Journal of Applied and Natural Science
13(2): 654 - 667 (2021)
Published online: June 2, 2021
ISSN : 0974-9411 (Print), 2231-5209 (Online)
journals.ansfoundation.org

Research Article

Melittopalynological studies of *Apis dorsata* honey samples from Kolar District, Karnataka, India

Gopal, T.C.
Department of Botany, J.S.S Arts, Science and Commerce College, Gokak (Karnataka), India

Email: gopaltcgokak@gmail.com

Article Info
https://doi.org/10.31018/jans.v13i2.2189
Received: April 3, 2021
Revised: May 26, 2021
Accepted: May 29, 2021

How to Cite
Gopal, T. C. (2021). Melittopalynological studies of *Apis dorsata* honey samples from Kolar District, Karnataka, India. *Journal of Applied and Natural Science*, 13(2), 654 - 667. https://doi.org/10.31018/jans.v13i2.2189

Abstract
Honeybees, while foraging for nectar on flowers, also gather some pollen which retains in the honey even after extraction. Pollen grains are the essential tools in the analysis of honey. The aim of the present report was to find the *Apis dorsata* honey floral resources in Kolar district state Karnataka. In the present study, the pollen content of 28 *A. dorsata* honey samples were collected from 5 different locations of Kolar district, Karnataka, India. Samples were subjected to Melittopalynological studies to identify their honey plant resources and colour, optic density and collection places were documented. A wide variety of pollen types represent their plant sources and their frequency classes were recognized in each honey sample. Among 28 honey samples analysed, 10 samples were identified as multifloral, 18 unifloral with predominant pollen types such as *Syzygium cumini*, *Pongamia pinnata*, Eucalyptus sp, *Guizotia abyssinica*, *Psidium guajava* and *Coriandrum sativum*, each count was found above 45%. Pollen spectra indicated a total of 56 pollen types belonging to 27 plant families. Fabaceae was represented as the largest family with 14 species contributing honey production. Among the habit, tree was dominant with 51.78%, followed by herbs (32.14%) and shrubs (16.07%). The economic importance of identified plants with apiculture importance was categorized as medicinal, ornamental, vegetable, timber and oil yielding, weeds, fruits and nuts. *A. dorsata* depends on wild trees and cultivated plants bloom throughout the year as pollen and nectar source. From the results, it is evident that there is a lot of potential in establishing beekeeping industries in the study area.

Keywords: *Apis dorsata,* Kolar district, Melittopalynology, Multifloral, Unifloral

INTRODUCTION

Melittopalynology is an applied branch of Palynology deals with the microscopic analysis of pollen grains in honey. Honeybees depend on plants for pollen and nectar. In turn bees provide pollination services to a wide variety of flowering plants. Honey contains pollen grains, which are collected by honeybees while foraging the flowers for nectar. The microscopic analysis of pollen is a standard method to identify the abundance of nectar sources, distribution, geographical and botanical origin, and honey adulteration in a given area (Silva and Santos, 2014). Knowledge of floral diversity of apicultural importance is a prerequisite for beekeepers to undertake migratory beekeeping to increasing honey production and pollination (Singh *et al*., 2016). Beekeeping provides self-employment to the farmers and tribes to generate income. Honeybees naturally produce honey from the nectar of plants. It is widely consumed as a health food product worldwide, but adulteration and the false labelling of honey are common problems in many countries (Sajwani *et al*., 2007; Louveaux *et al*., 1978). In this context, Melittopalynology plays an important role in ascertaining honey's botanical and geographical origins by studying the pollen contained in the honey (Anklam, 1998; Oliveira *et al*., 2010; Ramirez-Arriaga *et al*., 2011; Upadhyay and Bera, 2012).

In the growth and development of honey bees, nectar is the source of carbohydrates and proteins are provided by pollen (Turner, 1984; Lin *et al*., 1993). Pollen analyses of honey and bee loads are used to learn honey bee foraging ecology, the habitat and vegetation, habitat composition, changes in honey bee food sources and the geographical region of the hive location (Ramalho and Kleinert-Giovannini, 1986; Feller-Demalsy *et al*., 1989; Barth, 1990; Diaz-Losada *et al*., 1998; Terrab *et al*., 2004). Pollen contents of honey samples offer dependable evidence on floral resources of honey along with the relative predilections of bees

amongst the varied assemblies of plant species flowering synchronously (Deodikar and Thakar, 1953; Deodikar, 1961; Garg, 2006).

Melittopalynological study was introduced over a hundred years ago by several scientists from different part of the world (Maurizio, 1975; Lieux, 1980; Agwu and Akanbi, 1985; Moar, 1985; Deodikar, 1961; Alves and Santos, 2014; Jesus *et al*., 2015; Majid *et. al*., 2020). In India, the earliest contribution in this field was by Deodikar and Thakar (1953), Sen and Banerjee (1956) and Novais *et al*. (2009) characterized pollen in honey samples of Mahabaleshwar hills of Maharastra State and from West Bengal, respectively. Later, Vishnu-Mittre (1958) analyzed the pollen content of honey from Nepal, Kashmir and Lucknow. Recently, several scientists reported the botanical origin of honey in many places of India (Shubharani *et al*., 2012; Raghunandan and Basavarajappa, 2014; Neha Singh and Chaturvedi, 2016; Manju Sahney *et al*., 2018). However, no study has been reported from Kolar district, Karnataka. The present study aimed to identify the floral diversity of apicultural importance by melittopalynogical studies of *A. dorsata* honey of Kolar district, Karnataka state.

MATERIALS AND METHODS

Study area

The Kolar district is situated in the southeastern part of Karnataka state and called the land of gold, silk and milk. The district lies almost in the central part of peninsular India, which has an immense bearing on its geo-climatic conditions and experiences tropical climatic condition throughout the year. The district is situated between 12' 46' and 13' 58' north latitude and 77' 21' and 78' 35' east longitude between Eastern and Western coast and is bound on the West by Bangalore and Tumkur districts, South by North Arcot and Dharmapuri districts of Tamilnadu, East and North by Chittor district of Andhra Pradesh. The district has an area of 8,233 sq km and occupies 12th place in the state, having 11 Taluk viz., Bagepalli, Bangarpet, Chikaballapur, Chintamani, Gudibande, Gauribidanur, Kolar, Malur, Mulbagal, Siddlagatta and Srinivasapura (Fig. 1). The district is endowed with a number of hills with peaks of varying heights, particularly in the northern part.

Kolar district falls in the eastern dry agro climatic zone. It experiences a semi-arid climate, characterized by typical monsoon tropical weather with hot summer and mild winter. The average rainfall is around 850 mm with 55-65 rainy days in Kolar district and the greater portion of the rainfall is from September to November. District experience scanty and erratic rainfall with uneven distribution during monsoon. The large variation in rainfall was noticed from year to year and amongst talk to a larger extent. The main occupation of the people of this district is agriculture; 5% of the total area in the district is covered by forest, 46% under cultivation and 28% is uncultivated area.

Preparation of honey samples

In the present study, 28 honey samples were collected from the hives of *A. dorsata* from 5 different locations of Kolar district such as Kolar, Srinivasapura, Mulbagal, Malur and Bangarpet during 2017-2019. The Honey samples collected details are documented in Table 1.

Melittopalynological analysis

The collected honey samples were subjected to pollen analysis to characterize and identify the floral origin, according to the guidelines of Erdtman (1960), Louveaux *et al*. (1978) and Moore *et al*. (1991). Ten grams of crude honey sample was dissolved in 20 ml of warm (40 °C) distilled water and then centrifuged for 10 min at 2500 rpm. The sediment was treated with acetolysis mixture, centrifuged and the supernatant was decanted. The sediment was washed twice with distilled water to remove the debris. A drop of glycerine was added to prevent the sample from drying and gently heated. Five different slides were prepared from each honey sample by adding 50 µl of treated sample and cover with a coverslip. The slides were subjected to microscopic study to identify the pollen type by using a Leica DM2500 light microscope. The pollen types present in honey samples were identified by comparison with reference slides and pollen photomicrographs. The pollen types and their number were counted by using Haemocytometer. Based on the percentage of pollen type and its distribution frequency, the honey was categorised into unifloral (one pollen type represented >45%) or multifloral (no pollen type >45%) and also classified to different groups like pre-

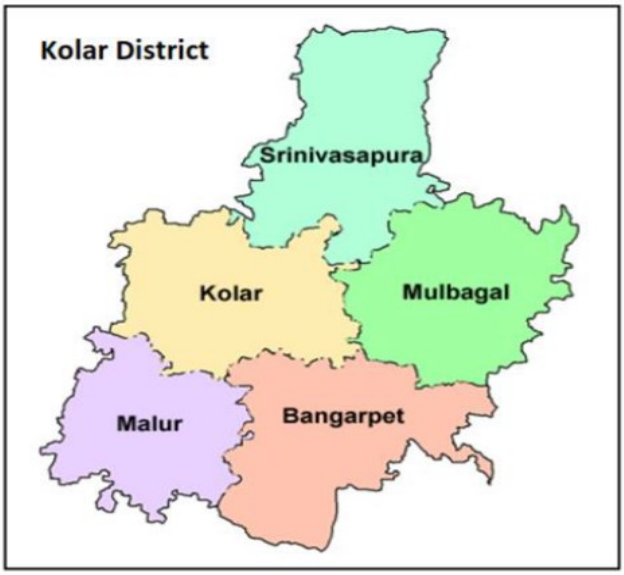


Fig. 1. *Map of Kolar district of Karnataka showing honey samples collected areas.*

Table 1. Details of honey samples collected from Kolar district.

Sl. No.	Code No.	Place of Collection	Colour of the Honey sample	Optical density
	ADH -1	Kolar	Light yellow	0.383
	ADH -2	Malur	Yellow	0.591
	ADH -3	Srinivasapura	Reddish yellow	0.209
	ADH -4	Mulbagal	Reddish yellow	0.448
	ADH -5	Bangarpet	Light yellow	0.490
	ADH -6	Mulbagal	Dark red	0.215
	ADH -7	Malur	Orange	0.616
	ADH -8	Kolar	Light yellow	0.873
	ADH -9	Srinivasapura	Light yellow	0.510
	ADH -10	Mulbagal	Orange	0.751
	ADH -11	Kolar	Reddish yellow	0.473
	ADH -12	Srinivasapura	Light yellow	0.807
	ADH -13	Malur	Reddish yellow	0.540
	ADH -14	Malur	Light yellow	0.359
	ADH -15	Mulbagal	Light red	0.803
	ADH -16	Kolar	Orange	0.255
	ADH -17	Malur	Light yellow	0.996
	ADH -18	Mulbagal	Reddish yellow	0.481
	ADH -19	Kolar	Yellow	0.712
	ADH -20	Mulbagal	Dark red	0.857
	ADH -21	Bangarpet	Light yellow	0.988
	ADH -22	Kolar	Dark yellow	0.954
	ADH -23	Srinivasapura	Light yellow	0.470
	ADH -24	Kolar	Yellow	0.301
	ADH -25	Bangarpet	Yellow	0.208
	ADH -26	Malur	Orange	0.590
	ADH -27	Bangarpet	Light yellow	0.725
	ADH -28	Kolar	Yellow	0.255

dominant pollen (>45%), secondary pollen (16-45%), important minor pollen (3-15%) and minor pollen (<3%) by constructing pollen spectrum (Louveaux *et al*., 1978; White, 2005). Furthermore, the pollen morphology of the identified pollen from the honey samples was also documented.

RESULTS AND DISCUSSION

Kolar district has established beekeeping centres, maintained by the Department of Industries and Commerce of Apiculture wing. The present study identified the bee foraging plants of apiculture importance with particular reference to floral fidelity. The giant bee, *A. dorsata* is a widely distributed wild bee and is one of the important natural pollinators with high foraging potential (Neupane *et al*., 2006). Twenty-eight honey samples collected from 5 different regions in the study area were subjected to Melittopalynological studies to identify its honey plant resources. The colour, Optic density and place of the collection are documented in Table 1. The colour of the collected honey samples varied from light yellow to dark red. This variation may be due to floral source or exposure of honey to high temperature (Matos and Santos, 2016). The colour classification of honey is very important for commercial purpose. The optical density of the honey samples ranged from 0.208-0.996. Melittopalynological analysis is one of the main tools to determine the honey's botanical origin and differentiate the type of honey as unifloral or multifloral (Rodopoulou *et al*., 2018). A wide variety of pollen types representing their plant sources and their frequency classes were recognized in each honey samples and listed in Table 2. Among 28 honey samples analysed, 10 samples were identified as multifloral, whereas 18 were unifloral with predominant pollen types such as *S. cumini, P. pinnata, Eucalyptus* sp*, G. abyssinica, P. guajava* and *C. sativum. E*ach count was found to be above 45% (Table 2).

The pollen type of *Eucalyptus* sp. was identified in 8 honey samples collected from the study area. The two different species, *E. globules* and *E. citriodor*a have been known to occur in this region, has a significant role in providing nectar and pollen to *A. dorsata.* Bees

Table 2. Pollen spectrum of honey samples collected from Kolar District.

Honey sample	Predominant pollen types 45% & above	Secondary pollen types (16-45%)	Important minor pollen types (3-15%)	Minor pollen types (Less than 3%)	Honey types
ADH-1	*S. cumini*	*Eucalyptus C. indicum*	*C. eqisetofolia, C. sativum, C. nucifera*	*D. regia, M. pudica,* Poaceae, *H. auriculata,* Amaranthaceae, Fabaceae, *C. bonplandianum, C. lemon,*	Unifloral
ADH-2	*P. pinnata*	--------	*Eucalyptus, A. catechu, A. lebbeck*	*M. pudica, C. nucifera, P. pterocarpum,* Poaceae, *E. alsinoides*	Unifloral
ADH-3	-------	*P. guajava*	*P. Pterocarpum, C. nucifera*	*M. pudica, Asteraceae, D. metal, E. alsinoides, A. catechu,* Poaceae, *C. sativum.*	Multifloral
ADH-4	*Eucalyptus*	-------	Asteraceae, *M. pudica, A. indica*	*C. nucifera, S. jambosa,* Amaranthaceae *sp., Cassia sp., O. sanctum, C. lemon*.	Unifloral
ADH-5	*G. abyssinica*	*Eucalyptus*	*H. auriculata, M. pudica, C. nurifera, O. sanctum, C. benghalensis,*	*P. hysterophorus,* Poaceae, *B. nigra,* Fabaceae, *J. simplex, T. angustata, O. sanctum*	Unifloral
ADH-6	*P. guajava*	*C. nucifera*	Asteraceae, *D. metal, C. lemon*.	*C. argentea,* Poaceae, *T. angustata,* Fabaceae, *A. catechu, C. equisetifolia*, *O. sanctum, C. bonplandianum, A. chundra.*	Unifloral
ADH-7	*Eucalyptus*	-------	*M. pudica, B. nigra,* Asteraceae, *C. nucifera, C. benghalensis,*	*H. auriculata, M. alba, O. sanctum, Poaceae, C. sativum.*	Unifloral
ADH-8	-----	Asteraceae, *Eucalyptus*	*C. nucifera, M. pudica, Amaranthus sp.*	*A. catechu, Poaceae, H. auriculata, C. benghalensis, R. indica.*	Multifloral
ADH-9	*Eucalyptus*	*M. pudica*	*Asteraceae, C. nucifera, O. sanctum.*	*B. nigra, A. catechu, C. benghalensis, H. auriculata, C. lemon, Solanaceae, R. communis.*	Unifloral
ADH-10	*Eucalyptus*	*M. pudica*	*Asteraceae, C. nucifera, O. sanctum.*	*A. catechu, Fabaceae, B. nigra, Poaceae, C. benghalensis.*	Multifloral
ADH-11	*Eucalyptus*	--------	*Asteraceae, M. pudica, O. sanctum*	*Amaranthus sp., H. auriculata, C. sativum, C. nucifera, D. metal, T. terrestris*	Unifloral
ADH-12	*Eucalyptus*	-------	*C. sativum, C. nucifera, H. auriculata,*	*M. pudica, Solanaceae, P. sylvestris, C. lemon, O. sanctum.*	Unifloral
ADH-13	*Eucalyptus*	*H. auriculate*	*Asteraceae, C. sativum, C. nucifera.*	*Amaranthus sp., O. sanctum, B. nigra, M. pudica.*	Unifloral
ADH-14	-------	*Eucalyptus, Bignoniaceae*	*Asteraceae, C. sativum, G. sepium.*	*P. sylvestris, Poaceae, Asteraceae, C. nucifera, Citrus sp., M. pudica, Solanaceae, Acacia sp.*	Multifloral
ADH-15	------	*Asteraceae, Eucalyptus*	*C. sativum, O. sanctum, H. auriculata, M. pudica, C. nucifera.*	*T. argentia, P. sylvestris, Fabaceae, Acacia sp. Amaranthus sp. C. bonplandianum, D. metal. Poaceae,*	Multifloral
ADH-16	------	*Eucalyptus, Bignoniaceae*	*Asteraceae, C. nucifera*	*A. catechu, Acacia sp., Poaceae, M. pudica, R. communis, C. sativum, A. lebbeck.*	Multifloral
ADH-17	*P. guajava*	------	*P. pinnata, Asteraceae, Eucalyptus.*	*C. nucifera, Citrus sp., A. indica, Poaceae, C. bonplandianum, P. sylvestris, D. regia,*	Unifloral
ADH-18	--------	*Eucalyptus, Syzygium sp., M. pudica*	*C. nucifera, Asteraceae*	*P. pinnata, Poaceae, P. guajava, P. sylvestris, Fabaceae, C. bonplandianum.*	Multifloral

Contd…….

Table 2. Contd…….

ADH-19	*Eucalyptus*	*Syzygium sp., Asteraceae*	*P. guajava, M. pudica, Commelina sp., C. nucifera.*	*H. auriculata, Amaranthus sp., C. sativum, Poaceae, O. sanctum, V. negundo*	Unifloral
ADH-20	-------	*Eucalyptus, M. pudica*	*Asteraceae, C. sativum, S. laurifolius*	*O. sanctum, Commelina sp. C. lemon, Poaceae, H. auriculata, Z. oenopilia*	Multifloral
ADH-21	*P. guajava*	*M. pudica*	Asteraceae, *Syzygium sp., Eucalyptus, Ipomea sp.*	*C. equisetifolia, C. nucifera, Amaranthus sp. B. nigra, Citrus sp., Commelina sp., C. sativum.*	Unifloral
ADH-22	*P. guajava*	Asteraceae, *M. pudica*	*Syzygium sp., C. nucifera, Eucalyptus, O. sanctum.*	*C. benghalensis, C. argentea, B. nigra,* Solanaceae, *C. lemon, H. auriculata, Cyperus sp*., Poaceae.	Unifloral
ADH-23	*Eucalyptus*	*Asteraceae, M. pudica*	*Amaranthus sp., C. sativum, B. nigra*	*C. nucifera, Acacia sp., C. bonplandianum, O. sanctum, H. auriculata, T. asiatica.*	Unifloral
ADH-24	*Eucalyptus*	*C. nucifera, T. indicus*	Asteraceae, *M. pudica, J. simplex*	*Amaranthus sp., Cyperus sp., Acacia sp., O. sanctum, C. sativum, H. auriculata, C. inerme, C. bonplandianum.*	Unifloral
ADH-25	*C. sativum*	*O. sanctum*	*Eucaluptus,* Asteraceae	*C. nucifera, C. benghalensis, Amaranthus sp.,* Poaceae, *B. hispida, C. inerme.*	Unifloral
ADH-26	------	*Eucalyptus, C. nucifera*	Asteraceae, *M. pudica, C. sativum, M. indica*	*A. catechu, Amaranthus sp., H. auriculata,* Poaceae, *O. sanctum, A. marmelos*	Multifloral
ADH-27	*Syzygium sp.*	*M. pudica*	*Eucalyptus, C. nucifera, H. auriculalta*	*O. sanctum, C. sativum, Citrus sp., H. annus*	Unifloral
ADH-28	*P. pinnata*	*Eucalyptus, Asteraceae*	*F. elephantum, E. alsinoides*	*G. robusta,* Rubiaceae, *D. regia,* Poaceae, *A. chundra*	Unifloral

prefer pollen and nectar of *Eucalyptus* tree to a larger extent, because of the tree flowers throughout the year (Tamar Keasar and Avi Shmida, 2009; Layek and Karmakar, 2018). This is evident in the honey sample of *A. dorsata* honey (ADH-4, 7, 9,12, 13, 19, 23 and 24) and all these honey samples were unifloral type. The other pollen types identified with *Eucalyptus* were as *Acacia sp., B. nigra, Cassia sp., C. lemon, Clerodendrum inerme, Cocos nucifera, Commelina benghalensis, Coriandrum sativum, Croton bonplandianum, Cyperus sp., Hygrophila auriculata, Mimosa pudica, Morus alba, Ocimum sanctum, Phoenix sylvestris, Ricinus communi* and *S. jambosa*. Likewise, *Psidium guajava* pollen was identified as dominant in 4 honey samples collected from Mulbagal (ADH-6), Malur (ADH-21), Bangarpet (ADH-21) and Kolar (ADH-24). *P. guajava* is a small tree, belongs to the *Myrtaceae* family that flowers throughout the year. *Psidium* flowers produce a sufficient amount of pollen and nectar to honey bees (Anita *et al*., 2012). The pollen spectrum of this unifloral honey also showed the pollen types of *P. pinnata, Eucalyptus* Sp. *C. nucifera, Azaadirachta indica, C. lemon, C. bonplandianum, P. sylvestris, Delonix regia, Datura metal, Celosia argentea, Typha angustata, Casuarina equisetifolia, Brassica nigra, C. sativum, C. benghalensis, Hygrophila auriculata, Amaranthus* sp. and *Cyperus* sp.

S. cumini (ADH-1 and 27) and *P. pinnata* (ADH-2 and 28) pollen type were found in 2 samples each. *S. cumini* is a large evergreen tree found all along the avenues and around the forest area. It is an important source of nectar and pollen for honeybees because the tree flowers from February and continues to bloom till the end of April (Abou-Shaara, 2014). *Eucalyptus, C. eqisetofolia, C. sativum, C. nucifera, D. regia, M. pudica, H. auriculata, C. lemon, C. bonplandianum* and *O. sanctum* pollen types were associated with this unifloral honey. Whereas *P. pinnata,* a much branched bushy tree, widely cultivated medicinal application. A non-timber tree flowers profusely during the onset of summer month, it closes before the early monsoon. The *Pongamia* honey associated with *Eucalyptus* sp*., A. catechu, M. pudica, C. nucifera, Peltophorum pterocarpum, Evolvulus alsinoides, Ferronia elephantum, Grevillea robusta* and *Delonix regia*. Further, pollen spectrum revealed the association of *Guizotia abyssinica* uniforal honey sample (ADH-5) was *Eucalyptus* Sp., *Hygrophila auriculata, M. pudica, Commelina benghalensis, C. nurifera, O. sanctum, P. hysterophorus, B. nigra, Justicia simplex* and *Typha angustata*. *Guizotia abyssinica* is an annual erect herb to a height of 3 feet. It is cultivated as a minor crop along with ragi or groundnut which flowers during August to December. *Coriander* pollen occurs as dominant pollen in the sam-

Table 3. Floral calendar of bee forage plants of Kolar district during 2017-2019.

Sl. No.	Plant species	Family	Habit	Flowering period	Economic importance
1	*Acacia catechu* (L.f.) Willd.	Fabaceae	Tree	June-October	Medicinal
2	*Acacia chundra* (Roxb. ex Rottler)	Fabaceae	Tree	April-August	Medicinal
3	*Albizia lebbeck* (L.) Willd	Fabaceae	Tree	July-November	Timber
4	*Amaranthus spinosus* L.	Amaranthaceae	Herb	July-October	Vegetable
5	*Areca catechu* L.	Arecaceae	Tree	January-March	Nut
6	*Azadirachta indica* Juss.	Meliaceae	Tree	March-April	Medicinal
7	*Bauhinia purpurea* L.	Fabaceae	Tree	August-November	Ornamental
8	*Borreria hispida* (L.) Schum.	Rubiaceae	Herb	January-December	Medicinal
9	*Borreria stricta* (L.f.) Schum.	Rubiaceae	Herb	January-December	Medicinal
10	*Brassica nigra* (L.) Koch.	Brasicacece	Herb	March-June	Oil Yielding
11	*Caesalpina pulcherrima* (L.) Swart.	Fabaceae	Tree	January-December	Ornamental
12	*Cassia mimosoides* L.	Fabaceae	Tree	August-October	Ornamental
13	*Casuarina equisetifolia* J.R.and G.forsst.	Casuarinaceae	Tree	February-September	Timber
14	*Celosia argentea* L.	Amaranthaceae	Herb	June-September	Vegetable
15	*Chrysanthemum indicum* L.	Asteracece	Herb	January-December	Ornamental
16	*Citrus aurantium* L.	Rutaceae	Tree	April-May	Fruit
17	*Citrus medica* L	Rutaceae	Tree	April-May	Fruit
18	*Clerodendrum inerme*	Lamiaceae	Shrub	October-March	Medicinal
19	*Cocos nucifera* L.	Arecaceae	Tree	January-December	Oil Yielding
20	*Commelina benghalensis* L.	Commelinaceae	Shrub	June-October	Medicinal
21	*Coriandrum sativum* L.	Apiaceae	Herb	June-July	Vegetable
22	*Croton bonplandianum* Baill.	Fabaceae	Shrub	January-December	Medicinal
23	*Cyperus* Sp	Cyperacece	Herb	May-June	Medicinal
24	*Datura metal* L.	Solanaceae	Shrub	January-June	Weed
25	*Delonix regia* (Boj.ex.) Raf.	Fabaceae	Tree	June-July	Ornamental
26	*Eucalyptus* Sp.	Myrtaceae	Tree	March-June	Timber
27	*Evolvulus alsinoides* L.	Convolvulaceae	Shrub	February-June	Medicinal
28	*Feronia elephanum* Correa	Rutaceae	Shrub	January-December	Fruit
29	*Gliricidia sepium* (Jacq) Kunth ex. Steud.	Fabaceae	Tree	November-March	Medicinal
30	*Grevillea robust* A. Cunn	Proteaceae	Tree	January-December	Timber
31	*Guizotia abyssinica* Cass.	Asteraceae	Herb	May-October	Oil yielding
32	*Helianthus annus* L.	Asteraceae	Shrub	July-October	Oil Yielding
33	*Hygrophila auriculata* (Schum) Heine.	Acanthaceae	Herb	October-April	Medicinal
34	*Ipomoea* sp. L	Convolvulaceae	Herb	January-December	Weed
35	*Justicia simplex* Don.	Acanthaceae	Herb	October-December	Weed
36	*Mangifera indica* L.	Anacardiaceae	Tree	March-April	Fruit
37	*Mimosa pudica* L.	Fabaceae	Herb	Januaru-December	Weed
38	*Morus alba* L.	Moraceae	Tree	May-June	Silk Production
39	*Ocimum sanctum* L.	Lamiaceae	Herb	January-December	Medicinal
40	*Partheniumhyserophorus* L.	Asteraceae	Herb	January-December	Weed
41	*Peltophorum pterocarpum* (DC) Baker.	Fabaceae	Tree	March-April	Ornamental
42	*Phoenix sylvestris* (L.) Roxb.	Arecaceae	Tree	June-August	Fruit
43	*Pongamia pinnata* Vent.	Fabaceae	Tree	April-June	Oil Yielding
44	*Prosopis julifera* D.C.	Fabaceae	Tree	August-Feb	Medicinal
45	*Psidium guajava* L.	Myrtaceae	Tree	February-April	Fruit
46	*Ricinus communis* L.	Euphorbiaceae	Tree	March-April	Oil Yielding
47	*Rosa indica* L.	Rosaceae	Shrub	January-December	Ornamental
48	*Sapindus laurifolius* Vahl.	Sapindaceae	Tree	February-April	Medicinal
49	*Syzygium cumini* (L.) Skeels.	Myrtaceae	Tree	March-April	Fruit
50	*Tabebuia argentia* (R & S) Britt.	Bignoniaceae	Tree	April-May, August-September	Ornamental
51	*Tamarindus indicus* L.	Fabaceae	Tree	March-May	Fruit
52	*Toddalia asiatica* (L.) Lamk.	Rutaceae	Herb	March-September	Medicinal
53	*Tribulus terrestris* L.	Zygophyllaceae	Herb	March-May	Weed
54	*Typha angustata* L.	Typhaceae	Herb	May-July	Medicinal
55	*Vitex negundo* Mill.	Lamiaceae	Shrub	July-August	Medicinal
56	*Ziziphus oenoplia* (L.) Mill.	Rhamnaceae	Tree	July-November	Fruit

Table 4. Floral calendar of bee forage plants of Kolar district during 2017-2019.

Sl. No.	Taxonomical Name of the Plant	Jan	Feb	March	April	May	June	July	Aug	Sept	Oct	Nov	Dec
1	*Acacia catechu* (L.f.) Willd.												
2	*Acacia chundra* (Roxb. ex Rottler)												
3	*Albizia lebbeck* (L.) Willd												
4	*Amaranthus spinosus* L.												
5	*Areca catechu* L.												
6	*Azadirachta indica* Juss.												
7	*Bauhinia purpurea* L.												
8	*Borreria hispida* (L.) Schum.												
9	*Borreria stricta* (L.f.) Schum.												
10	*Brassica nigra* (L.) Koch.												
11	*Caesalpina pulcherrima* (L.) Swart.												
12	*Cassia mimosoides* L.												
13	*Casuarina equisetifolia* J.R.and G.forsst.												
14	*Celosia argentea* L.												
15	*Chrysanthemum indicum* L.												
16	*Citrus aurantium* L.												
17	*Citrus medica* L												
18	*Clerodendrum inerme*												
19	*Cocos nucifera* L.												
20	*Commelina benghalensis* L.												
21	*Coriandrum sativum* L.												
22	*Croton bonplandianum* Baill.												
23	*Cyperus* Sp												
24	*Datura metal* L.												
25	*Delonix regia* (Boj.ex.) Raf.												
26	*Eucalyptus* Sp.												
27	*Evolvulus alsinoides* L.												
28	*Feronia elephanum* Correa												
29	*Gliricidia sepium* (Jacq) Kunth ex.Steud.												
30	*Grevillea robust* A. Cunn												
31	*Guizotia abyssinica* Cass.												
32	*Helianthus annus* L.												
33	*Hygrophila auriculata* (Schum) Heine.												
34	*Ipomoea* sp. L												
35	*Justicia simplex* Don.												
36	*Mangifera indica* L.												
37	*Mimosa pudica* L.												
38	*Morus alba* L.												

Contd.....

Table 4. Contd……

39	*Ocimum sanctum* L.
40	*Partheniumhyserophorus* L.
41	*Peltophorum pterocarpum* (DC) Baker.
42	*Phoenix sylvestris* (L.) Roxb.
43	*Pongamia pinnata* Vent.
44	*Prosopis julifera* D.C.
45	*Psidium guajava* L.
46	*Ricinus communis* L.
47	*Rosa indica* L.
48	*Sapindus laurifolius* Vahl.
49	*Syzygium cumini* (L.) Skeels.
50	*Tabebuia argentia* (R & S) Britt.
51	*Tamarindus indicus* L.
52	*Toddalia asiatica* (L.) Lamk.
53	*Tribulus terrestris* L.
54	*Typha angustata* L.
55	*Vitex negundo* Mill.
56	*Ziziphus oenoplia* (L.) Mill.

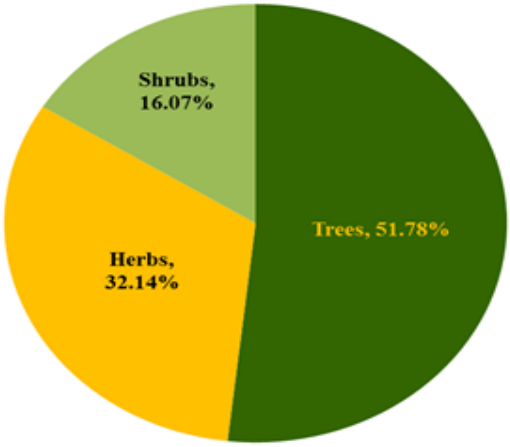


Fig. 2. *Plant species representing floral diversity in Kolar district.*

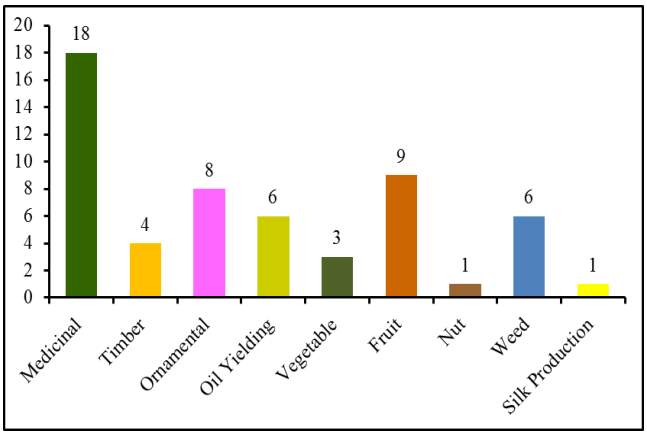


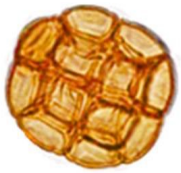
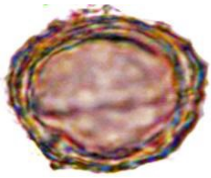
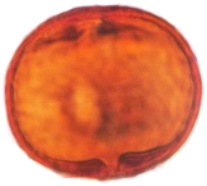
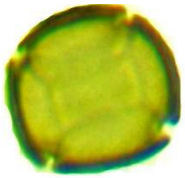
Fig. 3. *Number of plant species with economic importance.*

ple ADH-25. It is a small, herbaceous and aromatic plant flower from January to March. In this sample, along with *Coriander* pollen, *O. sanctum, Eucaluptus* Sp., *C. nucifera, C. benghalensis, Amaranthus* Sp., *Borreria hispida* and *Clerodendrum inerme* pollen types were identified. In the present study, *Eucalyptus* and *Syzygium* pollen types dominate others and sometimes occur as secondary or important minor pollen (Chauhan *et al*., 2017; Manju Sahney *et al*., 2018; Behera *et al*., 2018).

Pollen is very significant for honeybee nourishment (Dietz, 1975; Dimou and Thrasyvoulou, 2009). Honeybees gather pollen grains from entomophilous and anemophilous plants to get protein for their endurance and reproduction (Yao *et al*., 2006; Barth *et al*., 2009). The bees often collect a wide range of pollen types, but they normally ponder on a few species (Dimou and Thrasyvoulou, 2007; Bauma *et al*., 2011). The present study offers new insights into the pollen configuration of honey samples from Kolar region of Karnataka, India.

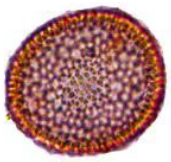
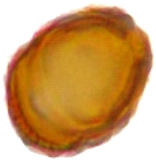
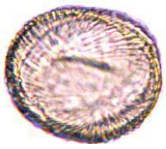
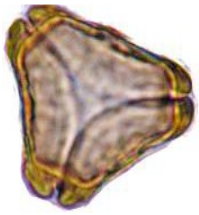
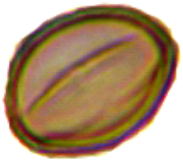
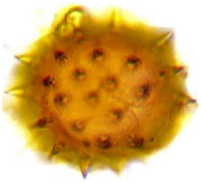
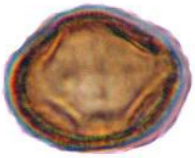
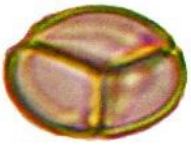
A total 56 pollen types belonging to 27 plant families were identified from honey samples and listed in Table 3. Fabaceae represented as the largest plant family

Table 5. Pollen morphology of some dominant pollen types of the study area.

Sl. No.	Taxon	Aperture	Ornamentation	Size, Shape & Exine pattern	Photomicrograph
1	*Acacia sp.*	Tricolpoid	Striato Reticulate	38-45, 50-58 µm, exine 1.5-3µm	
2	*Asteraceae*	Tricolporate	Echinulate	35-38µm, exine 5µm	
3	*A. indica*	Tetracolporate	Reticulate	Prolate spheroidial, exine 1-0.5µm	
4	*B. purpurea.*	Tricolporate	Striate	25x30µm, exine 1.5 µm	
5	*B. nigra*	Tricolpate	Reticulate	28-31µm subspheri-cal, exinie 1.5µm	
6	*Citrus sp.*	Tetracolporate	Reticulate	30-34, 24-31 µm amb tetragonal	
7	*C. nucifera*	Monosulcate	Granulate	Oblate	
8	*C. sativum*	Tricolporate ora elliptic	Granulate	25-28, 40-50µm, exine 2µm	

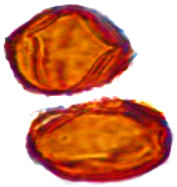
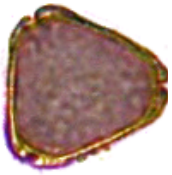
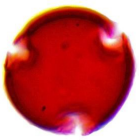
Contd…….

Table 5. Contd…….

9	*C. bonplandi-anum.*	Omni aperturate	Reticulate with cro-tonoid pattern	46-48µm, exine 3µm	
10	*Cyperus sp.*	3-4 colpoid	Granulate	36-41, 26-34µm, exine 1µm	
11	*D. metal*	Tricolporate	Strito reticulate	50x50µm spheroidal, exine 4µm	
12	*Eucalyptus sps.*	3-4 Syncolporate	Psilate	19-22x26-31µm, exine 1µm amb semi-angular exine 0.5µm	
13	*G. sepium*	Tricolporate	Psilate	25-28, 29-31µm, exine 1.5µm	
14	*G. abyssinica*	Tricolporate	Echinulate	25-30µm spheroidal	
15	*M. indica*	Tricolporate	Striato reticulate	28-24µm, exine 2µm	
16	*M. pudica*	Tetrad	Psilate	Spheroidal, exine 1µm	
17	*O. sanctum*	Hexacolpate	Reticulate	55-75µm suboblate, exine 4µm	

Contd…….

Table 5. Contd…….

18	*P. pterocarpum*	Tricolporate	Reticulate	35-40, 51-55µm, exine 3-5µm	
19	*P. pinnata*	Tricolporate	Psilate	21-41, 23-43µm, exine 2µm	
20	*P. guajava*	Tricolporate	Psilate	14-20µm triangular, exine 1.4µm	
21	*R. communis*	Tricolporate	Reticulate	26x26µm spheroidal, exine 2µm	
22	*R. indica*	Tricolporate	Striate reticulate	25x45µm, exine 2.5µm	
23	*S. cumini*	Trisyn colporate	Psilate	12x28µm oblate, exine 1.5µm	
24	*T. argentea*	Tricolporate	Reticulate	44-31µm subprolate to prolate	
25	*T. indicus*	Tricolporate	Striate	35-35µm, amb circular, exine 2µm	

with 14 species contributing to the honey production in the study area. In addition, Rutaceae and Asteraceae comprised of 4 species each, followed by Arecaceae, Lamiaceae and Myrtaceae recorded with 3 species each. Convolvulaceae, Amaranthaceae, Rubiaceae and Acanthaceae were found with 2 species each and Anacardiaceae, Apiaceae, Bignoniaceae, Brasicaceae, Casurinaceae, Commelinaceae, Cyperaceae, Euphorbiaceae, Moraceae, Proteaceae comprised of single species each.

All the 56 pollen types recorded comprised several plant types such as trees, shrubs and herbs. Among the reported habit, there was a dominance of the tree with 51.78%, followed by herbs and shrubs with 32.14% and 16.07%, respectively, represent floral diversity (Fig. 2). The economic importance of the identi-

fied plants of apiculture importance was categorized as medicinal, ornamental, vegetable, timber, oil yielding, weeds, fruits and nuts (Fig. 3). According to the present result, predominant and secondary dominant pollen types with medicinal importance were *A. catechu, A. chundra*, *A. indica, Gliricidia sepium, C. inerme, B. hispida, B. stricta, C. benghalensis, Croton bonplandianum, Cyperus* sp., *Evolvulus alsinoides, H. auriculata*, *O. sanctum, Prosopis julifera, Sapindus laurifolius, Toddalia asiatica, Typha angustata* and *Vitex negundo.* Pollen types of *Bauhinia purpurea, Caesalpina pulcherrima, Delonix regia, C. mimosoides, Chrysanthemum indicum, Rosa indica, Tabebuia argentia* and *P. pterocarpum* were grouped as ornamental plants. *Amaranthus spinosu, Celosia argentea* and *C. sativum* were vegetables and *Albizia lebbeck*, *Casuarina equisetifolia, Eucalyptus* sp. and *Grevillea robust* were timber plants. *B. nigra, Guizotia abyssinica, H. annus, C. nucifera, P. pinnata* and *R. communis* are important oil yielding plants. The fruit and nuts yielding plants were *Feronia elephanum, P. sylvestris, P. guajava, S. cumini, C. aurantium, C. medica, Tamarindus indicus, Ziziphus oenoplia* and *A. catechu.* Weeds of forage importance to *A. dorsata* in the study area were *D. metal, M. pudica, P. hyserophorus, Ipomoea* sp., *J. simplex* and *Tribulus terrestris,* whereas *M. alba* was cultivated for production of silk.

From the study it is observed that, most of the plant species such as *B. hispida, B. stricta, C. pulcherrima, C. nucifera*, *C. indicum*, *C. bonplandianum, Eucalyptus* sps. *F. elephanum, G. robust*, *Ipomoea* sp, *M. pudica*, *O. sanctum, P. hyserophorus*, *R. communis* and *R. indica* have prolonged blooming period throughout the year. These species provide greater forage potential for honeybees in the study area. Pollen grains are the most important component of honey helps to identify the distribution of floral source of honey. The blooming period of each species was recorded as shown in Table 4. According to the present observation, *B. hispida, B. stricta, C. pulcherrima*, *C. indicum*, *C. nucifera, C. bonplandianum, F. elephanum, G. robust*, *Ipomoea* sp., *M. pudica*, *O. sanctum, P. hyserophorus* and *R. indica* bloom throughout the year. The peak flowering period of most important honey plants were observed during February to June and less blooming period was observed during October to January. Microscopic analysis of honey helps to identify the pollen types with their size, shape and ornamentation. The morphology of pollen grains differ in shapes, exine structure, symmetry and sculpture among plant species. Table 5 demonstrated the morphology of various types of pollen obtained from the present study. The pollen of *Acacia* sp. are sub globes, whereas *P. pinnata* pollen are spherical. It has been established in this study that the species belongs to the family Asteraceae pollen type were spinolous, Myrtaceae pollen types are colporate and prolate. But there is variability in the pollen type of the species belongs to family Fabaceae. Therefore, it is essential to examine a large number of pollen grains from one family in order to obtain a complete knowledge of different types within that family.

Conclusion

The present study contributes to the floral resources of *A. dorsata* honey produced in Kolar district of Karnataka state. *A. dorsata* mainly depends on the wild tree and cultivated plant blooms throughout the year as pollen and nectar source. From the results, it is evident that there is a lot of potential in establishing beekeeping industries in the study area. Among 28 honey samples analysed, 18 were unifloral, with the predominant pollen types were *C. sativum, E. globulus, G. abyssinica, S. cumini, P. pinnata* and *P. guajava.* The most represented families were Fabaceae, Rutaceae and Asteraceae. These plants may be introduced in social forestry and afforestation programs to enhance the honey yield. Further, the yield of economic crops may also be able to increase by pollination. Assessment of honey bee pollen as a bioindicator of the environment may throw more light on floral diversity.

Conflict of interest

The author declares that he has no conflict of interest.

REFERENCES

1. Abou-Shaara, H.F. (2014). The foraging behaviour of honey bees, *Apis mellifera*: A review. *Veterinarni Medicina*, 59 (1), 1-10. doi:10.17221/7240-VETMED
2. Agwu, C.O.C. & Akanbi, T.O. (1985). A palynological study of honey from four vegetation zones in Nigeria. *Pollen et Spores*, 27, 335-348.
3. Alves, R.F. & Santos, F.A.R. (2014). Plant sources for bee pollen load production in Sergipe, Northeast Brazil. *Palynology*, 38(1), 90-100. doi.10.1080/01916122.2013.846280
4. Anita, M., Sivararam, V. & Jayaramappa, K.V. (2012). Influence of bee attractants on pollination and yield parameters in guava (*Psidium guajava* L.). *International Journal of Plant Reproductive Biology*, 4(1), 41-46.
5. Anklam, E. (1998). A review of the analytical methods to determine the geographical and botanical origin of honey. *Food Chemistry*, 63, 549-562. doi.org/10.1016/S0308-8146(98)00057-0
6. Barth, O.M. (1990). Pollen in monofloral honeys from Brazil. *Journal of Apicultural Research*, 29(2), 89-94. doi.org/10.1080/00218839.1990.11101202
7. Barth, O.M., Munhoz, M.C. & Luz, C.F.P. (2009). Botanical origin of *Apis* pollen loads using colour, weight and pollen morphology data. *Acta Alimentaria*, 38(1), 133-139. doi.org/10.1556/aalim.2008.0026

8. Baum, K.A., Rubink, W.L., Coulson, R.N. & Bryant Jr. V.M. (2011). Diurnal patterns of pollen collection by feral honey bee colonies in southern Texas, USA. *Palynology*, 35(1), 85-93. doi.org/10.1080/01916122.2010.546621
9. Behera, S.S., Ray, R.C. & Zdolec, N. (2018). *Lactobacillus plantarum* with functional properties: An approach to increase safety and shelf-life of fermented foods. *BioMed Research International*, 9361614. doi.org/10.1155/2018/9361614
10. Chauhan, M.S., Farooqui, A. & Trivedi, A. (2017). Plants foraged by bees for honey production in northern India: The diverse flora of India and its implications for apiculture. *Acta Palaeobotanica*, 57(1), 119-132. doi:10.1515/acpa-2017-0003
11. Deodikar, G.B. & Thakar, C.V. (1953). A pollen study of honey yielding plants of Mahabaleshwar hills. Apicultural Lab. *Bulletin,* No.1, 1-6.
12. Deodikar, G.B. (1961). Some aspects of bee botany. *Indian Bee Journal*, 23, 60-61.
13. Diaz-Losada, E., Ricciardelli-d'Albore, G. & Saa-Otero, M.P. (1998). The possible use of honeybee pollen loads in characterizing vegetation. *Grana*, 37(3), 155-163. doi.org/10.1080/00173139809362660
14. Dietz, A. (1975). Nutrition of the adult honey bee. In: The hive and the honey bee, (Graham JM, ed.) Hamilton, Illinois: Dadant & Sons. pp.125-156.
15. Dimou, M. & Thrasyvoulou, A. (2007). Seasonal variation in vegetation and pollen collected by honeybees in Thessaloniki, Greece. *Grana*, 46(4), 292-299. doi.org/10.1080/00173130701760718
16. Dimou, M. & Thrasyvoulou, A. (2009). Pollen analysis of honeybee rectum as a method to record the bee pollen flora of an area. *Apidologie*, 40, 124-133. doi.org/10.1051/apido/2008066
17. Erdtman, G. (1960). The acetolysis method. A revised description. *Svensk Botanisk Tidskr*, 54, 561-564.
18. Feller-Demalsy, M.J., Parent, J. & Strachan, A. (1989). Microscopic analysis of honeys from Manitoba, Canada. *Journal of Apicultural Research*, 28(1), 41-49. doi.org/10.1080/00218839.1989.11100819
19. Garg, A. (2006). Bee botany of Bhimtal in Western Himalayas: Melissopalynological analysis. 1st ed. Dehra Dun: Bishen Singh & Mahendra Pal Singh.
20. Jesus, M.C., Borges, R.L.B., Souza, B.A., Brandao, H.N. & Santos, F.A.R. (2015). A study of pollen from light honeys produced in Piaul state, Brazil. *Palynology*, 39(1), 10-124. doi:10.1080/01916122.2014.942440
21. Layek, U. & Karmakar, P. (2018). Pollen analysis of *Apis dorsata* Fabricius honeys in Bankura and Paschim Medinipur districts, West Bengal. *Grana*, 57(4), 298-310. doi:10.1080/00173134.2017.1390604
22. Lieux, M.H. (1980). Acetolysis applied to microscopical honey analysis. *Grana*, 19, 57-61. doi.org/10.1080/00173138009424988
23. Lin, S.H., Chang, S.Y. & Chen, S.H. (1993). Nectar and pollen sources for honeybee (*Apis cerana* Fabr.) in Qinglan mangrove area, Hainan Island, China. *Journal of Integrative Plant Biology*, 48, 1266-1273.
24. Louveaux, J., Maurizio, A. & Vorwohl, G. (1978). Methods of melissopalynology. *Bee World*, 59(4), 139-157. doi.org/10.1080/0005772X.1978.11097714
25. Manju Sahney, Snehlata Rahi, Ajay Kumar & Roma Jaiswal. (2018). Melissopalynological studies on winter honeys from Allahabad, Uttar Pradesh, India. *Palynology*, 42(4), 540-552. doi:10.1080/01916122.2017.1418445
26. Matos, V.R. & Santos, F.A.R. (2016). Pollen in honey of *Melipona scutellaris* L. (Hymenoptera: Apidae) in an Atlantic rainforest area in Bahia, Brazil. *Palynology*, 41, 144-156. doi:10.1080/01916122.2015.1115434
27. Maurizio, A. (1975). Microscopy of honey. In: Honey, a comprehensive survey. (Crane E, editor). New York: Crane, Russak and Co., pp. 240-257.
28. Majid, M., Ellulu, M.S. & Bakar, M.F.A. (2020). Melissopalynological Study, Phenolic Compounds, and Antioxidant Properties, of *Heterotrigona itama* Honey from Johor, Malaysia. *Hindawi Scientifica*, Volume 2020, Article ID: 2529592, 9 pages doi.10.1155/2020/2529592
29. Moar, N.T. (1985). Pollen analysis of New Zealand honey. *New Zealand Journal of Agricultural Research*, 28(1), 39-70. doi.org/10.1080/00288233.1985.10426997
30. Moore, P.D., Webb, J.A. & Collinson, M.E. (1991). Pollen analysis. London, Blackwell Sci. Publ., (2nd edition), pp. 216.
31. Neha Singh & Chaturvedi, S.K. (2016). Melissopalynological Studies of Honey Samples from Bastar District, Chhattisgarh. *The International Journal of Plant Reproductive Biology*, 9(1), 37-40. doi.10.14787/ijprb.2017 9.1.37-40
32. Neupane, K.R., Dhakal, D.D., Thapa, R.B. & Gautam, D.M. (2006). Foraging preference of giant honeybee *Apis dorsata* F., to selected horticultural crops. *Journal of the Institute of Agriculture and Animal Science*, 27, 87-92.
33. Novais, J.S., Lima, L.C.L. & Santos, F.A.R. (2009). Botanical affinity of pollen harvested by *Apis mellifera* L. in a semi-arid area from Bahia, Brazil. *Grana*, 48(3), 224-234. doi:10.1080/00173130903037725
34. Oliveira, P.P., Van Den Berg, C. & Santos, F.D.A.R.D. (2010). Pollen analysis of honeys from Caatinga vegetation of the state of Bahia, Brazil. *Grana*, 49(1), 66-75. doi.org/10.1080/00173130903485122
35. Raghunandan & Basavarajappa. (2014). Melissopalyonology of multifloral honey of Asian giant honeybee *Apis dorsata* fabricius at Southern Karnataka, India. *Indian Journal of Applied Research*, 4(8), 667-669.
36. Ramalho, M. & Kleinert-Giovannini, A. (1986). Some aspects of the utilization of pollen analysis in ecological research. *Apidologie*, 17(2), 159-174. doi.org/10.1051/apido:19860207
37. Ramirez-Arriaga, E., Navarro-Calvo, L.A. & Diaz-Carbajal, E. (2011). Botanical characterisation of Mexican honeys from a subtropical region (Oaxaca) based on pollen analysis. *Grana*, 50(1), 40-54. doi.org/10.1080/00173134.2010.537767
38. Rodopoulou, M.A., Tananaki, C., Bimou, M., Liolios, V., Kanelis, D., Goras, G. & Thrasyvoulou, A. (2018). The determination of the botanical origin in honeys with over□ represented pollen: combination of melissopalynological, sensory and physicochemical analysis. *Journal of the Science of Food and Agriculture*, 98(7), 2705-2712. doi.org/10.1002/jsfa.8764
39. Sajwani, A., Farooq, S.A., Patzelt, A., Eltayeb, E.A. & Bryant, V.M. (2007). Melissopalynological studies from Oman. *Palynology*, 31, 63-79.
40. Sen, J. & Banerjee, D. (1956). A pollen analysis of Indian

honey. *Bee World*, 37(3), 52-54. doi.org/10.1080/00057 72X.1956.11094919
41. Shubharani, R., Sivaram, V. & Roopa, P. (2012). Assessment of honey plant resources through pollen analysis in Coorg honeys of Karnataka state. *The International Journal of Plant Reproductive Biology*, 4(1), 31-39.
42. Silva, A.P.C. & Santos, F.A.R. (2014). Pollen diversity in honey from Sergipe, Brazil. *Grana*, 53(2), 159-170. doi:10.1080/00173134.2014.896941
43. Singh, A.K. Deepak Kumar Jaiswal, Singh, H.K. & Thakur, R.K. (2016). Diversity of Bees' flora and floral calendar of native honey bees in Nagaland, India. *Advances in Life Sciences*, 5(6), 2285-2292.
44. Tamar Keasar & Avi Shmida. (2009). An evaluation of Israeli forestry trees and shrubs as potential forage plants. *Israeli Journal of Plant Sciences*, 57(1), 49-64. doi:10.1560/IJPS.57.1-2.49
45. Terrab, A., Pontes, A., Heredia, F.J. & Diez, M.J. (2004). Palynological and geographical characterization of avocado honeys in Spain. *Grana*, 43(2), 116-121. doi.org/10.1080/00173130310017634
46. Turner, V. (1984). Banksia pollen as a source of protein in the diet of two Australian marsupials *Cercartetus nanus* and *Tarsipus rostratus*. *Oikos*, 43, 53-61.
47. Upadhyay, D. & Bera, S. (2012). Pollen spectra of natural honey samples from a coastal district of Orissa, India. *Journal of Apicultural Research*, 51(1), 10-22. doi.org/10.3896/IBRA.1.51.1.03
48. Vishnu-Mittre. (1958). Pollen content of some Indian honeys. *Journal of Scientific and Industrial Research*, 17, 123-124.
49. White, J.W. (2005). Honey. In: The hive and the honey bee, (Graham JM, ed.) Hamilton, Illinois: Dadant & Sons. pp. 869-927
50. Yao, Y.F., Bera, S., Wang, Y.F. & Li, C.S. (2006). Nectar and pollen source for honeybee *Apis cerana* cerana Fabr. during October-November in Qinglan Harbor mangrove area, Hainan Island, China. *Journal of Integrative Plant Biology*, 11(48), 1266-1273.