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Diversity of nectariferous and polleniferous bee flora at Anjaneri and Dugarwadi hills of Western Ghats of Nasik district (M. S.) India

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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 Anjaneri and Dugarwadi hills. 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 results revealed that 52 plant species were useful to honeybees, out of which 29 were agricultural crops and 23 wild plants. The identified flora was further grouped into pollen, nectar and both pollen and nectar yielding plants. 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 the year. 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.

1. Introduction

Honeybees are one of the most important pollinators of angiosperms because of their vegetarian diet, flower visiting habits, hairy bodies that readily pick up pollen grains and visit many flowers of the same species during a single trip thus affecting pollination [1, 2]. This enables the reproduction, productivity and diversification of plants. The mutual interdependence of the anthophilous insects and entomophilous angiosperms hastened their co-evolution [3].

Beekeeping is agro-horticultural and forest based industry and it is of great importance to farmers for pollination benefit. Insect pollination of agricultural crops is a critical ecosystem service. Honeybees pollinate 16% of flowering plant species in the world and nearly 400 species of agricultural plants [4]. Fruits, vegetables or seed production from 87 of the 115 leading global food crops depends upon animal pollination [5]. The value of insect pollination for worldwide agricultural production is estimated to be 153 billion, which represents 9.5% of the value of the world agricultural production used for human food in 2005 [6]. By investing limited expenses, beekeeping can be practiced to obtain maximum subsidiary income through honey, beeswax and other bee products with agricultural activity. The practice of beekeeping is not only depends on the better strain of honeybees but also on abundance and occurrence of pollen and nectar sources within the surrounding area of an apiary [7, 8].

Flowers are the mainstay of bee's life. However flowering plants of several plant families are blossoming at different time intervals of the year [7]. Depending upon the soil type, climatic factors and the habitat of the vegetation, the time of the blooming may change for even the same nectar plants [9]. Sound information on duration of flowering and blooming time is essential for proper beekeeping management [10]. The extensive knowledge on type, density and quality of bee flora in a region are prerequisites for enhancing the efficiency of beekeeping industry and successful beekeeping. Such information may enable beekeepers to utilize beekeeping at the maximum level, so that they can harvest a good yield of honey and other bee products in addition to effective. Every region has its own honey flow and dearth periods of short and long duration. Such knowledge on bee flora will help in the effective management of bee colonies during such periods. Many researchers studied the various aspects of botanical sciences, with special emphasis on floral biology, taxonomy, and palynology [11-19].

Therefore, the present investigation was carried out to prepare an inventory of existing nectariferous/ polleniferous bee flora and develop floral calendar for Anjaneri and Dugarwadi hills of Western Ghats of Maharashtra (India).

2. Materials and Methods

2.1 Study sites

Geographically Anjaneri, and Dugarwadi hills are located in

Trimbakeshwar taluka of Nasik district at 19.56° N latitude and 73.32° E longitude. The average altitude of this area is 1350 meter above the sea level. The foraging area of honey bee ranges approximately 38 km^2 (fig.1). The annual rain fall at Anjaneri and Dugarwadi hills is approximately 130-150 cm. The Anjaneri and Dugarwadi hills are evergreen forest. Tribal people use this land for agriculture purpose.

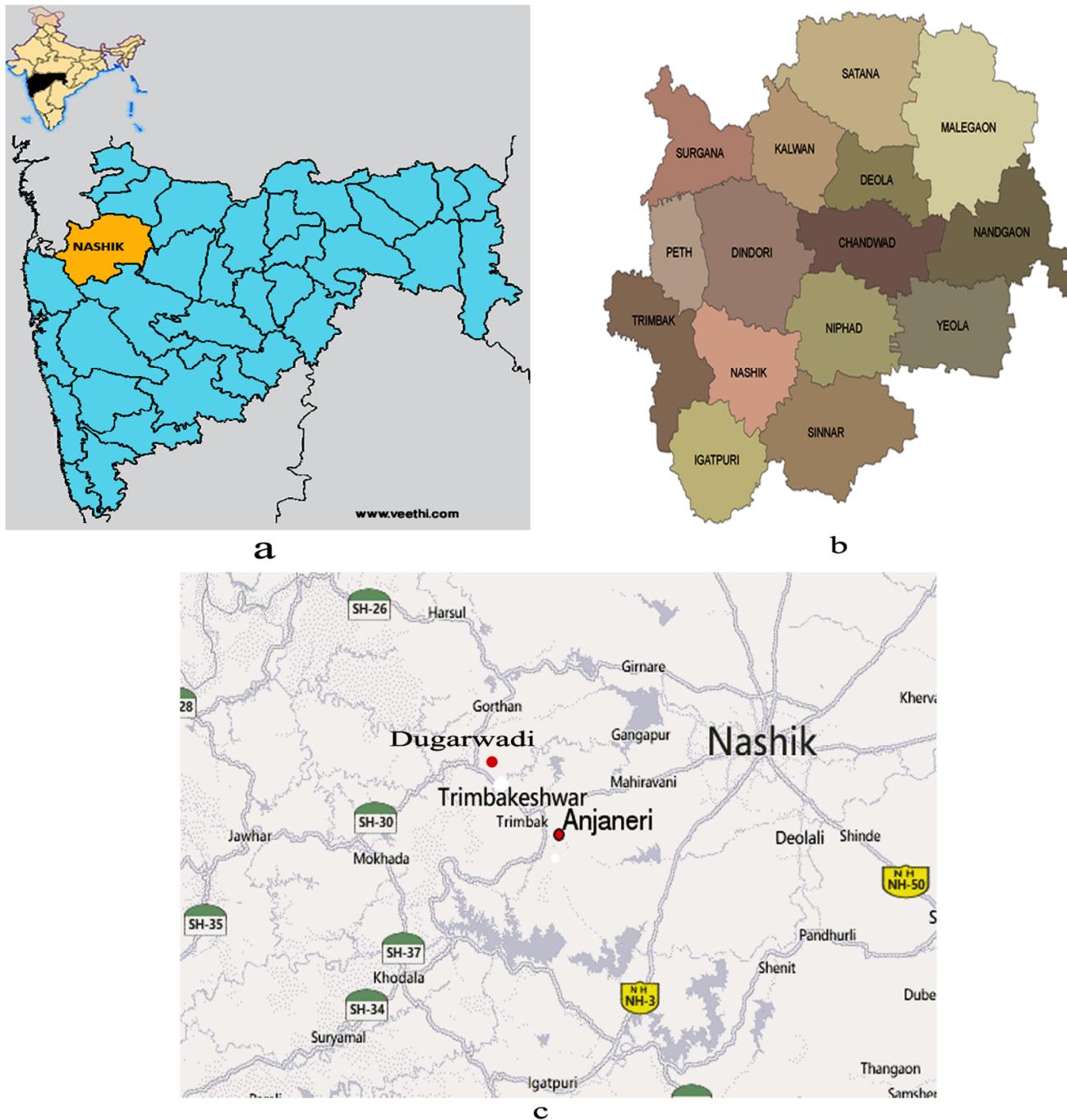


Fig 1: Map of the study area showing location of the sites

2.2 Identification of bee-flora

Field data were collected through monthly visit to the study

sites, during April 2008– March 2009. Each study visit served as pseudo replicates for the site and all observations were

taken between 0700-1730 hours. The study included observation of bee's activities 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 observation.

The observation on nectar and pollen source was based on activities performed by honeybees on different flowers. 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 [20]. 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 futures like its leaves, flower and portion of stem were cut and arranged in herbarium, identified with the

help of taxonomist and compared with the published reports [21, 22]. The observations were recorded for three seasons.

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

3. Results and Discussion

The study area is typically hilly area, which includes a considerable area of natural forest and tree plantations, besides large extent of foot hills land is under the cultivation of agro-horticultural crops. In the present investigation honeybee foraging activities were recorded on different agricultural and wild plant species during April 2008-March 2009 (Tables 1-2, Figures 2-3). The result revealed that 52 plant species were useful to honeybees, out of which 29 were agricultural crops and 23 were wild plants, which are well distributed and commonly found in the study area. The identified flora was further grouped into pollen, nectar and both pollen and nectar yielding plants (Tables 1-2) out of 29 agricultural bee plant species, nine (9) plants

Table 1: The nectariferous/polleniferous agricultural bee flora and floral calendar of Anjaneri and Dugarwadi hills during April 2008–Mar 2009.

Sr. no.	Common name	Botanical name	Family	Flowering period	Bee forage value		
					Nectar	Pollen	Nectar+Pollen
1	Custard apple	<i>Annona squamosa</i>	Annonaceae	Aug – Oct.	-	-	N1P2
2	Coriander	<i>Coriandrum sativum</i>	Apiaceae	Jan – Dec.	-	-	N1P2
3	Sunflower	<i>Helianthus annuus</i>	Compositae	March – April.	-	-	N2P1
4	Mustard	<i>Brassica rapa</i>	Brassicaceae	Jan – March.	N1	-	-
5	Bottle gourd	<i>Lagenaria siceraria</i>	Cucurbitaceae	Oct – Feb.	-	-	N2P2
6	Cucumber	<i>Cucumis sativus</i>	Cucurbitaceae	Aug – Oct.	-	P1	-
7	Musk melon	<i>Cucumis melo</i>	Cucurbitaceae	March – May.	-	P1	-
8	Pumpkin	<i>Cucurbita pepo</i>	Cucurbitaceae	Aug – Oct.	-	-	N2P2
9	Water melon,	<i>Citrullus lanatus</i>	Cucurbitaceae	July – Aug.	-	P1	-
10	Silk gourd	<i>Luffa acutangula</i>	Cucurbitaceae,	July – Oct.	-	-	N1P1
11	Turkish gram balls	<i>Vigna aconitifolia</i>	Fabaceae	March - May.	N3	-	-
12	Black eyed pea	<i>Vigna unguiculata</i>	Fabaceae	Jul – Aug.	N3	-	-
13	Black gram	<i>Vigna mungo</i>	Fabaceae	Aug – Sep.	N3	-	-
14	Chickpea	<i>Cicer arietinum</i>	Fabaceae	Dec – March.	N2	-	-
15	Ground nut	<i>Arachis hypogaea</i>	Fabaceae	July - Oct, April – June.	-	P2	-
16	Mung bean	<i>Vigna radiata</i>	Fabaceae	Aug – Sep.	N3	-	-
17	Pea	<i>Pisum sativum</i>	Fabaceae	Aug- Sep.	-	-	N1P1
18	Pigeon pea	<i>Cajanus cajan</i>	Fabaceae	July – Sep.	N2	-	-
19	Cluster bean	<i>Cyamopsis tetragonolobus</i>	Leguminosae	Jun - Aug.	N2	-	-
20	Onion	<i>Allium cepa</i>	Liliaceae	Jun- Aug.	-	P1	-
21	Drumstick	<i>Moringa oleifera</i>	Moringaceae	Nov – Feb.	-	-	N1P2
22	Sesame	<i>Sesamum indicum</i>	Pedaliaceae	July – Aug.	-	-	N1P2
23	Maize	<i>Zea mays</i>	Poaceae	Aug – Sep, Feb – March.	-	P2	-
24	Wheat	<i>Triticum aestivum</i>	Poaceae	Feb – April.	N1	-	-
25	Pomegranate	<i>Punica granatum</i>	Punicaceae	March – June.	-	-	N2P1
26	Ziziphus	<i>Ziziphus jujuba</i>	Rhamnaceae	July – Oct.	-	-	N2P3
27	Citrus	<i>Citrus limon</i>	Rutaceae	Oct – Jan, July – Sep.	-	-	N2P1
28	Sweet lime	<i>Citrus aurantifolia</i>	Rutaceae	Nov – March.	-	-	N2P2
29	Brinjal	<i>Solanum melongena</i>	Solanaceae	Jan to March, June to July.	-	P3	-

N1 = Low nectar percentage, N2 = Medium nectar percentage and N3 = High nectar percentage.

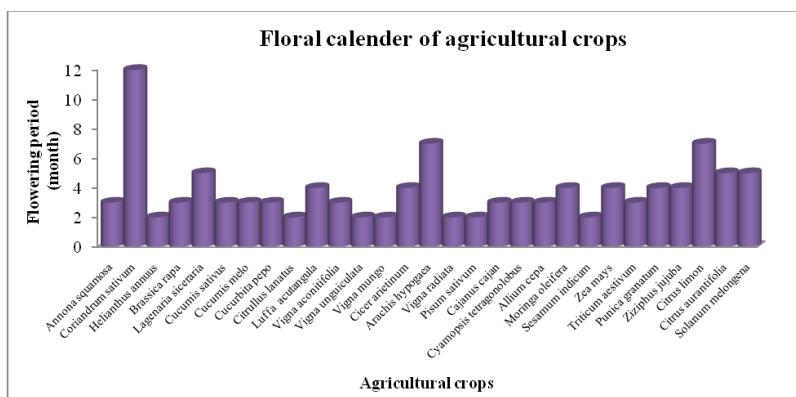
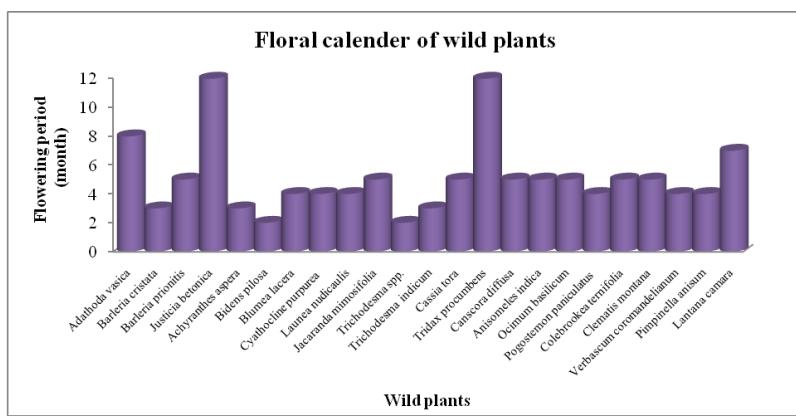
P1 Low pollen percentage, P2 = Medium pollen percentage and P3 = High pollen percentage.

Table 2: The nectariferous/polleniferous wild bee flora and floral calendar of Anjaneri and Dugarwadi hills during April 2008–Mar 2009.

Sr. No.	Common name	Botanical name	Family	Flowering period	Bee forage value		
					Nectar	Pollen	Nectar+Pollen
1	Malabar nut	<i>Adhatoda vasica</i>	Acanthaceae	Nov-July.	-	-	N2P2
2	Philippine Violet	<i>Barleria cristata</i>	Acanthaceae	Feb-Apr	-	-	N2P3
3	Porcupine flower	<i>Barleria prionitis</i>	Acanthaceae	Feb-Jul.	-	-	N2P3
4	Squirrel tail	<i>Justicia betonica</i>	Acanthaceae	Jan-Dec.	-	-	N2P2
5	Devil's Horsewhip	<i>Achyranthes aspera</i>	Amaranthaceae	Dec-Feb.	-	P2	-
6	Cobbler's pegs	<i>Bidens pilosa</i>	Asteraceae	Jul-Aug.	-	-	N3P1
7	Janglimuli	<i>Blumea lacera</i>	Asteraceae	Dec-Mar.	-	-	N2P2
8	Purple bane	<i>Cyathocline purpurea</i>	Asteraceae	Sep-Dec.	-	-	N1P1
9	Bold-leaf Launaea	<i>Launaea nudicaulis</i>	Asteraceae	Sep-Dec.	-	-	N2P2
10	Jacaranda trees	<i>Jacaranda mimosifolia</i>	Bignoniaceae	Apr-Aug.	-	-	N2P2
11	Camel bush	<i>Trichodesma spp.</i>	Boraginaceae	Apr-May.	-	-	N2P2
12	Indian borage	<i>Trichodesma indicum</i>	Boraginaceae	Aug-Oct.	-	-	N1P2
13	Wild Senna	<i>Cassia tora</i>	Caesalpinaeae	Mar-Jul.	-	P2	-
14	Tridax daisy	<i>Tridax procumbens</i>	Compositae	Jan-Dec.	-	-	N2P1
15	Kilwar	<i>Canscora diffusa</i>	Gentianaceae	Sep-Jan.	-	P2	-
16	Indian catmint	<i>Anisomeles indica</i>	Labiatae	Nov-Mar.	-	-	N3P2
17	Basil	<i>Ocimum basilicum</i>	Labiatae	Oct-Feb.	-	-	N1P3
18	Panicled pogostemon	<i>Pogostemon paniculatus</i>	Labiatae	Jan-Apr.	-	-	N3P3
19	Indian squirrel tail	<i>Colebrookea ternifolia</i>	Labiatae	Aug-Dec.	-	-	N1P2
20	Anemone clematis	<i>Clematis montana</i>	Ranunculaceae	Dec-Apr.	-	-	N2P2
21	Flannel Plant	<i>Verbascum coromandelianum</i>	Schrophulariaceae	Nov-Feb.	N2	-	-
22	Aniseed	<i>Pimpinella anisum</i>	Umbelliferae	Sep-Dec.	-	-	N1P2
23	Lantana	<i>Lantana camara</i>	Verbenaceae	Jan-Apr, Jul-Sep.	N2	-	-

N1 = Low nectar percentage, N2 = Medium nectar percentage and N3 = High nectar percentage.

P1 Low pollen percentage, P2 = Medium pollen percentage and P3 = High pollen percentage.

**Fig 2:** Flowering periods of agricultural bee plants recorded during, April 2008–Mar 2009.**Fig 3:** Flowering periods of wild bee plants recorded during, April 2008 – Mar 2009.

were nectar yielding, seven (7) pollen yielding and thirteen (13) plants species were both pollen and nectar yielding. Results also demonstrate that out of 23 weeds/wild plant species two (2) plant species were nectar yielding, three (3) were pollen yielding and 18 plants species were both pollen and nectar yielding.

The bee colony efficiency, development as well as production of honey, beeswax and other bee products depends on quality and quantity of pollen and nectar obtained from bee forage plants [23, 24]. These food sources provide the nutritional requirements to the bee colony. The nectar acts as source of honey and provides heat and energy for bees and pollen provides the protein, vitamins, fatty substance and other nutrients to bees [25, 26, 27]. Therefore, a direct consequence of nutritional deficiency (pollen shortage) is a decrease in the colony population [23].

It was observed that the bee-flora consists of mostly ornamentals, timber, medicinal, fruits, vegetables and other commercially important plants like spices, pulses, cereals, oil seed/yielding, fibre, and fodder crops etc. Two wild plant species *Pogostemon paniculatus* and *Colebrookea ternifolia* belonging to family Labiateae, were dominating in the field area with the flowering period of (4) four and (5) five months respectively, while *Punica granatum*, *Allium cepa* and *Brassica rapa* were the major agricultural bee crops of the area with flowering period of four (4), three (3) and three (3) months respectively. These plants species served as the excellent sources of pollen and nectar in the study area. In dearth period when agro-horticultural crops are not in blooming, then weeds and wild flowering plants were observed as alternate food source for honeybees. Survival of any species in a geographical area follows the law of minimum. Wild flora provides nourishment to bees in adverse situations when cultivated plants are not in flowering state.

3.1 Honey flow and dearth period

For Anjaneri and Dugarwadi hills study area the honey flow and dearth period was determined and results are summarized in (Tables 1-2, Figure 2-3). The peak periods of honeybee foraging activity (honey flow period) were recorded during mid December–February of winter season and mid July to September of monsoon season of the year. During the seasons, abundant bee floral plants were found blossoming. During first honey flow period mid December–February of winter season, ten agricultural plants species were recorded as source of food for honeybees. Out of ten three agricultural plants species viz *Brassica rapa*, *Cicer arietinum*, *Triticum aestivum*, were nectar yielding, two species viz *Zea mays*, *Solanum melongena* were pollen yielding, and five plants species viz *Coriandrum sativum*, *Lagenaria siceraria*, *Moringa oleifera*, *Citrus limon*, *Citrus aurantifolia* were both nectar and pollen yielding. During the same period thirteen wild plant species were blooming in succession, out of which one species viz *Verbascum coromandelianum*, was nectar yielding, two species viz *Achyranthes aspera*, *Canscora diffusa*, were pollen yielding and ten plants species viz *Adhatoda vasica*, *Barleria cristata*, *Barleria prionitis*, *Justicia betonica*, *Blumea lacera*, *Tridax procumbens*, *Anisomeles indica*, *Ocimum basilicum*, *Pogostemon paniculatus*, *Clematis montana* were both nectar and pollen yielding.

The second honey flow period was recorded from mid July to September of monsoon season. During period fourteen agricultural plant species were recorded as source of food for honeybees. The four agricultural plants species viz *Vigna unguiculata*, *Vigna mungo*, *Cajanus cajan*, *Cyamopsis tetragonolobus*, were nectar yielding, five species viz *Cucumis sativus*, *Citrullus lanatus*, *Arachis hypogaea*, *Allium cepa*, *Zea mays*, were pollen yielding and five plant species viz *Annona squamosa*, *Luffa acutangula*, *Sesamum indicum*, *Ziziphus jujuba*, *Citrus limon* were both nectar and pollen yielding. During the second honey flow period seven wild plants species were recorded as bee plants, out of which one species viz *Lantana camara*, was nectar yielding and six species viz *Justicia betonica*, *Bidens pilosa*, *Trichodesma indicum*, *Colebrookea ternifolia*, *Jacaranda mimosifolia*, *Tridax procumbens*, were both pollen and nectar yielding. 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. In the

second honey flow period mid-July to August was the heavy rainfall period, atmosphere was cloudy. In this period there were many plants on bloom, but because of unfavorable condition bee foraging activity was very less, this was the gap period in honey flow period.

Mid- April–mid June (summer season) period was identified as the dearth period for honey bee at Anjaneri and Dugarwadi hills. Summer season was critical dearth period with high temperature (over 35 °C), scarcity of water and few flowering plants. The few agricultural plants like *Coriandrum sativum*, *Vigna aconitifolia*, *Arachis hypogaea*, *Punica granatum*, and wild plants like *Barleria prionitis*, *Justicia betonica*, *Jacaranda mimosifolia*, *Trichodesma spp.*, *Cassia tora*, *Tridax procumbens* 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 [28]. Because of high temperature and scarcity of water for flowering plants this period was found unfavorable for honeybee foraging. Similar studies have also been carried out by some investigators [10, 29, 30, 31].

The presence of number of bee floral species in the area suggests that the study area is undoubtedly suitable for commercial beekeeping. The diversified bee flora of the area supports beekeeping throughout the year. Zamarlicki [32] reported that the knowledge of honey plants is the most important factor in bee management and that the survival of honey bees is related to the abundance of bee plants. The success of bee plants in a given area including botanical and palynological aspects provides information on floral and beekeeping potential [33].

It was observed that, due to bee activity farmers are benefitted tremendously because of the ample presence of bee foraging plants in the vicinity of their farms. Sahli and Conner, [34] reported that bee pollination increase the crop yield in a kind of mutualistic relationships. According to Thakur, [35] in India, about 80 percent or more of the crop plants were dependent on insect pollination.

Various ecological habitats in these hills revealed several sites where alternative normal nectar and pollen sources were available during the dearth period. The economically important bee plants provide substantial quantity of pollen and nectar for bees during different months of the year.

3.2 Bee floral calendar

A complete chronological record of flowering periods of all plant species was made. The results are presented in Tables 1-2 and Figure 1-2. The floral calendar has considerably facilitated the standardization of routine management practices in apiaries. The region has more number of perennials and their distribution and blooming period is very essential in predicting the pollen and nectar flow for successful beekeeping. The knowledge of blooming season is important factor for sustainable management of bee colonies and for good honey harvest. The flowering duration of any given region helps in migratory beekeeping practice.

At Anjaneri and Dugarwadi hill area four species of honey bees, viz *A. dorsata*, *A. cerana indica*, *A. florea* and *A. mellifera* were reported. However *A. mellifera* was newly introduced in the region. The giant bee *A. dorsata* was well distributed in both hilly and plain region of the Anjaneri and Dugarwadi area. The wild bees are considered as effective pollinators of various agro-horticulture crops.

4. Conclusion

The present investigation revealed the presence of 52 plant species useful for beekeeping, out of which 29 were agricultural and 23 were wild plant species. Anjaneri and Dugarwadi hilly areas were recorded with two honey flow periods during mid December–February (winter season) and mid July to September (monsoon season) and dearth period during mid April–mid June (summer season). The results also showed that the area has large number of plants yielding both pollen and nectar than pollen or nectar yielding. Based on the study and available flora, Anjaneri and Dugarwadi hill area can be considered suitable to initiate beekeeping. However attention must be given to maintain the existing bee flora and multiplication of multipurpose

plant species in order to make it sustainable. In addition, attention must be given to provide artificial food during the rainy and summer months.

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