Documentation of Honeybees flora and Blooming period in major Horticultural and Agricultural crops growing in dryland regions of Northern Karnataka, India

Abstract:

The goal of the present study was to determine the variety of nectariferous and polleniferous bee flora in the Koppal district of Northern Karnataka in order to enhance the bees' blooming season. When the blooming plants were visited, the honeybees' presence and foraging activity were documented. In a ten-minute interval when at least three honeybees visited the flowers, the plants were identified as bee foraging species. The various plant groupings that worker bees visit, including as fruit crops, vegetable cops, field crops, plantations, flower and ornamental plants, etc., are included in the identified bee flora. The detected flora was further divided into plants that yielded nectar, pollen, and both. A total of sixty-four crops were identified as forage crops. Of those, the Koppal district had plants that yielded nectar (14), pollen (13), and both (36), according to documentation. The major dearth times were discovered to be mid-April to mid-June, whereas the honey flow seasons were determined to be mid-December to mid-February and mid-July to mid-September. Based on the flora's availability, utility status, and duration of flowering, a floral calendar was established for the study area. The listed species (*Syzygium, Cassia, Citrus, Pongamia, Azadirachta, Brassica, Areca, Cocos, Guizotia, Hilianthus, Albezia, Lagerstroemia, Polinathus, Sapindus, Tecoma*) and others are some of the common and significant bee food plants.

Keywords: Flora, flow period, honey beekeeping,honey dearth period, floral calendar.

Introduction:

These highly developed social insects, honey bees, are becoming more and more important pollinators in the modern world. Humans have coexisted well with honey bees because they are sociable insects. The crop production rises and improves in terms of seed and fruit yield quantity and quality as a result of bee pollination. Thus, in addition to providing a second source of income through the sale of honey and bee wax, beekeeping can significantly increase crop yields (Sharma *et al.*, 2015).Numerous studies have consistently demonstrated that, with proper pollinator management, It is possible to increase yield levels by 50–60% for fruits and plantation crops, and 45–50% for niger, sunflower, and sesamum, and 100–150% in

cucurbitaceous crops (Melnichenko and Khalifman, 1960). A crucial crop management technique is insect pollination, which can be effectively harnessed by utilising the activity of wild bees, domestic honeybees, and other pollinators, such as solitary bees. The effective and planned employment of honey bees to boost production and enhance crop quality and quantitative characteristics is essential to achieving the intended pollination (Sharma *et al.,* 2015).

A common species in Karnataka is the Indian bee (*Apis cerana* Fabricius), which is closely related to species like *Apis dorsata*, *Apis florea*, *Trigona irridipennis*, and *Apis mellifera*. The cornerstone of Indian beekeeping is the Indian honey bee (A. cerana), which is widespread in the nation. Furthermore, the Indian honey bee, *A. cerana*, is found in Pakistan, Sri Lanka, Malaysia, Indo-China, the Philippines, China, the USSR, Japan, and Indonesia (Ruttner, 1988; Hepburn *et al.*, 2001). Up to 2500 m above mean sea level, it can flourish. It possesses numerous attractive traits that are significant from a biological and economic standpoint, such as a docile attitude and a decreased susceptibility to parasitic mite attacks and nosema disease. As a result, a study of the bee flora and the honey bee flowering seasons in the Koppal district was conducted.

Material and Methods:

The study region that includes Koppal was chosen to be the location for the visit of bees fro flora and blooming time (November 2016 to November 2017) (15° 21' 2.5488" N, 76° 9' 19.5624" E). For the Koppal district, the yearly average rainfall was 571.99 mm. Twenty study sites within a 25-kilometer radius of the study area must be chosen in order to obtain the data. Throughout the flowering seasons, worker bees from numerous plant categories, such as ornamental plants, fruit crops, vegetable cops, plantations, and field crops, were observed.

Identification of bee-flora: From 2016 to 2017, information was gathered on a monthly basis while visiting the research locations. Every research visit functioned as a pseudo replicate for the location, and all observations were made between the hours of 7:00 and 17:30. Bee activity on blooms from several plant types was observed as part of the study. When bees were discovered on these plants' blossoms, their feeding habits were studied for ten minutes. If at least three (3) honeybees visited the blooms at the same time within ten minutes of the observations, if the success of any foraging attempt could be determined. The activities that honeybees carried out on various flowers were examined with the use of binoculars (Nikon 8x42 Aculon Camo) to gather data on nectar and pollen sources. Bees that carry pollen on their back legs are identified

as pollen sources, whereas honeybees, because of their proboscis-extending behaviour inside flowers, are thought to be nectar providers. Honeybees were identified as nectar and pollen-producing plants because of their proboscis-extending behaviour into the blooms and their hind leg collection of pollen. The foraging value of a flower is determined by the frequency with which worker bees visit it, plants rich in pollen and nectar varying in concentration were identified. The bee floral catalogue were used to identify these plants on-site. The plants were only given a presence score if they were identified as bee foraging species at one location and then discovered at other sites during a later survey. Plants lacking essential botanical characteristics, such as leaves, flowers, or a piece of the stem, were chopped and put in a herbarium. These plants were then identified using a botanist and compared to published reports if they could not be identified in the field. Three reasons led to the recording of the observations. A detailed record of the flowering cycle of every plant species was preserved during the survey. The information entered into the field notebooks was utilized to create the yearly floral calendar, as well as to calculate the dearth period and honey flow.

Result and Discussion:

Bee flora and the blooming time were recorded in the Koppal district under field settings because a thorough and intense field observation is necessary to create a complete picture of the situation of bee pollinators. The November 2016–November 2017 period covered the field observations.To apply pesticides at the right time and avoid harming pollinators, this fundamental information is needed. Depending on the type of plant, the Koppal district's flora was divided into four groups: flowers, decorative crops, fruits, vegetables, and plantations. The findings showed that 64 plant species in the Koppal district were beneficial to honeybees, of which 19 were recognised and discovered in the study region. These species included (fruits -15, vegetables-19, field crops-15 and plantation, flower, and decorative crops- 15. The detected flora was then divided into plants that yielded pollen, nectar, and both (Tables 1-4) out of 64 crops; plants that yielded (nectar-14, pollen-14 and both (Tables, 1-4 and Fig-1).

Of the nineteen vegetables, only three—the bottle guard, the bengal melon, and the pumpkin—were used as sources of pollen and nectar. Comparatively, most of the fifteen fruit crops provided both nectar and pollen, such as citrus, pomegranate, custard apple, banana, guava, etc., while the low pollen yielders include rose apples, guava, bananas, corondas, sweet limes, ber, and custard apples. The following fifteen field crops provided both nectar and pollen:

sunflower, blackgram, chickpea, ground nut, maize, niger and castor. In plantations, flower and decorative crops (15) such as antigonum functioned as sources of pollen and nectar. These are the principal crops that maintain pollinator populations. The untamed vegetation patches also show which pollinators need to be protected.

The present results are in close agreement with those of Bhalchandra et al. (2014), who produced a floral calendar for the hills of Anjaneri and Dugarwadi and documented the variety of nectariferous and polleniferous bee flora. We visited the flowering plants and looked for signs of honeybee activity, including presence and foraging. When at least three honeybees visited a plant's blossoms in a 10-minute period, the plant was categorised as a species that bees foraged on. The findings showed that 52 plant species—of which 23 were wild plants and 29 were farmed crops—were beneficial to honeybees.

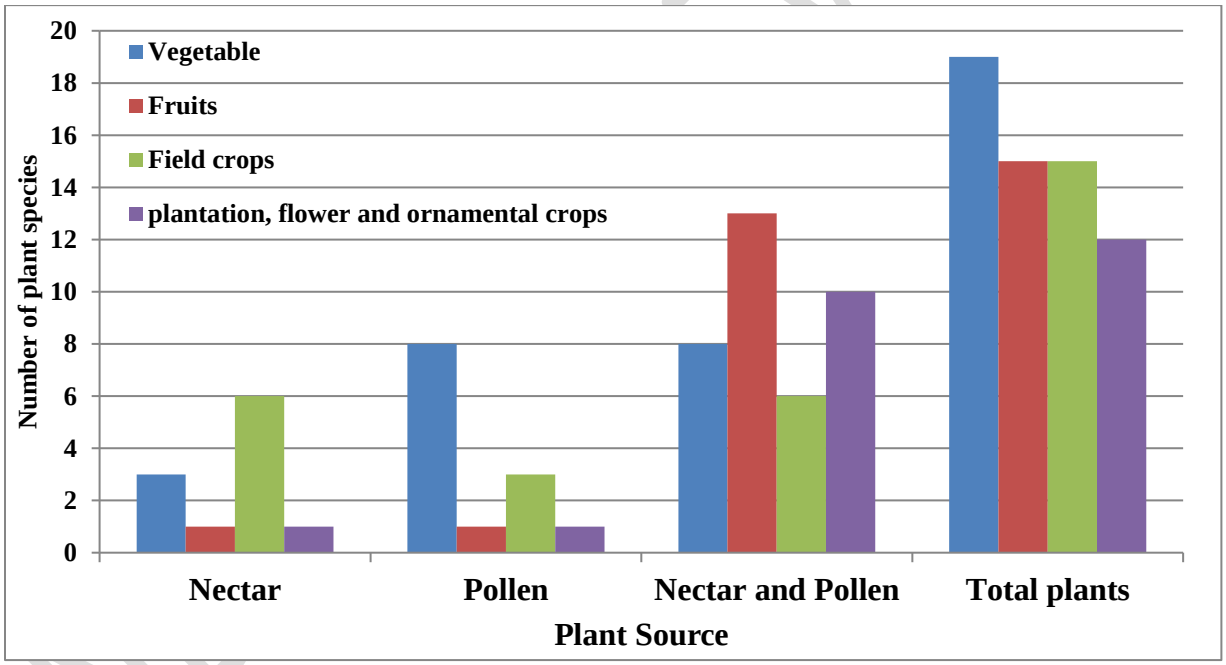

Fig.1. Flowering calendar in crops and the nectariferous and polleniferous bee flora in Koppal district

According to the study, honeybees can benefit from over 340 different types of plants. The bee flora that has been recognised includes ornamentals, wood, medicinal, fruits, vegetables, and other plants that are significant for commerce such as cereals, spices, lentils, oil-producing plants, fibre, fodder, etc. Many varieties (*Syzygium cumini* L., *Cassia tora*, *Citrus*, *Pongamia*, *Azadirachta*, *Brassica*, *Areca*, *Cocos*, *Guizotia*, *Helianthus annuus* L., *Albezia*, *Lagerstroemia*,*Polinathus*, *Sapindus* and *Tecoma*) etc. are frequent and significant bee food plants (Sivaram, 2001).According to a study, close observation of foraging bees in Nigeria

allowed researchers to identify 61 different species of savanna plants that the honeybee, *Apis mellifera*, visits. It was found that the family Fabaceae had the highest number of species (26.2%). Arecaceae, Lamiaceae, Poaceae, Rhamnaceae, and Rubiaceae tied for third place with 4.9% of the total species, while Combretaceae came in second with 9.8% (Dukku, 2013).

Flow and dearth period of Honey

Honeybee foraging activity increased during the winter months of June through October and the summer months of January through March each year; this period is commonly referred to as the "honey flow period." From June to October is when the honey flow period occurs, and during this time many bee-flowering plants were seen to blossom (Tables 1-4). Certain plant species have been identified as honeybee food sources. Many plant families have flowering plants that bloom at various times of the year. Foraging bees' access to pollen and nectar varied according to the season and the blooming season of various plant species (Free, 1970). Blooming phase at the same time. Even the same nectar plant might have different flowering times depending on the kind of soil, climate, and environment (Rodionov and Shabanshov, 1986). Prominent plants high in nectar are *Phaseolus vulgaris* beans, *Vigna radiata* mung beans The *Cyamopsis tetragonolobus* cluster bean The bitter gourd (*Mordica charantia*) *Mangifera indica* (mango) *Brassica rapa*, Cowpea *Vigna* spp., *Porgemia Pinnacamia* pinnata, Bajra tyhhoides Pennisetum Stap must be used.

Plants high in pollen, such as brinjal, *Melongena solanum*The tomato*Lycopercicon esculentum,Capsicum sp*. chilli Cool cucumber *Curcumis sativus* Musk Melon *Mel Cucumis*, Rajgiri/Amaranthus *Citrullus lanatus, Amaranthus gracilus,*ground Nut *Arachis hypogaea* Corn*Zea Mays* Meta *Cocos nucifera*, and*Hibiscus sutrattensis*.

With high tempearture of above 35^{0}°C, scant supplies of water, and few blossoming plants, the summer was a crucial time for shortages. Some wild plants, *Jacarandaamimosifolia, Cassia tora, Arachis hypogaea, Punica granatum, Coriandrum sativum,* and *Vigna aconitifolia* were among the few agricultural species that flowered during the season, along with *Azardirhacta indica, Jacaranda amimosifolia, Cassia tora, Tridax procumbens*, and Antigonum leptopes (creeper). However, they either had less pollen or nectar or were less abundant per unit area. Bees use these smaller sources when important bee plants are scarce. Because of the high temperatures and little water for blooming plants, this time of year has been found to be inappropriate for honeybee foraging.

Choudhary and Kumar (1998) observed that *Apis florae* L. is the most common visitor on Niger (84.50%), with *Apis cerana* L. (7.90%) and *A. mellifera* (5.7%) in Pune following closely behind. These findings corroborate the current findings. *A. florea* was active from 0600 to 1830 hours, whilst *A. mellifera* and *A. Cerana* were active from 6:00 to 17:30 hours and 06:00 to 16:30 hours, respectively. According to Bisht and Pant (1968), january through March saw the most pollen gathering activity by *A. cerana*, while May and June saw the lowest activity.

In Raichur (Karnataka), *A.cerana* Raichur's foraging profile was investigated by Viraktamath and Anagoudar (2002). He noticed that the majority of the pollen (up to 80%) was foraged before midday, while the nectar was foraged all day, peaking between 0600 and 1100 hours and again between 1600 and 1800 hours. The pollen load of returned bees peaked in March, when 72–81% of them were loaded, and peaked again in May, when 79–79% were, most likely, due to a high flowering rate and favourable environmental conditions.

In the winter, honeybees were an outstanding pollinator of tomatoes, yielding high-quality fruits with a fruit set of 98 percent (Sabara *et al.*, 2002), which is comparable to bumblebee fruit set. The main pollination insect was *A. ceranawa*, which was discovered to be more effective than *A. florea* and Trigona. Additionally, the population of *A. Cerana*bee peaked about 0900 hours, and more pollen was collected during that time. On onion crops, the abundance of all insect pollinators, regardless of species, was highest between 1200 and 1400 hours (Priti, 1998).

Plants and honeybees have a unique symbiotic interaction. The establishment of the bee keeping sector depends on the bee flora. Because of differences in geography, climate, and other factors related to culture and farming techniques, different places have different plant kinds and different flowering times.Understanding the Baramati region's bee flora helps beekeepers make the most of their resources, allowing them to collect a healthy crop yield through efficient pollination. This area has both brief and extended times of floral shortage. This kind of information on bee flora facilitates the efficient running of bee colonies during these times. Based on the accessible flora, important characteristics of these plant species, availability of pollen and nectar, and duration of flowering, a bee floral calendar according to the season was created. The current flora needs to be maintained and multiplied in order to preserve these floras. In light of these facts, the current study is being conducted in order to create a floral calendar for that specific location and to compile an inventory of the current bee flora (Kumar *et al.,* 2013).

Conclusion:

We visited the flowering plants and looked for signs of honeybee activity, including presence and foraging. In order to be classified as a bee foraging species, a plant required to attract at least three honeybee visits to its blossoms in a 10-minute period. Worker bees from various plant groups, such as (vegetable cops, fruit crops, field crops, plantations, flower and decorative plants) etc., visit the designated bee flora. Overall, it can be concluded that in Koppal district, 64 plant species were useful to honeybees based on which floral calendar was created for the research region based on the availability, utility status, and length of flowering of the flora.

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Table 1. Vegetable crops in Koppal district identified forNectariferous / polleniferous for bee flora in floral calendar

Sl. No.	Name of the plant species	Scientific name	Family	Period of flowering	Forage value		
					N	P	N+P
Vegetables							
1.	Brinjal	*Solanum melongena*	Solanaceae	Jan to March, June to July.	-	P:2	-
2.	Tomato	*Lycopercicon esculentum*	Solanaceae	Jul-Sep	-	P:1	-
3.	Chilli	*Capsicum sp.*	Solanaceae	Jul-Feb	-	P:2	-
4.	Bhendi	*Abelmoschus esculentus*	Malvaceae	Aug – Nov	-	-	P1+N2
5.	Beans	*Phaseolus vulgaris*	Fabaceae	Dec-Feb	N:2	-	-
6.	Bottle gourd	*Lagenaria siceraria*	Cucurbitaceae	Oct – Feb.	-	-	N2+P2
7.	Cucumber	*Cucumis sativus*	Cucurbitaceae	Aug – Oct.	-	P:1	-
8.	Musk melon	*Cucumis melo*	Cucurbitaceae	March – May.	-	P:1	-
9.	Pumpkin	*Cucurbita pepo*	Cucurbitaceae	Aug – Oct.	-	-	N2+P2
10.	Water melon	*Citrullus lanatus*	Cucurbitaceae	July – Aug.	-	P:1	-
11.	Onion	*Allium cepa*	Liliaceae	Jun– Aug.	-	P:1	-
12.	Drumstick	*Moringa oleifera*	Moringaceae	Nov – Feb.	-	-	N1+P2
13.	Ridge gourd	*Luffa acutangula*	Cucurbitaceae,	July – Oct.	-	-	N1+P1
14.	Pea	*Pisum sativum*	Fabaceae	Aug- Sep.	-	-	N1+P1
15.	Cluster bean	*Cyamopsis tetragonolobus*	Leguminosae	Jun - Aug.	N:2	-	-
16.	Rajgiri/ Amaranthus	*Amaranthus gracilus*	Amaranthaceae	Feb-Mar	-	P:1	-
17.	Bitter gourd	*Momordica charantia*	Cucurbitaceae	Aug-Oct	N:2	-	-
18.	Snake gourd	*Trichosanthesanguina*	Cucurbitaceae	Jan-Mar	-	-	P2+N2
19.	Little gourd	*Coccinia grandis*	Cucurbitaceae	Aug-Oct	-	-	N1+P1

(Low nectar yield= N:1, High nectar yield=N:2 " -" = absent Low pollen yield= P:1, High pollen yield= P:2)

Table 2. Fruit crops in Koppal district identified for Nectariferous / polleniferous for bee flora in floral calendar

Sl. No.	Scientific name	Family	Period of flowering	Forage value		
				N	N	N
1.	*Citrus limon*	Rutaceae	Oct – Jan, July – Sep.	-	-	N2+P1
2.	*Mangifera india*	Anacardiaceae	Dec- Jan	N:2	-	-
3.	*Ziziphus jujuba*	Rhamnaceae	July – Oct.	-	-	N2+P2
4.	*Annona squamosa*	Annonaceae	Aug – Oct.	-	-	N1+P2
5.	*Punica granatum*	Punicaceae	March – June	-	-	N2+P1
6.	*Citrus aurantifolia*	Rutaceae	Nov – March	-	-	N2+P2
7.	*Carissa carandas*	Apocynaceae	Mar-Apr	-	-	P2+N2
8.	*Citrullus lanatus*	Cucurbitaceae	Sep-Oct	-	P:1	-
9.	*Citrus reticulata*	Rutaceae	Mar-Apr	-	-	P2+N1
10.	*Musa sp.*	Musaceae	Jan-Dec	-	-	P2+N2
11.	*Psidium guajava*	Myrtaceae	Mar-Jun	-	-	P2+N1
12.	*Syzygiumjambos*	Myrtaceae	Mar-Jun	-	-	P2+N1
13.	*Manilkara achras L.*	Sapotaceae	Mar-Jun	-	-	P1+N1
14.	*Phyllanthus emblica*	Phyllanthaceae	April-may	-	-	P1+N1
15.	Syzygiumcumini	Myrtaceae	Apr-May	-	-	P2+N2

(Low nectar yield= N:1, High nectar yield=N:2 " -" = absent Low pollen yield= P:1, High pollen yield= P:2)

Table 3. Field crops in Koppal district identified for Nectariferous / polleniferous for bee flora in floral calendar

Sl. No.	Scientific name	Family	Period of flowering	Forage value		
				N	N	N
1.	*Helianthus annuus*	Compositae	March – April.	-	-	N2+P1
2.	*Vigna mungo*	Fabaceae	Aug – Sep.	N:2	-	-
3.	*Cicer arietinum*	Fabaceae	Dec – March.	N:2	-	-
4.	*Arachis hypogaea*	Fabaceae	July - Oct, April – June.	-	P:2	-
5.	*Cajanus cajan*	Fabaceae	July – Sep.	N:2	-	-
6.	*Sesamum indicum*	Pedaliaceae	July – Aug.	-	-	N1+P2
7.	*Zea mays*	Poaceae	Aug – Sep, Feb – March.	-	P:2	-
8.	*Brassica rapa*	Brassicaceae	Jan – March.	N:1	-	-
9.	*Hibiscus sutrattensis*	Malvaceae	Aug-Nov	-	P2	-
10.	*Guizotiaabyssinica*	Asteraceae	Sep-Nov	-	-	P1+N1
11.	*Oryza sativa*	Poaceae	Aug-Sep	-	P2	-
12.	*Ricinus comunis*	Euphorbiaceae	Feb-Apr	-	-	P2+N2
13.	*Lablab purpureus*	Fabaceae	Jul - September	N:1	-	-
14.	*Pennisetum typhoides*	Poaceae	Jul - September	N:2	-	-
15.	*Gossipium spp.*	Malvaceae	Sept-Jan	-	-	P2+N2

(Low nectar yield= N:1, High nectar yield=N:2 " -" = absent Low pollen yield= P:1, High pollen yield= P:2)

Table 4. Plantation, flower and ornamental crops in Koppal district identified for Nectariferous / polleniferous for bee flora in floral calendar

Plantation crops							
1.	Coconut	*Cocos nucifera*	Arecaceae	Jan-Dec	-	P:1	-
2.	Tamarind	*Tamarindus indicus*	Fabaceae	Apr-Jun	-	-	P2+N1
3.	Pongemia	*Pongamia pinnata*	Fabaceae	Feb-Apr	N:1	-	-
4.	Neem	*Azardirhacta indica*		Mar-Apr	-	-	P2+N1
5.	Cashew nut	*Anacardium occidentale*	Anacardiaceae	Dec-Jan	-	-	P2+N1
Flower and ornamental plants							
1.	Antigonum	*Antigonumleptopes*	Polygonaceae	Apr- May	-	-	P1+N2
2.	Jasmine	*Jasminum* sp.	Oleaceae	July-Aug	N:1		
3.	Rose	*Rossa* spp	Rosaceae	April-june			N1+P1
4.	Gladiolus	*Gladiolus communis*	Iridaceae	Nov-Dec	N:1	-	-
5.	Marigold	*Tagitus*sp	Asteraceae	Oct-Nov	-	-	N1+P2
6.	Chrysanthimum	*Chrysantimumsinararif olium*	Asteraceae	August-Oct	-	-	N1+P1
7.	Tuberose	*Polianthes tuberosa*	Asparagaceae	Sept- Oct	-	-	N1+P1
8.	Gaillardia	*Gaillardia aristata*	Asteraceae	Sept- Oct	-	-	N1+P1
9.	Nandi Battlu/ crape jasmine	*Tabernaemontana coronaria*	Apocynaceae	Sept- Oct	N:1	-	-
10.	Kantaphala/ brahma dande	*Echinopsechinatus*	Asteraceae	Throught year	-	-	N1+P1

(Low nectar yield= N:1, High nectar yield=N:2 " -" = absent Low pollen yield= P:1, High pollen yield= P:2)