|          |        |                 |                          |                          |                        | Senecio sp.,               |                  |
| Mohal    | Autumn | Brown           | Unifloral                | Prinsepia utilis       | Rubus ellipticus,      | Medicago sp.,              | Ocimum basilicum,|
|          |        |                 |                          |                          | Impatiens sp.         | Rumex nepalensis,          | Senecio sp.      |
|          |        |                 |                          |                          |                        | Foeniculum vulgare         | Aster sp.        |
|          |        |                 |                          |                          |                        | Adhatoda vasica            |                  |
|          |        |                 |                          |                          |                        | Caesalpinia sp.            |                  |
| Sarvari  | Autumn | Brown           | Multifloral              | -                       | Aesculus indica,       | Elaeagnus sp.,             |                  |
|          |        |                 |                          |                         | Impatiens sp.,        | Juglans regia,             |                  |
|          |        |                 |                          |                         | Brassica sp.          | Ageratum conyzoides,       |                  |
|          |        |                 |                          |                         |                        | Bidens pilosa              |                  |
| Katrain  | Autumn | Light Yellow    | Multifloral              | -                       | Pyrus sp.,             | Elaeagnus sp.,             | Sonchus asper    |
|          |        |                 |                          |                         | Plectranthus coestia   | Juglans regia,             |                  |
|          |        |                 |                          |                         |                        | Ageratum conyzoides,       |                  |
|          |        |                 |                          |                         |                        | Bidens pilosa              |                  |
| Banjar   | Autumn | Watery white    | Multifloral              | -                       | Impatiens sp.,         | Solidago sp.,              | Chenopodium album,|
|          |        |                 |                          |                         | Plectranthus gerardiana,| Taraxacum officinale,      | Vitex negundo    |
|          |        |                 |                          |                         | Fagopyrum sp.         | Prinsepia utilis           |                  |
|          |        |                 |                          |                         | Aesculus indica       | Pyrus sp., Prinsepia utilis|                  |
|          |        |                 |                          |                         |                         | Juglans regia,             |                  |
|          |        |                 |                          |                         |                        | Foeniculum vulgare         |                  |
| Patlikuhl| Autumn | Light Brown     | Unifloral                | Plectranthus sp.       | Indigofera sp.,       | Elaeagnus sp.              |                  |
|          |        |                 |                          |                          | Plectranthus sp.       | Salvia sp.,                |                  |
|          |        |                 |                          |                          |                        | Cannabis sativa,            |                  |
|          |        |                 |                          |                          |                        | Rhus sp.                   |                  |

Predominant pollen type = 45 % and above; Important minor pollen type = 3 to 15 %; Secondary pollen type = 16 to 45 %; Minor pollen type = < 3 %;
## Table 3: Frequency distribution of pollen types in autummhoney samples of *Apis cerana* F. collected from different areas of Kullu hills of Himachal Pradesh (expressed as percentage of total number of pollen grains).

| Plant species | Larji | Bajaura | Sarabai | Bhunter | Shogi | Garsa | Piplage | Mohal | Sarvari | Katrain | Banjar | Patlikuhl | Bhekli |
|---------------|-------|---------|---------|---------|-------|-------|---------|-------|---------|---------|--------|-----------|--------|
| *Adhatoda* sp. | 5.77  | -       | -       | -       | -     | -     | -       | -     | -       | -       | -      | -         | -      |
| *Aesculus* sp. | -     | -       | -       | 15.4    | 8.2   | -     | -       | -     | -       | -       | 31.2   | -         | 17.0   |
| *Ageratum* sp. | -     | -       | -       | 6.2     | -     | -     | -       | -     | -       | -       | -      | -         | 5.12   |
| *Aster* sp.    | -     | 4.06    | -       | 1.21    | 2.2   | -     | -       | 1.5   | -       | -       | -      | -         | -      |
| *Bidens* sp.   | -     | -       | -       | 7.2     | -     | -     | -       | -     | 16.14   | -       | -      | -         | -      |
| *Brassica* sp. | -     | -       | -       | -       | -     | -     | -       | -     | 3.28    | -       | -      | -         | -      |
| *Caesalpinia* sp. | -   | -       | -       | -       | -     | -     | -       | -     | -       | -       | -      | -         | -      |
| *Callistemon* sp. | 19.8 | -       | -       | -       | -     | -     | -       | -     | -       | -       | -      | -         | -      |
| *Cannabis* sp. | 2.5   | -       | -       | -       | -     | -     | -       | -     | -       | -       | -      | -         | 1.43   |
| *Cassia* sp.   | 40.9  | -       | -       | -       | -     | -     | -       | -     | -       | -       | -      | -         | -      |
| *Chenopodium* sp. | - | -       | -       | -       | -     | -     | -       | -     | -       | -       | -      | -         | 2.26   |
| *Coriandrum* sp. | - | 1.17    | -       | 6.7     | 2.03  | -     | -       | -     | -       | -       | -      | -         | -      |
| *Elaeagnus* sp. | -     | -       | -       | -       | -     | -     | -       | -     | -       | -       | 15.43  | -         | 7.5    |
| *Eriobotrya* sp. | -   | 28.0    | -       | 27.3    | 47.14 | -     | -       | -     | -       | -       | -      | -         | -      |
| *Fagopyrum* sp. | -     | -       | -       | 21.8    | -     | 17.6  | -       | -     | -       | -       | -      | 18.38     | -      |
| *Foeniculum* sp. | -   | -       | -       | -       | -     | -     | -       | -     | 3.1     | -       | -      | 3.22       | -      |
| *Impatiens* sp. | -     | 40.32   | -       | 16.02   | -     | -     | -       | 15.9  | 30.9    | -       | -      | 3.22       | -      |
| *Indigofera* sp. | -     | 11.57   | -       | -       | -     | -     | -       | -     | -       | -       | -      | 21.03      | -      |
| *Juglans* sp.  | -     | -       | -       | -       | -     | -     | -       | -     | -       | -       | -      | -         | 6.0    |
| *Lonicera* sp. | -     | -       | -       | -       | -     | -     | -       | -     | -       | -       | -      | -         | 2.13   |
| *Luffa* sp.    | -     | -       | -       | -       | -     | -     | -       | -     | -       | -       | -      | -         | -      |
| *Medicago* sp. | -     | -       | -       | 5.51    | 17.43 | -     | 9.4     | -     | -       | -       | -      | -         | -      |
| *Ocimum* sp.   | -     | -       | -       | -       | 2.0   | -     | 2.0     | -     | -       | -       | -      | -         | -      |
| *Phoenix* sp.  | 2.23  | -       | -       | -       | -     | -     | -       | -     | -       | -       | -      | -         | -      |
| *Plectranthus* sp. | - | -       | -       | -       | -     | -     | -       | -     | -       | -       | 30.04  | 19.13     | 47.14  |
| *Polygonum* sp. | -     | -       | -       | 2.0     | 2.0   | -     | -       | -     | -       | -       | -      | -         | -      |
| *Prinsepia* sp. | -     | -       | -       | -       | -     | -     | -       | -     | -       | -       | -      | -         | 10.03  |
| *Prunus* sp.   | -     | -       | -       | 7.6     | 61.21 | 29.1  | -       | -     | -       | -       | -      | -         | -      |
| *Pyrus* sp.    | -     | -       | 7.1     | 33.59   | -     | 32.6  | -       | 12.48 | -       | -       | -      | -         | -      |
| *Rhus* sp.     | -     | -       | -       | -       | -     | -     | -       | -     | 1.61    | -       | -      | -         | 2.75   |
| *Rubus* sp.    | -     | -       | -       | -       | 7.0   | -     | 16.3    | 7.57  | -       | -       | -      | -         | -      |
| *Rumex* sp.    | -     | -       | -       | 6.0     | -     | -     | -       | 4.3   | -       | -       | -      | -         | -      |
| *Salvia* sp.   | 7.1   | 33.59   | -       | -       | 19.0  | -     | -       | -     | -       | -       | -      | -         | 1.57   |
| *Senecio* sp.  | -     | -       | -       | -       | -     | -     | -       | -     | -       | -       | -      | -         | -      |
| *Sesamum* sp.  | -     | -       | -       | 4.0     | 2.9   | -     | -       | -     | -       | -       | -      | -         | -      |
| *Solidago* sp. | -     | -       | -       | -       | -     | -     | -       | 10.84 | -       | -       | -      | 48.65      | -      |
| *Sonchus* sp.  | -     | -       | -       | -       | -     | -     | -       | 2.0   | -       | -       | -      | -         | -      |
| *Taraxacum* sp. | 21.7 | 3.02    | 12.3    | -       | -     | 11.36 | -       | -     | -       | -       | -      | 10.02     | -      |
| *Tilia* sp.    | -     | 4.88    | -       | -       | -     | -     | -       | -     | -       | -       | -      | -         | -      |
| *Viola* sp.    | -     | -       | -       | -       | -     | -     | -       | -     | -       | -       | -      | -         | -      |
| *Vex* sp.      | -     | -       | -       | -       | -     | -     | -       | 2.0   | -       | -       | -      | -         | -      |
| *Zea* sp.      | -     | 1.39    | -       | -       | -     | -     | 1.04    | -     | -       | -       | -      | -         | -      |
unifloral; *Prunus cerasoides* in Bhunter; *Eriobotrya japonica* in Garsa; *Prinsepia utilis* in Mohal; *Plectranthus* sp. in Patlikuhl and *Solidago* sp. in Bhekli were present as predominant sporomorphs. While, 17 pollen types were secondary sources and 38 were important minor and minor pollen sources. *Cassia* sp., *Taraxacum officinale* Callistemon citrinus, *Salvia splendens*, *Eriobotrya japonica*, *Fagopyrum* sp., *Impatiens* sp., *Prunus* sp., *Salvia officinalis*, *Medicago* sp., *Rubus ellipticus*, *Aesculus indica*, *Brassica* sp., *Pyrus* sp., *Plectranthus coesta* and *Plectranthus gerardiana* were

![Pollen grains: A. Chenopodium album L. (Amaranthaceae), B. Coriandrum sativum L. (Apiaceae), C. Ageratum conyzoides L. (Asteraceae), D. Solidago sp. (Asteraceae), E. Cannabis sativa L. (Cannabinaceae), F. Luffa cylindrica (L.) Roem. (Cucurbitaceae), G. Caesalpinia sp. (Fabaceae), H. Indigofera pulchella Roxb. (Fabaceae), I. Ocimum basilicum L. (Lamiaceae), J. Ocimum sanctum L. (Lamiaceae), K. Plectranthus coesta Buch.-Ham. (Lamiaceae), L. Plectranthus gerardianus Wall. ex Benth. (Lamiaceae), M. Salvia sp. (Lamiaceae), N. Zea mays L. (Poaceae), O. Eriobotrya japonica Thunb. Lindley (Rosaceae), P. Prinsepia utilis Royle (Rosaceae), Q. Prunus cerasoides D. Don. (Rosaceae), R. Pyrus sp. (Rosaceae), S. Aesculus indica Colebr. (Sapindaceae), T. Vitex negundo L. (Verbenaceae).
the secondary pollen sources. Whereas, *Salvia* sp., *Adhatoda vasica*, *Cannabis sativa*, *Phoenix sylvestris*, *Zea mays*, *Coriandrum sativum*, *Indigofera pulchella*, *Tilia* sp., *Taraxacum officinale*, *Aesculus indica*, *Rumex nepalensis*, *Prunus* sp., *Sesamum indicum*, *Vitis vinifera*, *Polygonum* sp., *Ageratum conyzoides*, *Medicago* sp., *Aster* sp., *Brassica* sp., *Rubus* sp., *Ocimum* sp., *Foeniculum vulgare*, *Ocimum basilicum*, *Senecio* sp., *Caesalpinia* sp., *Rhus* sp., *Luffa cylindrica*, *Elaeagnus* sp., *Juglans regia*, *Bidens pilosa*, *Sonchus asper*, *Solidago* sp., *Prunsepia utilis*, *Chenopodium album*, *Vitex negundo*, *Pyrus* sp., *Lonicera* sp. and *Viola odorata* were important minor and minor pollen types.

**Fig 3:** Larji - Multifloral.

**Fig 4:** Bajaura - Multifloral.

**Fig 5:** Sarabai - Multifloral.

**Fig 6:** Bhunter - Unifloral.

**Fig 7:** Shogi - Multifloral.

**Fig 8:** Garsa - Unifloral.

**Fig 9:** Mohal - Unifloral.

**Fig 10:** Sarvari - Multifloral.
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The most widely represented families were Lamiaceae (Salvia sp., Salvia splendens, Salvia officinalis, Plectranthus coesta, Plectranthus gerardiana, Phoenix sp., Ocimum basilicum, Ocimum sp.); Asteraceae (Ageratum conyzoides, Aster sp., Bidens pilosa, Solidago sp., Sonchus asper, Taraxacum officinale, Senecio sp.); Rosaceae (Eriobotrya japonica, Prinsepia utilis, Prunus cerasoides, Pyrus sp., Rubus sp., Rubus ellipticus); Fabaceae (Caesalpinia sp., Cassia sp., Indigofera pulchella, Medicago sp.); Polygonaceae (Polygonum sp., Falopyrum sp., Rumex nepalensis); Apiaceae (Coriandrum sativum, Foeniculum vulgare), whereas, Acanthaceae, Amaranthaceae, Anacardiaceae, Araceae, Balsaminaceae, Brassicaceae, Cannabinaceae, Caprifoliaceae, Cucurbitaceae, Elaeagnaceae, Juglandaceae, Myrtaceae, Pedaliaceae, Poaceae, Sapindaceae, Tiliaceae, Verbenaceae, Violaceae and Vitaceae are represented by one member each.

Microscopic analysis showed that out of 50 morphological pollen types, 44 were nectariferous and 6 from nectarless species as Cannabis sativa, Juglanrs regia, Rumex nepalensis, Polygonum sp. and Zea mays.

Melissopalynological analysis of autumn honeys indicates that Kullu hills have tremendous potential for the development of bee colonies and for sustainable beekeeping because of the diversity of nectar and pollen sources. The presence vast array of predominant, secondary, important and important minor pollen types in honey samples indicates that all samples were of botanical and geographical origin. The honey samples, rich in both pollen concentration and pollen diversity display a vivid landscape of the bee forage plants growing vicinity of beehive. This was also a clear indication of the wide range of collection of pollen grains from many flowering plants (Ebenezer and Olugbenga, 2010).

Fifty pollen types belonging to twenty five families were recorded in this study. Thirty three were identified to species level and 17 upto family level. The identified species belong to varying genera of native trees, herbs, shrubs and trees. There were pollen of varying shapes, sizes and morphological features. The pollen spectra of these honeys showed that honeybee’s foraged considerable distance in search nectar and pollen which is needed for their survival and production of honey. The presence of these large number of pollen types also indicated that the honey samples were pure and not adulterated.

Pollen analytical data of the samples was given in Table 2 and 3. The predominant pollen types were Prunus cerasoides, Eriobotrya japonica, Prinsepia utilis, Plectranthus sp. and Solidago sp. The dominant wild trees/plants were Adhatoda vasica, Aesculus indica, Aster sp., Agaratum conyzoides, Bidens pilosa, Cannabis sativa, Cassia sp. Caesalpinia sp., Elaeagnus sp., Falopyrum sp., Impatiens sp., Indigofera pulchella, Loniceria sp., Phoenix sylvestris, Plectranthus coesta, Plectranthus gerardiana, Polygonum sp., Prinsepia utilis, Prunus cerasoides, Rhus sp., Rubus ellipticus, Rumex nepalensis, Salvia officinalis, Senecio sp., Solidago sp., Sonchus asper, Taraxacum officinale, Tilia sp., Viola odorata and Vitex negundo. Cultivated plants were represented by Brassica sp., Coriandrum sativum, Chenopodium sp., Eriobotrya japonica, Juglans regia, Foeniculum vulgare, Luffa cylindrica, Medicago sp., Ocimum basilicum, Pyrus sp.,
**Prunus** sp., *Sesamum indicum*, *Vitis vinifera* and *Zea mays*. Ornamental plants include *Callistemon citrinus* and *Salvia splendens*.

**CONCLUSION**

From the above observations it is clear that the study area exhibits diversified flora and unlimited potential for bee forage. Moreover, the diverse pollen spectrum indicated that the honey samples are of botanical origin and are adulterated. This study also gives insights into the vegetation type of the respective locations in which honeys were produced as well as provides additional information on the major botanical florals foraged by honeybees in the studied region. Thus, identification of melliferous pollen taxons also helps in establishment of organized apicultural industry and for scientific development. It also helps beekeepers to formulate seasonal bee management programmes especially for migratory beekeeping.

Present melissopalynological studies revealed that honeys from Kullu fall under the category of Group I (<20,000 pollen grains), Group II (20,000–100,000) and to Group III (100,000–500,000) formed by International Commission for Plant Bee Relationships. i.e. honeys having absolute pollen count from 10,000 to 5,00,000 per 10 gm of honey.

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