Bee Flora and floral calendar of honey bees in dry land regions of northern Karnataka

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Abstract
The present investigation was conducted to study the diversity of bee flora which includes both nectariferous and polleniferous plants and also to develop a floral calendar for Haveri districts. The study revealed that in Haveri district, 75 plant species were useful to honeybees. Out of which nineteen species of vegetables, fruits (13), field crops (15) and plantation, flower and ornamental crops and other plants constituted fifteen species and medicinal plants (13). The identified flora was further grouped into pollen, nectar and both pollen and nectar yielding plants. Out of 75 crops, there were 16 species of nectar yielding plants, pollen (12) and both pollen and nectar were 44species. The peak periods of honeybee foraging activity (honey flow period) were recorded during June–October of winter season and January to March of summer season of the year. During the honey flow period (June–October), abundant bee floral plants were found blossoming and plants species were recorded as source of food for honeybees. Based on the availability, utility status and flowering duration of flora, floral calendar was developed for the study area.

Keywords: Bee flora, beekeeping, honey flow period, dearth period, floral calendar

Introduction
Bees are dependent on flowering plants as they provide food in the form of pollen and nectar. Similarly, plants are also depending on bees for pollination. This mutual interdependence of insects and plants increased their coevolution [1]. The flowering plants of many plant families are blooming at different time periods and seasons of the year. Pollen and nectar availability to foraging bees varied with time of the season and flowering periods of different plants species. The blooming period does not commence simultaneously in all the bee flora attending in the main honey-flow season. Climatic factors, soil parameters, habitat of vegetation, the time of blooming may change even in the same nectar plant [2]. The types of honey harvest not similar in all the ecosystems and regions of a country because honey plants are not similar in all the ecosystems as they are restricted to particular climatic conditions. Flowers are main resources for successful apiculture and bee’s life. Flower period and major blooming time the information is very prime important for successful apiculture. Since beekeeping includes multi approach as it includes agri-horticultural and forest based industry and nowadays it is of great importance for farmers with respect to their pollination services in improving the Agri-Horticultural productivity and other useful bee products. By spending little investment beekeeping can be practiced to get maximum subsidiary income along with other routine agricultural activities. Successful Beekeeping is not only depends on the good strain of honeybees but it also depends on bee floral availability i.e., pollen and nectar sources within the surrounding area of an apiary [3]. The present study has been undertaken to study the bee-flora in dry land region of northern Karnataka in particularly Haveri district for determining the honey and pollen flow seasons and also develop floral calendar of the different plants existing in and around the study area

Materials and Methods
The study area of Haveri (14°47’36″ N, Lat: 75°24’16″ E Long, 576 m aslm) is selected for studying bee-flora and floral calendar during 2009-2011. The average annual rainfall of Haveri districts was 625mm. For the purpose of collection of data,
25 km radius area was marked in which 20 study sites were selected. Observations were recorded during flowering periods of principal crops of that are visited by worker bees of different plant groups viz., vegetable cops, fruit crops, field crops, plantation, flower, medicinal and ornamental plants.

Identification of bee-flora: Field data were collected through monthly visits to the study sites, during 2010-2011. Each study visit served as pseudo replicates for the site and all observations were observed between 0700-1730 hours. The study included observations of activities of bees on flowers of different plant species whenever bees were found on the flowers of such plants, their foraging behavior was observed for a period of 10 minutes. If the success of any foraging attempt was ascertained, the plant was scored as bee foraging species if at least three (3) honeybees visited the flowers simultaneously within 10 minutes of the observations. The observations on nectar and pollen source were based on activities performed by honeybees on different flowers observed by using Binoculars (Nikon 8x42 Aculon Camo). Honey bees with activity of extending their proboscis into the flowers was considered as nectar source and bees carrying pollen on their hind legs were determined as pollen source. Honey bees with activity of extending their proboscis into the flowers and also collecting pollen on their hind legs were determined as nectar and pollen yielding plants. Based on frequency visitation of worker bees to a flower, forage value was established as low and high nectar and pollen rich plant. Such plants were identified using the books in situ. If the plants were recorded as bee foraging species at particular site and later encountered in subsequent surveys on the other sites; it was only scored for presence of bees. Plants that could not be identified in the field their portion or twig of a branch with necessary botanical features like leaves, flowers and portion of stem were cut and arranged in herbarium, identified with the help of Botanist from UAS, Dharwad and compared with the published reports. The observations were recorded for three seasons during 2009-2011. A complete chronological record of flowering periods of plant species was made during the survey. The data recorded in field’s notebooks was compiled into annual floral calendar and was also used to prepare honey flow and dearth periods (Methodology used as followed by Wayker et al., 2014) [4].

Results and Discussion

Bee flora and floral calendar were documented under field conditions at Haveri districts. The field observations were recorded during 2009-2011. This basic information is required to time the pesticide application without causing any inimical effects on the pollinators. A complete chronological record of flowering periods of all plant species was made. The results are presented in Tables 1-4 and the floral calendar has considerably facilitated the standardization of routine management practices in apiaries. The districts has number of Agricultural, Horticultural, forest and weed plants and their distribution, blooming period, honey flow time in the confined area is very essential and important tool in predicting the pollen and nectar flow periods for successful beekeeping. The thorough knowledge of flowering season and time duration are important factors for sustainable management of bee colonies and for good honey harvest. The flowering duration of any particular locality will also helps the beekeeper in migratory beekeeping practice also. The present findings revealed that, in Haveri district, 62 plant species were useful to honeybees, out of which vegetables (19), fruits (13), field crops (15) and plantation, flower and ornamental crops and other plants (15) and medicinal plants (13) identified and found in the study area. The identified flora was further grouped into pollen, nectar and both pollen and nectar yielding plants (Tables 1-4) out of 55 crops, nectar (16), pollen (12) and both pollen and nectar (34) yielding plants

Among the 19 vegetables there were few plants viz., Bhendi, Bottle guard and Pumpkin those served as both nectar and pollen sources. Similarly among the fruit crops (13) majority viz., citrus, ber, custard apple, banana, guava etc served as both nectar and pollen source where as rose apple, guava, banana, coronda, sweet lime, ber, custard apple are the source low pollen yielders. Among field crops (15) sunflower, blackgram, chickpea, groundnut, maize, niger and castor served as both nectar and pollen source. Similarly in plantation, flower and ornamental crops (15), antagonum served as both nectar and pollen sources. And medicinal plants (10) both served as pollen and nectar sources (Table 1 to 4).

Honey flow and dearth period

In Haveri district the honey-flow and dearth periods were determined and results are summarized in Tables 1-4. The peak periods of honeybee foraging activity (honey-flow period) were recorded during June-October of winter season and January to March of summer season of the year. During the honey-flow period (June-October), abundant bee floral plants were found blossoming and plants species were recorded as source of food for honeybees.

Major nectar-rich plants included viz., Beans Phaseolus vulgaris, Mung bean Vigna radiate, Cluster bean Cyamopsis tetragonolobus, Bitter gourd Momordica charantia, Mango Mangifera indica, Black gram Vigna mungo, Chickpea Cicer arietinum, Pigeon pea Cajanus cajan, Mustard Brassica rapa, Beans Dolichus lab lab, Cow pea Vigna spp., Pongemia Pongamia pinnata, Bajra Pennisetum tyhoides

Pollen rich plants viz., Brinjal Solanum melongena, Tomato Lycopericon esculentum, Chilli Capsicum spp., Cucumber Cucumis sativus, Musk melon Cucumis melo, Water melon Citrullus lanatus, Rajgiri/ Amaranthus Amaranthus gracilis, Groundnut Arachis hypogaea, Maize Zea mays, Mesta Hibiscus subtrattensis and Coconut Cocos nucifera.

Both nectar and pollen rich plants viz., Bhendi Abelmoschus esculentus, Bottle gourd Lagenaria siceraria, Pumpkin Cucurbita pepo, Onion Allium cepa, Drumstick Moringa oleifera, Ridge gourd Luffa acutangula, Pea Psium sativum, Snake gourd Trichosanthes anguina, Citrus Citrus limon, Ber Ziziphus jujube, Custard apple Annona squamosa, Papaya Carica papaya, Caronda (Kavale) Carissa carandas, Banana Musa sp., Gauva Psidium guajava, Rose apple Syzygium jambos, Sunflower Helianthus annuus, Sesame Sesamum indicum, Niger Guizotia abyssinica, Paddy Orzya sativa, Castor Ricinus communis, Cotton Gossippium spp., Tamarind Tamarindus indicus, Neem Azadirachta indica, Antigonon Antigonon leptopus and other bee-flora of the region supported honey production. The flowering plants of an area having good value as bee pasture are necessary to maintain bee colonies. Honey bees foraged on these plants extensively for honey production.

Both nectar and pollen Medicinal plants identified were, Moringa oleifera, Ricinus communis, Tamarindus indicus, Azadirachta indica, Ocimum sp, Butea monosperma, Murraya koeingi, Melia dubia, Mimosa pudica, Solanum nigrum, Echinops echinatus, Tylophora asthmatica, Mesua
furea, Butea monosperma, and other bee floras of the region supported honey production. The flowering plants of an area having good value as bee pasture are necessary to maintain bee colonies. Honeybees visited these plants extensively for honey production and colony multiplication. (Table. 1-4) Summer season was critical dearth period with high temperature (over 35 °C), scarcity of water and very few species are in blooming. The few cultivated plants like Moringa oleifera, Cucumis melo, Psidium guajava, Phyllanthus niruri, Coriandrum sativum, Vigna aconitifolia, Arachis hypogaea, Punica granatum, Pennisetum typhoides and wild plants like Azadirhacta indica, Cassia tora, Trichard procumbens, Antigonum leptopes (creeper) were in bloom during the season. However, their numbers per unit area was less or having lesser quantity of pollen or nectar. Hence they during the season. However, their numbers per unit area was less or having lesser quantity of pollen or nectar. Hence they provide minor nutritional requirements to the bee colony, these minor food sources are utilized by bees during the scarcity of major bee flora. Because of high temperature and scarcity of water resources in dry lands for flowering plants, this period was found unfavorable for foraging of honeybees and large-scale management of apiary. The present findings supported by (Dalio, 2012) and Kumar. et al., (2013) during dearth period when agro-horticultural crops are not in blooming, then weeds and wild flowering plants were observed as alternate food source for honeybees and higher temperature and scarcity of water resources for flowering plants unfavorable for bee foraging. The present findings are also supported by Bisht and Pant (1968) reported that A.cerana gathered pollen throughout the year under Delhi conditions. The higher pollen gathering activity was recorded during January-March where as May and June was the period of lesser activity. Similarly Venkatachalapathi et al., (2013) documented 66 species of medicinal plants which are potential forages of honey bees in Walayar Valley of Coimbatore district in Western Ghats. Present findings also in conformity with the records of Sivaram, (2001) recorded 192 plant species in southern Karnataka during 1993-1999. These plant species includes medicinal, fruit, ornamental, vegetable, pulses and spice crops and also documented that flowering duration of bee plant provided to know the peak blooming period by the beekeeper

| Sl. No. | Common name | Botanical name | Family | Flowering period | Bee forage value |
|--------|-------------|----------------|--------|------------------|-----------------|
|        |             |                |        |                  | Nectar | Pollen | Nectar + Pollen |
| Vegetables |
| 1. | Brinjal | Solanum melongena | Solanaceae | Jan to March, June to July. | - | P2 | - |
| 2. | Tomato | Lycopersicon esculentum | Solanaceae | Jul-Sep | - | P1 | - |
| 3. | Chili | Capsicum sp. | Solanaceae | Jul-Feb | - | P2 | - |
| 4. | Bhendi | Abelmoschus esculentus | Malvaceae | Aug – Nov | - | - | P1N2 |
| 5. | Beans | Phaseolus vulgaris | Fabaceae | Dec-Feb | N2 | - | - |
| 6. | Bottle gourd | Lagenaria siceraria | Cucurbitaceae | Oct – Feb. | - | - | N2P2 |
| 7. | Cucumber | Cucumis sativus | Cucurbitaceae | Aug – Oct. | - | P1 | - |
| 8. | Musk melon | Cucumis melo | Cucurbitaceae | March – May. | - | P1 | - |
| 9. | Pumpkin | Cucurbita pepo | Cucurbitaceae | Aug – Oct. | - | - | N2P2 |
| 10. | Water melon | Citrullus lanatus | Cucurbitaceae | July – Aug. | - | P1 | - |
| 11. | Onion | Allium cepa | Liliaceae | Jun– Aug. | - | - | P1N2 |
| 12. | Drumstick | Moringa oleifera | Moringaceae | Nov – Feb. | - | - | N1P2 |
| 13. | Ridge gourd | Luffia acutangula | Cucurbitaceae, | July – Oct. | - | - | N1P1 |
| 14. | Mung bean | Vigna radiata | Fabaceae | Aug – Sep. | N2 | - | - |
| 15. | Pea | Pisum sativum | Fabaceae | Aug- Sep. | - | - | N1P1 |
| 16. | Cluster bean | Cyanopsis tetragonolobus | Leguminosae | Jun - Aug. | N2 | - | - |
| 17. | Rajgri/ Amaranthus | Amaranthus graecus | Amaranthaceae | Feb-Mar | - | P1 | - |
| 18. | Bitter gourd | Momordica charantia | Cucurbitaceae | Aug-Oct | N2 | - | - |
| 19. | Snake gourd | Trichosanthes anguina | Cucurbitaceae | Jan-Mar | - | - | P2N2 |

Table 1: Nectariferous / polleniferous bee flora and floral calendar in vegetable crops at Haveri district

| Sl. No. | Common name | Botanical name | Flowering period | Bee forage value |
|--------|-------------|----------------|------------------|-----------------|
|        |             |                |                  | Nectar | Pollen | Nectar + Pollen |
| Fruit crops |
| 1. | Citrus | Citrus limon | Rutaceae | Oct – Jan, July – Sep. | - | - | N2P1 |
| 2. | Mango | Mangifera indica | Anacardiaceae | Dec- Jan | N2 | - | - |
| 3. | Ber | Ziziphus jujuba | Rhamnaceae | July – Oct. | N2 | - | - |
| 4. | Custard apple | Annona squamosa | Annonaceae | Aug – Oct. | - | - | N1P2 |
| 5. | Papaya | Carica papaya | Caricaceae | May-June | N2 | - | - |
| 6. | Caronda (Kavale) | Carissa carandas | Apocynaceae | Mar-Apr | - | - | P2N2 |
| 7. | Water melon | Citrullus lanatus | Cucurbitaceae | Sep-Oct | P1 | - | - |
| 8. | Banana | Musa sp. | Musaceae | Jan-Dec | - | - | P2N2 |
| 9. | Gauva | Psidium guajava | Myrtaceae | Mar-Jun | - | - | P2N1 |
| 10. | Rose apple | Syzygium jambos | Myrtaceae | Mar-Jun | - | - | P2N1 |
| 11. | Sapota | Manilkara achras L. | Sapotaceae | Mar-Jun | N1 | P1 | - |
| 12. | Amla | Phyllanthus niruri | phyllantaceae | April-may | - | - | P2N2 |

Table 2: Nectariferous / polleniferous bee flora and floral calendar in fruit crops at Haveri district

| Sl. No. | Common name | Botanical name | Flowering period | Bee forage value |
|--------|-------------|----------------|------------------|-----------------|
|        |             |                |                  | Nectar | Pollen | Nectar + Pollen |

N1 = Low nectar yield N2 = High nectar yield "-"= absent
P1 =Low pollen yield P2 = High pollen yield

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Table 3: Nectariferous / polleniferous bee flora and floral calendar in field crops at Haveri district

| Sl. No. | Common name       | Botanical name     | Family      | Flowering period | Bee forage value |
|---------|-------------------|--------------------|-------------|------------------|------------------|
|         |                   |                    |             |                  | Nectar | Pollen | Nectar + Pollen |
| 1       | Sunflower         | Helianthus annuus  | Compositae  | March – April.   | -      | -      | -              |
| 2       | Black gram        | Vigna mungo        | Fabaceae    | Aug – Sep.       | N2     | -      | -              |
| 3       | Chickpea          | Cicer arietinum     | Fabaceae    | Dec – March.     | N2     | -      | -              |
| 4       | Ground nut        | Arachis hypogaea   | Fabaceae    | July - Oct, April – June. | -      | P2     | -              |
| 5       | Pigeon pea        | Cajanus cajan      | Fabaceae    | July – Sep.      | N2     | -      | -              |
| 6       | Sesame            | Sesamum indicum    | Pedaliaceae | July – Aug.      | -      | -      | NIP2          |
| 7       | Maize             | Zea mays           | Poaceae     | Aug – Sep, Feb – March. | -      | P2     | -              |
| 8       | Mustard           | Brassica rapa      | Brassicaceae | Jan – March.     | N1     | -      | -              |
| 9       | Mesta             | Hibiscus sעותטריסטי | Malvaceae   | Aug-Nov          | -      | P2     | -              |
| 10      | Niger             | Guzotia abyssinica | Asteraceae  | Sep-Nov          | -      | -      | N1P1          |
| 11      | Paddy             | Oriza sativa       | Poaceae     | Aug-Sep          | -      | -      | P2N1          |
| 12      | Castor            | Ricinus comunis    | Euphorbiaceae | Feb-Apr | -      | -      | P2N2          |
| 13      | Lab lab           | Fabaceae           |             | Jan-Dec          | N1     | -      | -              |
| 14      | Cotton            | Gossipium spp.     | Malvaceae   | Sept-Jan         | -      | -      | P2N2          |
| 15      | Cow pea           | Vigna spp          | Leguminiaceae | Jan-Dec          | N2     | -      | -              |

N1 = Low nectar yield N2 = High nectar yield P1 = Low pollen yield P2 = High pollen yield

Table 4: Nectariferous / polleniferous bee flora and floral calendar in plantation, flower, ornamental and medicinal crops at Haveri district

| Sl. No. | Common name           | Botanical name   | Family       | Flowering period | Bee forage value |
|---------|-----------------------|------------------|--------------|------------------|------------------|
|         |                       |                  |              |                  | Nectar | Pollen | Nectar + Pollen |
| 1       | Coconut               | Cocos nucifera   | Arecales     | Jan-Dec          | -      | -      | P1             |
| 2       | Tamarind              | Tamarindus indicus | Fabaceae   | Apr-Jun          | -      | -      | P2N1          |
| 3       | Pongemia              | Pongamia pinnata | Fabaceae    | Feb-Apr          | N1     | -      | -              |
| 4       | Neem                  | Azadirbacta indica | Meliaceae | Mar-Apr          | -      | -      | P1N1          |
| 5       | Oil palm              | Elaeis guineensis | Arecaceae  | Throught Year    | -      | -      | P2N2          |
| 1       | Antigonum             | Antigonum leptopus | Polygonaceae | Apr-May          | -      | -      | P1N2          |
| 2       | Marigold              | Tagitus spp      |             |                  | -      | -      | -              |

Flower and ornamental plants

| Sl. No. | Common name           | Botanical name   | Family       | Flowering period | Bee forage value |
|---------|-----------------------|------------------|--------------|------------------|------------------|
| 1       | Tulasi                | Ocimum sp.       | Lamiaceae    | Jan-Dec          | -      | -      | P3N1          |
| 2       | castor                | Ricinus communis | Euphorbiaceae | Feb-Apr          | -      | -      | P2N2          |
| 3       | Neem                  | Azadirbacta indica | Meliaceae | Mar-Apr          | -      | -      | P1N1          |
| 4       | Drumstick             | Murraya koenigii | Rutaceae    | Apr-Jun          | -      | -      | P2N2          |
| 5       | Tamarind               | Tamarindus indicus | Fabaceae | Apr-Jun          | -      | -      | P1N1          |
| 6       | Tulasi                | Ocimum sp.       | Lamiaceae    | Jan-Dec          | -      | -      | P3N1          |
| 7       | Brahma Dande          | Echinos echinatus | Asteraceae  | Through Year     | -      | -      | N2P1          |
| 8       | Aadumuttada balli     | Tylophora asthmatica | Apocynaceae | March-Jul        | -      | -      | P2N1          |
| 9       | Nagalinga             | Mesua jurea      | Calophyllaceae | March-May        | -      | -      | P1N1          |
| 10      | Bael                  | Aegle marmirose  | Rutaceae     | Nov-Dec          | N1     | P2     | -              |
| 11      | Muttlaka              | Butea monosperma | Papilionaceae | Jan-Marh         | -      | -      | P1N1          |
| 12      | Dodaggono soppu       | Portulaca oleracea | Portulacaee | Jan-Feb          | P2     | -      | -              |
| 13      | Womens tongue tree    | Albijia lebeck   | Fabaceae     | April-May        | -      | -      | P2             |

N1 = Low nectar yield N2 = High nectar yield P1 = Low pollen yield P2 = High pollen yield

Conclusion: Bee flora and floral calendar was documented under field conditions at Haveri districts. This basic information is required to time the pesticide application without causing any inimical effects on the pollinators. The results revealed that in Haveri district, 62 plant species were useful to honeybees, of which vegetables (19), fruits (13), field crops (15) and plantation, flower and ornamental crops and other plants (15) identified and found in the study area. The identified flora was further grouped into pollen, nectar and both pollen and nectar yielding plants out of 62 crops, nectar (16), pollen (12) and both pollen and nectar yielding plants (34).

Honey flow and dearth period

In Haveri districts the honey flow and dearth period was determined and the peak periods of honeybee foraging activity (honey flow period) were recorded during June–October of winter season and January to March of summer season of the year. During the honey flow period (June–October), abundant bee floral plants were found blossoming and plants species were recorded as source of food for honeybees. Summer season was critical dearth period with high temperature (over 35 °C), scarcity of water and few flowering plants during this period weeds and wild flowering plants were served as alternate food source for honeybees.

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