

Diversity of bee foraging flora and floral calendar of Paithan taluka of Aurangabad district (Maharashtra), India

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Abstract

The study was conducted at Paithan taluka of Aurangabad district during October 2012–September 2013 to identify existing bee flora and to determine honey flow and dearth period to develop the floral calendar. The flowering plants were visited and observed for the presence of honey bees and their foraging activities. Plants were reported as bee foraging species when at least three honey bees had visited the flowers within the period of 10 minutes. The result revealed that 63 plant species were useful to honeybees as source of food, out of which 41 were wild and 22 were agro-horticultural plants. The identified flora was further grouped into nectar, pollen and both nectar and pollen supplying plants. Out of 41 wild bee plant species, 17 were nectar producing, 4 were pollen producing and 20 were both nectar and pollen producing. Results also revealed that out of 22 agriculture bee plant species, 6 were nectar producing, 5 were pollen producing and 11 were both nectar and pollen producing. Mid-October to mid-December was identified as honey flow period of the year, having number of flowering plants. Mid-May to mid-August was the critical dearth period with few flowering plants. Based on the availability of flora, major characteristics of these plant species, utility status and flowering duration, the bee floral calendar was developed for Paithan taluka of Aurangabad district. The result indicated that the area has rich bee flora and is suitable for commercial bee keeping. Paithan taluka has four honey bee species, viz., *Apis dorsata*, *A. cerana indica*, *A. florea* and *A. mellifera*. Among these, *A. florea* and *A. dorsata* were dominant bee species, whereas *A. mellifera* was introduced species and only few colonies of *A. cerana indica* were observed.

Key words: Bee flora, floral calendar, honey flow period, dearth period, *Apis dorsata*, *A. cerana indica*, *A. florea*, *A. mellifera*.

Introduction

Beekeeping is agro-horticultural and forest based industry and it is of great importance to farmers for pollination benefit. By investing limited expenses, less land requirement, beekeeping can be practiced to obtain maximum subsidiary income through honey, beeswax and other bee products with increased agricultural output. The demand of bee keeping has been increased tremendously in world. Success of beekeeping depends upon many factors, among which abundant availability of bee flora within the surrounding area of an apiary is most important (Akratanakal, 1987; Crane, 1990; Singh, 2005). There are three types of bee flora: plants that only supply nectar, plants that only supply pollen, and plants that provide both (Crane *et al.*, 1989; Allen *et al.*, 1998; Bhattacharya, 2004; Waykar *et al.*, 2014).

The honey flow period and dearth period varies from one location to another and with altitudes. The flowering plants of several plant families blossom at different time interval of the year (Free, 1970). 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 plant (Rodinov and Shabanshov, 1986; Abrol, 2013). The extensive knowledge on flower type, flowering duration, main blooming time, density and quality of bee flora in a region are prerequisites for enhancing the efficiency of beekeeping industry and successful beekeeping (Kumar *et al.*, 2013). Such information 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 enable higher crop yields.

A floral calendar for beekeeping is a time table that indicates the approximate date and duration of the blossoming period of the important honey and pollen plants in the area. Preparation of a floral calendar for any specific area requires the complete observations of the seasonal changes in the vegetation patterns and/or agro ecosystems of the area (Yadav and Kaushik, 2012). Such knowledge on the bee flora helps in the effective management of bee colonies during the honey flow period and dearth period.

The study aimed on identification of plant species useful to honey bees as source of food and critical dearth period for effective management of bee colonies.

Materials and methods

Study area: Geographically, Paithan taluka of Aurangabad district is located at 19°29' N 75° 26' E. The average altitude of this area is 458 meter above sea level. The farmers cultivate major crops (sunflowers, mustard, sugarcane, cotton, bajara, wheat and jawar), pulses and vegetables in the area. The study area is also known for cultivation of horticultural crops. Paithan taluka of Aurangabad district has been greatly endowed with these resources and is one which has not been explored so far for beekeeping.

Identification of bee-flora: Field data was collected through regular visits to the study sites, during October 2012-September 2013 regularly. Each study visit served as pseudo replicates for the site and all observations were made between 0700-1800 hours

in winter and monsoon season and 0700-1830 hours in summer season. 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 after at least three (3) honeybees visited the flowers simultaneously or within the observation period (10 minutes).

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 in their pollen basket were considered 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 (Bista and Shivakoti, 2001). Samples of plants that could not be identified in the field were collected and saved in herbarium sheets in specimen box. All collected samples were identified in the Department of Botany, Dr. B. A. Marathwada University, Aurangabad by taxonomist and then compared with the published reports (Shrestha, 1998; Sivaram, 2001; Waykar *et al.*, 2014) for their probable use by honeybees.

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

Results and discussion

The survey on the flowering plants with special reference to beekeeping importance was carried out during the study period October 2012–September 2013 and obtained data was summarized in Table 1 and 2 and Figs. 1 and 2. The results revealed that 63 plant species were useful for beekeeping as source of food, out of which 41 were wild and 22 were agro-horticultural plants, which were well distributed and commonly found in the study area. The identified flora was further grouped into nectar, pollen and both nectar and pollen producing plants (Table 1 and 2), out of 41 wild bee plant species 17 were nectar producing, 4 were pollen producing and 20 plant species were both nectar and pollen producing. Results also revealed that out of 22 agro-horticulture bee plant species 6 were nectar producing, 5 were pollen producing and 11 were both nectar and pollen producing.

The bee-flora consists of mostly ornamental, medicinal,

vegetables, horticultural and other commercially important plants like spices, pulses, cereals, oil yielding, fibre and fodder crops etc. Four species of weeds *viz.*, *Alternanthera paronochyoides* St. Hil, *Lantana camara* L. Hil, *Parthenium hysterophorus* L. and *Tridax procumbens*, with the flowering period of 3, 12, 12 and 7 months, respectively, four wild plants, the *Azadirachta indica* A. Juss., *Pongamia pinnata* L. Pierre, *Tamarindus indica* L. and *Delonix regia* Hool Raf., with the flowering period of 3, 5, 3 and 3 months respectively, and five agro-horticultural crops *viz.*, *Citrus aurantium* L., *Cajanus cajan* L. Mill sp., *Moringa oleifera* Lamk., *Mangifera indica* L., and *Triticum aestivum* L., with the flowering period of 9, 4, 4, 3 and 3 months, respectively, were dominant in the field area. These plant species served as the excellent sources of pollen and nectar in the study area. In dearth period when agro-horticultural plants were not in blooming stage, weeds and wild flowering plants were observed as alternate food source for honeybees.

The bee colony efficiency and its development as well as production of honey, beeswax and other bee products depend on quality and quantity of pollen and nectar obtained from bee forage plants (Keller *et al.*, 2005; Brodschneider *et al.*, 2010). 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 (Fluri and Bogdanov, 1987). Therefore, a direct consequence of nutritional deficiency (pollen shortage) is a decrease in the colony population (Keller *et al.*, 2005).

Bee floral calendar: During the survey, a complete chronological record of flowering periods of the plant species was made and obtained data was compiled into annual floral calendar and data is presented in Tables 1 and 2 and Figs. 1 and 2. Amongst total 41 wild plants, identified as bee plants 15 were blooming in summer season, 18 in winter season and 21 in monsoon season. Out of 22

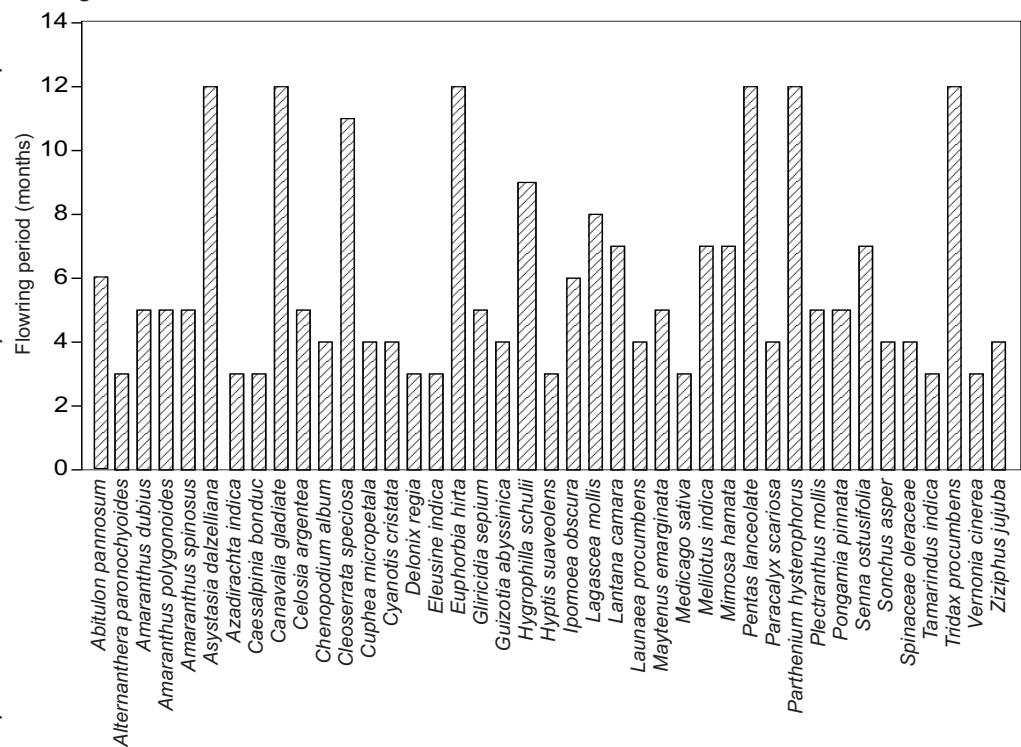


Fig. 1. Flowering duration of wild bee plants recorded during October 2012–September 2013

Table 1. The wild bee flora and floral calendar of Paithan taluka during October 2012–September 2013

| Botanical name | Family | Flowering period. | Bee forage value | | |
|---|-----------------|-------------------------------|------------------|--------|---------------|
| | | | Nectar | Pollen | Nectar+Pollen |
| <i>Abitulon pannosum</i> Forst. f. Schlecht. | Malvaceae | January-June | | - | NP |
| <i>Alternanthera paronochyoides</i> St. Hil. | Amaranthaceae | February-April. | N | - | - |
| <i>Amaranthus dubius</i> Mart. Ex. Thell. | Amaranthaceae | November-March | - | P | - |
| <i>Amaranthus polygonoides</i> L. | Amaranthaceae | June-October | - | - | NP |
| <i>Amaranthus spinosus</i> L. | Amaranthaceae | April-August | - | P | - |
| <i>Asystasia dalzelliana</i> | Acanthaceae | January-December | N | - | - |
| <i>Azadirachta indica</i> A Juss. | Meliaceae | April-June | N | - | - |
| <i>Caesalpinia bonduc</i> L. Roxb. | Caesalpiniaceae | February-April | - | - | NP |
| <i>Canavalia gladiata</i> Jacq. DC. | Fabaceae | January-December | N | - | - |
| <i>Celosia argentea</i> L. var. argentea | Amaranthaceae | April-August | - | - | NP |
| <i>Chenopodium album</i> L. | Chenopodiaceae | March-June | - | - | NP |
| <i>Cleoserrata speciosa</i> Raf. Iltis | Cleomaceae | January-November | - | - | NP |
| <i>Cuphea micropetala</i> L. | Lythraceae | August-November | N | - | - |
| <i>Cyanotis cristata</i> L. D. Don. | Commalinaceae | July-October | N | - | - |
| <i>Delonix regia</i> Hook Raf. | Fabaceae | April-June | - | - | NP |
| <i>Eleusine indica</i> L. Gaertn. | Poaceae | July-September. | - | - | NP |
| <i>Euphorbia hirta</i> L. | Euphorbiaceae | January-December | - | - | NP |
| <i>Giricidia sepium</i> Jacq. Kunth ex Steud. | Fabaceae | February-June | - | P | - |
| <i>Guizotia abyssinica</i> L. f. Cass. | Asteraceae | July-October | - | - | NP |
| <i>Hygrophilla schulii</i> Buch-Ham. M.R. and S.M. Almeida. | Acanthaceae | September-May | N | - | - |
| <i>Hyptis suaveolens</i> L. Poit. | Lamiaceae | August-October | N | - | - |
| <i>Ipomoea obscura</i> L. Ker-Gawl. Forma obscura | Convolvulaceae | October-March | N | - | - |
| <i>Lagascea mollis</i> Cav. | Asteraceae | August-March | - | - | NP |
| <i>Lantana camara</i> L. | Verbenaceae | January-April, July-September | N | - | - |
| <i>Launaea procumbens</i> Roxb. Ramayya and Rajgopal. | Asteraceae | September-December | - | - | NP |
| <i>Maytenus emarginata</i> Willd. Ding Hou. | Celastraceae | March-July | - | - | NP |
| <i>Medicago sativa</i> L. | Fabaceae | June-August | N | - | - |
| <i>Melilotus indica</i> L. All. | Fabaceae | August-February | N | - | - |
| <i>Mimosa hamata</i> Willd. | Mimosaceae | August-February | - | - | NP |
| <i>Pentas lanceolata</i> Frossk. Deflers. | Rubiaceae | January-December | N | - | - |
| <i>Paracalyx scariosa</i> Roxb. Ali. | Fabaceae | November-February | - | - | NP |
| <i>Parthenium hysterophorus</i> L. | Asteraceae | January-December | - | - | NP |
| <i>Plectranthus mollis</i> Ait. Spreng. | Lamiaceae | August-December | - | P | - |
| <i>Pongamia pinnata</i> L. Pierre. | Fabaceae | May-September | - | - | NP |
| <i>Senna ostusifolia</i> L. Irwin and Barneby | Caesalpiniaceae | May-November | N | - | - |
| <i>Sonchus asper</i> L. Hill. | Asteraceae | July-October | - | - | NP |
| <i>Spinaceae oleraceae</i> L. | Chenopodiaceae | June-September | N | - | - |
| <i>Tamarindus indica</i> L. | Legiminosae | May-July | N | - | - |
| <i>Tridax procumbens</i> L. | Asteraceae | January-December | - | - | NP |
| <i>Vernonia cinerea</i> L. Less. | Asteraceae | January-March | N | - | - |
| <i>Ziziphus jujuba</i> Mill. | Rhamnaceae | July-October | - | - | NP |

N – Nectar yielding plant. P – Pollen yielding plant. NP – Nectar and pollen yielding plants

agro-horticultural plants identified as bee plants, 7 plant species bloom in summer season, 9 in winter season and 11 in monsoon season. The data was also used to prepare honey flow and dearth period of the region.

The knowledge of blooming seasons and variation in plant species having different blooming season is important for sustainable management of bee colonies and for good honey harvest. The flowering duration of any given region helps in migratory beekeeping practice.

Honey flow and dearth period: For Paithan taluka of Aurangabad district, the honey flow and dearth period was determined and are summarized in Table 1. The peak periods of honeybee foraging activity (honey flow period) was recorded during mid-October to mid-December of winter season of the year. During the season, abundant bee floral plants were found blossoming. During honey flow period mid-October to mid-December of winter season, 15 wild plant species were recorded as source of food

for honeybees. Out of 15 plants, 6 plants species viz *Asystasia dalzelliana* Santapau, *Azadirachta indica* A Juss, *Canavalia gladiata* Jacq. DC., *Melilotus indica* L. All., *Pentas lanceolata* Frossk. Deflers, and *Tamarindus indica* L., were nectar producing, two plant species viz., *Amaranthus dubius* Mart. Ex. Thell. and *Plectranthus mollis* Ait. Spreng, were pollen producing and 7 plant species viz., *Delonix regia* Hook Raf., *Euphorbia hirta* L., *Launaea procumbens* Roxb., *Mimosa hamata* Willd., *Paracalyx scariosa* Roxb. Ali., *Parthenium hysterophorus* L. and *Tridax procumbens* L. were both nectar and pollen producing. During the same period 7 agro-horticultural plants were blooming viz., *Citrus aurantifolia* Christm. Sw., *Citrus aurantium* L., *Coriandrum sativum* L., *Cucumis sativus* L., *Cucurbita pepo* L., *Lagenaria siceraria* Molina Standl., and *Moringa oleifera* Lamk., out which 1 agro-horticultural plant was pollen producing and remaining 6 were both nectar and pollen producing. Other bee flora of the region supported honey production. The flowering plants of an area having good value as bee pasture are necessary to maintain

Table 2. The agro-horticultural bee flora and floral calendar of Paithan taluka during October 2012–September 2013

| Botanical name | Family | Flowering period. | Bee forage value | | |
|---|---------------|-------------------------------------|------------------|--------|---------------|
| | | | Nectar | Pollen | Nectar+Pollen |
| <i>Allium cepa</i> L. | Alliaceae | June– August | - | P | - |
| <i>Brassica juncea</i> L. Czern. Et cross. | Brassicaceae | July-August | N | - | - |
| <i>Cajanus cajan</i> L. Millsp. | Fabaceae | July-September | N | - | - |
| <i>Carthamus tinctorius</i> L. | Asteraceae | May-July | N | - | - |
| <i>Cicer arietinum</i> L. | Fabaceae | December – March. | N | - | - |
| <i>Citrullus lanatus</i> Thunb. Matsum. & Nakai | Cucurbitaceae | July – August | - | P | - |
| <i>Citrus aurantifolia</i> Christm. Sw. | Rutaceae | October – January, July – September | - | - | NP |
| <i>Citrus aurantium</i> L. | Rutaceae | March- November | - | - | NP |
| <i>Coriandrum sativum</i> L. | Apiaceae | January – December | - | - | NP |
| <i>Cucumis melo</i> L. | Cucurbitaceae | March – May | - | P | - |
| <i>Cucumis sativus</i> L. | Cucurbitaceae | August– October | - | P | - |
| <i>Cucurbita pepo</i> L. | Cucurbitaceae | August– October | - | - | NP |
| <i>Cyamopsis dentata</i> N.E.Br. Torre | Leguminosae | June- August | N | - | - |
| <i>Helianthus annuus</i> L. | Asteraceae | July – September | - | - | NP |
| <i>Lagenaria siceraria</i> Molina Standl. | Cucurbitaceae | October – February | - | - | NP |
| <i>Mangifera indica</i> L. | Anacardiaceae | January-April | - | - | NP |
| <i>Moringa oleifera</i> Lamk. | Moringaceae | November – February | - | - | NP |
| <i>Pisum sativum</i> L. | Fabaceae | August- September | - | - | NP |
| <i>Punica granatum</i> L. | Punicaceae | March – June | - | - | NP |
| <i>Rosa damascene</i> Mill. | Rosaceae | February-April | - | - | NP |
| <i>Solanum melongena</i> L. | Solanaceae | January to March, June to July. | - | P | - |
| <i>Triticum aestivum</i> L. | Poaceae | February – April. | N | - | - |

N – Nectar yielding plant. P – Pollen yielding plant. NP – Nectar and pollen yielding plants

bee colonies. Honeybees visited these plants extensively for honey production and colony multiplication.

The mid-May to mid-August period was identified as the dearth period for honey bee at Paithan taluka of Aurangabad district. Based on the climatic conditions, the dearth period of study area may be divided into two periods. The mid-May to mid-June was critical dearth period with high temperature (over 39°C), scarcity of water for flowering plants and was unfavorable for honeybee foraging. The few of wild plants like, *Abitulon pannosum* (Forst. f.) Schlecht. *Azadirachta indica* A Juss. *Chenopodium album* L. *Delonix regia* Hook Raf., and *Gliricidia sepium* Jacq. Kunth ex Steud, and agricultural plants like, *Carthamus tinctorius* L., *Citrus aurantium* L., and *Punica granatum* L. were blossomed during the season.

The period of early monsoon *i.e.* from mid-June to mid-August was critical dearth period because of unfavorable environmental condition for foraging. Though relatively more flowers bloomed during rainy season, but due to heavy and continuous rain fall, bee foraging activity was limited. The few wild plants like, *Amaranthus polygonoides* L., *Cyanotis cristata* L. D. Don., *Eleusine indica* L. Gaertn., *Lantana camara* L., *Medicago sativa* L., *Spinaceae oleraceae* L., and *Ziziphus jujuba* Mill and agricultural plants like, *Allium cepa* L., *Brassica juncea* L. Czern. Et cross., *Cajanus cajan* L. Millsp., *Citrullus lanatus* Thunb. Matsum. & Nakai, *Citrus aurantifolia* Christm. Sw., *Cyamopsis dentata* N.E.Br. Torre and *Solanum melongena* L. were blossomed during the season. These minor sources are utilized by bees during the time of scarcity of food (Dalio, 2012). Similar studies have also been carried out by some investigators (Singh, 2005; Adhikari and Ranabhat,

2011; Kumar *et al.*, 2013 and Waykar *et al.*, 2014).

The presence of number of diversified bee floral species in the area suggests that the study area is undoubtedly suitable for commercial beekeeping. Zamarlicki (1984) 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 beekeeping potential (Sharma, 1972).

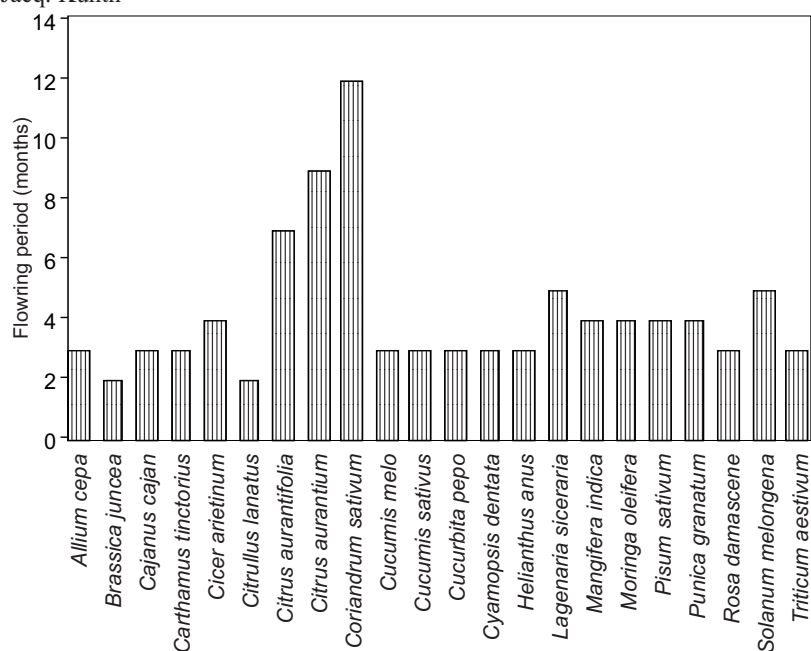


Fig. 2. Flowering duration of agro-horticultural bee plants recorded during October 2012–September 2013

Beekeeping practice is very much useful for enhancing the quality and quantity of various agricultural crops. Sahli and Conner, (2007) reported that bee pollination increase the crop yield in a kind of mutualistic relationships. The economically important bee plants provide substantial quantity of pollen and nectar for bees during different months of the year. According to Thakur (2012), in India, about 80 percent or more of the crop plants were dependant on insect pollination.

At different locations of Paithan taluka of Aurangabad district, four honey bee species, viz., *A. dorsata*, *A. cerana indica*; *A. florea* and *A. mellifera* were reported. Among these four species *A. florea* and *A. dorsata* were dominant bee species, whereas *A. mellifera* was introduced species and only few colonies of *A. cerana indica* were observed.

The results revealed that 63 plant species were useful to honey bees as source of food, out of which 41 were wild and 22 were agro-horticultural plants. Mid-October to mid-December (winter season) was honey flow period and mid-May to mid-August (late summer and early monsoon season) was critical dearth period at Paithan taluka. The results also shows that the area has large number of plants producing nectar and both pollen and nectar than pollen producing. Paithan taluka has four honey bee species, viz., *A. dorsata*, *A. cerana indica*, *A. florea* and *A. mellifera*. Among these *A. florea* and *A. dorsata* are dominant bee species, whereas *A. mellifera* is introduced species and only few colonies of *A. cerana indica* were observed. Based on the study and available flora, Paithan taluka can be suitable to initiate sustainable and commercial 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, there is a need to provide artificial food to bees during the rainy and summer months.

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