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Melissopalynological investigations on honey samples of Kangra hills, Himachal Pradesh, India

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Abstract
Melissopalynology and Bee Botanical exploration of 16 honey samples of *Apis cerana* F. were accomplished from Kangra hills of Himachal Pradesh, India during 2010 to 2012. A total of 90 pollen types pertaining to various species and families of plants were recorded. Among these, 4 were predominant, 29 were secondary and rests were important and important minor types. The highest pollen frequency for various honey samples were noted for Fabaceae (12), succeeded by Asteraceae (7), Rosaceae (6), Malvaceae (4), and Myrtaceae (4). The pollen were also categorized, as per economic value i.e. ornamental, medicinal, timber etc. and as per plant's nature i.e. wild (22), wild as well as cultivated (23) and cultivated (29). From this study honey capability for each area studied were pretty clear and it explicit the enormous flora for honeybees, which could assure the augmentation of honeybees industries and horticulture productivity in concerned area.

Keywords: melissopalynology, honeybees, bee botanical investigation, pollen types

1. Introduction
Among insects, honeybees are among social insects with worldwide presence and have established congenial relationship with human being [1]. They not only produce honey and bees wax but they are also important players of pollination, by this they help us to increases crop yield through cross-pollination, improves quality of the seed and fruit and heterosis can be harnessed [2]. Thus, boost agricultural and horticultural crop productivity, preserve and maintain biological diversity and also conserve forest and grassland ecosystem [3]. The relationship between flowering plants and their pollinators leads to evolve a interdependence system, which is a significant step in organic evolution [3, 4].
Honeybees agglomerate nectar, pollen and transpose it after blending it with some important substances and left it in the comb, to get it ready for consumption [5]. There are number of chemical substances which attribute to honey, it primarily include carbohydrates which is above 82% [6], proteins which are present in the form of different enzymes and eighteen free amino acid of which most prevalent is proline [7, 8]. The importance of understanding honey use, from health point of view is also valuable for mankind. [9]. Pollen grain (male gametophyte) is an integral part of plant which is prime source of nutrients, which are required by the honeybees for the production of larval food [10, 11].
Melissopalynology, is an applied branch of palynology, which involves microscopic examination of pollen grain present in the honey and any confirmatory evaluation of bee plants is incomplete without this [12, 13, 14]. It also provides a significant tool with large range of applications among masses such as, in comparative evaluation of honeys originated from different physiographic regions and in detecting the adulteration of honeys [15, 16]. In Himachal Pradesh, the total area under fruit crops was only 63,370 ha in 1975-76, which has increased to more than 2, 08,153 ha in 2009-10 [17]. This leads to reduction of the floral resources for bees as cash crop is over. This problem can be acknowledged by providing pollen and nectar plant in such areas or moving bees to locations where floral resources are plentiful. This can be achieved only through melissopalynology and bee botanical studies.
As extensive pollen analytical studies, have been carried in Tamilnadu, Karnataka; Maharastra and other states surrounding Himachal Pradesh but, in Himachal Pradesh despite vast potential, only marginal work is done. Thus, present study aims on objectives as to know pollen analysis of honey samples from different parts of Kangra hills, identification of major, medium and minor sources of pollen and nectar to honeybees and to prepare a floral almanac for Kangra hills.

2. Materials and Methods
Present investigation (a part of Ph.D. work carried out during 2010 to 2012) were conducted on 16 summer honey samples, collected from domesticated Indian hive bees *A. Cerana* located in different areas of Kangra hills of Himachal Pradesh (Fig. 1) which is situated in Western Himalayas between 31º40' to 32º25' East longitude and 70º35' to 77º5' North latitude with altitude varying from 500 m to 5500 m. The climate varies from humid to sub-humid, sub-tropical and wet to humid sub-temperate. Moreover, Kangra valley is meeting place of Eastern and Western monsoon which causes high rainfall in Dharamshala [18].
For pollen analysis, pollen slides of honey samples were prepared by taking 10 g of honey dissolved in 20 ml distilled water (40°C), centrifugation at 2500-3000 rpm for 10 minutes. Supernatant liquid drained off, sediment recentrifuged, acetolysed and then placed in water bath (10 min.; 70ºC), and centrifuged. Sediment, centrifuge again with distilled water and a drop of strong detergent (teepol) before adding a drop of glycerine and water mixture (1:1), dried in oven and then mounted in glycerine gelatin [19, 20]. Identification of different pollen types was done with the help of standard works [13, 21, 22] and pollen slide collection of Entomology and Biodiversity Laboratory, Department of Biosciences, Himachal Pradesh

University, Shimla and pollen source almanac for different plants was prepared.

Quantative analysis is done with the help of a haemocytometer [23, 24]. Pollen spectra, absolute pollen count as well as percentage of pollen types was calculated and formulated on the basis of these percentages [25]. The honey samples were rich, poor and extremely poor as per total number of pollen grains present in 10 gm of honey that is: 1,00,000; 20,000 to 1,00,000 and below 20,000 respectively [26]. Frequencies of pollen grains were recorded as: 'Predominant pollen' (>45% of the pollen grains counted); 'Secondary pollen' (16 to 45%); 'Important minor pollen' (3 to 15%) and 'Minor pollen' (<3%) [19]. Honey sample was termed as 'Unifloral honey' if it was having 45% or more grains of a single pollen type and honey sample' with several pollen types in considerable percentage was termed as 'Multifloral honey' [15, 20, 24]. Reference slides were prepared from the identified honey plants using Acetolysis Method and Glycerine Jelly Method [19].

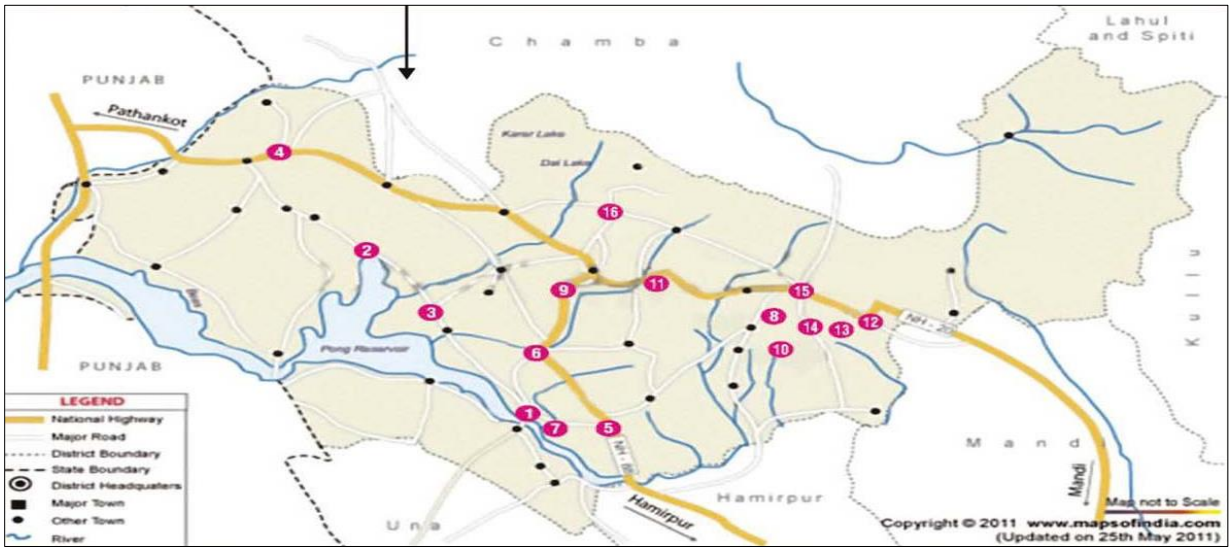

Fig 1: Map of Kangra District

Study Sites:1. Dehra 2. Jwali 3. Nagrota Surian 4. Nurpur 5. Jwalamukhi 6. Ranital 7. Pragpur 8. Jaisinghpur 9. Kangra 10. Chadiar 11. Nagrota Bagwan 12. Baijnath 13. Paprola 14. Panchrukhi 15. Palampur 16. Dharamshala

2.1 Statistical analysis

The frequency of different pollen types in each honey sample were taken in triplicate (repeated three time) and SD (± mean) were calculated.

3. Results

In Kangra hills, a total of 90 pollen types of different species and families of plants were observed in honey samples collected from different sites. Of these, 4 pollen types were predominant; 29 were secondary and 57 were of important minor and minor pollen types. However among these identified pollens, some were present in more than one sample with varying percentage (Figs. 2-17). Predominant pollen types were: *Citrus grandis*.; *Acacia catechu*.; *Bauhinia variegata* and Myrtaceous member. Secondary pollen types recorded were: *Emblica officinalis*; *Murraya koenigii*; *Woodfordia fruticosa*; *Mangifera indica*; *Pyrus pashia*.; *Vicia faba*.; *Adhatoda vasica*; *Punica granatum*.; *Dalbergia sissoo*; *Ageratum conyzoides*; *Cedrela toona*; *Carissa caranda*.; *Taraxacum officinale* ; *Brassica campestris*.; *Eriobotrya japonica*; *Callistemon citrinus*; *Syzygium cumini*; *Albizzia lebbek*.; *Prunus domestica*.; *Hibiscus rosa sinensis*.; *Salvia* sp.; *Phoenix* sp.; *Psidium gaujava*; *Grewia optiva*.; *Trifolium repens*.; *Rosa moschata*. and *Sechium edule*; *Vitex negundo*. and *Bombax ceiba*. Whereas, important minor and minor pollen types present were: *Allium cepa*.; *Ipomoea batatas*.; *Impatiens balsamina*.; *Pinus roxburghi*.; *Hypericum* sp.; *Foeniculum vulgare*.; *Raphanus sativus*.; *Plectranthus* spp., *Asculus indica* etc.(Fig. 18: A-X)

Among the 90 plants pollen type reported in honey samples collected from different sites, 74 plant pollen types (32 trees, 25 herbs, 12 shrubs and 5 others) shown in table 1 were identified up to genus and species level whereas, rest up to family level. The investigation reveals that all the reported genus and species level pollens belong to 35 families; of which the Fabaceae family contribute highest 12 plant species; followed by Asteraceae family which have 7 plant species; Rosaceae family with 6 plant species; Malvaceae and Myrtaceae family with 4 plant species each; Rutaceae, Brassicaceae and Lamiaceae with 3 plant species each; Meliaceae, Polygonaceae Cucurbitaceae, Sapindaceae and Lytheraceae with 2 plant species each; whereas, 1 plant species each in Acantheceae, Amaryllidaceae, Anacardiaceae, Apiaceae, Apocynaceae, Arecaceae, Bignoniaceae, Bombacaceae, Balsaminaceae, Caricaceae, Chenopodiaceae, Convolvulaceae, Euphorbiaceae, Hypericaceae, Punicaceae, Pinaceae, Pedaliaceae, Proteaceae, Ranunculaceae, Rhamnaceae, Tiliaceae and Verbenaceae. The reported plants were also categorized as per their economic value as ornamental, medicinal, timber, fruits and vegetables etc. Among species level identified plants, 11 were medicinal, 17 were ornamental and so far as wild and cultivated were concern: 22 were wild, 23 were wild as well as cultivated and 29 were cultivated.

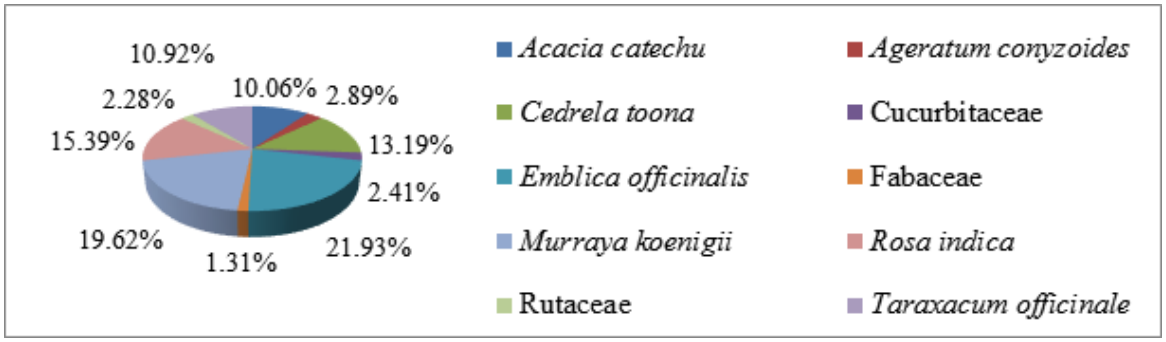

Fig 2: Dehra Honey Frequency

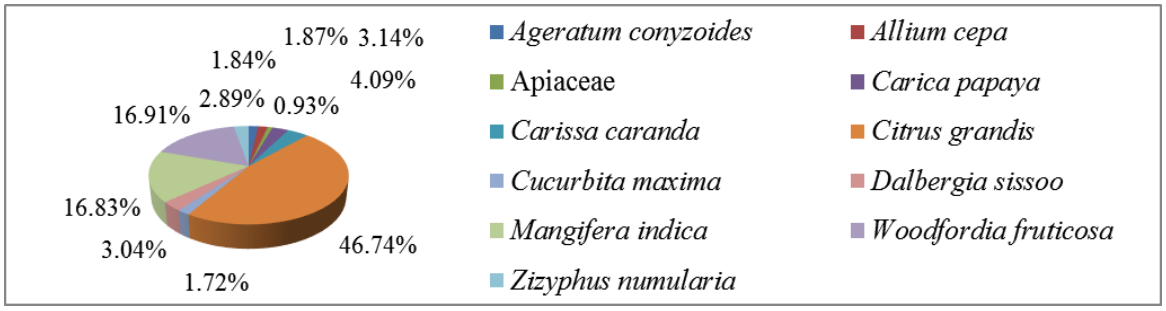

Fig 3: Jwali Honey Frequency

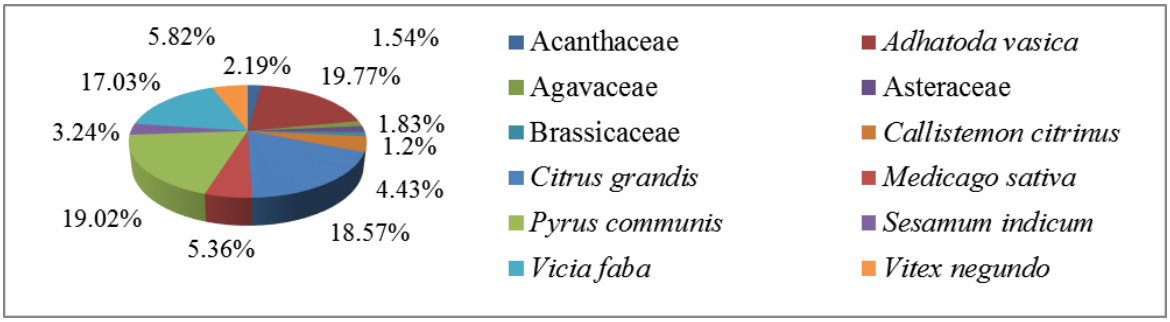

Fig 4: Nagrota Surian Honey Frequency

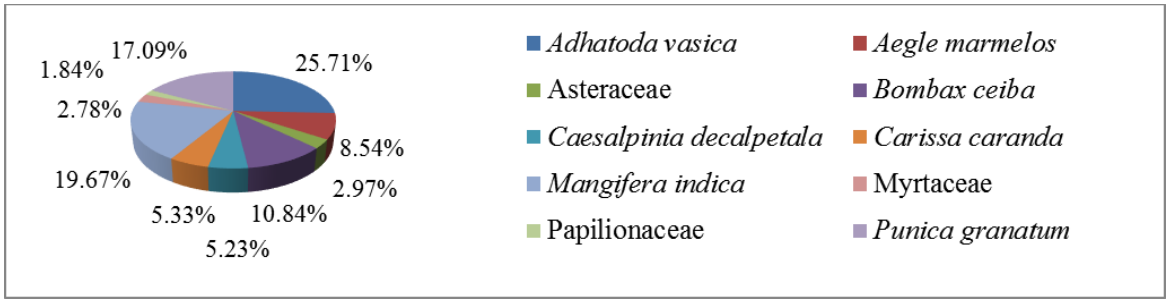

Fig 5: Nurpur Honey Frequency

Fig 6: Jwalamukhi Honey Frequency

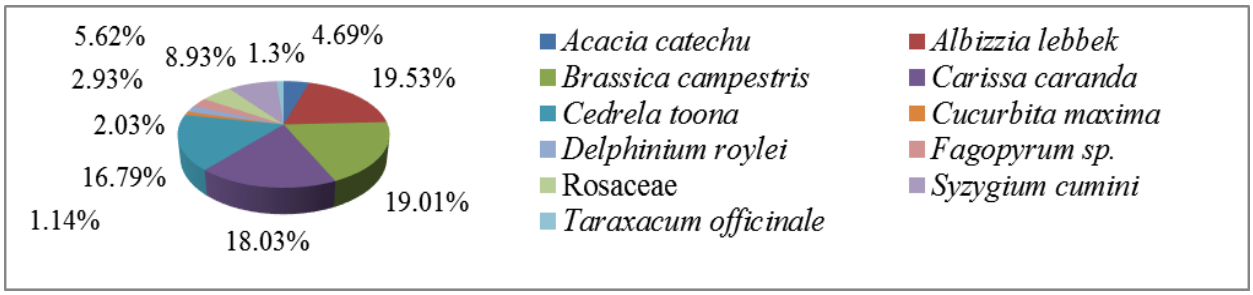

Fig 7: Ranital Honey Frequency

Fig 8: Pragpur Honey Frequency

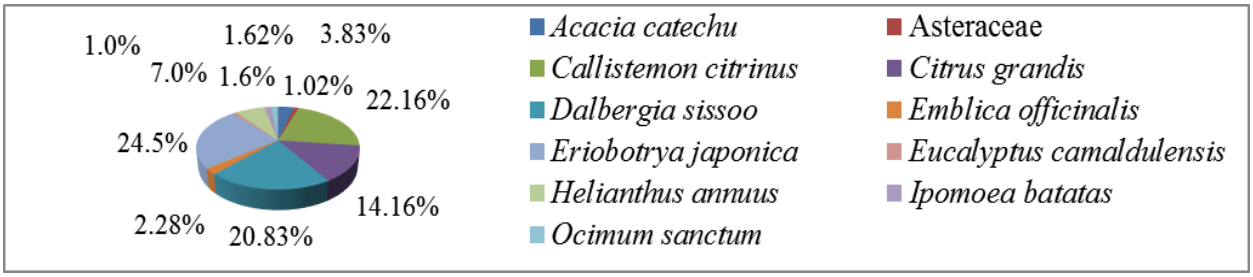

Fig 9: Jaisinghpur Honey Frequency

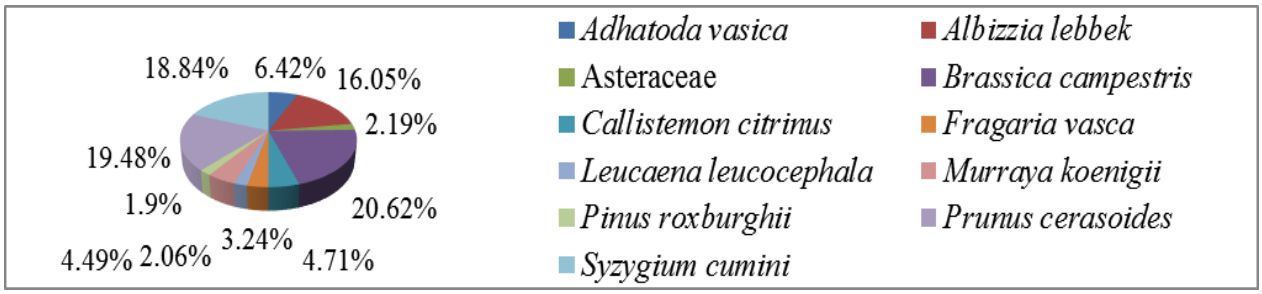

Fig 10: Kangra Honey Frequency

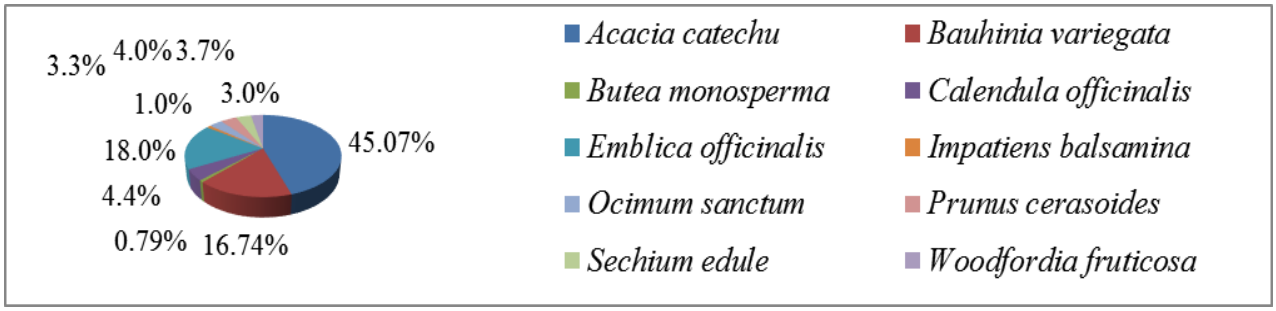

Fig 11: Chadiar Honey Frequency

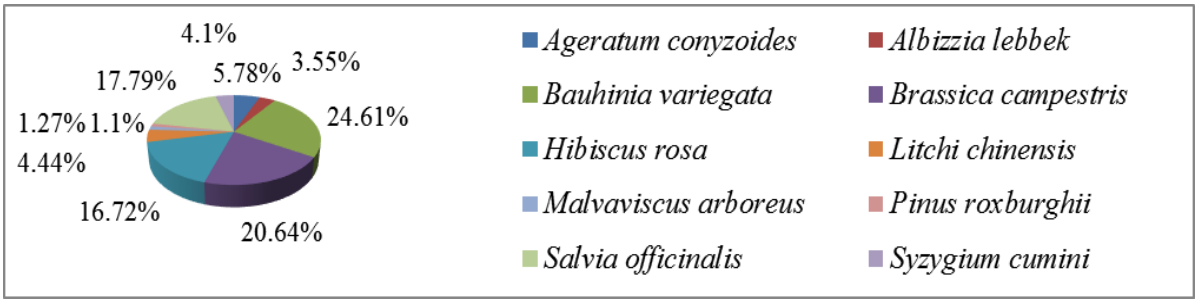

Fig 12: Nagrota Bagwan Honey Frequency

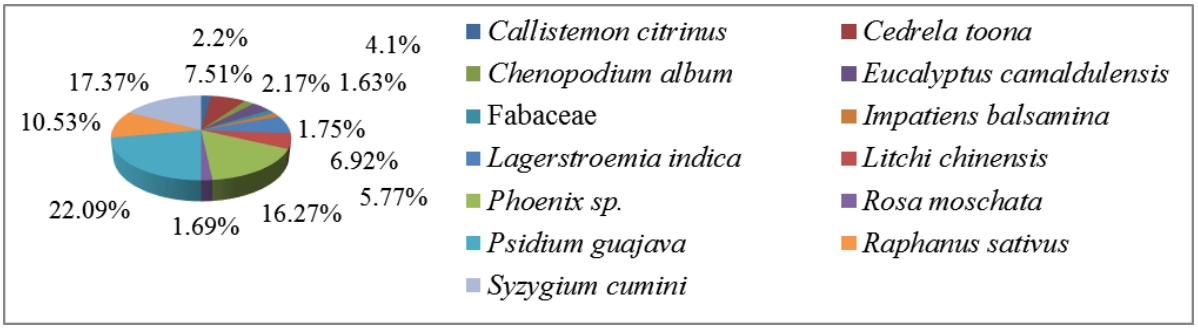

Fig 13: Baijnath Honey Frequency

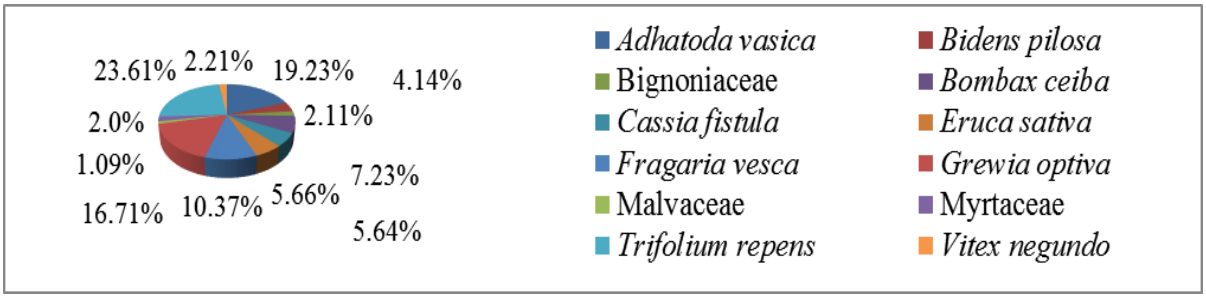

Fig 14: Paprola Honey Frequency

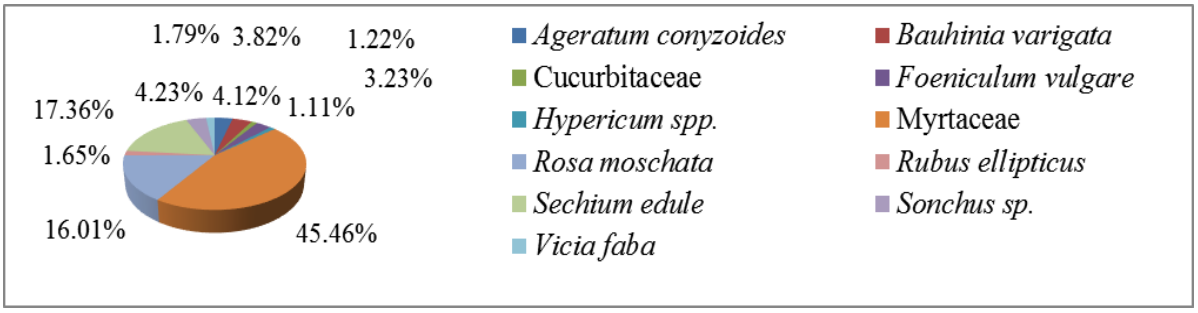

Fig 15: Panchrukhi Honey Frequency

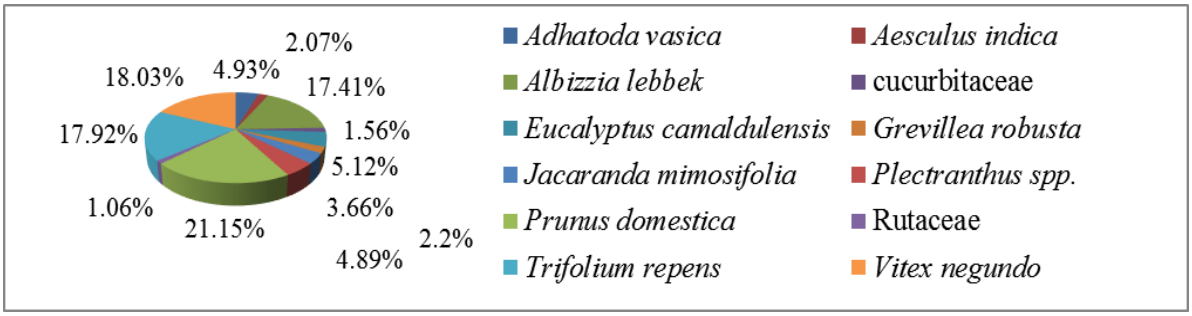

Fig 16: Palampur Honey Frequency

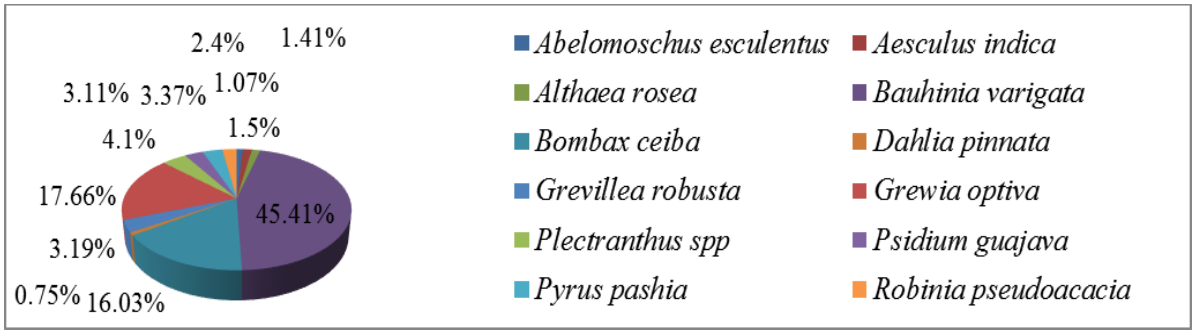

Fig 17: Dharamshala Honey Frequency

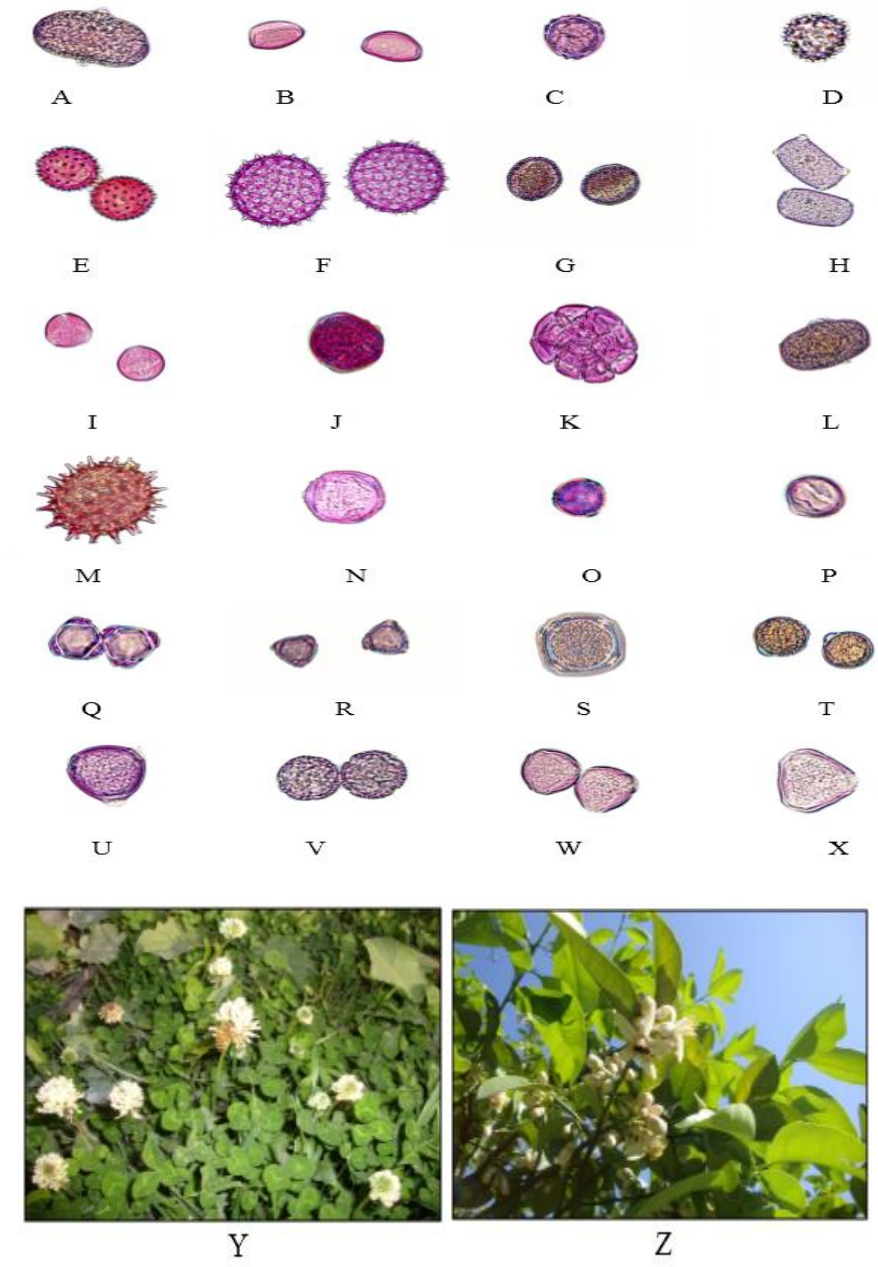

Fig 18: Pollen grain of A) *Adhatoda Vasica*, B) *Allium cepa* L., C) *Carissa caranda* L., D) *Ageratum conyzoides* L., E) *Bidens pilosa* L., F) *Ipomoea batatas* Lam, G) *Brassica campestris* L., H).*Impatiens balsamina* L., I) *Trifolium repens* L., J) *Dalbergia sissoo* Roxb., K) *Albizzia lebbek* Benth., L) *Vicia faba* L., M) *Hibiscus rosa sinensis* L., N) *Lagerstroemia indica* L., O) *Woodfordia fruticosa* (L.) Kurz, P) *Hypericum* spp., Q) *Eucalyptus camaldulensis* Dehn., R) *Callistemon citrinus* (Curt) Skeels, S) *Melia azaderach* L., T) *Punica granatum* L., U) *Murraya koenigii* Spreng, V) *Aegle marmelos* L. Correa, W) *Rosa moschata* Miller, X) *Fragaria vesca* L., Y) *Apis cerana* F. foraging on: *Trifolium repens* L. and Z) *Citrus grandis* (L) Osbeck.

Table 1: Honey Pollen sources almanac for Kangra hills.

Family/Plant species	Family	Common name	Honey yielding capabilitiesss	Flowering period	Distribution	Nature/Economic importance
1	2	3	4	5	6	7
Adhatoda vasica Nees	Acanthaceae	Basuti	N^2P^2	Apr-Nov	Throughout	Shurb(w)
Allium cepa L.	Amaryllidaceae	Onion	N^3P^3	May-Jun	Throughout	Herb, Vegetable(c)
Mangifera indica L.	Anacardiaceae	Mango	N^3P^3	Mar-Apr	Valley & low hills	Fruit tree, Fuel & Timber(c)
Foeniculum vulgare Mill.	Apiaceae	Funnel	N^3P^3	Aug-Sept	Throughout	Herb, Condiment(c)
Carissa caranda L.	Apocynaceae	Karandas	N^2P^2	Apr-May	Throughout	Shrub, preservation(w/c)
Phoenix spp.	Arecaceae	Wild date plam	N^2P^3	May-Jul	Valley & low hills	Shrub, Fruits (w)
Ageratum conyzoides L.	Asteraceae	Ageratum or Goat weed	N^3P^3	Jul-Sept	Throughout	Herb, Ornamental(w/c)
Bidens pilosa L.	Asteraceae	Badi-gumbri	N^3P^3	Jun-Sept	Throughout	Herb(w)
Calendula officinalis L.	Asteraceae	Marigold	N^3P^3	May-Jul	Valley, low & mid hills	Herb, Ornamental(w/c)
Dahlia pinnata Cav.	Asteraceae	Dahlia	N^2P^2	Jul-Jan	Throughout	Herb, Ornamental(c)
Helianthus annuus L.	Asteraceae	Sunflower	N^1P^1	Jul-Sept	Throughout	Herb, Oilseed, Ornamental, Fodder(w/c)
Sonchus spp.	Asteraceae	Sow thistle	N^3P^3	Jun-Oct	Throughout	Herb, Weed(w)
Taraxacum officinale Weber.	Asteraceae	Dandelion	N^1P^1	Mar-Sept	Throughout	Herb, Juicy weed(w)
Impatiens balsamina L.	Balsaminaceae	Pink balsam	N^1P^2	Jul-Sept	Throughout	Herb, Ornamental(c)
Jacaranda mimosifolia D. Don	Bignoniaceae	Jacaranda	N^3P^3	May-Jun	Valley, low & mid hills	Tree, Ornamental(w/c)
Bombax ceiba L.	Bombacaceae	Silk cotton tree	N^1P^1	Feb-Mar	Throughout	Fodder tree, fibre, Timber (w)
Brassica campestris L.	Brassicaceae	Mustard	N^1P^1	Dec-May	Throughout	Herb, Oilseed(c)
Eruca sativa Mill	Brassicaceae	Rocket Salad	N^1P^1	Dec-Mar	Throughout	Herb, Oilseed, Fodder(c)
Raphanus sativus L.	Brassicaceae	Radish	N^1P^1	Feb-Mar	Throughout	Herb,Vegetable(c)
Carica papaya L.	Caricaceae	Papaya	N^1P^1	May	Valley & low hills	Tree, fruit edible (c)
Chenopodium album L..	Chenopodiaceae	White goose foot	N^3P^3	Mar-May and Aug-Oct	Throughout	Herb, Weed,Fodder(w/c)
Ipomoea batatas Lam.	Convolvulaceae	Sweet Potato	N^2P^3	July-Nov	Throughout	Herb,Vegetable, Climber(c)
Cucurbita maxima L.	Cucurbitaceae	Great Pumpkin	N^1P^1	Feb-Apr	Throughout	Climber, Vegetable(c)
*Sechium edule (*Jacq.)Sw.	Cucurbitaceae	Chayote	N^2P^2	Jun- Oct	Throughout	Climber, Vegetable(c)
Emblica officinalis Gaertn.	Euphorbiaceae	Indian Gooseberry	N^2P^2	Mar-May	Valley, low & mid hills	Tree, Medicinal (c)
Acacia catechu (L.f.) Willd.	Fabaceae	Acacia	N^1P^1	Apr-Jul	Valley, low & mid hills	Tree, Timber, Fodder, Fuel (w/c)
Albizzia lebbek Benth.	Fabaceae	Siris	N^3P^3	Apr-May	Valley, low & mid hills	Tree, Timber, Fodder, Fuel (w/c)
Bauhinia variegata L.	Fabaceae	Kachnar	N^2P^3	Feb-Apr	Throughout	Tree, Fodder, Fuel, Vegetable, Ornamental (w)
Butea monosperma (Lam.) Kuntze	Fabaceae	Palas	N^3P^3	May-Sept	Valley, low & mid hills	Tree, Fodder, Fuel, Food for lac insect, Medicinal (w)

Caesalpinia decalpetala (Roth.) Alston	Fabaceae	Kingari	N^2	Feb-Sept	Valley, low & mid hills	Tree Fodder, Medicinal (w)
Cassia fistula L.	Fabaceae	Indian laburnum	N^2P^2	Apr-Jul	Valley, low & mid hills	Avenue tree (w)
Dalbergia sissoo Roxb.	Fabaceae	Sissoo	N^1P^1	Mar-May	Valley, low & mid hills	Tree, Timber, Fodder, Fuel, Shade (w)
Leucaena leucocephala (Lam.) De Wit	Fabaceae	Ipil-Ipil	N^3P^1	May-Oct	Valley& low hills	Small tree, Fodder, Fuel (w/c)
Medicago sativa L.	Fabaceae	Alfalfa	N^1P^2	May-Aug	Throughout	Herb, Fodder (w/c)
Robinia pseudoacacia L.	Fabaceae	Black locust	N^1P^2	Apr-Jun	Throughout	Tree, Fuel, Ornamental, Timber (w/c)
Trifolium repens L.	Fabaceae	White clover	N^1P^1	Apr-Jul	Throughout	Herb, Fodder, Cover crop (w/c)
Vicia faba L.	Fabaceae	Field beans	N^3 P^1	Apr-Aug	Throughout	Crop, Edible, Fodder (w/c)
Hypericum spp.	Hypericaceae	Hypericum	P^1	Apr-Oct	Throughout	Shrub, Twigs used as toothbrush, seed as Condiment for flavoring curry (w)
Ocimum sanctum L.	Lamiaceae	Tulsi	N^2	Apr-Nov	Throughout	Aromatic herb, Medicinal (w/c)
Plectranthus spp.	Lamiaceae	Shain	N^1P^2	Aug-Oct	Mid & high hills	Under shrub (w)
Salvia spp.	Lamiaceae	Red Sage	N^2P^2	Jul-Oct	Throughout	Herb, Medicinal(w)
Lagerstroemia indica L.	Lytheraceae	Pride of India	N^2P^2	Jul-Sept	Throughout	Tree, Timber, Ornamental (w/c)
Woodfordia fruticosa (L.) Kurz	Lytheraceae	Dhawi	N^1P^1	Mar-Apr	Throughout	Shrub, Dye, Medicinal, Fodder, Fuel (W)
Abelmoschus esculentus L.	Malvaceae	Lady's finger	N^2P^2	Jul-Sept	Throughout	Herb, Vegetable (c)
Althaea rosea Cav.	Malvaceae	Hollyhock	N^2P^2	Jul-Oct	Valley, low & mid hills	Herb, Ornamental (c)
Hibiscus rosa sinensis L.	Malvaceae	Chinese Rose	N^2P^2	Mar-Apr	Valley, low & mid hills	Shrub, Ornamental (c)
Malvaviscus arboreus	Malvaceae	Malvaviscus	N^2P^2	Whole Year	Valley, low & mid hills	Shrub, Ornamental (c)
Melia azaderach L..	Meliaceae	Chinaberry	N^2P^3	May-Sept	Valley & low hills	Avenue tree, Forest tree (w)
Cedrela toona Roxb. Ex Rottl. & Willd	Meliaceae	Cedrela	N^1P^2	Mar-Jun	Valley, low & mid hills	Tree, Woody, Furniture (w)
Callistemon citrinus (Curt) Skeels	Myrtaceae	Bottle Brush	N^1P^1	Mar-Oct	Valley & low hills	Tree, Ornamental (c)
Eucalyptus camaldulensis Dehn.	Myrtaceae	Eucalyptus	N^1P^1	May-Jun	Valley & low hills	Avenue tree, Fuel wood, Charcoal,Paper pulp, Termite resistant timber, Medicinal (w/c)
Psidium guajava L.	Myrtaceae	Guava	N^1P^1	May-Jun	Valley, low & mid hills	Tree, Fruit (c)
Syzygium cumini (L.) Alston	Myrtaceae	Jambolan	N^1P^1	Apr-Jun	Valley, low & mid hills	Avenue tree, Fruit (w/c)
Sesamum indicum L.	Pedaliaceae	Sesamum	N^1P^1	Jul-Sept	Throughout	Crop, Oilseed (c)
Pinus roxburghii Sarg.	Pinaceae	Chir	P3	Mar-April	Throughout	Tree (w)
Fagopyrum spp.	Polygonaceae	Buck Wheat	N^1P^2	Jun-Sept	Throughout	Herb, Grain, Fodder (c)
Rumex hastatus D. Don	Polygonaceae	Almor	N^3P^3	Jun-Oct	Throughout	Herb (w)

Grevillea robusta A. Cunn. Ex. R.Br.	Proteaceae	Silky Oak	N^1P^1	Apr-May	Valley, low & mid hills	Avenue tree, Timber, Ornamental (c)
Punica granatum L.	Punicaceae	Pomegranate	N^2P^1	Apr-May	Valley, low & mid hills	Tree, Fruit (c)
Delphinium roylei Munz.	Ranunculaceae	Larkspur	N^3P^3	Mar-May	Valley, low & mid hills	Herb, Ornamental (c)
Zizyphus jujuba Mill.	Rhamnaceae	Chinese date	N^1P^3	Jul-Sept	Valley, low & mid hills	Tree,Fruit,Fodder, Oilseed (w/c)
Eriobotrya japonica Thunb. Lindley	Rosaceae	Loquat	N^1P^1	Feb-Mar & Sept-Oct	Valley, low & mid hills	Fruit tree (c)
Fragaria vesca L.	Rosaceae	Strawberry	N^2P^2	May-Sept	Mid & high hills	Herb, Fruit, Ornamental (c)
Prunus domestica L.	Rosaceae	Plum	N^2P^1	Feb-Mar	Mid & high hills	Fruit tree (c)
Pyrus pashia Buch-Ham. Ex D. Don	Rosaceae	Wild Pear	N^2P^2	Feb-Mar	Mid & high hills	Fruit tree (w)
Rosa moschata Miller	Rosaceae	Wild Rose	N^3P^1	Apr-Jun	Throughout	Shrub, Ornamental (w/c)
Rubus spp.	Rosaceae	Berries	N^2P^2	Apr-Jun	Throughout	Shrub, Climber, Hedges, Fruit (w/c)
Aegle marmelos L. Correa	Rutaceae	Bel	N^2P^2	Mar-June	low & mid hills	Edible, Medicinal (w)
Citrus grandis (L.) Osbeck	Rutaceae	Pumelo	N^1P^1	Mar-Apr	Throughout	Fruit tree(c)
Murraya koenigii Spreng	Rutaceae	Curry leaf plant	N^2P^2	Mar-Apr	Valley, low & mid hills	Shrub, Medicinal (w/c)
Aesculus indica Colebr.	Sapindaceae	Horse Chestnut	N^1P^1	May-Jun	Mid & high hills	Tree,Timber, Fodder, Medicinal (w/c)
Litchi chinensis Sonner	Sapindaceae	Litchi	N^1P^1	Feb-Mar	Valley, low & mid hills	Fruit tree (c)
Grewia optiva Dumm. Ex Burret	Tiliaceae	Beol or Bhemal	N^1P^1	May-Jul	Throughout	Tree, Fruit, Fodder, Timber (w/c)
Vitex negundo L.	Verbenaceae	Indian privet	N^1P^2	May-Jun	Throughout	Shrub, Insect repellent, Medicinal (w)

N^1 = Major nectar source P^1 = Major pollen source
N^2 = Medium nectar source P^2 = Medium pollen source
N^3 = Minor nector souce P^3 = Minor pollen source
W = Wild Throughout = Valley, low, mid & high hills
C = Cultivated

4. Discussion

Kangra area with diverse climatic conditions become rich in vegetative diversity, this multi vegetation was conformed as pollen analytical studies of honeys samples shows 12 out of 16 samples were multifloral [27, 28] and rest were unifloral, it was mainly attributed due to apiary location at particular area, availability of specific vegetation and Floral Fidelity [29]. Uniflorality and multiflorality of honey samples were also recorded in honey of northwest and northeast Himalayan region [15, 24, 30].

Present study shows *Acacia* sp., *Bauhinia* sp. and *Citrus* sp. as predominant pollen source in honey samples. *Acacia* sp. were also predominant pollen source in Malaysian honey[31] and as important source in Dharwad, Karnataka [32]; *Bauhinia* sp. was also reported as important minor pollen source from Kamrup district Assam [33] and as medium source in different parts of Northeast Himalaya and Indo-gangetic plains [13, 22] similarly, *Citrus* sp. was reported as important minor pollen source in Garhwal Himalayas [34] and as major pollen source in Punjab and adjoining areas [35, 36, 37].

The honey samples from Kangra hills contained both entomophilous and anemophilous pollen types. The anemophilous types were: *Psidium* sp., *Pinus* sp. and Poaceous members whereas, all other morphotypes recorded in various honey samples were of entomophilous types [38]. Beside this, honey pollen analysis also indicate that minor percentage of pollen from plants blooms in autumn season may be due to; sticking of pollen to old comb and its extraction in next season [39] or due to small variation in the flowering period in some region.

These studies also revealed that honeys from Kangra hills fall under category of Group 1 to Group 3 formed by International Commission for plant bee relationship i.e. honeys having absolute pollen count from 10,000 to 50,000/ 10gm of honey[26].

5. Conclusion

This study concluded that Kangra hills have diverse flora available for honeybees, as most of the honey samples were multifloral. Predominant pollen source: *Citrus* sp., *Acacia* sp.

and *Bauhinia* sp. were considered as major nectar and pollen source to honeybees. Similarly, secondary and important minor sources also provides significant amount of nectar and pollen. Family Fabaceae was the highest contributor of different pollen types followed by Asteraceae, Rosaceae, Malvaceae, Myrtaceae, Rutaceae etc. Therefore, this voluminous availability of flora in Kangra hills advocate the wide scope for local farmers and orchardist to get involve in multi dimensional agriculture, by practicing beekeeping, agriculture and horticulture simultaneously. This study is quite useful for forest department and general public, as it provides them information to conserve and maintain the valuable bee flora. It is also useful for new entrepreneur who want to establish plant based industries.

This study indirectly can also be helpful for the government to frame its policies of: afforestation; employment generation programmes; skill development initiatives and rural development. It will help us, to create flora of multipurpose nature which will boost the beekeeping on large scale, to provide part-time or full time employment in rural areas of hilly states, to improve rural economy through enhancing the monetary and self-employment opportunities.

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