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Diversity of Pollen Collected by the Indian Honey Bee (*Apis cerana* F.)

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ABSTRACT

The present study was undertaken to delineate the foraging preferences of the Indian honey bee using palynological methods. This was done by comparing pollen spectra obtained from the selected hives at fortnightly intervals from August 2015 to December 2016 at three sampling locations within a confined landscape. The results revealed that, there were about 55 pollen taxa / types belonging to 50 dicotyledonous and five monocotyledonous species, encompassing 22 botanical families involving, trees, shrubs, epiphytes, herbs, climbers, grasses and sedges. Further, the diversity index for pollen collected by *Apis cerana* in 2015 was low (H= 0.78 to 1.85; D= 0.58 to 0.83) as compared to the 2016, the pollen diversity index was highest in the month of June (H= 2.49) and lowest in April (H=1.22). Pollen from species of Arecaceae, Myrtaceae, Fabaceae and Poaceae represented more than 70 per cent of all the pollen collected.

Keyword: Palynology, *Apis cerana,* pollen types

MORE than 70 per cent of flowering plants in the world depend on insects, mostly social and solitary bees, for pollination (Klein *et al.,* 2007; Gallai *et al.,* 2009 and Potts *et al.,* 2010). Variations in colour, shape and size of flowers we see around us is an indication that they have developed these adaptations for attracting pollinators. Plant-pollinator interactions play a significant role in maintaining the functional integrity of most terrestrial ecosystems (Ollerton *et al*., 2011).

The shared pollinators hypothesis suggests that plant species sharing pollinators segregate flowering temporarily to minimize interspecific overlap in flowering times and thus minimize ineffective pollination or competition for pollinators, indicating strong phylogenetic constraints in timing and variation of flowering. Comparison of phenology within and among forests species may help in understanding of phenological diversity (Sakai, 2001).

Since honey bees collect pollen both actively as well as passively, analyzing the diversity of pollen carried by the bees through sampling pollen from the nests in different times of the year may give an idea about the floral diversity and changes in flowering phenology in a given location. The present study aimed to understand this relationship among bee floral diversity, through replicability of pollen over months and to delineate the foraging preferences of bees with local floral diversity. We have used palynological methods (Ramanujan, 1992 and Bilisik, 2008) to compare the pollen collected by bees with the available flora in the study area.

MATERIAL AND METHODS

Study area : The study was conducted at the Gandhi Krishi Vignana Kendra (GKVK) campus of the University of Agricultural Sciences, Bengaluru, Karnataka state, India. The campus is spread over 526 ha (5.3 Km^2) (13^0 04' 37" N, 77^0 34' 39.99" E; 930 msl) and receives a mean annual rainfall of 915.8 mm. The study area comes under the eastern dry Agro-climatic zone of Karnataka state and it has diverse vegetation.

Three sampling sites were selected for the study: Agriculture College building (AB), Medicinal garden (MG) and National seed project unit (NSP) and in each site one colony of *Apis cerana* Fabricius was maintained from August 2015 till December 2016. The study area is characterized by diverse flora including cultivated crops (in agricultural fields), plantations (in horticultural blocks), medicinal plants, and several species of garden plants, wild trees, shrubs and weeds that would be sources of nectar and pollen for the bees.

Sampling and Identification of Pollen : Species of plants flowering in the study area was recorded at monthly intervals and reference pollen slides were prepared from pollen samples collected from freshly opened flowers. For each species a duplicate set of slides were prepared following Wodehouse (1953) and also by the standard acetolysis method (Erdtman, 1952, 1969, Kearns and Inouye, 1993). Photomicrographs of pollen were made using ZEISS Axio Scope A1 Trinocular Microscope (Fig. 1).

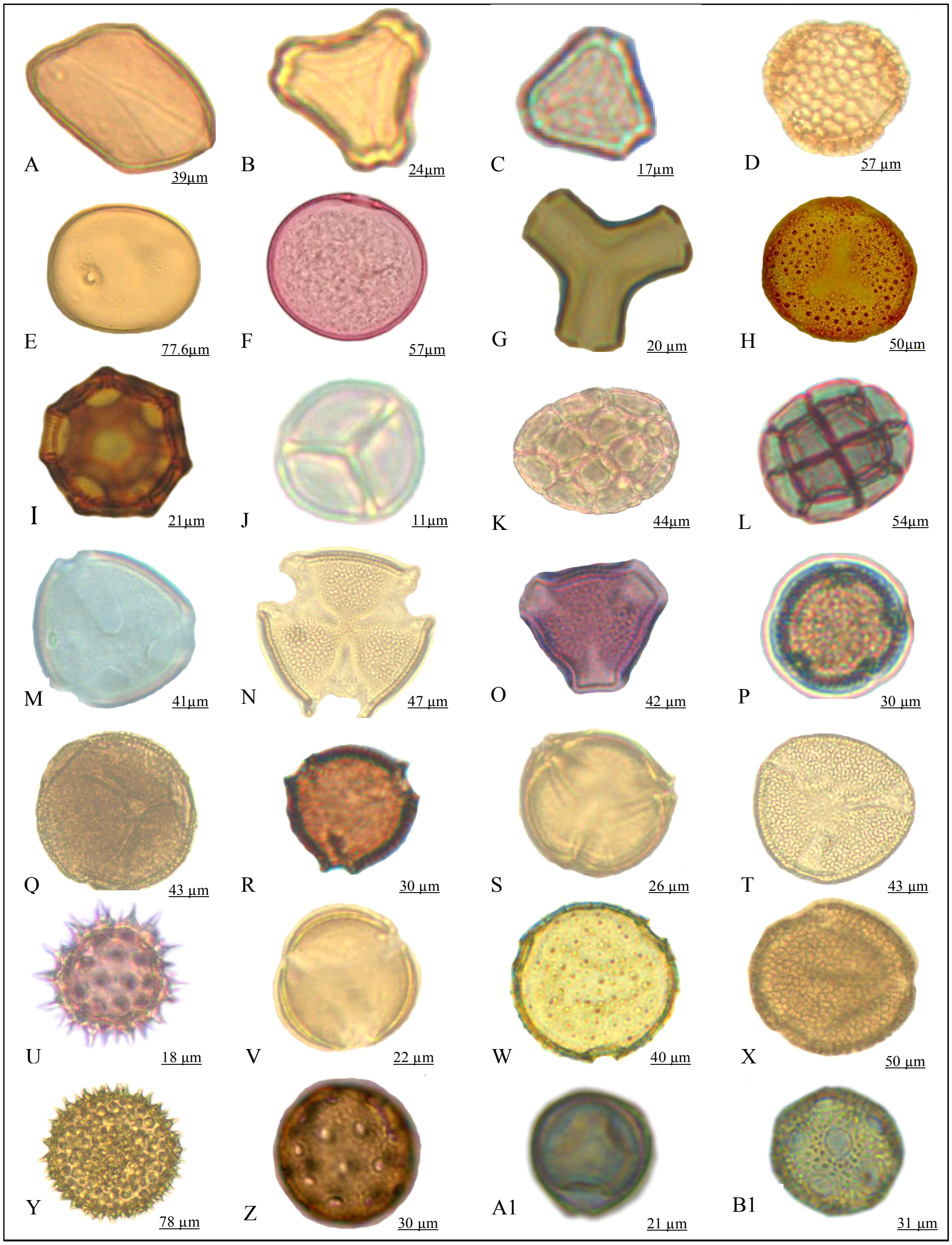

Fig.1: Photomicrographs Showing the predominant pollen types *i.e.*, **A** *Cocos nucifera*, **B** *Eucalyptusoblique*, **C** *Syzegium sp*, **D** *Pheltophoram ptreocarpum*, **E** *Zea maize*, **F** *Bouteloua dactyloides*, **G** *Dendropthoe falcate*, **H** *Portulaca* sp, **I** *Alternanthra bettzickiana*, **J***Mimosapudica*, **K** *Acacia sp*, **L** *Albezia* sp, **M** *Sennasiamea*, **N** *Tecoma* sp, **O** *Bauninia* sp, **P** *Phyllanthus emblica*, **Q** *Spathodea companulata*, **R** *Tamarindus indica*, **S** *Ricinus cummunis*, **T** *Millingtona hortensis*, **U** *Helianthus annus*, **V** *Tectonagrandis*, **W** *Clerodendrum* sp, **X** *Turnerasubulata*, **Y** *Malvestrum* sp, **Z** *Amaranthus* sp, **A1** *Flacourtia* sp, **B1** *Celosia argentia*

Bee collected pollen were sampled at fortnightly intervals from August 2015 to December 2016 using a pollen trap placed in front of the hive on the sampling day from morning till evening. Characterization and identification of bee pollen was done using pollen reference slides under a Olympus BX40 Trinocular Microscope. The major data collected in the course of this study was analysed using R statistics (R package RIOJA) and the pollen spectra were prepared.

Results and Discussion

Pollen spectra

Analysis of 29 pollen samples drawn from August 2015 to December 2016 yielded 55 pollen taxa / types representing 50 dicotyledons and five monocotyledons encompassing 22 botanical families (Fig. 2a, 2b).

Three families such as Arecaceae (32%), Myrtaceae (21%), Fabaceae (13%) accounted for more than half the total number of pollen types (Fig. 3a,). A *Cocos nucifera* pollen was the most abundant which was recorded in all the months. Despite the year round presence of Apiacea, Convolulaceae, Passifloraceae, and Bignoniaceae, their proportion was found to be meager/low (Fig. 2a, 2b). Species of Phyllanthaceae, Cambritaceae and Sapindaceae and some species of Fabaceae exhibited seasonal representation (Fig. 2b).

The analysis of pollen spectra (Fig, 2a, 2b) also showed the species *Cocos nucifera*, remained available through all seasons and even during peak flowering of other taxa, the bees continued to visit and collect pollen from *Cocos nucifera*. Because, it was the only pollen available throughout the year and these results are in conformity with finding of Bhargava, *et al*., 2009 and Ramanujam, *et al*., 1992).

Frequency of pollen types

Among the 55 species, *C. nucifera* was the predominant one (28%) followed by *Eucalyptus* (14%), *Richordia* (6%), and *Pheltophorum* (5%) and most of the other pollen were represented in lower frequencies (Fig. 3b). McCaughey (1980) suggested that several pollen types may be actually sought out

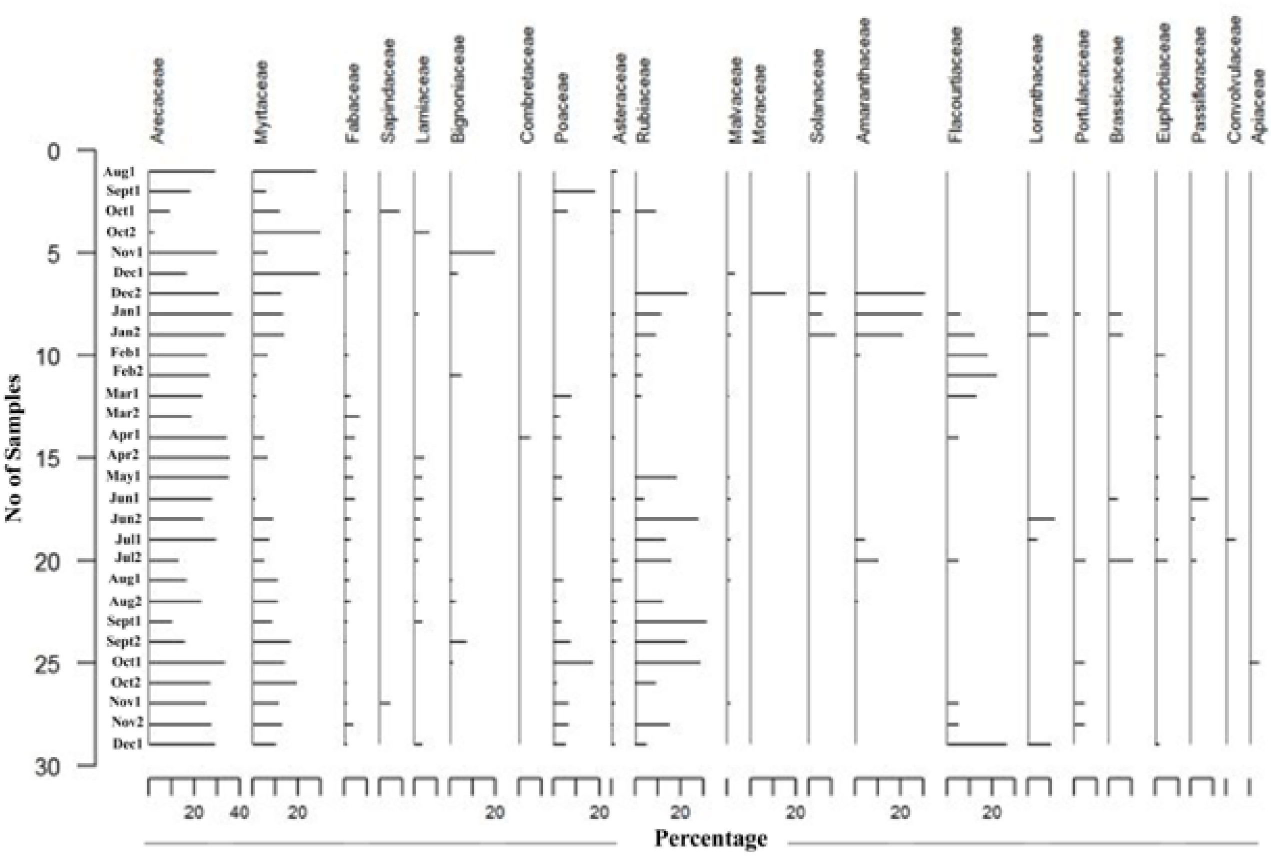

Fig. 2a: Pollen spectra showing the percentage of the family taxa.

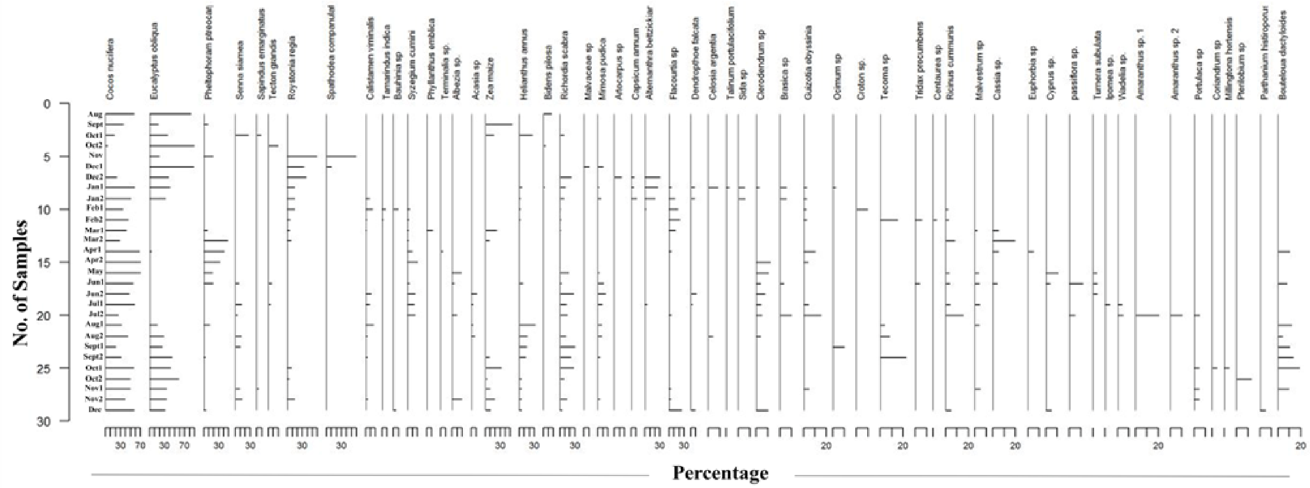

Fig. 2b: Pollen spectra showing the percentage of the main taxa

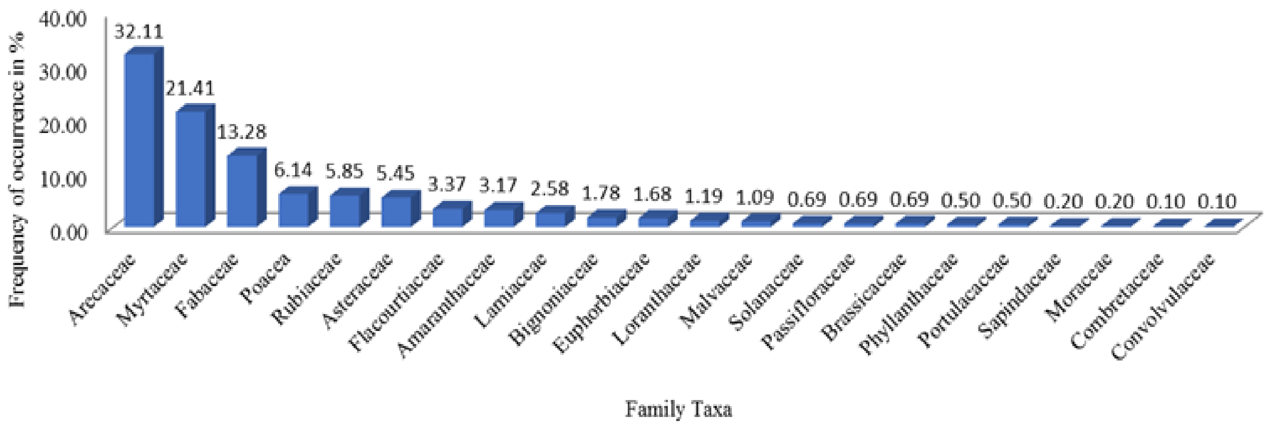

Fig. 3a: Frequency of pollen Family Taxa of GKVK

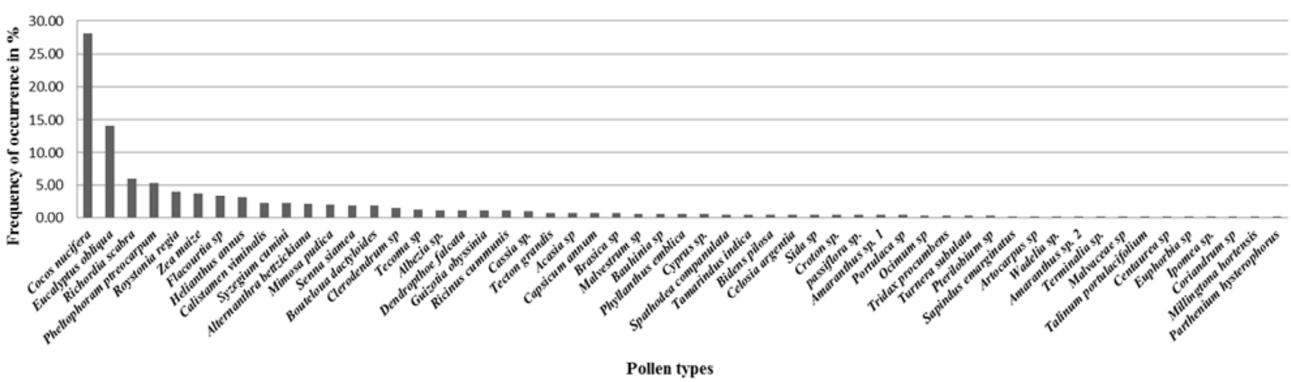

Fig. 3b: Frequency of pollen types in the pollen samples of GKVK

by bees for their nutritive value. Though the present study indicates that bees may largely depend on a few species, they also collect pollen from many other species.

Pollen Diversity Index

The diversity of pollen collected by *A. cerana* foragers in 2015 (August to December) was low (H= 0.78 to 1.85; D= 0.58 to 0.83) probably due to abiotic factors like low sunshine hours, cloudy weather and heavy rainfall. Gebremedhn, *et al.,* (2014) also observed a positive relation between peak bee activity and sunshine hours, and a negative association with relative humidity and cloudiness.

Interestingly, in 2016 the diversity was high (H=1.29 to 2.56; D=0.66 to 0.87) with greater (Table I) evenness (E= 0.77 to 0.95) and higher species

TABLE I

A. Cerana *pollen diversity collected at GKVK*

Year	Sampling Time	Species (S)	Evennes (E)	Simpson's index (D)	Shannon;s index (H)
2015	Aug-1	3	0.86	0.58	0.94
	Sept-1	4	0.87	0.66	1.20
	Oct-1	7	0.95	0.83	1.84
	Oct-2	4	0.56	0.41	0.78
	Nov-1	4	0.91	0.69	1.26
	Dec-1	5	0.76	0.61	1.22
	Dec-2	7	0.95	0.83	1.85
2016	Jan-1	18	0.82	0.86	2.36
	Jan-2	14	0.87	0.87	2.31
	Feb-1	13	0.86	0.86	2.21
	Feb-2	13	0.78	0.79	2.00
	Mar-1	11	0.81	0.81	1.95
	Mar-2	7	0.84	0.76	1.63
	Apr-1	10	0.77	0.76	1.77
	Apr-2	5	0.80	0.66	1.29
	May-1	10	0.79	0.76	1.81
	Jun-1	19	0.84	0.86	2.49
	Jun-2	9	0.90	0.83	1.98
	Jul-1	16	0.83	0.83	2.31
	Jul-2	15	0.94	0.91	2.56
	Aug-1	10	0.89	0.85	2.06
	Aug-2	12	0.87	0.85	2.16
	Sept-1	7	0.95	0.83	1.85
	Sept-2	10	0.89	0.84	2.04
	Oct-1	9	0.86	0.82	1.88
	Oct-2	7	0.75	0.70	1.45
	Nov-1	11	0.82	0.80	1.96
	Nov-2	12	0.90	0.87	2.23
	Dec-1	13	0.84	0.84	2.15
	Average	**9.83**	**0.84**	**0.78**	**1.85**

richness. Foragers of *A. cerana* were active throughout the study period. According to Pasquale *et al*., (2013) social bees keep a wide host range to meet high nutritional requirement of their colony since quality and diversity of pollen shapes their physiology and health. The present study also indicates that *A. cerana* is a generalist.

The result shows that, there is seasonal variation in the pollen types collected by honey bees. The delineation of pollen collected by bee gives valuable information for beekeeping and source of honey. Through periodical monitoring of pollen and analysis of honey pollen sample, one can map the local bee flora. The study also highlighted honey bees not only collected entamophilous pollen but also anemophilous pollen from Cyperaceae and Poaceae.

In addition, beyond their monetary value for sustaining our fragile food supply, bees also make an irreplaceable contribution to ecosystems around the world. Seeds, fruits and berries eaten by birds and small mammals are the result of pollination by bees, creating them custodians of the food chain and the biodiversity of our species.

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