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Diversity of nectariferous and polleniferous bee flora and floral calendar of honey bees in dryland regions of Koppal District

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Abstract

The present investigation was conducted to study the diversity of nectariferous and polleniferous bee flora and to develop a floral calendar for Koppal district. The flowering plants were visited and observed for the presence and foraging activities of honeybees. Plants were scored as bee foraging species when at least three honeybees had visited to the flowers within the period of 10 minutes. The identified bee flora comprises visited by worker bees of different plant groups viz., vegetable crops, fruit crops, plantation, aromatic, ornamental plants and medicinal plants etc. The identified flora was further grouped into pollen, nectar and both pollen and nectar yielding plants. Out of, 84 plant species were useful to honeybees, among vegetables (19), fruits (15), plantation (3) aromatic and ornamental crops (9) and medicinal plants (38) respectively were identified and found in the study area. The identified flora was further grouped into pollen, nectar and both pollen and nectar yielding plants. Nectar source (7), pollen (17) and both pollen and nectar (59) yielding plants respectively. It was observed that Mid-December to February and mid-July to September were identified as honey flow periods and mid-April to mid-June were the critical dearth periods during investigation. 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

Honeybee and plant have a special symbiotic association. The awareness to maintain the existing bee flora and multiplication of plant species is important for its sustainability. Plant types and their flowering duration differ from one place to another due to variation in geography and environmental conditions. The extensive understanding on type, density and value of bee flora are the significant factors for effective bee keeping. Each range has its own honey flow and floral dearth periods of short and long duration. Honeybees are entirely depends upon flowering plants for their food requirements. Nectar is the sweet liquid comes from floral and extra floral resources; and is the raw material for honey while pollen is highly proteinaceous food for bees. The plants that yield both these substances are collectively referred as "bee pastures" (Abrol, 1997) [1]. If the nectar yield is abundant from a good number of plants of a particular species is called "major honey flow period" on the hand collection of small amount of nectar is known as "minor honey flow period" while "dearth period" is no honey flow period [Atval, 2000]. As nectar and pollen plants are basic requirements for beekeeping and honey production their knowledge is essential for beekeepers. Bee forage plants may be fruits, vegetables, ornamental plants, crops, medicinal plants, herbs, shrubs, bushes, trees, forest and weeds (Abrol, 1997; Kumar *et al.* 2015) [1]. The knowledge of foraging behaviour of honeybees and their flora is essential for management of beekeeping (Dalio, 2013) [5].

Bee forage calendar for beekeeping is a period that indicates the approximate date and the duration of the blossoming period of the existing honey or pollen plants in an area. In addition to the time and duration of blossoms of honey plants, it also involves the mapping of density, distribution, and honey potential of the regional bee flora. The bee forage calendar is one of the most useful tool in the sector of the apicultural operations which requires complete

observation of the seasonal changes in the floral patterns of an area, the foraging behavior of the bees, and the manner in which the honeybee colonies interact with their floral surroundings.

Hence, an investigation on study of bee flora and floral calendar of honey bees in Koppal districts was undertaken.

Material and Methods:

The study area of Koppal situated on 15° 09' 16° 03' north latitude and 75° 47' and 76° 48' east longitude and 529 m from msl which was selected for studying bee-flora and floral calendar during July 2016 to June 2017. The average annual rainfall of Koppal districts 582 mm, for the purpose of collection of data 25 km radius being representatives of 20 study sites were selected. Observations were recorded during flowering periods that are visited by worker bees of different plant group's viz., vegetable crops, fruit crops, plantation, aromatic, ornamental and medicinal plants

Identification of bee-flora: Field data were collected through monthly visits to the study sites, 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 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. Honeybees with their activity of extending their proboscis into the flowers are considered as nectar source and bees carrying pollen on their hind legs were determined as pollen source. Honeybees with their 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 bee to a flower, forage value 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 survey on the other sites; it was only scored for presence. Plants that

could not be identified in the field their portion or twig of a branch with necessary botanical features like its leaves, flower and portion of stem were cut and arranged in herbarium, identified with the help experts and compared with the published reports. The observations were recorded for three seasons.

A complete chronological record of flowering periods of the plants species was made during the survey. The data recorded in field's notebooks was compiled into annual floral calendar and also used to prepare honey flow and dearth period.

Result and Discussion

In order to develop a comprehensive picture of the scenario of bee pollinators a field extensive and intensive field observation are required therefore bee flora and floral calendar was documented under field conditions in Koppal district. The field observations recorded during July 2016 to June 2017

This basic information is required to time the pesticide application without causing any inimical effects on the pollinators. The flora of Koppal districts were categorized to 5 groups depending upon the type of the plants viz., Vegetables, fruits, plantation, aromatic, ornamental and medicinal crops. The data is presented in table 1 to 4.

The result revealed that in koppal district, 84 plant species were useful to honeybees, out of which vegetables (19), fruits (15), plantation (3) aromatic and ornamental crops (9) and medicinal plants (38) respectively documented and found in the study area. The identified flora was further grouped into pollen, nectar and both pollen and nectar yielding plants. Out of 84 crops, nectar (7), pollen (17) and both pollen and nectar (59) yielding plants respectively. (Table.1-4)

In study area Major nectar rich plants recorded were, *Phaseolus vulgaris*, *Cyamopsis tetragonolobus*, *Momordica charantia*, *Mangifera indica*, *Pongamia pinnata*, *Jasminum sp.* *Gladiolus communis*, *Echinops echinatus*, and *Santalum album* respectively.

Whereas Pollen rich plants documented were, *Solanum melongena*, *Lycopersicon esculentum*, *Capsicum sp.*, *Cucumis sativus*, *Cucumis melo*, *Citrullus lanatus*, *Amaranthus gracilis*, *Cocos nucifera*, *Eugenia jambolana*, *Justicia adhatoda*, *Melia azedarachta* and *Cassia tora* respectively (table1-4)

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

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

N1 = Low nectar yield N2 = High nectar yield “-“ = absent

P1 =Low pollen yield P2 = High pollen yield

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

Sl.No.	Common name	Botanical name	Family	Flowering period	Bee forage value		
					Nectar	Pollen	Nectar + Pollen
Fruit crops							
1.	Citrus	<i>Citrus limon</i>	Rutaceae	Oct – Jan, July – Sep.	-	-	N2P1
2.	Mango	<i>Mangifera india</i>	Anacardiaceae	Dec- Jan	N2	-	-
3.	Ber	<i>Ziziphus jujuba</i>	Rhamnaceae	July – Oct.	-	-	N2P2
4.	Custard apple	<i>Annona squamosa</i>	Annonaceae	Aug – Oct.	-	-	N1P2
5.	Pomegranate	<i>Punica granatum</i>	Punicaceae	March – June	-	-	N2P1
6.	Sweet lime	<i>Citrus aurantifolia</i>	Rutaceae	Nov – March	-	-	N2P2
7.	Caronda (Kavale)	<i>Carissa carandas</i>	Apocynaceae	Mar-Apr	-	-	P2N2
8.	Water melon	<i>Citrullus lanatus</i>	Cucurbitaceae	Sep-Oct	-	P1	-
9.	Mandrin	<i>Citrus reticulata</i>	Rutaceae	Mar-Apr	-	-	P2N1
10.	Banana	<i>Musa sp.</i>	Musaceae	Jan-Dec	-	-	P2N2
11.	Gauva	<i>Psidium guajava</i>	Myrtaceae	Mar-Jun	-	-	P2N1
12.	Rose apple	<i>Syzygium jambos</i>	Myrtaceae	Mar-Jun	-	-	P2N1
13.	Sapota	<i>Manilkara achras L.</i>	Sapotaceae	Mar-Jun	-	-	P1N1
14.	Amla	<i>Phyllanthus emblica</i>	Phyllanthaceae	April-may	-	-	P1N1
15.	Jamun	<i>Syzygium cumini</i>	Myrtaceae	Apr-May	-	-	P2N2

N1 = Low nectar yield N2 = High nectar yield “ - “ = absent

P1 =Low pollen yield P2 = High pollen yield

Table 3: Nectariferous / Polleniferous bee flora and floral calendar in plantation, aromatic and ornamental crops in Koppal district

Plantation crops							
1.	Coconut	<i>Cocos nucifera</i>	Arecaceae	Jan-Dec	-	P1	-
2.	Pongemia	<i>Pongamia pinnata</i>	Fabaceae	Feb-Apr	N1	-	-
3.	Cashew nut	<i>Anacardium occidentale</i>	Anacardiaceae	Dec-Jan	-	-	P2N1
Aromatic And Ornamental Plants							
1.	Antigonum	<i>Antigonum leptopes</i>	Polygonaceae	Apr- May	-	-	P1N2
2.	Jasmine	<i>Jasminum sp.</i>	Oleaceae	July-Aug	N1	-	-
3.	Rose	<i>Rossa spp</i>	Rosaceae	April-june	-	-	N1P1
4.	Gladiolus	<i>Gladiolus communis</i>	Iridaceae	Nov-Dec	N1	-	-
5.	Marigold	<i>Tagitus sp</i>	Asteraceae	Oct-Nov	-	-	N1P2
6.	Chrysanthimum	<i>Chrysanthimum sinararifolium</i>	Asteraceae	August-Oct	-	-	N1P1
7.	Tuberose	<i>Polianthes tuberosa</i>	Asparagaceae	Sept- Oct	-	-	N1P1
8.	Gaillardia	<i>Gaillardia aristata</i>	Asteraceae	Sept- Oct	-	-	N1P1
9.	Jungle flame	<i>Ixora Coccinea</i>	Rubiaceae	Feb-Mar	-	-	P2N1

N1 = Low nectar yield N2 = High nectar yield “ - “ = absent

P1 =Low pollen yield P2 = High pollen yield

Table 4: Nectariferous / polleniferous bee flora and floral calendar medicinal crops in Koppal district

Sl.No.	Common name	Botanical name	Family	Flowering period	Bee forage value		
					Nectar	Pollen	Nectar + Pollen
Medicinal crops							
1.	Tulasi	<i>Ocimum sp.</i>	Lamiaceae	Jan-Dec	-	-	P3N1
2.	Sandal wood	<i>Santalum album</i>	Santalaceae	Jan-Jul	-	-	P2N2
3.	caster	<i>Ricinus communis</i>	Euphorbiaceae	Feb-Apr	-	-	P2N2
4.	porcupine flower	<i>Barleria lupulina</i>	Acanthaceae	Feb-April	-	-	N2P3
5.	Gum Arabica tree	<i>Acacia nilotica</i>	Fabaceae	Jul-Oct	-	-	P2N2
6.	Neem	<i>Azadirachta indica</i>	Meliaceae	Mar-Apr	-	-	P1N1
7.	Aonla	<i>Phyllanthus emblica</i>	Euphorbiaceae	Mar-May	-	-	P1N1
8.	Jamun	<i>Eugenia jambolana</i>	Myrtaceae	Feb -March	-	P2	-
9.	Plame of forest	<i>Butea monosperma</i>	Fabaceae	Jan-March	-	-	P2N2
10.	Ashoka	<i>Saraca asoca</i>	Leguminaceae	Feb-April	-	-	P2N2
11.	Drumstick	<i>Murraya koenigii</i>	Rutaceae	Apr-Jun	-	-	P2N1
12.	Tamarind	<i>Tamarindus indica</i>	Fabaceae	Apr-Jun	-	-	P1N1
13.	Pomogranate	<i>Punica granatum</i>	Punicaceae	March-June	-	-	N2P2
14.	Lakki	<i>Vitex negundo</i>	Verbenaceae	Sep-Nov	-	-	P2N3
15.	Adusoge	<i>Justica adhatoda</i>	Acanthaceae	Feb- April	-	P2	-
16.	Lemon	<i>Citrus lemon</i>	Rutaceae	Throughout Year	-	-	P1N1
17.	Lantana	<i>Lantana camera</i>	Verbenaceae	Jan-April, Jul-Sep	-	-	P2N1
18.	Tumbe	<i>Leucas aspera</i>	Lamiaceae	Jan-Aug	-	-	P1N2
19.	Hebbevu	<i>Melia azedarachta</i>	Meliaceae	Feb-May	-	P2	-
20.	Senna	<i>Cassia fistula</i>	Caesalpinaceae	Jan- Feb	-	-	P2N1
21.	Ekke	<i>Calotropis gigantea</i>	Asclepiadaceae	Feb-May	-	-	P2N1
22.	Ishwari balli	<i>Aristolochia indica</i>	Aristolochiaceae	Feb-May	-	-	P2N1
23.	Malbar Nut	<i>Adhatoda vasica</i>	Acanthaceae	Nov-July	-	-	N2P2
24.	Camels foot	<i>Bauhinia purpurea</i>	Caesalpinaceae	Sept-Nov	-	-	N2P1

25.	Wild Senna	<i>Cassia tora</i>	Caesalpinaceae	March-Jul	-	P2	
26.	Tridax	<i>Tridax procumbens</i>	Asteraceae	Jan-Dec	-	-	N2P1
27.	Ummatti	<i>Datura sp.</i>	Solanaceae	Apr-Dec	-	-	P1N1
28.	Hebbevu	<i>Melia dubia</i>	Meliaceae	Mar-May	-	-	P1N2
29.	Touch me not	<i>Mimosa pudica</i>	Mimosaceae	Jan-Dec	-	-	P1N2
30.	Makoi	<i>Solanum nigrum</i>	Solanaceae	Jan-Dec	-	-	P2N3
31.	Kantaphala/ brahma dande	<i>Echinops echinatus</i>	Asteraceae	Throught Year	-	-	N2P1
32.	Aadumuttada balli	<i>Tylophora asthematica</i>	Apocynaceae	March-Jul	-	-	P2N1
33.	Nagalinga	<i>Mesua furea</i>	Calophyllaceae	March-May	-	-	P1N1
34.	Bael	<i>Aegle marmilose</i>	Rutaceae	Nov-Dec	-	P2	P1N1
35.	Muttuga	<i>Butea monosperma</i>	Papilionaceae	Jan March	-	-	P1N1
36.	Doddagono soppu	<i>Portulaca oleraceae</i>	Portulacaceae	Jan-Feb	-	P2	-
37.	Womans tongue tree	<i>Albija lebeck</i>	Fabaceae	April -May	-	P2	-
38.	Champak	<i>Michalea champaca</i>		Mar-May	-	-	P2N1

N1 = Low nectar yield N2 = High nectar yield “ - “ = absent

P1 =Low pollen yield P2 = High pollen yield

Both nectar and pollen rich plants identified were, *Abelmoschus esculentus*, *Lagenaria siceraria* *Cucurbita pepo*, *Allium cepa*, *Moringa oleifera*, *Luffa acutangula*, *Pisum sativum*, *Trichosanthes anguina*, *Citrus limon*, *Ziziphus jujube*, *Annona squamosa*, *Carica papaya*, *Carissa carandas*, *Musa sp.*, *Psidium guajava*, *Syzygium jambos*, *Ricinus comunis*, *Tamarind Tamarindus indicus*, *Azardirhacta indica*, *Antigonum leptopes*, *Manilkara achras*, *Phyllanthus emblica*, *Syzygium cumini*, *Anacardium occidentale*, *Tagitus sp.*, *Chrysantimum sinararifolium*, *Polianthes tuberosa*, *Gaillardia aristata*, *Ixora coccinea*, *Ocimum sp.* *Santalum album* *Ricinus communis* *Barleria lupulina* *Acacia nilotica*, *Azadirachta indica*, *Phyllanthus emblica*, *Butea monosperma*, *Saraca asoca*, *Murraya koenigii*, *Tamarindus indica*, *Punica granatum*, *Vitex negundo*, *Citrus lemon*, *Lantana camera*, *Leucas aspera*, *Cassia fistula*, *Calotropis gigantean*, *Aristolochia indica*, *Adhatoda vasica*, *Bauhinia purpurea*, *Tridax procumbens*, *Datura sp.*, *Melia dubia*, *Mimosa pudica*, *Solanum nigrum*, *Echinops echinatus*, *Tylophora asthematica*, *Mesua furea*, *Butea monosperma*, and *Michalea champaca* 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, hence there is a scarcity of water and only few flowering plants available viz., *Coriandrum sativum*, *Vigna aconitifolia*, *Punica granatum*, *Melia dubia*, *Echinops echinatus*, *Barleria lupulina* and wild plants like *Azardirhacta indica*, *Jacarandaa mimosifolia*, *Cassia tora*, *Tridax procumbens*, *Antigonum leptopes*, *Murraya koenigi* and some weed species were blossomed during the season. However, their number per unit area was less or having lesser quantity of pollen or nectar. These minor sources are utilized by bees during the time of scarcity of major bee flora. Because of high temperature and scarcity of water for flowering plants this period was found unfavorable for honeybee foraging.

Honey flow and dearth period

In study area of Koppel district the honey flow and dearth period was determined and results are summarized in (Tables 1-5). The peak periods of honeybee foraging activity ie. Honey flow period were recorded during June– October of winter season and January to March of summer season and mid -April to mid- June were the critical dearth periods during investigation. During the honey flow period abundant bee floral plants were found blossoming and plants species were recorded as source of food for honeybees. The flowering

plants of several plant families are blossoming at different time intervals of the year. Pollen and nectar availability to foraging bees fluctuated with time of the year and flowering of different species of plants (Free, 1970). The phase of the blooming period does not commence simultaneously in all the honey-flora participating in the main honey-flow. Depending on the soil type, climatic factors and the habitat, the time of blooming may change for even the same nectar plant (Rodionov and Shabanshov, 1986).

The present findings are supported by Bisht and Pant (1968) [3] 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) [9] documented 66 species of medicinal plants which are potential forages of honey bees in Walayar Valley of Coimbatore district in Western Ghats, were 66 species of plants were promising as potential forages for honeybees. And found that the social bees are mainly helpful to tribal people economy and sustaining the floral biodiversity. The present findings were also in conformity with the findings of Dalip Kumar *et al.*, (2015) [6] who documented As many as twenty different medicinal plant species belonging to eleven tree species, three shrub species and six herb species under thirteen families were identified as potential honeybee forage plants in Chandigarh district and also they made made to prepare and observe mapping of existing medicinal flora as honey bee forage.

Present findings also in conformity with the records of Sivaram, (2001) [8] he 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.

Conclusion

The present findings reveled that in koppal district, 84 plant species were useful to honeybees, out of which vegetables (19), fruits (15), plantation (3) aromatic and ornamental crops (9) and medicinal plants (38) respectively documented and found in the study area. The identified flora was further grouped into pollen, nectar and both pollen and nectar yielding plants. Out of 84 crops, nectar (7), pollen (17) and both pollen and nectar (59) yielding plants respectively. Honeybee and plant have a special symbiotic relationship. Bee flora is important for establishing bee keeping industry. The awareness to maintain the existing bee flora and multiplication of plant species is important for its sustainability. Plant types and their flowering duration differ

from one place to other due to variation in topography, climate and other cultural and farming practices. The knowledge of bee flora enable beekeepers to utilize them at the maximum level, so that they can harvest a good yield of honey and other bee products in addition to effective pollination, which enhances crop yields. This region has its own honey flow and floral dearth periods of short and long duration. Such knowledge on bee flora help in the effective management of bee colonies during such periods. Based on available flora, major characteristics of these plant species, pollen and nectar availability and flowering duration, a bee floral calendar as per the season were developed. To conserve these floras, attention must be given to maintain and multiply the existing flora. Considering these facts, the present study is carried out to prepare an inventory of existing bee flora and develop floral calendar for that particular region (Balchandra *et al.* 2014).

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