Indian Journal of Entomology 85(Special Issue) May 2023: 75-83 eRef. No. NWRABNRG16 DoI. No.: 10.55446/IJE.2023.1165

A PERSPECTIVE ON URBAN BEEKEEPING WITH *APIS CERANA* F. IN BENGALURU, KARNATAKA WITH SPECIAL REFERENCE TO BEE FLORA AND HIVE SUITABILITY

K T Vijayakumar*, T Nayimabanu, H L Nithin Kumar, S Shabarish Kumar, G C Kuberappa[1], A N Sringeshwar[2], U Sahana and T Neethu

All India Coordinated Project on Honey Bees and Pollinators, UAS, GKVK, Bengaluru 560065, Karnataka, India
[1]Department of Apiculture, UAS, GKVK, Bengaluru 560065, Karnataka, India
[2]Mahatma Gandhi Botanical Garden, Department of Forestry and Environmental Sciences, UAS, GKVK, Bengaluru 560065, Karnataka, India
*Email: vijayakumarktagri@gmail.com (corresponding author): https://orcid.org/0000-0001-5445-8322

ABSTRACT

Urban beekeeping is nowadays attracting immense popularity. Many people in large cities are installing hives on the rooftops. A significant drawback for beekeeping in urban areas of India is limited bee flora which may lead to poor honey yield and performance. As more people take to urban beekeeping, the competition for resources between honey bee colonies increases. Since the space covered by vegetation in the city remains relatively constant, each honey bee colony ends with less honey production per year. It slows the growth of individual urban honey bee colonies and affects the foraging potential of the honey bee colonies. Thus, urban beekeeping could be made effective by providing sufficient bee forage in surrounding beekeeping areas and by the selection of hives suitable for urban areas. Therefore, the present work was undertaken to study the diversity of nectariferous and polleniferous honey bee flora found in the major cosmopolitan city of India: Bengaluru. We recorded 58 major bee floras grown in the Bengaluru urban to make beekeeping activities throughout the year. In addition, hives with different frame numbers (5, 6 and 8) were evaluated for their performance in 3 different locations. Results clearly showed that hives with six frames are equally good compared to the conventional eight frame hive. Therefore, hives with six frames are more suitable for urban beekeeping, which would be efficient by reducing energy requirements in activities like comb construction of the colony. Appropriate hive selection was an important factor for successful beekeeping, especially in urban areas of Bengaluru.

Key words: Apiculture, bee flora, diversity, honey, pollination, urban beekeeping, hive selection

Honey bees obtain significant pollen and nectar of diverse nutritional value from many native plant species found in natural habitats. Developed environments sometimes provide fewer resources than natural habitats and present unique challenges that should be addressed. Urbanization causes an irreversible change to the environment, leading to fragmented habitats in urban and suburban areas. Not enough is known about urbanization effects on the composition of insect communities, including beneficial insects such as bees, wasps and other beneficial arthropods that are vital to sustaining healthy ecosystems.

According to a Native Bee Survey (Frankie et al., 2014), urban landscapes provide floral square footage of pollinator-supportive plants throughout the foraging seasons and help sustain diverse bee populations. The public can positively impact pollinator health by providing plentiful nectar and pollen resources by planting a diversity of pollinator-supportive plants. Public awareness about pollinator importance and the growing interest in urban beekeeping has led many people worldwide to acknowledge and potentially facilitate this developing resurgence in the trade and hobby.

Urban beekeeping is a solution to fill the gap between rural producers and urban consumers for honey and exploit bees for pollinating urban grown plants. It can be carried on private rooftops, terraces, and obviously, gardens work best. However, bees need a place where they aren't disturbed by people and enough space to have a clear flight path. Urban and suburban beekeepers could also promote the importance of pollinators in urban ecosystems and educate the public to support pollinators by planting pollinator-supportive plants.

The popularity of urban beekeeping was proliferating outside India. For example, between 1999 and 2012, London noticed a 220% increase in beekeepers (Nessen

and Stephen, 2012; Alton and Francis, 2016). Urban beekeeping has been a popular hobby in Europe and North America for the last few years, but this trend is yet to make its mark in India.

The major drawback with beekeeping in urban areas in India is limited bee flora which may lead to poor honey yields and performance of colonies. Therefore, in addition to planting pollinator-supportive plants, it is essential to realise that some other factors like the alterations in hive design would be helpful to overcome the problems associated with urban beekeeping. Therefore, guidelines for best management practices are needed to ensure good stewardship by beekeepers in urban and suburban areas.

Therefore, The All India Coordinated Research Project on Honey bees and Pollinators, UAS, Bengaluru conducted a study to evaluate suitable hives and identify bee floral plants for urban beekeeping during 2018-2020.

MATERIALS AND METHODS

Study area Bengaluru (12.97° N and 77.59° E) is a metropolitan area of 8,005 km². The mean temperature of the area is 25 °C with mean annual precipitation of 857 mm, humidity of 66% and wind velocity is 5 km/h (IMD Bengaluru).

The identification of bee flora in the region was made by observing the bee visits. The flower species were identified as a bee plant only after visual confirmation on the plant and collection of food by honey bees (Sivaram, 1995; Naim and Phadke, 1976). A herbarium of specimens of bee visited flowering plant species in each study sites was maintained by following standard procedure for further reference. The identified bee floral plants were further classified based on the source of pollen, nectar or both.

Hives performance with 5, 6 and 8 frames were evaluated in three locations of Bengaluru Urban in premises of GKVK, Bengaluru (Site 1, Site 2 and Site 3) from September 2019-January 2020. Each site was 3 km away in distance hives with uniform *Apis cerana* colonies were placed in the selected areas in 3 replications. The selected colonies were strong and well established. Equal honey bee management practice was undertaken to each beehive type. During the study period observation were recorded on initial brood area, honey area and colony population. Further, observations were recorded on monthly honey storage, absconding behaviour, swarming behaviour, and honey yield in all the hives from September 2019 to January 2020, which is a major honey flow season in Bengaluru.

Foraging activity of bees was determined by counting the number of worker bees moving out and returning to the hive with and without pollen loads per five minutes by using a hand tally counter and stopwatch (Reddy et al., 2015). Bees returning without pollen loads were considered nectar gatherers. The observations on foraging activity were recorded thrice in a day viz., 08.00 hrs, 12.00 hrs and 4.00 hrs for 5 minutes. The mean value of observations at three intervals was taken as the foraging activity of that particular day.

RESULTS AND DISCUSSION

Identification of bee flora in Bengaluru

In the present study we recorded 58 bee floral plants in and around the beekeeping areas of the district which included trees (25.9%), plantation crops (19%), medicinal plants (5.2%), ornamental plants (17.2%), vegetable crops (20.7%) and field crops (12.1%) (Table 1; Fig. 1). These plants are well distributed and commonly found in study area. It was observed that the bee-flora consisted of mostly ornamentals, timber, medicinal, fruits, vegetables and other commercially important plants like spices, pulses, cereals, oil seed/yielding, fibre and fodder crops as also recorded by Bhalchadra et al. (2014).

In the present study, majority of the bee flora recorded are trees. Among the identified plants 13.8% were only source of pollen for the visiting bees and 27.6% were only source of nectar while 58.6% of bee flora offered both nectar and pollen (Fig. 2). The bee colony efficiency, development as well as production of honey, beeswax and other bee products depends on the quality and quantity of pollen and nectar obtained from bee forage plants (Keller et al., 2005; Brodschneider and Crailsheim, 2010). These food sources play an essential role in providing the nutritional requirements of the bee colony. The nectar is a source of honey and provides heat and energy for bees and pollen provides protein, vitamins, fatty substances and other nutrients to bees (Fluri et al., 1987; Crailsheim, 1992). Among identified bee flora 37.9% flowered throughout the year, 29.3% flowered during honey flow season (October to April) and 12.1% flowered during the dearth period (May-September) (Fig. 3). Through the management of the listed bee flora, we could get 50% flowering plants in the dearth period and therefore, a direct consequence

Table 1. List of flowering plants identified in the Bengaluru urban area

Sl.No.	Common Name	Botanical name	Family	Flowering period												Pollen source	Nectar source
				Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec		
1	Coconut	*Cocus nucifera* L.	Arecaceae	*	*	*	*	*	*	*	*	*	*	*	*	$	
2	Guava	*Psidium guajava* L.	Myrtaceae			*	*	*								$	$
3	Ber	*Ziziphus jujuba* Mill.	Rhamnaceae					*	*							$	$
4	Banana	*Musa paradisiaca* L.	Musaceae	*	*	*	*	*	*	*	*	*	*	*	*	$	$
5	Mango	*Mangifera indica* L.	Anacardiaceae	*	*	*										$	$
6	Cashew nut	*Anacardium occidentale* L.	Anacardiaceae	*	*	*									*	$	$
7	Sapota	*Manilkara zapota* L.	Sapotaceae	*	*	*							*	*	*		$
8	Papaya	*Carica papaya* L.	Caricaceae	*	*	*	*	*	*	*	*	*	*	*	*	$	$
9	Pomegranate	*Punica granatum* L.	Punicaceae				*	*	*	*						$	$
10	Custard apple	*Annona squamosa* L.	Annonaceae				*	*	*							$	$
11	Jamun	*Syzigium cumini* L.	Myrtaceae			*	*									$	$
12	Leucas (Tumbe)	*Leucas aspera* (Willd.) Link	Lamiaceae	*	*	*	*	*	*	*	*	*	*	*	*	$	$
13	Holy basil	*Ocimum tenuiflorum* L.	Lamiaceae	*	*	*	*	*	*	*	*	*	*	*	*		$
14	Mint	*Mentha arvensis* L.	Lamiaceae	*	*	*	*	*	*	*	*	*	*	*	*	$	$
15	Portulaca	*Portulaca oleracea* L.	Portulacaceae	*	*	*	*	*	*	*	*	*	*	*	*	$	$
16	Jacquemontia	*Jacquemontia violacea* Kunth.	Convolvulaceae	*	*	*	*	*	*	*	*	*	*	*	*		$
17	Golden rod	*Solidago virgaurea* L.	Asteraceae	*	*	*	*	*	*	*	*	*	*	*	*	$	$
18	Cuphea	*Cuphea hyssopifolia* Kunth.	Lythraceae	*	*	*	*	*	*	*	*	*	*	*	*		$

(contd.)

19	Euryops	*Euryops pectinatus* Cass.	Asteraceae	*	*	*	*	*	*	*	*	*	*	*	*			$
20	Mexican butterfly Weed	*Asclepias curassavica* L.	Apocynaceae	*	*	*	*	*	*	*	*	*	*	*	*			$
21	Cosmos	*Cosmos* sp.	Asteraceae			*	*	*	*	*	*					$	$	
22	Fire bush	*Hamelia patens* Jacq.	Rubiaceae	*	*	*	*	*	*	*	*	*	*	*	*			$
23	Globe amaranth	*Gomphrena globosa* L.	Amaranthaceae	*	*	*	*	*	*	*	*	*	*	*	*			$
24	Bottle brush	*Callistemon* sp.	Myrtaceae	*	*	*	*	*	*	*	*	*	*	*	*	$	$	
25	Singapore Cherry	*Muntingia calabura* L.	Muntingiaceae	*	*	*	*	*	*	*	*	*	*	*	*			$
26	Karanj	*Pongamia pinnata* (L.) Pierre	Fabaceae				*	*	*							$	$	
27	Tabebuia	*Tabebuia aurea* (Silva Manso) Benth. & Hook.f. ex S.Moore	Bignoniaceae	*	*	*	*											$
28	Brinjal	*Solanum melongena* L.	Solanaceae	*	*	*	*	*	*	*	*	*	*	*	*	$		
29	Tomato	*Lycopersicon esculentum* L.	Solanaceae	*	*	*	*	*	*	*	*	*	*	*	*	$		
30	Chilli	*Capsicum annum* L.	Solanaceae	*	*	*	*	*	*	*	*	*	*	*	*	$		
31	Onion	*Allium cepa* L.	Amaryllidaceae			*	*	*	*	*						$	$	
32	Coriander	*Coriadrum sativum* L.	Apiaceae		*	*										$	$	
33	Fenugreek	*Trigonella foenum-graecum* L.	Fabaceae	*	*	*	*	*	*	*	*	*	*	*	*			$
34	Cucumber	*Cucumis sativus* L.	Cucurbitaceae											*	*		$	$
35	Watermelon	*Cucumis melo* L.	Cucurbitaceae								*	*				$	$	
36	Ridge Gourd	*Luffa acutangula* L.	Cucurbitaceae											*	*	$	$	
37	Bitter gourd	*Momordica charantia* L.	Cucurbitaceae				*	*	*	*						$	$	
38	Pumpkin	*Cucurbita moschata* L.	Cucurbitaceae		*	*										$	$	

(contd.)

39	Drum Stick	*Moringa oleifera* L.	Moringaceae			*	*		*	*						$			
40	Sunflower	*Helianthus annuus* L.	Asteraceae						*	*	*	*	*	*		$	$		
41	Mustard	*Brassica nigra* L.	Brassicaceae								*	*				$	$		
42	Sunhemp	*Crotolaria juncea* L.	Fabaceae				*	*	*								$		
43	Dolichus bean	*Dolichos lablab* L.	Fabaceae									*				$	$		
44	Castor	*Ricinus communis* L.	Euphorbiaceae										*	*	*	$	$		
45	Cowpea	*Vigna mungo* L.	Fabaceae								*					$	$		
46	Red Gram	*Cajanus cajan* L.	Fabaceae									*	*	*	*	$	$		
47	Copper pod	*Peltophorum pterocarpum* (DC.) Backer ex K.Heyne	Fabaceae	*	*	*	*	*	*							$			
48	Blue Jacaranda	*Jacaranda mimosifolia* D.Don	Bignoniaceae		*	*										$			
49	Eucalyptus	*Eucalyptus tereticornis* Sm.	Myrtaceae	*	*	*	*							*	*	$	$		
50	Moulmein rosewood	*Millettia peguensis* Ali	Fabaceae	*	*	*											$		
51	Bevu	*Azadirachta indica* A.Juss.	Meliaceae			*	*									$	$		
52	Jagalaganti	*Diospyros montana* Roxb.	Ebenaceae	*											*	$	$		
53	Pride of India	*Lagerstroemia speciosa* (L.) Pers.	Lythraceae					*	*	*						$	$		
54	Rain tree	*Samanea saman* (Jacq.) Merr.	Fabaceae			*	*	*	*							$	$		
55	Hunise	*Tamarindus indica* L.	Fabaceae				*	*	*								$		
56	Royal palm	*Roystonea regia* (Kunth) O.F.Cook	Aracaceae	*	*	*	*	*	*	*	*	*	*	*	*	$			
57	Sandal	*Santalum album* L.	Santalaceae	*	*	*	*	*	*								$		
58	Whip Tree	*Colvillea racemosa* Bojer ex Hook.	Fabaceae									*	*				$		

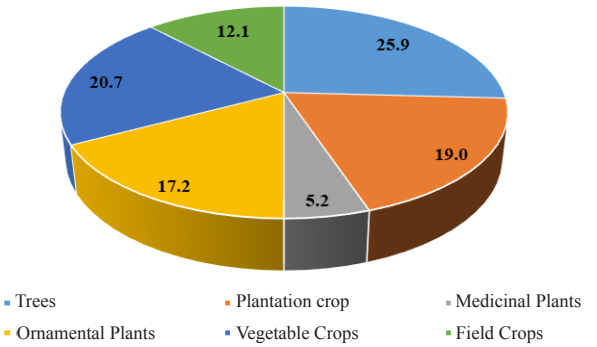

Fig. 1. Type of bee flora in beekeeping areas of Bengaluru urban

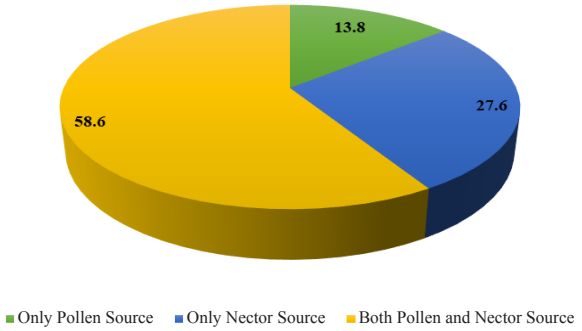

Fig. 2. Distribution of the bee flora based on the apicultural value

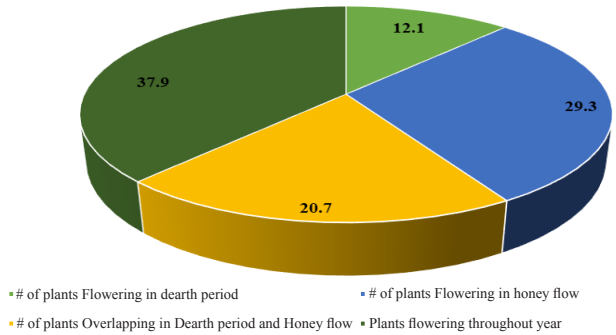

Fig. 3. Distribution of bee flora in Bengaluru urban based on the flowering period

of nutritional deficiency like lack of pollen and nectar can be avoided which helps in upkeeping the healthy colony population (Standifer, 1980). These flowering plants of an area have good value as bee pasture to maintain bee colonies.

Performance of beehives with different frames for growth and development

The sole purpose of a hive is to encourage the bees to build their nests in such a way that it is easy to manage and maintain them (FAO, 2012). Different beehive types are used for maintaining honey bees in India. In recent years, ISI 8 A type hives are being used as standard hives for the management of *A. cerana* in Southern India. High yield of honey, ease of inspection to know the status of the colony and ease of product harvesting are the major advantages of modern hives over traditional ones (FAO, 1990; Beyene et al., 2015).

However, the colony strength and hive preference of honey bees varied in different environmental conditions and different honey bee races (Abou-Shaara et al., 2013). So far, there is no study to assess the performance of colonies in different beehives and their profitability under environmental conditions of urban areas. In order to improve the beekeeping sector in urban areas, the selection and adoption of hive types suitable for the location are very important.

The data on the effect of different frame hives viz., 5, 6 and 8-frame colonies on colony build up (brood, population and honey stores) in three locations of Bengaluru urban region are presented in Table 2. The maximum brood area of 141.82 inch^2 was recorded in 8 frame hives as an average of all the three locations. The brood area of 8 frame hive is correlated with the colony strength which was found to be highest (1831.3 gm) in the 8-frame hives. The minimum brood area (115.16 inch^2) was observed in the 5-frame hive with the least colony strength (919 gm). The brood area recorded in 6-frame hive was 128.03 inch^2 with the colony population size 1608 gm. However, there was no significant difference ($F_{5.14}$ =1.14, $p>0.05$) in the brood area among the different frame hives. The present findings are in agreement with that of Mohapatra et al. (2012) who reported the average brood area ranges 123.3 -156.8 inch^2 in April-May and 130.6-146.6 inch^2 in November and December in *A. cerana* colonies. The population size varies significantly among the different frame hives ($F_{5.14}$ =25.9, $p<0.05$). There was a significant difference among the different frame hives for the average honey area in the brood chamber ($F_{5.14}$ =12.9, $p<0.05$).

The highest honey area was recorded in 6-frame hive (102.3 inch^2) followed by 5 frame hive (85 inch^2). The least honey area was recorded in the 8-frame hive (64 inch^2). The honey store of 236.22 inch^2 was recorded by Mohapatra et al. (2012) during honey flow season but the present study is not correlated with previous reports. This might be due to the lack of bee flora in the urban areas. The 5 and 6 frame hives performed better in terms of the honey store as compared to that of 8-frame hive (Fig. 4). Five-frame hive recorded the least time (17days) to fill the honey chamber followed by 6-frame (20 days). Whereas the honey fill was delayed

Table 2. Performance of different beehive types with *Apis cerana* under different locations of Bengaluru urban region

Locations	Average brood area of the colony			Average honey area of the colony			Population size (bees) (gm)		
	5 frame	6 frame	8 frame	5 frame	6 frame	8 frame	5 frame	6 frame	8 frame
Site 1 (Bee Park)	80.5	152.1	140.26	95	105	65	854	1,882	1,711
Site 2 (FTI, GKVK)	130	114	135.2	76	112	70	923	1557	1876
Site 3 (Canara bank layout, Kodegehalli)	135	118	150	84	90	59	980	1387	1907
	Non-significant F 5.14= 1.14, p>0.05			Significant F 5.14= 12.9, p<0.05			Significant F 5.14= 25.9, p<0.05		

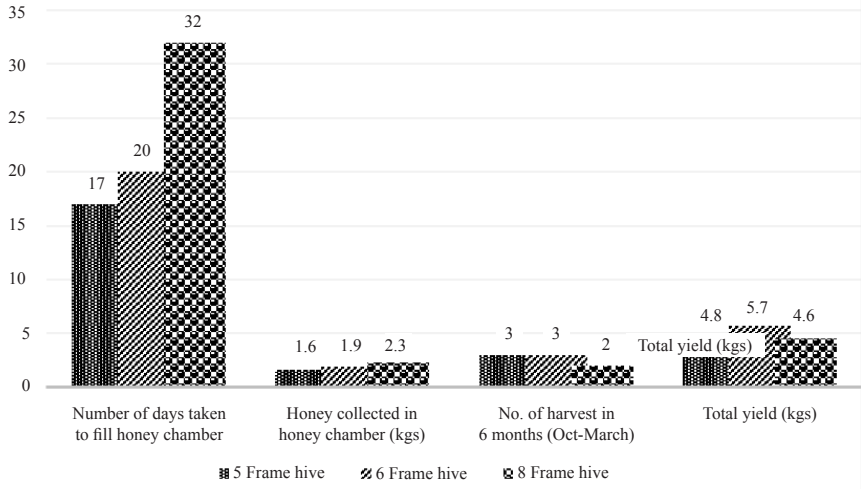

Fig. 4. Evaluation of honey yield in *Apis cerana* colonies in different frame hives

in 8-frame hives (32 days). However, there was no significant difference in the time taken to fill the honey chamber among the different frame hives. The weight of honey collected in the honey chamber was maximum in 8-frame hive (2.3 kg) followed by 6-frame hive (1.9 kg) and 5 frame hive (1.6 kg). However, the maximum number of honey harvest were recorded in 5 frame and six frame hive (3 times) followed by 2 times in 8-frame hive during the study period (October-March) there was no significant difference in quantity of honey collected in different frame hives. The total honey yield was found maximum in 6-frame hive (5.7 kg) followed by 5-frame (4.8 kg) and 8-frame (4.6 kg) hives. Therefore, in current investigation 6-frame hives followed by 5-frame hives were found better in terms of the honey yield in urban situations with limited bee floral availability. Average honey production from *A. cerana* per hive ranged from 5 kg/ hive in the coastal region to 9 kg/ hive Malnad region in Karnataka (Ramachandra et al., 2012). However, the present study showed a non-significant difference in honey yield among the different frame hives, the time taken to fill the honey chamber was relatively less in 5-frame and 6-frame hives as compared to the 8-frame hives which demonstrates the benefit of the same in the urban situations with less bee forage availability. The amount of honey beekeepers can harvest highly depends on the level of management and appropriate volume of the hive provided to the bee colonies (Awraris et al., 2015). The mellisopalynological studies of Bengaluru honey samples revealed the richness of honey with pollen grains of *Eucalyptus* sp., followed by *Pongamia pinnata*, *Azadirachta indica, Synedrilla nodiflora* and *Suregada angustifolia* (Vijayakumar et al., 2020).

Foraging performance of *A. cerana* colonies in different frame hives

The foraging performance of *A. cerana* in different frame hives in Bengaluru was studied in November-

Fig. 5. Average foraging activity of *Apis cerana* in different frame hives

December (Fig. 5). The successful survival of honey bee colony depends on the foraging efficiency of worker bees. Hence, the number of bees going out for foraging per unit time is an indicator of colony activity. Besides, the availability of sufficient flora within the foraging range and the prevailing environmental factors could affect foraging activity through energy needs of bees for flight activity (Abrol, 2005). The maximum number of pollen foragers was found in 8-frame hive (45.7 bees/5mins) followed by 6 frame hive (34.7 bees /5min) and the least number of pollen foragers were found in 5 frame hive (13.4 bees/ 5min). The nectar foragers were found maximum in 8-frame hives (43.9 bees/ 5mins) followed by 6-frame hives (33.9 bees/ 5mins) and 5-frame hives (10 bees/ 5 mins). Population of the colony has a greater impact on the colony productivity and efficiency. The foraging pattern in turn is influenced by the colony strength viz., number of workers, presence of brood, pollen and honey stores and also of artificial feeding. Brood rearing is an essential activity of bee colonies. This depends upon the availability of pollen and nectar, as also on climate factors prevailing in the locality. The colony strength influences the foraging pattern of bees (Chand et al., 2017).

The urban beekeeping could be made effective by maintaining sufficient bee forage plants in surrounding areas. The present investigation recorded 58 major bee floras which can be grown in the Bengaluru urban areas to make profitable beekeeping throughout the year. In addition, 6 frame hives were found to be performing better in terms of time taken to gather the honey as compared to the 8-frame hive. Thus 6 frame hives could be chosen for urban beekeeping which would be efficient by reducing energy needs of bees particularly in activities like comb construction. However, no major variations were found among the different types of hives with other parameters such as brood area and total honey yield. The type of hive must be chosen based on the purpose of beekeeping in urban area.

ACKNOWLEDGEMENTS

The authors acknowledge Department of Apiculture, UAS (B) for helping in designing hives and the Department of Forestry and Environmental Sciences, UAS, Bengaluru for technical guidance in the identification of bee flora. AICRP on honey bees and pollinators for funding this study.

REFERENCES

Abou-Shaara H F, Al-Ghamdi A A, Mohamed A A. 2013. Honey bee colonies performance enhance by newly modified beehives. Journal of Apicultural Science 57: 45-57.

Abrol D P. 2005. Pollination energetics. Journal of Asia-Pacific Entomology 8: 3-14.

Alton K, Francis R. 2016. Roof top hives: Practical beekeeping or publicity stunt? Bee World 93(3): 64–67.

Awraris G, Amenay A, Hailemariam G, Nuru A, Dejen A, Zerihun T, Asrat T. 2015. Comparative analysis of colony performance and profit from different beehive types in Southwest Ethiopia. Global Journal of Animal Scientific Research 3(1): 178-185.

Beyene T D, Abi G, Chalchissa W, Tsadik M. 2015. Evaluation of transitional and modern hives for honey production in mid rift valley of Ethiopia. Global Journal of Animal Scientific Research 3(1): 48-56.

Bhalchandra W, Baviskar R K, 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.

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

Chand D, Sharma D, Ganai S A, Norboo T, Sharma S. 2017. Effect of colony strength on colony build up and foraging activity of *Apis mellifera* L. Journal of Entomology and Zoology Studies 5(6): 1369-1373.

Crailsheim K. 1992. The flow of jelly within a honey bee colony. Journal of Comparative Physiology 162: 681-689.

FAO. 1990. Beekeeping in Africa: Food and Agriculture Organization of the United Nations, Rome, Italy.

FAO. 2012. Beekeeping and sustainable livelihoods: Food and Agriculture Organization of the United Nations, Rome, Italy.

Fluri P, Bogdanov S, Eder J, Rembold H. 1987. Age dependence of fat body protein in summer and winter bees (*Apis mellifera*). pp. 170-171. Munchen Verlag J. Peperny (eds.), Chemistry and biology of social insects. Germany.

Frankie G, Thorp R, Coville R, Etter B. 2014. California bees and blooms: A guide for gardeners and naturalists. Berkeley, Heyday.

Keller I, Fluri P, Imdorf A. 2005. Pollen nutrition and colony development in honey bees part II. Bee World 86(1): 310.

Mohapatra L N, Patnaik H P, Satapathy C R. 2012. Studies on the brood rearing trends and causes of absconding in Asian hive bee, *Apis cerana indica* F. under coastal Orissa conditions. Indian Journal of Entomology 74(2): 103-104.

Naim N, Phadke R P. 1976. Bee flora and seasonal activity of *Apis cerana indica* at Pusa (Bihar). India Bee Journal 38(1-4): 13-19.

Nessen, Stephen. 2012. Two years after legalized beekeeping, city may be running short on forage. WNYC News. http://www.wnyc.org/story/218358-urban-bees-may-be-running-out-foraging-ground/.

Ramachandra T V, Subash Chandran M D, Joshi N V, Balachandran C. 2012. Beekeeping: sustainable livelihood option in Uttara Kannada, Central Western Ghats. ENVIS Technical Report 49: 143.

Reddy P V R, Rashmi T, Verghese A. 2015. Info P. Foraging activity of Indian honey bee, *Apis cerana* in relation to ambient climate variables under tropical conditions. Journal of Environmental Biology 36: 577-581.

Sivaram V. 1995. Bee flora, honey flow and beekeeping in the plains of Karnataka. Doctoral thesis, Bangalore University, Bangalore, India.

Standifer L N. 1980. Honey bee nutrition and supplemental feeding. Beekeeping in the United States Agriculture Handbook 335:39-45.

Vijayakumar K T, Neethu T, Bhat N S, Nayimabanu T, Varsharani H. 2020. Physico-chemical property of different floral honeys of Bangalore region, Karnataka. Journal of Entomology and Zoology Studies 8(5): 846-854.

(Paper presented: February, 2021;
Peer reviewed, revised and accepted: April, 2022; Online Published: May, 2023)
Online published (Preview) in www.entosocindia.org and indianentomology.org (eRef. No. NWRABNRG16)