Eco. Env. & Cons. 28 (November Suppl. Issue) : 2022; pp. (S325-S330)
Copyright@ EM International
ISSN 0971–765X

DOI No.: http://doi.org/10.53550/EEC.2022.v28i07s.053

Diversity of bee foraging flora and floral calendar of Chandigarh region (U.T.), India during winter and summer season

Sunaina Jaswal*, Dalip Kumar and Neelam K. Sharma

Post Graduate Government College for Girls, Sector- 42, Chandigarh 160 036, Punjab, India

(Received 6 March, 2022; Accepted 27 May, 2022)

ABSTRACT

The study was conducted at Chandigarh during winter and summer seasons to identify existing bee flora and to determine honey flow and dearth period. Visual observations were done to know the presence of honey bees and their foraging activities on different plants. Plants were reported as bee foraging species when at least 50% honey bee frequency was observed on them. Results concluded that winter season has 21 plant taxa of 11 families and summer has 50 plant taxa of 28 families. The identified flora was further grouped into nectar, pollen and both nectar and pollen sources. Results also revealed that winter has 7 and summer has 16 bee forage plants which provide both pollen and nectar in good quantity to honey bees. Late summer and raining seasons were identified as critical dearth period. Based on the availability of flora and their utility status the bee floral calendar was developed for Chandigarh. The result indicated that some parts of Chandigarh has rich bee flora in these seasons. By multiplying those highly preferred bee forage plants equally in all parts of different sub- divisions of Chandigarh, commercial bee keeping could be increased in future for economic purposes.

Key words: *Bee flora, Floral calendar, Bee forage plants, Dearth period, A. mellifera, Beekeeping*

Introduction

Beekeeping is agricultural based industry which is essential for pollination and production of various honey bee products. It needs limited expenses and less land to obtain maximum benefit. The demand of bee keeping has increased and its success depends upon various in- colony and out-colony factors (Crane, 1990 and Singh, 2005). Honey bees obtain pollen or nectar or both pollen and nectar from foraging plants (Bhattacharya, 2004 and Waykar *et al*., 2014). The honey flow period and dearth period are not same in all types of geographical areas during different seasons. The blooming period of plants is also highly affected by light, temperature and various other climatic conditions (Free, 1970). Foraging behaviour and frequency of honey bees is also affected by various climatic factors and electromagnetic rays (Kumar *et al.*, 2011 and Thielens, 2020). The detailed knowledge about bee forage plants of any area is very important for maintaining and enhancing the beekeeping industry in that particular area (Kumar *et al*., 2013). Such information enables beekeepers to utilize them at the maximum level to harvest a good yield of honey bee products and effective crop pollination. Preparation of a bee forage calendar of any area requires the complete observations of the seasonal changes, frequency of honey bees on different plants, time spent by honey bees on flower and also number of flowers visited by honey in per unit time. Such knowledge about the bee flora helps the beekeepers in the effective man-

agement of bee colonies during the honey flow period and dearth period. The study aimed on identification of bee forage plants as source of food for honey bees and critical dearth period for effective management of bee colonies to increase the economy of people of Chandigarh.

Materials and Methods

Study area

The present study was carried out in Chandigarh area. The area of Chandigarh has been divided into 5 sub- divisions (Table 1). All these sub-divisions were marked by Horticulture Department, Municipal Corporation, U. T., Chandigarh, on the basis of tree plantation pattern. Honey bee (*A. mellifera* L.) colonies were installed and maintained in particular area of each sub- division (Table 2).

Study period

- The seasonal variations in Chandigarh include mainly two seasons, i.e. summer (mid April to June end) and winter (mid November to mid February).
- Visual observations were done thrice a day, i.e. morning: 700-800 hrs, afternoon: 1300-1400 hrs, evening: 1700-1800 hrs.

Identification of bee forage

Foraging frequency of honey bees

- Foraging frequency was observed by calculating the percentage of honey bees on each plant calculated by following method:

$$\frac{\text{Number of honey bees in collection}}{\text{Total number of insects collected}} \times 100$$

Foraging behaviour of honey bees

- Foraging behaviour of honeybee on plants where it is found was studied in terms of number of flowers visited per unit time and time spent by honey bee per flower / inflorescence per visit by using stop watch.

Statistics

All the observations were done in triplicate thrice a day. Readings were calculated in mean ± standard deviation form.

Diversity and evenness of bee forage plants in different seasons were calculated using Shannon-weaver diversity index.

$H=-\Sigma[(p_i)*\log(p_i)]$,

H - Shannon diversity index; p_i - Proportion of individuals of i^{th} families in a whole community; $p_i = n / N$; n - individuals of a given type, N - total number of individuals in a community; Σ - Sum symbol; and log - Usually the natural logarithm, but the base of the logarithm is arbitrary.

Results

Chandigarh is the city which is known for its greenary and pattern of plantation. It also has great diversity of plants and seasons. Our study has included the diversity of vegetation and bee forage plants in different sub- divisions during winter and summer seasons. During these seasons different types of plants were observed and their diversity also varies in different sub- divisions. The survey on the flowering plants with special reference to their importance was carried out during the study period 2017- 2019 and obtained data were summarized in Table 3-6. Some sub- divisions have large density of bee forage plants in specific season while others have less density. Distribution of bee flora was not found equal in all sub- divisions, even in same season not all sub- divisions have equal distribution of pollen and nectar rich plants.The identified flora was further grouped into nectar, pollen and both nectar and pollen producing plants (Table 3 and 5).

Winter Season

Winter season included 21 plant taxa of 11 families (Table 3). Each sub- division has its own diversity of flora. In studied flora, some plants were greatly preferred by honey bees like *Chrysanthemum indicum, Brassica campestris, Ocimun basilicum, Bauhinia blackiana, Chrysanthenum* sp., etc. The observations like activities and frequency of honey bee on each plant were noted and categorized the flora into source of pollen, nector or both. 14 plants were identified as major pollen sources and 18 plants were found as main nector sources. Few plants like *Chrysanthemum indicum, Brassica campestris., Eucalyptus* sp., *Bauhinia purpurea, Chrysanthemum* sp, *Pyrostegia venusta*, *Lobularia maritima*, *Gypsophila paniculata*, *Matricaria* sp., *Antirrhinum* sp., *Lagerstroemia alba, Dombeya bergessiae* and *Tecoma stans* were observed as source of both pollen and nector. During winter, temprature of morning and evening was very low which was not favourable for foraging of honey

bees. As temprature raised from morning to afternoon, foraging activities of honey bees were also increasing. During afternoon, honey bees did foraging activities mostly from 11:00 to 16:00, peak foraging hours were observed between 12:00 noon to 14:00.

During winter Shannon weaver diversity index is 2.17, evenness= 0.907, richness (tota number of families)= 11, Total number of individuals= 21 and average population size= 1.91 (Figure 1).

Summer Season

Summer is the dearth period because of less number of nectar rich plants. Chandigarh has good diversity of plants during summer as compared to winter and

Table 1. Different sub- divisions of Chandigarh

Sub- Divisions	Area Details
Sub-division 1	SECTOR 25, 36- 42, Attawa, Buterla, Dhanas, Dadumajra, Maloya Colony, Janta Colony.
Sub-division 2	SECTOR 27- 32, Industrial area phase I and II, Karson Colony, Hallomajra, Bair-majra.
Sub-division 3	SECTOR 1- 24 and KhudaLahora.
Sub-division 4	SECTOR 26, Bapudhamtragt Camp II Phase II Sec- 26E, Transport area Sec- 26-E, EWS Housing Board, Bapudhamtragt Camp I Phase I, Camp III Phase III and Madarsi Colony (HUTS), Mouli Complex, Ambedkar Avas Yojna, Old Mnimajra (NAC), Shanti Nagar, Mai Wala Town, Chandigarh Housing Complex, Mohalla Govindpura, Dhillo Complex and I.T. park.
Sub-division 5	SECTOR 20, 33, 34, 35, 43, 44, 49, 50, 51, 52 (Nizam Pur Burail), 51, Brick- Killin, Nizampur Kumbra, Sub jail, Nimpur Kumbra and Sec- 55, 56, 60, 61, 63, Sec-45.

Table 2. Details of honey bee colony installation

Sub- division	Honey bee colony installation area	Date of installation
Sub- division 1	Post Graduate Govt. College for Girls, Sector-42, Chandigarh	02.02.2017
Sub- division 2	Sector- 29 (Nursery)	\02.02.2017
Sub- division 3	Sector- 23 (Nursery)	05.02.2017
Sub- division 4	Central Reserve Police Force Camp	\07.02.2017
Sub- division 5	Sector- 33 (Nursery)	05.02.2017

Table 3. Flora of winter season

S.No	Name of Plants	Family	Source type
1	*Chrysanthemum indicum*	Asteraceae	P1,N
2	*Rosa indica*	Rosaceae	N1,P1
3	*Brassica campestris*	Brassica ceae	N1,P1
4	*Eucalyptus* sp.	Myrtaceae	N1,P1
5	*Calendula officinalis*	Asteraceae	P3,N1
6	*Ocimum basilicum*	Lamiaceae	N2,P3
7	*Bauhinia blackiana*	Fabaceae	N1,P1
8	*Bauhinia purpurea*	Fabaceae	N1,P1
9	*Chrysanthemum* sp.	Asteraceae	N,P1
11	*Lobularia maritime*	Brassica ceae	N1,P
12	*Raphanus sativus*	Brassica ceae	N3,P1
13	*Gypsophila paniculata*	Caryophyllaceae	N3,P1
14	*Calliandra haematocephala*	Fabaceae	N3,P2
15	*Matricaria* sp.	Asteraceae	N3,P3
16	*Dahlia hybrid*	Asteraceae	P2
17	*Antirrhinum* sp.	Plantaginaceae	N3,P2
18	*Lagerstroemia alba*	Lythraceae	N2,P2
19	*Dombeya burgessiae*	Malvaceae	N3,P3
20	*Tecomastans*	Bignoniaceae	N1,P1
21	*Trifolium pretense*	Fabaceae	N3,P2

autumn. Despite of great diversity, honey bees did not get enough nectar for survival because of less nectar producing plants. In summer, 50 plant taxa of 28 families were observed as bee forage plants. Out of these 50 plants, 41 plants were considered as most visited plants by honey bees. It was also observed that during summer season, days are longer than the nights. In this season, honey bee started foraging early in the morning due to favourable temperature. As temprature was increasing in the day, honey bees preferred to stay in the hive. Maximum foraging was observed during morning upto 11:00 am, after that there was sudden decline in honey bee foraging. Peak timing of foraging during summer was observed between 5:00 am to 8:00 am. Some foragers were also observed during evening hours because of low temprature as compared to noons. Summer included the dominance of families Euphorbiaceae, Compositae, Asteraceae, Saliaceae, Bignoniaceae, Rutaceae and Cactaceae (Table 5 and 6).

During summer, Shannon weaver diversity index is 3.09, eveness= 0.926, richness (tota number of families)= 28, Total number of individuals= 50 and average population size= 1.79 (Figure 1).

Discussion

Survey revealed that winter has 21 plant taxa of 11 families and summer has 50 plant taxa of 28 families (Table 3- 6). Potentiality of bee forage plants highly affects the colony development as well as production of honey bee products (Keller *et al*., 2005). The nectar acts as raw material of honey and providesenergy for bees and pollen is the sole source of the protein which is necessary for brood rearing and colony development. Pollen also provides various vitamins, fatty substance and other nutrients to bees (Fluri and Bogdanov, 1987). Therefore, a direct effect of nutritional deficiency (pollen shortage) may lead to colony collapse disorder (Keller *et al*., 2005). According to Shannon- weaver diverstiy index, summer has more diversity (3.09) than winter (2.17). Winter represents the least diversity but the evenness of flora in winter is greater (0.907) than summer. Average population size of summer (1.79) is smaller than winter (1.91) (Figure 1)

Bee floral calendar: During the survey, a complete chronological record of plant species was made in each season and obtained data was compiled and presented (Table 3- 6). Plants were categorized as source of pollen, nectar or pollen and nectar both in different seasons (Table 3 and 5).

Honey flow and dearth period: For Chandigarh, the honey flow and dearth period was determined. The peak periods of honey bee foraging activity (honey flow period) was recorded during late winter and

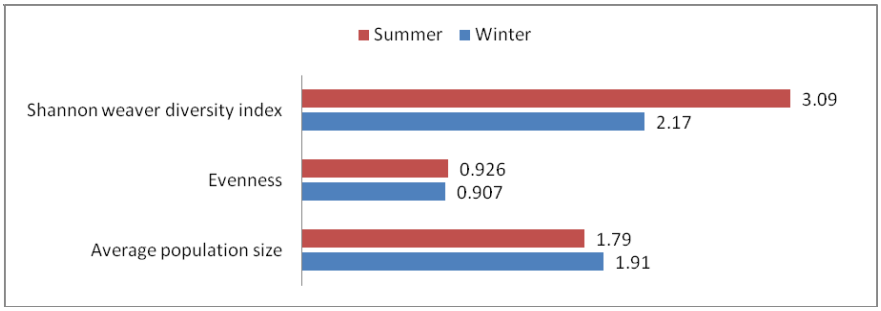

Fig. 1. Diversity, evenness and population size of different honey bee forage plants were calculated by using Shannon- weaver diversity index formula.

Table 4. Plant diversity during winter season in different sub- divisions of Chandigarh

Family	Number of taxa	Family	Number of taxa
Asteraceae	5	Myrtaceae	1
Bignoniaceae	2	Caryophyllaceae	1
Rosaceae	1	Brassicaceae	3
Lamiaceae	1	Lythraceae	1
Fabaceae	4	Plantaginaceae	1
Malvaceae	1		

Table 5. Flora of summer season

S.No	Name of Plants	Family	Source type
1	*Calendula arvensis*	Asteraceae	P2
2	*Trifolium pretense*	Fabaceae	N3,P2
3	*Tecoma gaudichaudi*	Bignoniaceae	N1,P1
4	*Thevetica peruviana*	Apocynaceae	N3,P2
5	*Leucaena leucocephala*	Fabaceae	P1
6	*Calotropis procera*	Apocynaceae	N1
7	*Murraya koenigii*	Rutaceae	N3,P3
8	*Syndrella nodiflora*	Asteraceae	N1,P1
9	*Asphodelus sp.*	Asphodelaceae	P2
10	*Dalbergia sissoo*	Fabaceae	N2,P2
11	*Rosa alba*	Rosaceae	N2,P3
12	*Pterospermum adenophyllum*	Malvaceae	N2,P1
13	*Jacaranda mimosifolia*	Bignoniaceae	N2,P1
14	*Helianthus annus*	Asteraceae	N1,P3
15	*Adhatoda vasica*	Acanthaceae	N3,P3
16	*Salix babyonica*	Saliaceae	N3,P2
17	*Calliandra haematocephala*	Fabaceae	N3,P2
19	*Hamelia patens*	Rubiaceae	N2,P1
20	*Bauhinia racemosa*	Fabaceae	N1,P2
21	*Aegle marmelos*	Rutaceae	N3,P3
22	*Lagerstroemia flosreginae*	Lythraceae	N1,P2
23	*Tecomaria capensis*	Bignoniaceae	N3
24	*Cosmos sulphureus*	Asteraceae	N1,P1
25	*Tamarindus indica*	Fabaceae	N2,P1
26	*Mimusopselengi*	Sapotaceae	N3,P2
27	*Lagerstroemia indica*	Lythraceae	P2,N1
28	*Lagerstroemia parviflora*	Lythraceae	P1,N1
29	*Nerium indicum*	Apocynaceae	N2,P2
30	*Portulacagrandi flora*	Portulacaceae	P3
31	*Luffa cylindrical*	Cucurbitaceae	N3,P1
32	*Cyanodon doctylon*	Poaceae	P3
33	*Azadirichta indica*	Meliaceae	N2
34	*Syzygium cumini*	Myrtaceae	N2,P1
35	*Delonix regia*	Fabaceae	N1,P1
36	*Lagerstroemia speciosa*	Lythraceae	N2,P2
37	*Sapium sebifera*	Euphorbiaceae	P3
38	*Quisqualis indica*	Combretaceae	N
39	*Saraca asoca*	Fabaceae	N1,P
40	*Polyalthia longifolia*	Annonaceae	N
41	*Barringtonia acutangula*	Lecythidaceae	N1
42	*Vitex negundo*	Lamiaceae	N2,P
43	*Amaranthus spinosus*	Amaranthaceae	N1
44	*Emblica officinalis*	Phyllanthaceae	N1,P1
45	*Psidium guajava*	Myrtaceae	N3,P3
46	*Ocimum tenuiflorum*	Lamiaceae	N2,P3
47	*Abelmoschus esculentus*	Malvaceae	N3,P2
48	*Solanum lycopersicum*	Solanaceae	N2,P1
49	*Lagenaria siceraria*	Cucurbitaceae	N3,P2
50	*Opuntia dillenii*	Cactaceae	N1,P2

Table 6. Plant diversity during summer season in different sub- divisions of Chandigarh

Family	Number of taxa	Family	Number of taxa
Asteraceae	4	Bignoniaceae	3
Rutaceae	2	Asphodelaceae	1
Lythraceae	4	Rubiaceae	1
Meliaceae	1	Euphorbiaceae	1
Amaranthacae	1	Myrtaceae	2
Apocynaceae	3	Lamiaceae	2
Sapotaceae	1	Portulacaceae	1
Combretaceae	1	Annonaceae	1
Phyllanthaceae	1	Solanaceae	1
Acanthaceae	1	Fabaceae	8
Cactaceae	1	Amaryllidaceae	1
Poaceae	1	Rosaceae	1
Cucurbitaceae	2	Malvaceae	2
Lecythidaceae	1	Saliaceae	1

early summer. Dearth period was observed during late summer and rainy seasons.

The presence of number of diversified bee floral species in the area suggests that the study area is undoubtedly suitable for commercial beekeeping practices. Zamarlicki (1984) reported that the knowledge of bee flora is the most important factor in management of honey bee because their survival is related to the abundant of bee flora plants. Beekeeping practice is also much useful for enhancing the quality and quantity of various agricultural crops (Sivaram, 2001).

Sahli and Conner (2007) reported the role of bee pollination to 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. In India, about 80 percent or more of the crop plants were dependent on pollinationby insects (Thakur, 2012). Chandigarh 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 late summer months (dearth period).

Acknowledgement

The authors are thankful to Principal of Post Graduate Government College for Girls, Sector 42, Chandigarh for providing lab facilities for my work and Department of Botany, Panjab University, for extending the help for identification and authentication of bee plants. Thanks to DST-INSPIRE for providing financial help in the study.

References

Bhattacharya, A. 2004. Flower visitor and fruit set of *Anacardiumoccidentole*. *Annales Botanici. Fennici.* 41: 385-392.

Brodschneider, R. and K. Crailsheim, 2010.Nutrition and health in honeybees. *Apidologie.* 41: 278-294.

Crane, E. 1990. *Bees and Beekeeping: Science Practice and World Resource*. Henemann News, Hally court Jordan Hill OX28Ej.

Fluri, P. and Bogdanov, S. 1987. Age dependence of fat body protein in summer and winter bees (*Apismellifera*). In: *Chemistry and Biology of Social Insects*,

Free, J.B. 1970. *Insect Pollination of Crops*. Academic press, London, 544.

Keller, I., Fluri, P. and Imdorf, A. 2005. Pollen nutrition and colony development inhoney bees: Part II. *Bee World.* 86(1): 3-10.

Kumar, R., Rajput, G.S., Mishra, R.C. and Agrawal, O.P. 2013. A study on assessment of duration of dearth period for Honey bees in Haryana, India. *Munis Entomology Zoology.* 8(1):434-437.

Sahli, H.F. and Conner, J.K. 2007. Visitation, effectiveness, and efficiency of 15 genera of visitors to wild radish, *Raphanusra phanistrum* (Brassicaceae). *American Journal of Botany*. 94(2): 203-209.

Singh, S.T. 2005. *Bee plant diversity in Southern Peninsular India.* Ph.D. thesis, submitted to University of Pune, India.

Sivaram, V. 2001. Honey bee flora and beekeeping in Karnataka State, India. *Proceedings of the 37th International Apicultural Congress, Apimondia,* Durban, South Africa. 28 October -1 November 2001.

Thakur, M. 2012. Bees as Pollinators – Biodiversity and Conservation. *International Research Journal Agricultural Science Soil Science*. 2(1) : 1-7.

Thielens, A., Greco, M.K., Verloock, L., Martens, L. and Joseph, W. 2020. Radio-frequency electromagnetic field exposure of western honey bees. *Scientific Reports*, 10(1): 1-14.

Waykar, B., Baviskar, R.K. and Nikam, T.B. 2014. Diversity of nectariferous and polleniferous bee flora at Anjaneri and Dugarwadi hills of Western Ghats of Nasik district (M.S.) India. *Journal of Entomology and Zoology Studies.* 2(4): 244-249.

Zamarlicki, C.C. 1984. Evaluation of honeybee plants in Burma – A case study. *Proceedings of the FAO (UN) expert Committee.* 57-76.