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Diversification of Honey bees' flora and bee flora calendar for Nagpur and Wardha districts of Maharashtra, India

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Abstract

Honey bees perform a special service by pollinating several plant species. But the performance of honey bees depends on the over-all health of the colony which directly depends on the availability of bee flora in a region. The present investigation Nagpur and Wardha regions were surveyed for study of diversification of honey bees' flora from April 2017 to March 2018 which is under the cultivation of agro-horticultural crops and covered with wild plantation. Total 92 plant species were recorded as bee flora, out of which 35 were horticultural crops, 15 were agricultural crops, 12 were ornamental plants and 30 were wild plant species. It was observed that different fruits, vegetables, cereal, pulses, oilseed crops, fiber crops, ornamental plants and wild plants species were the supplier of nectar and pollen in natural and crop ecosystem. Results on intensity of visitation demonstrate that in the entire categories frequent visit and moderate visits were common except in ornamental plants. Among the fifty (50) cultivated plant species twenty-six (26) plant species received frequent visit of honey bee. It was also observed that percent abundance of bee flora were highest in March with maximum 48.9%. On the basis of information on overlapping flowering period, circular bee flora calendar was developed which can be used as a ready reckoner for the farmers. It revealed the presence of some of the plants which acted as a food source of honey bee throughout the year.

Keywords: Abundance, bee flora, beekeeping, calendar, honey bee

1. Introduction

Pollination is a key ecological process in sustainable agricultural production ^[1]. Honeybees are the most important and superior pollinator of the natural ecosystem, as they store pollen and nectar for future purposes. To fulfil their requirement honey bees, pollinate wide variety of flower in mutualistic form right from cultivated to wild species and ornamental crops ^[2-8]. Scientifically, honey bee comprises mainly 4 species namely *Apis dorsata*, *Apis florea*, *Apis cerana*, and *Apis mellifera*. For commercial beekeeping, *Apis cerana* and *Apis mellifera* are the main species of honey bees generally practiced for honey production in India. In the area under investigation, Nagpur and wardha region, all the four (4) bee species are present. But very few colonies of Indian honey bee were observed during the study in managed form. Beekeepers mainly prefer Italian honey bee *Apis mellifera* for the beekeeping as honey yield is more and bee are less aggressive in comparison to Indian honey bee *Apis cerana*. Farmers adopt beekeeping as an agro-based rural industry because it can be integrated with farming system as a component for better benefit and to improve the livelihood ^[9]. Success of beekeeping depends on health of colony, which further depends on the availability of food ^[10, 11]. Weak colonies are more susceptible for insect and diseases attack even though new insect attack like wax beetle, *Platybolium alvearium* Blair (Coleoptera: Tenebrionidae) ^[12]. Honeybee gets its food from local floras. They collect nectar, a sweet liquid; carbohydrate rich source of energy from floral and extra floral nectaries present in flower and leaves; which is the raw material for honey and pollen as a protein source. That's why farmers should have some idea about the availability of food in their vicinity in natural form. The plants that yield nectar and pollen are collectively referred as bee flora or bee pastures ^[2]. For the initiation or promotion of beekeeping in any area, it is mandatory to study the bee flora of that region ^[13]. Proper documentation of bee flora in some ready reckoner form helps the beekeeper and beginners of that particular area to start beekeeping and the beekeepers who migrate their colony from other places as type, density, flowering duration and quality of bee flora of one place differ from another place because of variation in topography, climate and other farming

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practices of an area [14, 15]. Development of bee calendar on the basis of availability of bee flora blooming period is a basic tool for the beekeepers of a particular area [16] which work as a decision-making tool for them as according to availability of flora they can decide if the supply of pollen substitute [17, 18] or nectar supplement [19, 20] and migration of beekeeping is required or not. Therefore, keeping the basic necessity of beekeeping in mind, we surveyed the area, enlisted the beeflora and categorized them on the basis of availability over the months. Circular bee calendar was also prepared as a ready reckoner for the farmers of Nagpur and Wardha region which includes approximate duration of the blooming period of existing honey or pollen plant source in an area.

2. Materials and Methods

2.1 Study sites

The present study was conducted during April, 2017 to March, 2018 at Nagpur and Wardha district of Maharashtra, India in agro ecological subregion (AESR) 10.2 and observations were made during 3 consecutive seasons. AESR 10.2 receives rainfall of 1000 to 1500 mm with potential evapotranspiration (PET) 1400 to 1600 mm and mean temperature 24 to 26° C. The climate of subregion is hot dry subhumid with shallow and medium loamy to clayey Black soils (deep clayey black soils as inclusion), medium to high available water capacity and length of growing period of 150-180 days [21].

2.2 Identification of bee-flora

For identification of prevailing bee flora resources in nature keen visual observation was made on flowers at their blooming period to observe the activities of bees for a period of 10 minutes. Flowers, being visited at least by three (3) bees within stipulated time were considered as bee flora.

$$\text{Per cent abundance of bee flora for a month} = \frac{\text{Number of bee flora species in particular month}}{\text{Total number of bee flora species}} \times 100 \quad \dots\dots (1)$$

Per cent abundance of cultivated bee flora were also calculated.

$$\text{Per cent abundance of cultivated bee flora for a month} = \frac{\text{Number of cultivated bee flora in particular month}}{\text{Total number of bee flora species in particular month}} \times 100 \quad \dots\dots\dots (2)$$

By simple mathematical subtraction share of ornamental plants with wild plant was calculated.

2.5 Preparation of bee flora calendar

During survey on the basis of flowering periods of the identified bee flora complete chronological record was maintained and used for the preparation of bee flora calendar. According to the range of blooming period of bee flora, particular bee flora got the entry for those months. Circular bee flora chart was also developed which comprise 2 circle of bee flora sp. In inner circle, all the cultivated bee flora were included and in outer circle wild and other bee flora were included.

3. Results and Discussion

The area of study was under the cultivation of agro horticultural crops and covered with wild plantation. During the present investigation honeybee forager were recorded from March 2017 - March 2018.

2.3 Observation on nectariferous (N) and polleniferous (P) bee flora

Honey bee visits different plant species flower as a forager sometimes for nectar and sometimes for pollen and sometimes for both. Classification of plant as nectariferous and polleniferous depends on activities performed by honeybees on different flowers. After landing on flower if honey bee sits calmly and extends its proboscis into the flower or collect the nectar from outside nectaries the flora was considered as nectariferous flora and if bees are hyperactive inside the flower carrying pollen on their body or in pollen basket (hind leg) from the flower, the flora were considered as polleniferous flora. Flowers with honey bees showing both the activities were considered under nectariferous as well as polleniferous flora [22].

The intensity of visitation was also monitored visually during the same time period. The identified bee flora were categorized into frequently visited, moderately visited and poorly visited bee flora and indicated by '+++', '++' and '+', respectively on the basis of frequency of visit by honey bees *i.e.* number of bees visiting flower/minute [23]. The most frequently visited and moderately visited flora were considered under major bee flora and poorly visited flora considered under minor bee flora. Identification of plant was done in field itself, with the help of local people as well as by collecting their parts to be identified scientifically in laboratory condition with the help of published document [24, 25, 26].

2.4 Percent Abundance of bee flora: The monthly per cent abundance of bee flora were worked out using following formula after pooling all the data and expressed in percentage:

3.1 Identification of bee flora: Overall picture of recorded observation revealed the presence of total 92 plant species as in form of bee flora which are common and widely distributed in the study area. Out of 92 plant species observed as a bee flora from the surveyed area, 35 were horticultural crops including 18 vegetables and 17 fruit plant species; 12 were ornamental plants; 15 were agricultural crops including cereal, pulses, fiber and oilseed and 30 were wild plant species (Table: 1 A, B, C, D, E and Table: 2). Similarly, several studies have been performed worldwide like for Hindu Kush-Himalayan region [27, 25] and bee flora of India [28] are some existing examples of such efforts.

Table 1: The diversity of Agriculture and Horticulture Crop bee flora in Nagpur and Wardha during March 2017–Mar 2018 A) Vegetables

S. No.	Common: Scientific Name	Family	Food Source	Intensity of visitation	Flowering period
1	Bhindi: <i>Abelmoschus esculentus</i>	Malvaceae	P	++	June -Aug; Mar to Apr
2	Bitter gourd: <i>Momordica charanta</i>	Cucurbitaceae	N; P	++	June - Sept
3	Brinjal: <i>Solanum melongena</i>	Solanaceae	P	+++	Mar - June, Sept -Dec
4	Onion: <i>Allium cepa</i>	Liliaceae	P	+++	Dec-Feb, Mar- May
5	Kate math: <i>Amaranthus sp</i>	Amaranthaceae	P	+++	Sept-Oct
6	Methi: <i>Trigonella foenum</i>	Fabaceae	N; P	++	Jan- Apr
7	Garlic: <i>Allium sativum</i>	Liliaceae	N; P	++	Aug- Sep
8	Cucumber <i>Cucumis sativus</i>	Cucurbitaceae	N; P	++	Aug -Oct
9	Garden pea <i>Pisum sativum</i>	Fabaceae	N; P	++	Sept-Dec
10	Bottle gourd: <i>Lagenaria siceraria</i>	Cucurbitaceae	N; P	++	Aug - Sept
11	Pumpkin: <i>Cucurbita pepo</i>	Cucurbitaceae	N; P	++	Aug - Oct
12	Silk gourd: <i>Luffa acutangula</i>	Cucurbitaceae,	N; P	++	July - Oct
13	Cluster bean: <i>Cyamopsis tetragonolobus</i>	Leguminosae	N	+++	June - Aug
14	Shevga/ Drumstick: <i>Moringa oleifera</i>	Moringaceae	N;P	+++	Apr; Nov -Feb
15	Muli: <i>Raphanus sativus</i>	Brassicaceae	N; P	+++	Jan - Dec
16	Coriander: <i>Coriandrum sativum</i>	Apiaceae	N; P	+++	Jan - Dec
17	Cauliflower: <i>Brassica oleracea</i>	Brassicaceae	N; P	+++	Jan-Apr
18	Curry patta: <i>Murraya koenigii</i>	Rutaceae	N	+++	Mar - May

+++ frequent visit; ++ moderate visit; + poor visit
N= Nectariferous plants; P= Polleniferous plants

B) Fruits

S. No.	Common: Scientific Name	Family	Food Source	Intensity of visitation	Flowering period
1	Water melon: <i>Citrullus lanatus</i>	Cucurbitaceae	P	++	Feb - Mar
2	Guava: <i>Psidium guajava</i>	Myrtaceae	P	+++	June - Sept
3	Banana: <i>Musa spp</i>	Musaceae	N; P	+++	Jan- Dec
4	Custard apple: <i>Annona squamosa L.</i>	Annonaceae	N; P	+++	June -Aug
5	Dalimb /Pomegranate: <i>Punica granatum</i>	Punicaceae	N; P	++	Mar - June
6	Santra/Orange: <i>Citrus reticulata</i>	Rutaceae	N; P	+++	Jan -Mar, June - Jul
7	Ber: <i>Ziziphus jujuba</i>	Rhamnaceae	N; P	++	Jul - oct
8	Ber: <i>Ziziphus mauritiana</i>	Rhamnaceae	N; P	++	May - June
9	Bel: <i>Aegle marmelos</i>	Rutaceae	N; P	++	May - June
10	Mango: <i>Mangifera indica</i>	Anacardiaceae	P	+++	Jan -Apr
11	Papaya: <i>Carica papaya</i>	Caricaceae	N; P	++	Feb- Mar
12	Ale: <i>Zingiber officinalis</i>	Zingiberaceae	N; P	++	Nov-Feb
13	Jackfruit: <i>Artocarpus heterophyllus</i>	Moraceae	N	++	Feb-Mar
14	Lemon: <i>Citrus limon</i>	Rutaceae	N; P	+++	Oct - Jan, Jul - Sep
15	Kaghiinimboo: <i>Citrus aurantifolia</i>	Rutaceae	N; P	+++	Nov - Mar
16	Naral/ nariyal: <i>Cocos nucifera</i>	Arecaceae	P	+++	Jan-Dec
17	Amla: <i>Phyllanthus emblica</i>	Euphorbiaceae	N; P	++	Mar-May

+++ frequent visit; ++ moderate visit; + poor visit
N= Nectariferous plants; P= Polleniferous plants

C) Ornamental plants

S. No.	Common: Scientific Name	Family	Food Source	Intensity of visitation	Flowering period
1	Tulsi: <i>Ocimum sanctum</i>	Lamiaceae	N; P	+++	July-Sept/Mar -Apr
2	Basil: <i>Ocimum basilicum</i>	Labiatae	N; P	+++	Oct-Feb
3	Rose: <i>Rosa indica</i>	Rosaceae	P	++	Mar-Sept
4	Marigold: <i>Tagetes erecta</i>	Asteraceae	N	++	Sept-Dec
5	Adhulsa: <i>Adhatoda vasica</i>	Acanthaceae	N	++	Jan-Dec
6	Kalmegh: <i>Andrographis paniculata</i>	Acanthaceae	N; P	+++	Apr-Jul
7	Shatavari: <i>Asparagus racemosus</i>	Asparagaceae	P	+	May-June
8	Brahmi: <i>Bacopa monieri</i>	Scrophulariaceae	P	+	June-Oct
9	Ashoka: <i>Saraca asoca</i>	Caesalpinaceae	N; P	++	Feb-Apr
10	Gul Mohor: <i>Delonix regia</i>	Fabaceae	N; P	+++	Mar- May
11	Malti: <i>Quisqualis indica</i>	Combretaceae	N	++	Apr-June
12	Kenar: <i>Thevetia peruviana</i>	Apocynaceae	N	++	May-Aug

+++ frequent visit; ++ moderate visit; + poor visit
N= Nectariferous plants; P= Polleniferous plants

D) Cereal, Pulses

S. No.	Common: Scientific Name	Family	Food Source	Intensity of visitation	Flowering period
1	Chick pea: <i>Cicer arietinum</i>	Fabaceae	N	+++	Dec - Mar
2	Moong: <i>Vigna radiata</i>	Fabaceae	N	+++	Aug - Sep
3	Pigeon pea: <i>Cajanus cajan</i>	Fabaceae	N	+++	Jul - oct
4	Urd black gram: <i>Vigna mungo</i>	Fabaceae	N	+++	Aug -Sep
5	Black eyed / cow pea: <i>Vigna unguiculata</i>	Fabaceae	N	+++	Jul - Aug
6	Wheat: <i>Triticum aestivum</i>	Poaceae	N	++	Jan – Apr
7	Maize: <i>Zea mays</i>	Poaceae	P	++	Aug - Sep, Feb - Mar
8	Rice: <i>Oryza sativa</i>	Poaceae	P	++	Sept- Oct
9	Jowar: <i>Sorghum vulgare</i>	Poaceae	P	++	Feb-Mar

+++ frequent visit; ++ moderate visit; + poor visit

N= Nectariferous plants; P= Polleniferous plants

E) Other crops (fibre, oilseed)

S. No.	Common: Scientific Name	Family	Food Source	Intensity of visitation	Flowering period
1	Cotton: <i>Gossypium spp</i>	Malvaceae	N;P	+++	Sept - Dec
2	Ground nut: <i>Arachis hypogaea</i>	Fabaceae	P	++	July - Oct, Apr– June
3	Soybean: <i>Glycine max</i>	Leguminosae	N	++	July -Oct
4	Sunflower: <i>Helianthus annuus</i>	Compositae	N; P	+++	Aug- Sept
5	Sesame/Til: <i>Sesamum indicum</i>	Pedaliaceae	N; P	+++	Jul - Sept
6	Castor: <i>Ricinus communis</i>	Euphorbiaceae	N;P	+++	Nov -Feb

+++ frequent visit; ++ moderate visit; + poor visit

N= Nectariferous plants; P= Polleniferous plants

Table 2: The diversity of Forest tree/ wild plantation bee flora in Nagpur and Wardha during March 2017–Mar 2018

S. No.	Common/Vernacular: Scientific Name	Family	Food Source	Intensity of visitation	Flowering period
1	Tamarind: <i>Tamarindus indica</i>	Fabaceae	P	+++	Apr-May; Dec - Jan
2	Neem: <i>Azadirachta indica</i>	Meliaceae	N; P	+++	Mar-May
3	Eucalyptus: <i>Eucalyptus spp</i>	Myrtaceae	N; P	+++	Nov - Mar
4	Jamun: <i>Syzygium cumini</i>	Myrtaceae	N; P	+++	Mar -May
5	Palas/ Flame of forest: <i>Butea monosperma</i>	Papilionaceae	N; P	+++	Feb - Apr
6	Kachnaar/Kanchan: <i>Bauhinia purpurea</i>	Caesalpinaceae	N; P	+++	Jan - Feb
7	Apta: <i>Bauhinia racemosa</i>	Caesalpinaceae	N; P	+++	Mar-Aug
8	Khair: <i>Acacia catechu</i>	Mimosaceae	N; P	+++	Sept-Dec
9	White siris tree: <i>Albizia procera</i>	Mimosaceae	N; P	+++	Apr-May
10	Kadamb: <i>Anthocephalus cadamba</i>	Rubiaceae	N; P	+++	Jan-Mar
11	Semal/ Red silk cotton: <i>Bombax ceiba</i>	Bombacaceae	N; P	+++	January-May
12	Rui: <i>Calotropis gigantea</i>	Asclepiadiaceae	N; P	++	Nov-Dec
13	Bahava: <i>Cassia fistula</i>	Caesalpinaceae	P	++	Apr-May
14	Lantana: <i>Lantana camara</i>	Verbenaceae	N	+	Jan-Apr, Jul-Sep
15	Nimbara: <i>Melia azadirach</i>	Meliaceae	P	+++	Feb-May
16	Shami: <i>Prosopis juliflora</i>	Fabaceae	P	++	May -June, Sept-Oct
17	Arjun: <i>Terminalia arjuna</i>	Combretaceae	N; P	++	Apr-May
18	Ekdandi: <i>Tridax procumbens</i>	Asteraceae	N;P	+	Jan-Dec
19	Squirrel tail: <i>Justicia betonica</i>	Acanthaceae	N; P	+	Jan-Dec
20	Devil's Horsewhip: <i>Achyranthes aspera</i>	Amaranthaceae	P	+	Dec-Feb
21	Cobbler's pegs: <i>Bidens pilosa</i>	Asteraceae	N; P	++	Jul-Aug
22	Janglimuli: <i>Blumea lacera</i>	Asteraceae	N; P	+++	Dec-Mar
23	Bold-leaf Launaeae: <i>Launaea nudicaulis</i>	Asteraceae	N; P	+	Sep-Dec
24	Wild Senna: <i>Cassia tora</i>	Caesalpinaceae	P	++	Mar-Jul
25	Indian catmint: <i>Anisomeles indica</i>	Labiatae	N; P	+	Nov-Mar
25	Flannel Plant: <i>Verbascum coromandelianum</i>	Schrophulariaceae	N	++	Nov- Feb
27	Aniseed: <i>Pimpinella anisum</i>	Umbelliferae	N; P	+++	Sep-Dec
28	Touch me not: <i>Mimosa pudica</i>	Fabaceae	P	+++	July- May
29	Milk thistle: <i>Silybum marianum</i>	Asteraceae	N	+++	Feb -Mar
30	Karanj: <i>Pongamia pinnata</i>	Fabaceae	N; P	+++	Feb-May

+++ frequent visit; ++ moderate visit; + poor visit

N= Nectariferous plants; P= Polleniferous plants

3.2 Observation on nectariferous /polleniferous bee flora and intensity of visitation:

The identified bee flora were further grouped into nectariferous and polleniferous bee flora along with the intensity of visitation by honey bees on the flowers. In agricultural and horticultural crops all type of food source such as pollen food source, nectar food source and pollen nectar both with different intensity of visits were recorded

Table 1 (A, B, C, D, E) and Table 2. While studying, it was observed that different fruits, vegetables, cereal, pulses, oilseed crops, fiber crops, ornamental plants and wild plants species were the supplier of nectar and pollen in natural and crop ecosystem. Among vegetable plant species (Table: 1 A) four (4) were pollen yielding, two (2) were nectar yielding and twelve (12) were both pollen and nectar yielding. Under fruit crops four (4) plant species were pollen yielding, one (1)

were nectar yielding and twelve (12) were both pollen and nectar yielding (Table: 1 B). In ornamental crop category three (3) plant species were pollen yielding, four (4) were nectar yielding and five (5) were both pollen and nectar yielding (Table: 1 C). In case of cereal pulses three (3) plant species were pollen yielding and six (6) were nectar yielding (Table: 1 D). None of the plant had attribute to supply both nectar and pollen in this case. In fiber and oilseed crop one (1) was pollen source, one (1) was nectar source and four (4) were nectar pollen yielding plant species (Table: 1 E). Seven (7) pollen yielding, three (3) nectar yielding and twenty (20) nectar pollen yielding plant species were also recorded either in wild form or in forest vegetation for the supply of food source to honey bees (Table:2).

Result on intensity of visitation demonstrate that in all the categories frequent visit and moderate visits were common in agricultural and horticultural crops including vegetables, fruits, cereal pulses, fiber and oilseed crops (Table: 1 A, B, D, E) except in ornamental plants (Table: 1 C) in which two (2) plant species Shatavari: *Asparagus racemosus* belonging to family asparagaceae and Brahmi: *Bacopa monieri* belonging to family scrophulariaceae received poor visit of honey bee. Among the fifty (50) cultivated plant species which were the bee flora, twenty-six (26) plant species received frequent visits of honey bee means honey bee prefers these plants as a major food source, rest twenty-four (24) plants received moderate visits. Under wild plant species out of thirty (30) plants seventeen (17) plants received frequent visits, seven (7) plant species received moderate visit and six (6) plant species

received poor visit by the honey bees (Table:2). Many investigators have conducted similar type of studies in different study area of India [5, 29, 30, 31].

From the above discussion it is clear that Nagpur and Wardha which comes under the agro ecological subregion (AESR) 10.2 are dwelling with bee flora as twenty-two (22) plant species were pollen yielding, seventeen (17) were nectar yielding and fifty-three (53) were both nectar and pollen yielding for honey bees which is the significant number for the survival of managed and feral colonies of honey bees because the health of colony, its performance and ultimately direct and indirect benefits of beekeeping depends on the availability of food [32, 33]. Presence of diversified bee flora supports the apiaries in well manner [29, 34]. Honey bee required only two major food from nature; nectar as a source of carbohydrate and pollen as a source of protein. Weak colony is a soft target for insect pests attack whether it is new as wax beetle in Meghalaya [12] or previously reported and for colony collapse disorder. It is well researched and studied that, bee activity in crop field benefits the farmer by increasing crop yield after the proper pollination [35, 36].

3.3 Percent abundance of beeflora

It was observed that percent abundance of bee flora were highest with maximum 48.9% during march followed by 42.3% in February, April, September, 39.1% during August, 36.9% in May, 34.7% in July, 33.6% in January, 32.6% in December, 30.4% in October, 29.3% in June and 27.1% in November (Fig: 1).

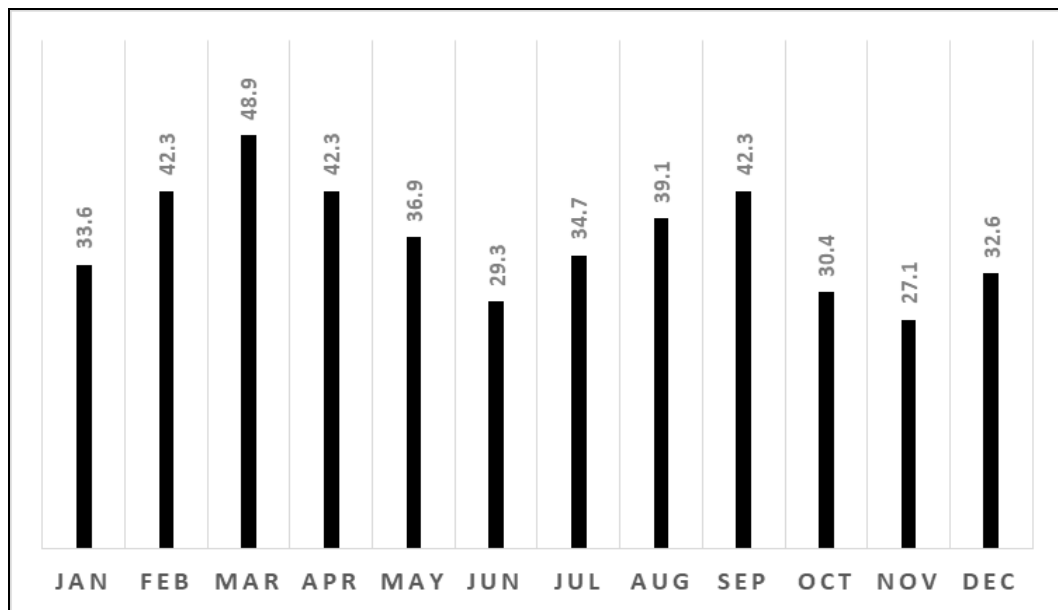


Fig 1: Per cent abundance of Total Bee flora during 2017-18

Cultivated plants contributed maximum 69.4% during August followed by 66.6% during September; 60.7% in October, 56.2% in July; 51.6% in January, 51.2% in February, 51.1% in March, 48.0% in November, 46.6% in December, 41.0% in April, and it was lowest with 35.2% during May. In case of wild plants, it was in reverse order as it was calculated only through the subtraction and it was 64.8%, 59.0%, 53.4%, 52.0%, 48.9%, 48.8%, 48.4%, 44.5%, 43.8%, 39.3%, 33.4% and 30.6% in descending order during May, April, December,

November, March, February, January, June, July, October, September and August respectively (Fig:2).

From the percent bee flora abundance, it was clear that cultivated bee flora were lowest during May month followed by April however it came at 6th position after taking all the bee flora under consideration while calculation. This data provides a valid proof for wild bee flora in contributing towards sustainable beekeeping throughout the year.

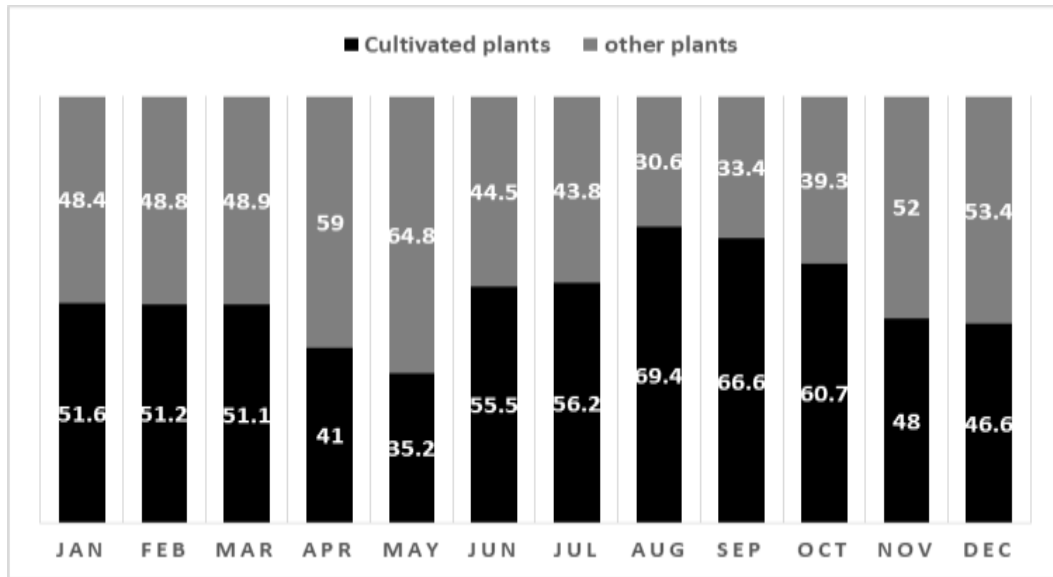


Fig 2: Per cent abundance of cultivated plants and others plants bee flora during 2017-18

3.4 Preparation of bee flora calendar

On the basis of information on overlapping flowering period of these bee flora, it was observed that in each month among the cultivated crop always 12 bee flora were present as a food source like in May and November and these number of bee flora were up to 26 during September followed by 25, 23, 20, 18, 17, 16, 15 and 14 during August, March, February, July, October, January-April, June and December respectively. In case of ornamental plants and wild flora it was recorded that from 11 to 23 wild bee florawere present depends upon the month (Table: 3). It was calculated that total bee flora

including cultivated plant species, ornamental plant species and wild bee flora, maximum bee flora were recorded during March which was forty five (45) number of bee flora followed by September, February and April, with thirty nine (39) number of bee flora, August, thirty six (36) number of bee flora, May, thirty four (34) number of bee flora, July, thirty two (32) number of bee flora, January, thirty one (31) number of bee flora, December, thirty (30) number of bee flora, October, twenty eight (28) number of bee flora and June, twenty seven (27) number of bee flora. Least number of bee flora twenty-five (25) were observed in November.

Table 3: Bee flora calendar of Nagpur and Wardha region during 2017-18

Name of plant	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec
Bhindi			*	*		*	*	*				
Bitter gourd						*	*	*	*			
Brinjal			*	*	*	*			*	*	*	*
Onion	*	*	*	*	*							*
Kate math									*	*		
Methi	*	*	*	*								
Garlic								*	*			
Cucumber								*	*	*		
Garden pea									*	*	*	*
Bottle gourd								*	*			
Pumpkin								*	*	*		
Silk gourd							*	*	*	*		
Cluster bean						*	*	*				
Drumstick	*	*	*	*							*	*
Muli	*	*	*	*	*	*	*	*	*	*	*	*
Coriander	*	*	*	*	*	*	*	*	*	*	*	*
Cauliflower	*	*	*	*								
Curry patta			*	*	*							
Water melon		*	*									
Guava						*	*	*	*			
Banana	*	*	*	*	*	*	*	*	*	*	*	*
Custard apple						*	*	*				
Pomegranate			*	*	*	*						
Orange	*	*	*			*	*					
Ber ¹					*	*	*	*	*	*		
Bel					*	*						
Mango	*	*	*	*								
Papaya		*	*									
Ale	*	*									*	*
Jackfruit		*	*									
Lemon	*						*	*	*	*	*	*
Kaghziinimboo	*	*	*								*	*

nariyal	*	*	*	*	*	*	*	*	*	*	*	*
Amla			*	*	*							
Chick pea	*	*	*									*
Moong								*	*			
Pigeon pea							*	*	*	*		
Urd black gram							*	*	*			
cow pea							*	*				
Wheat	*	*	*	*								
Maize		*	*					*	*			
Rice									*	*		
Jowar		*	*									
Cotton									*	*	*	*
Ground nut				*	*	*	*	*	*	*		
Soybean							*	*	*	*		
Sunflower								*	*			
Sesame							*	*	*			
Castor	*	*									*	*
Total cultivated plants/month	16	20	23	16	12	15	18	25	26	17	12	14
Tulsi			#	#			#	#	#			
Basil	#	#								#	#	#
Rose			#	#	#	#	#	#	#			
Marigold									#	#	#	#
Adhulsa	#	#	#	#	#	#	#	#	#	#	#	#
Kalmegh				#	#	#	#					
Shatavari					#	#						
Brahmi						#	#	#	#	#		
Ashoka		#	#	#								
Gul Mohor			#	#	#							
Malti				#	#	#	#					
Kenar					#	#	#	#				
Total ornamental plants/month	2	3	5	7	7	7	7	5	5	4	3	3
Tamarind	x			x	x							x
Neem			x	x	x							
Eucalyptus	x	x	x								x	x
Jamun			x	x	x							
Palas		x	x	x								
Kachnaar	x	x										
Apta			x	x	x	x	x	x				
Khair									x	x	x	x
White siris tree				x	x							
Kadamb	x	x	x									
Semal	x	x	x	x	x							
Rui											x	x
Bahava				x	x							
Lantana	x	x	x	x			x	x	x			
Nimbara		x	x	x	x							
Shami					x	x			x	x		
Arjun				x	x							
Ekdandi	x	x	x	x	x	x	x	x	x	x	x	x
Squirrel tail	x	x	x	x	x	x	x	x	x	x	x	x
Devil's Horsewhip	x	x										x
Cobbler's pegs							x	x				
Janglimuli	x	x	x									x
Bold-leaf Launaeae									x	x	x	x
Wild Senna			x	x	x	x	x					
Indian catmint	x	x	x								x	x
Flannel Plant	x	x									x	x
Aniseed									x	x	x	x
Touch me not	x	x	x	x	x		x	x	x	x	x	x
Milk thistle		x	x									
Karanj		x	x	x	x							
Total wild plants /month	13	16	17	16	15	5	7	6	8	7	10	13
Total plant species/month	31	39	45	39	34	27	32	36	39	28	25	30

¹Z. jujube and Z. mauritiana, * cultivated plants; #ornamental plants, x wild plant

On the basis of chronological record maintained during the study circular bee flora calendar was developed (Fig: 3) especially for Nagpur and Wardha region which can be used as a ready reckoner for the farmers, beginners-

beekeepers because continuous supply of natural food in form of nectar and pollen from the flowers during blooming period are essential for sustainable beekeeping. The inner circle of the bee flora calendar included the entire cultivated crops of

farmers' field which were more or less present in throughout the year. Outer circle comprised of ornamental plants along with wild plant species which worked as a supplementary supplier of the food source in absence of cultivated crop plant species.

On the basis of bee flora calendar prepared using flowering period as a basic tool, some of the plants could be fairly included as a food source of honey bee throughout the year. Among the cultivated crops Muli: *Raphanus sativus*, Coriander: *Coriandrum sativum*, Banana: *Musa spp* and Nariyal: *Cocos nucifera* were the ones falling under this category than others were Adhulsa: *Adhatoda vasica*, Ekdandi: *Tridax procumbens* and Squirrel tail: *Justicia betonica* supplying food throughout the year. Plants species, which supplied the food to honey bee up to 5 months include Bhindi: *Abelmoschus esculentus*, brinjal: *Solanum melongena*; onion: *Allium cepa*; drumstick: *Moringa oleifera*; Orange: *Citrus reticulata*, lemon: *Citrus limon*, Kaghziniimboo: *Citrus aurantifolia* and ground nut: *Arachis hypogaea*. This way, bee flora calendar can aid the farmers in predicting the natural food availability to their honey bee colonies in particular month. It can be well utilized as decision making parameter for supplement food and migration of colonies.

4. Conclusion

Honey bee are the essential elements of crop ecosystem by pollinating wide range of crops. This study presents 92 plant species as a bee flora in the respective area out of which 35 were horticultural crops including 18 vegetables and 17 fruit plant species; 12 were ornamental plants; 15 were agricultural crops including cereal, pulses, fiber and oilseed and 30 were wild plant species. As per the observations recorded different fruits, vegetables, cereal, pulses, oilseed crop, fiber crop, ornamental plants and wild plants species were the supplier of nectar and pollen in natural and crop ecosystem. Frequent and moderate visit on flower clear that honey bees preferred all the plants as major food source. On the basis of information on overlapping flowering period, the number of bee flora ranges between 25-45 for each month. From the above discussion it can be concluded that Nagpur and Wardha region can be considered appropriate area for initiation of scientific beekeeping to improve the livelihood of the farmers. Bee flora calendar share the knowledge to the farmers about natural food availability in particular month and give them power to make decision for sustainable beekeeping. The record of wild bee flora during the study encourages their conservation for sustainable bee keeping in future as well.

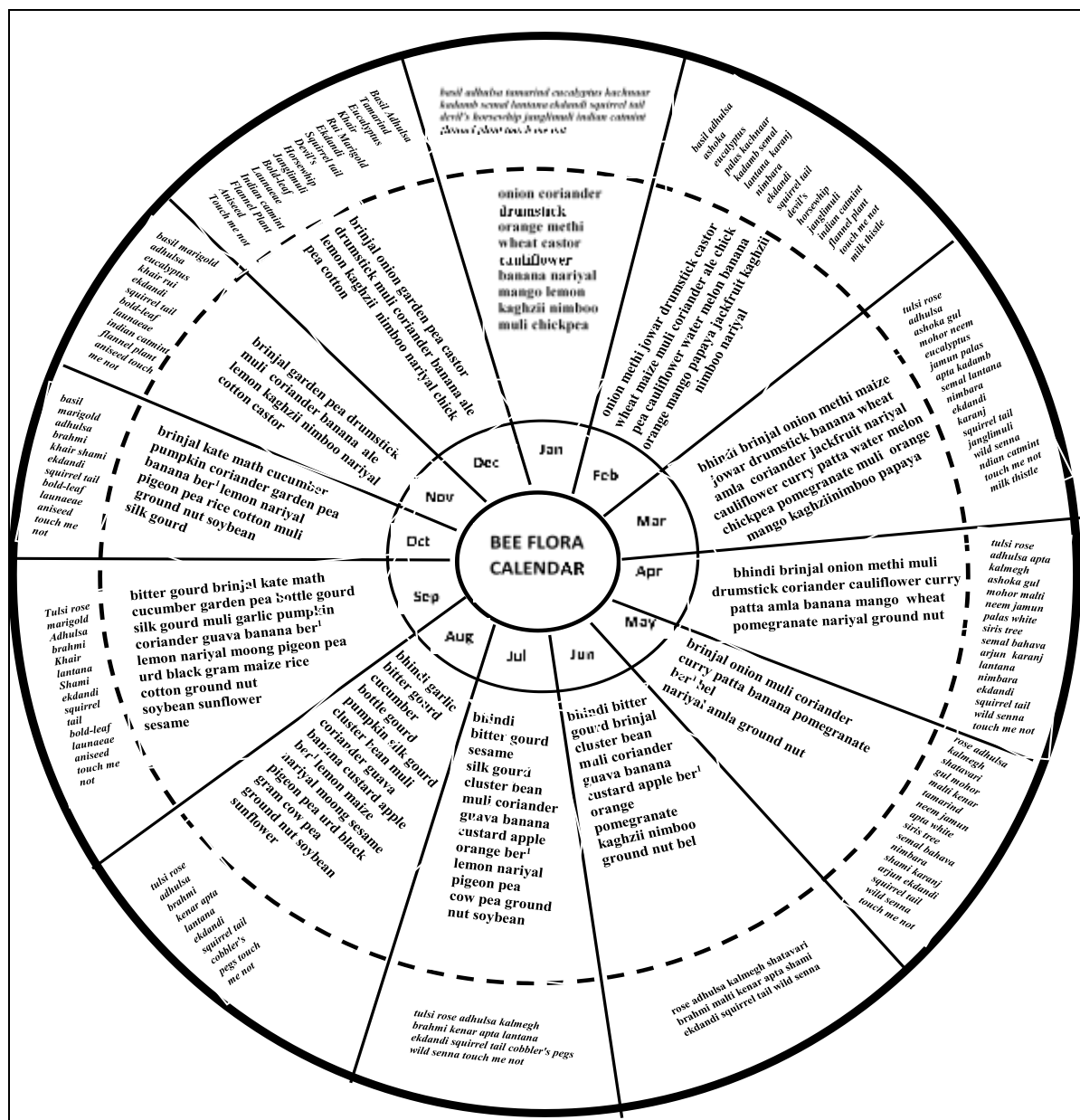


Fig 3: Bee flora calendar of Nagpur and Wardha region

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