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Research Paper

Seasonal pattern of foraging activity in *Apis cerana* (indica) for assessment of colony performance index and weight gain in Kashmir valley

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ABSTRACT

Indian honey bee, *Apis cerana* is the base of Indian bee keeping and is distributed throughout India. It has many valuable characters of biological and economic importance. These include their ferocious, tamed and industrious nature, less prone to attack of parasite, mite and nosema diseases. However, absconding is a common problem in this species. Absconding is generally either disturbance induced or resource induced. Colony Performance Index (CPI) is used to measure the overall ability of the colony to stay at the nesting site. The foraging behavior of bees during different hours of the day from March to August 2020-21 was studied, wherein April and May showed greater foraging activity and better colony performance. The highest foraging behavior (139.33 bees entering/hive/5 min.) was recorded from 12:00 Noon to 1:00 pm in April (second fortnight) and the lowest foraging behavior (5 bees entering/hive/5 min.) was observed from 4:00 to 5:00 pm in August (second fortnight). The Colony Performance Index was recorded as 30.27 (highest) in the month of April and 3.18 (lowest) in the month of August. Monthly variation in Colony Performance Index (CPI) of *Apis cerana* assured the onset of dearth period as last week of July. The maximum space covered by eggs (177.20 sq cm), larvae (291.21 sq cm) and pupae (520.77 sq cm) was recorded in April (second fortnight) while the minimum space covered by eggs (80.59 sq cm), larvae (180.56 sq cm) and pupae (394.83 sq cm) was recorded in August (second fortnight).

Key words: *Apis cerana*, foraging activity, dearth period, colony performance index

Honey bees are of great economic importance because they not only produce honey and other byproducts but also act as primary pollinating agents of many agricultural and horticultural crops. Proper pollination increases crop yield and is a critical input to fruit and seed production (Giannini *et al*., 2015). Honey bees during foraging for pollen and nectar from flowers of different species; enhance agricultural productivity to the tune of 30-80 per cent annually through cross-pollination (Singh, 2000). Beekeeping can play a vital role in sustainable agricultural development as it increases resource without changing environmental balance act as cottage industry, it is a source of income of the rural people and is one of the important components of integrated rural development programmes (Verma, 1990). Beekeeping is an important component for the sustainable management of hill agro-eco system and integrated rural development programs in Jammu and Kashmir. It is a non-land based farming system and provide with nutritional food, economical and ecological security to the hilly regions of the union territory. The traditional hives serve as shelter for *Apis cerana* and are very popular among the beekeepers in rural areas, probably due to the low cost of construction of traditional hives (log and wall) using locally available materials. There are around 12, 662 colonies of *A. cerana* in traditional hives out of which 5, 150 colonies of *A. cerana* are kept in log hives and 7, 512 colonies in wall hives in J and K (Sharma *et al.*, 2015). The successful beekeeping with the indigenous honeybee, *Apis cerana* is threatened in Jammu and

Kashmir and throughout Asia due to its absconding behavior and ferocious nature which make its handling difficult (Attri *et al*., 2010; Tiwari *et al*., 2013). However the feature of absconding and swarming are necessary for colony survival but unfavorable to beekeepers (Verma, 2003). During the peak pollen flow time of the day, a colony's relative pollen income, or Colony Performance Index (CPI), is assessed. The foragers' daily pollen harvests reveal a specific pattern of pollen collection during different hours of the day. Pollen gathering does not occur at the same pace throughout the day. Instead, in many cases, the daily pollen income is collected between the hours of 7:00 am and 12:00 pm and the most intense pollen period is confined to only about 3 hours, usually between the hours of 8:00 am and 11:00 pm, when more than 80 per cent of the daily pollen income is collected (Punchihewa, 1994). The CPI monitoring system alerts beekeepers about colony absconding and thereby forewarn them to take the preventive measures to avert the problem (Nagarathna *et al.,* 2016).

MATERIALS AND METHODS

The study was undertaken at an apiary maintained at the Division of Entomology, Faculty of Horticulture, SKUAST-K, Shalimar from March to August during 2020-21. Six honeybee colonies of 10 frame strength were evaluated for various colony developmental parameters at the apiary. The beehives were made of homogenous material and were of same dimensions. The observations were recorded on foraging behavior, space covered by eggs, larvae and pupae (sq cm) and weight of whole colony with its hive (Kg) at fortnightly interval during the experimental period. Colony Performance Index (CPI) was studied on alternate days during the experimental period while as the foraging activity was studied by counting the total number of worker bees each entering the hive with or without pollen at different time intervals; from 8:00 am to 9:00 am, 12:00 noon to 1:00 pm and 4:00 pm to 5:00 pm for continuous five minutes, fortnightly, throughout the experimental period. The colonies were observed on alternate days during the months of March to August in order to ascertain the dearth period in Kashmir. The Colony Performance Index (CPI) was calculated with the help of a tool proposed by Punchihewa (1994).

$$\text{CPI} = \frac{(\text{Number of pollen foragers entering the hive})^2}{\text{Total no. of bees entering the hive} \times \text{Observation period in seconds}} \times 100$$

Where, CPI is Colony Performance Index

The space (sq cm) covered by eggs, larvae and pupae in the combs was measured with the help of wire grid device (8 cm × 8 cm). The weight of whole colony with its hive was measured by digital weighing machine.

RESULTS AND DISCUSSION

The data presented in Fig. 1 reveals that the foraging activity escalated from March (first fortnight) to April (second fortnight) and decreased from May (first fortnight) to August (second fortnight). The highest foraging activity 139.33 bees entering/hive/5 min. was recorded from 12:00 noon to 1:00 pm in April (second fortnight) followed by (131.33 bees entering/hive/5 min.) and (125.83 bees entering/ hive/5 min.) on April (first fortnight) and May (first fortnight) from 12:00 noon to 1:00 pm, respectively and it varied significantly at ($p \leq 0.05$) .

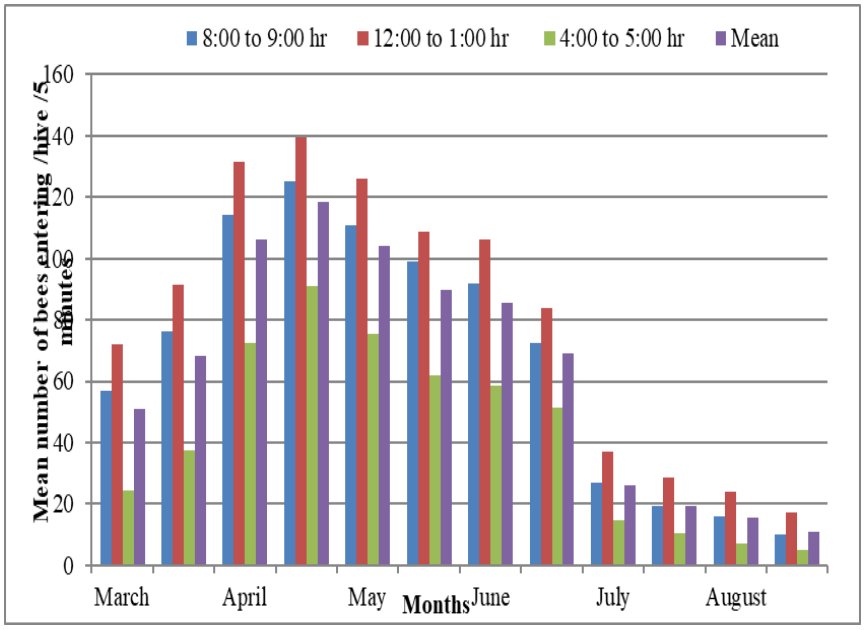

Fig. 1: Foraging activity of *Apis cerana* colonies under natural conditions

Table 1: Monthly variation in Colony Performance Index (CPI) of *Apis cerana*

Alternate days	Colony Performance Index (CPI)					
	Spring			Summer		
	March	April	May	June	July	August
Day 1	6.38	17.91	29.52	16.50	7.89	3.51
Day 3	7.42	19.92	28.81	15.43	6.39	3.39
Day 5	8.35	21.53	27.50	14.45	5.67	3.36
Day 7	9.37	22.59	26.65	13.61	5.09	3.25
Day 9	9.83	23.26	25.61	12.89	4.54	3.23
Day 11	10.15	24.14	24.65	12.13	4.26	3.21
Day 13	10.88	24.83	23.63	11.88	4.13	3.18
Day 15	11.17	25.40	22.31	11.10	4.05	3.20
Day 17	11.86	26.56	21.43	10.88	4.00	3.27
Day 19	12.17	27.32	20.88	9.91	3.89	3.32
Day 21	12.77	28.14	20.08	9.20	3.83	3.39
Day 23	13.15	29.06	19.87	9.04	3.79	3.50
Day 25	13.88	29.10	19.11	8.87	3.72	3.57
Day 27	14.55	29.88	18.35	8.32	3.60	3.64
Day 29	15.64	30.27	17.42	8.04	3.57	3.78
Mean		**19.85**			**6.47**	
	CD (p≤ 0.05)					
Months	0.053					
Alternate Day	0.084					

Each figure in the column is mean of 6 observations

The lowest foraging activity (5 bees entering/hive/5 min.) was found from 4:00 pm to 5:00 pm in August (second fortnight). These results were supported by Thakur *et al.* (1982) who reported that at noon, the foraging activity was maximum (300 bees returning in 5 minutes) and there were more pollen foragers in the morning than afternoon. Gupta *et al*. (1984) reported the foraging activity of *Apis cerana* and noticed the variations in the rate of foraging activity during different day hours. Maximum numbers of pollen gatherers of *A. cerana* were seen during 7:00 am to 9:00 am, while nectar collection activity reached the peak at 12:00 noon. Hosamani *et al*. (2019) also reported maximum foraging activity of honeybees from 12:00 noon to 1:00 pm. During the spring season (March to May) the maximum Colony performance index (CPI) of 30.27 was recorded in April and minimum CPI of 6.38 was recorded in March (Table 1 and Fig. 2) and was significantly different from each other. There is abundant flora availability during the spring season in Kashmir. In summer season (June to August) maximum CPI of 16.50 was recorded in June and the minimum CPI of 3.18 was recorded in August which showed significant differences. The mean Colony Performance Index was 19.85 in spring season and 6.47 in summer season. There was significant increase in CPI for successive six weeks from the beginning of the experiment. Monthly variation in Colony performance Index (CPI) of *A. cerana* assured the onset of dearth period as the last week of July.

These findings are in conformity with the results of Pradeepa (2012) that during Rainy season (Aug 15-Sept 15) reported the minimum CPI of 3.54 in August and maximum CPI of 8.34 in September. In winter season (Nov 15-Dec 15) the minimum CPI of 7.30 was recorded and maximum CPI of 19.60 was registered in second week of December. And during Spring (Feb 20-March 15), the minimum and maximum CPI recorded was 4.4 in February and 10.0 in March, respectively.

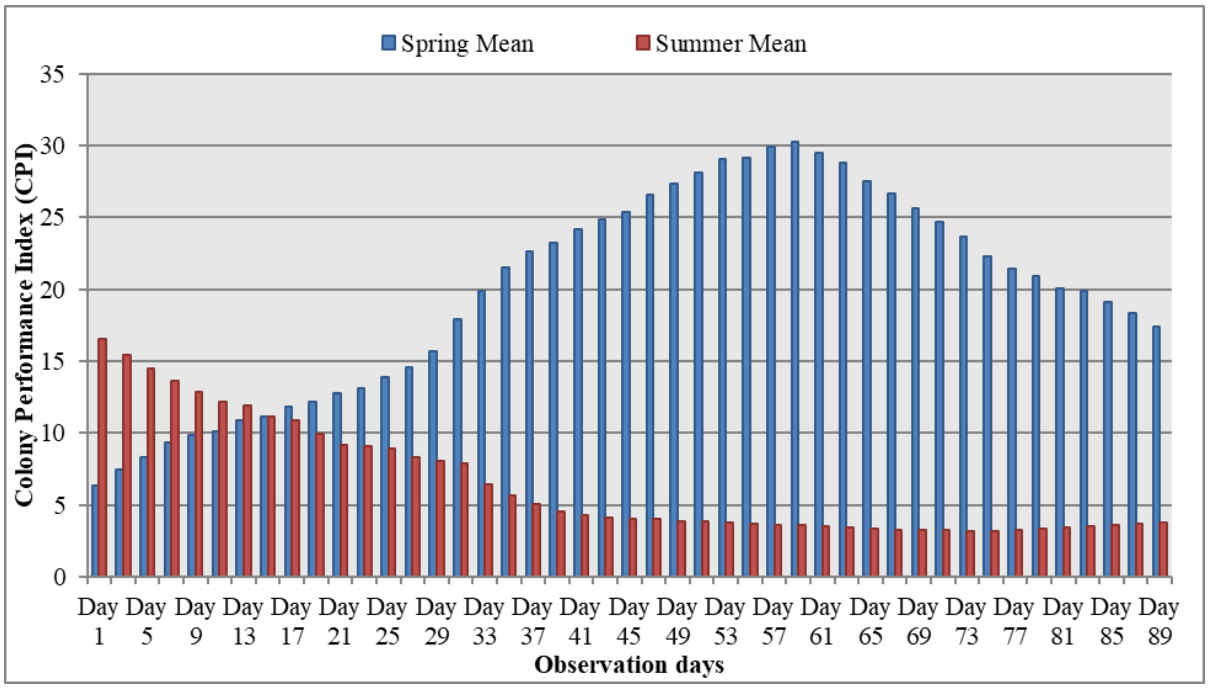

Fig. 2: Monthly variation in Colony Performance Index (CPI) of *Apis cerana*

Table 2: Performance of colonies (*Apis cerana)* under natural conditions during March, 2020 to August, 2020

		Space covered (cm^2)		
		Life stages of honeybee		
Months (2020-21)	**Duration (Fortnight)**	**Egg**	**Larvae**	**Pupae**
March	1	87.70	190.92	400.85
	2	95.94	204.99	421.21
April	1	155.86	275.17	481.28
	2	177.20	291.21	520.77
May	1	173.83	284.01	491.40
	2	152.83	260.76	471.31
June	1	145.75	235.75	453.41
	2	137.25	224.40	439.50
July	1	119.19	211.68	425.75
	2	99.87	201.00	415.16
August	1	88.87	191.25	404.33
	2	80.59	180.56	394.83
Mean		**126.64**	**229.31**	**443.32**
		CD (p≤ 0.05)		
Life stages of honeybee			0.575	
Duration			1.150	

Each figure in the column is mean of 6 observations

The mean Colony Performance Index was 5.46 in Rainy, 14.14 in winter and 7.28 in spring and these showed significant differences among themselves. The CPI of 16.50 in summer months observed during present study is in close consonance with the CPI of 19.60 reported by the author during winter season. The variation in seasons could probably be due to tropical conditions at place of investigation and in Kashmir we have different climate

and seasons of bloom than tropical regions of india. The results obtained during the study were more or less similar to the observations of Standifer *et al*. (1973), Doull (1980) and Mishra (1995) who reported the dearth period for honeybees starts in May and ends in September.

Further, they emphasized the necessity of feeding protein rich artificial diets to bee colonies during this period to strengthen their stores. The data in Table 2 reveals that the continuous brood rearing was observed throughout the experimental period with little fluctuations in the brood area coverage. The maximum space covered by eggs (177.20 one sq cm), larvae (291.21 one sq cm) and pupae (520.77 one sq cm) was recorded in April (second fortnight) and minimum space covered by eggs (80.59 sq cm), larvae (180.56 one sq cm) and pupae (394.83one sq cm) was recorded in August (second fortnight).

In March (first fortnight), the space covered by eggs was 87.70 1 sq cm, which increased to 95.94 1 sq cm, 155.86 one sq cm and 177.20 1sq cm in March (second fortnight), April (first fortnight) and April (second fortnight), respectively. These results draw their support from Sheikh (2019) who reported maximum brood area (980.60 1 sq cm) during April and minimum brood area (620.00 1sq cm) during August. During present investigations, brood area peaked during the month of April as a result of active egg laying by queen and maximum bee foraging; while exhibited its decline by June-July due to the floral dearth period. The data in the Table 3 reveals that the maximum weight of whole colony with its hive (23.74 Kg) was observed in June (second fortnight) and minimum weight of whole colony with its hive (18.19 Kg) was observed in March (first fortnight). In March (first fortnight), the weight of whole colony with its hive was 18.19 Kg, which increased to 18.63 Kg, 22.10 Kg, 23.49 Kg and 23.74 Kg in March (second fortnight), April (second fortnight), May (second fortnight) and June (second fortnight), respectively.

The weight of whole colony with its hive started declining from July (first fortnight) till August and the minimum weight of whole colony with its hive (18.19 Kg) was observed during August (second fortnight).The increase in colony weight, during April-June represents the bulk of the available resources (flora) were exploited, which shows a positive influence on the brood production and ultimately on the weight of whole colony (Lecocq *et al*., 2015). The reduction in weight of bee colony during July to August was due to the floral dearth period, which is having a negative influence on the development of colony, resulting in decline in the brood production and ultimately reduction in colony weight (Riessberger and Crailsheim, 1997).

Table 3: Weight of *Apis cerana* beehive colony under natural conditions

Weight of whole colony with its hive (Kg)			
Months (2020-21)	Duration (Fortnight)	Mean value of weight of whole colony with its hive (Kg)	Pooled mean
March,	1	18.19	18.41
	2	18.63	
April	1	20.35	21.22
	2	22.10	
May	1	22.94	23.21
	2	23.49	
June	1	23.63	23.68
	2	23.74	
July	1	23.65	23.61
	2	23.58	
August	1	23.50	23.51
	2	23.53	
CD (p≤ 0.05)	0.048		

Each figure in the column is mean of 6 observations

CONCLUSION

The assessment of Colony Performance Index and the trend exhibited by forging activity paves a way regarding the onset of dearth period for honeybee colonies. The maximum brood area during spring indicates the maximum availability of floral availability within flight range, weather conditions and other ecological factors. The study also indicates that the decline of foraging activity correlates with decline of brood area and can lead to chances of absconding. Hence, it emphasizes upon the fact that colonies should be supplemented with the artificial diet during the said period.

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