

Identification of Bee Forage Plants by Pollen Analysis of *Apis cerana* Honey Collected from Tropical Areas of Tumkur District, Karnataka, India

Gopal T.C.*

Department of Botany, J.S.S Arts, Science and Commerce College, Gokak-591 307, Karnataka, India

*Corresponding author: gopaltcgokak@gmail.com

Received December 14, 2022; Revised January 22, 2023; Accepted February 02, 2023

Abstract The present work refers to the pollen analysis of 10 honey samples collected from 4 different locations of Tumkur district, Karnataka State, India. The honey samples were collected from the domestic bee hives of *Apis cerana*, subjected to physico-chemical and pollen analysis to determine color, optical density and botanical origin of honey. The color of the honey sample varies from light yellow to dark red color and optical density of honey samples varies from 0.258 to 0.991. Pollen analysis indicated that the study areas comprised of diverse bee flora. Out of 10 samples analyzed, the predominant pollen types were identified in 6 samples, where *Mimosa pudica* was represented in 2 samples. *Cocos nucifera*, *Mangifera indica*, *Eucalyptus globulus* and *Syzygium cumini* pollen types were reported as predominant pollen from one sample each and making these honey unifloral. The remaining 4 samples were multifloral where predominant pollen types were not identified. From the results, it is clear that the factors like vegetation, pollen spectra and chemical analysis revealed a lot of potentiality in establishing bee keeping industries in the study areas. Beekeeping is an added source of income to amplify the economic upliftment without much investment.

Keywords: bee flora, optical density, pollen analysis, pollen count, predominant pollen type

Cite This Article: Gopal T.C., "Identification of Bee Forage Plants by Pollen Analysis of *Apis cerana* Honey Collected from Tropical Areas of Tumkur District, Karnataka, India." *Applied Ecology and Environmental Sciences*, vol. 11, no. 1 (2023): 15-21. doi: 10.12691/aees-11-1-3.

1. Introduction

India is one of the few countries, where Melissopalynological studies have been undertaken on war-footing measures [1]. Honey samples collected from a small private garden in Calcutta were subjected to pollen analysis and reported the presence of number of pollen grains of anemophilous plant species (79 %) and identified *Impatiens balsamina* as an important source of nectar [2]. The pollen content of ten honey samples under the names of Nepal honey, Kashmir honey, Lucknow honey, etc., examined and reported that the commercial samples are of multifloral honeys [3]. Melissopalynology, apart from botanical studies has tremendous application in beekeeping industry, apiculture and pollen morphology [4]. Melissopalynology or pollen study is well reputable and has been used to govern floral bases, topographical basis and plants genus that the bees go to [5]. Earlier studies recommended that abundant pollen analysis initiates on honey combs and bee hives gives the reliable information on botanical and ecological origin of the honeys as well as the biochemistry and quality honeys [6,7,8]. Significant Melissopalynological investigation have been reported from different region in Western Ghats

of Karnataka [9,10,11]. Therefore, in the present study, the aim and objectives were to identify the pollens collected by *Apis cerana* Honeys, to analyze the physico-chemical parameters and bee forage plants by Melissopalynological studies in Tumkur district, south-western zone of Karnataka State in India. The outcome of this study is useful to develop formulations or application strategies suitable for future use in apiculture industry and honey production.

1.1. *Apis cerana* – Indian Honey Bee

The Indian honey bee is the only domesticated bee available in India. It is distributed in Pakistan, Sri Lanka, Malaysia, Philippines, China, Russia, Japan and Indonesia. This species is widely distributed up to 2,500 m and accepted by the people for commercial beekeeping in the country. *Apis cerana* construct many parallel combs in semi-circular shape, in hollow cavities of trees, rock crevices, old walls, snake pits and internal galleries of termite mounds. Its rapid abandonment and teeming behavior in certain phases are the main constraints for its successful rearing; about 2-3 swarms in a year can be seen from a colony. Absence of flora and infestation by natural enemies results in its absconding. Domesticated colonies face serious threat from the wax moth menace. The honey

yield from these colonies varies from 8-10 kg per year in plains and 20-25 kg per year in hilly areas. In Karnataka, there are two strains in *Apis cerana*, one is a black / dark strain found in Malnad parts and another yellowish establish in the plains.

2. Materials and Methods

2.1. Study Area

Tumkur district is situated in the south-western part of Karnataka state. The District is located between 12° 45' and 14° 20' of North Latitude and between 76° 20' and 77° 37' of East Longitude. It is bounded on the north by Anantapur district of Andhra Pradesh, on the east by Chikkaballapura and Bangalore districts, on the south by Mandya district and on the west by Chitradurga, Chikmagalur and Hassan districts. There are 10 taluks in the district viz, Chikkanayakanahalli, Gubbi, Koratagere, Kunigal, Madhugiri, Pavagada, Sira, Tumkur, Turuvekere and Tiptur (Figure 1). Tumkur district has no natural features like rivers or mountains dividing it from the other districts of the state. The district is generally an open tract except in south of Kunigal taluk is wooded and hilly, the other parts consisting mainly of undulating plains, interspersed with clumps of tall and well grown trees. To the east of Tumkur, Devarayanadurga the hilly region intersected by the cultivated valleys. The open parts of the district maintain a generally even level above the sea, except Sira and Pavagada taluks are considerably at a lower level than the rest of the district. The forest region in the district is classified under the dry-belt zone, as

distinct from the evergreen and the mixed belt. Dry belt zone lies to the east to the mixed-belt and includes in it the whole of Tumkur area. The forest regions in the district are found, to a large extent, in the lower slopes of hilly ranges viz, Devarayanadurga hills, hills around Koratagere and Madhugiri, a chain of hills to the west of Kibbanahalli, the region around Bukkapatna and Huliurdurga. The total area of forest in the district is 548 sq km., consists of fuel trees, providing fuel throughout the year. Characteristic of the forest region belongs; the vegetation growth is of the dry deciduous type, typical of the Maidan tracts. The district climate excluding the northernmost part is generally agreeable. But the climate of the Pavagada region and part of Sira is like that of Chitradurga district with a slightly hotter summer. The average annual rainfall in the district is 687.9 mm. A proper knowledge of bee plant preference is necessary to improve the beekeeping industry and to assess the bee keeping potentiality of the place. To introduce better bee plants, this will adapt to the local conditions that in-turn will boost up the honey production. Therefore, pollen study is significant to the apiculture industry in emerging the superior marketable honey.

In the present study, a total of 10 *Apis cerana* honey samples were collected from four different locations like Tumkur (ACH1, ACH2, ACH3), Sira (ACH4, ACH5, ACH6), Kunigal (ACH7, ACH8) and Madhugiri (ACH9, ACH10) of Tumkur district. Pure honey was pipetted from honey cells by micropipettes to avoid contamination and stored in clean, dry, colored glass bottles. These honey samples were given code ACH (*Apis cerana* Honey) and subjected to physico-chemical and microscopic analysis to determine the color, optical density and origin of honey.

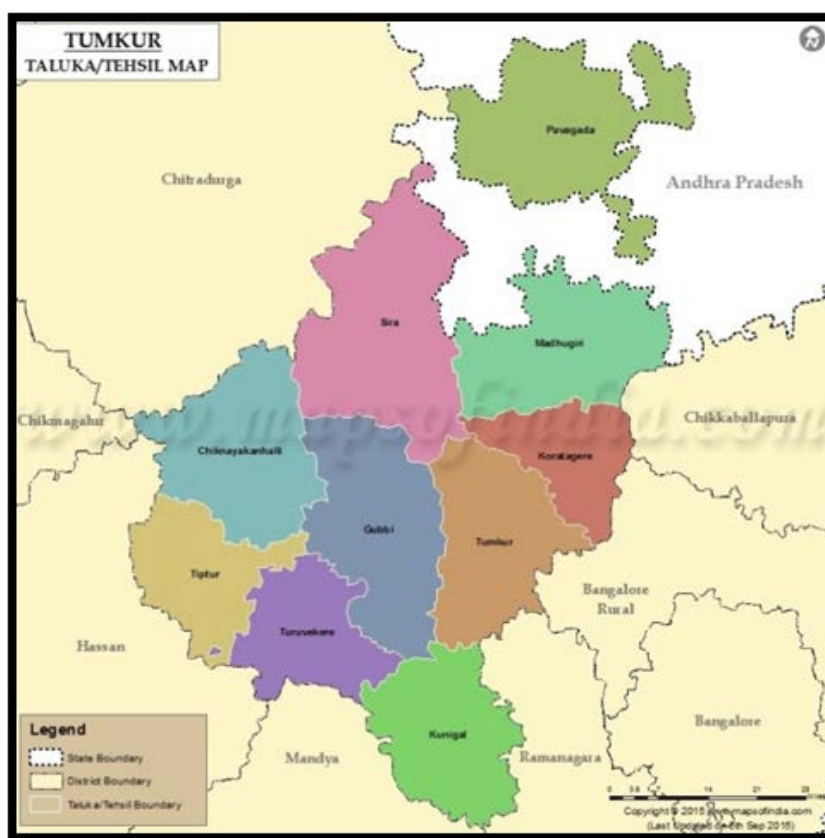


Figure 1. Tumkur District Map showing Study Areas

2.2. Physico-chemical and Pollen Analysis of Honey Samples

The optical density of honey samples was obtained by dissolving 2 g of honey in distilled water to make 10 ml of the solution and centrifuged at 3000 rpm for 10 min. The absorbance of filtrate was measured at 660 nm against distilled water as blank using spectrophotometer [12]. The absorbance of the filtrate supernatant was measured at 530 nm against distilled water as 1 gram of honey was diluted with 9 ml of distilled water and centrifuged for 10 min at 3000 rpm. To identify the pollen source of honey sample, 10 g of honey sample was dissolved in 20 ml of warm water; the solution was centrifuged for 10-15 minutes. The supernatant liquid was decanted and sediment was taken on a clean glass slide with a drop of glycerine jelly. Stained and unstained preparation of the sediment was made on the same slide and preserved for microscopic examination. A drop of solution was placed in 1 mm square of the Haemocytometer and covered with a cover slip. The microscopic study was carried out by using a light microscope. The pollen types and their number present in the central square were counted. Twenty such readings were taken for each honey samples and the average was calculated. The absolute pollen count in 10 g of honey samples was calculated and interpreted in terms of frequency classes like predominant pollen (>45 %), secondary pollen (16-45 %), important minor (3-15 %) and minor (<3 %). Based on frequency, honey samples were classified as unifloral (pollen type represented >45 %) or multifloral (pollen type <45 %) type [13,14,15]. The frequency distribution of a species in honey samples collected was determined by dividing the number of samples in that the species occur by total number of honey samples analyzed [13]. Likewise, the identified species are classified as very frequent (more than 45 %), frequent (16-45 %), infrequent (15-3 %) and rare (less than 3 %) species [4].

3. Results and Discussion

The pollen types indicated that the study areas comprised of diverse species. Pollen in the honey depends on various factors like honey bee species, plants grown near the bee hives and climatic conditions. According to the present study, 10 honey samples collected from four different locations such as Tumkur (3), Sira (3), Kunigal (2) and Madhugiri (2) of Tumkur district were microscopically analysed for color and optical density (Table 1). Color is an important property of honey used to identify its botanical source [16]. The color of the honey samples varies from light yellow to dark red. The samples collected from Tumkur (ACH1, ACH3), Kunigal (ACH7, ACH8) and Madhugiri (ACH10) were having yellow color. However, the samples collected from Sira (ACH4, ACH5, ACH6) were light red in color. The honey samples obtained from Tumkur (ACH2) and Madhugiri (ACH9) were dark red in color. The variation in the color of honey sample depends on the diversity of species and climatic conditions [17]. The optical density of honey samples studied varies from 0.258 to 0.991. The maximum optical density was observed in Tumkur (ACH2) sample, whereas,

the minimum was observed in Madhugiri (ACH10) sample. The positive correlation was found between the color and optical density, where light color honeys have a minimum optical density compared to dark colored honey [12]. The variation in optical density may be due to color of honey [18]. The concentration of pollen grains per 10 g of honey varies from 5823 to 462921. The absolute pollen count of each honey samples, pollen types representing their plant sources and honey type are presented in Table 2. The absolute pollen count per 10 grams of honey varied from 1,42,300 - 2,82,100 found in ACH7 and ACH9 respectively. According to the species identified, 4 samples were classified as multifloral. However, 6 were unifloral with *Mimosa pudica*, *Cocos nucifera*, *Mangifera indica*, *Syzygium cumini* and *Eucalyptus globulus* as predominant pollen types where the frequency class was above 45 %. Honeybees are very specific in their choice of nectar and pollen collection, the pollen spectra of each honey sample showed the preference of bees for collection of nectar and pollen from the selected plants [19].

The microscopic analysis of honey sample collected from Tumkur (ACH1) revealed the absolute pollen count of 2,21,300/10 g of honey. *Mimosa pudica* was over represented and considered this sample as unifloral honey. *Psidium guajava* (30.05 %) and *Syzygium jambosa* (32.21 %) formed secondary pollen types. *Eucalyptus* (16.02 %), *Eupatorium odoratum* (8.42 %) and *Colvillea racemosa* (3.54 %) have formed an important minor pollen type. *Cocos nucifera*, *Casuarina equisetifolia*, *Areca catechu* and *Delonix regia* were formed as minor pollen types and honey were yellow in color with an optical density of 0.574. The multifloral honey was collected from Tumkur (ACH2) reported the absolute pollen count of 2,30,700/10 g of honey. *Eucalyptus globulus* (33.06 %) and *Eupatorium odoratum* (30.12 %) formed the secondary pollen types. *Syzygium cumini* (8.43 %), *Commelina benghalensis* (4.01 %) and *Cocos nucifera* (5.74 %) formed the important minor pollen types. *Ocimum sanctum*, *Brassica nigra*, *Cyperus sp.*, *Celosia argentea*, *Parthenium hysterophorus*, *Casuarina equisetifolia*, *Citrus lemon*, *Ricinus communis* and *Coriandrum sativum* were recorded as minor pollen types. The honey was dark red in color with an optical density of 0.991. Honey samples collected from Tumkur (ACH3) was found with 2,49,500/10 g pollen count. In this unifloral honey, *Mimosa pudica* pollen was found to be a predominant pollen type and *Eupatorium odoratum* (39.18 %) and *Syzygium cumini* (33.62 %) formed the secondary pollen types. *Celosia argentea* (8.13 %), *Commelina benghalensis* (3.41 %) and *Cocos nucifera* (6.72 %) formed important minor pollen types. *Albizia spp.*, *Borreria hispida*, *Brassica nigra*, *Clerodendrum inerme* and *Delonix regia* formed minor pollen types and the honey was yellow in color with an optical density of 0.533. Honey sample collected from Sira (ACH4) determined the absolute pollen count as 2,11,200/10 g of honey and sample had no predominant pollen type, hence considered as multifloral. *Eupatorium odoratum* (40.18 %) and *Eucalyptus* (32.21 %) formed the secondary pollen types. *Areca catechu* (3.52 %), *Ocimum sanctum* (4.03 %), *Commelina benghalensis* (3.02 %) and *Citrus lemon* (3.42 %) formed the important minor pollen types. *Cocos nucifera*, *Casuarina equisetifolia*, *Amaranthus spinosus*.

Brassica nigra, *Cyperus* spp., and *Mimosa pudica* were recorded as minor pollen types. The honey was light red in colour with an optical density of 0.733. The multifloral honey was collected from Sira (ACH5) with an absolute pollen count of 1,71,500/10 g of honey. Microscopic analysis of the sample revealed no predominant pollen type. *Eucalyptus globulus* (32.04 %) and *Mimosa pudica* (18.46 %) as secondary important pollen types. *Mangifera indica* (5.13 %), *Ocimum sanctum* (4.21 %) and *Cocos nucifera* (4.07 %) formed important minor pollen types. *Casuarina equisetifolia*, *Croton bonplandianum*, *Phoenix sylvestris*, *Amaranthus spinosus*, *Hibiscus rosa sinensis*, *Peltophorum pterocarpum* and *Justicia* spp., were recorded as the minor pollen types, where the honey was light red colour with an optical density of 0.674. The microscopic analysis of the honey sample collected from Sira (ACH6) showed an absolute pollen count of 1,51,000/10 g honey. The predominant pollen type was

Mangifera indica with (48.49 %). The secondary pollen type encountered in this sample was *Eupatorium odoratum* (22.02 %), *Cocos nucifera* (13.02 %) and *Bauhinia racemosa* (9.16 %) formed important minor pollen types. *Areca catechu*, *Mimosa pudica* and *Casuarina equisetifolia* were recorded as minor pollen types. The honey was light red color with an optical density of 0.785. The honey sample collected from Kunigal (ACH7) revealed the pollen count 1,42,300/10 g of honey. *Cocos nucifera* (47 %) formed predominant pollen type and considered as unifloral honey. *Eupatorium odoratum* (17.13 %) and *Eucalyptus globulus* (16.17 %) were formed secondary pollen types. *Mimosa pudica* (8.42 %) and *Areca catechu* (3.74 %) formed important minor pollen types. *Hygrophila auriculata*, *Citrus lemon*, *Ocimum sanctum* and *Brassica nigra* were recorded as minor pollen types. The honey was yellow in color with an optical density of 0.518.

Table 1. Physical analysis of honey samples from different places of Tumkur district

Sl. No.	Code No.	Place of Collection	Honey Colour	Optical Density
1	ACH – 1	Tumkur	Yellow	0.574
2	ACH – 2	Tumkur	Dark red	0.991
3	ACH – 3	Tumkur	Yellow	0.533
4	ACH – 4	Sira	Light red	0.733
5	ACH – 5	Sira	Light red	0.674
6	ACH – 6	Sira	Light red	0.785
7	ACH – 7	Kunigal	Yellow	0.518
8	ACH – 8	Kunigal	Yellow	0.423
9	ACH – 9	Madhugiri	Dark Red	0.859
10	ACH – 10	Madhugiri	Yellow	0.258

Table 2. Pollen spectra of *Apis cerana* honey samples collected in Tumkur region

Honey Sample	Absolute Pollen Count/10 gm	Predominant Pollen Types 45 % & above	Secondary Pollen Types (16-45 %)	Important Minor Pollen Type (3-15 %)	Minor Pollen Types (Less than 3 %)	Honey Type
ACH1	2,21,300	<i>Mimosa pudica</i>	<i>Syzygium cumini</i> , <i>Psidium guajava</i>	<i>Eucalyptus globulus</i> <i>Eupatorium odoratum</i> <i>Colvillea racemosa</i> .	<i>Cocos nucifera</i> , <i>Casuarina equisetifolia</i> , <i>Areca catechu</i> , <i>Delonix regia</i>	Unifloral
ACH2	2,30,700		<i>Eucalyptus globulus</i> <i>Eupatorium odoratum</i>	<i>Syzygium cumini</i> , <i>Commelina benghalensis</i> , <i>Cocos nucifera</i> .	<i>Ocimum sanctum</i> , <i>Brassica nigra</i> , <i>Cyperus</i> Sp., <i>Celosia argentea</i> , <i>Parthenium hysterophorus</i> , <i>Casuarina equisetifolia</i> , <i>Ricinus communis</i> , <i>Citrus lemon</i> , <i>Coriandrum sativum</i> ,	Multifloral
ACH3	2,49,500	<i>Mimosa pudica</i>	<i>Eupatorium odoratum</i> <i>Syzygium cumini</i>	<i>Celosia argentea</i> , <i>Commelina benghalensis</i> , <i>Cocos nucifera</i>	<i>Albizia</i> Sp., <i>Borreria hispida</i> , <i>Brassica nigra</i> , <i>Clerodendrum inerme</i> , <i>Delonix regia</i> .	Unifloral
ACH4	2,11,200		<i>Eupatorium odoratum</i> , <i>Eucalyptus globulus</i>	<i>Areca catechu</i> , <i>Ocimum sanctum</i> , <i>Citrus lemon</i> <i>Commelina benghalensis</i> ,	<i>Cocos nucifera</i> , <i>Casuarina equisetifolia</i> , <i>Amaranthus spinosus</i> ., <i>Brassica nigra</i> , <i>Cyperus</i> Sp., <i>Mimosa pudica</i>	Multifloral
ACH5	1,71,500		<i>Mimosa pudica</i> , <i>Eucalyptus globulus</i>	<i>Cocos nucifera</i> , <i>Mangifera indica</i> , <i>Ocimum sanctum</i> .	<i>Casuarina equisetifolia</i> , <i>Croton bonplandianum</i> , <i>Phoenix sylvestris</i> , <i>Amaranthus spinosus</i> , <i>Hibiscus rosa sinensis</i> , <i>Peltophorum pterocarpum</i> , <i>Justicia simplex</i> .	Multifloral
ACH6	1,51,000	<i>Mangifera indica</i>	<i>Eupatorium odoratum</i>	<i>Cocos nucifera</i> , <i>Bauhinia racemosa</i>	<i>Areca catechu</i> , <i>Mimosa pudica</i> , <i>Casuarina equisetifolia</i> ,	Unifloral
ACH7	1,42,300	<i>Cocos nucifera</i>	<i>Eupatorium odoratum</i> , <i>Eucalyptus globulus</i>	<i>Mimosa pudica</i> , <i>Areca catechu</i> .	<i>Hygrophila auriculata</i> , <i>Citrus lemon</i> , <i>Ocimum sanctum</i> , <i>Brassica nigra</i> .	Unifloral
ACH8	1,68,500	<i>Syzygium cumini</i> .	<i>Eupatorium odoratum</i> , <i>Eucalyptus globulus</i>	<i>Mimosa pudica</i> , <i>Commelina benghalensis</i> ,	<i>Cocos nucifera</i> , <i>Solanum</i> sp., <i>Hygrophila auriculata</i> , <i>Areca catechu</i> .	Unifloral
ACH9	2,82,100	<i>Eucalyptus globulus</i>	<i>Mimosa pudica</i> , <i>Syzygium cumini</i> .	<i>Ricinus communis</i> , <i>Celosia argentea</i> , <i>Delonix regia</i>	<i>Artocarpus heterophyllus</i> , <i>Ocimum sanctum</i> , <i>Cocos nucifera</i> , <i>Brassica nigra</i> , <i>Citrus lemon</i> . <i>Peltophorum pterocarpum</i> , <i>Justicia simplex</i>	Unifloral
ACH10	1,99,400		<i>Eupatorium odoratum</i>	<i>Cocos nucifera</i> , <i>Ocimum sanctum</i> , <i>Mimosa pudica</i>	<i>Artocarpus heterophyllus</i> , <i>Commelina benghalensis</i> , <i>Croton bonplandianum</i> , <i>Ludwigia</i> Sp., <i>Clerodendrum inerme</i> , <i>Hibiscus rosa-sinensis</i> , <i>Justicia simplex</i> , <i>Amaranthus spinosus</i> .	Multifloral

Absolute pollen count of 1,68,500/10 g of honey sample collected from Kunigal (ACH8). This unifloral honey carries *Syzygium cumini* (50 %) as a predominant pollen type. *Eupatorium odoratum*, (17.03 %) and *Eucalyptus* (16.91 %) formed secondary pollen types. *Mimosa pudica* (3.42 %) and *Commelina benghalensis*, (3.04 %) formed important minor pollen types. *Cocos nucifera*, *Hygrophila auriculata*, *Solanum spp.* and *Areca catechu* formed minor pollen types recorded in this sample. The honey was yellow in color with an optical density 0.423. Honey collected from Madhugiri (ACH9) contains an absolute pollen count 2,82,100/10 g of honey. The predominant pollen type in this unifloral honey was *Eucalyptus globulus* (47.03 %). *Mimosa pudica* (16.01 %), *Syzygium cumini* (16.03 %) and *Eupatorium odoratum* (10.00 %) formed secondary pollen type. *Ricinus communis* (3.11 %), *Delonix regia* (3.09 %) and *Celosia argentea* (3.06 %) formed important minor pollen types. *Artocarpus heterophyllus*, *Ocimum sanctum*, *Cocos nucifera*, *Brassica nigra*, *Peltophorum pterocarpum*, *Justicia simplex* and *Citrus lemon* formed minor pollen types. The honey is dark red in color with an optical density of 0.859. The multifloral honey was extracted from Madhugiri (ACH10) and the microscopic analysis revealed an absolute pollen count of 1,99,400/10 g of honey but no predominant pollen type was reported. However, *Eupatorium odoratum* (42 %) formed secondary pollen type. *Cocos nucifera* (14.81 %), *Ocimum sanctum* (13.62 %) and *Mimosa pudica* (13.06 %) formed important minor pollen types. *Amaranthus spinosus*, *Artocarpus heterophyllus*, *Clerodendrum inerme*, *Commelina benghalensis*, *Croton bonplandianum*, *Hibiscus rosa sinensis*, *Justicia simplex* and *Ludwigia spp.*, formed minor pollen types and honey was yellow colour with an optical density of 0.258.

Out of 10 honey samples, 6 were found unifloral honey, in which 2 samples (ACH1, ACH3) collected from Tumkur region showed *Mimosa pudica* as predominant

pollen type with 30.05 % and 39.18 % respectively. Honey sample from Sira (ACH6) showed *Mangifera indica* (48.49 %) as the predominant type whereas, *Cocos nucifera* (47 %) formed primary pollen type in honey sample collected from Kunigal (ACH7). However, *Syzygium cumini* (50 %) and *Eucalyptus globulus* (47.03 %) was reported as predominant pollen type in honey samples from Kunigal (ACH8) and Madhugiri (ACH9) respectively. This may be due to *Mimosa pudica* and *Eucalyptus globulus* blooms throughout the year and it was reflected in many honey samples collected and remaining samples (ACH2, ACH4, ACH5, ACH10) were found multifloral. The honey sample from Madhugiri (ACH9) was considered as highest in the absolute pollen count and pollen diversity. The quality of honey depends on floral richness, honeybee preferences for pollen, nectar and the richness of pollen diversity [20]. The study revealed that a total of 34 pollen types belongs to 20 families were identified from collected honey samples (Figure 2). Fabaceae the most frequent family with 7 pollen type, followed by Arecaceae and Myrtaceae with 3 pollen type. Acanthaceae, Amaranthaceae, Asteraceae and Lamiaceae with 2 pollen type whereas, Anacardiaceae, Apiaceae, Brassicaceae, Casuarinaceae, Commelinaceae, Cyperaceae, Euphorbiaceae, Malvaceae, Moraceae, Onagraceae, Rubiaceae, Rutaceae and Solanaceae were signified with 1 pollen type each. Frequency distribution pollen types represented as ‘very frequent’ were *Mimosa pudica*, *Syzygium cumini*, *Eucalyptus globules*, *Areca catechu*, *Cocos nucifera*, *Casuarina equisetifolia*, *Eupatorium odoratum*, *Ocimum sanctum*, *Brassica nigra* and *Commelina benghalensis*. Other pollen types such as *Colvillea racemosa*, *Psidium guajava*, *Coriandrum sativum*, *Parthenium hysterophorus*, *Phoenix sylvestris*, *Bauhinia racemosa*, *Solanum spp.*, *Albizia spp.*, *Borreria hispida* and *Ludwigia spp.*, were considered as ‘Rare pollen’ types. Bee forage for nectar and pollen depends on availability of plant capitals and ecological issues [21,22] (Table 3).

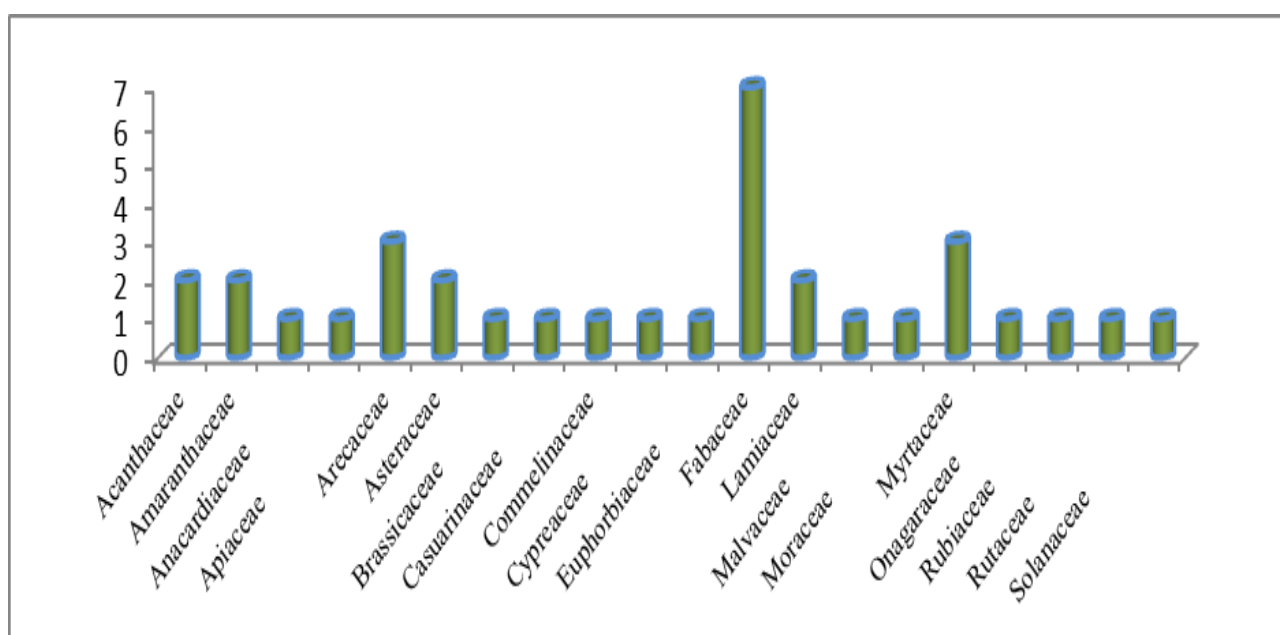


Figure 2. Family wise distribution of Pollen types

Table 3. Frequency distribution and pollen types from *Apis cerana* honey samples

Sl. No.	Species	Family	ACH1	ACH2	ACH3	ACH4	ACH5	ACH6	ACH7	ACH8	ACH9	ACH 10	FD (%)
1	<i>Amaranthus spinosus</i>	Amaranthaceae			M		M					M	30
2	<i>Mimosa pudica</i>	Fabaceae	P		M	IM	S	M	IM	P	S	IM	90
3	<i>Syzygium cumini</i>	Myrtaceae	S	IM					P	S	S		50
4	<i>Eucalyptus globulus</i>	Myrtaceae	IM	S	S	S	S		S		P		70
5	<i>Cocos nucifera</i>	Arecaceae	M	IM	M	P	IM	IM	M	IM	M	IM	100
6	<i>Areca catechu</i>	Arecaceae	M		IM	IM		M	M				50
7	<i>Delonix regia</i>	Fabaceae	M							M	IM		30
8	<i>Casuarina equisetifolia</i>	Casuarinaceae	M	M	M		M	M					50
9	<i>Eupatorium odoratum</i>	Asteraceae	IM	S	S	S		S	S	S		S	80
10	<i>Colvillea racemosa</i>	Fabaceae	IM										10
11	<i>Psidium guajava</i>	Myrtaceae	S										10
12	<i>Ocimum sanctum</i>	Lamiaceae		M	IM	M	IM				M	IM	60
13	<i>Ricinus communis</i>	Euphorbiaceae		M							IM		20
14	<i>Coriandrum sativum</i>	Apiaceae		M									10
15	<i>Citrus lemon</i>	Rutaceae		M	IM	M					M		40
16	<i>Parthenium hysterophorus</i>	Asteraceae		M									10
17	<i>Celosia argentea</i>	Amaranthaceae		IM						IM	IM		30
18	<i>Brassica nigra</i>	Brassicaceae		M	M	M				M	M		50
19	<i>Cyperus sp</i>	Cypreaceae		M	M								20
20	<i>Hygrophila auriculata</i>	Acanthaceae				M			M				20
21	<i>Mangifera indica</i>	Anacardiaceae					IM	P					20
22	<i>Croton bonplandianum</i>	Fabaceae					M					M	20
23	<i>Hibiscus rosa sinensis</i>	Malvaceae					M					M	20
24	<i>Phoenix sylvestris</i>	Arecaceae					M						10
25	<i>Peltophorum pterocarpum</i>	Fabaceae					M				M		10
26	<i>Justicia simplex</i>	Acanthaceae					M				M		10
27	<i>Bauhinia racemosa</i>	Fabaceae						IM					10
28	<i>Solanum sp.</i>	Solanaceae							M				10
29	<i>Commelina benghalensis</i>	Commelinaceae		IM	IM				IM	IM		M	50
30	<i>Albizia sp.</i>	Fabaceae								M			10
31	<i>Borreria hispida</i>	Rubiaceae								M			10
32	<i>Clerodendrum inerme</i>	Lamiaceae								M		M	20
33	<i>Artocarpus heterophyllus</i>	Moraceae									M	M	20
34	<i>Ludwigia sp.</i>	Onagraceae										M	10

Frequency classes: Predominant pollen type (P) >45 %, Secondary pollen type (S) 16-45 %, Important Minor pollen (IM) 3-15 %, Minor pollen type (M) <3 %, FD-Frequency distribution.

4. Conclusion

Apis cerana (Indian honey bee) is the domesticated honeybee accepted by the individuals for commercial beekeeping in Karnataka. This species is abundant and widely distributed in Tumkur district. Hence the study was undertaken to bring more knowledge on bee foraging plants and apiculture with reference to floral fidelity. From this study, it is evident that out of 10 samples collected from Tumkur district, the predominant pollen types were identified in 6 samples, where *Eucalyptus globulus* was represented in 2 samples. *Mimosa pudica*, *Cocos nucifera*, *Mangifera indica* and *Syzygium cumini* pollen types were reported in one sample each as predominant pollen and making these honeys Unifloral. These pollen types were very frequently found in many samples provided nectar and pollen to honeybees. The remaining 4 samples were multifloral where predominant pollen types were not identified. From the results, it is clear that the factors like vegetation, pollen spectra and chemical analysis revealed a lot of potentiality in establishing bee keeping industries in the study area. *Eucalyptus globulus*, *Syzygium cumini*, *Mimosa pudica*,

Areca catechu, *Casuarina equisetifolia*, *Cocos nucifera*, *Citrus lemon*, *Psidium guajava*, *Celosia argentea*, *Brassica nigra* and *Commelina benghalensis* may be introduced in social forestry and afforestation programs to enhance the honey yield. Beekeeping is an added source of income to amplify the economic upliftment of populaces with no investment.

Conflicts of Interest

The author declares no conflicts of interest regarding the publication of this paper.

References

- [1] Deodikar, G.B. and Thakar, C.V., "A pollen study of honey yielding plants of Mahabaleshwar hills". *Apicultural laboratory, Bulletin*, No. 1: 1-6. 1953.
- [2] Sen, J. and Banerjee, D., "A pollen analysis of Indian honeys". *Bee World*, 37: 52-54. 1956.
- [3] Vishnu-Mittre, "Pollen control of some Indian honeys". *Journal of Scientific and Industrial Research*, 17: 123-124. 1958.

- [4] Jones, G. and Bryant, V.M, "Melissopalynology". In *Palynology: Principles and Applications*, (Ed. By Jansonius, J. and McGregor, D.C.) American Association of Stratigraphic Palynologists Foundation, Dallas, Texas. pp. 933-938. 1996.
- [5] Ponnuchamy, R, Bonhomme, V, Prasad, S, Das, L, Patel, P, Gaucherel, C, Pragasa, A. and Anupama, K, "Honey Pollen: Using Melissopalynology to Understand Foraging Preferences of Bees in Tropical South India". *PLoS ONE*, 9(7): e101618. 2014.
- [6] Herrero, B, Valencia-Barrera, R.M, Martin, R.S. and Pando, V, "Characterization of Honeys by Melissopalynology and Statistical Analysis". *Canadian Journal of Plant Science*, 82: 75-82. 2002.
- [7] Montenegro, G, Pena, R.C. and Pizarro, R, "Multivariate Analysis of Pollen Frequency of the Native Species *Escallonia pulverulenta* (Saxifragaceae) in Chilean Honeys". *Brazilian Journal of Botany*, 33(4): 615-630. 2010.
- [8] Alia Sajwani, Sardar A. Farooq and Vaughan M. Bryant, "Studies of bee foraging plants and analysis of pollen pellets from hives in Oman". *Palynology*, 38(2): 207-223. 2014.
- [9] Chauhan, M.S. and Murthy, S, "Melitopalynological investigation of honeys from Chamarajanagar District, Southern Karnataka". *Geophytology*, 39(1&2): 41-47. 2010.
- [10] Sivaram, V, Roopa, P, Shubharani, R. and Suwannapong, G, "Pollen analysis in honeys collected from Karnataka region of Nilgiri Biosphere, South India". *Journal of Apiculture*, 27: 223-231. 2012.
- [11] Raghunandan, K.S. and Basavarajappa, S, "Analysis of multifloral honey of the giant honey bee, *Apis dorsata* F., for pesticide residues in southern Karnataka, India". *European Journal of Zoological Research*, 2: 22-28. 2013.
- [12] Wakhle, D.M, "Beekeeping technology-production, characteristics and uses of honey and other products". In *Perspectives in Indian Apiculture*, (Ed. Mishra, R.C, Agro-Botanica, Bikaner). pp. 134-139. 1997.
- [13] Louveaux, J, Maurizio, A. and Vorwohl, G, "Method of melissopalynology". *Bee World*, 59(4): 139-157. 1978.
- [14] Moore, P.D, Webb, J.A. and Collinson, M.E, "Pollen Analysis". 2nd Edition, Blackwell, Oxford. pp. 1-216. 1991.
- [15] White, J.W, Honey. In: Graham J.M. (Ed.), "The hive and the honey bee, Hamilton". IL: Dadant & Sons. pp. 869-927. 2005.
- [16] Bertoncelj, J, Dobersek, U, Jamnik, M. and Golob, T, "Evaluation of the phenolic content, antioxidant activity and colour of Slovenian honey". *Food Chemistry*, 105: 822-828. 2007.
- [17] Akhtar, S, Ali, J, Javed, B, Hassan, S, Abbas, S. and Siddique, M, "Comparative physiochemical analysis of imported and locally produced Khyber Pakhtunkhwa honey". *Global Journal of Biotechnology and Biochemistry*, 9(3): 55-59. 2014.
- [18] Belay, A, Solomon, W.K, Bultossa, G, Adgaba, N. and Melaku, S, "Botanical origin, colour, granulation, and sensory properties of the Harenn forest honey, Bale, Ethiopia". *Food Chemistry*, 167: 213-219. 2015.
- [19] Layek, U. and Karmakar, P, "Pollen analysis of *Apis dorsata* Fabricius honeys in Bankura and Paschim Medinipur districts, West Bengal". *Grana*, 57(4): 298-310. 2017.
- [20] Ige, O.E. and Apo, K.A, "Pollen analysis of honey samples from two vegetation zones in Nigeria". *Advanced Science Focus*, 13: 36-43. 2007.
- [21] Stawiarz, E. and Wroblewska, A, "Melissopalynological analysis of Multifloral honeys from the Sandomierska upland area of Poland". *Journal of Apiculture Science*, 54(1): 65-75. 2010.
- [22] Fechner, D.C, Moresi, A.L, Diaz, J.D.R, Pellerano, R.G. and Vazquez, F.A, "Multivariate classification of honeys from Corrientes (Argentina) according to geographical origin based on physicochemical properties". *Food Bioscience*, 15: 49-54. 2016.

